Economic Linkages Between Coastal Wetlands and Habitat/Species Protection: A Review of Value Estimates Reported in the Published Literature

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Summary

This manuscript summarizes a total of 8 peer-reviewed studies,[1] published from 1975 to 2001, reporting 24 separate estimates for the disaggregate[2] value of habitat and species protection services provided by coastal and non-coastal wetlands. Estimates varied within a single order of magnitude and were fairly tightly bounded. Considering only coastal zone wetlands across all study categories, the value of habitat and species protection ranged from \$168.96/acre/year to \$403.16/acre/year, with a mean and median of \$249.44/acre/year and \$253.47/acre/year, respectively.[3, 4] By comparison, reported estimates of willingness-to-pay (WTP) values for wetland habitat and species protection services ranged from a low of \$30.12 to \$434.67, with a mean and median of \$211.59 and \$213.86, respectively. Geographic location and type of wetland appeared to have a relatively minor impact on the estimated values.

Introduction

Coastal wetlands are increasingly recognized as essential to natural systems and human activities because of the environmental services that they provide. However, this recognition has not resulted in capitalized economic value for landowners (Heimlich et al. 1998). Nonmarketed wetland benefits may be important to society, but the lack of a market value for the services means that they are often de-emphasized relative to physical loss or the private economic gains that can arise from conversion of wetlands to other land uses (van Vuuren and Roy 1993). While the search for quantitative measures of wetland values is challenging due to the diversity, socioeconomic context, and complex hydro-biological functions of wetlands (Scodari 1990), informed policy requires that both market and nonmarket wetland values be incorporated into the decision making process.

One of the most important, but nonmarketed, services provided by coastal wetlands is habitat and species protection, and in particular the provision of reproductive habitat for threatened and endangered species. Wetland preservation efforts began early in the last century out of concern for waterfowl habitat when President Roosevelt established the first National Wildlife Refuge in 1903 to protect Pelican Island,

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[1] To the author's knowledge this represents all the peer-reviewed published studies that explicitly seek to value the linkage between wetlands and water quality/purification services.

[2] From a theoretical economic perspective, the services provided by wetlands generally should not be disaggregated and valued separately due to the potential for double counting and offsetting effects (see Pendleton and Shonkwiler [2001] for a discussion of this in a different context). For example, the provision of water purification services may, in many cases, simultaneously provide for increased habitat and species protection. Valuing each of these services separately (when, in fact, they are inseparable) and summing will lead to overestimating total potential wetland value.

[3] All values in year 2000 dollars (see Table 1).

[4] In a partial review of wetland valuation studies, Heimlich et al. (1998) calculated a much broader range on the per acre value estimates, in part because they considered the provision of a number of different services besides water quality, but also because they converted household and individual willingness-to-pay (WTP) values to per acre values using various assumptions not necessarily contained in the original studies. The review presented in this manuscript does not take this approach, and instead lists the WTP values separately (if not originally presented on a per acre basis) for comparison purposes.

a nesting site for colonial water birds. The Migratory Bird Hunting Stamp Act of 1934 established a special fund to finance wetlands acquisitions for duck habitat. In 1961, the Wetlands Loan Act allowed advanced appropriations for the purchase of wildlife refuges and waterfowl production areas (National Aududon Society 1996), leading to the current National Wildlife Refuge system that contains over 500 refuges and nearly 200 Waterfowl Protection areas (Stewart 1996). Recent legislative and administrative efforts to protect wetlands and the critical habitat that they encompass include the 1970 Water Bank program, Section 404 of the Federal water Pollution Control Act Amendments of 1972, Executive Order 11990 issued by President Carter in 1977, the Small Wetlands Acquisition program of the U.S. Fish and Wildlife Service, "Swampbuster" provisions in the 1985 Food Security Act, and the Wetland Reserve Program (Heimlich et al. 1998). Most of these programs and polices were implemented without any explicit consideration of the economic benefits associated with habitat and species protection.

This report documents the current status of knowledge concerning the economic value of the habitat and species protection services generated by coastal and other wetlands. In particular, studies that focus on valuing habitat and species protection services as an unbundled product of wetland function are highlighted.[5] A brief overview of the economic linkages between wetland ecosystems and habitat/species protection is first presented, thus providing a basic framework for understanding why specific variables and measurement methods are of interest. Second, the common methods used to value the habitat and species protection services of wetlands are outlined, along with their major advantages and disadvantages. This information can help the reader evaluate the usefulness of any particular estimate. Next, the results of individual valuation studies are presented and summarized. Lastly, the report concludes with a complete list of the literature cited.

Relationship Between Wetlands and Habitat/Species Protection

Policymakers face complex, multi-objective trade-offs when attempting to develop strategies for coastal restoration and protection.[6] Implementation of any specific strategy will result in benefits and costs that will, in general, be different than those experienced under alternative strategies. Economics can be used to help inform policymakers about the relative benefits and cost of different strategies, but analysts require information on (1) the relationship between anthropogenic activities and coastal wetland loss, (2) the costs imposed on society from coastal wetland loss, and (3) the costs of taking action to prevent coastal wetland loss. In the typical environmental management scenario, human activities are considered to be a cause of degradation, and the management of these activities via regulation or the use of economic instruments has the goal of reducing environmental impacts. Changing established human activities is potentially costly, and the cost will vary by the specific type of activity and its interrelationship with the environment. While some Louisiana coastal wetland loss can be attributed to traditional human industrial, municipal, and agricultural activities, natural environmental processes on a regional, hemispheric, and global scale are also important. Complicating the identification of causal linkages and their importance to habitat and species protection is the heterogeneity of existing wetlands. Some wetlands perform many functions, but some may perform few or even none. In addition, many of the environmental services are generated simultaneously in varying degrees by the same wetland function. From this perspective, the habitat and species protection services of wetlands can best be understood as part of an economic joint product. This jointness-in-products creates difficulties in measuring the economic importance of specific wetlands functions, and as a result the literature contains a limited

[5] A substantial part of the wetland valuation literature attempts to measure the theoretically correct multi-product value of wetlands and not the individual service components. An overview of the results generated by these studies is presented in the report (Table 2) for comparison to the single-product water quality value estimates.

