Recreation

MEASURING THE ECONOMIC VALUE OF WILDLIFE RECREATION: AN EVALUATION OF TECHNIQUES

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I. Introduction

In this paper we are interested in problems of estimating the economic value of wildlife for policy purposes. The general problem faced by wildlife managers and agencies, such as the Fish and Wildlife Service, is estimating the value of the effect of changes in the habitat and the stock of wildlife enjoyed by recreationists. We begin with a framework for addressing this issue. This framework permits us to undertake the ostensible purpose of the paper: a discussion of methodologies for valuing the net economic benefits of wildlife recreation. An important concern in evaluating each methodology is how well it deals with valuing wildlife for policy purposes. We argue that much of the confusion associated with the valuation methodologies stems from uncertainty about the nature and interaction of decisions by public agencies and private individuals.

The decision structure of a public agency responsible for managing stocks and habitats of wildlife can be simplified in order to focus on particular issues of concern to us. Suppose that the public agency has some control variable, denoted A, which affects the stock of wildlife. For example, A might represent acres of wetlands for waterfowl, the magnitude of a stocking program or even discrete decisions, such as whether to construct a dam. The agency needs to evaluate the net economic returns from the

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effects of A. Let C(A) represent the cost of A. The net returns go to n (assumed exogenous) recreationists, whose benefits are measured by the function B(d,c) where d represents days per season and c represents some success rate such as encounters or catch per day. Hence benefits are[1]

(1) $nB(d,c) - C(A).$

We must add the connection between benefits per recreationist and the policy instrument A. The success per day is a technological function of two types of inputs: one type, w, represents inputs into the household production function controlled by the individual; the other type, S, is a public input which in our simple case is limited to the stock of wildlife. Hence

(2) $c = c(w,S).$

To complete the connection between benefits per user and the policy instrument, A, we assume a biological relationship between public and private decisions and the stock of wildlife. This relationship is given by:

(3) $S = S(A,n,d,c)$

where c is the success per day, d is days per user, and n is the number of users.[2]

Our structure emphasizes the relationship between public decisions and private benefits. In the chain of causation, the policy variable, A, affects the stock of wildlife, S, which in turn determines in part the catch per day, c, which then influences net benefits per user. In this chain, the relation between the success per day and net benefits is crucial. One problem which emerges in all approaches is the relationship between success per day, whether endogenous or exogenous, and the demand for days.

Our purpose in this paper is to make some specific points in the context of this general framework to evaluate current methodologies for measuring the economic value of wildlife. In the following parts of the paper we discuss the household production function method, the bidding game approach, and willingness to pay surveys. Our concern will be with methods of measuring net benefits of wildlife recreation. We assume that net benefits are equivalent to willingness to pay. We do not explore the possible divergence of willingness to sell from willingness to pay.

II. The Household Production Function Approach to Valuing Wildlife

Perhaps the most interesting and theoretically appealing of current methodologies for valuing wildlife is the household production function approach. This approach is exemplified by Brown, Charbonneau, and Hay [1978]. It offers a means of estimating a demand function for the activity from data on expenditures and frequency of participation, yielding a basis for calculating consumer's surplus. This is accomplished, despite unobservable prices for the activity, by deriving implicit (hedonic) prices.

Treatment of the household's decision involves an extension of the model set out in the introduction. The household maximizes utility subject to 1) the household's technological production function for days and encounters and 2) the household's budget constraint. Solution of this constrained maximization problem yields demand functions for the commodities (d and c), which are arguments of the utility function.

Since commodities are both produced and consumed by the household, prices for the commodities are unobservable, making it operationally necessary to dichotomize the maximization process. For example, if the commodity is days, the household production model treats the consumer as first minimizing the cost of producing a given number of days:

$$\text{Min Expenditures} = \text{Min } P_z' \cdot z = \text{Min } E(d)$$

where z is inputs into production and P_z their prices. Second, he maximizes his utility subject to a budget constraint, where the price of days is derived from the first step and is the marginal cost of producing days

$$P_d = \partial E/\partial d = \text{hedonic price of days}$$

$$E = \text{minimum expenditures}$$

Despite the conceptual appeal of this approach, we have several concerns regarding its use for wildlife valuation. Our discussion focuses on the assumptions, concerning the model's technological relations, which are necessary to accomplish two ends. First, under what conditions can we estimate, even in the simplest of models, a demand for the recreational activity; and second, how do we capture the effects of policy-stimulated changes in the success variable on demand and thus on consumer's surplus.

