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ECONOMIC VALUATION OF WETLAND RESOURCES: A REVIEW OF THE VALUE ESTIMATES

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ABSTRACT

Following the recognition that wetlands are valuable ecosystems and the necessary methodological developments, economists have attempted to estimate monetary values for wetland resources. Estimated economic values for wetland resources have been significantly greater than zero. However, several studies that estimate wetlands value consider only a subset of wetland functions and services and, therefore, only partially measure the total value of wetland resources to society. Other studies may overestimate wetland values due to double-counting of value components.

1. INTRODUCTION

Wetlands resources historically have been undervalued. Only fairly recently has the economic value of preserved wetlands resources been widely recognized. Wetlands, which used to be thought of as only wastelands that should be drained to allow for valuable development, are now regarded by many as valuable ecological systems that should be preserved. Following this recognition and the development of the required methodologies, economists have attempted to assign monetary values to wetland functions, services, and resources. Monetary valuation of wetlands allows comparisons of preservation values to development values. The time is opportune to take stock of the efforts economists have made to measure the value of wetland resources. The primary purpose of this article is to make such an assessment. Section 2 of this article sketches a theory of wetlands valuation, Section 3 provides a brief review of the valuation methods in current use and Section 4 reviews the existing wetlands valuation estimates. The last section offers some observations and conclusions on the strengths and weaknesses of the research literature on wetlands valuation.

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2. THE THEORY OF WETLANDS VALUATION

The sole value of wetlands resources typically has been (and often still is) thought to reside in the potential financial value of a wetland area. However, it can be argued that the total economic value of preserved wetlands resources is the amount of money individuals would be "willing to pay" to preserve wetlands and wetlands functions. Willingness to pay often exceeds the market price of the land itself because wetlands are nonrival and nonexcludable goods, meaning that people other than the landowner enjoy wetland benefits.

To see why willingness to pay could exceed the market price of the wetland, consider the functions of the wetland and those who benefit. Wetland areas simultaneously provide flood control, groundwater recharge, nutrient retention and storage, fishery production, wildlife habitat and recreation, and aesthetics, among other functions. Many people may benefit from these functions other than the owners of the land. For instance, flood plain homeowners are protected from flooding, commercial fishing firms gain increased catch from the fishery production and nutrient retention functions, outdoor recreationists enjoy the wildlife supported by the wetland, and environmentalists enjoy the knowledge that wetlands perform their ecological functions. Since each of these groups of people benefit from the wetland, they would be willing to pay to see it preserved.

Economic theory can be used to define the economic value of wetland resources. It can be assumed that decision makers, including heads of households, consumers, and business owners, possess utility (satisfaction) functions which can be expressed as

$$U = U(W,Y) \qquad (1)$$

where U is the satisfaction level enjoyed, W is the wetland resource, and Y is household income (or business profit). Utility is increasing in both wetlands and income, that is, decision makers are better off with more wetlands and with more income.

The economic value of wetland resources is the maximum amount of money the decision maker would be willing to give up to avoid economic development of the wetland resource. Define the maximum willingness to pay to avoid development using a comparison of utility functions

$$U(W^o, Y - WTP) = U(W'', Y) \qquad (2)$$

where W^o is the original level of the wetland resource, W'' is the degraded (post-development) level of the wetland resource, and WTP is maximum willingness to pay. Willingness to pay is the dollar value taken away that makes the decision maker indifferent between preserved or developed wetland areas. Willingness to pay includes commercial, recreational, and aesthetic values of wetland resources.

Wetland resources have functions (such as wildlife habitat) that can each provide several services (such as hunting and fishing), $W = f(X_i)$, where $i = 1,...,n$ wetland functions. The functional form, $f(\cdot)$, can be multiplicative, linear, or some other functional form. Function values of the wetland resource can be estimated using a similar theoretical construct

$$U(f(X_1^0,...,X_n^0),Y\text{-}WTP_1) = U(f(X_1'',...,X_n^0),Y) \qquad (3)$$

where WTP_1 is the willingness to pay to preserve function 1. This model shows that each function value is less than the total value of the wetland resource. Also, it is not true that summing individual function or service values will equal the total economic value of the wetland resource unless the functional form of $f(\cdot)$ is linear. It is likely, especially if services or functions are substitutable, that this will result in overestimation of economic value because of double counting which results from the multiple services supplied by individual wetland functions.