[6] The following discussion was adapted from Keithly and Ward (2001) and Heimlich et al. (1998).

number of empirical studies that isolate the habitat and species protection benefits associated with wetland integrity.

Abstracting from the technical measurement difficulties, there a number of general benefits that accrue to society from its interaction with any large-scale ecosystem such as coastal wetlands (Pearce and Turner 1990). Ecosystems supply both stock and flow resources that can be used as direct and indirect inputs to production and consumption activities, thereby generating productivity and growth in the overall economic system. While the resources can be either renewable or nonrenewable, goods and services provided by Louisiana's coastal wetlands (and their associated marine ecosystems) are generally considered renewable resources.[7] The provision of habitat and species protection services via ecological support processes can be considered one of these renewable resources.

Wetlands are the most biologically productive ecosystems in the temperate regions, rivaling tropical rain forests (Mitsch and Gosselink 1993). Their biological productivity derives from an ability to recycle nutrients and energy, and provide habitat for living organisms.[8] Some fish and wildlife species spend their entire lives in wetlands and others using them intermittently for feeding or reproduction. Amphibians and reptiles also depend on wetlands, and are particularly sensitive to wetland degradation. In addition, over one-third of all bird species in North America rely on wetlands for migratory resting places, breeding or feeding grounds, or cover from predation (Kroodsma 1979). Many larger animals, such as muskrat, beaver, otter, mink, and raccoon prefer wetlands as their habitat, and wetland habitats are critical for the survival of a number of threatened and endangered species. The linkage of these habitat-related biophysical functions with economic value comes from the nonconsumptive, nonmarket value of the species and the nonmarket value of wetland aesthetics. This nonmarket orientation complicates wetlands policy because the habitat services rendered by wetlands are public goods whose benefits accrue to society at large, not specifically to wetland owners. As a result, many private wetland owners may find it more profitable to convert wetlands to alternative uses or abandon its maintenance altogether.

Once the conceptual benefits of an ecosystem are identified, economic values need to be assigned to these benefits. Having these assigned values allows policy makers to quantitatively assess the economic benefits that society might gain from marginal improvements in the integrity of the ecosystem. Value is associated with the amount that society (both current and future generations) would be willing to pay for the economic system characteristics (primarily the services and attributes) provided by the ecosystem if they were not provided free of charge. The greater the benefits derived from the services provided by any particular ecosystem, the more that ecosystem is valued by society. In general, the value of these services tends to be positively related with the integrity of the ecosystem. Of course, any action taken to decrease the loss of Louisiana's coastal wetlands, and thus increase the welfare of society at large, comes with a cost. These costs must be weighed against the benefits to determine, from the criteria of welfare economics, whether action is warranted, and to what extent.

[7] While significant nonrenewable mineral extraction, and the related economic activity, takes place in coastal Louisiana and the adjacent continental shelf, to a large extent its continued existence is not dependent on maintaining the integrity of the coastal wetlands. The extraction industry's cost structure may change if coastal wetlands are lost, but not likely to the extent that they would become economically infeasible. Navigation and port activities, however, are more likely to be negatively affected by the loss of coastal wetlands.

[8] And thus the joint-product link between habitat/species protection and the water quality services of wetlands.

Valuation Methods

The total economic value of a wetland area is the sum of the amount of money that all people who benefit from the wetland area would be willing to pay to see it protected (Whitehead 1992). If this definition of wetland value is to be empirically viable, individuals that benefit must (1) realize that they benefit, (2) understand the full extent to which they benefit, and (3) be capable of placing a dollar value on the level of their benefits, either through reference to market-based prices or some alternative, nonmarket pricing system. Methods for valuing the stock of natural capital assets and service flows generated by wetlands have been extensively discussed in both the published and unpublished literature.[9] While philosophical debate has occurred over the ability to empirically measure the full range of benefits that flow from an environmental resource, economists generally agree that accurate measurement is possible if valuation studies are carefully conducted (U.S. Department of Commerce 1993). In fact, review of past nonmarket valuation studies suggests that previously perceived variability and unreliability in the estimated values does not actually exist, particularly if one controls for the varying characteristics of the resources being valued and the way in which the estimated values are presented (Carson et al. 1996). Thus, published value estimates might be useful in analyzing the economic impact of Louisiana's coastal wetlands as long as careful attention is given to the details of the study and the resources being valued.[10]

Four theoretically plausible valuation methods have been used in the neoclassical economic literature to place valid dollar values on wetland resources.[11] These methods are the net factor income (NFI) method, the contingent valuation method (CVM), the travel cost method (TCM), and the hedonic price method (HPM). A fifth set of methods found in the literature, but not theoretically valid under typical application, is the damage cost or replacement cost methods (DCM or RCM). All of these methods are briefly described below. In addition, the non-neoclassical literature, as well as the biological literature, often contains studies employing energy analysis methods (EAM), whereby the value of ecosystem assets are directly related to their energy processing abilities.[12] Shabman and Batie (1978) detailed the fundamental problems and economic fallacies imbedded in this approach,[13] and no further discussion of its use is included in this report. The results from two studies employing EAM, however, are reported in Table 2 in order to completely characterize the wetland valuation literature.