In part, our discussion depends on the results of Pollak and Wachter's work, which rigorously demonstrates that the expenditure and demand relations cannot be estimated independently if the household's technology exhibits nonconstant returns or joint production. The implications of their results are spelled out in part by Deyak and Smith [1978]. We argue that the implications of these findings for empirical work are not well understood. These findings place considerable restrictions on the type of model and sample data to which the household production function may be meaningfully applied. Additionally, we argue that the assumptions underlying the travel cost method, as well as the characteristics of the sample data generated by this method, are consistent with the restrictions which must be placed on the application of the household production function approach.

At first, we abstract from the problem of the household's production of c. Assume that the success variable may vary among individuals, but cannot be affected by individuals' decisions. In other words, the success rate is assumed exogenous. Thus w in equation (2) is suppressed, and there is no possibility of joint production in the model. The expenditure function is simply $E = E(d)$ and the demand function for days is $d = d(\partial E/\partial d, y, c)$ where c is exogenous to the individual.

1. Clearly, if the expenditure function is linear, there is no variation in marginal cost, and a demand function cannot be estimated. This has caused researchers to estimate nonlinear expenditure functions, such that $\partial E/\partial d$ is a function of days. However, a system in which

$$d = d(\partial E/\partial d)$$

and

$$\partial E/\partial d = g(d)$$

is simply a difficult variant of the traditional simultaneous estimation problem for supply and demand. Both days and hedonic price (marginal cost) of days are endogenous variables and $\partial E/\partial d$ is not observable for simultaneous estimation. Two step, rather than simultaneous, estimation not only yields simultaneous equation bias, but an identification problem, destroying any confidence in the interpretation of any of the estimated coefficients.

2. Despite the simultaneity of the problem, we have doubts as to whether the household production function model can be estimated simultaneously. There is, of course, the obvious problem of often not having sufficient exogenous variables from recreational survey data to identify the system or at least the demand function. However, a more serious barrier

to estimation is that one of the endogenous variables is unobservable. While we have information on expenditures, we cannot derive marginal cost (hedonic price) unless we have first estimated the expenditure function. It may be possible to estimate such a complex simultaneous system as

$$E = E(d)$$

$$d = d(\partial E/\partial d, y, c).$$

We have not yet identified any means of doing so.

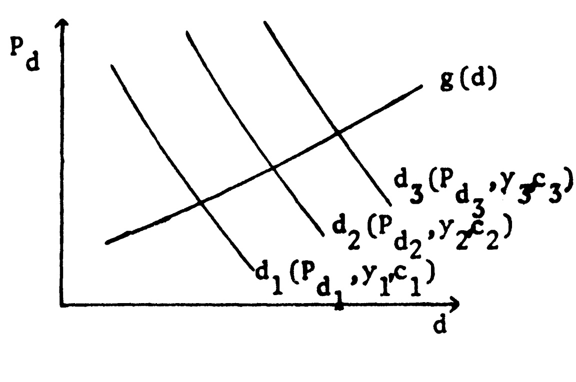
3. There appears to be confusion about the means of obtaining variation in the derived hedonic prices. Estimation of one non-linear expenditure function yields different marginal costs (hedonic prices) for different levels of participation, but not different marginal cost functions. This implies a structural model which cannot be expected to yield information about the demand function.

To make this point clear, consider the conceptual supply and demand functions for an individual:

$$d_i = d(P_{d_i}, y_i, c_i)$$

$$P_{d_i} = \partial E_i/\partial d_i = g(d_i).$$

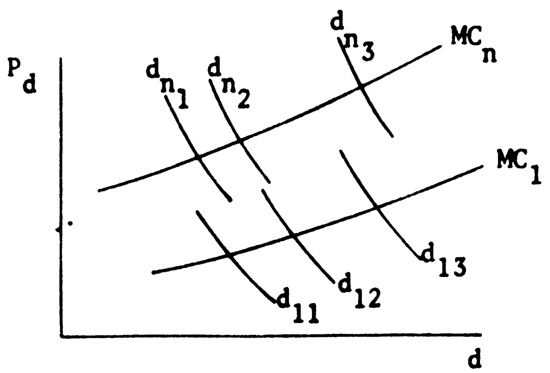
If all households face the same marginal cost function g(d), then variation in P_{d_i}, within the sample can come about only if individuals face different values for y_i or c_i and thus different demand curves.



