MEASURING UNPRICED VALUES: AN ECONOMIC PERSPECTIVE AND ANNOTATED BIBLIOGRAPHY FOR ONTARIO

A collaborative project between the Ontario Ministry of Natural Resources and Forestry Canada, Ontario Region

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ABSTRACT

This report provides a perspective on how economists have come to deal with society's preferences for unpriced (non-market) values. Numerous methods have been developed to derive monetary estimates for these values. The report describes the relevant economic theory for cost-benefit analyses that include unpriced values, identifies various value categories, describes currently recognized techniques for estimating many of these values, and summarizes 19 unpriced-value studies that have taken place in Ontario. The last section highlights some issues that are relevant to future unpriced-valuation studies in forestry.

RÉSUMÉ

Le présent rapport fournit un aperçu des vues des économistes sur les préférences de la société concernant les valeurs sur lesquelles on ne peut mettre de prix (non commerciales). De nombreuses méthodes ont été élaborées pour établir des évaluations monétaires de ces valeurs. Ce rapport décrit la théorie économique pertinente des analyses coûts/avantages qui comprennent des valeurs non évaluables en termes de prix, identifie diverses catégories de valeurs, décrit des techniques présentement reconnues pour évaluer plusieurs de ces valeurs, et résume 19 études sur ce sujet faites en Ontario. La dernière section souligne certaines questions pertinentes pour les études ultérieures portant sur ces valeurs en foresterie.

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INTRODUCTION

The Ontario Ministry of Natural Resources (OMNR) recently established a Forest Values Initiative. This initiative arose from Ontario's "Sustainable Forestry Program" and the "Directions 90's" strategy and was intended to enhance the Ministry's knowledge of resource values based on the full range of potential benefits from integrated resource management. The Sustainable Forestry Program essentially consists of a number of initiatives related to forest policy, management and research. Directions 90's provides some general policy guidelines for numerous issues including natural resource pricing practices and public involvement in resource valuation and use.

The Forest Values Initiative has two major components. The first is the "Industrial Values" initiative, which deals primarily with wood allocation, pricing and tenure issues. The second is the non-industrial initiative, which deals with the other values of relevance to forest management. It is this initiative that is the driving force behind this report.

This report provides a perspective on how economists have come to deal with society's preferences for unpriced values (i.e., values that are not established through market transactions). Numerous methods have been developed to derive monetary estimates of these values. The goal is to provide a common numeraire for comparing *competing* resource uses. Economic analysis applied to forest management planning can, in principle, deal with the production of the full range of possible forest services, ranging from nature conservation to wood supply through time.

However, moving toward more economically oriented forest management is not simply a matter of placing dollar values on unpriced forest "outputs" or services. Economic analysis requires an understanding of the underlying biophysical "production possibilities" or at least explicit assumptions about what planners expect these possibilities to be. The report does not deal with this issue.

There are numerous value concepts that have been recognized by economists. These include both market (priced) and non-market values. The non-market values have been broken down into various categories, including consumptive, non-consumptive, existence, bequest and option values. The second section of the report describes these in detail. Non-market values can relate to issues as wide-ranging as recreation, water and air quality, old-growth forests, hunting, and preservation of endangered species.

The third section of the report describes the generally accepted methods of analysis that have been developed over the last three decades (i.e., contingent valuation, travel cost, hedonic pricing, etc.). The contingent valuation technique uses surveys to elicit people's preferences. The travel cost approach uses the cost of travel as a proxy for the value of recreational experiences. Hedonic pricing uses people's behavior in actual markets to infer value from the characteristics of goods or services in those markets. More detail on the assumptions, strengths and weaknesses of these methods is given in this section. Each method still has practical and theoretical problems that require additional research to resolve.

Relatively few (19) unpriced-values studies have been undertaken in Ontario.The studies that have occurred primarily address wetland values, sport fisheries and water quality. The fourth section of this report reviews these studies. There do not appear to be any studies specifically related to the issues or problems of integrated forest management planning.

The last section of the report highlights some issues that are relevant to future unpriced valuation studies. These include the reliability of the methods, stability of preferences for environmental values, and the problem of providing results that are actually relevant to decision-makers.

The report is intended to provide a systematic treatment of the economics of non-wood services in Ontario. Although the application of economic logic is in no way suggested as a panacea, it can help provide a systematic approach to the problem of understanding society's desires for natural resource management through a systematic, critical approach. The increasing interest in this area indicates the importance of the subject. Studies of unpriced values can be used in cost-benefit analysis, natural resource accounting exercises, and in providing decision-makers with some additional information on social preferences.

The section that follows provides some background on the valuation problem in forestry and the relevance of unpriced or non-market valuation.

The Valuation Problem in Forestry

Foresters have long considered themselves as land stewards. Generally, within the constraint of providing a sustained flow of timber, other important social concerns were met. The primacy of wood production is now being questioned. Table 1 identifies numerous "outputs" of forest land that are often raised as matters of concern by members of the public and public agency foresters in this province and elsewhere. The table is not intended to be a definitive description of all possible outputs; of interest here are things that are related to forested lands and that can be affected by management.

The second column in Table 1 identifies whether the output is taken by firms or by households. In economics it is necessary to talk of two types of agents: (1) firms or producers, and (2) households, individuals or consumers. With households, the output is a *direct* input to consumption and hence to human satisfaction or *utility*. With firms, the output must be transformed by some productive activity before being consumed by households.

Table 1. The range of possible "outputs" from forested lands.

Outputs	User(s)	Marketed
Harvested timber	Firms	Yes (?)
Standing timber	Households	No
Mineral	Firms	Yes
Grazing	Firms	Yes (?)
Flora	Households (Firms)	No
Fauna	Households (Firms)	No (?)
Flood protection	Households and Firms	No
Water	Households and Firms	No
Soil	Firms	No
Local climate	Households and Firms	No
Global climate	Households and Firms	No
Scenic vistas	Households	No
Biodiversity	Households and Firms	No

This is an important point, since the cost of the productive activity is often incorrectly associated with the net economic benefit of the forest "output"(e.g., the market price of pulp or paper being associated with the value of standing trees). The valuation problem in forestry that we are discussing here stems from an understanding of the *relative* values of the myriad of potential outputs from the forest itself. Although other issues such as community stability, employment in the wood processing sector and so on may also enter the decision-making process, it is important to separate these issues when examining the costs and benefits of particular forest management strategies. This will be clarified later when the economics of public forestry are described.

Table 1 reveals the fact that most forest outputs are not distributed through markets. The use of market prices for determining social preferences for all types of forest services is likely to remain limited. Thus, non-market valuation is necessary for a wide range of forest outputs.

From an economic perspective, the value of something is the maximum amount of an individual's scarce resources that he is willing to exchange for the item or service. Alternatively, it is the minimum amount the individual would accept in exchange for the item or service. Value, therefore, is not necessarily the price of a good or price times quantity; clearly, goods or services without prices may also have economic value.

Growing concerns about nature and the environment have spurred a number of research initiatives in recent years. One area is the attempt to assign monetary values to a wide range of environmental goods and services. The initial reasons for monetary valuation of unpriced resources were an attempt to include the values in cost-benefit analyses. Thus, project development decisions could include both market-based and unpriced values.

Second, valuation of unpriced goods and services is sometimes required, and in fact has been used to determine compensations in lawsuits involving loss or damage to the environment. Court battles are underway in Canada and the United States in which firms or individuals are liable for damages to environmental resources. Disputes over the use and management of natural resources are expected to increase in future. There will be a greater demand for objective measures of the value of the damage to the environment for litigation purposes.

A third rationale relates to some special economic analyses such as "environmental asset valuation" or "natural resource accounting", which also require unpriced or non-market value estimates (Hartwick 1990). Natural resource accounting attempts to value a nation's natural resources and environmental assets in the context of the national income accounts. The concern is that measures such as gross domestic product (GDP), as presently derived, are insufficient measures of social welfare. For example, "a country could exhaust its mineral resources, cut down all its forests, erode its soils, pollute its aquifers, and hunt its wildlife to extinction, but measured income would not be affected as these assets disappeared" (Repetto et al. 1989). Few of these resources have market values comparable to those of minerals and the wood from trees. To be complete, natural resource accounting requires value estimates of the unpriced natural resources and environmental amenities.

Clearly, managers and planners make decisions that reflect and imply particular values about all forest resources and services. As public pressure increases to account for all uses and values, so too will the requirement to justify management strategies. Advanced forest planning will involve not only a better understanding of all the production possibilities from forests but also a more critical and systematic evaluation of society's preferences for those possibilities.

THE ECONOMICS OF PUBLIC FORESTRY

The purpose of this section is to provide a brief overview of the concepts of economic efficiency and cost-benefit analysis as they relate to multiple-use forestry or integrated resource management. It is worth noting at the outset that economics is divided into two fields. The first, *positive economics*, is concerned with understanding and predicting economic behavior. Positive economics deals with what "is". Identifying the factors that determine the price of a house, the value of land in Ontario, etc., are the types of questions that positive economics tries to answer. *Normative economics*, on the other hand, deals with what "ought" to be if economic efficiency is a social objective. From the perspective of applied economics, normative economics carries positive economics one step further. For example, one can build a model to forecast future demand, supply and prices for various forest products in Ontario. These forecasts are often based on complex models and are positive in nature. Normative work could take this analysis one step further. The demand and supply functions on which these forecasts are based could be used to compute and evaluate the effects of government policy changes (e.g., raising the stumpage fee or altering the existing tenurial arrangement in Ontario's forestry) on consumers' income and corporate profits. See Just et al. (1982) for a more in-depth discussion of positive and normative economics.

Modern forest economics is derived from *capital theory*. Capital theory is concerned with the problem of resource allocation through time. In this regard, forested land is just one of a variety of assets that society can manage; wood is but one of the goods or services that forested land can provide. The normative economic criterion for management of any resource is the notion of *inter-temporal allocative efficiency*[1]. This means arriving at an investment regime in which no reallocation is possible between different assets that would improve *future* consumption possibilities. It requires that the rates of return on investment in all assets be equal everywhere in the economy. When rates of return are not equal, then future consumption can be increased without reducing current consumption. This can be done by reducing investment where rates of return are lower and increasing it where the returns are higher.

Economic theory shows that under certain conditions, private agents operating for their own self-interest will achieve *market-clearing equilibria* that represent inter-temporally efficient allocations (Bohm 1973). These conditions include a perfectly competitive environment, the absence of external effects[2] and public goods[3]. When all these conditions are met, market prices reflect proper valuations according to standard economic criteria. Under these conditions, forestry enterprises maximizing the value of their assets through time would serve a particular notion of the public interest—inter-temporal efficiency. Although the assumption of a perfectly competitive market economy is not a true description of the real world, it does provide an ideal against which to consider the actual outcomes.

Historically, capital theory directly related to forest management has dealt mainly with the problem of rotation length as it relates to wood production; that is, the timing of when to harvest a stand of trees. Initial efforts date back as far as 1849 and Martin Faustmann's work on the valuation of forest land (Faustmann 1849). Faustmann was a German forester who is credited with the development of discounted cash-flow analysis. Discounting is a method of calculating the present value of future costs and benefits.

Samuelson (1976) provides an excellent summary and an intuitive explanation of the correct capital analysis required for calculating the optimal timber rotation for a forest stand. Samuelson's description reviews a number of the mistakes that have been made by previous researchers when they attempted to solve the optimal rotation problem. Incorrect approaches include maximizing the internal rate of return, simple discounted cash flow analysis over one rotation period, and maximizing the biological sustained yield of wood flow over time. The methods discussed by Samuelson essentially ignored the opportunity costs involved with wood production, particularly the time value of monetary investments and land rental costs.

The economically correct calculation of optimal rotation length determines the rotation period that maximizes the discounted net benefits (revenues minus costs) of the wood-producing enterprise, excluding land rent, for an infinite number of rotation periods.