The NFI method uses market prices to measure the additional profit earned by firms due to the contribution of the wetlands to production activities, and it generates use values. Thus, the NFI method is

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[9] For excellent early overviews, see Greenley et al. (1982) and Amacher et al. (1989). Scodari (1990) provides a thorough review of the advantages and disadvantages of various methods specifically within a wetland valuation context, while Whitehead (1992) contains a lucid, if somewhat terse, review of the methods and the theory behind them. More recent papers detailing established and newer methods include Feather et al. (1995), Apogee Research, Inc. (1996), Mahan (1997), Bockstael (1998) and Pendleton and Shonkwiler (2001). For comprehensive reviews of the theory and application of contingent valuation methods for nonmarket goods and services, see U.S. Department of Commerce (1993) and Bishop et al. (1998).

[10] This type of detailed examination was beyond the time constraints of this study, but it should be seriously considered for inclusion in future phases of a valuation project.

[11] The brief methods discussion borrows from Amacher et al. (1989), Whitehead (1992), and others.

[12] This approach, which first received widespread publicity and policy attention due to a study by Gosselink et al. (1974), is based on the Odum and Odum (1972) contention that society's use of resources should maximize the net energy production of the total environment (including its natural and developed components).

[13] The fundamental problem is that EAM fails to recognize the nature of the process by which economic values are determined, and makes an "illegitimate marriage" of the principles of systems ecology with economic theory (Shabman and Batie 1978). "This leads to estimates of marsh service value that are, at best, inaccurate. At worst, these inaccurate estimates may capture the focus of policy debate, and hinder, rather than improve, the resource management process for coastal wetlands."

most appropriate when the wetland provides a service that leads to an increase in producer surplus, or the economic gains attained by the users of the resource, because it exploits the relationship between the value of the production activity and the wetland acreage. In the NFI method the physical relationship between wetland areas and the economic activity is empirically estimated from data on the production activity. It is then possible to identify the increase in producer surplus (economic gain) associated with the use of the wetland resource.[14] If the empirical estimates are obtained through statistical regression, then estimates of the marginal value product (MVP) of the wetland resource can be generated. In this context, the MVP provides a direct measure of the firm owner's willingness-to-pay to avoid wetland degradation.

Producer surplus generated by the use of a wetland can also be estimated using the RCM. This approach values the wetland=s service based on the price of the cheapest alternative way of obtaining that service. For example, the value of a natural wetland in the treatment of wastewater might be estimated using the cost of chemical, mechanical, or constructive alternatives. The use of RCMs needs to be governed by three considerations (Shabman and Batie 1978): (1) the alternative considered should provide the same services, (2) the alternative selected for cost comparison should be the least-cost alternative, and (3) there should be substantial evidence that the service would be demanded by society if it were provided by that least-cost alternative. Taken together, these condition differentiate RCM from the more general class of DCMs, where the entire value of a marketable good or service is tied to the preservation of a wetland resource, ignoring consumer and producer substitution possibilities. Even with restrictive application, the RCM can only be considered to yield an upper bound on the true WTP for the wetland service because the producer may not choose to actually use the alternative considered (Anderson and Rockel 1991).

The CVM is a survey approach that measures the total economic value of all wetland goods and services by directly asking individuals about their WTP. The CVM establishes a hypothetical market by providing information about wetland resources, specifying payment rules and vehicles, and posing valuation questions. Answers to these questions can be used to directly measure WTP, and CVM may be the only way to estimate many non-use values of environmental resources. But, in order for CVM to yield valid economic measures, study participants must be both willing and able to reveal their values. Other valuation approaches, such as TCM and HPM discussed below, depend on revealed preferences through market transactions and other behavior. Statements from economic actors about how they would act under hypothetical circumstances, as used in the CVM, are a very different measure and ultimately need to assessed for validity (Bishop et al. 1998). A panel of experts organized by the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce, and co-chaired by Nobel laureate economists Kenneth Arrow and Robert Solow, concluded that (1) there is too much positive evidence to dismiss CVM and its usefulness in providing information about values, (2) CVM studies do not automatically generate value information, but are highly dependent on the content validity of the survey, and (3) CVM is an evolving market valuation technique (U.S. Department of Commerce 1993). In the words of the panel (p. 4610), “CV studies convey useful information. We think it is fair to describe such information as reliable by the standards that seem to be implicit in similar contexts, like market analysis for new and innovative products and the assessment of other damages normally allowed in court proceedings . . . . Thus, the Panel concludes that CV studies can produce estimates reliable enough to be a starting point of a judicial process of damage assessment, including lost passive-use values.”

The TCM approach is often used to measure the recreational benefits of wetlands, but it is generally applicable to valuing any nonmarket wetland good or service that individuals are willing to

[14] In practice, it is often assumed that the demand for the good being produced by the user is perfectly elastic, and thus changing wetland services has no effect on consumer surplus.

travel to and use at the wetland site. The TCM method estimates the costs incurred traveling to visit and use the site, with the concept being that the travel and time costs are measures of implicit market prices. The estimated costs are then used to construct demand functions that use travel and time costs as independent variables.[15] Consumer surplus per recreation trip and year can then be approximated from the estimated demand curve. The application of TCM assumes that (1) users have identical utility functions for the activity, and thus will have identical demand functions, (2) users are indifferent between incurring costs as user fees or travel costs, (3) weak complimentarity holds in that changes at competing sites do not affect use at the site being valued, and (4) site use is not congested. Given these assumptions, TCMs cannot be used to value nonmarket goods and services that either do not require the user to visit the site or that are offsite products. Furthermore, TCM generally cannot account for multiple sites, visits to multiple sites on the same trip, or the impact of small resource changes on user perceptions and travel patterns.

