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VALUING URBAN WETLANDS: A REVIEW OF NON-MARKET VALUATION STUDIES

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

Key Words: wetlands, urban wetlands, non-market valuation

INTRODUCTION

Many human decisions, both of private landowners and public agencies, affect wetlands. Urban wetlands, in particular, are affected by human actions. It is not clear that those who make decisions that impact upon wetlands have good information about the consequences of their decisions on these wetlands and the consequent impact on the provision of a range of ecosystem services provided by wetlands. Without such information, inferior decisions resulting in reduced overall benefits to society may result. To fill the information void, economists and others have undertaken research to estimate the value of various benefits to people created by wetlands. In this paper, we review recent literature on ‘‘non-market valuation’’ as applied to wetlands, with a particular focus on the value of urban wetlands.

Until around the middle of the 20th century, wetlands were often perceived as unhealthy, dismal places that were impediments to economic development (Vileisis 1997). Ditching and draining wetlands was encouraged and widespread. Roughly 50 percent of all wetlands that occurred in the lower 48 states at the time of arrival of European settlers have been drained. In some areas, such as California and the U.S. Midwest Corn Belt, wetland losses are as high as 80 to 90 percent (Mitsch and Gosselink 1993). More recently, attitudes towards wetlands have changed, thanks in large part to increased understanding of the ecological role played by wetlands. Wetlands provide a variety of valuable ecosystem services, including water purification, filtration, retention of nutrients, flood control, ground-water recharge, and providing habitat for a variety of species. Wetlands are also valued for recreational and aesthetic reasons.

Along with the shift in scientific understanding and public opinion, there has also been a shift in public policy. Instead of encouraging landowners to drain wetlands, policy is now directed toward protecting wetlands. For example, the ‘‘Swampbuster’’ provision introduced in the Food Security Act of 1985 requires farmers to protect wetlands on their land if they wish to be eligible for U.S. Department of Agriculture farm program benefits. Section 404 of the Clean Water Act requires a permit from the U.S. Army Corps of Engineers for discharge of dredged or fill material into wetlands. Federal government policy, along with policies of many state governments, calls for ''no net loss'' of wetlands. If wetland destruction is permitted, a landowner may be required to restore wetlands elsewhere to compensate for the loss.

Despite the increased appreciation of wetlands and government policies directed towards protecting wetlands, loss of wetlands continues. Wetland losses in the period 1980 to 1990 were estimated to be 23,674 hectares annually (Dahl 2000). This figure was down from an estimated 117,359 hectares per year from 1970 to 1980 and 185,346 hectares per year from 1950 to 1970 (Dahl 2000). Changes in agricultural policy, including ''Swampbuster,'' have gone a long way toward reducing loss of wetlands to agriculture. Other categories of threat have not been reduced as much. In fact, for the period of 1980 to 1990, wetland losses to urban development outpaced losses from agriculture. During this period, 30 percent of wetland losses were to urban development, while 26 percent of the losses were to agriculture (Dahl 2000).

Urbanization has become a major cause of the loss of wetland area. Wetland destruction in urban areas occurs primarily through commercial and residential development and establishment of road infrastructure. In addition to outright wetland destruction, urbanization also leads to the impairment of wetland function in remaining urban wetlands (e.g., see Booth 1991, Knutson et al. 1999, Lehtinen et al. 1999, Azous and Horner 2000). Urbanization directly impacts these remaining wetlands by changing their hydrology, increasing runoff of nutrients and pollution, increasing exposure to introduced species, and increasing fragmentation.

The battle to protect wetlands may face its toughest test in urban areas. The stakes in urban areas are high because both the benefits generated by wetlands and the costs of protecting wetlands are likely to be high. Urban wetlands are likely to be valuable precisely because few wetlands remain in urban areas. Urban areas have high (human) population densities, dense transportation infrastructure, and highly developed land. The opportunity to observe birds and other wildlife is typically limited in urban areas, as is the existence of open space and natural habitat. Urban wetlands provide aesthetic and recreational benefits close to where large numbers of people live. Similarly, flood-control protection provided by wetlands is likely to be of greatest value in urban areas where such protection can limit damage to residential, commercial, and industrial properties. However, the costs of preserving wetlands in urban areas are also likely to be high. Land is expensive in urban areas. Undeveloped land in urban areas is a scarce and valuable commodity. A landowner can earn large returns by draining wetlands to build houses, a shopping center, or some other type of urban development. Such profit margins offer powerful incentives for individuals to seek permits to destroy wetlands to make way for development even if a larger area of restored wetland or on-site or off-site mitigation is required.

The costs of wetland protection described in the previous paragraph may not show up as a direct expenditure by a government agency or a private party. The costs of wetlands protection are often ''opportunity costs,'' which equal the foregone value of urban development that could have occurred without wetlands protection, rather than an actual expense that shows up on account ledgers. Despite this, opportunity costs are quite real. High opportunity costs give landowners the incentive to lobby hard to be allowed to drain wetlands, and they generate heavy political pressure on agencies responsible for wetlands protection to allow development.

