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ECONOMIC VALUE OF WILDLIFE

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Estimates of the economic value of wildlife are essential to the wise management of natural environments. Wildlife value estimates are especially needed for a complete accounting of foregone benefits or costs of land, water, and energy development projects that affect wildlife. For example, full-scale oil shale development in Colorado would destroy a substantial portion (as much as 80 percent) of the Piceance Basin mule deer herd. This loss would be felt not only by deer hunters but others who engage in non-consumptive forms of wildlife recreation such as wildlife photography, wildlife observation, etc. A complete environmental assessment of oil shale impacts should, therefore, include the value of deer lost. Unfortunately, the lack of accurate value estimates for deer have hampered the economic assessment of energy-related wildlife losses.

The accuracy of wildlife value estimates depends in part on the validity of the economic valuation method employed. Intuition suggests that the value of wildlife in wildlife recreation is less than the value of the total wildlife recreation experience particularly for consumptive forms of wildlife recreation such as hunting and to a certain extent for non-consumptive forms. If this relationship can be demonstrated, then valuation methods that equate the economic value of wildlife to the economic value of wildlife recreation, e. g. Horvath [6, 7], are inappropriate.

The major objectives of this paper are 1) to present a theoretical framework that demonstrates the value of wildlife in a wildlife recreation experience, primarily hunting and 2) to consider methods of implementing this framework in empirical studies concerned with measuring the economic value of wildlife.

RECREATION BEHAVIOR MODEL

Wildlife recreation such as hunting and fishing can be viewed as activities that an individual produces by combining inputs such as land, water, wildlife, equipment and time to get oneself to the area.[1] An individual produces recreation activities because they satisfy certain needs and desires. The model is based on the assumption that an individual maximizes the satisfaction derived from recreation activities subject to certain constraints. The household production function (p-f) approach to consumer behavior is employed. Contributors to the development of the p-f approach include Reid [14], Muth [12], and Michael and Becker [10]. In certain respects the p-f approach resembles the characteristics-goods approach to consumer behavior developed by Lancaster [8]. Applications of the p-f model have been made to transportation [4], leisure time [13], human capital [11], health care [5] and other areas. It has also been used in estimating the demand for a new resource development [3].

Model Formulation

The structure of the model is based on the assumption that a wildlife recreationist attempts to allocate his recreation budget E_R to the resources and time used to produce recreation activities so as to maximize recreation satisfaction. Letting $u_R(Y_1, \ldots, Y_m)$ denote the utility subfunction for recreation activities and $Y_j = Y_j(X_j, t_j)$ the production function for the jth recreation activity, maximization of recreation satisfaction can be represented mathematically as follows,

(1) max. $u_R(Y_1,\ldots,Y_m)$ utility subfunction for recreation subject to:

(2) $Y_j = Y_j(X_j, t_j)$ production functions

(3) $P' X = E_R$ expenditure constraint

(4) $\sum_i^{n_j} \sum_j^{m} t_{ij} = T_R$ time constraint

[1]In reality the individual does not have the freedom to vary input combinations at will. However, he implicitly chooses an input combination when he selects a specific recreation site (s). Other analysts have viewed recreation as providing joint products or a bundle of characteristics. [15, p. 19].

where

Y_j = jth recreation activity, $j = 1, \ldots, m$,

X_j = vector of inputs used to produce the jth recreation activity,

P = vector of input prices,

t_j = vector of times used to produce jth recreation activity,

E_R = expenditures on all recreation activities

T_R = time allocated to the production of recreation activities.

Restating (1) through (4) in Lagrangean form and differentiating with respect to Y_j and X_{ij} gives (partial) first-order conditions for recreation utility maximization,

$$(5) \quad \frac{\partial L_R}{\partial Y_j} = \frac{\partial u_R}{\partial Y_j} - \lambda_R \sum_{i=1}^{n_j} P_i \frac{dX_{ij}}{dY_j} + W \sum_{i=1}^{n_j} \frac{dt_{ij}}{dY_j} = 0$$

$j = 1, \ldots, m$

$$(6) \quad \frac{\partial L_R}{\partial X_{ij}} = \frac{\partial u_R}{\partial Y_j} \frac{\partial Y_j}{\partial X_{ij}} - \lambda_R P_i = 0 \qquad i = 1, \ldots, n_j$$

Equation (5) shows that the marginal utility of Y_j is proportional to the shadow price of Y_j. Taking the ratio of first-order conditions for Y_j and Y_j' and letting P_j denote the the price and MU_j the marginal utility of Y_j gives,

$$(7) \quad \frac{MU_j}{P_j} = \frac{MU_j'}{P_j'} \qquad j, j' = 1, \ldots, m; \quad j \neq j'$$

which states that in equilibrium the marginal utility per dollar's worth of each recreation activity must be the same for all recreation activities.

Equation (6) can be rewritten as,

$$(8) \quad MU_1 MP_{i1} = MU_2 MP_{i2} = \ldots. = MU_m MP_{im} \quad i = 1, \ldots, n_j$$

Condition (8) states that inputs should be combined in such a way that the utility value of the marginal physical product of an input is the same for all activities.