Under these conditions, there is no hope of estimating the demand function d(•). The crucial point is that if different households are assumed to face the same expenditure function, they must face the same marginal cost function. Thus estimation of a single expenditure function on the entire sample cannot contribute to the estimation and identification of a demand function.[3]

Conversely, if households are assumed to face different marginal cost functions, then they must face different expenditure functions and the estimation of one expenditure function on the entire sample yields a mongrel function with no useful interpretation.

4. In fact, it appears to us that there is only one case in which the demand function can be estimated when there are non-constant marginal costs. Suppose we can partition the sample such that different subsets of the sample 1, ..., n face different marginal cost functions MC_1, ..., MC_n and thus different expenditure functions E_1, ..., E_n, but that there is enough variation in income or other demand shifters within each subset to provide more than one equilibrium point on each marginal cost function.



If there were sufficient observations within each subset, it would be possible to 1) estimate n separate expenditure functions independently, 2) calculate marginal cost for each household from the relevant expenditure function, and 3) use all days and marginal cost observations to estimate the simultaneous system. This approach would appear to avoid the identification problem, although the two step estimation process would still yield biased estimators.

5. The above points should help clarify why constant marginal cost is such a useful assumption. It eliminates the simultaneity in the problem, since marginal cost is no longer a function of days. Again it is important to note that variation in hedonic prices will be obtained only if households face different marginal cost (and expenditure) functions, and regression of expenditures on days for all observations will again yield a meaningless function. With constant marginal cost, however, it is possible to avoid the first step of the estimation process since simply $MC_i = E_i/d_i$. Thus if marginal cost is constant, having information on expenditures and participation is equivalent to having information on hedonic prices (marginal costs), and it implies that individuals have different expenditure functions.

We argue that the travel cost method is consistent with the assumptions necessary to apply the household production function model. Travel cost methodology requires the collection of data on expenditures incurred by different individuals traveling from different distances to the same site. Thus more days can be produced by a household at constant marginal cost, but the marginal cost of a day is different for households traveling from different distances.

If success is exogenous, we can consider it as a demand shifter. Then, the travel cost method can be used to value the effect on c of changes in the stock of wildlife, by measuring the change in the area under the demand curve for days which would be induced by this change in c. We are aware that this method of valuation is limited by the restrictions set out by Maler [1974]. However, we feel that these restrictions are not nearly as severe as those imposed on estimation procedures by the household production function methodology.

6. The evaluation of policy changes which affect stocks of wildlife in the context of the household production function approach requires 1) that it be possible to estimate demand functions and 2) that these demand functions accurately reflect the changes in benefits and adjustments in behavior elicited by changes in the wildlife stock. If catch or encounters per day is an endogenous variable, it cannot be treated simply as a quality shift variable in the demand for days, since conceptually it has its own demand and implicit (hedonic) price. The relationship between participation and success is complex—they are related through tastes, since the demand for days is a function of success rate and the demand for encounters (or other success variable) may be affected by participation rates. They also may be related technologically, if some inputs such as time contribute simultaneously to the production of both days and encounters (or catch). This technological interrelationship is joint production. Pollak and Wachter demonstrate that joint production in the household production function framework yields hedonic prices which are not independent of the quantities of the commodities (d and c) consumed.

We argue that given the complexity of the interrelations and given the estimation problems that arise when hedonic prices are functions of quantities, it is imperative that the joint production problem be avoided. This requires that the commodities' production functions be defined such that there are no common inputs and resulting expenditure functions are separable. This provides another important reason for focusing on encounter or catch per day rather than per season. If c were defined as encounters or catch per season, then the inputs which produce days would also contribute to the production of c. However, if c is encounters per day, then it is reasonable to eliminate time as an input, thus avoiding joint production.