Although wetlands provide important services to society, these services typically are not sold nor do they have a market price. Therefore, private landowners do not typically receive a return on preserving wetlands, even though these wetlands may provide valuable services to society. The prospect of large returns to a landowner through development and the lack of returns from protecting wetlands stack the deck toward development. In the absence of regulation, most private landowners will decide to fill wetlands because the private benefit from development is typically far greater than the value captured from preserving the wetland. From a social point of view, however, just the opposite may be true. If one could add up all of the values generated by a wetland, the benefits might outweigh the value of development. Public policy can correct for this bias of the market toward development either by regulating the loss of wetlands, (e.g., the ''no net loss'' policy), or creating subsidy programs for wetland preservation such as the Conservation Reserve Program, the Wetland Reserve Program, and the Wildlife Habitat Incentive Program. Introduced by the Food Security Act of 1985, the Conservation Reserve Program (CRP) was created to protect environmentally sensitive cropland and pastureland. Producers voluntarily remove land from agricultural production and seed the land to a permanent cover crop or, in some cases, restore and revegetate a farmed wetland. In return, farmers receive annual rental payments from the Farm Service Agency for the retired land and assistance for establishing permanent land cover for a contracted period of 10 to 15 years. Like the CRP, the Wetlands Reserve Program (WRP) and Wildlife Enhancement Incentive Program, both administered by the Natural Resources Conservation Service, provide cost-share agreements for wetland restoration and payments for conservation easements on restored wetlands. The WRP does allow for permanent conservation easements to retire wetland or adjacent upland from farming or development permanently. Landowners cannot enroll their property in multiple programs.

Knowing when it is in society's best interest to prevent wetland loss, however, requires having some way to estimate the values of wetland preservation in order to weigh this against the values of development. Establishing such estimates is a difficult, and some would say impossible, task. Economists have developed a number of methods for estimating non-market benefits and applied these methods to estimate benefits provided by wetlands. In this paper, we focus on non-market valuation approaches. We will not review alternative approaches, such as the method of measuring energy embodied in natural resources (Odum 1996). In the next section, we discuss the role of non-market valuation in making decisions to preserve, restore, or develop wetlands. In section three, we review the methods for estimating benefits and review the application of these methods to estimating the value of services provided by wetlands, with particular attention to urban wetlands. In the final section of the paper, we discuss some of the continuing controversies over these valuation methods and their application. We also discuss some of the gaps in our understanding and our own view of the debate over valuation of ecosystem services in the context of urban wetlands.

NON-MARKET VALUATION AND DECISION-MAKING

Non-market valuation arose from the desire to include the natural environment in the decision-making calculus. Goods and services that are sold in markets are valued via market prices. Any policy proposal that affects the value of marketed goods and services for some segment of society brings forward advocates with evidence on how much (market) value will be gained or lost should the proposal go forward. Often, those who favor protecting the natural world find themselves at a disadvantage in political debates because they cannot express the gains or losses in values arising from environmental changes in monetary terms. Sometimes, the lack of a monetary estimate of value for the natural world is treated as if the natural world has zero value. To make a fair comparison of policy alternatives, all of the consequences of a proposal should be weighed, not just those consequences that are easily measured and valued in monetary terms because they are bought and sold in a market. To fill this void, economists and others have attempted to supply monetary estimates of value created by the natural environment, as well as other things that are not bought and sold in a market but nonetheless have value.

Some analysts object to the whole exercise of non-market valuation as applied to the environment (e.g., Sagoff 1988, Spash 2000). One objection to valuation arises because it is a strictly anthropocentric measure and does not account for non-human values and needs. An alternative to an anthropocentric view is a biocentric or ecocentric view in which the source of value may be other species or ecosystem processes rather than how species or ecosystems satisfy human wants and needs. In a practical sense, there may be less to the distinction between anthropocentric views on the one hand and bio/ecocentric views on the other than appears at first glance. If some people decide that nature has intrinsic value, an anthropocentric valuation exercise of these individuals would find similar answers to questions about relative values or alternative policies as would a bio/ecocentric approach. In other words, if people place intrinsic value on other species or have desires to see natural processes work unfettered by human interference, an anthropocentric view can still place high value on protecting the natural world. In most democratic countries, outcomes are determined by the desires of the majority of citizens. In the end, what matters is what the majority of people in a society care about. In policy debates, each side will attempt to marshal compelling evidence that their preferred alternative is in society's best interest, which is ultimately an anthropocentric exercise.

A second objection to non-market valuation is that the pricing of the natural world is a particularly poignant example of the moral failings of the capitalist system in which everything is thought of in terms of commodities and money. To some, it just seems wrong to try to look at nature through this prism. The point of valuation, however, is not to think in money or market terms but to frame choices and make clear the tradeoffs between alternative outcomes. Allowing draining of a wetland may increase crop production or increase the supply of developable land for housing but does so at the cost of decreased habitat, potential loss of species, potential water quality degradation, and ecosystem processes. Is this tradeoff worthwhile? This is the type of question for which valuation can provide useful information.

A third objection to non-market valuation, particularly when trying to value elements of the natural world, is raised on practical rather than philosophical grounds. One way to think about the value of wetlands or other ecosystems is to think about the value of the range of ecosystem ''goods and services'' produced by the ecosystem (Daily 1997). Valuing ecosystems goods and services requires a) that the complete range

Table 1. Classification of total economic value for wetlands.