[1] The relevance of much of natural resource economics theory cannot be appreciated without at least a basic understanding of the notion of intertemporal efficiency. Chapters 6 and 7 of Common (1988) cover the main ideas and applications to natural resources in an introductory, non-mathematical way. More rigorous treatments of capital theory in general are given by Burmeister (1980) and Henderson and Quandt (1971). Bohm (1973) also presents an excellent, concise treatment of efficiency under perfect and imperfect market conditions.

[2] External effects, also known as externalities, can be positive or negative. An externality occurs when the action of one agent affects another but is not captured by the market mechanism.

[3] Economic analysis of unpriced values requires an understanding of the notion of public goods. According to Samuelson (1954, 1955), public goods can be jointly consumed by many households at the same time. There is *non-rivalry* in consumption, which means the consumption of a public good by one individual does not interfere with the consumption of the same public good by others. Once a public good is provided, excluding individuals from its benefit is generally difficult and costly and may be impossible. If this exclusion is not possible, a beneficiary has no incentive to help finance or purchase the good. This is the well-known *free rider* problem. The result is an inefficient allocation of resources and an undersupply of public goods. For this reason, the optimum provision of public goods represents a case of market failure.

The above discussion of the characteristics of public goods relies exclusively on Samuelson's definition of public goods. In the literature, these are known as *pure public goods*. In reality, there are very few pure public goods (e.g., national defence, air quality etc.). However, a wide variety of *impure* public goods exist. For example, a national or provincial park satisfies the definition of a public good as long as there are only a few visitors at a time. If, however, a large number of visitors results in congestion at various recreational facilities in the park, the "consumption" possibilities of one individual become dependent on the quantities consumed by others. Consequently, the non-rivalry in consumption of a public good disappears; consumption in this case is characterized by some elements of rivalry as is the case with private goods. Public goods of this type combine the properties of both private and public goods and are sometimes referred to as *mixed* public goods.

Alternatively, the firm can maximize the net present value over the first rotation period but include land rent in the calculation (Samuelson 1976). The two approaches would give the same result. Only in special cases would this result match that of the traditional forestry principle of managing for maximum sustained wood yields.

The above approach considered the management of a single stand when only harvested wood is valued. It is now widely recognized that forested land has other values and that these values can be economically important to private landowners as well as public foresters. Hartman (1976), partly in response to Samuelson (1976), adapted the Faustmann model to include a benefit function that related stand age to non-wood or amenity values. The general problem can be stated similarly to the wood-only case: A rotation period must be chosen that maximizes not only the value of wood harvests but also the value of amenity flows (non-wood "outputs") from the stand in perpetuity.

The Hartman multiple-use rotation length occurs when the rate of change in value, including that of the amenity flow, equals the marginal cost of operating capital and land rent. The net present value in this approach includes the value of land for both wood and amenity values. The Faustmann rotation length is a special case of the Hartman model. Only if the amenity values are equal to zero would the rotation period occur at the same time as the result for wood only.

Hartman (1976) and Bowes and Krutilla (1989) show that the multiple-use harvest may occur before or after the Faustmann harvest, depending on the nature of the amenity value function. For example, the Hartman rotation is longer than the Faustmann rotation only if the value of the amenities increases monotonically (continuously) with the age of the stand. However, it is not realistic to regard amenity values as increasing with age for all non-wood values. Some flora and fauna prefer young stands. The solution is essentially empirical and depends on which non-wood benefits are considered in the problem formulation. This point was first illustrated in a case study by Calish et al. (1978), who used paired combinations of wood and seven different non-wood yield functions (for cutthroat trout, non-game wildlife diversity, visual aesthetics, soil movement, black-tail deer, elk and water flow) and a single-stand approach like Hartman's. It is conceivable that the magnitude of the non-wood values can preclude any timber harvesting in some cases.

The Hartman formulation illustrates some of the complexities in the economics of multiple-use forestry for a single timber stand. However, the theory discussed above ignores situations in which interactions between stands affect the value of forest resources; such interdependencies are common in forestry. Examples include situations in which the harvest pattern and timing affects the probability of windthrow, and hence stumpage value; in which wildlife have habitat requirements over large areas that are affected by the age structure of multiple timber stands; and in which the logical unit of analysis for water production from forested areas is a catchment or drainage basin that contains many timber stands.

In the presence of significant stand interdependencies, single-stand analysis could lead to non-optimal forest harvesting. Bowes and Krutilla (1989) developed an analytical approach to a multiple-use problem in which stand interdependencies were defined as amenity values related to the age-class structure of the forest. They used a hypothetical data set to illustrate the effect of different multiple-use values on harvesting strategies. A number of scenarios were created in which stumpage price and discount rate varied. At low stumpage prices, some stands were harvested to provide more recreational benefits through increased diversity. With a higher discount rate, intermediate stumpage prices resulted in complete harvesting but no further forest management: neither the stumpage price nor the amenity value were sufficient to justify additional management. At the highest stumpage price, the forest was managed on a renewable basis for wood production. Bowes and Krutilla showed that multiple-use forest management may not converge to a steady state in the long run. Depending on relative values, fluctuating harvests may be the norm, with some stands managed under very short rotations and others preserved as old growth.

This discussion illustrates that there does not appear to be a general solution to the multiple-use management problem at the theoretical level. This means that simple rule-of-thumb management principles applicable to large areas are difficult to obtain. The qualitative nature of Bowes and Krutilla's solutions cannot be established without some numerical specifications. This is not unexpected given the complexities demonstrated by Hartman (1976), but it does contrast with the results obtained by applying Faustmann's (1849) methods. Straightforward general solutions and steady states (e.g., a simple progression of many age classes of timber stands) do arise from Faustmann's model, but the same cannot be said for economic multiple-use management. Multiple-use solutions for any given forest will depend on the initial endowments (i.e., the nature of the forest), relative values and costs. Thus, although the goal of a steady-state forest via a rule-of-thumb management principle such as maximum sustained yield may be operationally simple and therefore appealing, only by accident will such a strategy be socially optimal according to economic efficiency criteria.

Operational applications of any of the models described above are essentially cost-benefit analyses[4]. Cost-benefit analysis provides a basis for rational decision-making that has its roots in capital investment theory;

[4] There are numerous texts available on the principles and procedures of cost-benefit analysis (e.g., Dasgupta and Pearce 1972, Mishan 1977, Sassone and Schaffer 1978, Sugden and Williams 1978, Pearce and Nash 1981).

cost-benefit analysis is the appraisal of changes to the state of the world according to the criteria of intertemporal efficiency.

The most general criterion for socially worthwhile investments and management is that the discounted (present) value of all benefits less all costs occurring through time must be greater than or equal to zero. In the case of multiple-use forestry, this includes the management of all assets, priced and unpriced.

Although some regard cost-benefit analysis as providing a definitive decision rule, a more realistic interpretation is that it is a means of generating and organizing information relevant to decision-making through time (i.e., consumption and production possibilities for all relevant assets). In the end, it is always the decision-maker who makes the decision; the most efficient strategy may not be chosen on the grounds of equity or some other social considerations.

The type of cost-benefit analysis of interest in the present report is the evaluation of various forest management strategies that include both wood and a range of non-wood values. Foresters from public agencies do not appear to have widely accepted cost-benefit analysis and utilized it as a decision-making tool for management problems with intertemporal consequences. One concern could be that cost-benefit analysis ignores values that are not priced. However, unpriced values can, in principle, be included in cost-benefit analysis. The major problem lies in somehow quantifying measures of monetary benefit for the less tangible forest "outputs".

There are few cost-benefit analyses in the published literature that examine the multiple-use problem. Foresters know that the problem is not just one of social valuations. Another problem arises in identifying and enumerating the biophysical consequences of forest management activities. In many cases, these consequences are not well understood. Nevertheless, these problems lie in practice not in principle: cost-benefit analysis can, in principle, provide an internally consistent, systematic framework to generate information about alternative forest management strategies that include both priced and unpriced values. Another advantage is that the planner's beliefs about relative values, costs and biophysical consequences are revealed in a more open manner. Thus, at least part of the decision process could be open to public scrutiny.

It is beyond the scope of this report to delve further into the economic theory behind multiple-use management of public forests. Interested readers can consult Bowes and Krutilla (1989) for an excellent in-depth discussion of the subject. The following three sections attempt to clarify the concept of values in economics.

Categories of Economic Values

It is worth noting explicitly that economic values are anthropocentric by nature; that is, they are human-oriented and human-assigned. Non-anthropocentric concepts such as intrinsic value also exist and are a matter of concern to some members of the public. In practical terms, these values essentially deal with the inherent right of other life forms to exist, independent of humans. An elaboration of such a value system is beyond the scope of this report and in fact outside the realm of economics. For an interesting discussion of these values, see Redcliff (1990), and Pearce and Turner (1990). Nevertheless, economic analysis could be used to help identify what society might have to be prepared to give up to maintain a particular form of intrinsic value.

Figure 1 is a schematic diagram of various value concepts in economics. The two major categories are market and non-market values. *Market values* are determined in the marketplace through the interactions of demand and supply. Occasionally, market values are also described as *values in exchange*. *Non-market values* are those attributed by agents to goods and services for which there is no explicit market.

Non-market values can be further classified into use and non-use values. *Use value* refers to those preferences an individual has for participating in an activity. Examples include visiting a national park, hiking, camping, fishing, hunting, bird-watching, etc. Within the category of use value are consumptive and non-consumptive values. *Consumptive values* are those preferences associated with an activity that actually consumes environmental resources (e.g., hiking, camping, hunting, and fishing). *Non-consumptive values* are those associated with an activity that does not affect the resource (e.g., bird-watching in a national park, appreciating a view at a lookout). *Non-use values* can be further classified as existence, option, quasi-option, bequest and vicarious values.

Existence value refers to the value an individual places on the existence of a good or service even though he or she does not contemplate using it. For example, some individuals may value the existence of rainforests around the world, even though they may never visit one. Existence values are quite controversial and capturing them in economic analysis is a challenging task.

The concept of *option value* was introduced by Weisbrod (1964). It is the difference between *option price* and the expected benefits of a recreation service. Option price is defined as the maximum amount consumers, with uncertain supply, are willing to pay for an option to have resources or services available in the future (Bishop 1982). For example, some people who expect to visit a particular park would be willing to pay for an option that would guarantee their future access to the park. Notice, however, that *risk aversion* is necessary to the generation of a positive option value. This is because only a risk-averse person would care about supply uncertainty in the future and would be willing to pay a price for guaranteed future supply.

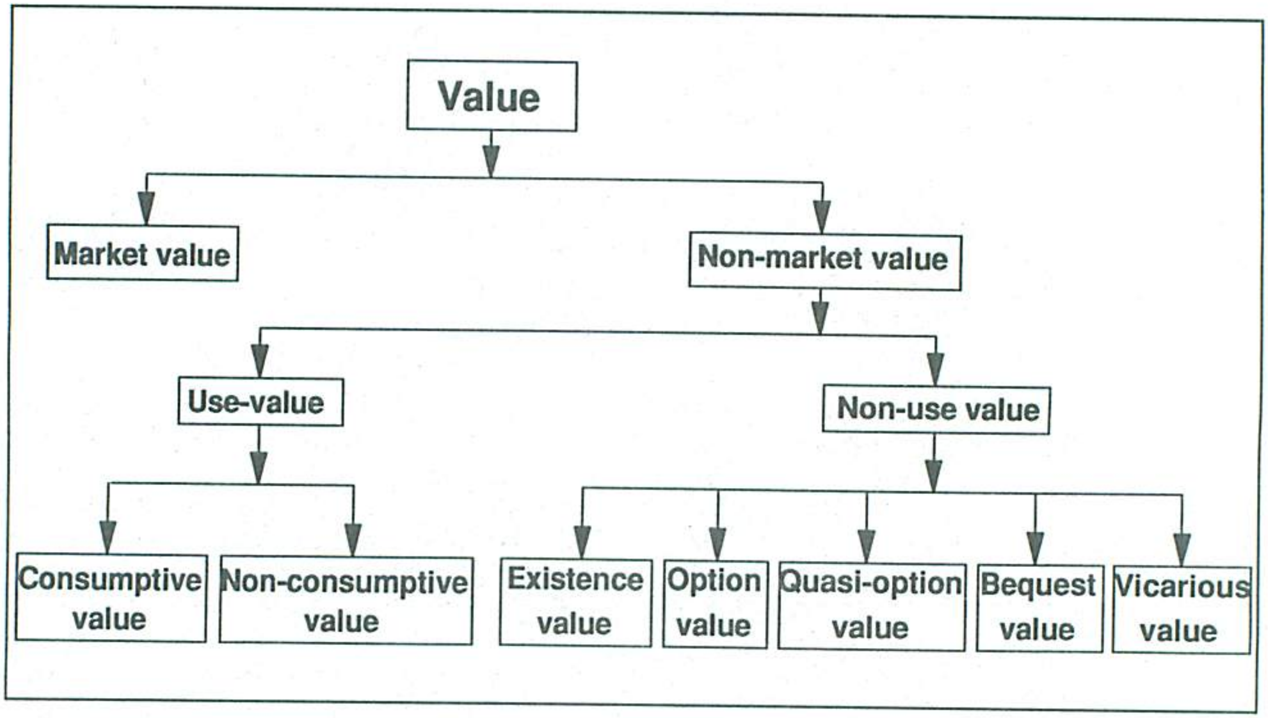

Figure 1. A schematic diagram of value concepts in economics.