The HPM has been used to measure the contribution of wetlands for flood control and the role of wetland aesthetics in housing and property prices. Thus, HPMs attempt to tie wetland service value directly to a market price (Freeman 1998). In a market at equilibrium, land values and land rents should be a function of land characteristics, including the proximity to and services provided by wetlands. The increment to the land or housing price arising from wetland services is a measure of the implicit price of that service. There are three key assumptions required to apply HPM to estimate the wetland contribution to land values. First, there must be data on a continuum of sites with varying wetland characteristics and acreage. Second, purchasers and sellers of wetland parcels are assumed to have access to the same information regarding the condition of the site and the nature and use of the wetland. Third, wetland purchasers (or purchasers of property near wetlands) are assumed to have identical preferences for wetland characteristics. The assumption of identical preferences makes estimation of demand curves possible when data does not exist about individual preferences.

The valuation method employed in any particular habitat and species protection valuation study depends primarily on the ability to quantitatively discern the biophysical linkages between characteristics of a particular wetland area and the potential changes in the quality and quantity of habitat for a given species. Given that this relationship is often poorly understood from a quantitative perspective, CVM may be most appropriate valuation approach even in light of its limitations. No habitat/species protection valuation studies were found that employed NFI, TCM, HPM, or RCM approaches.

Review of Estimated Values

No estimates for the value of Louisiana wetlands in the provision of habitat and species protection services were found in the published literature. Studies conducted for wetlands in other regions of the U.S. reported habitat and species protection service values that ranged from a low of \$168.96/acre/year to a high of \$403.16/acre/year, with a mean and median value of \$260.09/acre/year and \$258.14/acre/year, respectively.[16, 17] One international study reported an aggregate world-wide wildlife habitat service value of \$142.92/acre/year for coastal wetlands. Considering only coastal zone wetlands across all study categories, the value of habitat and species protection ranged from \$168.96/acre/year to

[15] Other independent variables are also employed, including the theoretically requisite income and various potential demand shifters, depending on the situation being modeled.
[16] All values in year 2000 dollars.
[17] It should be emphasized that all but one of the reported U.S. valuation studies were conducted by one set of authors in the mid-1970s. The importance of this information to understanding the value of habitat and species protection services derived wetlands is not clear, although it is always preferable to have multiple, independent studies on which to base inferences.

$403.16/acre/year, with a mean and median of $249.44/acre/year and $253.47/acre/year, respectively. For comparison purposes, reported estimates of willingness-to-pay (WTP) values for habitat and species protection ranged from a low of $30.12 to $434.67, with a mean and median of $211.59 and 213.86, respectively. Geographic location and type of wetland appeared to have a relatively minor impact on the estimated values.

Table 1. Published estimates of habitat and species protection service values provided by wetlands, 1975-2001.

Study	Location	Site Type	Site Use	Site Size (acres)	Valuation Method	Discount Rate (%)	Time Horizon (years)	Base Year	NPV Estimate (base yr $)	Annualized Value/Acre (base yr $)	Annualized Value/Acre (yr 2000 $)[a]
					U.S. Specific Studies						
Gupta and Foster 1975	White Cedar Bog, Massachusetts	-----	Wildlife habitat	-----	Average state acquisition price scaled by wildlife habitat productivity score	5.375	Infinite	1970	670	36.01[b]	168.96
Gupta and Foster 1975	Otis Fresh Meadows, Massachusetts	-----	Wildlife habitat	-----	Average state acquisition price scaled by wildlife habitat productivity score	5.375	Infinite	1970	744	39.99[b]	187.64
Gupta and Foster 1975	Bear Meadows, Massachusetts	-----	Wildlife habitat	-----	Average state acquisition price scaled by wildlife habitat productivity score	5.375	Infinite	1970	893	46.39[b]	217.67
Gupta and Foster 1975	Hyannis Wooded Swamp, Massachusetts	-----	Wildlife habitat	-----	Average state acquisition price scaled by wildlife habitat productivity score	5.375	Infinite	1970	911	48.97[b]	229.77
Gupta and Foster 1975	Moore's Pond, Massachusetts	-----	Wildlife habitat	-----	Average state acquisition price scaled by wildlife habitat productivity score	5.375	Infinite	1970	1,005	54.02[b]	253.47
Gupta and Foster 1975	Chicopee River Marshes, Massachusetts	-----	Wildlife habitat	-----	Average state acquisition price scaled by wildlife habitat productivity score	5.375	Infinite	1970	1,042	56.01[b]	262.80
Gupta and Foster 1975	Hoosic River Swamp, Massachusetts	-----	Wildlife habitat	-----	Average state acquisition price scaled by wildlife habitat productivity score	5.375	Infinite	1970	1,079	58.00[b]	272.14
Gupta and Foster 1975	Lawrence Swamp, Massachusetts	-----	Wildlife habitat	-----	Average state acquisition price scaled by wildlife habitat productivity score	5.375	Infinite	1970	1,172	63.00[b]	295.60
Gupta and Foster 1975	Wenham Swamp, Massachusetts	-----	Wildlife habitat	-----	Average state acquisition price scaled by wildlife habitat productivity score	5.375	Infinite	1970	1,228	66.01[b]	309.73

Table 1. Published estimates of habitat and species protection service values provided by wetlands, 1975-2001 – continued.

