# Can environmental economic valuation techniques aid ecological economics and wildlife conservation?

by John B. Loomis

**Abstract** I evaluate the potential usefulness of nonmarket valuation concepts and techniques from environmental economics for improving wildlife conservation. The concepts include distinguishing between on-site recreation use value and off-site passive use or existence values. In addition, I review 3 nonmarket valuation techniques. I illustrate the concepts and use of the technique of contingent valuation with a case study of valuation of increased ecosystem services for a riverine ecosystem. Results suggested that the benefits to households living along the river exceeded the costs of water rental from farmers and conservation easements.

**Key Words** contingent valuation, ecosystem services, passive use value, valuation techniques

## Relationship between ecological economics and neoclassical economics

There are many visions of ecological economics that include a strong tie to sustainability. Both the fields of ecological economics and sustainability share concerns over the scale of the economy, distribution (with and between generations), and efficient allocation of resources (Costanza et al. 1997). Thus, ecological economics is broader in emphasis than neoclassical environmental economics, which devotes most of its attention to efficient allocation of resources. Environmental economics is based on microeconomic or price theory of individual consumer and business behavior and does not emphasize concerns over scale of the economy per se. Much of the effort in environmental economics is expended in getting the prices right to reflect the full environmental costs of production and consumption (Pearce et al. 1989). Thus, pollution taxes and green accounting are emphasized by environmental economists.

Many practitioners of ecological economics distrust market prices as a guide to the relative values of society and as a policy instrument. One of the limitations of prices is their dependence on the current distribution of income, which reinforces the current inequality of income distribution. A more pervasive critique of market prices is that of Norgaard (1990), who argues that for prices to correctly reflect scarcity, there must be near perfect knowledge of society's future demand, stock of the resource, and technology for extraction. Because these conditions are rarely met in the real world, market prices are not sufficient to attain efficiency of resource use over time, let alone sustainability or appropriate scale.

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While full environmental costing of consumption and production may not by itself be sufficient to meet the goals of ecological economics, it can contribute to these goals. Because the quantity demanded of a resource is related inversely to its price, the greater the price, the less will be consumed. Thus, adjusting market prices upward via pollution taxes to reflect the external costs will reduce the production and consumption of the taxed natural resource. This reduction in natural resource use contributes to sustainability, as more will be available for future generations. For example, rising real costs of pumping, using, and discharging water have actually resulted in declines over the past 15 years in overall freshwater withdrawals in the United States, despite population and economic growth (Scolley et al. 1998).

**The scarcity of ecosystem services and competing uses of ecosystems force choices. Economic valuation of these services helps society to make informed choices about the trade-offs.**

While full environmental cost pricing is a relevant tool of environmental economics, its use in ecological economics must apply to more than individual environmental media. It also must be ap-plied to valuation of ecosystem services (Costanza et al. 1997: 142). Valuation of ecosystem services that provide life support to all living things on the planet and aesthetic enjoyment to humans may seem irreverent to some. However, as Costanza et al. (1997:143) noted "We believe that society can make better choices about ecosystems if the valuation process is made as explicit and participatory as possible." It is the scarcity of ecosystem services and competing uses of ecosystems that force choices. Valuation helps society to make informed choices about the trade-offs.

If values are to be used to assist in trade-offs, values need to reflect sacrifices that individuals are willing and able to make. Because it is humans who are making the trade-offs, an anthropocentric view is adopted. Thus, our measure of value is what humans would trade or sacrifice to improve or restore ecosystem services. If some humans must accept reduced ecosystem services, the valuation focus shifts to minimum willingness to accept compensation for this reduction in ecosystem services. In a framework of weak sustainability (Gowdy 2000) involving nondeclining consumption or capital (human, constructed, and natural), minimum willingness to accept (WTA) can be in the form of money. This is the traditional view of neoclassical economics. However, to those who believe in strong sustainability, willingness to accept might be in the form of what other natural resources or natural capital they would accept for a diminution of a particular resource. While measuring WTA in monetary form is challenging for nonmarket resources, measuring it in nonmonetary form is even more difficult. However, there has been a successful example of this concept in Madagascar (Shyamsundar and Kramer 1993). Here, the probability of villagers accepting additional baskets of rice in exchange for not farming or grazing livestock in a new park reserve rose with the number of baskets of rice offered. Thus, the responses had internal validity. Further, the willingness to accept baskets of rice had a systematic association with socioeconomic variables of the individual villagers. In addition, the method of paired comparison appears promising to elicit WTA for monetary (Loomis et al. 1998) and nonmonetary values (Peterson and Brown 1998).