Use Values			Non-Use-Values
Direct Use Value	Indirect Use Value	Option Value	Existence Value
Fisheries	Nutrient retention	Potential future uses (direct and indirect)	Biodiversity (habitat)
Agriculture	Flood control	Future value of information	Culture, heritage
Fuel-wood/Timber	Storm protection		Bequest values
Recreation	Ground water recharge		
• Hunting			
• Fishing			
• Birdwatching			
• Hiking			
Transport	External ecosystem support		
Wildlife harvesting	Micro-climate stabilization		
Peat/energy	Shoreline stabilization		
Water purification (wetlands created for sewage treatment)	Water filtration from pollutants, such as nitrogen and phosphorus.		

Adapted from Barbier et al. (1997).
Available at http://www.ramsar.org/lib_val_e_1.htm#cap2

of goods and services be identified, b) that these goods and services can be quantified, and c) that quantities of these goods and services can be valued in a common metric, typically in monetary terms. Each of these three steps presents practical challenges for trying to value wetlands. Wetlands are complex, dynamic systems. It may be difficult even to list all of the services provided by wetlands, much less quantify the amount of each service produced. Some ecosystem goods and services can be readily valued in monetary terms (e.g., commercially harvested fish), while others present severe challenges (e.g., existence value for a species or the aesthetics of a view). We will have more to say about practical concerns about valuation as applied to wetlands as we proceed.

Market and non-market valuation of wetlands attempts to account for all of the values that individuals place on the goods and services provided by wetlands, such as bird watching, flood control, water filtration, and aesthetic value. Some of these values are consumptive use values that accrue from directly exploiting elements of wetlands (e.g., timber harvesting or duck hunting). Some consumptive use values can be estimated using market prices (e.g., timber harvests), while others typically cannot. For example, estimates of the value of duck hunting are typically done using non-market valuation (Hammack and Brown 1974, Gan and Luzar 1993, Cooper 2000). There are also non-consumptive use values where the activity causes no physical change in the wetlands. A good example of a non-consumptive use is bird watching. Individuals who live downstream may benefit from the indirect use value of upstream wetland services for water filtration, water retention, and flood prevention. Both non-consumptive use values and indirect use values are typically measured using non-market valuation techniques. Even things for which there is no known use at present may eventually prove to be useful. For example, forest owners considered the Pacific yew tree (*Taxus brevifolia*) worthless until the discovery of a drug useful in fighting cancer (Taxol) that could be made from its bark. The potential for future use value generates an option value, so-named because there is value only if there remains the option to use the resource in the future (i.e., only by preserving the resource). Finally, there may also be non-use values when individuals place value on the existence of an item, even though they will never use it, even indirectly. Almost by definition, non-use values must be measured by non-market valuation techniques. Table 1 provides a classification of use and non-use values for wetland functions and services.

Five principal methods are used in the context of valuing wetlands: i) the hedonic method, ii) travel cost, iii) production methods, iv) replacement cost, and v) survey-based methods—contingent valuation and conjoint analysis. An excellent general treatment and review of these methods is given in Freeman (1993). In the next section, we review applications of these techniques to the valuation of wetlands.

APPLICATION OF VALUATION METHODS TO WETLANDS

Estimating the value of wetlands in monetary terms goes back at least as far as 1926 when Percy Viosca, Jr., a fisheries biologist, estimated that the value of fishing, trapping, and collecting activities from wetlands in Louisiana was worth $20 million annually (Vileisis 1997, p. 162). Economists did not enter the business of estimating the value of wetlands until much later. A landmark early valuation study by economists was by Hammack and Brown (1974). Hammack and Brown focused on wetlands as waterfowl habitat and estimated the value that wetlands provided in terms of hunting. The focus on hunting and fishing values directed attention primarily to rural areas. It has only been fairly recently that attempts to value wetlands have moved beyond estimates for fishing and hunting. By now, however, there are a growing number of empirical studies of the value of a wide variety of services provided by wetlands. Despite the increase in breadth of services studied, it remains the case that the vast majority of wetlands valuation studies are done for wetlands in rural areas. Virtually the only works valuing urban wetlands to date are studies using the hedonic method (see below).

Valuation studies of wetlands done to date show a very wide range of estimates. A recent meta-analysis covering 39 valuation studies by Woodward and Wui (2001) found that the mean value per hectare per service of a wetland varied from $1.21 per hectare for amenity value to as high as $490 per hectare for bird watching (1990 dollars). In a review covering 33 studies, Heimlich et al. (1998) found a range of empirical estimates for wetland values between $0.02 and $8,924 per hectare. The wide range of values occurs because different studies focused on different wetland services in different areas (mostly rural). Part of the variation, however, is also caused by the use of different methods. We now turn to individual valuation studies that focus on particular wetland services in particular areas. We group these studies by the valuation method employed.