Study	Location	Site Type	Site Use	Site Size (acres)	Valuation Method	Discount Rate (%)	Time Horizon (years)	Base Year	NPV Estimate (base yr $)	Annualized Value/Acre (base yr $)	Annualized Value/Acre (yr 2000 $)[a]
U.S. Specific Studies											
Woodward and Wui 2001	-----	Mixed	Wildlife habitat	-----	Econometric meta-analysis of 39 studies yielding per acre values; excludes WTP where per acre value was not generated	-----	-----	1990	-----	306 90% C.I. of 95 - 981	403.16
International Studies											
Costanza et al. 1997	World wide	Coastal wetlands	Wildlife habitat	815 million	Mixed aggregation of various studies; little detail given concerning specific studies	-----	-----	1994	-----	123	142.92
Studies Where Value Not Reported on an Area Basis											
Morrison et al. 1999	New South Wales, Australia	Ephem. wetlands	Habitat and endangered species; non-use employment	297,000	WTP using choice modeling	-----	-----	1997	-----	34.04-73.19 [e] with job losses ($Australian)	30.12 [c e]
Morrison et al. 1999	New South Wales, Australia	Ephem. wetlands	Habitat and endangered species; non-use employment	297,000	WTP using choice modeling	-----	-----	1997	-----	48.75-102.62 [e] no job losses ($Australian)	41.01 [c e]
Pate and Loomis 1997	San Joaquin Valley, CA	General wetlands	Protection of wildlife from contamination	90,000	WTP mail survey of Oregon residents, with emphasis on distance effect	-----	-----	1989	-----	51.92 [e]	72.10 [e]
Stevens et al. 1995	New England	General wetlands	rare species protection	-----	WTP contingent valuation mail survey	-----	-----	1993	-----	88.42 [e]	105.37 [e]
Pate and Loomis 1997	San Joaquin Valley, CA	General wetlands	Protection of wildlife from contamination	90,000	WTP mail survey of Washington residents, with emphasis on distance effect	-----	-----	1989	-----	86.35 [e]	119.92 [e]
Creel and Loomis 1992	San Joaquin Valley, California	Wetland recreation areas	Viewing	-----	Linked site selection and trip count models	-----	-----	1988	-----	140.00[d e]	203.79 [e]

Table 1. Published estimates of habitat and species protection service values provided by wetlands, 1975-2001 – continued.											
Study	**Location**	**Site Type**	**Site Use**	**Site Size (acres)**	**Valuation Method**	**Discount Rate (%)**	**Time Horizon (years)**	**Base Year**	**NPV Estimate (base yr $)**	**Annualized Value/Acre (base yr $)**	**Annualized Value/Acre (yr 2000 $)[a]**
					Studies Where Value Not Reported on an Area Basis						
Loomis et al. 1991	San Joaquin Valley, California	General wetlands	Preservation and maintenance	85,000	WTP contingent valuation with acreage reference	-----	-----	1989	-----	154.00 [e]	213.86 [e]
Loomis et al. 1991	San Joaquin Valley, California	General wetlands	Waterbird protection from increased contamination	-----	WTP contingent valuation	-----	-----	1989	-----	188.00 [e]	261.08 [e]
Pate and Loomis 1997	San Joaquin Valley, CA	General wetlands	Protection of wildlife from contamination	90,000	WTP mail survey of Nevada residents, with emphasis on distance effect	-----	-----	1989	-----	203.08 [e]	282.02 [e]
Pate and Loomis 1997	San Joaquin Valley, CA	General wetlands	Protection of wildlife from contamination	90,000	WTP mail survey of California residents outside the San Joaquin Valley, with emphasis on distance effect	-----	-----	1989	-----	222.69 [e]	309.25 [e]
Pate and Loomis 1997	San Joaquin Valley, CA	General wetlands	Protection of wildlife from contamination	90,000	WTP mail survey San Joaquin Valley residents, with emphasis on distance effect	-----	-----	1989	-----	233.86 [e]	324.76 [e]
Loomis et al. 1991	San Joaquin Valley, California	General wetlands	Improvement	125,000	WTP contingent valuation with acreage reference	-----	-----	1989?	-----	254.00 [e]	352.73 [e]
Loomis et al. 1991	San Joaquin Valley, California	General wetlands	Decrease contamination of waterbirds	125,000	WTP contingent valuation	-----	-----	1989?	-----	313.00 [e]	434.67 [e]

[a] Study values inflated to common year 2000 values using the Bureau of Labor Statistics (BLS) CPI Inflation Calculator, which bases yearly adjustments on the average consumer price index by year.
[b] All values were based on a $70/acre/year value for a site with a score of 100 on the productivity scale.
[c] Inflated to year 2000 using the BLS CPI Inflation Calculator and converted to U.S. dollars using the ratio $1.89 Australian/$1.00 U.S.
[d] Mean of two differently specified models.
[e] Value is not reported on a per acre per year basis. In most cases, the value represents household willingness-to-pay for the service where the service/wetland quantity relationship is not defined.

Table 2. Published estimates of total service values provided by wetlands, 1975-2001.

Study	Location	Site Type	Site Use	Site Size (acres)	Valuation Method	Discount Rate (%)	Time Horizon (years)	Base Year	NPV Estimate (base yr $)	Annualized Value/Acre (base yr $)	Annualized Value/Acre (yr 2000 $)[a]
					Louisiana Specific Studies						
Costanza and Farber 1987	Terrebonne Parish, Louisiana	Coastal Louisiana	Summation of commercial fishing, trapping, recreation, and storm protection	650,000	Simple summation of mixed method estimates of individual services	8.0	Infinite	1983	586.73	46.94	81.16
Costanza et al. 1989	Louisiana	Coastal wetlands	Commercial fishing, trapping, recreation, and storm protection	-----	Production function, revenue accounting, travel cost, and WTP contingent valuation	8.0 , 3.0	Infinite	1983	2,429 - 8,977	194.32[b]	335.96
Costanza and Farber 1987, Costanza et al. 1989	Terrebonne Parish, Louisiana	Fresh coastal wetlands	All services	650,000	Energy analysis based gross primary productivity conversion, net value lost when converting wetland to open water	8.0	Infinite	1983	6,400	512.00	885.20
Costanza and Farber 1987	Terrebonne Parish, Louisiana	Saltwater coastal wetlands	All services	650,000	Energy analysis based gross primary productivity conversion, net value lost when converting wetland to open water	8.0	Infinite	1983	6,700	536.00	926.70
Costanza and Farber 1987	Terrebonne Parish, Louisiana	Brackish coastal wetlands	All services	650,000	Energy analysis based gross primary productivity conversion, net value lost when converting wetland to open water	8.0	Infinite	1983	10,602	848.16	1,466.40

Table 2. Published estimates of total service values provided by wetlands, 1975-2001 -- continued.

