Proceedings of the Iowa Academy of Science

Volume 75 | Annual Issue | Article 24

1968

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Abstract. There is an increasing demand for methods to determine wildlife values and costs in order to allow comparisons with marketed goods which compete with wildlife for funds and resources. For relatively small changes in the total wildlife supply, estimation of the value of this increment in supply should be compared with the associated costs for the increment in supply. Statewide average values and costs are usually meaningless in this type of comparison. It is advocated that better estimates of changes in wildlife abundance caused by government and private activities will provide much useful information even with the limited economic information available. Estimation of wildlife values is most easily handled in terms of the number and value of recreation days provided by wildlife. Market values for some types of wildlife recreation are becoming available for use in evaluating small changes in the wildlife supply. However, evaluation of large changes in the wildlife supply and estimation of values for entire state wildlife resources is a much more complex problem. The difference between estimating incremental wildlife values is explained and a promising method to estimate the total value of major segments of Iowa's wildlife is proposed.

COMPARISONS AT THE MARGIN

There is much controversy about the propriety of various methods to place values on wildlife and recreation. However, there are established economic techniques available to make cost and value comparisons on small-scale wildlife projects. Value refers to the intangible benefit received by recreationists from wildlife put in terms of dollars. Value and cost comparisons are necessary to determine when costs to produce or save units of wildlife become prohibitive relative to their value.

Americans seem willing to pay large sums to prevent extinction of a species, but the value to Americans of additional animals above the survival minimum becomes less and less. Average values do not adequately express this relationship between value and abundance.

Iowa wildlife is produced at a very low average cost to the state, but the costs of game management practices to produce additional wildlife would climb far above the over-all average. Averages do not adequately describe the relationship between costs and abundance.

One of the fundamental tools of economists is the use of marginal costs and marginal values. Marginal costs and marginal values are the cost and value of small additions to the existing supply. Only for incremental changes in wildlife numbers can meaningful wildlife cost and value comparisons be made. Comparisons at the margin requires comparing the added cost of supporting one additional animal against

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the value of the additional animal. In practice it is usually necessary to compare larger units of wildlife or to make comparisons in terms of recreation days.

Comparing total costs and values is often inappropriate. For example, comparing the value of Iowa's wildlife population against state costs to promote these populations would be meaningless. Most wildlife would be produced with no state support at all. The use of marginal values would permit an evaluation of state wildlife costs relative to their contribution to wildlife numbers. A $100 expense on pheasant habitat is not justified by a total value of say $2 million for Iowa's pheasants, but may be justified if it contributes $100 to the value of Iowa's pheasants.

In economic terms, the optimum species density and range for government agencies and individuals to aim for is the condition called economic efficiency. The basic requirements for economic efficiency are met when marginal costs equal marginal value, and the marginal costs of the methods used to reach this quantity are less than or equal to marginal costs of alternative methods.

The wildlife quantity where marginal values = marginal costs is considered optimum because up to this quantity the value of each additional animal exceeds the cost to produce the animal. A quantity any lower would forfeit part of the opportunity to increase total net value. A quantity any higher would have a value for each additional animal less than the added cost and total net value would decline.

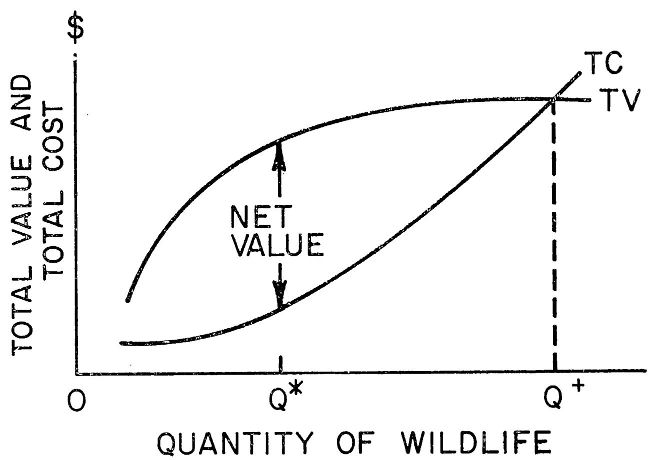

Figure 1. Relation of quantity of wildlife to total value and total cost.

An economically efficient condition is at Q+ in Figures 1 and 2. Net value (total value — total cost) is maximized at Q+ where marginal cost and marginal value are equal and is reduced to zero where total cost and total value are equal.