Hedonic Method

The hedonic method uses observed market prices for composite (multi-attribute) goods with many characteristics that contribute to its value to uncover the value of particular characteristics for which there is no readily available signal of value. Many hedonic studies use data on sales prices of houses to estimate the value of various aspects of environmental quality. Using data on the market sale prices of houses, along with structural, neighborhood, and environmental characteristics of the houses, one can estimate how a change in one characteristic, such as proximity to a wetland or the attributes of a nearby wetland (size or type), is related to a change in property value, holding other characteristics of the property constant. Urban areas are ideal for application of this approach because there is typically a wealth of data available on house sales.

Three studies have applied the hedonic method to estimate the value of wetlands to nearby property owners in urban areas (Lupi et al. 1991, Doss and Taff 1996, Mahan et al. 2000). All three studies find a positive impact from wetlands on property values. Mahan et al. (2000) used data on over 14,000 home sales in the Portland, Oregon metropolitan area, along with detailed information about housing characteristics, GIS information on location of wetlands, lakes, rivers, streams, and other environmental amenities, as well as the location of industrial, commercial sites and other neighborhood characteristics. They found that closer proximity to a wetland increased property value. Decreasing the distance to the nearest wetland by 300 meters from an initial distance of 1.6 kilometers resulted in an estimated increase in property value of $436 (1994 dollars). They also found a $24 increase in house value with an increase in the size of the nearest wetland by one hectare. Lupi et al. (1991) used data from Ramsey County, Minnesota, where St. Paul is located. They estimated that an increase in wetlands acreage in the survey section where the house was located increased housing value by $19 per hectare of increased wetlands (1989 dollars). The increase in value for wetland area tended to be greater in areas where there were few nearby wetlands. Doss and Taff (1996) also found a positive value from nearby wetlands using data from Ramsey County, Minnesota. They found a preference for open-water wetlands and scrub-shrub wetland types over emergent-vegetation and forested wetlands.

Hedonic studies of the value of wetlands in rural areas show a more mixed response. Reynolds and Regalado (2002) found the type of wetland largely determined whether the presence of a wetland positively or negatively affected land values. They found that forested and emergent palustrine wetlands in Florida, which accounted for 94% of the wetlands in the study, had negative effects on rural land values. However, scrub-shrub and shallow pond wetlands had a positive effect on land values. Shultz and Taff (2004) found that farmland prices in North Dakota with wetlands were lower by $85 per hectare than those without wetlands, almost half of the average local cropland values from 1995 to 2002. They noted that using rural land sales can be problematic because there are often few land sales in a geographic region. For agricultural land values, the predominantly negative effect of wetlands was not surprising since the hedonic method measured the relative decrease in agricultural production value as reflected in land price received by the private owner, rather than the public values for wildlife and species protection. Using data from eastern North Carolina, Bin and Polasky (2004) found that proximity to inland wetlands lowered property values.

The hedonic method is the only approach to date that has been applied in more than a passing manner to the valuation of urban wetlands. These studies show that proximity to wetlands increases nearby property values. The availability of data on housing sales and housing characteristics and the recent increase in availability of GIS data on environmental characteristics make this an attractive approach. The main drawback of the hedonic method is that it only measures the value of wetlands as perceived by nearby property owners. Services such as flood control, water-quality improvement, habitat provision for species, and ground-water recharge and discharge may provide values that accrue far away to individuals other than local property owners. In addition, such services may be largely invisible to the typical property owner. If so, the hedonic method will not accurately capture the full value of services provided by wetlands.

Travel Cost

The travel cost approach uses information about the number of trips to particular sites and the cost of those trips to infer how much individuals are willing to pay for access to the site. Travel cost studies are applied primarily to studies of the value of recreation, in which people travel to particular sites to hunt, fish, hike, or watch wildlife. Although there are numerous travel cost studies in environmental economics, there have been very few applications specifically to wetlands and none to urban wetlands. Van Vuuren and Roy (1993) used travel costs of individuals to estimate the benefits of hunting and fishing in the Lake St. Clair wetlands in Ontario. They estimated a net present value of $271 per hectare for un-diked wetlands and $1,715 to $2,952 per hectare for diked wetlands (1985 Canadian $, over 50 years, and assuming a four percent discount rate). Cooper and Loomis (1991) estimated the value of seven wildlife reserves in the San Joaquin Valley in California at $55.41 per waterfowl hunter per season using data on the 1987 and 1988 seasons. The total consumer surplus from hunting in the seven refuges was estimated to be over $3 million annually (1989 dollars).

The travel cost method can be used to value recreational fishing, hunting, and birdwatching associated with wetlands. To date, however, there has been very limited application of this approach to wetlands. As with the hedonic method, travel cost studies only evaluate part of the total value of wetlands and cannot be used to value public goods aspects of wetlands, such as flood control or ground-water recharge and discharge that are unrelated to recreation. Unlike the hedonic method, there seems to be limited applicability of the travel cost method to the valuation urban wetlands.

Production Methods

Production methods can be used to estimate the value of increased economic productivity attributable to wetlands. There is a long history of using estimates of fish and wildlife production from wetlands going back to work of Viosca in 1926 (as cited in Vileisis 1997, p. 162), Hammack and Brown (1974) and others.

