wildlife valuation problem: A critical review of economic approaches

by William A. Langford and Donald J. Cocheba

Occasional Paper Number 37

Canadian Wildlife Service

The wildlife valuation problem: A critical review of economic approaches

by William A. Langford[1] and Donald J. Cocheba[2]

Canadian Wildlife Service
Occasional Paper Number 37

[1]Present address:
Economic – Financial Services,
Department of Energy and Natural Resources,
Edmonton, Alberta

[2]Present address:
School of Business and Economics,
Central Washington University,
Ellensburg, Wash. 98926

Fisheries and Environment Canada
Pêches et Environnement Canada

Issued under the authority of the
Minister of Fisheries and the Environment

Canadian Wildlife Service

Catalogue No. CW69-1/37
ISBN-0-662-01546-0
ISSN-0576-6370

Contents

List of figures

Acknowledgements

The authors thank E. A. Driver, CWS, for commenting on an earlier draft and Lynne Sargeant, Cathy Wheten and Caroline Bischoff for their expert typing and for their patience.

Perspective

The Canadian Wildlife Service (CWS) originally expressed interest in the socio-economic aspect of wildlife resource management at an interdisciplinary gathering at the University of Saskatchewan in September 1970. Research done on contract by the Institute of Northern Studies suggested that new techniques were required for the quantitative valuation of the waterfowl resource. The CWS, therefore, asked the Department of Agricultural Economics, University of Saskatchewan to study and extend the theory of quantitative valuation of wildlife. This paper documents the research done by the department under a CWS contract.

Abstract

We identify and discuss the major sources of wildlife value and specify three requirements which must be met by any wildlife valuation technique and employ them to assess the usefulness of existing valuation methods. The HCK or travel-cost method, being essentially a site valuation technique, is judged to have limited potential for wildlife valuation. The DCS (direct consumer's surplus) approach is seen to offer greater potential. Although the DCS method is not without problems, it has the major advantage of allowing the researcher to isolate the value of wildlife from that of other inputs. In addition, the technique is extremely versatile and can be applied to a wide range of valuation problems.

A particular DCS approach used by Hammack and Brown is modified and extended to include a previously neglected aspect of wildlife value — the collective-good aspect. An approach for valuing wildlife in uses other than hunting is analyzed; a critical aspect of data collection discussed; and finally, some general recommendations on valuing waterfowl are made.

Résumé

Nous déterminons et analysons les principaux éléments qui font la valeur de la faune. Nous formulons trois exigences que doit respecter toute méthode d'évaluation de la faune et nous les utilisons pour évaluer l'utilité des méthodes existantes. On considère que la méthode HCK fondée sur le rapport déplacement/coût, qui constitue essentiellement une technique d'évaluation de l'emplacement, n'offre que des possibilités limitées sur le plan de l'évaluation de la faune. La méthode DCS dite du surplus direct au consommateur semble supérieure à la précédente. Bien qu'elle ne soit pas dépourvue de défauts, elle a le grand avantage de permettre d'isoler la valeur de la faune de celle des autres facteurs. De plus, elle est très souple et peut s'appliquer à une vaste gamme de problèmes d'évaluation.

Nous reprenons une forme particulière de la méthode du surplus direct au consommateur, celle qu'ont employée Hammack et Brown, nous la modifions et l'étendons à un aspect auparavant négligé de la valeur de la faune: celui de bien collectif. Nous analysons une forme d'évaluation de la faune en-dehors du domaine de la chasse. Nous étudions un aspect important de la collecte des données. Enfin, nous formulons des recommandations générales concernant l'évaluation des oiseaux aquatiques.

Introduction

The basic issues which pervade attempts to measure the value of wildlife were outlined by Crutchfield (1962) 15 years ago. Since then, considerable progress has been made in both problem conceptualization and quantitative valuation. However, a complete conceptualization of the wildlife valuation problem has not yet been formulated.

This report assesses the state of the art of wildlife valuation and presents some ideas which should lead to a better understanding of this complex issue. We begin by identifying the major sources of wildlife value and specifying three requirements which should be met by all valuation methods. This is followed by a critical analysis of valuation methods developed and used by others. Next, we present a modification of an existing hunting model and analyze an approach to valuing wildlife in uses other than hunting. A critically important aspect of data collection is considered and the use of recommended approaches to valuing waterfowl discussed before the final summary and conclusions section.

1. The orientation of this report

This report assumes that the goal of wildlife valuation is to provide information which can be used in making wildlife management decisions. The most basic wildlife management problem, in our opinion, is to determine optimum population levels of wildlife species. Resolution of this basic problem and related decisions (including decisions concerning the acquisition and management of wildlife habitat) require information on the value of an animal in the population or stock (Davis and Seneca 1971).

2. The fundamental problem

Because of law and tradition, the activities which are made possible by wildlife are available on a basis which does not reveal how much these activities are worth to us (Crutchfield 1962): in other words, they are not priced in a market. Without market transaction data, traditional market models are not directly applicable to wildlife valuation problems and it is necessary either to make significant modifications to the existing models or to develop new ones.

3. Measuring value

The existence of wildlife permits people to participate in certain activities which produce varying amounts of satisfaction or utility. The satisfaction or utility received by an individual represents a primary benefit. Whether we are measuring value, primary benefits or the amount of satisfaction generated by participation in a particular activity, we need a "cardinal index of satisfaction" to serve as a measure of value.

Of course, we are assuming that wild birds and animals are to be managed for the benefit of human beings. But this does not prevent people from incorporating what they conceive to be the preferences of the wildlife itself, or what they think wildlife "deserves", into their own (human) preferences.

According to the consumer's surplus concept, money can be an acceptable cardinal index of satisfaction or utility. Although it is by no means a perfect unit of measure, some of the more persistent arguments against using it for this purpose are indefensible. For example, there are some who argue that because of the aesthetic aspects of wildlife-based experiences, monetary valuation is not acceptable. Yet individuals make monetary assessments of the value of automobiles, houses, night club entertainment and works of art — all of which possess some aesthetic appeal. The amount of aesthetic appeal of a commodity has little to do with whether or not money is an acceptable measure of its value to a consumer. For further comments on this and

other misunderstandings see Davis (1963), Davis and Seneca (1971) and Sinden (1967). The fact remains that money *is* the medium of exchange in our society and it should therefore come as no surprise that economists use it as a measure of value. Only the naïve can believe that using money to measure value is synonymous with a materialistic ethic. Thus, since no one has found a workable alternative, this monograph will accept the consumer's surplus concept, with its assertion that money *can* be a satisfactory cardinal index of satisfaction or utility, as the theoretical framework within which to develop methods for measuring the value of wildlife.

We will not dwell on the technical aspects of consumer's surplus theory. This topic has been dealt with comprehensively by Currie *et al.* (1971), Willig (1976) and others. What the literature makes clear is that while consumer's surplus can be measured in a number of ways, only two are appropriate for measuring the value of wildlife, and only one of these is usually relevant for any specific situation (Hammack and Brown 1974).

One method measures the willingness to sell, or the minimum amount an individual would have to be paid to give up the consumption of a commodity and at the same time leave him as well off as he was before giving up that commodity. Willingness to sell is useful for the situation where resources are presently used to generate wildlife-based experiences but a possible transfer to alternative and incompatible uses is being considered: for example, if a federal wildlife refuge is considered for conversion to an asphalt-covered parking lot, this first measure (the Hicksian equivalent variation) is the correct one to use.

A second method measures willingness to pay and applies to situations in which a transfer of resources from some other purpose to the production of wildlife-based experiences is being considered. Thus if farm land is to be converted to a nesting area for waterfowl, this second measure (Hicksian compensating variation) is the proper measure to use. For brevity, our discussion will be framed in terms of willingness to pay; translation into willingness to sell will be left to the reader. One last point: willingness to pay (and, for that matter, all measures of consumer's surplus) is a measure of benefits in excess of costs, or net benefit. Throughout this report "net benefits", "benefits" and "value" will be used interchangeably.

Sources of wildlife value

Wildlife is used in a variety of ways, yet most wildlife valuation studies deal exclusively with hunting. In fact, we know of no published attempt to quantify the value of wildlife in nonhunting uses. Since we intend to deal with all the relevant aspects of wildlife valuation, it is necessary to identify and define all significant sources of wildlife value.

Although this report will focus on the valuation of wildlife, that is, wild animals and birds, most of the topics discussed in this monograph apply (with minor modifications) to the valuation of fish as well.

1. Recreational hunting

For the purposes of this report, hunting is the act of pursuing and attempting to kill wildlife. If the primary reason for doing so is recreational enjoyment, this activity is considered recreational hunting.

2. Nonhunting activities

Wildlife is of central importance to certain nonhunting recreational activities. Examples include outings, the primary purpose of which is to study, to observe or to photograph wildlife: these activities will be referred to as *wildlife-based activities*. In other cases, rather than being the central focus of an activity, wildlife may be one of a number of inputs which together produce the recreational activity. Examples include hiking, camping, canoeing, picnicking and driving for pleasure: these activities will be referred to as *wildlife-related activities*. A third group is composed of activities which are not outings in the same sense as implied by the first two categories: watching wildlife at backyard feeding stations or observing flights of migrating waterfowl from one's own back yard are examples of this type of activity. All of those wildlife-based or related activities which are pursued in the immediate vicinity of a participant's permanent residence are referred to as *endemic wildlife activities*. A fourth category will be *recording-based wildlife activities*. This type of activity includes watching wildlife films on television or at a movie theatre, listening to recordings of bird songs and activities such as wildlife painting and carving. The use of wildlife in recording-based wildlife activities may be indirect in comparison with the first three categories, but it certainly should not be ignored.

Obviously, other nonhunting activities could be defined, but for the purposes of this report, the above selection is adequate.

3. Existence value

Each of the wildlife benefits discussed so far is based on sensory perception activities. That is, people enjoy hunting, wildlife-based, wildlife-related, endemic and recording-based wildlife activities through their senses of sight, hearing, taste and touch. However, it is possible for individuals to derive satisfaction simply from knowing that wild birds and animals exist. For example, an individual at home in his or her living room making no sensory contact with wild geese may derive real satisfaction from just contemplating the existence of these birds. People who contribute their time and money for the preservation of a wildlife species such as the blue whale (even though they are not ever likely to make sensory contact with these animals) exhibit behaviour which suggests this possibility. This behaviour may also be due to interest in recording-based activities or option demand. [See Krutilla (1967) and Krutilla and Fisher (1975) on option values.] Such contemplation, attributable to the existence of a wildlife species but occurring in the absence of sensory contact with that species, is defined as a *contemplative wildlife activity*. Thus defined, this activity

is mutually exclusive with previously defined wildlife activity categories.

All contemplation which occurs in conjunction with sensory contact activities is considered an integral part of those activities. All other contemplation attributed to the existence of a wildlife species is assigned to the contemplative wildlife activity category.