Ecosystem services include water purification, groundwater recharge, nutrient cycling, wildlife habitat provision, and even recreation. When a policy or project affects just one of these services, there are several methods for valuation that can measure either willingness to pay (WTP) or WTA.

## Valuation methods

### *Revealed preference*

If recreation or wildlife production is the ecosystem service affected by a project, then actual behavior-based methods (i.e., revealed preference), such as Travel Cost Method (TCM) to estimate a demand curve, may be applicable. For example, if some project improves fishing, hunting, wildlife viewing, or the quality of water used for swimming or boating, then a demand curve can be estimated using the Travel Cost Method by using travel costs as a proxy for price and number of trips as the quantity demanded. TCM uses the spatial variation in travel costs of visitors living at different distances from the wildlife area as the price of a trip and the number of trips taken each season to statistically derive a demand curve. This demand curve allows one to calculate the dollar amount a person would pay in excess of his/her current travel costs for continued access to the wildlife area under the current resource conditions. This dollar amount is known as the maximum net willingness to pay (WTP) or consumer surplus for continued access to the wildlife. For example, if it currently costs a visitor $20/trip to visit the wildlife area and at that price he takes 6 trips, then his current expenditure is $120. But his maximum WTP in excess of this expenditure is $75,

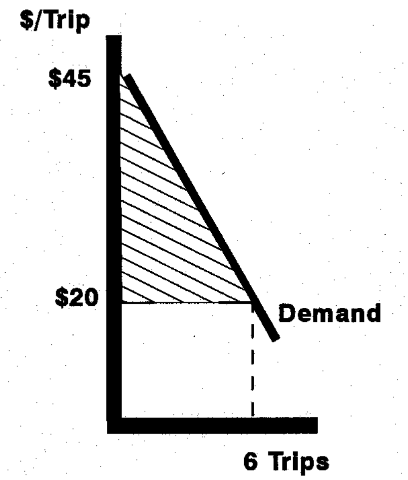


Figure 1. Calculating consumer surplus from a TCM demand curve. Striped area is consumer surplus.

the striped area under the demand curve (Figure 1). To measure how WTP changes with the quantity or quality of wildlife, one can pool visitation data across areas with high and low levels of these ecosystem services and estimate a composite demand curve. Increased quantity or quality of the ecosystem service shifts the demand curve outward. The area between the original demand curve and the new demand curve represents the amount visitors would pay for that increase in quality.

The TCM is used widely to value hunting, fishing, and water-based recreation (Walsh et al. 1992). It also has been used to value improvements in recreation benefits of improved water quality (Smith and Desvousges 1986).

If one or more ecosystem services are changed in an urban or suburban environment, then the hedonic property method (HPM) can be used to estimate WTP of households for the improvement or their WTA for a loss. The HPM is based on the principle that scarcity for greater levels of ecosystem services will force households to bid up properties that have access to better levels of air quality, water quality, recreation access, or aesthetic amenities. The method has been applied widely to value improvements in water quality (d'Arge and Shogren 1989) and stream restoration (Streiner and Loomis 1995).

### *Stated preference approaches for nonmarket valuation*

Many large-scale development or restoration projects affect a group of interrelated ecosystem services. For example, forest clearing alters wildlife habitat for many species, water quality, and recreation. If an analyst calculated separately the value of each of these ecosystem services and then added them up, such a process could miss important complementarities or substitution possibilities in consumption or in the income–budget constraints of individual households (Hoehn and Randall 1989). Thus, a more holistic approach that accounts for interactions is more desirable. This approach would elicit values from individuals based on the entire suite of ecosystem services provided.

Services provided by the ecosystem may support biodiversity, stability, and resilience of natural and human systems that humans know are important for their well-being and the well-being of future generations, even if they do not physically visit the resource. For example, some people derive satisfaction from knowing that the life cycles of migratory species will continue to signal the changing of the seasons or that the entire web of life in a prairie ecosystem continues unabated. That is, the continued existence of these ecosystem services is valued by these people. From an economic standpoint, they are willing and able to sacrifice market goods to maintain or enhance these ecosystem services for themselves (existence value) and future generations (bequest value). Empirical evidence of these existence and bequest values can be found in letters written in support of protecting remote areas like the Arctic National Wildlife Refuge from oil drilling and local sales-tax referenda to preserve open-space or water-quality bond measures for Lake Tahoe by citizens of California and Nevada.