III. The Bidding Game Approach to Measuring the Benefits of Wildlife

The bidding game approach is one of several direct questioning techniques which use individuals' responses to hypothetical questions to evaluate non-market goods. The approach has been most conscientiously developed in Randall, Ives and Eastman [1974], Brookshire, Ives and Schulze [1976] and Randall and Brookshire [1978].

The bidding game approach to valuing non-market goods is not a theoretical construct, but an approach designed to reveal preferences from responses to hypothetical situations. Rather than define the bidding game approach, we quote Randall and Brookshire [1978]:

> (a) The alternative levels of provision of the public good are described. . . . (b) A hypothetical market is created in substantial . . . detail. . . . (c) The respondent reacts to prices posed by an enumerator, indicating whether he would . . . pay the price or go without the good. The price is varied iteratively, until the price at which the respondent is indifferent is identified. [Randall and Brookshire, pp. 10-11].

The bidding game approach has been used in the evaluation of two different types of non-market goods. First, it has been used to measure the value of public goods in the form of environmental disamenities; an example of this use is the bidding game studies of air pollution in the Four Corners area of the Southwest. Second, the bidding game approach has been used to measure the value of a public input into the private production process; an example of this use is the Wyoming study of elk encounters. In this symposium, we are dealing with the bidding game approach only as it is used to measure the value of wildlife.

As is evidenced in Randall and Brookshire [1978], researchers have devoted considerable thought to the many problems associated with bidding games. In particular, the problems associated with intentional or unintentional bias and the potential differences between equivalent and compensating measures of welfare have been dealt with rather thoroughly. The following issues seem to us to be important when the bidding game approach is applied to the valuation of wildlife.

1. The bidding game approach is designed to measure the marginal value of a unit of success. For the case of the Wyoming elk study, the unit of success was chosen to be encounters of elk. From the published work to date, it is difficult to determine how this fits into a seasonal model of demand for the activity which provides encounters. It is not clear whether the marginal unit of success relates to success per day or annual success, and in either case, there seems to be no connection between choice of activity level by the individual (i.e., number of days per year) and the level of success variable. Without accounting for the interaction between days and the success variable it is not possible to trace out the effects of a change in the policy instrument on success. In fact, the use of equivalent and compensating surplus, rather than variation, suggests that there is nothing for the individual to adjust. The general implication of the bidding game approach is that individuals do not adjust days in response to changing success. This may be true of public goods such as air pollution, but does not seem to hold for public inputs such as stocks of wildlife.

2. The confusion over whether the marginal value of success variable refers to an annual or per trip figure causes econometric problems. This difficulty exists only if the bidding game approach is being used to value such dimensions as encounters of elk. The discussion here in terms of

encounters could be stated in terms of a more general success variable. It does not cause problems if the good being valued is a public good such as air quality.

Let us suppose that the bids represent consumer's surplus per trip, or annual consumer's surplus divided by annual trips. To determine the effect of a success variable, we might estimate the following relationship: bid = consumer's surplus/trips = f(encounters, other variables). To make good econometric sense out of such an equation, we must be able to specify a priori expectations on the sign of encounters. We know that increasing encounters increases consumer's surplus:

$$\partial(\text{consumer's surplus})/\partial \text{ encounters} > 0.$$

This is completely consistent with economic theory. However, economic theory does not tell us the sign of

$$\partial(\text{consumer's surplus/trip})/\partial \text{ encounters} = \frac{\partial \text{ bid}}{\partial \text{ encounters}} \gtrless 0.$$

This relationship can be positive or negative, depending on the functional form of the preference function, and not violate the more general condition:

$$\partial(\text{consumer's surplus})/\partial \text{ encounters} > 0.$$

Hence, when econometric results tell us that ∂ bid/∂ encounter > 0 at a statistically significant level, we are not really testing any hypothesis that is consistent with economic theory. Thus, the use of per trip bids makes it quite difficult to invoke economic theory for refutable hypotheses.