Demand functions for recreation activities are obtained by solving the first-order conditions for Y_j's to obtain,

$$(9) \quad Y_j = Y_j (P_1, \ldots, P_m, T_R, E_R).$$

Since the shadow price of Y_j is

$$(10) \quad P_j = \sum_i P_i \frac{dX_{ij}}{dY_j} + W \sum_i \frac{dt_{ij}}{dY_j},$$

(9) shows that the demand for recreation activities depends on input prices, marginal input-output coefficients and the amount of time and expenditure allocated to recreation. Marginal input-output coefficients, dX_{ij}/dy_j, indicate the amount of input required to produce another unit of recreation activity. Since the same input can be used to produce several recreation activities, the demand for an input is derived from the demands for all recreation activities that utilize that input.

RESOURCE VALUATION

The value of wildlife in wildlife recreation can now be established. Letting Y° denote the vector of utility maximizing recreation activities, the net market value of the jth recreation activity is

$$(11) \quad V_j = \sum_i P_i \frac{dX_{ij}}{dY_j} + W \sum_i \frac{dt_{ij}}{dY_j} \quad Y^{\circ}_j$$

Applying (11) to the specific recreation activity, such as hunting, shows that the net market value of hunting would be the sum of the costs of market inputs (such as equipment), the value of natural resources (including wildlife) and the value of time used to produce a hunting day times the number of days hunted. Letting i′ denote wildlife and j denote hunting, (11) can be restated as,

$$(12) \quad V_j = P_{i'} \frac{dX_{i'j}}{dY_j} + W \frac{dt_{i'j}}{dY_j} \quad Y^{\circ}_j +$$

$$\sum_{i \neq i'} P_i \frac{dX_{ij}}{dY_j} + W \sum_{i \neq i'} \frac{dt_{ij}}{dY_j} \quad Y^{\circ}_j$$

where the first right hand term is the value of wildlife and the second term is the value (or cost) of all non-wildlife inputs to hunting. Since the second term is positive, the value of hunting will exceed the value of wildlife to hunting. Consequently, estimates of the value of the entire wildlife recreation experience would overestimate the value of wildlife in that recreation experience. The degree of upward bias is expected to be substantial since transportation and equipment costs, which comprise the second term in (12), are substantial. This implies that accurate estimates of wildlife values cannot be obtained by determining the value wildlife recreationists place on their wildlife recreation activities.

WILDLIFE VALUATION METHODS

Several methods have been used to estimate wildlife values. Although normally applied to recreation sites, the travel cost method has been used to estimate the net economic value of Oregon steelhead fisheries [2]. A major drawback of applying the travel cost approach to wildlife resources is that the estimated consumer surplus includes the value of non-wildlife activities such as traveling to and from the site, camping and hiking, etc. The willingness-to-pay method has strong appeal if correctly applied. Mathews and Brown [9] used this approach to value salmon fisheries. They asked a sample of fishermen to state their willingness-to-pay for the right to fish for a year. The major weakness of their question is that the values obtained refer to the entire fishing activity and not just the fish. A somewhat innovative valuation method was developed by Brown and Hammack [1] to estimate the marginal value of waterfowl. Their value estimates were derived from the coefficients of a regression equation that was used to explain how much hunting costs would have to increase before waterfowl hunters would give up hunting. Unfortunately, their estimates pertain to only the number of animals (waterfowl) killed and are based on consumers' surplus instead of total value of the experience.

Two alternative methods based on the above theoretical model can be used to estimate the marginal value of wildlife to a hunting experience. The first method requires data on the total value of the hunting experience, V_j, and several explanatory variables including: hunter type, socio-economic status, number of days hunted, round trip mileage to hunting site, whether or not an animal(s) was harvested and the number of animals seen by the hunter. Regressing V_j on these explanatory variables provides estimates of the marginal value of killing an animal (coefficient of animals harvested) and the marginal value of seeing another animal (coefficient of number of animals seen). The reliability of these marginal value estimates depends on how well the total value function is specified and the accuracy of the data. Perhaps the biggest problem with this method is the difficulty of obtaining reliable estimates of the total value of the hunting experience. While estimates of consumer surplus are likely to be more reliable, the recreation model developed earlier implies that total value and not consumer surplus should be used as the dependent variable in regression equations for estimating marginal value.

The second method is based on the use of scenarios. Hunters are presented with scenarios which describe hunting conditions that are alike in all respects except the probabilities of encountering and killing an animal. The hunter is then asked his additional willingness to pay for scenarios involving higher probabilities. This method gives a range of marginal value of wildlife estimates for each hunter. These values can be analyzed by regression analysis to estimate the relative importance of selected variables on marginal wildlife values.

CONCLUDING REMARKS

Economic valuation of wildlife resources often proceeds without a conceptual framework to explain how wildlife values are formed. This procedural deficiency increases the risk of adopting a valuation method that gives misleading estimates of wildlife values. Adoption of a utility/production function model of recreation behavior reveals that the value of wildlife recreation is composed of the value of wildlife plus the value of other market and non-market inputs used to produce wildlife recreation. Using hunting as an example, two wildlife valuation methods based on this recreation behavior model are presented. Application of these methods is expected to yield more accurate estimates of the value of wildlife resources to hunting experiences.

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