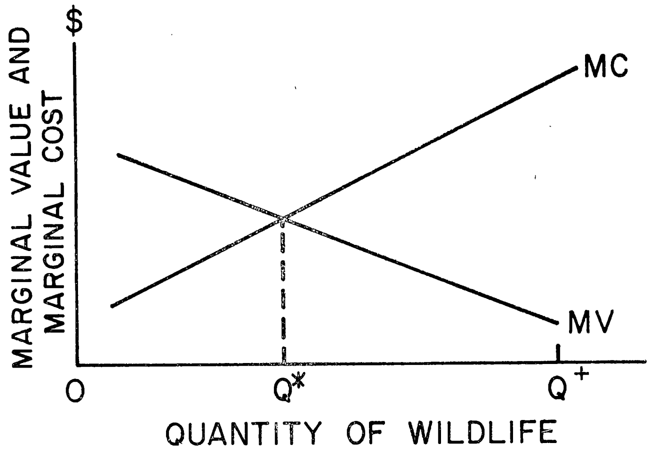

Figure 2. Relation of quantity of wildlife to marginal value and marginal cost.

Marginal costs for wildlife are seldom published in the literature probably because of one or more of the following reasons: (1) estimates are considered too specific for application by other researchers; (2) estimates are too difficult to obtain; (3) too little confidence is placed in the estimate; (4) the estimates are embarrassingly large. Surprisingly, more basic data and guidelines are available for marginal value estimates than for marginal costs.

Some indications of wildlife marginal values are given by actual hunting leases, shooting preserve prices and personal opinions of reasonable values. To derive estimates for marginal costs, however, requires both an estimate of project costs plus an estimate of added wildlife productivity. Cost estimates are relatively easy to make, but estimates of the amount of wildlife added to the existing supply are very difficult to make. For many wildlife value and cost comparisons the lack of estimates of added productivity is the most limiting factor.

The equation, marginal value = marginal cost, offers several applications even when some of the value and cost coefficients are not known. An equation to compare marginal values and marginal costs is essentially a comparison of values and costs for small wildlife projects with both project costs and values put on a per additional animal basis. A general form of marginal value = marginal cost is equation (1):

$$(1)\quad P = \frac{\sum_{j=1}^{n} (Cj\triangle xj)}{\triangle Q} + \frac{\triangle k}{w\triangle Q}$$

where P = value of each additional animal

$\Sigma Cj\triangle xj$ = summation of cost times quantity of added annual inputs

$\triangle k$ = additional capital investment
$\triangle Q$ = additional productivity
w = present value of a \$1 annuity for T years compounded annually at an interest rate i. This converts the capital investment into an annual capital cost.

Equation (1) can be used in its above form to determine a minimum value per animal to justify a game management project or practice. Equation (1) applies equally as well for value based on actual fees or for nonmonetary values. As stated before, the major limitation of equation (1) is a lack of estimates on added productivity ($\triangle Q$).

Equation (1) contains five unknowns. Estimates of expected costs are the easiest to obtain, leaving P and $\triangle Q$ unknown. Reasonable estimates of one or the other will often provide useful information.

Application

Following is an example using the criteria that marginal value equal marginal cost to estimate a minimum necessary value for each additional pheasant produced on wildlife habitat plots.

Let:

w = 20; discount factor for a perpetual life at i = 5%
$\triangle k$ = \$300; one acre of land/section
$\Sigma Cj \triangle xj$ = \$2; annual upkeep of \$2/acre
$\triangle Q$ = 1 pheasant harvested/section; similar to roadside production

$$P = \frac{\triangle Cj \triangle xj}{\triangle Q} + \frac{\triangle k}{w \triangle Q} = \frac{2}{1} + \frac{300}{20} = \$17/\text{additional pheasant}$$

The establishment of this particular area would be unjustified unless those paying the costs felt that each additional pheasant was worth \$17. However, other types of game produced would lower the charge against pheasants.

Wildlife Value of Land. To estimate the contribution of wildlife to the value of non-agricultural land, let:

w = 20; present value of a perpetual flow of \$1 annually at i = 5%.
$\triangle Q$ = 1 pheasant/acre; similar to roadside productivity
$\Sigma Cj \triangle xj$ = \$2/acre; additional unkeep and supervision
P = \$5/pheasant harvested; shooting preserve price
$\triangle k = w\,(P \triangle Q - \Sigma Cj \triangle xj) = 20\,(\$5.1 - \$2) = \$60/\text{acre}$

The above form of equation (1) is equivalent to saying that the contribution of pheasants to land value is equal to the present value of a perpetual flow of net annual value from pheasants. Additional increments to land values due to the value of waterfowl hunting and other recreation could be estimated similarly and summed as long as annual costs are calculated only from costs caused by including each type of activity.