American bald eagle (Haliaeetus leucocephalus). Photo by Len Rue, Jr.

However, many times people lack a real or political market in which to express their existence and bequest values. To fill this void, a survey approach called the contingent valuation method (CVM) is used to simulate markets or voter referenda to allow citizens to value the benefits they receive from unpriced ecosystem services. There are numerous examples of the contingent valuation of entire ecosystems, including the Great Basin Mono Lake ecosystem (Loomis 1987), wetlands (Loomis et al. 1990), and critical habitat for threatened and endangered species (Hagen et al. 1992, Loomis and Ekstrand 1997).

CVM surveys involve describing the baseline ecosystem services and the improved level or extent of ecosystem services on which the individual can vote. The ecosystem services are often described in words, diagrams, drawings, and sometimes photos. In the survey, individuals are asked typically to pay for the increased ecosystem service. In the referendum format, the specific dollar amount is varied across individuals to allow statistical estimation of a demand-like relationship. The form of payment may be greater taxes (sales, income, property), utility bills (water, electricity), or payment into a trust fund.

One frequent concern with reliance on stated preference as compared to actual behavior has to do with whether the stated responses are reliable and valid. All the published studies to date have shown CVM-derived responses of WTP for use and existence values to be reliable in test–retest studies (Loomis 1989, Carson et al. 1997). CVM has been recommended by federal agencies for performing benefit–cost analysis (United States Water Resources Council 1983) and valuing natural resource damages (United States Department of the Interior 1986, 1994). CVM has been upheld by a federal court (*State of Ohio v. United States Department of Interior* 1989) against challenges by the American Chemical Manufacturers that the technique was not reliable enough to be used in natural resource damage assessment. CVM has been recommended as being reliable enough to provide initial estimates of existence values by the National Oceanic and Atmospheric Administration's panel co-chaired by 2 Nobel Laureate economists (Arrow et al. 1993).

Nonetheless, CVM-derived estimates of public-good values such as existence and bequest values may overstate actual cash WTP by a factor of 2 or more (Brown et al. 1996). Recent efforts at calibrating stated WTP values show promise at producing equality of stated and actual cash WTP (Champ et al. 1997). The following case study illustrates the application of CVM to estimate dollar values of ecosystem services.

## Case study of the South Platte River

Three ecologists worked with 2 economists to develop a survey that would communicate to the public the current level of ecosystem services being provided by the South Platte River near Denver, Colorado, and how these could be improved. The current ecological baseline analysis has been summarized in Strange et al. (1999). The study section of the South Platte River also was selected based on an actual policy proposal. This rural stretch of river extends from Kersey to Fort Morgan, Colorado. The first step was to define ecosystem services that could be provided by the South Platte River: wastewater dilution, water purification, erosion control, habitat provision for fish and wildlife, and recreation.

Once the key ecosystem services were identified, management actions necessary to increase their levels were developed. These actions involved a 16-km-wide conservation easement along 72 km of the South Platte River downstream of Greeley. The area is 121,450 ha in size. Next, native vegetation would be restored along the river as buffer strips, and cropland and cattle grazing in the buffer strip area would be eliminated. Livestock grazing would be allowed in the remainder of the conservation easement. Using water leasing, irrigation diversions for agriculture would be reduced from their current 75% to 50% of the total flow, with a corresponding increase in instream flow from 17% to 42%. This would result in an annual gain of 46,632 cubic meters of water for instream flow, wastewater dilution, and aquatic habitat provision. This water would be used to restore the historical high spring flow regime that would be desirable to maintain the native cottonwoods (*Populous deltoids*) needed by native birds, instead of the encroaching exotic Russian olive trees (*Elaeagnus angustifolia*). Eliminating grazing in the riparian area allows for growth of cottonwoods. The payment mechanism was an increase in household water bills.

The interdisciplinary team worked jointly to develop drawings and narrative that conveyed the concept of increased ecosystem services. An initial set of drawings illustrating a natural level of ecosystem services (Figure 2) as compared to the current condition of degraded ecosystem service (Figure 3) was prepared.