The concept of *quasi-option value*, introduced by Arrow and Fisher (1974), is very different from that of option value. Quasi-option value can be defined as the value of the opportunity for obtaining better information by delaying a decision that may cause irreversible changes. Suppose the decision problem is whether to harvest a particular forest site or to preserve it. Based on the assumption of no new information, the decision-maker may be able to generate an expected value for preservation, say V*(o). While recognizing that new information is in the offing, he obtained an expected value for preservation say, V(o), which is as high as or higher than V*(o). The difference between V(o) and V*(o) is the quasi-option value, the expected value of better information conditional on choosing preservation at the present time (Hanemann 1983). For option value, the focus is on individual decision-making behavior under uncertainty whereas for quasi-option value the focus is on the public sector decision-makers who are evaluating public policies or projects under uncertainty (Freeman 1986)[5].

A *bequest value* refers to the value one places on being able to pass good things on to future generations. In a forestry context, a bequest value could occur when an individual is willing to pay for the preservation of natural biodiversity and/or wilderness so that his children or grandchildren would have the opportunity to enjoy the forest in a less disturbed state. Bequest value generally depends on the uncertainty associated with supplying "unique and irreplaceable" natural environments for future generations. Bequest value is different from existence value in that it is manifested by perceived *intertemporal* and *interdependent* preferences (Brookshire et al. 1987). This essentially means that people in the present think that people in the future will desire these things as they themselves do. Concepts such as option value and bequest value can be linked to the notion of "safe minimum standards" (Ciriacy-Wantrup 1968). Policies such as implementing buffer strips and land withdrawals for reserves and wilderness are related to uncertainty of supply for unpriced resources to future generations.

Finally, *vicarious value* occurs when individuals derive satisfaction simply from knowing via pictures, descriptions and accounts made available through the various media that certain rare species (e.g., spotted owl, pine martens, peregrine falcons, etc.) and environmental amenities (e.g., old-growth forests) still exist. In the case of vicarious consumption there is no motive other than the mere knowledge of the existence or preservation of a natural environment (Krutilla and Fisher 1975). Because of this characteristic, vicarious values are often recognized as a variant of existence values in the economics literature.

Some additional categories such as scientific, scenic, genetic, stewardship, altruistic, on-site, off-site and

[5] For more discussion of option and quasi-option values, see Bishop (1982), Freeman (1984, 1985a), Fisher and Hanemann (1986) and Smith (1983, 1984, 1985).

preservation values, among others, have also been proposed in the literature. However, a close look at these values reveals that they can generally be accommodated in the value concepts discussed above.

Although our classification is somewhat arbitrary, the above discussion is a relatively complete taxonomy of various value concepts recognized in the economics literature. If the purpose of an economic analysis is to examine and evaluate trade-offs, the values of most interest are those that compete with each other. Keeping this in mind can help narrow the scope of any particular analysis.

Valuation of Goods and Services in a Market Context

The value a person assigns to something is related to his or her own preferences. Economists do not generally ask how people form their preferences; they simply assume that human actions are based on preferences. Given initial endowments of resources, agents (i.e., producers and consumers) will trade back and forth, if allowed to trade, until there are no remaining possibilities for trading, which will increase the utility for all agents involved. At this stage, the value of the good to the consumer is the maximum amount of scarce resources that he is willing to give up in exchange for the good. Similarly, for a producer it is the minimum amount he is willing to accept in return for giving up the good. When there is a match between the maximum willingness to pay and the minimum willingness to accept, the system is said to be in *equilibrium* and the value determined through this process is unique. This is known as the *market model* and is depicted in Figure 2.

The demand and supply curves in Figure 2 represent the maximum willingness to pay and minimum willingness to accept, respectively, for the good. The intersection of these market demand and supply curves at E_0 determines a

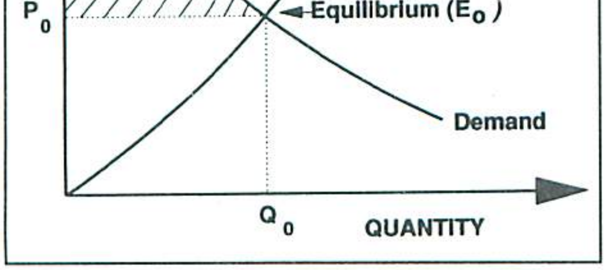

Figure 2. An illustration of the market model.

unique value P_0 (which is also the price in this case) and equilibrium output quantity Q_0. The shaded area under the demand curve and above the price line (i.e., the area BP_0E_0) is called the *consumer's surplus*. This is the difference between the maximum amount all consumers are willing to pay for a total quantity equal to Q_0 and the total amount they actually pay. The valuation is unique in this case because the market provides an institutional exchange arrangement that helps moderate the willingness to pay and willingness to accept bids through time. Can such a valuation system be applied to the provision of unpriced values? This leads us to the next section.

METHODS OF VALUING UNPRICED GOODS AND SERVICES

Non-market valuation involves identifying *perceived preferences*. This turns out to be a rather challenging task. The reason is not because the task is difficult conceptually, but because of the inherent problems associated with eliciting preferences in a systematic, reliable way that is useful to decision-makers. Nevertheless, during the last three decades a number of valuation methods have been developed to derive monetary measures of the value of changes in the quality or quantity of unpriced goods or services. Applications have included assessing the value of: days of outdoor recreational activities (e.g., boating, camping, canoeing, fishing, hiking and hunting); the effects of changes in environmental amenities (such as scenic vistas, water quality, wildlife habitat, etc.) on recreational activities; and the effects of environmental attributes on property values (e.g., air pollution, water and noise pollution, acid rain, etc.). In addition, attempts have also been made to estimate the value of endangered species, rainforests, and the preservation of wetlands. The non-market valuation techniques can be classified into two major groups, *direct* and *indirect* methods.

The direct approach uses surveys or interviews to obtain individual valuations for hypothetical changes in natural resources and environmental amenities. The direct approach is based on the assumption that the respondents understand the good/service to be valued, its present situation and the hypothetical changes in quantity and quality of the good/service.

The indirect approach, also known as the market approach, relies on the use of market information. Three of these methods (the travel cost, hedonic price and household production function methods) are described in later sections. A number of variations of each of these methods also exist in the economics literature.

The assumption of *weak complementarity* between market goods and environmental goods or services is at the heart of all indirect methods. This assumption implies that some market goods such as a fishing rod, fishing tackle, etc.,

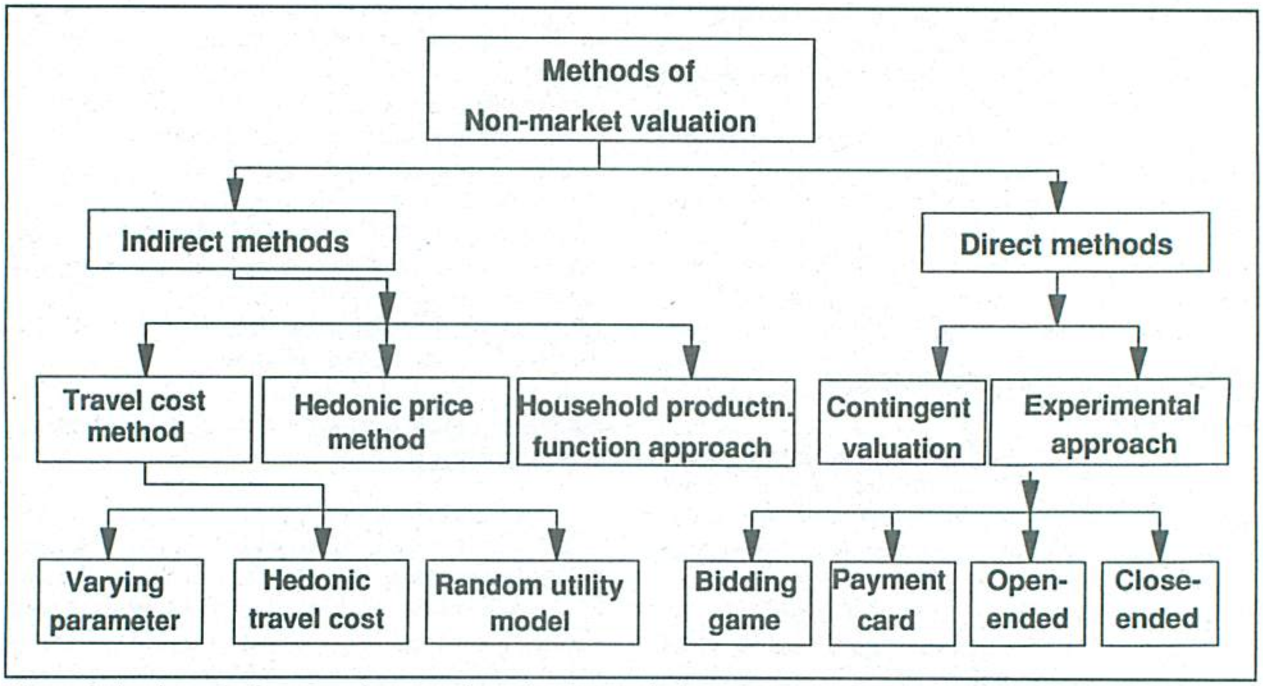

Figure 3. A schematic diagram of non-market valuation methods.

are purchased because they are complementary to a fishing trip (an environmental good). Thus, behavior in actual markets can be used to reveal the value of non-marketed goods and services. This complementarity assumption, however, rules out the estimation of non-use benefits by the indirect methods: if no related market goods are consumed, there is no apparent demand for the environmental amenity.

Figure 3 is a schematic diagram of various unpriced valuation techniques described in this report. The following sections elaborate on each of these techniques along with their strengths and weaknesses.

The Contingent Valuation Method

Contingent valuation uses surveys to elicit consumer willingness to pay or willingness to accept for un-priced goods and services[6]. The approach is based on the assumption that individuals are capable of answering questions to reveal their preferences for public goods or services (Mitchell and Carson 1989). The method is called "contingent" because the valuation questions are couched in some hypothetical market setting.

The developmental history of the contingent valuation method is quite interesting. Although Ciriacy-Wantrup (1947) suggested the use of direct interviews to measure the non-traditional values of natural resources, the contingent valuation method did not come into use until the early 1960s. Davis (1963) first used this method to estimate the benefits of outdoor recreation in a Maine backwoods area. In the early 1970s, a number of economists followed Davis' lead and used the contingent valuation method to value different recreational amenities. By the mid 1970s, the contingent valuation method was recognized by the U.S. Environmental Protection Agency and the U.S. Water Resources Council as a credible benefit-estimation technique. For a detailed discussion of the historical development of the contingent valuation method, see Mitchell and Carson (1989).