3. 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. The commercial fisher would be willing to pay the amount of money that the wetland contributes to profit by increasing fishery production. The homeowner would be willing to pay the amount of money saved in flood damage. The recreationist would be willing to pay for the right to hunt the wildlife supported by the wetland area. These notions have led to the development of several innovative economic methods used to estimate dollar values for wetland functions, services, and resources.

Four theoretically plausible valuation methods have been used in the (neoclassical) economics literature to place dollar values on wetland resources. Theoretically plausible methods can be used to estimate theoretically valid measures of the willingness to pay defined in equation (2). The methods are the net factor income (NFI) method, the contingent valuation (CV) method, the travel cost (TC) method, and the hedonic price (HP) method. A fifth method, which is often used but is not theoretically valid, is the damage cost (DC) method. See Scodari [1] for a thorough examination of the strengths and weaknesses of these methods in the context of wetlands valuation.

The NFI method uses market prices to measure the additional profit earned by business firms from the contribution of wetlands. For instance, fishery firms earn money from wetland-produced fish stocks. The method exploits the relationship between the value of the fishery (or other biological resource) harvest and wetland acreage

$$P \cdot H = f(W,E) \qquad (4)$$

where P·H is the value of the fishery harvest, P is the market price of the fish, H is the harvest, and E is the effort applied to the fishery. Empirical implementation of equation (5) takes forms such as

$$P \cdot H = \alpha_0 + \alpha_1 W + \alpha_2 E + \varepsilon \tag{5}$$

where α_0, α_1, α_2 are regression coefficients and ε is a mean zero error term. Regression equations, specifically the coefficient of the wetland acreage variable, can be used to estimate the marginal value product of the wetland resource. The marginal value product of the wetland resource provides a measure of fishery firm owners' willingness to pay to avoid wetland degradation. The NFI method can not be used to measure values of other wetland functions.

The CV method is a household survey approach that can measure the total economic value of all functions of natural wetlands by asking people directly about their willingness to pay (see Mitchell and Carson [2] for a review of the CV method). The CV method establishes a hypothetical market by providing information about wetland resources, specifying payment rules and vehicles, and posing valuation questions. A CV question might be "What is the maximum amount of money you would be willing to pay in higher annual taxes to preserve the wetland area just described?" Answers to this question can be used to directly measure willingness to pay. The CV method has been criticized since it measures value from behavioral intentions and not revealed behavior. To date, however, it is the only method that can be used to estimate non-use values, such as bequest values, for wetlands.

The TC method can measure the recreation benefits of wetlands. The insight of the travel cost method is that the travel and time costs that recreationists incur in getting to the wetland area are measures of implicit market prices. Regression equations of the form

$$X = \beta_0 + \beta_1 P + \beta_2 Y + \mu \tag{6}$$

where X is recreational visits to a wetland area, P is the travel and time costs of the trip, β_0, β_1, β_2 are regression coefficients, and μ is a mean zero error term are estimated and consumer surplus per recreation trip and year can be approximated. Using the linear functional form in equation (7), consumer surplus per year would be the triangle above the mean value of travel and time costs and below the estimated demand curve

$$CS = \int_{P}^{P^*} \hat{\beta}_o + \hat{\beta}_1 P + \hat{\beta}_2 Y \, dP \tag{7}$$

where P* is the reservation travel cost and P is the mean travel cost. Consumer surplus can be measured for other functional forms as well. The TC method can only be used to measure the benefits of recreational services of wetlands.

The HP method can measure the contribution of wetlands for flood control and aesthetics to a housing price. The increment to the housing price arising from wetland functions is a measure of the implicit price of the wetland function. For instance, the housing price could depend on distance from the wetland and other house or land parcel characteristics, $P^H = f(D_w, \underline{Z})$ where P^H is the housing price, D_w is the distance to the wetland resource, and $\underline{Z}$ is a vector of housing characteristics. Empirical HP functions can be specified as

$$P^H = \tau_0 + \tau_1 D_2 + \underline{\tau_2 Z} + \delta \quad (8)$$

where τ_0, τ_1, are regression coefficients, $\underline{\tau}_2$ is a vector of regression coefficients, and δ is a mean zero error term. The estimated coefficient on the distance variable is expected to be negative and, if so, the absolute value of this coefficient measures the marginal contribution of proximity of the wetland resource to the housing price.