### *Pretesting*

To investigate the validity of these drawings and narrative to convey the sense of the ecosystem services, we tested them at 3 small-group discussions in the study area. These discussions (called focus groups) were composed of 4–10 individuals. Each visual aid was presented individually. Participants were asked to describe in their

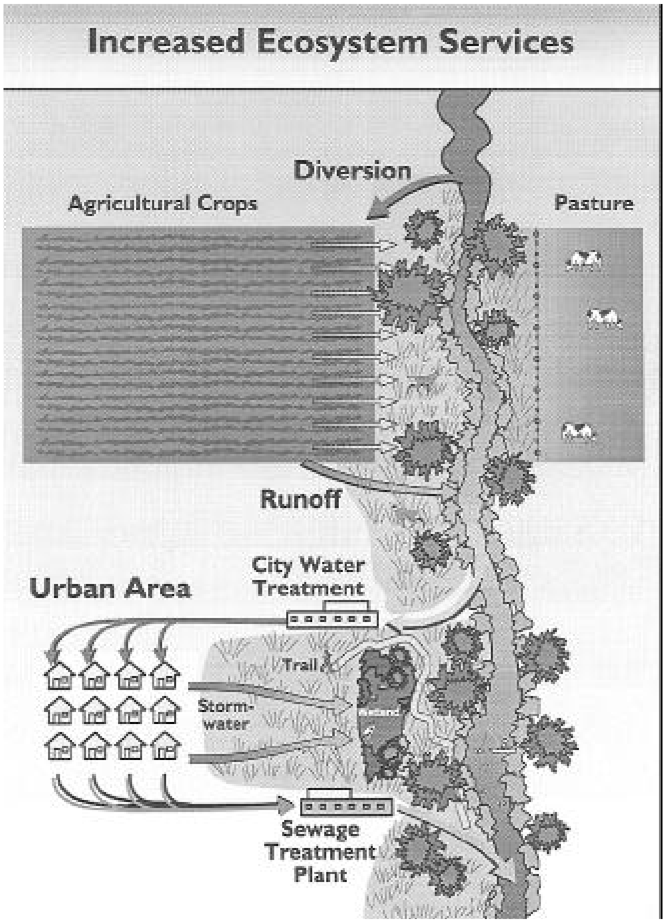


Figure 2. Composite diagram showing increased ecosystem services resulting from restoration.

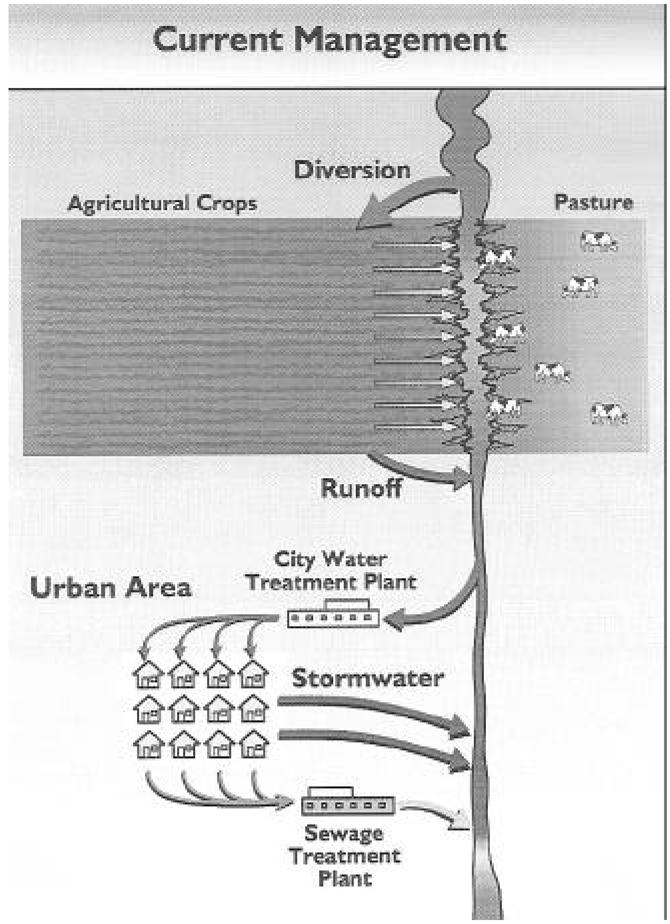


Figure 3. Composite diagram depicting current degraded ecosystem services.

own words what each diagram illustrated. We compared this to our intended meaning and made modifications to the diagrams. Once we had established internal validity of the diagrams, we often adopted the respondent's choice of wording to aid in providing a text description of the illustration. After the first focus group follow-up discussion, we determined that comprehension would be improved by including a summary diagram that was a composite of all of the ecosystem services that had been presented individually. After further revisions following the focus groups, the survey script and a revised set of diagrams were prepared and pre-tested. We pre-tested the script and drawings on 4 individuals, 2 of whom also served as training subjects for the interviewers. Refinements following these pretests appeared to have resulted in a script and diagrams that were fairly effective in eliciting household willingness to pay for increasing ecosystem services in the South Platte River.