4. Option value

Another way of categorizing the sources of wildlife value discussed in sections 1–3 is to call them use values, meaning values due to demand for the use of a wildlife species in some current period activity. Option value itself is not a use value, but an additional source of benefits which deserves explicit recognition.

Option demand and option value exist when an individual places value on having the option, for himself or others, to participate in an activity in the future. It can exist separately from consumer's surplus, firstly, when there is uncertainty as to future demand for (and/or supply of) a wildlife species and individuals are adverse to taking risks; secondly, when re-establishing or expanding a curtailed supply would be very costly in the short run or technically impossible (i.e. extinction of a species); and thirdly, when there is no practical way for the resource owner to be paid for providing the option because exclusion is not possible. By "exclusion" we mean the ability to identify everyone who would benefit from assured availability of the good or service in question and to exclude them for failure to pay for their option value. The inability to exclude those who do not pay for the option of future consumption establishes the relevance of option value for public policy. Note that the first two conditions are necessary but not sufficient for the existence of option value. For detailed comments on option value see Cicchetti and Freeman's (1971) refinement of Weisbrod's (1964) and Lindsay's (1966) insights; also see Long (1967), Byerlee (1971) and Krutilla and Fisher (1975).

Cicchetti and Freeman (1971) refer to the second condition as irreversibility of supply. As specified, this irreversibility is a matter of degree (Krutilla and Fisher 1975). If the number of a given species could be increased instantaneously without an increase in the cost of production, an individual would have no reason to be willing to pay for an option because he would already have the option. However, this type of instantaneous increase in wildlife populations is simply not possible. (We ignore changes in population levels due to changes in legal constraints.) At the other extreme is extinction: since, by definition, it is not possible to reverse extinction, any options associated with extinct species have been lost and option value is irrelevant. With this exception, then, irreversibility is a matter of time and relative cost.

How much it will cost to increase the population of a wildlife species by a given amount depends upon the number of animals in existence at the time the increase is to take place, the technical conditions of production (i.e., the relevant production function) and the opportunity cost of required resources. Consequently there are a variety of ways in which "irreversibility of supply" can occur. Sometimes the length of time needed for an increase in wildlife populations — usually several years — will make it costly or impossible to expand the supply in the short run. Or, the availability of suitable habitat could be the limiting factor. In any case there is little doubt that the second condition will be met.

The first condition, uncertainty in demand, occurs when the probability of demanding a good or service at some future time is greater than zero but less than one. Uncertainty in supply occurs when the probability of future availability of a given good or service is greater than zero but less than one. Cicchetti and Freeman (1971) demonstrate that: "At probabilities of close to one, option value is both small and a small percentage of expected consumer surplus. But at the middle and low probabilities, option value is large relative to expected consumer surplus". They go on to conclude that "where there is a large number of low probability demanders, omission of the option value benefit and a consideration of only the consumer surplus of the expected number of users would result in a significant understatement of benefits". Even in the case of the certain demander, they argue, there will be option value when there is uncertainty in supply.

Knowing the degree of demand or supply uncertainty is of critical importance in any attempt to measure wildlife benefits. Most wildlife management decisions will not be irreversible, such as the decision to dam and flood a canyon. In this latter case, the question is whether or not the amenities associated with the canyon in its natural state should be destroyed forever, so that the canyon can be used for other purposes. A parallel and rather extreme example is whether or not a wildlife species should be forced into extinction by destruction of its habitat. Most wildlife management decisions involve increases or decreases in wildlife populations rather than outright extinction.

But because future participation in a particular wildlife-associated activity may require it, an effective option demand for maintaining the population of a given species well above a level which threatens extinction may exist. Thus, even when populations are large enough to permit legal hunting and the value of an incremental change in population is considered, option value should not be ignored.

5. Sources of wildlife value — a summary

Figure 1 presents a summary of the sources of value which have been identified and discussed to this point. It is divided into five levels: from the bottom, they are activity, use, demand, value and time dimension.

As this report is limited to the consideration of the value of wildlife as an input into private consumption activities, the value of wildlife as breeding stock is being excluded from consideration. However, it should be noted that the value of wildlife as a capital good depends upon its value as a producer of hunting or nonhunting benefits.

There are at least four additional sources of consumer benefits which deserve recognition. In certain cases *meat hunting* may be important enough to warrant consideration. By meat hunting, we mean the act of attempting to kill wildlife primarily for the purpose of supplying one's family, or others, with meat — excluding commercial hunting, fishing and guiding. Because it entails using wildlife in a private consumption process, meat hunting could be included with the activities listed in Figure 1.

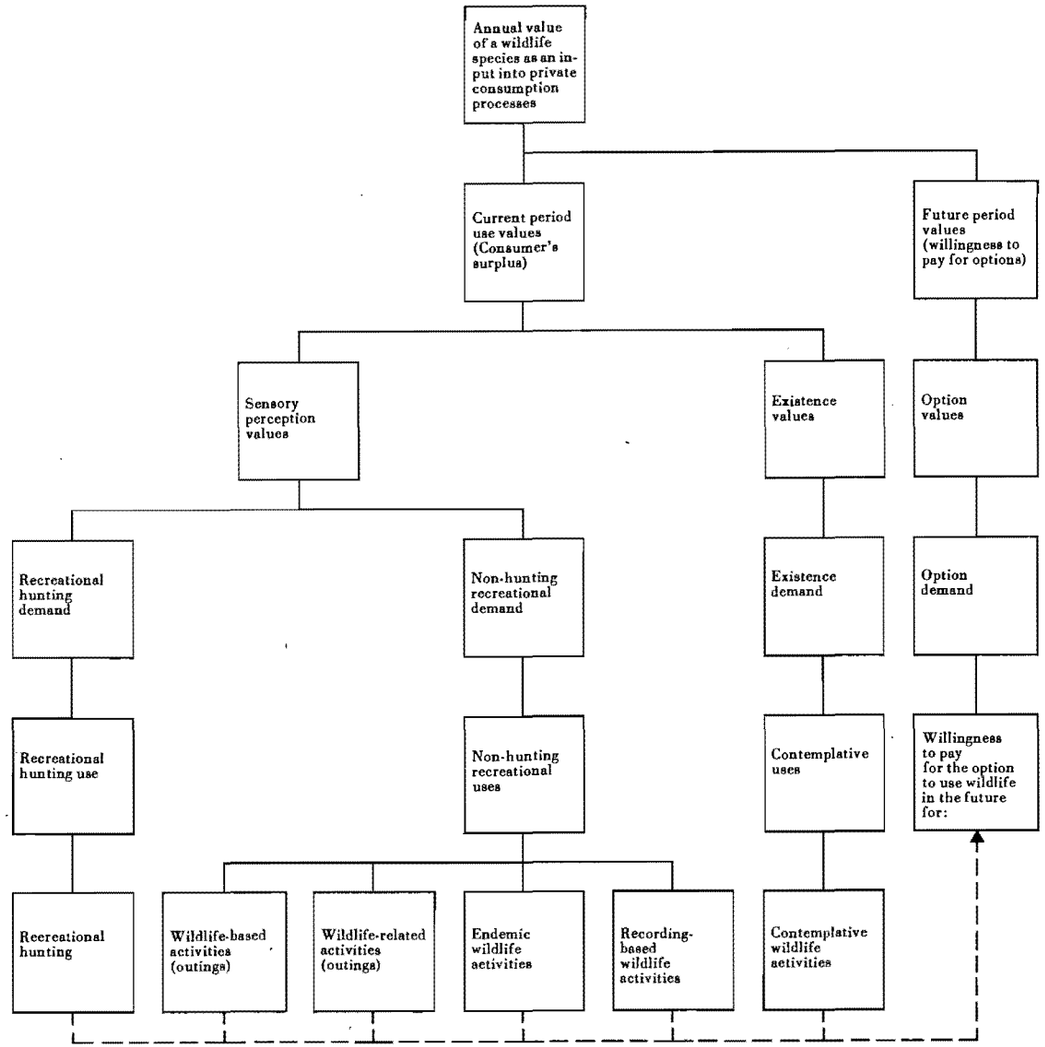
Commercial hunting and fishing are obvious sources of wildlife benefits. This source of benefits is not being considered simply because the focus of this report is on extra-market activities. Valuing commercial products is a separate topic.

The values of wildlife as an input into research processes and as a pool of genetic material are also potential sources of wildlife benefits. These uses are considered public consumption rather than private consumption processes; therefore, they are not given detailed attention.

Although we have narrowed the focus of our attention to the sources of value summarized in Figure 1, the task of valuing wildlife is still an unwieldy one. By definition, each of the activity categories (except recreational hunting) includes

Figure 1
Sources of wildlife value — a summary

Figure 1



a number of different activities: each of these can be viewed as having a number of dimensions which affect the value of wildlife. Clawson (1962) lists five phases of a recreational experience: (1) the planning and anticipation phase, (2) the travel to the recreation site, (3) the on-site experience, (4) the return trip and (5) the recollection of the experience. Any wildlife valuation approach must recognize the complexities of such recreational experiences.

Value estimate requirements

Identifying and defining the significant sources of wildlife value are important steps toward resolving the wildlife valuation problem. However, it is equally important to know what criteria an empirical estimate of wildlife value must meet in order to be useful to wildlife managers.

1. Valuing a wildlife component

Since recognizable products or activities can be defined and the users identified, valuation of wildlife is theoretically possible. But it is important to recognize that the products are the activities which wildlife *help* to produce, rather than the animals themselves (Crutchfield 1962). Herein lies the basic dilemma in attempting to value wildlife. For management decisions, an estimate of the value of the animals, as such, is required. However, the individuals who provide the necessary data can be expected to think in terms of the value of activities rather than the value of the animals which help to produce the activities. Conceptually and empirically, the problem becomes one of separating the value of wildlife from the value of the other inputs which are used to produce wildlife recreation activities.

As an example, let us consider a situation where the objective is to estimate the value of waterfowl in the hunting activity. A recreation day of hunting is produced by combining a number of inputs: waterfowl, transportation, the natural surroundings, decoys, a gun, shells, etc. Given the fact that individuals spend hundreds of dollars on equipment, transportation and so on and invest significant amounts of time in travel and the hunting activity itself, it is reasonable to expect that a hunter will have some idea of what a day of hunting is worth to him (see also Davis and Seneca 1971). However, when asked to estimate the dollar value of wildlife (only) to his

recreational activity, the hunter cannot be expected to have mentally separated the value of wildlife from the rest of the inputs. Still, it is the value of wildlife only that is required for decision-making purposes, and hunters are the individuals who must be relied upon to provide this information. A way must be found to isolate the value of wildlife from the other sources of value.