3. A second difficulty with the use of bidding games concerns the irrefutability of its answers. This difficulty is clearly recognized by Randall and Brookshire [1978], who observe that testing bidding game results as "refutable hypotheses is usually not possible (p. 18)." We do not want to dwell on this difficulty, but perhaps with some additional theoretical

structure, the predictive ability of the bidding game approach can be compared with other models. As an example of this type of comparison Sinden [1974] looked at two models: the travel cost model and a gaming approach. By ensuring that the gaming approach yielded results consistent with demand theory, Sinden was able to get predictions of use from the gaming approach. By comparing these predictions with predictions from the travel cost method, Sinden was able to provide a crude test of refutability to a gaming approach which was similar to the bidding game approach.

In conclusion, the bidding game approach appears the most promising of direct interview approaches or "contingent valuation mechanisms." There are clearly many cases where inferring values from revealed preferences or market data is impossible. In particular, the bidding game approach is appealing when it is used to value public goods; i.e., when it is used to compute equivalent and compensating surpluses. However, when the environmental amenity is a public input into a household production process (such as stocks of wildlife into the production of encounters), the consumer is able to adjust other inputs in response to changes in the public input. Bidding game proponents could greatly strengthen the case for their approach if it were demonstrated how the bids fit into the economic-econometric structure.

IV. Willingness to Buy and Sell Questions as Methods of Wildlife Valuation

The use of direct willingness to pay and willingness to sell questions is best exemplified by the work of Hammack and Brown [1974] and the 1975 National Survey of Hunting, Fishing, and Wildlife Recreation. This approach to measuring the value of wildlife implicitly assumes the theoretical structure that annual consumer's surplus depends on trips, a measure of annual or per trip success, and other relevant arguments of the demand function. The approach then asks people, more or less directly, for the amount of money they would give or receive for the right to use the resource as they experienced it.

The main difference between the direct approach and the more indirect approach of the bidding games is the tactics themselves. The bidding game is designed to give the respondent a "feel" for the problem, and has extensive feedbacks built into the questioning process. Hence, the direct approach is basically an underdeveloped form of the bidding game approach.

Briefly, the following difficulties seem to characterize the use of mail questionnaires for the direct question approach to measuring consumer's surplus.

1. In the use of willingness to buy and sell questions on mail questionnaires, there is substantial room for misunderstanding and no feedback mechanism to correct for misunderstanding when it occurs.

2. There is no way to check for any of the many biases that can slip into a direct approach to measuring preferences.

3. The theoretical structure for interaction between the stock of wildlife, the measure of success, and the number of annual trips is not clear in current applications. How does one model the demand for trips if the success per trip variable is not constant for each trip? What is the correct econometric specification of a willingness to pay function implied by utility maximization? What are the correct arguments of the utility function? These questions need to be answered satisfactorily for a reasonable application of the direct interview approach.

4. A problem which this approach shares with the bidding game approach is its irrefutability. There is no scientific method by which one can reject "wrong" results.

V. Summary

In this paper we have examined three approaches to estimating the benefits of wildlife recreation. Our examination has focused on the applicability of these approaches in a setting where public policy influences the stock of wildlife. We argue that a more complete theoretical framework will enhance the returns of future work in this area. The absence of a theoretical structure has obscured some of the difficulties encountered in using each method. Additionally, comparison of the methodologies is impossible without such a framework.

Footnotes

[1]Benefits per user can logically be viewed as a function of catch or encounters per day or per season. It is immaterial which enters the utility function. However, when we consider the effect of policy changes, we will argue that encounters or catch per day, rather than per season, is the relevant variable.

[2]This model could easily be reformulated in a dynamic optimal control framework, but for our purposes, we are interested only in the static structural relations. Also, there are a number of critical problems which are not addressed above, but which could be included in this framework. The effects of a policy decision on other variables (e.g., congestion) associated with the quality of the experience, are ignored. Likewise, no consideration is given to other types of policy decisions such as seasons, bag limits, license fees, etc.

[3]The assumptions made by Brown, Charbonneau and Hay in their conceptual model would permit identification of the demand function, if input prices were available. They assume identical expenditure functions for all individuals with differing input prices as arguments. The varying input prices yield different marginal cost curves. However, if varying input prices are not actually included in the estimation procedure, different marginal cost curves cannot be computed and the arguments within out paper hold. The travel cost method is an important case where varying input prices are available for use in the estimation process.

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