The DC method uses market prices or replacement costs to measure the economic damages avoided by preservation of natural wetlands. The costs are estimated by multiplying market prices by quantities of marketed goods purchased to replace flood or hurricane damaged resources or by adding expenditures on wetland-related recreational trips. This approach, however, does not provide a theoretically valid measure of willingness to pay. The flaw in this method is that it attributes all of the value of the marketed good to the wetland resource and, thus, overestimates the value of the wetland resource. More elaborate DC methodologies, that correct for the upward bias in wetland values, have been used [3]. But, in general, the DC method is less preferred than other valuation methodologies.

4. WETLANDS VALUE LITERATURE REVIEW

The annotated bibliography of Leitch and Ekstrom was reviewed to identify studies published in the academic literature that estimated dollar values for wetland resources [4]. Studies that were published after 1989 have also been included. The studies are arranged by wetland area, wetland type, and wetland functions (Table 1). Annual values of individual wetland functions per acre and, if available, estimates of annual total economic values per acre are presented. In Table 1 all values are converted to 1982 U.S. dollars using the implicit price deflator of GNP to facilitate comparison [5].

Net Factor Income Method

At least three published studies have used the NFI method. Batie and Wilson measure the value of wetlands to Chesapeake Bay oyster production in Virginia [6]. They find the average contribution of a wetland acre is $47.11 to the oyster fishery. Lynne, Conroy, and Prochaska measure the value of the productivity of

Table 1. Wetland Economic Values[a]

Study	State	Type	Flood	Groundwater	Nutrient	Fishery	Recreation	Storm	Amenity	WTP
Gupta and Foster (1975)	MA	Fresh	$86	$3011			$76		$290	$3463
Thibodeau and Ostro (1981)	MA	Fresh	$2128	$6430	$1660		$200		$160	$10,578
Farber (1987)	LA	Coastal						$7-$23		
Farber (1988)	LA	Coastal					$5			
Farber and Costanza (1987)	LA	Coastal				$37				
Bergstrom et al. (1990)	LA	Marsh					$7			
Shabman and Batie (1988)	LA	Marsh								$712
Lynne et al. (1981)	FL	Marsh				$0.32				
Whitehead (1990)	KY	Fresh								$450
Miller and Hay (1981)	MF[b]	Fresh					$99			
Batie and Wilson (1978)	VA	Marsh				$118				
Raphael and Jaworski (1979)	MI	Coastal				$98	$630			
Loomis et al. (1990)	CA	Fresh								$12,948

[a]Wetland values per acre, 1982 dollars.
[b]Mississippi Flyway.

tidal marsh and estuaries in the production of the blue crab fishery in the Gulf coast of Florida [7]. The average value of marsh in blue crab production is $.30 per acre. Farber and Costanza measure the fishing and trapping values of Louisiana wetlands [8]. The sum of the marginal value product of wetlands to the production of shrimp, blue crab, oyster, menhaden, muskrat and nutria is $37.46.

Contingent Valuation Method

An increasing number of studies have used the CV method to measure wetland values. Bergstrom, Stoll, Titre, and Wright measure the value of recreational benefits of 3.25 million acres of Louisiana marsh [9]. The average recreational value of an acre of marsh is $8.42. In related research, Bergstrom, Stoll, and Randall find that willingness to pay increases when nonconsumptive wetlands-recreation is valued along with consumptive recreation [10].

Farber and Costanza [8] and Farber [11] measure the outdoor recreation benefits of 650,000 acres of wetlands in Louisiana. These studies find that the economic value of an acre of Louisiana wetlands for recreation is $4.86.

Loois, Wegge, Hanemann, and Kanninen measure the total economic value of 90,000 acres of seasonal and permanently flooded wetlands in the San Joaquin Valley in California [12]. Each California household is estimated to be willing to pay $154 to preserve the entire wetland area. Considering California's large population this amounts to preservation benefits of $16,833 per wetland acre. In related research, Mannesto and Loomis measure the recreational fishing value of 90,000 acres of wetlands in the San Joaquin Valley in California [13]. Each angler would be willing to pay $50.45 for preservation of the entire wetlands resource.

Whitehead measures the recreation, aesthetics, water quality improvement, flood control and nonuse values for 5000 acres of Kentucky bottomland hardwood forested wetlands [14]. The most conservative per acre wetland value estimate is $588. This value includes the effect of reclamation (on-site) and other wetlands in the area that are not threatened with coal mining. Whitehead and Blomquist show that the economic value of these wetlands faced with surface coal mining falls by about 50 percent when information about reclamation of the mined area is known [15].