Coastal wetlands are recognized as being important nurseries for commercially harvested fish species (Boesch and Turner 1984, NRC 1995, Beck et al. 2001). The majority of applications of the production approach to wetlands have estimated the value of coastal wetlands for increased fishery productivity. Lynne et al. (1981) estimated that a hectare of estuarine marsh in Florida's Gulf Coast would yield an additional 2.3 pounds of crab per year generating an annual value of about $0.10 to $0.12 per hectare (1971 dollars). By itself, this value would not add much evidence in favor of preservation of Florida Gulf Coast marshes. Swallow (1994) estimated the value of coastal wetlands in North Carolina for commercial fisheries production and found values that were low in comparison to alternative land use in agriculture. In contrast, Batie and Wilson (1978) found that the marginal value of oyster production on the Virginia coast ranged from $0.46 per hectare to as high as $57.25 per hectare per year (1969 dollars), depending on the salinity, physical characteristics, and capital invested in oyster harvesting by site. Other studies estimating the value of wetland for commercial and recreational fisheries include Ellis and Fisher (1987), Farber and Costanza (1987), Bell (1989, 1997), and Freeman (1991). These studies assume simple relationships between area of wetlands and fishery productivity.

Recent papers by Barbier and colleagues have incorporated population dynamics as well as area to estimate the value of mangrove systems and coastal wetlands for fisheries production in Thailand, Mexico, and other countries. Barbier (2000) contains a useful review of many papers valuing mangrove-fishery relationships. Barbier et al. (2002) found that the value of remaining mangrove hectares for fisheries production in Thailand as mangroves continue to decline was quite sensitive to assumptions about the elasticity of demand for fisheries output (i.e., how responsive the quantity demanded is to changes in price). The estimated marginal value of a hectare of mangrove for fish and shellfish production was $135.44 per hectare per year, with highly inelastic demand (demand changed little with changes in price) but only $3.98 per hectare per year when demand is highly responsive (elastic) to price changes (1993 dollars). Mangrove degradation and losses cause a decline in production of fish and shellfish. When demand is inelastic, decreases in output bring forth a large increase in price and, hence, a high value per hectare for remaining mangroves. A similar study by Barbier and Strand (1998) modeled mangrove-shrimp fishery linkages in Campeche, Mexico. They found that the decrease in productivity of harvest effort was only partially due to mangrove destruction. An increase in the number of fishing vessels and consequent over-fishing were also partially to blame. Both the Mexico and Thailand studies illustrate the importance of looking at the interactions among property rights and fishing regulations, wetlands loss, and biological production on the valuation of wetland services in fishery production, a point also emphasized by Freeman (1991) and King (1998).

The production approach has also been used to estimate the value of wetlands in other contexts. Acharya and Barbier (2000, 2002) and Acharya (2000) used production methods to estimate the value of the hydrologic services (ground water recharge) of the Hadejia-Nguru wetlands in northern Nigeria. Acharya and Barbier estimated the loss in productive capacity with a reduction in ground water available for dry season agriculture and domestic use as a result of reduced recharge to the aquifer from wetlands. The loss of ground water affected welfare through decreased production, increased marginal cost of pumping, and increased costs of water provision for the household. The value of recharge by wetlands in agriculture was estimated to be $40.50 per hectare (1996 dollars) per season, or 6 percent of yearly income per farmer (Acharya 2000).

The production approach can be useful to estimate a partial value of wetlands when there is a clear link between wetlands and the production of an economically valuable commodity. The existence of market prices for commodities produced (e.g., commercially harvested fish) makes production-based valuation of use values for wetlands less controversial than most non-market methods. There are, however, a number of difficulties in regard to valuing urban wetlands. First, because this approach is usually applied to the value of fisheries or agricultural production, production method studies typically occur in rural settings. We are not aware of any application to date of this approach to urban wetlands. Second, the approach typically captures only one aspect of value of wetlands (e.g., increased fishery productivity) and should not be confused with an estimate of total value created by wetlands. Third, property rights and regulatory issues can heavily influence the estimates of value (Freeman 1991, King 1998, Barbier et al. 2002). For example, an open access fishery will generate far lower value estimates than an optimally regulated fishery. Finally, estimating a quantitative link between wetlands and productivity is often quite difficult. In the case of fishery productivity, natural variations in fish population due to changes in salinity or currents, abundance of prey or predator species, and disease may make it difficult to decipher the impact of wetlands on fish productivity. The production approach cannot be applied without a clearly established and quantifiable link between productivity and wetlands.

Replacement Cost

Another way to value a service provided by a wetland is to estimate the replacement cost of providing that service should the wetland no longer function properly or no longer exist. The most famous example of valuing ecosystem services involves pricing the cost of replacing the water filtration services provided by undeveloped watersheds with a drinking water filtration plant. The high replacement cost ($6–8 billion in 1996) led public officials to protect the watersheds in the Catskills as a cheaper means of providing clean drinking water for New York City (Chichilnisky and Heal 1998). Wetlands, both natural and constructed, are also effective at treatment of sewage. Kazmierczak (2001) provides a summary of a half dozen studies using cost savings for tertiary municipal wastewater treatment in Louisiana and Florida. The replacement cost estimates for wetland values ranged from $1.15 to $1,087.67 per hectare in 2000 dollars (Kazmierczak 2001). Breaux et al. (1995) estimated cost savings for wastewater treatment by wetlands at fifteen Louisiana seafood processing plants of $2,522 to $3,899 per year per hectare in 1992 dollars.