2. Total value vs marginal value

The consumer's surplus concept may be used as a guide to measuring either *total* net benefits or *marginal* net benefits; and although estimates of total value or total net benefits may affect public opinion and influence some decision makers, they are rarely the correct reference point for making rational wildlife management decisions. On this issue Hammack and Brown (1974) argue that: "Such a figure (i.e. total value) would be of interest if all of the birds (a given wildlife species) in the area were possibly to be destroyed by the actions of man, but it is far more likely that man's actions will cause incremental or decremental changes". Except in cases where the extinction of a species or the introduction of a new (exotic) species is at issue (and even these could be viewed as marginal changes), estimates of total value are useful for rational decision making only if they facilitate the derivation of marginal-value estimates. Thus, what is required for making wildlife management decisions are estimates of marginal value (marginal net benefits).

3. Aggregating wildlife values

When a person consumes a particular commodity so that no one else can consume that same unit of commodity, it is conventionally considered to be a pure private good. Given a fixed quantity of a particular private good, more units of that good for one individual means fewer for others (and vice versa). At the opposite end of the spectrum are the pure collective goods, or those which can be consumed by one individual without diminishing the quantity available to others. One of the standard examples of a public good is national defence. Everyone consumes the same amount of national defence, and although people added to the population of the area will also consume national defence, their consumption will not necessarily reduce the amount of defence available to others.

The use of wildlife as an input into consumptive processes may (as when a person shoots and kills an animal) preclude others from deriving benefits from that same animal. Consequently, there may be a private-good dimension to a wildlife valuation problem. But other uses, such as a person watching a flock of geese in flight, do not prevent others from using the same creatures at the same time or in the future. Consequently, wildlife valuation may have both a private-good and a collective-good dimension.

Relatively small collective-good values can result in very large aggregate values. This is simply the result (in some cases) of adding up these small values over a large number of individual demanders. Conversely, the killing of an animal may generate relatively high values per occurrence but, since this value can only be realized once, the resultant aggregate value may be small. The relative magnitude of private- and collective-good values is a question of considerable importance.

Returning now to the sources of wildlife value summarized in Figure 1, some useful generalizations can be made. First, existence and option demands are clearly collective goods. Second, for most valuation purposes, and if there are no congestion problems, recreational uses of wildlife other than hunting can justifiably be viewed as collective goods. That is, private-good benefits of nonhunting recreation are likely to be so insignificant compared to collective-good benefits that they can legitimately be ignored. When nonhunting wildlife recreation uses do disrupt the life cycle of certain animals in such a way as to cause deaths (or relative declines in population) and the impact is too significant to be ignored, the problem of aggregating both sets of benefits and placing a value on the animals involved is similar to that faced when dealing with recreational hunting (see Rieck 1975). Third recreational hunting benefits involve both a private- and a collective-good dimension. Killing an animal — whether it is bagged or not — is a private good. But assuming that the animal is not injured, getting a shot at and sighting the sought-after game are both collective-good dimensions of hunting. Finally, it follows that when there is recreational hunting demand for a wildlife species along with any other type of demand, any change in the population level of that species will have both a private-good and a collective-good value.

The procedure for aggregating demand curves for the two polar cases (private vs collective good) is well defined. All wildlife valuation problems will involve a collective-good aspect. For example, constraints and sanctions controlling how Whooping Cranes can be used by the public probably justify considering the benefits these birds provide as collective goods. On the other hand, no wildlife valuation problem will be exclusively concerned with private-good elements. In fact, hunting is the only activity which involves a significant private-good dimension, and it also includes a collective-good dimension. Because most wildlife valuation problems do not fit neatly into one category, the ability to aggregate values depends on the ability to distinguish private-good benefits from collective-good benefits.

4. Three requirements — a summary

If the goal of wildlife valuation is to provide information for making wildlife management decisions, the three basic requirements are to isolate the value of the wildlife from the value of other inputs, to make sure that value estimates are estimates of marginal net benefits and to separate private-good benefits from collective-good benefits.

Critical analysis of valuation approaches

A variety of approaches have been used in attempts to assign monetary values to recreational activities. The emphasis here is on those that are potentially useful for wildlife valuation, with a few comments on other approaches.

1. Indefensible approaches

Crutchfield (1962), Knetsch and Davis (1966), Carey (1965) and Sinden (1967) have rejected a number of early attempts to value recreational activities as being conceptually unsound. One of these, the expenditure method, is reviewed here only because it is still being used by a few researchers.

2. Gross expenditures method

More than 15 years ago Crutchfield (1962) rejected the gross expenditures method as an approach to valuing a sport fishery. Other researchers have supported his position (Carey 1965, Clawson 1962, Knetsch and Davis 1966, Sinden 1967 and Stevens 1966). Even though the argument against its use is devastating, this method is still used by some researchers (Horvath 1974). Therefore, an explanation of its basic defect is in order.

The gross expenditures method attempts to use the amount of money spent on a recreational experience to measure its value. Expenditure categories usually include travel expenses, equipment costs and expenses incurred while at the recreation site (Knetsch and Davis 1966). Travel expenses often include the cost of meals and lodging as well as transportation. Using food costs as an example, Carey (1965) effectively describes the problem:

> The food consumed may not be a 'means to an end' but rather an 'end' in itself. The tourist may have saved vacation money to dine in nice restaurants; he orders steak not merely to live but because he enjoys it. His food expenditures are not measuring the value of a visit to a recreation site; rather, they are measuring his subjective valuation of the eating experience. Using expenditure data to derive a value for the recreation benefit includes expenditures that would have been incurred even if the visitor had stayed home.

Gross expenditure figures would not measure the net benefits of a recreational experience even if they were adjusted for the deficiency described above. They do not measure the loss in value which would be incurred if this recreational opportunity were eliminated, nor do they estimate the gain in value which would be realized from the creation of a new recreational opportunity: as we argued earlier, what is required is an estimate of net value.

3. Acceptable valuation methods

Of the techniques which have been used in attempts to value wildlife, two deserve serious consideration. One is the Hotelling–Clawson–Knetsch (HCK) or travel cost approach. The other is what will be referred to as the Direct Consumer's Surplus (DCS) approach. The potential of these approaches as techniques for valuing wildlife will be evaluated from the standpoint of their ability to isolate the value of wildlife from the value of other inputs, to accommodate the estimation of marginal values and to facilitate the separation of collective-good benefits from private-good benefits.

4. The HCK method

The HCK method is the approach that is most often used by recreation resource economists: in fact, it has become a conventional method of analysis. It evolved from Hotelling's imaginative idea into a relatively sophisticated and promising technique. Although it is based on a number of often ignored assumptions and is obviously capable of further refinement, some researchers would probably argue that the HCK method is already capable of producing acceptable estimates (see Krutilla and Fisher 1975, and Burt and Brewer 1971).

Since the details of the technique have been discussed by others, they need not be repeated here (Cesario 1976, Clawson 1959, Knetsch 1963, Clawson and Knetsch 1966; for an excellent and brief critique, see Hammack and Brown 1974). However, it is important to emphasize that the HCK method is unequivocally a site valuation technique. It estimates the total net value of a flow of goods and services produced by a given site or set of resources (specific parks or wilderness areas) and attributes this value to the site. This is accomplished by using transportation and other travel cost data to estimate a demand function for the site. An integral of this demand function is then taken as an estimate of total consumer's surplus (total net value) of the site.

In this way, early HCK studies (Clawson 1962, Clawson and Knetsch 1966) estimated the total net value of goods or services produced by a set of resources *at* a given site *in a given use*. It is a small step from here to argue that if the site were to be used in a different way, the net benefits (as estimated for its current use) would be lost. This loss in value must then be compared to the value resulting from the proposed new use. However, it has been pointed out by Knetsch (1963), Scott (1965) and others that the availability of substitute sites must be incorporated into the demand function to legitimize this type of procedure; and, consequently, several investigators have made an effort to do this in their models (Gum and Martin 1975). Such a full and complete specification of each individual's demand function for a particular site would enable a decision maker to calculate the net benefits lost if the site were eliminated. But this is a great deal to ask without substantially increasing the scope and expense of the usual travel cost study.

5. The HCK as a method for valuing wildlife

As commonly used the HCK method values activities (e.g. visits or recreation days) produced at a site by the combination of resources in existence at that site (Brown *et al.* 1973, Gum and Martin 1975, Stevens 1966). The value estimates of the activities or visits are then used to impute a value to the site in question or, more precisely, to the combination of resources in existence at the site. This technique values an experience (the visit or a recreation day) and on the basis of this value attributes a value to the site. Even accepting all the assumptions required by the technique, one is still left with the conclusion that the value of the experience is produced by the set of resources at the site and there is no justification for attributing the entire value to one specific resource, e.g. wildlife, existing at the site.

Any potential that the HCK approach has for the valuation of wildlife is best expressed by the introduction of a quality variable into the travel cost model. By including a quality variable in the HCK model several authors have explicitly recognized the contribution to the value of the experience (i.e. visit) made by the existence or abundance of wildlife. For the most part, the authors in question seem to view this modification as a way of improving the demand estimates for visits to the site. The quality variable most frequently used for hunting or fishing activities is an estimate of expected success per unit effort. Often a lagged success variable is used as a proxy for expected success in the area under consideration (Capel and Pandey 1973, Stevens 1966, Brown *et al.* 1973). These studies are for the most part aimed at valuing the hunting activity and

not the animals (a distinction often not made). Although this type of model does not isolate the value of wildlife from other inputs, it may be possible to use such a model to estimate relative values of several wildlife species (e.g. moose vs deer). This approach may be useful if the difference in estimated value of a day of deer hunting of a specified quality and a day of moose hunting of the same quality can be attributed to the difference in species. This would require several basic assumptions and statistical models that are well specified and fairly powerful. If a difference could be established, however, and if there is a transformation function between the two species, it may be possible to improve the allocation of habitat between the two relevant species.

Stevens (1966) uses a quality variable to enrich the travel cost model but carries the analysis a step further by examining what he refers to as the "success elasticity". By estimating the effect of a change in the success ratio on the number of visits demanded, he predicts the loss in visits or recreation days at the site due to a reduction in the ratio of success per unit effort. Since a relationship between success per unit effort and stock size can (at least in principle) be established, the loss in value (from the lost recreation days) could be imputed to the reduction in the number of fish available. Stevens does not make the mistake of valuing fish in this fashion and, in fact, does not even discuss the pros and cons of this possibility.

Although the use of a quality variable expands the potential applicability of HCK models, use of a "bag" or "catch" variable such as success per unit effort will reflect quality only to *consumptive users* of the site. Even then, it is perhaps not a complete reflection of quality to those individuals even insofar as we restrict our consideration to wildlife-produced satisfaction. The fact that wildlife existing at a site can be used both by hunters and nonhunters in a non consumptive way is not accounted for by the use of such a quality variable. Using such a quality variable to derive value estimates of wildlife can only produce seriously biased estimates. In addition to this problem, even if it were possible to value a stock of a species *at* a site, this cannot be taken to be the total value of that stock because many species are mobile and will provide benefits to hunters and nonhunters outside the site being evaluated.