Travel Cost Method

Four studies have used the TC method. Raphael and Jaworski consider the recreational benefits of fish and wildlife produced in 105,855 acres of Michigan coastal wetlands [16]. The value of sport fishing is $286 per acre and the value of nonconsumptive recreational activities is $138.24 per acre. Miller and Hay use the TC method to estimate the recreational (waterfowl hunting) value of the wetlands in the Mississippi Flyway [17]. Using a value of $29 for a day of waterfowl hunting (see Charbonneau and Hay [18]) the average value of an acre of waterfowl habitat is $59.32 per acre. Thibodeau and Ostro value marsh and wooded swamp along the Charles River in Massachusetts for their recreation functions [19]. Recreation benefits are $187.74 per acre. Farber measures the outdoor recreation benefits of 650,000 acres of wetlands in Louisiana and finds the economic value of an acre of Louisiana wetlands for recreation is $1.96 to $6 per acre [11].

Hedonic Price Method

Only one study has applied the HP method to wetlands valuation. Thibodeau and Ostro value marsh and wooded swamp along the Charles River in Massachusetts for increased privacy (aesthetics) functions [19]. The benefits of increased privacy to homeowners who live next to the marsh is $150 per acre.

Damage Cost Method

Several studies have used the DC method and therefore, with one exception, have overestimated wetland value. Gupta and Foster measure the value of freshwater wetlands along the Charles River in Massachusetts for their wildlife recreation, flood control, aesthetics, and water supply functions [20]. The damage costs avoided are calculated for each wetland function. Wildlife values are found to be worth $45.56 per acre, aesthetics are worth $167.86 per acre, municipal water supply benefits are $2,800 per acre, and flood control benefits are $80 per acre.

Raphael and Jaworski consider the commercial benefits of fish and wildlife produced in 105,855 acres of Michigan's coastal wetlands [16]. Commercial revenue is used to estimate the value of waterfowl harvest ($31.23 per acre), fur harvest ($30.44 per acre), and commercial fishing ($3.78 per acre).

Thibodeau and Ostro value marsh and wooded swamp along the Charles River in Massachusetts for their flood control, pollution control, and water supply (groundwater recharge) functions [19]. Flood control benefits are $2000 per acre. Since these wetlands serve as a low cost sewage treatment plant substitute they generate $1560 per acre sewage treatment costs avoided. The cost of alternative water supplies is $6044.

Shabman and Batie develop a model of compensation for wetlands development [21]. The value of wetlands is the lesser of the cost of wetland substitutes that can provide the same services (constructed wetlands) and the value of the natural wetland. Estimates of wetlands construction in the Louisiana tidal marsh are taken from U.S. Army Corps of Engineers reports. The cost of controlled placement of dredge material to construct wetlands is $766.86 per acre.

Farber estimates a hurricane property damage function and, therefore, measures a theoretically valid estimate of willingness to pay [3]. Wetland acreage reduces hurricane damage and the marginal contribution of the damage reduction is estimated to be between $7 and $23 per acre.

5. DISCUSSION AND CONCLUSIONS

This preliminary look at wetland economic values suggests that the values may depend on the type of wetland, the valuation method used, services and functions considered, and the relevant population. Too few studies exist, however, to provide a definitive conclusion on the determinants of wetland value. This type of analysis must wait until the publication of more studies.

This review of the economics literature concerning wetlands valuation can be used to draw a few conclusions. First, several methods, most measuring the theoretically grounded definition of economic value, have been used to measure the value of wetlands. The resulting economic values for wetland resources have been significantly greater than zero. Few studies, however, have provided estimates of the total economic value of natural wetlands or enough information to compute a large portion of total economic value. Several studies estimate the value of only a single function of the wetland area. The functional values amount to only a fraction of the total economic value of the wetland resource. This approach will result in an underestimation of wetland value. Several studies estimate individual components of total economic value and sum these value components to estimate total economic value. As suggested by theory, this approach may result in an overestimation of wetland value.

Measures of the monetary value of wetlands preservation can be directly compared to the financial value of wetlands development. When this comparison occurs, the value of preserved wetlands can be more concretely considered in policy discussions. However, too few studies have been conducted for generalization of existing wetland values to other wetland areas. More applied valuation studies are needed. This type of research will increase the sample size of wetland value estimates and strengthen conclusions regarding them.

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