Replacement cost can be used as a measure of value of wetlands only in restricted circumstances. Two conditions must be satisfied for replacement costs to be a valid measure of wetlands value: a) the same service must be supplied by wetlands and another alternative, and b) the service must be of greater value than the replacement cost. It does not follow that services provided by wetlands are highly valuable just because human engineered alternatives to provide services are expensive. For example, building an expensive hatchery does not guarantee that the fish produced will be valuable. If replacement of lost wetland services would not be chosen should the wetland be destroyed, then replacement cost will exceed the value of the service and using replacement cost will overestimate value of that service. On the other hand, as with the production approach, replacement cost typically focuses on one service provided by a wetland (e.g., wastewater treatment) rather than the complete range of values associated with a wetland and should not be confused with the total value of the wetland.

Survey-Based Methods: Contingent Valuation and Conjoint Analysis

In some cases, there is no observable behavior, such as the purchase of a house or a trip to a recreational site, direct production links to commodities, or replacement alternatives that can be used to generate estimates of value. For such cases, the only approaches capable of generating estimates of value are survey-based (stated preference) methods. The most commonly used stated preference method is contingent valuation, in which respondents are asked whether they would be willing to pay a specified amount for some environmental amenity. By varying the size of the payment amount across different respondents, one can trace out the demand curve for the environmental amenity and estimate the mean willingness to pay of people in the sample for that amenity. Contingent valuation studies have been applied to estimate the value of virtually every type of environmental amenity (see Carson 2004 for a thorough bibliography). Conjoint analysis also uses surveys to gather information but, unlike contingent valuation, is not exclusively focused on generating estimates of willingness to pay. Conjoint analysis asks people what tradeoffs they are willing to make between different sets of choice attributes. In the context of wetlands, a survey may ask whether a wetland that provided better habitat for fish was preferable to a wetland that offered more bird habitat and better flood control. If one of the choice attributes is cost, then willingness-to-pay estimates can also be generated.

A number of contingent valuation studies have asked respondents the value they place on various services from wetlands (Woodward and Wui 2001 contains references to a number of such studies). Lant and Roberts (1990) estimated that the mean willingness to pay for increases in water quality attributable to riverine wetlands in 14 towns on the Illinois-Iowa border ranged from \$15.22 to \$19.09 per hectare per year (1987 dollars). Stevens et al. (1995) estimated that the mean willingness to pay for flood control, water supply protection, and pollution control from wetlands in New England was \$31.22 per hectare per year (1993 dollars).

Estimates of willingness to pay for protecting or restoring wetlands are sensitive to what is being valued, which is to be expected, but also to how questions are asked, which is troublesome. Mullarkey and Bishop (1999) tested the sensitivity of respondents to information about mitigation activities. The mean willingness to pay to avoid wetland impacts was \$8.41–\$23.40 per hectare per person in the group that was told that no mitigation would occur and \$5.54–\$15.13 per hectare for the group that was told that mitigation would occur (1993 dollars). Pate and Loomis (1997) found that willingness to pay for wetland quality and salmon fishing in the San Joaquin Valley was \$87 per hectare per year for California residents who were closer and only \$27.52 per hectare per year for Oregon residents (1989 dollars). Both Pate and Loomis (1997) and Mullarkey and Bishop (1999) find results that are sensitive to changes in ways that are expected. We expect individuals to be willing to pay more to avoid impacts when values will be lost forever or will not be restored and for wetland quality in their home state. The California study also illustrates that total willingness to pay can depend on the scale or group that is included in the survey design. However, other studies have found that survey responses about an identical environmental amenity can be quite different depending on how the question is asked. For example, Hammit et al. (2001) found a mean household willingness to pay of \$21 (1993 U.S. dollars) to preserve the Kuantu wetland in Taiwan when respondents were asked directly how much they were willing to pay. When asked whether they would be willing to pay a specified amount, and then a higher follow-up amount if they said yes and a lower amount if they said no (''double-bounded format''), the mean household willingness to pay was \$65 U.S. per household, more than three times the mean when asked directly for willingness to pay.

Critics of contingent valuation also point out that because the choice is hypothetical and does not require actual payment, respondents may say they are willing to pay more than they would if they were faced with an actual choice (e.g., Diamond and Hausman 1994). One way to test the degree to which survey responses to hypothetical situations and actual decisions in real situations are the same is to compare the two for the same issue. Earnhart (2001) combined discrete-choice hedonic analysis and survey responses to estimate the values for disturbed and restored wetlands in Fairfield, Connecticut. He found very high willingness to pay for both restored and disturbed wetlands in his survey results (over \$200,000). He found negative willingness to pay for disturbed wetlands (−\$32,000) and positive but somewhat smaller willingness to pay for restored wetlands (\$40,000) in his hedonic discrete choice analysis (1996 dollars). The magnitudes of the estimates of willingness to pay (both positive and negative) in this study are far higher than in other contingent valuation or hedonic studies.