The literature on contingent valuation has become extensive. The method has been used to determine values for a wide range of environmental services; for example, air quality improvements in Los Angeles (Brookshire et al. 1982), acid rain reduction (Johansson and Kriström 1988), agricultural pollution control (Hanley 1988), water quality improvements (Desvouges et al. 1987), forest recreation in the U.K. (Hanley and Common 1987) and wilderness preservation in Colorado (Walsh et al. 1984). Both Cummings et al. (1986) and Mitchell and Carson (1989) provide a thorough discussion of the approach from theoretical and practical perspectives.

Generally, a contingent valuation interview consists of three parts. In the first part, the researcher constructs a hypothetical market and presents it to the respondent; he describes the good or service to be valued, the benchmark level of provision, the range of available substitutes and the method of payment or compensation. This is followed by a set of valuation questions to elicit the respondent's maximum willingness to pay for the good or service being valued. Finally, a third set of questions is asked to collect

[6] Note that willingness to pay may not always equal willingness to accept. This point is explained later in this section.

information about the respondent's characteristics (e.g., age, income, previous experience with the good or service being valued, use of other related goods or services, etc.). If the survey is carefully designed and pretested, individual responses to the valuation questions would generate measures of willingness to pay or accept that correspond to the theoretical measures of economic welfare changes (see Just et al. [1982] and Mitchell and Carson [1989] for details). The revealed willingness to pay values can then be used to estimate aggregate benefits.

The contingent valuation method is based on the assumption that respondents have a clear understanding of the goods/services being valued, their current status, the hypothesized extent of changes in their quality or quantity and the method of payment. It also assumes that the respondents understand that the payment amount represents their maximum willingness to pay for the good/service being valued, not necessarily its fair price. Mitchell and Carson (1989) provide an elaborated discussion of these assumptions[7].

The objective of a contingent valuation study is to obtain measures of consumer surplus (Fig. 2) from the respondents. This is the maximum a respondent is willing to pay for an amenity before deciding to do without it. Depending on the nature of the good or amenity being valued, the respondents may find it difficult to properly reveal their maximum willingness to pay for the amenity. Contingent valuation researchers have developed different elicitation methods to make it easier for respondents to complete the valuation process and to reduce the number of non-responses and/or zero responses. Four major elicitation methods are described here: (i) the bidding game, (ii) the payment card, (iii) the open-ended, and (iv) the close-ended elicitation methods.

The *bidding game* is the oldest and most commonly used contingent valuation technique (Davis 1963). Once the amenity to be valued and the hypothetical market in which the amenity is to be traded are described to the respondent, the interviewer suggests a starting bid. If the respondent is willing to pay the initial bid, the interviewer gradually revises the bid upward until a negative response is obtained. Similarly, if there is a negative response to the initial bid, the interviewer gradually revises the bid downward until an acceptable bid is found. A few offshoots of the traditional bidding game have also been used in recent contingent valuation literature. For instance, whereas Schulze et al. (1983a,b) allowed respondents to choose the starting bid, Cummings et al. (1986) cite studies in which "payment cards" (see below) were used to establish the initial bid and the bidding game continued from there on. The bidding process helps respondents to evaluate their preferences step by step and, therefore, can capture the highest price consumers are willing to pay for the amenity. However, because of starting point bias and the potential lengthy interview procedure, use of the bidding game approach has been decreasing in recent years. Starting point bias means that the starting bids may unintentionally influence the results.

The *payment card* method was developed by Mitchell and Carson (1984) as an alternative to the bidding game in an attempt to avoid the starting point bias. In this method, payment cards portray a range of dollar values beginning at zero and increasing at fixed intervals; there is no need for a single starting value. Estimates of payments for selected public goods made in the most recent year by people from a specific income group are presented on each payment card. After the initial conversation and description of the good to be valued and the hypothetical market it is traded in, each respondent is given a payment card corresponding to his income category and asked to state a value for the good in question. This response is final and no bidding is necessary. For modified versions of the Mitchell-Carson payment card method, see Desvousges et al. (1983) and Randall et al. (1983). The payment card method is potentially vulnerable to the biases associated with a limited range of dollar values and other information portrayed on the payment cards. Because of such biases, this elicitation method has also been losing popularity in recent years.

In the *open-ended* method, respondents are asked to reveal their maximum willingness to pay for an amenity and are given a range of values to choose from, including a blank spot for the respondents to put a value in. In a *close-ended* format, on the other hand, respondents are not asked to put a value on the good or service to be valued; instead, they are asked to vote "yes" or "no" to the values presented to them. The listed amount is varied across individuals in the sample. The data generated are used to determine the probability of accepting a bid as a function of the bid amount. Finally, the expected value of the bid is determined as the probability of acceptance multiplied by the actual bid (see Hanemann [1984] for details).

Dichotomous choice and *multiple-question discrete choice* are only two of a number of possible variants of the close-ended format. In a dichotomous-choice question, respondents are given only two alternative answers to

[7] The valuation measures obtained by the contingent valuation method can be thought of as the difference between two expenditure functions. The expenditure function is one of the four equivalent ways to represent the constrained utility maximization problem. The difference represents the Hicksian compensating surplus, which can be positive or negative. If it is positive, the consumer would be willing to pay up to the point at which his utility is restored to its initial level. If it is negative, then the amount would represent the minimum compensation the consumer would be willing to accept. See Blackorby et al. (1978) and Varian (1984) for details.

choose from; in multiple-choice questions, they have more than two choices. Because of the ease of administering the interview and controlling bias, these formats are gaining popularity in recent contingent valuation studies.

To illustrate the contingent valuation method, consider the following scenario about biodiversity in Canadian forests. (Let us suppose for the moment that there was no controversy about defining biodiversity.) How much biodiversity is to be preserved? How could we measure the perceived benefits of preserving biodiversity in Canadian forests? Since biodiversity is neither a market good nor a weak complement to any market good, the benefits of preserving biodiversity cannot be measured by the travel cost or any other indirect methods of non-market valuation. The contingent valuation method appears to be the only feasible technique of valuation in this case. For example, a close-ended contingent valuation format could be used to ask people (both users and non-users of forests) to reveal their maximum willingness to pay for preserving a specified level of biodiversity in Canadian forests. The individual willingness to pay values could be used to generate an estimate of aggregate benefit for the specified level of biodiversity preservation.

The major strength of the contingent valuation method lies in its flexibility. It can be used to measure use values as well as non-use values and with fewer assumptions than some of the other approaches. As well, it can be used to measure the value of changes in the quantity as well as quality of an environmental good or service. The major weaknesses of the contingent valuation method include:

1) Respondents may not be able to determine their preferences for the good(s) in question in relation to other goods and services.
2) Respondents may respond in a way that does not reflect their true preferences.
3) Respondents may respond in a way that reflects attitudes as opposed to intended behavior.
4) There is a possibility of biases and other influences caused by the questionnaire design or the interviewer (Boyle et al. 1985).
5) Identifying the relevant population can be difficult for some environmental values, particularly non-use types.
6) There is a problem with informing respondents of the implications of changing environmental services. Increased information and decreased uncertainty may change relative preferences.

Well-designed surveys can reduce some of these weaknesses. The contingent valuation method appears to give results comparable to those of other methods (Duffield 1984, Seller et al. 1985, Hanley 1988).

Another problem associated with contingent valuation is that valuation questions asked in different orders may produce different results—a *sequence bias*. Kahneman and Knetsch (1992) consider still another problem in contingent valuation studies, called the *embedding effect* or the *part-whole, symbolic* or *disaggregation* effect. This means that respondents may assign a lower value for a good if it was considered within a more encompassing context than if it was evaluated on its own. This problem is best described through an example. Toronto residents were found to be prepared to pay only a little more to preserve fish stocks in all Ontario lakes then to preserve them in a small area of the province (Muskoka). This raises some important questions. Which value is appropriate to use for Muskoka? Should the greater value for the small area be expanded to represent the whole province, or is the lower value for the province more appropriately applied at the regional level?

Kahneman and Knetsch (1992) suggest an explanation for the embedding effect: that contingent valuation method subjects are actually expressing a willingness to pay for "a sense of moral satisfaction for contributing to a public good" rather than a willingness to pay for consumption (a true economic value). This view of contingent valuation is controversial and not held by all economists working in the area. Mitchell and Carson (1989), for example, take the view that the contingent valuation method is reliable enough for routine use provided enough care is taken in the exercise. Smith (1992) provides a similar viewpoint on this issue.

A major controversy also exists over the apparent disparity between willingness to pay and willingness to accept. This problem often arises from contingent valuation studies but is not necessarily an artifact of the method itself. There has been a general presumption in the environmental economics literature that willingness to pay and willingness to accept should not differ much (Freeman 1979a, Thayer 1981, Knetsch and Sinden 1984). There are, however, contingent valuation studies that offer evidence of large disparities between willingness to pay and willingness to accept (see Cummings et al. [1986] and Fisher et al. [1988]). This has raised questions about the reliability of contingent valuation results and the robustness of the method (Knetsch 1990). Are economists asking the right questions? When is willingness to pay appropriate, and when is willingness to accept more appropriate?

Very recently, Hanemann (1991) resolved at least some of the controversy over the issue of disparity between willingness to pay and willingness to accept measures theoretically. His analysis showed that these two measures may differ quite substantially due to small (or zero) substitution effects between the private goods and public goods. He showed that under certain situations the substitution effects can outweigh the income effects on the measures, producing great disparity between willingness to accept and willingness to pay. Hanemann concluded that the empirical divergence between willingness to pay and willingness to accept measures is not necessarily indicative of the inadequacy of the contingent valuation methodology.

Clearly, the difficult issue for analysts to consider is the potential for substitution between public and private goods so that they know the appropriate questions to ask in a particular context (i.e., willingness to pay or willingness to accept).

Despite its shortcomings, the contingent valuation method is the most easily understood and popular of the direct techniques of non-market valuation. The theoretical underpinnings of the method are well explained in Mitchell and Carson (1989). More than 100 published journal articles between 1975 and 1991 have used the contingent valuation method to measure a variety of use and non-use values of natural resources and environmental amenities.

The Travel Cost Method

The travel cost method is the most popular of the indirect approaches to non-market valuation. The basic travel cost model is based on the premise that even when there is no entry fee to use a public recreation site, recreationalists pay an "implicit price" for the site's attributes or services when they visit it. This implicit price is the cost to travel to the site. Included in this cost are vehicle-related costs and time costs of the trip. If visitors are coming to a particular site from different origins (distances) and if there is variation in the number of trips they take, a demand function for the number of trips can be estimated. This demand curve can then be used to obtain measures of individual willingness to pay and total consumer surplus. The latter indicates the economic value of the site[8].

The intellectual origin of the travel cost method is also quite interesting. The National Park Service of the United States sent a solicitation to 10 economists in 1947, asking them to suggest methods for measuring the economic benefits of national parks and other publicly managed areas. Harold Hotelling responded with the description of a method using travel cost to visit a park as the "implicit price" for visiting the site; however, he did not implement the proposed method and the National Park Service apparently ignored his suggestions initially (Smith 1989). Although the conceptional origin of the travel cost method is attributed to Harold Hotelling, its operational development and current popularity are due to Clawson (1959), Knetsch (1963, 1964), and Clawson and Knetsch (1966).

The basic travel cost model is based on a number of stringent assumptions. First, it assumes *weak separability* between demand for recreation and demand for market goods. Weak separability in this context means that changes in demand for a market good (e.g., a VCR) will have no impact on the demand for recreation (e.g., a ski trip to Colorado); only changes in the proportion of total income spent on the market good can affect the demand for recreation. Second, the model assumes that all recreation choices are made simultaneously and that the number of trips to be taken at a particular site is determined at the beginning of the season. Third, trips of different lengths (e.g., 1, 2 or 7 days) are assumed to be different goods, even if the trips were taken to the same site. Fourth, it assumes that the characteristics of all goods and sites and all prices are known with certainty. Finally, all of the prices, costs, income and site qualities are assumed to be *exogenous* to the choices of individual visitors. This implies that an individual recreationist's decision cannot or does not influence these factors. The basic travel cost method also tends to ignore the influence of substitute sites on the demand for visits to the site in question. In part due to these assumptions, modeling demand using the travel-cost model has been troublesome and has received considerable attention in the outdoor recreation literature[9].