Taber and Bolle (1962) have made an extensive national survey of increments in land values due to its lease value to hunters. They converted all information on landholders' wildlife income to a value per acre; presumably as in the above example. I gather that they chose to express values in units of acres rather than in units of wildlife partly to avoid the questions of whether actual values can be placed on wildlife and whether state-owned game can be legally marketed.

For comparing several different wildlife areas and wildlife species, I would recommend converting all values to units of recreation days. This measure is particularly suited for water areas. Recreation is the product that people actually demand when they go hunting, fishing, or bird-watching. This primary demand creates a derived demand for wildlife. Wildlife is actually an input to recreation—as are camping, equipment, shotguns and automobiles. In order to obtain wildlife inputs, a derived demand for land is created. Land areas acquire increments in value due to the wildlife they contain, which in turn is given a value due to its contribution as a recreation input. Wildlife is very seldom actually sold (even at shooting preserves), but it definitely has a value due to its contribution to the sale and welfare value of recreation.

Land, wildlife, and recreation all have an economic value. Converting direct values of recreation to the imputed value of wildlife, and vice-versa, is merely a problem of knowing the proper coefficients. The same is true for conversions between land values and wildlife values when dealing only with marginal wildlife values. This doesn't apply to estimating total wildlife values from total increments to land values caused by wildlife.

Minimum Added Productivity. The following example uses rather liberal pheasant values and deducts costs borne by the federal government to estimate how much added productivity is necessary to justify the costs of a windbreak improvement. Results such as these may be helpful in guiding research efforts toward the most promising projects.

Let:

$w = 7.7$; 5% discount rate over a ten-year life

$\Sigma Cj \triangle xj = 0$

$\triangle k = \$56$; net cost experience in Story County after A.C.P. assistance

$P = \$5$; shooting preserve price per pheasant

$$\triangle Q = \frac{\Sigma Cj \triangle xj}{P} + \frac{\triangle k}{wP} = \frac{\$56}{0 + (7.7)\ (\$5/\text{pheasant})} = 1.5 \text{ pheasants}$$

With the assumptions used, at least 1.5 additional pheasants must be produced by each windbreak improvement to bring the costs of each additional pheasant down to the marginal value of $5. This example attempts to calculate a technical coefficient from independent economic coefficients, which some may find objectionable. But like the other uses of the marginal criteria, this application narrows the range of the unknown. Instead of attempting to estimate △Q, it is only necessary to estimate whether △Q is less than or greater than 1.5.

Total Wildlife Values

The techniques suggested so far in this paper apply to relatively small changes to the total supply of wildlife. Only single estimates of marginal values and marginal costs were required. Total value estimates require a schedule of value estimates at many different wildlife quantities. Value estimates derived from actual market for certain types of recreation can often provide the necessary prices for marginal values. Non-economists will find the marginal comparison techniques suggested rather easy to apply if they can develop the necessary estimates for added productivity. Estimating total wildlife resource values will require much more complicated techniques which are still to be perfected.

Economists have derived methods for comparisons of marginal values, but they have not been able to devise any well accepted method to evaluate total wildlife values.

The most promising approach, though, seems to be the construction of a schedule of wildlife quantities demanded at different costs to the recreationists. This is a demand schedule or demand curve. The most obvious means to construct such a schedule is to simply ask people what they would pay for various quantities of recreation derived from wildlife. But, because of the lack of knowledge about the relationship between what people say they would pay and what they actually will pay, an objective appraisal of the evaluation results is impossible, even if the results are extremely accurate.

Clawson and Knetsch (1966) have promoted an alternative demand schedule technique based on transportation expenditure. A schedule of number of visits to a site from each of several travel cost zones is constructed. The falloff in visits with increased travel costs is then used to predict the reduction in attendance from each travel distance zone with increased entrance fees. The total value of a recreation site is then calculated by summing the revenue which could be obtained for each trip if the recreationists were forced to pay the estimated value of each additional trip. With certain modifications the technique could be applied to some Iowa wildlife evaluations. The travel distances can be estimated from returns of the many hunter postcard surveys. Total values can be estimated for individual counties or the entire state. The major limitation is a definite downward bias on values by excluding time costs in travelling to hunting sites. This can be easily adjusted for, though, if the user wishes to make an estimate on the magnitude of the value of time to hunters while travelling.

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