## *Synopsis of ecosystem services valued*

Land management actions necessary to restore ecosystem services were illustrated on a schematic map of the study area. Along 72 km of the South Platte River shown on the map, the government would purchase conservation easements on both sides over a 10-year period from willing farmers (8 km on either side for a total of 121,450 ha, shown on the map). Respondents were told that conservation easements would keep the land in private ownership but would be used to pay farmers to manage this land to improve wildlife habitat and water quality. For example, cows would be fenced out of the area along the river banks so vegetation could regrow and the stream banks could be stabilized. This area would be restored to natural vegetation such as grasslands, wetlands, and streamside trees. Some areas would be replanted with native vegetation. The revegetated streamside would reduce erosion, increase natural water purification by plants, improve water quality and wildlife habitat, help preserve native fish populations so they would not go extinct, and provide public access to restored natural areas for wildlife viewing, including 8 km of hiking trails. These management alternatives were illustrated by a series of color figures shown to respondents during the in-person interviews.

The second major change involved leaving more water in the South Platte River. This shift in water use was illustrated by comparing 2 pie charts shown to respondents. The top pie chart presented "Current Water Use," in which 75% of water supply is now primarily for agriculture. Respondents were told that additional instream flows in the river could be obtained by land purchase or lease from farmers along the river. Respondents were then directed to the lower pie chart, which illustrated 50% of the water being used by irrigated agriculture and instream flow increasing from 17% to 42%.

These changes were compared to the current condition, which was illustrated in the baseline figure shown to respondents. The specific wording of the willingness-to-pay scenario read to respondents was:

> "If the majority of households vote in favor of the South Platte River Restoration Fund, the 45 miles of river would look like the figure labeled "Increased Ecosystem Services," with increased water quality and fish and wildlife.
>
> If a majority vote against, these 45 miles of the South Platte River would remain as they are today, as illustrated in Current Management.
>
> If the South Platte River Restoration Fund was on the ballot in the next election and it cost your household $__ each month in a higher water bill, would you vote in favor or against?
>
> __I would vote Yes __I would vote No"

The "$__" was randomly filled in with one of 12 amounts: $1, 2, 3, 5, 8, 10, 12, 20, 30, 40, 50, 100.

### *Statistical model of WTP*

Given that individuals would simply respond with a "yes" or "no" to a single dollar amount, the probability that they would pay a given dollar amount is statistically estimated using a qualitative choice model such as a logit model (Hanemann 1984). A slope coefficient is estimated on the dollar amount they are asked to pay. A constant term also is estimated that reflects the mean effect of the other nondollar variables on the probability that a respondent will agree to pay the dollar amount. The constant term divided by the dollar coefficient yields an estimate of median willingness to pay. Confidence intervals of WTP were calculated using the variance–covariance matrix and a simulation approach of Park et al. (1991).

### *Survey implementation*

Funding was sufficient to allow for in-person interviews of about 100 individuals during 1998. The sample frame was individuals living in towns nearby or along the study area. A 41% response rate of individuals who could be contacted was obtained.

Viewing: a nonconsumptive use of wildlife.

### *Results*

The estimated logit model had a pseudo R square (formally the likelihood ratio index, Kmenta 1986) of 45%, and the coefficient on the dollar amount households were asked to pay was statistically significant at $P<0.01$ (Kent 1999). The dollar coefficient was negative, as would be expected by economic theory; i.e., the greater the dollar amount households were asked to pay, the less likely it was that they would agree to pay that amount. Using the logit coefficients to calculate willingness to pay resulted in a mean of $21/month/household, with a 95% confidence interval of $20.50–$21.65 for the increase in ecosystem services on this 72-km stretch of the South Platte River.

The counties in which the interviewees lived were classified as the pertinent areas where preservation benefits pertain. These counties included Adams, Boulder, Weld, and Morgan. Mean willingness to pay/household was multiplied by number of households in this area of the South Platte River Basin. Two sample expansions of these benefits to the population of regional households living along the South Platte River were made. The first treated the mean WTP as the best estimate of what the average household would pay. The second was a more conservative estimate that accounted for the 59% of households that did not respond to the survey. The proportion of households that refused to be interviewed regarding the South Platte River are conservatively treated as having zero WTP. These benefit estimates range from the conservative $29 million estimate to $79 million annually for all the households living along the South Platte River.