Finally, the fact that the HCK method is based primarily on *ex post* travel cost differentials leads to two further limitations. First, the HCK method can only cope with willingness-to-pay net benefits. Therefore, where willingness to sell is the correct measure, it will yield theoretically inappropriate underestimates (Hammack and Brown 1974). Second, the HCK method cannot be used when the activity in question involves no travel. Consequently, it is not capable of dealing with existence or option values.

In summary, the HCK method has not been effectively used to estimate wildlife values. It remains essentially a site valuation technique and, as long as the site is defined to be a set of resources producing value, the net benefit estimate provided by a HCK approach will reflect the value of that entire set of resources — one of which may or may not be species of wildlife. Although with a more careful specification of a disaggregated model inferences may be made about the value of wildlife or about relative values of different species, this would involve the use of a quality variable of some type.

6. The DCS method

The DCS makes a more straightforward use of the consumer's surplus concept than the HCK method. It relies on data collected by directly asking individual respondents to provide estimates of their own consumer's surplus. Both personal interview and mail questionnaire techniques have been used to collect the required data. The key question asks for an estimate of consumer's surplus and has been worded in a variety of ways. Usually it is phrased in terms of willingness to pay but other measures of consumer's surplus can be used (see Meyer 1975).

The most serious criticism of the DCS method is that, because consumer's surplus (or willingness-to-pay) questions are hypothetical, they result in hypothetical answers (Scott 1965). Although the use of data based on observed behaviour would be preferable, some valuation problems necessitate reliance on the DCS approach. Furthermore, results obtained in a variety of DCS applications indicate the usefulness of the technique (Davis 1963, Cicchetti *et al.* 1973, Hammack and Brown 1974 and McConnell 1977). Failure to elicit accurate responses in all cases does not necessarily mean that statistical estimates will be biased. It may simply result in larger statistical variances. This may account for the rather low $\bar{R}^2$'s yielded by DCS studies even though significant regression coefficients are obtained. In any event the hypothetical nature of the question is a major concern and the greatest challenge posed in using the technique is to phrase the key question so as to minimize misunderstandings and game-playing biases.

Although the DCS method is not without problems its major advantage is that it has the potential to effectively meet the three requirements specified in section 3 (Acceptable valuation methods). In addition, the technique is extremely versatile and can be applied to a wide range of valuation problems.

Failure to clearly define what is being valued has been and, in our judgment, continues to be a serious problem in the application of both the HCK and the DCS methods. Few studies clearly define the relationship between the relevant recreation activity and the wildlife resource being valued. Two exceptions are an article by Pearse (1969) and the study by Hammack and Brown (1974). Because it more closely suits our purpose, we focus here on the Hammack and Brown model.

Hammack and Brown's (1974) incisive conceptualization of the wildlife valuation problem goes directly to the heart of the matter by specifying the relationship between the value of a recreation day of hunting and the value of a bagged waterfowl. Simultaneously, they incorporate two important wildlife policy variables into their model, the daily bag limit and the length of the hunting season.

They develop their model from the perspective of an individual representative hunter. For the hunter, the maximum number of birds that may be legally bagged in one day (the bag constraint) and the number of days during which waterfowl may be hunted (the day constraint) have the potential to keep him from maximizing his net benefits from hunting. Assuming that both constraints are operational and relaxing one of them at a time, Hammack and Brown (1974) demonstrate that (1) increasing the bag limit while the season length remains unchanged improves the quality (increases the value) of each of the days the individual hunts during the season and (2) increasing the season length while leaving the bag limit unchanged results in the individual hunting more days and bagging more waterfowl. They refer to these two

marginal values as the quality margin and the quantity margin, respectively. They go on to conclude that:

> Since many hunters are subject to one or both constraints, the net benefits to them of the marginal waterfowl will be positive. A peculiar situation exists in that a single item, an additional waterfowl, can affect each of two margins: a quality margin and a quantity margin. The bird may be taken either as an additional bird shot on one of the (constant number of) hunting days, or as a benefit resulting from shooting (a fraction of) an additional day, with kill per day constant. Which margin is affected depends upon which constraint has been relaxed.

Note that Hammack and Brown, like other researchers, opt for using recreation days as the quantity variable for their analysis. What is unique about their approach is the way that they define their quantity and quality margins.

In defining these margins Hammack and Brown explicitly recognize the need to isolate the value of wildlife from other sources of value. They observe that bagged waterfowl is only one of many components which contribute to the value of a recreational experience and go on to argue that:

> . . . the scope of the valuation questions may be limited in such a way that subsidiary satisfactions of the recreation day (to repeat, such as exercise and exposure to natural surroundings) are effectively excluded. . . . Hence, the reported net benefit may be attributed to the waterfowl bagged.

In effect, Hammack and Brown argue that they can collect the necessary data in such a way as to isolate the value of wildlife from other sources of value. They assume that there are no synergistic satisfactions (i.e. satisfactions from other activities of a recreation day, which, when they are combined with the specific type of hunting in question, result in greater overall satisfaction than when that type of hunting is absent). We will comment on the usefulness of their data collection technique later.

The Hammack and Brown model requires data for estimating a function having total net benefits as the dependent variable. The first partial derivatives of this function are used to compute the quality and quantity margins. In the mathematical notation used by Hammack and Brown (1974), the model for an individual hunter is as follows:

$V = f(Y, U, D/Z, Z)$, where
V = a measure of consumer's surplus
Y = a measure of monetary income
U = some measure(s) of taste (preference)
D = the number of waterfowl bagged by the hunter during the season
Z = the number of days the individual hunted during the season

An approximation of the quality margin (i.e. the increase in the value of a recreation day resulting from shooting an additional waterfowl per day with the number of days hunted held constant) is found in the following way. First, the first partial derivative of V with respect to D/Z is determined. This is an approximation of the marginal value of an additional bird taken on each day the individual hunts during the season. Dividing this first partial derivative by Z gives an approximation of the quality margin; thus,

$$\frac{\frac{\delta V}{\delta (D/Z)}}{Z} = \text{the quality margin}$$

An approximation of the quantity margin (i.e. the increase in value due to bagging an additional bird on an additional fraction of a hunting day, holding constant the number of waterfowl killed on each hunting day, can be arrived at in a similar way. Therefore,

$$\frac{\frac{\delta V}{\delta Z}}{D/Z} = \text{the quantity margin}$$

The most important features of Hammack and Brown's model are that it correctly specifies the relationship between the value of recreational hunting days and the value of bagged waterfowl, and that it defines the two interrelated margins. In this way, the quantity and quality margins isolate the value of bagging additional birds from the value of other inputs which are then combined to produce the recreational hunting activities.

7. The DCS method: the only potentially useful technique — a summary

As presently formulated, the HCK method does not offer much promise for valuing wildlife. Since it is based on after the fact travel cost data it offers no solution in situations where estimates of willingness to sell are required or where the recreational activity involves no travel. Even when travel is involved and estimates of willingness to pay are desired, it will be difficult (if not impossible) to adapt this site valuation technique to meet the requirements we have specified for wildlife valuation methods.

The DCS method can be used to meet all three of the value estimate requirements specified earlier. Hammack and Brown's approach to using the DCS method already meets the first two requirements. We will demonstrate that conceptually it can meet the third.

Although Hammack and Brown's model is exclusively a model for estimating the hunting value of wildlife, the DCS method has the flexibility to deal with other sources of value. Whether or not the DCS method can be expected to be an effective technique for estimating non-hunting, existence and option values is a topic which will be given further consideration.

The major limitation of the Hammack and Brown approach is that it estimates only a portion of the value which can be attributed to wildlife, i.e. it is designed to estimate only the value of an additional bagged bird. As argued earlier, this private-good dimension of wildlife value is not likely to be the only significant source of wildlife benefits. Collective-good aspects of both hunting and nonhunting activities are almost certain to be relevant. As presently conceived, the Hammack and Brown model does not attempt to account for any collective-good benefits. However, it can be modified to include the collective-good dimensions of recreational hunting. Consequently, it will be used as the foundation for the model to be developed here.

A more complete recreational hunting model

Hammack and Brown's model is a solid foundation upon which to build. In this section we will present a modification of the Hammack and Brown model and discuss the data requirements of the modified model.

1. A more complete conceptual model

The Hammack and Brown (1974) model is focussed on one source of wildlife value, the value of bagged waterfowl. A modification of the model is required because the bagging of game is not the only way wildlife contributes to the quality of a recreation day. That is, downing a bird without retrieving it may make a positive contribution to the value of a recreation day of hunting. Even if the target is not hit, getting an additional shot at the sought-after game is almost certain to add to the enjoyment of a hunting experience. Similarly, if a hunter does not get a shot at the birds, just sighting additional game while he is hunting is likely to contribute positively to the quality of a recreation day.

Each of these additional aspects of wildlife value can be viewed as quality dimensions of a recreation day. As such, they can easily be incorporated into the Hammack and Brown model. Adding these variables, the model for an individual hunter becomes:

$V = f(Y, U, D/Z, R/Z, S/Z, W/Z, Z)$, where

V = a measure of consumer's surplus vis-à-vis recreational hunting
Y = a measure of monetary income
U = some measure(s) of taste (preferences)
D = the number of waterfowl bagged by the hunter during the season
R = the number of waterfowl downed but not bagged during the season
S = the number of missed shots during the season
W = the number of waterfowl sighted while hunting but not shot at during the season
Z = the number of days the individual hunted during the season

The quality margins are defined and determined in the same way as before but now, rather than just one, there are four dimensions. With the number of days hunted and the remaining three quality variables held constant, the following expressions approximate the respective quality margins:

$$\frac{\frac{\delta V}{\delta (D/Z)}}{Z}$$ = the bag quality margin, i.e. the value of an additional bagged bird

$$\frac{\frac{\delta V}{\delta (R/Z)}}{Z}$$ = the downed-but-not-bagged quality margin, i.e. the value of downing one additional bird when it is not retrieved

$$\frac{\frac{\delta V}{\delta (S/Z)}}{Z}$$ = the shot quality margin, i.e. the value of one additional missed shot

$$\frac{\frac{\delta V}{\delta (W/Z)}}{Z}$$ = the sight quality margin, i.e. the value of seeing one additional bird when the bird is not shot at

We would expect each of the quality margins to be positive. (A possible exception is the downed-but-not-bagged quality margin: downing a bird and failing to retrieve it may detract from the enjoyment of a hunting experience.) The constraint responsible for the expected positive quality margins may be either the legal bag limit (the bag constraint) or the number of birds in a given geographic area (the stock constraint).