To illustrate the travel cost model, consider the case of moose hunting in Ontario. Moose hunting is one of many services offered by Ontario's forests. Moose hunting season starts in the fall each year and lasts between 2 and 8 weeks. The OMNR sells hunting permits at a nominal price before the beginning of the season each year. Hunters from different parts of Ontario and neighboring provinces or states travel, in some cases great distances, to be able to hunt at particular locations. The price an individual pays to buy a hunting permit does not reflect the full economic value of the service offered by Ontario's forests. Can we measure the full economic value of moose hunting so that resource planners would have better information on where and for how many moose to manage? The travel cost model could be used to help do the job. If data were collected from individual hunters about where they came from, where they went, how much they paid for the permit, how many trips they took that season, the duration of each trip, their income, age, and number of years of hunting experience, information about other hunting sites, etc., then a demand function for moose hunting could be estimated. This demand function could be used to estimate people's willingness to pay for moose hunting and its total economic value. Appendix A

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[8] The most widely used measure of benefit in resource and environmental economics studies is consumer surplus. As mentioned earlier (see Figure 2), consumer surplus is the area under the demand curve and above the implicit price (i.e., the travel cost in this case). There are other measures such as compensating and equivalent variations that relate to the Hicksian (income compensated) demand function. For a good discussion of these measures and the relationships between them, see Just et al. (1982) and Broadway and Bruce (1984).

[9] To limit the scope of this report we have not discussed the troubling aspects of demand modeling. Interested readers should consult McConnell (1985), Smith (1989, 1990) and Fletcher et al. (1990).

provides a mathematical representation of what this exercise would involve.

The basic travel cost model estimates the gross value of a site at a point in time. It ignores the effect of quality changes on the demand for the site. Thus, it does not provide information on the value of quality changes, which is what decision-makers really need in their attempt to balance the costs of different management options against their potential benefits. In the 1980s, a number of important variants of the basic travel cost model were developed to analyze quality changes. These variants are briefly outlined below.

The first is the *varying-parameter* travel cost model. In this model, an individual's decision to visit a particular recreation site is assumed to be based on two sets of variables: (1) the costs to visit the site and the visitor's socioeconomic constraints, and (2) the characteristics of the site. Whereas the basic travel cost model incorporates the first set of variables, the varying-parameter travel-cost model attempts to incorporate both sets of variables.

The varying-parameter model involves a two-step procedure. The first step is an estimation of separate demand functions for each individual site. The estimated parameters are used as data for the second stage of the model, in which these parameters are regressed against various site attributes. The underlying hypothesis is that the parameter estimates vary because of differences in the site characteristics. The results of systematic parametric variations across sites can be used to determine the effect of quality changes on the value of a site[10].

The second variant of the basic travel cost method is the *hedonic travel cost model*. This model was introduced by Brown and Mendelsohn (1984) and also attempts to incorporate site characteristics into the basic travel cost model. Although the theory underlying this model is comparable to that of the varying-parameter model, its empirical orientation is quite different. In the varying-parameter model, the focus is on systematic variation of visitation demand parameters that arise due to variation in site characteristics. In the hedonic travel cost model, however, the focus is on actual estimation of demand for different site characteristics. The hedonic travel cost model assumes that individuals are willing to incur higher travel costs to visit sites with better quality or more attractive attributes.

Application of the hedonic travel cost model is a three-step procedure. In the first step, the implicit prices of characteristics are calculated. In the second step, the demand for trips is estimated by regressing the number of trips on the "price" of each characteristic and a set of socioeconomic variables. In the final step, demand functions are estimated for various site characteristics. This is done by regressing each characteristic's price on the quantities of all the characteristics, the number of trips, and on socioeconomic or other information (e.g., disposable income and prior experience)[11].

Two important issues related to the implementation of the hedonic travel cost model are: (1) how to define origin zones surrounding each model area, and (2) how to handle negative prices for the site characteristics. Although the definition of origin zones does not affect the estimated demand functions significantly, it can influence the benefit measures (Smith and Kaoru 1987). Second, there is no guarantee that the model will generate positive prices for site characteristics during the regression analysis. In fact, the existence of negative prices for some characteristics is quite common in hedonic travel cost applications (cf. Brown and Mendelsohn 1984, Mendelsohn 1984, Bockstael et al. 1987, Smith and Kaoru 1987, Smith et al. 1989, Adams 1990). A naive interpretation of negative prices is that recreationists would be willing to pay for not having those characteristics at the site in question. Nonetheless, negative prices remain a troubling aspect in the application of hedonic travel cost models.

The hedonic travel cost method is not simple to operationalize. It requires a great deal of data and expertise for analysis and interpretation. Despite these limitations, the model provides an interesting approach to estimate the impact of quality changes on the value of a site and it has already attracted considerable research attention from economists.

A third variant of the basic travel cost model is the *random utility model*. The random utility model essentially imposes some structures on how recreation choices are made by individuals. These structures are consistent with the notion of consumers maximizing their utility or satisfaction by choosing between possible recreation sites. This model can estimate recreation demand functions for several sites, including the possibility of zero consumption for some sites. It also incorporates site qualities and allows for substitution possibilities across sites.

Although the varying-parameter model and the hedonic travel cost model incorporate different site

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[10] Notice that this is an indirect approach to quantification of the effect of quality changes on the value of a site. Policymakers are often concerned with the temporal changes in quality of a particular site. The usefulness of the varying parametric approach lies in the fact that it provides a lower and an upper bound on the effect of quality changes. For detailed discussions on varying-parameter models and the varying-parameter travel cost model, see Maddala (1977, 1983), Vaughan and Russell (1982) and Smith and Desvousges (1986).

[11] In order to reduce the biasing effects of measurement error inherent in the hedonic prices, Brown and Mendelsohn (1984) recommended the use of the inverse demand functions instead of the regular demand functions for site characteristics.

characteristics, different sites are not explicitly treated as distinct alternatives. In real life, different sites are more likely to be seen as distinct alternatives. Moreover, neither the basic travel cost model nor the above two extensions to the model can account for changes in the extent of the market for recreation due to changes in policy, as each ignores the possible effects of changes in site characteristics on individual participation decisions. The introduction of the random utility model as a variant of the basic travel cost method may be considered as a response to these concerns.

The random utility model introduces four major assumptions. First, the time horizon of decision-making is altered; the trip decisions are made one at a time by individuals rather than all at the beginning of the season, as assumed by the basic travel cost model. Second, the model assumes that trip decisions taken during a season are independent of one another. Third, the model assumes that individuals are capable of comparing the utility that could be realized from all other related decisions, conditional on the selection of a particular site. Fourth, for each possible location, the choice is assumed to have both deterministic and stochastic (random) elements to it.

The stochastic element reflects the researcher's ignorance of all other factors that could possibly influence the decision process[12]. For each location chosen, the decision structure of an individual is assumed to result from two separate choices. The first choice involves whether to undertake a specific recreational trip (e.g., deer hunting, fishing, canoeing, etc.) given that the individual is among that form of recreation's user population. After a "yes" decision is made to the first choice, the second choice involves selecting a particular site from a set of alternative destinations where the recreational activity can be undertaken. A mathematical representation of this model is given in Appendix B.

One key feature of the random utility model is that it readily incorporates choice among multiple sites in a travel cost model; the attractiveness of a site in relation to other sites influences the probability of a visit in this model. Moreover, because one must estimate the parameters of a utility function, computing welfare estimates for changes in site characteristics is straightforward in this model (Hanemann 1982).

As with the hedonic travel cost model, the added complexity makes application of the random utility model more difficult. This stems from attempting to model individual recreational behavior more accurately. The added cost of complexity in exchange for more accuracy must be weighed against the type of decisions for which the information would be used.

The travel cost model and the variants described above provide a useful analytical framework in which to describe and test individual recreation behavior. The refinements of the basic travel cost model over the last two decades have considerably improved its general acceptability. The model has now been accepted as a tool for quantitative policy analysis in natural resource management in numerous jurisdictions and has been accepted as evidence in court cases in Canada and in the United States[13].

Recently Smith and Kaoru (1990) have documented the story of the travel cost methodology in measuring the values people place on the use of recreational resources. They conducted a "meta analysis" on welfare estimates derived from some 200 recreation demand studies completed since 1970 that used the basic travel cost model to investigate if those measures were systematically related to the types of resources involved and the assumptions made in developing them. The analysis revealed a remarkable consistency between models and their findings. The major strengths of the travel cost model are its simplicity and its exclusive reliance on observed behavior. This corresponds to the traditional economic approach to estimation of demand. The general weaknesses of the travel cost model include the following:

1) The behavioral model specified by an analyst may not reflect the actual decision process of a recreationist.
2) The observations of travel costs and site characteristics may not be enough to reasonably describe the decision process. Individual perceptions of site attributes affect decisions and the perceived qualities are often different from the objective measures used by analysts. There has been little use of perceived quality measures in these models.
3) The measurement of the value of time (both the time used to travel to a site and the time spent on the site) and its use in demand modeling still plague the travel cost models. The appropriate value to place on both traveling time and time at the site has not yet been resolved in the literature (Cesario 1976, Wilman 1980).
4) The definitions of a "site" and "origins" are still ad-hoc in travel cost models.
5) It is still not clear how to incorporate congestion in multiple-site models.
6) Travel cost models ignore demand uncertainty.
7) Many researchers emphasize that different behavioral assumptions in travel cost models result in significantly different measures of benefit. The behavioral models implied by all previously used travel cost models are

[12] An alternative interpretation is also possible. The stochastic component in the random utility model may also reflect uncertainty affecting an individual's decision, not just the researcher's ignorance. See Morey et al. (1988) for details.

[13] For an interesting application of the travel cost model to natural resource damage assessments in an American court, see Kopp and Smith (1989).

rather restrictive because they do not incorporate measures of familiarity and learning in an individual's decision-making process.

8) The most important limitation of travel cost models is that they cannot be used to measure the non-use values of natural resources and environmental amenities.

Hedonic Price Models

The term "hedonic" is derived from the Greek word *hedonikos*, which means pleasure (i.e., *utility* in economics). Hedonic price models are based on the hypothesis that goods are actually aggregations of characteristics and that demand for goods relates to these characteristics. This implies that characteristics are the true arguments of utility functions and that any transaction is therefore tied to a bundle of characteristics. Thus, the demand for quality attributes or particular characteristics is embedded in the prices and consumption level for market goods. Hedonic price models have been developed to quantify the contributions of the market and non-market components of a particular good to its market price through statistical analysis. The hedonic price model is based on the following assumptions. First, the observed prices reflect equilibrium conditions in the market. Second, the model assumes that both the buyers and sellers of properties have perfect information about the market and non-market components of the good and that the movements between properties in response to changes in market conditions is costless. Third, it assumes that an individual's willingness to pay for one attribute is independent of other attributes.

For an example, consider that the price of a house in a city includes the contribution of market goods (e.g., size and design of the house, number of rooms etc.) and the neighborhood environmental conditions (e.g., air quality when near an abattoir, noise pollution if near an airport, etc.). With enough information about house prices and characteristics across a wide range of neighborhoods it is possible to estimate the inferred values of the environmental characteristics. The value of the house with respect to any attribute (e.g., air quality) is the implicit price of that attribute. Thus, it represents the consumer's willingness to pay for the attribute (Wilman 1984)[14]. In this example, the estimation of the effect of changes in environmental quality on the welfare of individuals is possible through an examination of property values.