Study	Location	Site Type	Site Use	Site Size (acres)	Valuation Method	Discount Rate (%)	Time Horizon (years)	Base Year	NPV Estimate (base yr $)	Annualized Value/Acre (base yr $)	Annualized Value/Acre (yr 2000 $)[a]
Additional U.S. Studies											
van Vuuren and Roy 1993	Lake St. Clair, Michigan & Canada	Freshwater wetlands	Public and club hunting, angling, trapping	741 undiked	Travel cost	4.0	50	1985	4,435	83.55	133.71
Gupta and Foster 1975	Massachusetts	LLNN Wetland	Benefits of wildlife, visual/cultural, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	500	40	165
van Vuuren and Roy 1993	Lake St. Clair, Michigan & Canada	Freshwater wetlands	Public and club hunting, angling, trapping	370.7 diked	Travel cost	4.0	50	1985	6,027	113.54	181.71
van Vuuren and Roy 1993	Lake St. Clair, Michigan & Canada	Freshwater wetlands	Public and club hunting, angling, trapping	49.4 diked	Travel cost	4.0	50	1985	6,968	131.27	210.08
Roberts and Leitch 1997	Mud Lake, MN-SD	Fresh wetland	All services	-----	Cost savings, residual return to water utilities, contingent valuation	-----	-----	1995	-----	375	423.72
Gupta and Foster 1975	Massachusetts	HLNN Wetland	Benefits of wildlife, visual/cultural, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	1,400	113	466
Gupta and Foster 1975	Massachusetts	LLNH Wetland	Benefits of wildlife, visual/cultural, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	1,700	137	564

Table 2. Published estimates of total service values provided by wetlands, 1975-2001 -- continued.

Study	Location	Site Type	Site Use	Site Size (acres)	Valuation Method	Discount Rate (%)	Time Horizon (years)	Base Year	NPV Estimate (base yr $)	Annualized Value/Acre (base yr $)	Annualized Value/Acre (yr 2000 $)[a]
					Additional U.S. Studies						
Gupta and Foster 1975	Massachusetts	MMNM Wetland	Benefits of wildlife, visual/cultural, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	3,000	242	997
Gupta and Foster 1975	Massachusetts	LHNL Wetland	Benefits of wildlife, visual/cultural, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	4,100	330	1,359
Gupta and Foster 1975	Massachusetts	HHNH Wetland	Benefits of wildlife, visual/cultural, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	6,000	484	1,994
Gupta and Foster 1975	Massachusetts	LLLL Wetland	Benefits of wildlife, visual/cultural, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	6,400	519	2,138
Gupta and Foster 1975	Massachusetts	HHLH Wetland	Benefits of wildlife, visual/cultural, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	11,700	943	3,885

Table 2. Published estimates of total service values provided by wetlands, 1975-2001 -- continued.

Study	Location	Site Type	Site Use	Site Size (acres)	Valuation Method	Discount Rate (%)	Time Horizon (years)	Base Year	NPV Estimate (base yr $)	Annualized Value/Acre (base yr $)	Annualized Value/Acre (yr 2000 $)[a]
Additional U.S. Studies											
Gupta and Foster 1975	Massachusetts	HHMH Wetland	Benefits of wildlife, visual/cultur al, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	26,000	2,095	12,750
Gupta and Foster 1975	Massachusetts	LLHL Wetland	Benefits of wildlife, visual/cultur al, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	40,700	3,280	13,512
International Studies											
Gupta and Foster 1975	Massachusetts	HHHH Wetland	Benefits of wildlife, visual/cultur al, water supply, and flood control	-----	Average state acquisition price scaled by habitat score (wildlife) or quality (visual cultural), 1971 ACE study of Charles River (flood control), 1970 USGS study (supply)	7.0	30	1972	46,000	3,707	15,271
Thibodeau and Ostro 1981	Charles River Basin	Costal wetlands	All services	8,535	Simple summation of mixed method estimates of individual services	6	Infinite	1978	171,772	10,306.32	27,220
Gren et al. 1995	Danube floodplain	Mixed	All ecosystem services	4.3 m	Summation of individual service estimates	5.0 and 2.0 percent	infinite	1991	3,027 ecu to 7568 ecu per acre	151.35 ecu	174.13[c]
Costanza et al. 1997	World wide	Coastal wetlands	All services and products	815 m world wide	Mixed aggregation of various studies; little detail given concerning specific studies	-----	-----	1994	-----	5,983	6,952

Table 2. Published estimates of total service values provided by wetlands, 1975-2001 -- continued.