From a policy standpoint (assuming that quality margins are positive) it is important to know (*a*) the relative magnitudes of the quality margins, and (*b*) which of the quality margin constraints is dominant. The former is within the scope of our model, the latter is not, but determining whether the bag constraint or the stock constraint is dominant for the individual hunter should pose no serious problems. All we need to know is on how many of his hunting days the individual was able to kill the maximum number of birds allowed by law. In some cases, estimates of the average number of birds bagged per day may be so low in relation to the bag limit that it will be obvious that the stock constraint (population level) is the dominant constraint.

The quantity margin as defined by Hammack and Brown (1974) cannot be interpreted in the same fashion with this modified model. Hammack and Brown consider

$$\frac{\frac{\delta V}{\delta Z}}{D/Z}$$

an estimate of the marginal value of an additional waterfowl bagged on an additional fraction of a hunting day. This interpretation does not hold with the modified model specification and, in general, is correct if and only if bagging a bird is the only source of hunting benefits.

At this point Hammack and Brown's model has been modified to permit the inclusion of additional sources of wildlife value, i.e. benefits in addition to those attributable to bagging game. Downing game which is not retrieved, getting a shot at game which is not downed and sighting the sought-after game were identified as possible sources of wildlife benefits. It is also possible to include additional sources of benefits without altering the modified model.

The modified model retains the most significant feature of Hammack and Brown's model: the conceptual isolation of the value of a marginal stock (wildlife population) change from the value of other inputs into recreational hunting activities.

It should be apparent why a careful definition of what is to be valued is of critical importance. In an empirical analysis, it is of crucial importance to know whether an attempt is being made to value an increase in a wildlife population with no accompanying change in either the bag or day limit constraints, or whether the objective is to value a population increase along with a change in the bag limit or day limit constraints. The model specification should explicitly indicate which of the margins is being evaluated and how.

The construction of this modified model may permit the estimation of the value of an additional shot. The value of an additional shot is determined by the value of each possible outcome and the respective probabilities of each outcome. The value of an additional shot, therefore, includes a collective-good dimension as well as a private-good dimension. Because it includes both dimensions of value and because the number of shooting opportunities will be directly affected by changes in population levels, the most interesting marginal value may be the change in willingness to pay, V, produced by a change in the number of shots, T (Cocheba and Langford, in press).

2. Data requirements

The data requirements of our model overlap those of the Hammack and Brown model; both require the following data for individual hunters or household units: a measure of consumer's surplus, a measure of monetary income, a proxy measure for preferences, the number of waterfowl bagged during the season and the number of days hunted during the season. Hammack and Brown (1974) demonstrate that researchers can collect this information *ex post*.

To use our model as presented above, additional data would be required, that is, the number of waterfowl downed but not retrieved during the

season the number of shots missed during the season and the number of waterfowl sighted but not fired at during the season. The question is can reliable data on these variables be collected?

We feel that an attempt to collect data on the number of birds downed but not retrieved would be worthwhile. For obvious reasons, this type of data cannot be expected to be as reliable as data on the number of birds bagged, but attempting to acquire it would only add one question to the data collection instrument.

Directly asking hunters for the number of missed shots, that is, the number of shots fired which did not hit a bird, is not likely to provide reliable data. Hunters cannot be expected to have counted or mentally recorded the number of shots they missed while hunting. Therefore, a serious problem can be anticipated in an attempt to force the hunter to provide this information directly. Instead, we suggest that the respondent be asked for the total number of boxes of shells or the total number of shells he used while hunting. The total number of shells could be adjusted by deducting the number of shots which downed birds. This figure could then be used as a proxy variable for the number of shots missed.

For completeness, we included the number of waterfowl sighted as an independent variable in our conceptual model. But we know of no reliable way to obtain the necessary data. Hunters cannot be expected to know how many birds they have seen while hunting, and a proxy variable does not appear to be a feasible alternative.

Nonhunting, existence and option values

The five activity categories already outlined as separate recreational activities are *wildlife-based activities*, e.g. bird watching and bird photography; *wildlife-related activities*, e.g. hiking and camping; *endemic wildlife activities*, e.g. watching birds from the window of one's residence; *recording-based wildlife activities*, e.g. watching wildlife films on television and listening to recordings of bird songs; and *contemplative wildlife activities*, e.g. thinking about wildlife while relaxing at home. An individual may participate in any or all of these activities. He may also be a hunter, but since we have already dealt with hunting as a separate activity, it is ignored here.

1. A conceptual model

A major difference between these activities and hunting is that they are not subject to a legal bag limit or a legal season length constraint (with the possible exception of the situation where access to endangered species is denied during certain periods of the year). The weather, although it may be a binding constraint, is of little interest here because it is not a policy variable. This leaves only one other constraint, the wildlife population level (the stock constraint).

The wildlife population level may (or may not) be a binding constraint. If it is, an increase in the population of a particular wildlife species — the Blue Jay for example — will improve the quality of recreation days as well as increase the number of recreation days demanded. For example, let us consider an individual who participates in all five of the activities listed above; as well, let us assume that the number of birds in existence limits his enjoyment only of endemic wildlife activities and wildlife-based activities. If the stock of birds is then increased while all other things remain unchanged, the quality of his endemic wildlife and wildlife-based activities may be improved. If the quality does improve, he may spend more time pursuing these two types of activities.

Rather than the four quality margins of the hunting model, there is a single stock quality margin. Each activity has its own stock quality margin which relates the value of wildlife to the value of the recreation day.

2. Practical considerations

The conceptual model just described can be presented mathematically in a way which parallels the Hammack and Brown (1974) mathematical hunting model. For example, the equation for *bird watching* can be expressed as

$V = f(Y, U, D/Z, Z)$, where
V = a measure of consumer's surplus (total net value)
Y = a measure of monetary income
U = some measure(s) of preferences
D = the number of birds seen during the year
Z = the number of days the individual participated in the particular activity

Consideration of this model quickly reveals a serious problem. Derivation of the stock quality margin depends on reliable estimates of D, the number of birds seen during the year, and most people cannot be expected to be able to provide this information.

Consider what would be involved if D were defined to be the number of Mallards seen during the year. First of all, individuals would have had to have actually estimated the number of Mallards they saw each time they went bird watching. Obviously, any such estimates will be subject to errors — especially when large flocks of waterfowl are involved. As if this were not enough, bird watchers would have to be able to recall their estimates for the entire year. Casual bird watchers will likely have a difficult time even recalling the number of times they went bird watching during the year much less the number of birds of a given species seen during the year. On the other hand, some avid bird watchers keep detailed records and might be able to provide the required information.

It is even less likely that the Hammack and Brown method can be used to estimate the value of wildlife in other nonhunting uses. In fact, for existence and option values, a variable comparable to D (the number of birds seen during the year) cannot even be defined. This leads to the unfortunate conclusion that the Hammack and Brown approach probably cannot be used for an empirical estimate of the value of wildlife in any of these cases. In our judgement, there is only one alternative to the Hammack and Brown approach. It, too, is a DCS method.

The Hammack and Brown method involves asking respondents to report total net value (benefits); this information along with other data is then used to determine the marginal net values mathematically. An obvious alternative is to ask respondents to report marginal net values directly.

If we were interested in knowing the value of a change in the Mallard population, the following type of question could be asked: "How much are you willing to pay for a 5% increase in the Mallard population?" Obviously, such a question could be worded in many different ways, but we will return to this later. The point to be made here is that, as long as hunting is excluded from consideration, this type of question is compatible with all three of the value estimate requirements specified earlier: it can be designed to elicit the required marginal values; it can isolate the value of wildlife from that of other recreation activity inputs and it does not require the respondent to separate private- and collective-good values, since for most practical purposes, nonhunting, contemplative and option demands can be considered to involve only collective-good values.

Asking a direct question about marginal value has two additional advantages. First, the question can be worded in such a way as to obtain the values from all the different uses of a given species. The objective is to elicit a figure representing the sum of all values from all sources from each respondent. Second, the same single question can be used to collect data from a number of individuals who participate in a variety of combinations of different wildlife activities. This is particularly important, because what is ultimately required is an estimate of value for all individuals who benefit from the existence of a given wildlife species.

Given these advantages and the simplicity of the approach, the direct question about marginal value may seem to offer the perfect solution to the wildlife valuation problem. Unfortunately it does not. First, it is not capable of separating private- and collective-good value, therefore it offers no solution when the researcher is interested in the hunting value of a species. This is a serious shortcoming because hunting is an important use for many wildlife species. Second, no matter how well the marginal-value question itself is worded, there is no guarantee that respondents will be able to answer the question satisfactorily.

Concerning this latter shortcoming it may be useful to recall the basic dilemma we described earlier: wildlife "products" are the human activities which wildlife help to produce, not the animals themselves, thus the respondents will probably think in terms of the value of these activities rather than the value of the animals which help to produce the activity.

The direct marginal-value question attempts to force people to think in terms of the value of wildlife, i.e. to think in an unaccustomed way about a complex topic. If the species being valued is an endangered species, like the Whooping Crane, and there is a high degree of public awareness about its endangered status, respondents may be able to provide the required information. But if the species in question is not an endangered species and its contribution to the value of recreational activities is relatively small, respondents may not know how much a marginal change in the stock (population) is worth to them.

The reliability and validity of responses to direct questions about marginal value can legitimately be questioned and there is considerable disagreement on the potential of this technique. Resolution of the basic question will require more empirical evidence. In any event, it is clear that succcessful use of this approach is entirely dependent on a correct and effective wording of the key question.

The willingness-to-pay question

We have presented what we consider to be a useful conceptualization of the wildlife valuation problem. Also, we have recommended the Hammack and Brown (1974) approach for valuing wildlife in hunting activities and the direct marginal-value approach for valuing wildlife in other uses. We have argued that these approaches, based as they are on the DCS method, are the only potentially useful alternatives currently available. However, their viability as techniques for valuing wildlife is contingent upon researchers being able to acquire the necessary willingness-to-pay data. The validity of responses to willingness-to-pay questions has been, and will probably continue to be, the most controversial aspect of the DCS method.

1. The controversy

Scott (1965) rejects approaches which directly ask respondents to report their benefits. "Ask a hypothetical question and you get a hypothetical answer," he says. Hammack and Brown disagree. Referring to a study by Davis (1963), they comment on Scott's argument.

> The argument appears more substantive at a superficial level than at a deeper one. The statistically significant regression results obtained by Davis indicate that if the recreationists' answers were hypothetical, that term at least does not mean random or irrational.

Still, Scott's point is not without merit. Under certain circumstances, hypothetical questions will probably yield unsatisfactory responses. However, if a hypothetical question is one which asks for information about something other than actual past behaviour, researchers are using hypothetical questions successfully. For example, public opinion pollsters have been successful in using hypothetical questions to predict election outcomes. Thus we submit that Scott's assertion should be viewed as an hypothesis rather than a universal truth.