Azevedo et al. (2000) tested potential sources of bias in valuing recreational trips to wetlands by comparing actual travel costs versus survey responses to hypothetical changes in costs for recreational trips to wetlands in Iowa. In the survey, respondents were asked how many trips they would have taken that year if the price of visiting certain wetlands changed due to an access fee. They found that the measure of willingness to pay for wetland visits per year from the survey was more than two and half times the willingness to pay derived from resident's actual visits and travel costs ($264.65 versus $99.61 in 1997). It is not clear which of the two estimates is closer to reality. The hypothetical nature of surveys cast doubt on the higher estimate, while incorrect perceptions of the travel cost may cast doubt on the lower estimate. Azevedo et al. (2000) recommend that both methods be used jointly to estimate values. Using the same 1997 data on recreational visits to Iowa wetlands, von Haefen and Phaneuf (2003) explored technical refinements for estimating willingness to pay with continuous and count data travel cost models to provide more accurate predictions of recreation users behavior (i.e., changes in visits to a recreation sites given changes in quality or trip costs).

For sensitive environmental issues, survey respondents may be unwilling to compare environmental quality and money. For example, Steven et al. (1991) found many people unwilling to respond to questions about tradeoffs between money and species existence. Conjoint analysis can avoid forcing respondents to make tradeoffs between money and environmental quality while still gaining information about preferences of respondents. Morrison et al. (1999) used stated choice conjoint analysis to study tradeoffs between agricultural employment and the presence of wetlands and endangered species for the Macquarie Marshes, a large wetland in New South Wales, Australia. They found higher willingness to pay for an additional endangered species present in a wetland, roughly $4, than for an irrigation-related job, for which willingness to pay was about $0.13 (1997 Australian dollars). Although the willingness to pay for improving quality to protect endangered species was greater than existence values for rural employment, the inclusion of employment in the choice models lowered the overall willingness to pay for environmental improvements (e.g., increased bird breeding frequency, wetland area, and species presence) by 20–30 percent in the scenarios used. Johnston et al. (2002) examined the value of salt marshes to residents of Rhode Island. Survey respondents placed greatest value on mosquito control and protection of shellfish habitat, followed by protection of fish and bird habitat. Hoehn et al. (2002) analyzed how Michigan residents would trade off characteristics of a restored wetland, including type of wetland, the quality of habitat for categories of species, and their likelihood of seeing an animal while visiting, versus draining an existing wetland. Hoehn et al. (2002) found that in terms of area, 1.64 hectares of restored wetlands were needed to compensate for the destruction of an equivalent hectare of original wetland, showing that people place an intrinsically higher value on *in-situ* wetlands regardless of quality. Higher mitigation ratios were required when the quality of the restored wetland characteristics was not as high. A mitigation ratio of 2.14 to 1 was required when the restored wetland was of ''good'' rather than ''excellent'' quality. Hoehn et al. (2002) laid out the choice experiment design and survey administration process for the Michigan study, providing insight into the potential pitfalls of participant misperceptions and sources of bias when conducting conjoint choice valuation surveys.

There has been a lengthy, and at times, intense debate over the validity and reliability of results from survey-based methods, particularly contingent valuation (see, for example, articles by Diamond and Hausman (1994) and Hanemann (1994). Proponents of survey-based methods claim that useful empirical findings can be found from carefully crafted surveys, while some critics are skeptical of any results from responses to hypothetical situations. For some situations, however, there is no alternative to survey-based methods for ascertaining attitudes about environmental amenities. Recent work on conjoint analysis has generated interesting results on what attributes of wetlands are of greatest interest to survey respondents without asking people difficult willing-to-pay questions. However, these methods too are sensitive to how the survey is conducted. While, in principle, surveys can ask about the value of urban wetlands, most surveys to date have not focused on urban wetlands (with the exception of Earnhart 2002). It would be interesting to compare stated preferences for urban wetlands versus rural wetlands. In addition, it would also be interesting to compare attitudes toward wetlands as expressed on surveys of the general public and attitudes of wetlands scientists to see if there is significant agreement or disagreement.

DISCUSSION

There is at this point a fairly substantial and growing literature that attempts to value wetlands. However, only a very small portion of this literature addresses questions of valuing urban wetlands. Virtually all of the work on urban areas has used hedonic analysis, which is useful for estimating readily observable values to nearby property owners but is not very useful for measuring the value of services that are more indirect and therefore harder for property owners to see, and services that accrue to the larger public. More work that can estimate the value of water filtration, flood control, habitat, and other public good aspects of wetlands is needed. Production methods, which require close collaboration between natural scientists and economists, provide a promising line of research to estimate such values. These methods have been relatively under-utilized to date. Results from the hedonic studies that have been done to date seem to show that urban wetlands are more highly valued by nearby property owners than are rural wetlands. These results are consistent with reasons laid out in the Introduction for why urban wetlands should be of great value; however, more work is needed before such claims can be made conclusively.