Study	Location	Site Type	Site Use	Site Size (acres)	Valuation Method	Discount Rate (%)	Time Horizon (years)	Base Year	NPV Estimate (base yr $)	Annualized Value/Acre (base yr $)	Annualized Value/Acre (yr 2000 $)[a]
International Studies											
Sathirathai and Barbier 2001	Thailand	Mangrove wetland	Direct and indirect use (timber, fishing, coastline protection)	988	various	-----	-----	1993	-----	1,553[d]	1,851
Studies Where Value Not Reported on an Area Basis											
Mullarkey and Bishop 1999	Northwest Wisconsin	Fresh wetland	Total value under high certainty	110	WTP mail survey; respondent certainty and scope test included	-----	-----	1995	-----	20.77 [e]	23.47 [e]
Mullarkey and Bishop 1999	Northwest Wisconsin	Fresh wetland	Total value under low certainty	110	WTP mail survey; respondent certainty and scope test included	-----	-----	1995	-----	57.83 [e]	65.34 [e]
Pate and Loomis 1997	San Joaquin Valley, CA	General wetlands	Generalized to all uses	90,000	WTP mail survey of Oregon residents	-----	-----	1989	-----	67.80 [e]	94.15 [e]
Loomis et al. 2000	Nebraska	Platte River	Wastewater dilution, water purification, erosion control, habitat, and recreation	300,000	WTP mail survey	-----	-----	1998	-----	252 [e]	100.79 [e]
Stevens et al. 1995	New England	General wetlands	Recreation, rare species, food production, flood protection, water supply and pollution control	-----	WTP contingent valuation mail survey	-----	-----	1993	-----	114.29 [e]	136.20 [e]

Table 2. Published estimates of total service values provided by wetlands, 1975-2001 -- continued.

Study	Location	Site Type	Site Use	Site Size (acres)	Valuation Method	Discount Rate (%)	Time Horizon (years)	Base Year	NPV Estimate (base yr $)	Annualized Value/Acre (base yr $)	Annualized Value/Acre (yr 2000 $)[a]
					Studies Where Value Not Reported on an Area Basis						
Pate and Loomis 1997	San Joaquin Valley, CA	General wetlands	Generalized to all uses	90,000	WTP mail survey of Washington residents	-----	-----	1989	-----	99.75 [e]	138.52 [e]
Pate and Loomis 1997	San Joaquin Valley, CA	General wetlands	Generalized to all uses	90,000	WTP mail survey of Nevada residents	-----	-----	1989	-----	196.01 [e]	272.20 [e]
Pate and Loomis 1997	San Joaquin Valley, CA	General wetlands	Generalized to all uses	90,000	WTP mail survey California residents outside the San Joaquin Valley	-----	-----	1989	-----	210.77 [e]	292.70 [e]
Pate and Loomis 1997	San Joaquin Valley, CA	General wetlands	Generalized to all uses	90,000	WTP mail survey of San Joaquin Valley residents	-----	-----	1989	-----	215.55 [e]	299.34 [e]

[a] Study values inflated to common year 2000 values using the Bureau of Labor Statistics (BLS) CPI Inflation Calculator, which bases yearly adjustments on the average consumer price index by year.
[b] Storm protection accounted for 79 percent ($153.20/acre/yr) of the total value.
[c] Inflated to year 2000 using the BLS CPI Inflation Calculator and converted to U.S. dollars using the ratio 1.10 ecu/$1.00 U.S.
[d] Value is strongly influenced by estimates for coastline protection, which account for 96% of the total.
[e] Value is not reported on a per acre per year basis. In most cases, the value represents household willingness-to-pay for the service where the service/wetland quantity relationship is not defined.

Literature Cited

Amacher, G.S., R.J. Brazee, J.W. Bulkley and R.A. Moll. 1989. *Application of Wetland Valuation Techniques: Examples from Great Lakes Coastal Wetlands.* Report No. 88-G1569-02, School of Natural Resources, The University of Michigan and the Institute of Water Research, Michigan State University.

Anderson, R. and M. Rockel. 1991. *Economic Valuation of Wetlands.* Discussion Paper #065, American Petroleum Institute, Washington, D.C.

Apogee Research, Inc. 1996. *Monetary Measurement of Environmental Goods and Services: Framework and Summary of Techniques for Corps Planners.* IWR Report 96-R-24, U.S. Army Corps of Engineers Institute for Water Resources, Alexandria, Virginia.

Bishop, R.C., P.A. Champ and D.J. Mullarkey. 1998. "Contingent Valuation." In D.W. Bromley (ed.), *The Handbook of Environmental Economics.* Cambridge, Massachusetts: Blackwell Publishers Ltd.

Bockstael, N.W. 1998. "Travel Cost Models." In D.W. Bromley (ed.), *The Handbook of Environmental Economics.* Cambridge, Massachusetts: Blackwell Publishers Ltd.

Carson, R., N. Flores, K. Martin and J. Wright. 1996. "Contingent Valuation and Revealed Preference Methodologies: Comparing Estimates for Quasi-Public Goods." *Land Economics* 72:80-99.

Costanza, R. and S. Farber. 1987. "The Economic Value of Wetlands Systems." *Journal of Environmental Management* 24:41-51.

Costanza, R., S.C. Farber and J. Maxwell. 1989. "Valuation and Management of Wetland Ecosystems." *Ecological Economics* 1:335-361.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'neill, J. Paruelo, R.G. Raskin, P. Sutton and M. van den Belt. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* 387:253-260.

Creel, M. and J. Loomis. 1992. "Recreation Value of Water to Wetlands in the San Joaquin Valley: Linked Multinomial Logit and Count Data Trip Frequency Models." *Water Resources Research* 28(10):2597-2606.

Feather, T.D., C.S. Russell, K.W. Harrington and D.T. Capan. 1995. *Review of Monetary and Nonmonetary Valuation of Environmental Investments.* IWR Report 95-R-2, U.S. Army Corps of Engineers Institute for Water Resources, Alexandria, Virginia.