In wildlife valuation studies, we need to know whether or not the willingness-to-pay question is too hypothetical to yield usable data. This is a complicated empirical question which can only be thoroughly dealt with by a separate research project, but we can make some general comments on the critically important task of formulating the willingness-to-pay question.

2. Phrasing willingness-to-pay questions

To gather primary data through the use of a questionnaire effectively, a minimum of two conditions must be met. First, the respondents must either have the information readily available or be able to generate the desired information. This is a potentially critical problem; unfortunately, the researcher has little or no control over it. Second, the willingness-to-pay question must be stated in such a way that the potential respondent knows exactly what information is being requested and is encouraged to provide it without bias. The phrasing of the willingness-to-pay question is not only of fundamental importance but is within the control of the researcher.

Unfortunately, this type of question is subject to a number of potential biases. For example, if respondents think that their answers may be used to establish the fees which they will be charged, they may purposely understate their willingness to pay. Alternatively, individuals may overstate their willingness to pay if they feel that doing so will further a cause which they favour. Little is known about these and other potential biases. But, where possible, it seems logical to phrase the question so as to minimize the incentive for this type of game playing.

Hammack and Brown's question and Davis's approach have been used successfully:

both offer reasonable solutions to the problem of game-playing biases. We will discuss their procedures first. Following this, alternative approaches to phrasing the direct marginal-value question will be considered.

3. The Hammack and Brown question

The Hammack and Brown question can best be analyzed by presenting a segment of their questionnaire.

> *Question 7*
> *About how much do you figure your total waterfowl hunting costs were for the 1968–69 season?*
>
> Since we have been talking about costs, we would now like to ask you another question on the same subject, but this one again involves an entirely fictitious situation. Again, the question may seem difficult and take some thought, but we would like your best guess.
>
> *Question 8*
> *Suppose that your waterfowl hunting costs for the 1968–69 hunting season were greater than you estimated in Question 7. Assume these increased costs in no way affected general hunting conditions. ABOUT HOW MUCH GREATER DO YOU THINK YOUR COSTS WOULD HAVE TO HAVE BEEN BEFORE YOU WOULD HAVE DECIDED NOT TO HAVE GONE HUNTING AT ALL DURING THAT SEASON?*
>
> We emphasize that the dollar amounts given below are intended to represent imaginary increased costs, that is, costs over and above the actual costs you estimated in Question 7. Please check the answer below that you consider most appropriate.

The first thing to recognize about this excerpt is the relationship between questions 7 and 8. The questions themselves and the transition statement between the questions clearly explain their relationship to each other. What might not be clear is that question 7 provides the conceptually correct basis or reference point for question 8. Remember that willingness to pay (or consumer's surplus) is a measure of net benefits: benefits or value in excess of costs. Once this fact is recognized, it is obvious that Hammack and Brown are asking for the correct information.

Hammack and Brown's question 8 also asks for the conceptually correct information without actually using the words "willingness to pay". Because the question is phrased in terms of costs, most respondents will probably not recognize that they are being asked a willingness-to-pay question. If they do, they probably will not be sure whether an overestimate or underestimate favours their best personal interest. Consequently, as compared to using the willingness-to-pay phrase, Hammack and Brown's disguised question is likely to reduce game-playing biases.

The Hammack and Brown question is designed to provide a value estimate for wildlife in the hunting activity. Their particular phrasing of the question will be most satisfactory when the costs associated with the activity are easily identified. For this type of question to be useful for valuing marginal changes in population levels, it is preferable that the activity in question be oriented around a single species. Since bird watching activities are in general oriented around a multitude of species, it may be difficult to gain value estimates useful for management purposes from this type of question.

4. Davis's data collection approach

Davis (1963), like Hammack and Brown (1974), phrased his question in terms of costs. However, Davis used a significantly different data collection procedure. He developed a bidding-game approach in which respondents could react positively, negatively or indifferently to changes in the costs of visiting a recreation area. Knetsch and Davis (1966) state: "Bids were systematically raised or lowered until the user switched his reaction from inclusion to exclusion or vice versa. . . . His reaction to increased expenses connected with the visit constituted the essence of the bidding game." They go on to conclude:

> Respondent's comments indicated they were turning over in their minds the alternatives available in much the same way that a rational shopper considers the price and desirability of different cuts or kinds of meat. Both the success in finding acceptable and significant explanatory variables and a certain amount of internal consistency in the responses suggest that considerable weight can be attached to the interview method.

We have no reason to question these conclusions and see a distinct advantage in using the Davis approach. Rather than asking for dollar figures, the bidding-game question requires only a positive, negative or neutral reaction from the respondent. This is likely to make it easier for respondents to answer the willingness-to-pay question; it may even improve the accuracy of their answers.

As a final point, the bidding-game approach requires the use of a personal interview. The other questions discussed in this report are designed for mail questionnaires. This means that a bidding game may be more costly. Any advantage it holds over another method which uses a mail questionnaire must be significant enough to compensate for this additional cost.

5. Using the willingness-to-pay phrase in a question

This may at first appear to offer an easy solution to the problem of trying to collect willingness-to-pay data. However, the effective use of this phrase is not a simple task because of the likelihood of the game-playing biases mentioned earlier. To explain what is meant by this, we will use two questions, which in terms of length and complexity, can be considered examples of the polar extremes.

The question mentioned earlier is presented again as an example of a brief and simple form of willingness-to-pay question: "How much are you willing to pay for a 5% increase in the Mallard population?"

The briefness of this question is an obvious advantage. It does not take long to read, nor does it raise issues which could result in biases.

The problem is that it does not contain enough information. The respondent probably will know that he is being asked to place a value on something, but exactly what this something or product is may not be clear to him. He may well feel that this question is somewhat like asking him to value a box without telling him what it contains. If the question dealt with a familiar product, like a pound of butter, a three- or four-word description of that product might be adequate. However, given the extra-market nature of the wildlife valuation problem, a more lengthy description of the product is required.

An example of how to word the question more clearly follows:

> Next we would like to ask you a question involving something which has not actually happened. Asking you this type of question is the only way of getting the needed information. To fully understand the question, you may need to read it more than once, but we would appreciate your best answer.
>
> What we would like to know is how much you would be willing to donate to an organization for the purpose of increasing the *Mallard* population by 5%.
>
> Suppose the organization would operate in the following way:
>
> *a)* The organization would spend the money it receives in the most efficient way to keep the *Mallard* population 5% above what it would be without the organization's efforts.

b) Both hunters and nonhunters would benefit. For hunters, even though there would be NO change in the length of the hunting season or the daily bag limit, there would be 5% more *Mallards* during the hunting season. *Nonhunters* would benefit because at all times there would be 5% more *Mallards* to enjoy.

c) Everyone would pay for all of the enjoyment that they would get from there being more *Mallards*. (Don't worry about how this would be done. Just suppose that it would be done.) However, everyone's donation would be returned if enough money to finance the 5% increase is not collected.

Under these circumstances, what is the maximum amount you would give the organization for its operation during this year (1976)?

Explicit references to the possibility of an organization being formed to increase the Mallard population is an important part of the question's design. It imparts an air of reality to the question without creating the uncertainties which may give rise to biased answers. Statement *a* is designed to provide a limited amount of information about how the organization would operate. The type of organization selected as the reference point for this question is likely to affect respondent's reactions. One possible alternative to the approach being taken here is to specify a government agency as the reference point: the payment could then be described as a tax. This has the advantage of allowing the respondent to relate to a method of payment with which he is familiar and the potential to reduce concern about other people not having to pay their fair share. On the other hand, there may be serious biases against increased government activity.

Statement *b* attempts to reassure respondents that hunters will not be the only ones who will benefit from the increase in the Mallard population. The reason for inserting this statement is that an unstructured preliminary test of the question revealed that nonhunters often thought that the increase would only benefit hunters.

The first part of statement *c* is designed to reduce concern about other people not having to pay their fair share for the benefits they might receive (the free rider bias). The last part of the statement is designed to anticipate concerns about what happens if enough money to finance the 5% increase cannot be collected.

This type of lengthy and complex question may create more problems than it solves. Its length alone may be enough to cause its rejection by some researchers. However, the extra-market nature of the problem virtually guarantees that potential respondents will have little or no prior knowledge about the item being valued. Consequently, everything the respondent needs to know to make an intelligent decision and supply the correct answer must be provided within the questionnaire. This task probably cannot be accomplished with a one-sentence question of the type discussed earlier. It is our judgement that a question which leans toward the lengthy and complex is likely to be more effective than a one-sentence question.

6. Phrasing the question — some concluding remarks

The Hammack and Brown (1974) question is useful for valuing wildlife in hunting activities. Their question is designed for use with a mail questionnaire.

The Davis (1963) bidding-game approach to data collection requires the use of a personal interview. It can be used to collect data both for valuing wildlife in hunting and valuing wildlife in other uses. The bidding-game approach is actually just a way of eliciting the dollar figure representing respondents' willingness to pay. It must be preceded by a statement which explains what is being valued. This means that it can be used with

Estimation of values: some general considerations

Hammack and Brown's disguised question and our hunting model to estimate the value of wildlife in hunting activities. The type of question which uses the willingness-to-pay phrase could also be combined with the bidding-game approach to collect data for valuing wildlife in other uses.

If the researcher decides to use a mail questionnaire, the best choice for valuing wildlife in hunting activities is probably the Hammack and Brown question. For collecting data to be used in estimating nonhunting, existence and option values, the question which incorporates the willingness-to-pay phrase could be utilized. However, further experimentation is required to explore the effectiveness of this type of question in collecting willingness-to-pay data.

It must also be recognized that in any survey by mail questionnaire, those responding may not necessarily be representative of the population as a whole. The reliability of data gathered in this way will always depend on a satisfactory treatment of non response bias.

A few comments on the operational aspects of wildlife valuation are now in order. We will not consider the details of carrying out a full-blown valuation study. We intend simply to make a few general points which may assist in the development of an actual estimation procedure.

So far, attention has necessarily been focussed on eliciting value estimates from the individuals who benefit from the existence of wildlife. Broadening this orientation to consider the interrelationships between humans and wildlife will bring us one step closer to being able to value a given species or group of species. We use the Mallard duck as an example.

Mallards, which are present in each of the North American flyways, generate a stream of benefits to humanity on their yearly migrations until they are either killed by hunters or die from other causes. These benefits include sensory perception value resulting from hunting and nonhunting recreational uses, existence value and, perhaps, option value.

By definition, hunting and nonhunting activities require sensory contact with the birds. This means, among other things, that the amount of interaction which takes place between humans and Mallards is a determinant of value. The degree of interaction is affected by the mobility of both humans and Mallards. Consequently, the value of a Mallard is likely to vary from flyway to flyway.