To illustrate the hedonic price model in a forestry context, consider the following scenario about property values around a number of forest conservation areas or provincial parks that provide comparable services to visitors. These property values reflect the price of the property itself (i.e., size of the property, the house, the number of living rooms, the presence of a fireplace, etc.) and the environmental amenities surrounding the property (i.e., the quality attributes of the neighborhood and the ease of access to different amenity services such as trails, canoe routes, good fishing holes etc.). The hedonic price model can be used to measure an individual's willingness to pay for a change in the quality of an attribute (e.g., the ease of access to lake services in the park). In addition, a measure of the aggregate marginal benefit for a change in quality can also be derived[15].

The major strength of the hedonic price model is that it represents a very realistic "demand" and "supply" framework to determine the value of a change in quality attributes. This feature is not present in any other technique of unpriced valuation. Second, the model relies on expenditure data that are readily available.

The weaknesses of the hedonic price model are related to its assumptions. Since individual perceptions of quality attributes differ and change through learning, the "perfect information" assumption seems implausible. Second, issues of uncertainty are ignored in this model. Third, if the property values contain the capitalized values of recreation (i.e., if property prices reflect recreation values), then the implicit hedonic price will substantially overestimate the marginal willingness to pay for an attribute (McConnell 1990). Fourth, not all consumers own properties surrounding national parks or other resort areas and their valuation of environmental goods and services can be quite different from the implicit valuations of property owners. Hedonic pricing does not capture non-use benefits. Despite these weaknesses, hedonic price models do provide an interesting approach for revealing the value of some environmental amenities.

Other Approaches

The two other approaches briefly described in this section are the *household production function* and *experimental economics*.

The derived value for an "increment" or "decrement" of an environmental good or service could be given a more useful interpretation from a policy perspective if it was related to both public policy actions and individual decision-making. The household production function provides an

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[14] A hedonic price model was used by Griliches (1971) to estimate the value of quality changes in consumer goods. The hedonic price theory was further developed and refined by Rosen (1974). The model was used to evaluate the effect of air quality on urban property values by Harrison and Rubinfeld (1978), Nelson (1978) and Freeman (1979b). For a broader discussion of the hedonic price technique, see Freeman (1979a).

[15] However, this measure of benefit reflects a marginal change in quality. For a discussion on approximating the benefits of non-marginal changes in hedonic price models see Freeman (1985) and Bartik (1988).

intuitively appealing approach to constructing a model of recreation behavior that can establish a linkage between public policy and private decisions. Although the travel cost model and the hedonic price model provide credible estimates of benefits for a variety of environmental goods and services, they are not quite successful in establishing the link between public policy actions and private recreation decisions.

In the household production function model, individuals buy certain private inputs at market prices and combine them with their time and publicly provided natural resources and environmental amenities to produce outdoor recreational experiences. The model involves a two-stage optimization process. In the first stage, the household minimizes the cost of producing a given level of services. In the second stage, the recreationist maximizes his utility subject to a budget constraint to determine the level of recreational experiences to consume. One interesting feature of this model is that when households are unable to substitute their own inputs for any publicly provided input, the model is simplified to a simple travel cost model (Bockstael and McConnell 1981, McConnell 1985)[16].

The household production function approach is based on the assumption that the prices and qualities of private goods are known to the household with certainty. A second assumption is that the individuals have complete information on the quantity and quality of publicly provided natural resources and environmental amenities.

The major strength of this model lies in its conceptual structure, which establishes a link between public policy actions and private recreation decisions. The weaknesses of this model relate to its actual implementation. It is quite difficult to estimate the benefit measures if the quality and quantity of environmental resources are both endogenous to the model. In the household production function model, both quantity and quality and their marginal costs are endogenous. This poses a serious estimation problem in practical applications. The problem becomes even more complicated because costs are not directly observable. These problems have prevented the household production function approach from becoming a widely used tool for measuring the benefits of natural resources and environmental amenities.

Experimental economics is another method of non-market valuation of environmental goods and services. In this case, experiments are conducted in a controlled environment to elicit valuations. Conducting experiments in environmental economics is generally difficult and costly and only a few such studies exist in the literature (see Smith 1991). The approach is generally not deemed to be practical.

Our survey of the literature on non-market valuation reveals two interesting features. First, most of the published research efforts have concentrated on the development and refinement of the logic of the methods. Second, empirical applications have mainly taken place in the United States. In general, very little empirical analysis on non-market valuation has been done in Canada. Part of the task of this report was an extensive literature search of non-market valuation studies in Ontario. Departments at all universities in Ontario, a number of consultants, and various federal and provincial organizations were contacted and a number of published and unpublished studies were found. The following section discusses the findings.

ONTARIO CASE STUDIES

About 30 studies conducted in Ontario show close resemblance to non-market valuation in their titles. However, a closer look revealed that many were economic impact studies that considered only the impact of certain activities on local communities in terms of the throughput of the market economy on creating business, jobs, etc. Unpriced valuation studies are quite different from impact studies. Only the unpriced valuation studies are relevant for cost-benefit analyses. Impact studies do not weigh the costs and benefits of a particular policy option through time. Our final sample consisted of 19 studies that used some form of unpriced valuation method to estimate the value of particular non-marketed services in Ontario. These studies were carried out during the 1975–1991 period. Table 2 provides an overview of these studies.

Of the 19 studies, four dealt with the recreational values of wetland, four with the benefits of water quality improvements and five with the value of sport fishing in Ontario. Attempts were also made to quantify the value of wildlife recreation, of acid rain damage to sport fishing, and of reduced risk as a result of the Air Pollution Control Act in Ontario. Ten of the 19 studies used forms of the travel cost method to estimate non-market benefits. Brief descriptions of individual studies, along with their major findings, strengths and weaknesses, are provided in the following sections. Four independent studies are covered first, followed by seven studies sponsored or cosponsored by the Ontario Ministry of the Environment (OME). Seven studies sponsored or cosponsored by the Ontario Ministry of Natural Resources (OMNR) are presented at the end.

[16] The household production theory was developed by Becker (1965) and was subsequently refined to its present form by Muellbauer (1974). The usefulness of the household production function model in modeling individual recreation behavior has been explored by Deyak and Smith (1978), Bockstael and McConnell (1981, 1983) and Brown et al. (1978). The results were not very encouraging despite the intuitive appeal of the theoretical model.

Legg, R.D. 1989. Valuing recreational fishing: an application of the hedonic travel cost method. M.A. Thesis, Department of Economics, University of Guelph, Guelph, Ontario.

Recreational fishing is one of the preferred leisure activities in Ontario. Substantial private investments in boats, cottages, other equipments and time are attracted by this leisure activity. On the other hand, the maintenance of adequate angling facilities in the vast body of waters in Ontario require considerable public spending. Since recreational fishing is not a market good, public resource managers often face the dilemma of allocating recreational resources in the absence of any quantitative information on the value of these resources to society. This study was designed to estimate the value of recreational fishing, a multi-attribute non-traded good, in Ontario.

Based on the assumption that fishing success is only one of several valued features of a fishing trip, the study applied the hedonic travel cost method to ascertain the values recreationists place on selected characteristics of public sport fishing areas in Ontario. The data used in the estimation of the model were provided by OMNR's Fisheries Branch. Data were collected through a mail survey in July 1987 from a randomly selected sample of Ontario sport fishing licence holders from 13 residential origins.

The study estimated the demand for eight site characteristics: scenery, solitude, fish species and size, time to catch, access to the site, water quality and family holidays. The results indicate that only five site characteristics (solitude, species, time to catch, water quality and suitability for family holidays) were important to most recreational anglers in Ontario. The marginal values of these characteristics to an average angler were estimated at $12.59, $1.55, $11.51, $4.86 and $1.54, respectively. These characteristics were also found to be complementary to each other. The study also combined the eight characteristics into three major groups: "fishing quality", "environmental ambience" and "convenience". The highest willingness to pay was estimated at $53.71 for marginal changes in "environmental ambience" characteristics. The study concluded that environmental variables such as scenery, solitude, water quality, etc. were more important to anglers than fishing quality or convenience.

This study applied a relatively recently developed variant of the travel cost model to estimate the demand for site characteristics. This is a relatively complex method to apply. The results are interesting and informative. The weakness of this study relates to the method itself. In particular, it is difficult to give any reasonable economic interpretation to the negative price for three characteristics obtained in this study.

Adams, S.P. 1990. Estimating the demand for fishing site quality in Ontario: an application of the hedonic travel

Table 2. A synoptic view of Ontario case studies.

Authors	Problem investigated	Sponsoring agency[a]
Legg (1989)	The value of recreational fishing in Ontario.	Independent
Adams (1990)	The demand for fishing site quality in Ontario.	Independent
Cowan (1990)	Examines the small craft harbors.	Independent
Cowan (1991)	The value of recreational fisheries, with a modified hedonic travel cost model.	Independent
Auld (1985)	The demand for water quality in recreational use.	OME
Talhelm et al. (1987)	Acid rain damage to sportfishing in Ontario.	FOC
Apogee et al. (1990)	Economic benefits of Remedial Action Plans for the Great Lakes Areas of Concern.	OME
Ecologistics (1990)	Economic benefits to the Bay of Quinte recreational fishery from improved water quality.	OME
Ecologistics (1990)	Economic benefits to beach users from water quality improvements.	OME
Filion et al. (1990)	Economic significance of wildlife recreation in Ontario.	Environ. Can.
DPA et al. (1991)	Economic benefits from the proposed changes in Air Quality Regulation 308.	OME
White (1991)	Recreational value of wilderness.	MTR
Nautiyal and Chowdhary (1975)	Demand for recreational activities in Earl Rowe Provincial Park near Alliston.	Canada Council/OMNR
Kreutzwiser (1981a)	The recreational value of marshes at Long Point and Point Pelee on Lake Erie.	Univ. of Guelph/OMNR
Kreutzwiser (1981b)	Economic significance of the Long Point marsh on Lake Erie.	Univ. of Guelph/OMNR
Kreutzwiser (1984)	Economic benefits of the Upper Credit sportfishery.	OMNR
Roy (1986)	Economics of wetland preservation on the shore of Lake St. Clair.	OMNR
Usher (1987)	Socio-economic importance of the Ontario Lake of the Woods fishery.	OMNR
Van Vuuren and Roy (1990)	Social and private returns from wetland preservation in Kent county.	OMNR

[a] FOC = Fisheries and Oceans Canada, OME = Ontario Ministry of the Environment, OMTR = Ontario Ministry of Tourism and Recreation

cost method. M.A. Thesis, Department of Economics, Queen's University, Kingston, Ontario.

The popularity of sport fishing has been growing in Ontario since the mid-1970s. Although the sport fishing industry is receiving increased media attention and publicity, not much is known as to how anglers value the characteristics of different fishing sites in Ontario. This study was designed to provide quantitative information about this issue. The study used the hedonic travel cost method developed by Brown and Mendelsohn (1984) to estimate the demand for site characteristics. The data set used in this study was provided by the OMNR's Fisheries Branch; the data was actually a subset of data collected by OMNR in 1987 through a mail survey of recreational anglers in Ontario. Anglers from 12 origins were paired into six groups to facilitate econometric analysis.

The study estimated demand for five characteristics, but only three of them were important to the anglers: scenery, water quality and species availability. The willingness to pay for marginal changes in the levels of scenery, species availability and water quality were estimated as $2.60, $0.83 and $0.77 per angler per trip, respectively. The study also estimated price and income elasticities of demand for these characteristics. However, income was not a significant determinant in the demand for solitude, species, or water quality. Anglers with greater levels of experience seem more willing to pay for water quality and fish density, not for solitude or species availability. The study also revealed that part-time workers visit their preferred site more frequently than full-time workers. Students, retirees and unemployed individuals all appear to fish less frequently.

Water quality and fish density were found to be complementary. The study concluded with a note that attempts to improve a site's water quality should be accompanied by some sort of stocking program.

This study provides some interesting results concerning the demand for the characteristics of fishing sites in Ontario. It also reveals some interesting information as to the frequency with which different groups of people go fishing. The weakness of this study is the same as the previous one: it could not overcome the problem of negative prices for certain site characteristics.