At present, the range of estimates of value for wetlands is quite large. Some of this variation is to be expected. The value of wetlands depends on the circumstances and the services provided. Wetlands that provide flood control near urban areas, water filtration near sources of urban drinking water, bird watching or other wildlife watching opportunities near urban centers, nursery grounds for commercial or sport fisheries, or habitat for endangered species are likely to be quite valuable. Other wetlands that do not provide these services may not be highly valued. However, much of the currently measured variation in values is due to imprecision of the measurement techniques themselves. Despite advances in the state of the art in non-market valuation, there remain questions about reliability of estimates derived from non-market valuation methods. Some degree of skepticism is warranted in dealing with such estimates. Our view is that valuation studies can provide useful information about the relative rankings of value (e.g., showing that certain types of wetlands or certain services are more highly valued than others). These studies can also be useful in policy context when estimates of values from conserved wetlands far exceed costs of preservation, similar to the case of watershed preservation in the Catskills. However, at present, it does not seem that one can generate reliable precise estimates of the values of wetlands.

Some critics of using economic valuation of wetlands go further and argue that the whole valuation approach is fundamentally flawed and should not be pursued (see, for example, Sagoff 1988). King (1998) argued that the reduction of wetland values to monetary terms often results in ''small or indefensible'' numbers. Defensible numbers may be generated for only a small range or ecosystem services from wetlands, which will be only a fraction of the total value of wetlands. Attempts to derive more holistic estimates of total value suffer from severe data and model limitations that opponents can easily exploit. King presented a number of examples where poorly conducted or inappropriately scaled studies have backfired in the political or regulatory arena.

The key question in our minds is not whether valuation methods can yield complete accurate answers (they cannot), but whether properly conducted analyses yield useful information to decision-making. We think there are cases where such information will be helpful. For example, evidence about the value of flood reduction or water filtration may well be determinative for public policy decision-making. In other cases, where values are more ethereal and subjective (e.g., existence values), non-market valuation may be suggestive but is unlikely to be conclusive. Even here, valuation can be useful in providing insights on what types of wetlands are of greatest value to society and on how conservation priorities should be directed (Hoehn et al. 2002).

A number of challenges remain for improving the utility of valuation exercises for decision-makers concerned with wetlands in urban areas. There are large gaps in our understanding of wetland ecosystems and how perturbations of such systems will result in changes in the production of various valued ecosystem services, despite advances in classification systems and the use of reference wetlands for assessment (Brinson 1993, Brinson and Rheinhart 1996). For example, wetland ecosystems may have thresholds. Stress may be tolerated with little damage until a threshold is reached, at which point system function may change radically, giving rise to a large change in ecosystem services. Linking human actions in the surrounding landscape to changes in wetland ecosystem function is not well-understood but is crucial to evaluating which among a set of alternative choices are preferable.

Second, if the values of wetlands are uncertain and wetland destruction is to some degree irreversible, there will be an ''option value'' for conserving wetlands (Arrow and Fisher 1974). Option value is the value to avoiding irreversible outcomes (i.e., preserving flexibility) until after some uncertainty is resolved. We are likely to learn more about wetland functions and anthropogenic values through time. In addition, although it seems possible to restore some wetland functions at some cost, it is not clear that the full range of ecological functions or ecosystem services can be restored even for any cost. The restoration of the Everglades provides a case in point (Central and South Florida Project 1999). The demand for prediction of restoration success has outstripped scientific knowledge (Zedler 2000). Just measuring the expected costs and benefits of wetland protection is difficult. Yet, even if expected costs and benefits could be calculated, there is additional option value to avoiding irreversible loss of wetlands. While the theory of option values is well understood, estimating the size of such option values is relatively uncharted territory.

Third, most studies of the value of wetlands are done on a small scale that evaluates individual wetlands or wetlands on an individual or local rather than landscape or regional scale. Valuation of wetland benefits at the local level will result in a failure to account for the benefits to other users outside the area for flood control, water quality, habitat, and so on. Hey and Philippi (1995) estimated that in order to reduce seasonal flooding and improve water quality in the Upper Mississippi River basin, it would be sufficient to restore 3 percent of the watershed to wetland (approximately 5.38 million hectares). Restoration of wetlands in the Upper Mississippi watershed, in turn, would help to reduce the hypoxia or dead zone problem at the mouth of the Mississippi River. When wetlands are treated as local concerns, rather than regional, national, or international concerns, then some wetland values are ignored or discounted. However, evaluating all wetlands at a landscape, regional, national, or international level may be an overwhelming task.

Given that detailed valuation estimates of specific wetlands projects are extremely costly and time-consuming, it is tempting to use estimated values generated at one location and apply them to another location, a process called benefits transfer. However, the use of benefits transfer methods for wetlands is questionable given the range of values for ecosystem and human services shown in the literature and the site-specific nature of many values. There remains a need for well-implemented, site-specific research to determine both functions and values of wetland systems.

This paper has discussed valuation issues, yet it is of primary importance that regulatory and incentives issues are not overlooked. Private landowners may not see much value in protecting wetlands, even though there may be great social value in doing so. Without proper regulations or incentives in place, even wetlands that have been shown to generate high value for society may be lost. Further, even with rules and regulations in place that, in theory, protect wetlands, such as provisions for ‘‘no net loss,’’ wetland losses will continue unless these rules and regulations are adequately enforced and monitored. In the final analysis, understanding the incentives of private landowners and other decision-makers whose decisions affect wetlands, and designing adequate institutions and regulatory schemes, is probably of greater importance for wetland conservation than is accurately measuring values.

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