An empirical analysis will require the researcher to decide whether an estimate of marginal value or total value is required. As we argued earlier, marginal value is the relevant measure for most wildlife management decision making.

Of the rather wide range of benefits noted above, hunting has traditionally been considered to be the most important. Although we do not

necessarily share that opinion, we will deal with this activity first.

Larger waterfowl populations provide more opportunities for hunters to shoot at, down and bag birds. Therefore, an increase in the number of birds should be worth something to hunters: our modification of the Hammack and Brown approach can be used to estimate these sources of value. Once the respective values of bagging an additional bird, downing an additional bird without retrieving it and getting an additional shot are determined, any given increase in the population (i.e. during fall flight) must be translated into an increase in value to hunters. Since the value estimate will not include all the benefits hunters receive from sighting birds, it must be considered an underestimate of hunting value. The problem is further complicated by the fact that the value of a once-and-for-all stock increase accruing to hunters can occur over a period of years. That is, all the additional birds which are not killed and do not die from other causes during the first year of the increase will be available to generate benefits in future periods. This means that the actual distribution of the increase in benefits over time must be determined in order to calculate the present recreational hunting value of a stock increase.

Although our modification of the Hammack and Brown approach can be used to estimate hunting benefits, it does not appear to offer a great deal of promise for other sources of value. Estimation of these other values can be attempted by using a direct marginal-value question.

It seems logical to phrase the question so as to elicit specific estimates of the value of a marginal change in the population. Responses to this type of question will probably include existence value and may include option value. The issue of whether or not option value is included in respondents' value estimates can be important in some instances and further investigation of the issue is required. The design of the actual question is the most crucial aspect in the use of this approach. Although serious criticisms can be levelled at it, the direct-question approach is the only one available for attempting to estimate the benefits of wildlife to nonhunters.

In summary, our recommendation is to combine the modified Hammack and Brown approach and direct marginal-value question in order to estimate the value of a marginal change in the Mallard population (during fall flight). Procedurally, this requires separating respondents into two mutually exclusive categories, hunters and nonhunters. Where a hunter also derives benefits from nonhunting uses of the birds, it will probably be best to use the value estimate based on the direct marginal-value question. Because it only attempts to deal with hunting benefits, use of the modified Hammack and Brown approach will result in an underestimate of the true aggregate marginal value.

The value estimates arrived at by using the modified Hammack and Brown approach can be used to convert a given change in the Mallard population into a value estimate for hunters. This conversion is required before the benefits from all sources can be aggregated.

The aggregation of benefits is another crucial aspect of the valuation procedure. It requires the careful distinction between private-good and collective-good benefits. Hunting benefits should be viewed as having both a private-good and a collective-good dimension. All other sources of value (existence value, option value and value resulting from nonhunting recreational use) can be viewed as exclusively collective goods. The expressed values from all users can be aggregated and it is the resulting aggregate marginal value that is relevant for wildlife decision-making purposes.

Summary and conclusions

This report assesses the legitimacy and effectiveness of existing wildlife valuation techniques. A critical review of the literature found no single valuation approach to be wholly satisfactory. In an attempt to develop an improved conceptualization of the wildlife valuation problem, all major sources of wildlife value were identified and a new theoretical consideration was introduced. The estimate of hunting benefits was considered first, followed by consideration of a method for estimating nonhunting benefits. Finally, an attempt was made to explain how the two separate approaches can be combined.

Our major conclusions can be summarized as follows:

(1) Valuing wildlife has been difficult due to the lack of market data. Since wildlife recreation will probably continue to be provided on an extra-market basis, this fundamental difficulty will remain.

(2) A large proportion of both the published and unpublished reports contribute nothing substantive to a solution of the problem. Methods based on gross expenditures have been understood to be totally inappropriate for wildlife valuation since the early 1960s.

(3) We determined that there are *four* types of benefits associated with wildlife. Valuation should account for recreational hunting benefits, nonhunting recreational benefits, existence value and option value. Option value is a future period value while all other sources of benefits are current period values.

(4) Three conditions should be met for a wildlife valuation method to be acceptable. First, the method should facilitate the separation of the value of wildlife from the value of the other inputs which, when combined with wildlife, produce recreational experiences. Second, the technique should accommodate the estimation of marginal values. Third, it should allow for the segregation of benefits into collective-good benefits and private-good benefits.

(5) Two techniques, the Hotelling–Clawson–Knetsch (HCK) and the Direct Consumer's Surplus (DCS) methods, although fundamentally different, are both useful methods for nonmarket valuation problems. But because it is basically a site valuation technique, the HCK method has limited potential for valuing wildlife.

(6) It may be easier to obtain reasonable estimates of relative values (between or among species) than of absolute values (of a particular species or group of species). This possibility warrants further investigation. Relative value information would be useful for cost effectiveness analyses.

(7) The Hammack and Brown approach which uses the DCS method is particularly useful. It specifies the interrelationship between the value of wildlife and the value of a recreation day of hunting. The Hammack and Brown approach estimates the value of an animal in the bag as a private-good component of wildlife value.

(8) Since the Hammack and Brown approach accounts for only one source of benefits, bagged game, it may underestimate the hunting value of wildlife. Therefore, we concluded that it was necessary to develop their approach into a more complete model. This was accomplished by incorporating three additional sources of value into a conceptual model. They are the value of downing a bird without retrieving it, the value of getting a shot at a bird and the value of sighting additional game. Extending the model in this way is particularly important because of the implications for aggregating private-good and collective-good benefits. In essence, once a bird is killed it provides no further benefits to others. On the other hand, if an opportunity to shoot at a bird is worth something, a single bird may provide value to many hunters along the flyway.

(9) Although estimating the benefits derived from hunting is a complex and difficult task, it is even more difficult to estimate nonhunting, existence and option value.

(10) The DCS method, in conjunction with the direct marginal-value question as a data collection technique, shows some promise for estimating nonhunting, existence and option values. The success of this approach hinges on the ability of researchers to obtain valid reponses to a hypothetical question. The wording of the question, therefore, becomes critically important.

(11) As one possibility for estimating the aggregate value of a marginal change in a wildlife population (stock), we recommend combining the modified Hammack and Brown and DCS – direct-question methods. We noted that the potential of the DCS – direct-question approach has not been fully investigated.

(12) Separation of benefits into their private- and collective-good components is required for aggregating wildlife values. Hunting benefits have both a private and a collective dimension. All other sources of value (i.e. existence value, option value and value resulting from nonhunting recreation uses) can be viewed exclusively as collective goods.

(13) The nature of a collective good is such that under some circumstances relatively small collective-good values can result in very large aggregate values. This is simply a matter of it being possible to sum small values over a large number of individual demanders. Conversely, the killing of an animal may generate relatively high values per occurrence but, since this value can only be realized once, the resulting aggregate value may be small.

(14) Correct recognition of the nature and importance of collective-good benefits vis-à-vis private-good benefits is likely to suggest major changes in wildlife management policies — particularly in the case of hunted species. Therefore, the relative size of collective-good benefits as compared to private-good benefits is an empirical question of considerable importance.

Quantification of wildlife values remains a formidable challenge and there are no available valuation techniques which are without serious limitations. No matter what technique is chosen, it is not reasonable to expect high degrees of precision in the resulting estimates. Nevertheless, defensible approximations of aggregate marginal benefits can be extremely useful for making rational decisions. In fact, in the absence of information on the costs and benefits of alternative courses of action, decision making becomes a matter of random choices — random choices which may or may not be influenced by personal biases. Wildlife management decisions are too important to be left to chance and efforts aimed at improving the data base for making these crucial resource allocation decisions should be encouraged.

References

Benson, D. A. and A. L. Wiley. 1974. Notes and data on economic impacts of the migratory bird resource — the federal aspect. CWS Rep. CWCS 1534, Ottawa, Ont.

Brown, W. G., F. H. Nawas and J. B. Stevens. 1973. The Oregon big game resource: an economic evaluation. Oregon Agric. Exp. Sta. Spec. Rep. 379(3).

Brown, W. G., A. Singh and E. N. Castle. 1964. An economic evaluation of the Oregon salmon and steelhead sport fishery. Oregon Agr. Exp. Sta. Tech. Bull. 78(9).

Burt, O. R. and D. Brewer. 1971. Estimation of net social benefits from outdoor recreation. Econometrica 39(9):813–827.

Byerlee, D. R. 1971. Option demand and consumer's surplus: comment. Quart. J. Econ. 85(8):523–527.

Capel, R. E. and R. K. Pandey. 1972. Estimation of benefits from deer and moose hunting in Manitoba. Can. J. Agric. Econ. 20(7): 7–16.

Capel, R. E. and R. K. Pandey. 1973. Evaluating demand for deer hunting: a comparison of methods. Can. J. Agric. Econ. 21(11):6–14.

Carey, O. L. 1965. The economics of recreation: progress and problems. West. Econ. J. 3 (spring):169–173.

Cesario, F. J. 1976. Value of time in recreation benefit studies. Land. Econ. 52(2):32–41.

Chan, R. D. 1973. The economic and social impacts of non-resident goose hunting in west-central Saskatchewan: a pilot study and method evaluations. Unpubl. rep. for CWS. Edmonton, Alta.

Cicchetti, C. J., A. C. Fisher and V. K. Smith. 1973. Economic models and planning outdoor recreation. Oper. Res. 21(9–10):1104–1113.

Cicchetti, C. J. and A. M. Freeman III. 1971. Option demand and consumer surplus: further comment. Quart. J. Econ. 85(8):528–539.

Clawson, M. 1959. Methods of measuring the demand for and value of outdoor recreation. Resources for the Future, Inc., Repr. No. 10, Washington, D.C.

Clawson, M. 1962. Private and public provision of outdoor recreation. Econ. Stud. Outdoor Rec. U.S. Outdoor Rec. Resour. Rev. Com. Stud. Rep. 24, Washington, D.C.

Clawson, M. and J. L. Knetsch. 1966. Economics of outdoor recreation. Johns Hopkins Univ. Press, Baltimore, Md.

Cocheba, D. J., and W. A. Langford. In press. Wildlife valuation: The collective good aspect of hunting. J. Land Econ.

Crutchfield, J. A. 1962. Valuation of fishery resources. Land Econ. 38(5):145–154.

Currie, J. M., J. A. Murray and A. Schmitz. 1971. The concept of economic surplus and its use in economic analysis. Econ. J. 81(12):741–799.

Dainow, R. 1972. Perceptions, attitudes and economic impact of goose hunting in west-central Saskatchewan. Unpubl. rep. for CWS, Edmonton, Alta.

Davis, R. K. 1963. Recreation planning as an economic problem. Nat. Resources J. 3(10):239–249.

Davis, R. K. 1964. The value of big game hunting in a private forest. XXIXth N. Am. Wildl. Conf. 3:393–403.