Cowan, T. 1991. Modification and application of a hedonic model for evaluating recreational fisheries. Unpublished paper, Department of Fisheries and Oceans, Canada Centre for Inland Waters, Burlington, Ontario.

This report attempts to modify the hedonic travel cost model developed by Brown and Mendelsohn (1984) by incorporating fixed costs in the model. The stated purpose was to estimate the willingness to pay for various attributes of inland fisheries in Ontario. It automated the link between the two steps of the estimation procedure required in the hedonic travel cost model model. The report did not provide any estimate of willingness to pay, nor did it provide any complete demand estimates that could be used to produce these estimates. Furthermore, the report did not show the implications of incorporating fixed costs in the hedonic travel cost model.

Cowan, T. 1990. Value and impact of small craft harbours in Ontario. Unpublished report, Department of Fisheries and Oceans, Canada Centre for Inland Waters, Burlington, Ontario.

This paper provides an overview of the Small Craft Harbours program in Ontario. It attempts to highlight the costs and benefits of the program to the Canadian economy. However, it does not report any numerical estimates.

Auld, D.A.L. 1985. Valuing the environment: the demand for water quality in recreational use. Department of Economics, University of Guelph, Guelph, Ontario. (Sponsoring agency: OME)

This study was designed to explore the characteristics that influence individual preferences for water quality in recreation. Gibson Lake in the Parry Sound District of Ontario was selected as the study area and 1,987 residents of the area were interviewed during the summer of 1982. The sample size represented more than half of the area's permanent population.

The results indicate that education and age were the most important influences on an individual's preference for water quality in recreation. Contrary to common belief, income was not found to be an important explanatory variable in this regard.

This was an exploratory study and it did not estimate any demand function for recreation. The basic weakness of this study lies in the design of the survey. The information gathered was not used to estimate the demand for water-related recreational activities in the study area. Consequently, the study did not estimate the value of improved water quality for recreational use.

Talhelm, D., Hanna, J.E. and Victor, P. 1987. Product travel cost approach: estimating acid rain damage to sportfishing in Ontario. Transactions of the American Fisheries Society 116: 420–431. (Sponsoring agency: Fisheries and Oceans Canada, Ottawa, Ontario.)

The federal Department of Fisheries and Oceans is responsible for addressing the impacts of acid rain on Canadian fisheries. The department commissioned a number of studies in the early 1980s to examine both the biophysical and the economic damages caused by acid rain (see Hough et al. [1981] and Victor and Burrell [1981, 1983]). Using a modified travel cost method, the final report in this series (Victor and Burrell 1983) quantified the impacts of acid rain in the Haliburton–Muskoka region of Ontario. This paper summarizes the results of that report. The modified travel cost approach was described as Talhelm's product travel cost approach. This approach was used to estimate changes in the consumer surplus of anglers under varying levels of acid rain deposition in 232 lakes in eastern Ontario.

The modification in this study involved incorporating product definitions based on site quality into the basic travel cost model. This modification was based on the assumption that acid rain changes the product available to anglers. In particular, the authors used biophysical features such as lake area scores and morphoedaphic index scores to define nine fishing products. Demand functions were estimated for these fishing products.

The estimated demand functions were used to calculate aggregate consumer surplus for nine fishing products taken from the 232 lakes in the study. The estimated models were also used in computer simulations to determine the impacts of various levels of acid rain deposition in the lakes. Under the most severe acid loadings (simulated over the next 50 years), the model predicted that 5% of the lakes would provide no angling at all and angling quality would be reduced in another 20%. As a result, the annual amount of angling in the region would decline by 1% (by 6,000 angler-days). The annual angling consumer surplus would decline by 4% ($400,000). The present value of the loss over the 50 years was estimated to be $6,600,000 in 1980 dollars for the Haliburton–Muskoka region.

The study uses an interesting modification of the basic travel cost method to quantify the impacts of acid rain on sport fishing. The results are certainly helpful in an environment with no information. However, each demand function estimation was based on only 14 observations, which makes the empirical results rather weak. Moreover, the results are highly contingent upon the projected ecological response.

Apogee Research International Ltd., Peat Marwick S&K and James F. Hickling Management Consultants Ltd. 1990. Overview economic assessment of Remedial Action Plans for the Great Lakes Areas of Concern. Policy and Planning Branch, Ontario Ministry of the Environment, Toronto, Ontario. (Sponsoring agency: OME)

Canada and the United States signed an amendment to the Great Lakes Water Quality Agreement in 1987. This agreement specified the preparation of Remedial Action Plans (RAPs) for the Areas of Concern that had been designated by the International Joint Commission. Since that time, 17 RAP teams have been working in Ontario, studying various aspects of Great Lakes water quality, setting goals for remediation and examining a number of (preferred) options. The program is now at the stage of selecting preferred options and obtaining commitments for implementation of the plan. At this juncture, the Policy and Planning Branch of OME commissioned "Overview Economic Assessment Remedial Action Plans". This study reports the results of that initiative.

The study had two purposes: to provide a general framework for economic assessment of RAPs; and, second, to provide estimates of the costs and benefits of restoring the beneficial uses of the 17 Areas of Concern in the Great Lakes identified by the International Joint Commission.

Costs and benefits were calculated for each of the 17 sites and then aggregated to provide an overall picture for Ontario. The study was carried out using secondary data collected by local RAP teams and other published and unpublished reports. Four water-quality objectives were used in the study: water that was (a) aesthetically pleasing, (b) safe to swim in, (c) able to support edible fish, and (d) able to support a self-sustaining sport fishery.

The annual economic benefits for Ontario of achieving all water quality objectives at all 17 RAP sites were estimated to be $270 million. This represents the value of both use and non-use benefits that would arise in a typical year following implementation of the measures required to achieve all the water-quality objectives. The annual costs of achieving the specified objectives at all 17 sites were estimated to be $300 million.

The remedial expenditures were expected to generate income of $1.2 billion for Ontario residents and to create 27,400 jobs. Furthermore, the continuing operations and maintenance expenditures and increased recreational expenditures will generate about $205 million in additional income and an additional 4,700 jobs after all four water-quality goals are achieved.

This report provides interesting exploratory information drawing on relevant case studies done in Ontario. The weakness of the study relates to the fact that perceptions change over time; unpriced values based on 1980 data may not represent the values people have in 1991.

Ecologistics Ltd. 1990a. Bay of Quinte Remedial Action Plan: socio-economic assessment of proposed remedial measures. Policy and Planning Branch, Ontario Ministry of the Environment, Toronto, Ontario. (Sponsoring agency: OME)

This study documented an analysis of the benefits associated with the Bay of Quinte recreational fishery. It was part of an overall evaluation of the benefits and costs related to potential measures to improve water quality in the Bay of Quinte area of Ontario.

The study used the basic travel cost method to evaluate the benefits from the recreational fishery. Data used in the analysis were collected by the OMNR through the Bay of Quinte Open Water Creel Survey conducted from May to December 1988. The final data set consisted of 1,722 observations of Walleye fishermen and 76 observations of anglers seeking other fish. The estimated demand functions for Walleye fishermen and others were used to calculate total and per-angler consumer surplus per day. The consumer surplus per angler per day was estimated to be $9.60 for Walleye and $13.80 for other species.

This is another exploratory study. It provides some interesting quantitative information using a simple travel cost model. The weakness of the study stems from the fact that it used a travel cost model that was too simple. As such, it did not incorporate the possible effects of other fishing sites. It also did not include income or demographic variables in the analysis.

Ecologistics Ltd. 1990b. Benefits to beach users from water quality improvements. Policy and Planning Branch, Ontario Ministry of the Environment, Toronto, Ontario. (Sponsoring agency: OME)

During the summer of 1983, an unusually high number of beaches were closed in Ontario due to bacterial contamination. Subsequent research under the Beach Management Program initiated by OME identified the sources of the bacterial contaminations and suggested site-specific remedial measures for the problem (see Usher et al. 1987). However, there was little information on the magnitude of benefits that would result from the proposed remedial measures. This report describes the results of a study sponsored by OME to fill in this gap. In essence, the report documents an empirical study of the value of water-quality improvements at beaches in Ontario.

The major objective of the study was to provide a better understanding of the behavior of beach users in Ontario. The specific objectives were:

1) to monitor beach use and beach attributes, including water quality, at several Ontario beaches over a recreation season;
2) to interview beach users about their behavior and perceptions of water quality; and
3) to develop and compare alternative measures of the value of water quality to beach users.

Data for this study were collected through personal interviews with beach users at five Ontario beaches (Kelso, Rockwood, Fifty Point, Guelph Lake and Sunnyside) during the summer of 1988.

The results revealed that a typical beach user travelled 22 km and spent about 4 hours at the beach. Perceptions of water-quality attributes were consistent with the corresponding field measurements of those attributes. The benefits of improved water quality to beach users were estimated using the travel cost method and an open-ended contingent valuation method. The results indicate that if water quality was improved from existing conditions to very good conditions, an average beach-using household in Ontario would have a benefit of $60 to $70 per annum. The results also indicated that beach-use decisions of Ontario residents are influenced by travel costs, water quality, beach crowding and gross household income. The report concluded that perceived water quality at beaches is a significant factor that affects the decision to use a beach and that remedial measures will yield substantial benefits to beach users in Ontario. The authors asserted that the benefits of these measures will outweigh their costs.

This case study appears to represent the first major application of the contingent valuation approach in Ontario. The results of the study are interesting and informative. However, the study did not calculate any aggregate benefits for Ontario. The inclusion of beach-specific demand results would also have been revealing.

Filion, F., Jacquemot, A., Boxall, P., Reid, R., Bouchard, P., DuWors, E. and Gray, P. 1990. The importance of wildlife to Canadians in 1987: the economic significance of wildlife-related recreational activities. Canadian Wildlife Service, Environment Canada, Ottawa, Ontario. (Sponsoring agency: Environment Canada)

This report examined the economic significance of activities that depend on wildlife by addressing two fundamental questions: how much value do people place on wildlife-related activities, and what level of economic activity is generated by the use of wildlife resources.

A nationwide survey on the importance of wildlife to Canadians was carried out by Statistics Canada in 1987, under the sponsorship of the Federal–Provincial Wildlife Conference and the direction of the Canadian Wildlife Service. This was an open-ended contingent valuation survey that collected data from 80,000 Canadians in all 10 provinces who were aged 15 years and over. The intent was to provide national as well as provincial information concerning the perceived importance of wildlife resources.

The results indicate that, in 1987, considerable economic benefits resulted from wildlife-related recreational activities in Ontario. An average Ontarian derived a net benefit of about $20.00 per hunting trip and about $8.00 per non-consumptive trip. The total value of these wildlife-related activities was estimated to be $371.1 million. In addition, the residents of Ontario spent more than $1.6 billion on wildlife-related activities during 1987. These expenditures generated substantial indirect benefits for the economy of Ontario. The study also suggests that if the wildlife management program is successful in conserving wildlife populations for sustained utilization, the annual benefits to the residents of Ontario from wildlife-related activities would be $3.7 to $7.4 billion in perpetuity (based on 10% and 5% discount rates, respectively).

The study was simple but very informative and useful. A more disaggregated analysis (by site and wildlife species) would also have been revealing and perhaps more useful from a resource management point of view because the distribution of wildlife resources is not even across sites. As well, the benefits to different segments of the residents of Ontario may not be equal.

DPA Group Inc. and Associates. 1991. Estimated public benefits of implementing the proposed revisions to Regulation 308. Policy and Planning Branch, Ontario Ministry of the Environment, Toronto, Ontario. (Sponsoring agency: OME)

In November 1987, OME published a discussion paper on air pollution regulations in Ontario. It identified problem areas in the existing air pollution regulations and proposed reform measures that would impose limits on direct emission from all air pollution sources. As part of the review process for the proposed revisions to Regulation 308, OME commissioned four closely related studies to examine different aspects of these proposed changes. The purpose of these studies was to identify the air quality, health and environmental benefits expected from implementation of the proposed revisions and to quantify the benefits in economic terms.