This annual WTP can be compared to the cost of the conservation easements and water rental necessary to deliver the ecosystem management practices in the study area. To obtain an estimate of what a conservation easement may cost, one could look at county, state, or federal programs that purchase conservation easements in Colorado. One estimate of the cost can be obtained from the United States Department of Agriculture's Conservation Reserve Program (CRP), which pays farmers to idle their farmland to reduce erosion and improve water quality. Rental rates in northeastern Colorado average $101/ha (Page and Skold 1996). This would likely be the rate for most of the land within the easement, except for the land directly adjacent to the river. A recent State of Colorado and local (Centennial Land Trust) easement for 1,252 ha of land directly along 4 km of river had an easement cost of $347/ha. Using this as the price for the 72 km of riverfront land and the $101/ha for the remaining two-thirds of the area, the cost would be $17.83 million for the 121,450 ha of easements in our ecosystem management scenario.

Rental of the 46,632 cubic meters of water needed to increase instream flow, dilute pollution, and increase aquatic habitat would cost $1.13 million, given the average cost of water leases in the West reported by Landry (1998). Thus, total costs would be $18.96 million, well below the conservative estimate of WTP of $29 million. Therefore, it appears that WTP of responding households along the South Platte River exceeds the typical costs of the conservation easement and leasing the water rights. Thus, ecosystem restoration on this segment of river seems to pass the test of economic efficiency.

Exactly who would pay these costs and how the costs would be distributed among local, state, and perhaps federal taxpayers is a separate question involving principles of equity. In the public finance arena, the relevant principle involves comparing the distribution of the public-good benefits with the distribution of taxpayer cost. Ideally, these would be closely aligned, but the distribution of benefits does not always follow political boundaries used for taxing purposes. As a practical matter, the State of Colorado provides matching funds to local entities to purchase conservation easements. The local entities often hold referenda similar to what was de-scribed in the survey to raise their share. In the cost analysis performed above, we drew upon an actual transaction in which the State of Colorado would provide $300,000 of the $435,000 necessary to purchase a conservation easement along 4 km of the South Platte River within our study area. Thus, there would certainly be a sharing of costs among state and local taxpayers. As suggested by United States Department of Agricul-ture's conomic Research Service, a portion of the funds could come from the federal taxpayer through "benefit" targeting of CRP easements (Feather et al. 1999). The appropriate mix of local, state, and federal taxpayer funds could in principle be determined by aligning the percentage of tax payments with the spatial benefit (WTP) gradients. These spatial benefit gradients have been developed for other resources on which surveys were performed at a wide range of distances from the resources (Loomis, unpublished data). Such spatial benefit gradients were well beyond the scope of this pilot study.

A successful fisherperson: consumptive use of natural resources.

Nongame wildlife, like this snowy plover and chick, is often quite valuable.

## *Refinements and future research on ecosystem valuation*

In the near term, studies like the South Platte River could be refined by systematically varying the number of ecosystem services to be valued and the level of each ecosystem service to be provided. This can be done using multiple scenarios within a contingent valuation survey or by using contingent choice or conjoint analysis (Adamowicz et al. 1998). In this way, the incremental value of specific ecosystem services could be valued and compared to the cost of providing those specific services.

## Conclusion

This paper illustrates the potential of nonmarket valuation to supplement ecological economics and contribute to wildlife conservation. Valuation of nonmarket ecosystem services that would be lost due to development should help in setting full-cost prices of land or impact-mitigation fees for development of habitat. Government evaluations of proposals to increase constructed capital at the expense of natural capital such as wildlife are more meaningful when nonmarket effects are considered. Development interests often overlook non-market effects on wildlife, leading to overall losses in economic and social well-being. Use of contingent valuation to include the current generation's bequest values to future generations also may help link intergenerational concerns about wildlife conservation.

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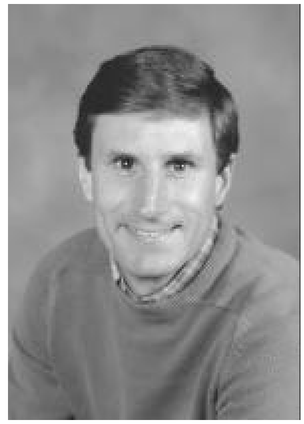

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