Davis, R. K. and J. J. Seneca. 1971. An evaluation of techniques for demand analysis in state fish and game planning. Nat. Res. Policy Cent., Geo. Wash. Univ., Rep. U.S. Bur. Sport Fish. Wildl. July.

Goldstein, J. H. 1968. An economic analysis of the wetlands problem in Minnesota. Ph.D. Thesis. Univ. Minn.

Gum, R. L. and W. E. Martin. 1975. Problems and solutions in estimating the demand for and value of rural outdoor recreation. Am. J. Agric. Econ. 57(11):558–566.

Hammack, J. 1969. Toward an economic valuation of a fugitive recreational resource: waterfowl. Ph.D. Thesis. Univ. Wash.

Hammack, J. and G. M. Brown, Jr. 1974. Waterfowl and wetlands: toward bioeconomic analysis. Resources for The Future, Inc., Johns Hopkins Univ. Press, Baltimore, Md.

Hanus, F. 1974. The role of birds in recreational activities of Saskatchewanians. Inst. N. Stud. U. Sask. Unpubl. rep. for CWS, Edmonton, Alta.

Hedlin, Menzies and Associates Limited. 1967. A proposed economic evaluation procedure for waterfowl habitat in Canada. Unpubl. rep. for CWS, Edmonton, Alta.

Hedlin, Menzies and Associates Limited. 1968. Assessment of the economic value of resources. Unpubl. rep. for CWS, Edmonton, Alta.

Horvath, J. (project leader). 1974. Detailed analysis: economic survey of wildlife recreation. Environ. Res. Group, Geo. Sta. Atlanta. March.

Knetsch, J. L. 1963. Outdoor recreation demands and benefits. Land Econ. 39(4): 387–396.

Knetsch, J. L. and Davis, R. K. 1966. Comparisons of methods for recreation evaluation. Water research, ed. A. Kneese and S. Smith. Johns Hopkins Univ. Press, Baltimore, Md.

Krutilla, J. V. 1967. Conservation reconsidered. Am. Econ. Rev. 57:777–786.

Krutilla, J. V. and Fisher, A. C. 1975. The economics of natural environments: studies in the valuation of commodity and amenity resources. Resources for the Future, Inc. Johns Hopkins Univ. Press, Baltimore, Md.

Lindsay, Cotton M. 1966. Option demand and consumer's surplus. Quart. J. Econ. 83(5):344–346.

Long, M. F. 1967. Collective-consumption services of individual-consumption goods: comment. Quart. J. Econ. 81(5):351–352.

Martin, W. E., R. L. Gum and A. H. Smith. 1974. The demand for and value of hunting, fishing and general rural outdoor recreation in Arizona. Ariz. Agr. Exp. Sta. Tech. Bull. 211.

McConnell, K. E. 1977. Congestion and willingness to pay: A study of beach use. Land Econ. 53(2):185–195.

Meyer, P. A. 1975. A comparison of direct questioning methods for obtaining dollar values for public recreation and preservation. Environ. Can. Fish. Mar. Serv. Pac. Reg. Tech. Rep. Ser. No. PAC/T–75–76.

Pattison, W. S. and W. E. Phillips. 1971. Economic evaluation of big game hunting: an Alberta case study. Can. J. Agr. Econ. 19(10):72–83.

Pearse, P. H. 1969. Toward a theory of multiple use: The case of recreation versus agriculture. Nat. Res. J., 9(10):561–575.

Pearse, P. H. and E. L. Laub. 1969. The value of the Kootenay Lake sport fishery. B.C. Fish. Wildl. Br. Stud. Rep. 3 Econ. Wildl. Rec.

Pearse Bowden Economic Consultants Limited. 1972. The value of resident hunting in British Columbia. B.C. Fish Wildl. Br. Stud. Rep. 6 Econ. Wildl. Rec.

Phillips, W. E. 1976. The conservation of the California tule elk. Univ. Alta. Press, Edmonton, Alta.

Prest, A. R. and R. Turvey. 1965. Cost-benefit analysis: a survey. Econ. J. 75(12):683–735.

Rieck, C. 1975. To watch . . . or to hunt: to help . . . or to complain. Wash. Wildl. 27(Spring):6–9.

Ross, C. 1975. Economic evaluation of resident big game hunting in Saskatchewan. Sask. Res. Plan. Pol. Br. Res. Rep. 1.

Schweitzer, D. 1973. Migratory bird resource management: user preferences and characteristics. Inst. N. Stud. Univ. Sask. Unpubl. rep. for CWS, Edmonton, Alta.

Scott, A. 1965. The valuation of game resources: some theoretical aspects. Can. Fish. Rep. No. 4(5):27–49.

Sinden, J. A. 1967. The evaluation of extra-market benefits: a critical review. World Agr. Econ. Rural Sociol. Abstr. 9(12):1–16.

Stabler, J. C. and M. Epstein. 1971. An approach to the evaluation of economic and social values of migratory birds in Western Canada. Inst. North Stud. Univ. Sask. Unpubl. rep. for CWS. Edmonton, Alta.

Stevens, J. B. 1966. Recreation benefits from water pollution control. Water Resour. Res. 2(2nd quarter): 167–181.

Weisbrod, B. A. 1964. Collective-consumption services of individual-consumption goods. Quart. J. Econ. 78(8):471–477.

Willig, R. D. 1976. Consumer's surplus without apology. Am. Econ. Rev. 66(9):589–597.

Other publications in the Occasional Papers Series

No. 1
Birds protected in Canada under the Migratory Birds Convention Act. 4th ed. Also available in French.
Cat. No. R69-1/1
No. 2
Canadian bird names, French, English and scientific. Bilingual publication.
Cat. No. R69-1/2
No. 3
Use of aerial surveys by the Canadian Wildlife Service by D. A. Benson. Out of print.
Cat. No. R69-1/3
No. 4
Queen Elizabeth Islands game survey, 1961 by J. S. Tener.
Cat. No. R69-1/4
No. 5
Age determination in the polar bear by T. H. Manning.
Cat. No. R69-1/5
No. 6
A wildlife biologist looks at sampling, data processing and computers by D. A. Benson. Out of print.
Cat. No. R69-1/6
No. 7
Preliminary report on the effects of phosphamidon on bird populations in New Brunswick by C. D. Fowle. Out of print.
Cat. No. R60-1/7
No. 8
Birds of Nova Scotia–New Brunswick border region by G. F. Boyer.
Cat. No. R69-1/8
No. 9
Effects of dietary methylmercury on Ring-necked Pheasants, with special reference to reproduction by N. Fimreite.
Cat. No. R69-1/9
No. 10
Trends in populations of barren-ground caribou over the last two decades: a re-evaluation of the evidence by C. R. Parker.
Cat. No. R69-1/10
No. 11
The Canada migratory game bird hunting permit and related surveys by D. A. Benson.
Cat. No. R69-1/11
No. 12
Observations on duck hunting in eastern Canada in 1968 and 1969 by H. J. Boyd.
Cat. No. R69-1/12

No. 13
Evaluation of ecological effects of recent low water levels in the Peace–Athabasca Delta by H. J. Dirschl.
Cat. No. CW69-1/13
No. 14
The Great Cormorants of eastern Canada by A. J. Erskine.
Cat. No. CW69-1/14
No. 15
Distribution of barren-ground caribou harvest in northcentral Canada by G. R. Parker.
Cat. No. CW69-1/15
No. 16
Bird migration forecasts for military air operations by H. Blokpoel.
Cat. No. CW69-1/16
No. 17
Waterfowl populations on the Peace–Athabasca Delta, 1969 and 1970 by D. J. Nieman and H. J. Dirschl.
Cat. No. CW69-1/17
No. 18
Gammarus predation and the possible effects of *Gammarus* and *Chaoborus* feeding on the zooplankton composition in some small lakes and ponds in western Canada by R. S. Anderson and L. G. Raasveldt.
Cat. No. CW69-1/18
No. 19
A summary of DDE and PCB determinations in Canadian birds, 1969 to 1972 by M. Gilbertson and L. Reynolds.
Cat. No. CW69-1/19
No. 20
Development of a simulation model of Mallard Duck populations by C. J. Walters, R. Hilborn, E. Oguss, R. M. Peterman and J. M. Stander.
Cat. No. CW69-1/20
No. 21
Use of museum specimens in toxic chemical research by A. M. Rick.
Cat. No. CW69-1/21
No. 22
Impoundments for waterfowl by W. R. Whitman
Cat. No. CW69-1/22
No. 23
Minimizing the dangers of nesting studies to raptors and other sensitive species by R. W. Fyfe and R. R. Olendorff.
Cat. No. CW69-1/23
No. 24
Waterfowl damage to Canadian grain: current problems and research needs by L. G. Sugden.
Cat. No. CW69-1/24

No. 25
Census techniques for seabirds of arctic and eastern Canada by D. N. Nettleship.
Cat. No. CW69-1/25
No. 26
Notes on the present status of the polar bear in James Bay and Belcher Islands area by Charles Jonkel, Pauline Smith, Ian Stirling and George B. Kolenosky.
Cat. No. CW69-1/26
No. 27
Limnological and planktonic studies in the Waterton Lakes, Alberta by R. Stewart Anderson and Roderick B. Green.
Cat. No. CW69-1/27
No. 28
Birds and mammals of the Belcher, Sleeper, Ottawa, and King George Islands, Northwest Territories by T. H. Manning.
Cat. No. CW69-1/28
No. 29
Developments in PPS sampling – Impact on current research by A. R. Sen.
Cat. No. CW69-1/29
No. 30
Dynamics of snowshoe hare populations in the Maritime Provinces by Thomas J. Wood and Stanley A. Munroe.
Cat. No. CW 69-1/30
No. 31
Migration and population dynamics of the Peace–Athabasca Delta goldeye population by D. B. Donald and A. H. Kooyman.
Cat. No. CW 69-1/31
No. 32
The effects of fire on the ecology of the Boreal Forest, with particular reference to the Canadian north: a review and selected bibliograph by John P. Kelsall, E. S. Telfer and Thomas D. Wright.
Cat. No. CW 69-1/32
No. 33
The ecology of the polar bear (*Ursus maritimus*) along the western coast of Hudson Bay by Ian Stirling, Charles Jonkel, Pauline Smith, Richard Robertson and Dale Cross.
Cat. No. CW69-1/33
No. 34
Canvasback habitat use and production in Saskatchewan parklands by Lawson G. Sugden.
Cat. No. CW69-1/34

No. 35
The diets of muskoxen and Peary caribou on some islands of the Canadian High Arctic by Gerald R. Parker.
Cat. No. CW69-1/35
No. 36
Observations of Mallards in the parkland of Alberta by Michael F. Sorensen.
Cat. No. CW69-1/36