Freeman, A.M. 1998. "Hedonic Pricing Methods." In D.W. Bromley (ed.), *The Handbook of Environmental Economics.* Cambridge, Massachusetts: Blackwell Publishers Ltd.

Gosselink, J.G. E.P. Odum and R.M. Pope. 1974. *The Value of the Tidal Marsh*. Publ. LSU-SG-74-03, Center for Wetland Resources, Louisiana State University, Baton Rouge, Louisiana.

Greenley, D.A., R.G. Walsh and R.A. Young. 1982. *Economic Benefits of Improved Water Quality: Public Perceptions of Option and Preservation Values.* Boulder, Colorado: Westview Press.

Gren, I-M., K-H. Groth and M. Sylven. 1995. "Economic Values of Danube Floodplains." *Journal of Environmental Management* 45:333-345.

Gupta, T.R. and J.H. Foster. 1975. "Economic Criteria for Freshwater Wetland Policy in Massachusetts." *American Journal of Agricultural Economics* 57:40-45.

Heimlich, R.E., K.D. Wiebe, R. Claassen, D. Gadsby and R.M. House. 1998. *Wetlands and Agriculture: Private Interests and Public Benefits*. Agricultural Economic Report No. 765, Resource Economics Division, Economic Research Service, U.S. Department of Agriculture, Washington, D.C. 94 p.

Keithly, W.R. and J.M. Ward. 2001. "An Economic Perspective of Hypoxia in the Northern Gulf of Mexico." In N.N. Rabalais and R.E. Turner (eds.), *Coastal Hypoxia: Consequences for Living Resources and Ecosystems*. Washington, DC: Coastal and Estuarine Studies 58, American Geophysical Union.

Kroodsma, D.E. 1979. "Habitat Values for Nongame Wetland Birds." In P.E. Greeson, J.R. Clark and J.E. Clark (eds.), *Wetland Functions and Values -- The State of Our Understanding*. Minneapolis, Minnesota: American Water Resources Association.

Loomis, J., M. Hanemann, B. Kanninen and T. Wegge. 1991. "Willingness to Pay to Protect Wetlands and Reduce Wildlife Contamination from Agricultural Drainage." In A. Dinar and D. Zilberman (eds.), *The Economics and management of Water and Drainage in Agriculture.* Boston, Massachusetts: Kluwer Academic Publishers, pp. 411-445.

Loomis, J., P. Kent, L. Strange, K. Fausch and A. Covich. 2000. "Measuring the Total Economic Value of Restoring Ecosystem Services in an Impaired River Basin: Results from a Contingent Valuation Survey." *Ecological Economics* 33:103-117.

Mahan, B.L. 1997. *Valuing Urban Wetlands: A Property Pricing Approach.* IWR Report 97-R-1, U.S. Army Corps of Engineers Institute for Water Resources, Alexandria, Virginia.

Mitsch, W. J. and J.G. Gosselink. 1993. *Wetlands, 2nd Edition*. New York: Van Nostrand Reinhold.

Morrison, M., J. Bennett and R. Blamey. 1999. "Valuing Improved Wetland Quality Using Choice Modeling." *Water Resources Research* 35(9):2805-2814.

Mullarkey, D.J. and R.C. Bishop. 1999. *Sensitivity to Scope: Evidence from a CVM Study of Wetlands*. Mimeo. Presented at the American Agricultural Economics Association meetings, Nashville, TN.

National Audubon Society. 1996. *Small and Farmed Wetlands: Oases for Life*. Washington, DC.

Odum, E.P. and H.T. Odum. 1972. "Natural Areas as Necessary Components of Man's Total Environment." *Transactions of the North American Wildlife and Natural Resources Conference.* pp. 178-189.

Pate, J. and J. Loomis. 1997. "The Effect of Distance on Willingness to Pay Values: A Case Study of Wetlands and Salmon in California." *Ecological Economics* 20:199-207.

Pearce, D.W. and R.K. Turner. 1990. *Economics of Natural Resources and the Environment.* Baltimore, Maryland: John Hopkins University Press.

Pendleton, L.H. and J.S. Shonkwiler. 2001. "Valuing Bundled Attributes: A Latent Characteristics Approach." *Land Economics* 77(1):118-129.

Roberts, L.A. and J.A. Leitch. 1997. *Economic Valuation of Some Wetland Outputs of Mud Lake, Minnesota-South Dakota.* Agricultural Economics Report No. 381, Department of Agricultural Economics, North Dakota State University, October.

Sathirathai, S. and E.B. Barbier. 2001. "Valuing Mangrove Conservation in Southern Thailand." *Contemporary Economic Policy* 19(2):109-122.

Scodari, P.F. 1990. *Wetlands Protection: The Role of Economics*. Environmental Law Institute, Washington, D.C. 89 pp.

Shabman, L.A. and S.S. Batie. 1978. "Economic Value of Natural Coastal Wetlands: A Critique." *Coastal Zone Management Journal* 4(3):231-247.

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

Thibodeau, F.R. and B.D. Ostro. 1981. "An Economic Analysis of Wetland Protection." *Journal of Environmental Management* 12:19-30.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 1993. "Natural Resource Damage Assessments Under the Oil Pollution Act of 1990." *Federal Register* 58(10):4601-4614.

van Vuuren, W. and P. Roy. 1993. "Private and Social Returns from Wetland Preservation Versus Those From Wetland Conversion to Agriculture." *Ecological Economics* 8:289-305.

Whitehead, J.C. 1992. "Economic Valuation of Wetland Resources: A Review of the Value Estimates." *Journal of Environmental Systems* 22(2):151-161.

Woodward, R.T. and Y.S. Wui. 2001. "The Economic Value of Wetland Services: A Meta-Analysis." *Journal of Ecological Economics* 37(2):257-270.