The study covered 96 contaminants emitted by more than 3,500 establishments in 48 industries across Ontario. Benefits are estimated under five alternative implementation scenarios from the proposed revisions. The study estimated public benefits in the form of lower risk of mortality ($0.3 to $2.6 billion per year due to reduced SO_2 emission), systematic health benefits from reduced hospitalization (at $0.004 to $0.05 billion per year), improved visibility ($1.2 to $4.2 billion per year) and reduced damage to materials benefits ($0.2 to $0.9 billion per year) resulting from reduced concentrations of emissions due to implementation of the proposed revisions to Regulation 308. The total value of the public benefits was estimated to be between $1.2 and $7.7 billion per year, depending upon the implementation scenario. All dollar values were in constant 1986 Canadian dollars. The public benefits were, however, underestimated because the possible benefits related to wildlife habitat, forest and wilderness areas, aquatic toxicity and surface water were not quantified.

The study provides a good overview of some very important issues on which no information existed previously. The major weakness of the study is that the public benefits were not estimated based on Ontario data; instead, information was taken from unpriced valuation studies done in the United States. This may have biased the results.

White, A. 1991. The unrecognized recreation value of wilderness: defining the future recreation needs of Ontarians. Environment Probe, Toronto, Ontario. (Sponsoring agency: Ontario Ministry of Tourism and Recreation.)

The recreational value of wilderness has grown steadily in Ontario since the mid 1970s. In1990, Ontario's provincial parks entertained about 8 million visitors, of which about 3.7 million were campers. This study attempted to provide an overview of recreational use in selected provincial parks in Ontario. The specific objectives were to develop economic estimates of the value of unpriced recreational resources in Ontario and to identify wilderness resources that require immediate management attention.

Five provincial parks (Grundy Lake, Darlington, Quetico, Killarney and Rondeau) were selected for the study. A survey was conducted by Environment Probe in cooperation with OMNR and the Ontario Ministry of Tourism and Recreation in 1990 to collect data from visitors to these parks. Only the responses of Ontario residents were used to measure the demand for wilderness recreation in Ontario.

The study used a simple travel cost model to estimate demand by the campers for the selected parks. The results indicate that the value per camper-night was highest at Killarney ($87), followed by Quetico ($72), Darlington ($48), Rondeau ($47), and Grundy Lake ($29). Using a discount rate of 5% per year, the present values of camping benefits from these parks over the next 50 years were estimated at $1,587, $1,314, $882, $860 and $526, respectively. Based on these estimates, the study generated a present value of $2 to 4 billion for camping in Ontario's provincial parks.

The study used a simple model to estimate the demand for camping at the five selected parks and provided some interesting inform on. However, the travel cost model used was too simple and did not include respondent income or any other socio-economic characteristics. Consequently, generalization of the results to provide the value of camping for all parks in Ontario is problematic and the results should be interpreted with caution.

Nautiyal, J.C. and Chowdhary, R.L. 1975. A suggested basis for pricing campsites: demand estimation in an

Ontario park. Journal of Leisure Research 7: 95–107. (Sponsoring agencies: Canada Council and OMNR)

In this paper, the authors attempted to estimate demand functions for various activities on campsites in the Earl Rowe Provincial Park near Alliston. The major objectives of the study were to determine the optimum number of campsites in that park and to determine the daily user fee per site. The authors used a slightly modified version of Pearse's (1968) travel cost method.

Based on the assumption that recreationists combine social visits with recreational trips, the travel cost was estimated not from the visitor's residence to the park, but from the last stopover of more than one night to the park. Based on the assumption that the effects of available leisure time and climatic conditions on the number of campsite visits are more pronounced than that of price, the 151 camping days of the 1971 season were grouped into five strata that minimized leisure and climatic variations within each stratum. The strata were called "experience types 1–5".

The authors first defined a marginal visitor for each income category and then defined the difference between the expenditures of the marginal visitor and those of other visitors (or visitor grouping) as consumer surplus for a visitor for the entire visitation period. Finally, the consumer surpluses for all income categories were arranged in descending order to obtain demand schedules. Using this procedure, the authors computed demand schedules for four of the five experience types and then summed them to obtain the demand schedule for the campsite. The intersection of this campsite demand schedule and the average cost for making sites available gave an optimum number of 368 campsites in the park in 1971. Based on this number, the authors estimated $6.00, $2.50 and $0.50 as fees for experience types 1, 2 and 3, respectively, and suggested that the park should charge different prices for different experience types.

The study was an interesting early attempt to calculate the demand for outdoor recreation in Ontario. The authors recognized some issues in estimating travel costs that are still being discussed in the literature. However, they used an obscure form of the travel cost model. Although the logic behind this approach appears interesting, it may not be tenable from the viewpoint of demand theory.

Kreutzwiser, R.D. 1981a. Recreational values of lakeshore marshes. p. 48–57 *in* A. Champagne, *Ed.* Proceedings of the Ontario Wetland Conference. Federation of Ontario Naturalists, Toronto, Ontario. (Sponsoring agencies: University of Guelph and OMNR)

This paper examined the value of lakeshore marshes as a recreational resource. Data were collected through personal interviews and mail-back questionnaires from 703 recreationists at the Long Point and Point Pelee marshes on Lake Erie during 1978. Using the travel cost method detailed by Pearse (1968), the marginal benefits per recreationist per trip were estimated at $34.85 and $46.03 for the Long Point and Point Pelee marshes, respectively. These benefit estimates generated total consumer surplus values of $213,404 and $1,664,399, respectively. In addition, the recreationists generated $225,000 and $1,924,000, respectively, in local business incomes in 1978.

The strength of this paper lies in its simplicity. Some useful information was generated using a very simple model. The weakness of the paper relates to the methodology used. Benefits were not estimated from an empirically estimated demand function for recreation. Moreover, benefit estimates for particular activities may have been more useful for policymakers if they had been expressed in terms of resource allocation policies concerning wetland in Ontario.

Kreutzwiser, R.D. 1981b. The economic significance of the Long Point Marsh, Lake Erie, as a recreational resource. Journal of Great Lakes Research 7: 105-110. (Sponsoring agencies: University of Guelph and OMNR)

Recreational activities in Ontario's wetlands compete with agricultural, residential, industrial and other uses. This study was designed to provide information on the economic significance of wetland recreation. During 1978, data were collected from 703 users of the public marshes at Long Point and Point Pelee on the northern shore of Lake Erie to estimate the economic significance of wetland recreation. The Long Point marsh provided various recreational activities such as nature viewing, birdwatching, fishing and waterfowl hunting for more than 17,000 users during 1978. Using the travel cost method suggested by Pearse (1968), this paper estimated per-user benefit to be $34.85 per visit. This translated into a total consumer surplus of $213,000. In addition, wetland recreation generated some $225,000 in local spending on food, accommodation and other items.

This paper appears to have been derived from two unpublished reports and incorporates some of the results of Kreutzwiser (1981a). The study used a variant of the travel cost method that may be untenable from the viewpoint of demand theory.

Kreutzwiser, R.D. 1984. The Upper Credit sport fishery: an appraisal of the potential economic benefits. Department of Geography, University of Guelph, Guelph, Ontario. (Sponsoring agency: OMNR, Richmond Hill, Ontario)

This study reported the results of an economic appraisal of The Upper Credit sport fishery. The purpose of the study was to examine the existing socioeconomic benefits of the resident trout fishery on the Upper Credit River and to assess the potential benefits of promoting the fishery. The study area extended from Georgetown to Orangeville. A survey was conducted by the author from 24 April to 30 September 1982. He collected on-site data from 242 anglers. This was supplemented by 1983 creel census data collected by the Credit Valley Conservation Authority and OMNR. A travel cost method was used to estimate a consumer surplus of $20.85 per angler per day. This translated into a total consumer surplus of $137,000. In addition, sport fishing activities in the Credit River generated $28,000 in income for local communities. The study concluded with a note that enhanced local economic benefits of the Upper Credit Sport Fishery can be sustained over a long period if a biologically productive fishery and quality recreational fisheries are maintained.

On the positive site, this simple study provided some exploratory information. On the negative side, it did not estimate a demand function based on the travel-cost model in order to generate the benefit estimates. Thus, the results of the study should be interpreted cautiously.

Roy, P. 1986. Economics of wetland preservation: the case of the Lake St. Clair Marshes. M.Sc. Thesis, Department of Agricultural Economics and Business, University of Guelph, Guelph, Ontario. (Sponsoring agency: OMNR)

The study reported the results of preserving the marshes on the shore of Lake St. Clair. This wetland area has a history of drainage and is located in a prime agricultural area. These marshes are also privately owned. Two cost-benefit analyses of wetland drainage were performed. The analyses were carried out to determine the tradeoffs between draining the marshes for agriculture (i.e., for private benefit) and preserving them (i.e., for social benefits). The net benefits of agriculture were estimated from secondary data sources. The cost of draining the marshes was determined using an engineering approach. Part of the net social benefits of wetland preservation (including hunting, angling and trapping) was estimated by the travel cost method. Data for this part were collected through interviews conducted during April 1986. The remaining preservation benefits (e.g., maintaining biodiversity, natural habitat or the existence value) were not quantified. Finally, the private and social net benefits of agriculture were compared with respective preservation values.

For all marshes studied, private agricultural net benefits were higher than private preservation net benefits. On the other hand, the social agricultural net benefits were found to be lower than the social preservation net benefits. Thus, the main conclusion of the study was that the net benefits of wetland preservation for society are higher than the net benefits from the next best (i.e., agricultural) use. Consequently, preservation of the Lake St. Clair Marshes was recommended.

The strength of the study lies in the fact that it investigated an important policy issue in Ontario using a simple methodology. The weakness of the study primarily relates to the survey design used. Instead of collecting information from individual recreationists, the author gathered information from the owners of the marshes. Moreover, the author did not include income and other socioeconomic variables in the regression while estimating travel cost demand functions.

Usher, A.J. 1987. Ontario Lake of the Woods fishery: economic and social analysis. Transactions of the American Fisheries Society 116: 352–366. (Sponsoring agency: OMNR)

In 1980, OMNR commissioned a study of the economic and social importance of the Lake of the Woods fishery for the purpose of improved resource management. Usher's paper was based on two reports (Hough et al. 1982a,b) prepared for OMNR. The objectives of the study were:

1) to determine the significance and contribution of the various uses of the fishery to the economy and society of the local area and of Ontario as a whole;
2) to determine the potential demands of the various uses of the fishery on the Lake of the Woods fishery resource;
3) to identify the limitations of the fishery resource in meeting present and potential user demands and in making continuing economic and social contributions within the limits of the resource;
4) to review the concerns of the various user groups over the current state of the fishery, competing uses of the fishery and the management of the fishery by OMNR; and
5) to identify and evaluate alternative strategies for allocating and managing the fishery on a sustained-yield basis in order to assist OMNR in managing the fishery to maximize economic and social benefits to local residents while preserving the quantity and quality of the resource for future generations.

To accomplish these objectives, data were collected through surveys (personal interviews as well as mail surveys) of Indian bands, commercial fishermen, local residents and cottagers, tourism operators and tourists. The direct revenues and costs of commercial and sport fishing enterprises and of OMNR were estimated. Domestic harvests were valued on a substitution-valuation basis, whereas consumer surpluses of the non-Indian locals and anglers were determined via contingent valuation. Economic responses to changes in harvests were predicted based on user predictions of their behavioral changes in the case of sport fisheries. As harvests exceeded sustainable yields (during the study period, 1980–1982), four alternative allocations of the sustainable yields among the user groups were identified, and the economic and social impacts and the management implications of each alternative were estimated.

Contingent valuation was only a minor component of this study. A multiple-choice close-ended contingent valuation method was employed and a willingness to pay of $3.40 per angler-day, for a total of $133,000 per year, was estimated as the consumer surplus for angling use by local residents.

This is an interesting exploratory study. Since it dealt with use value, the travel cost method might have been a better approach for the study.

Van Vuuren, W. and Roy, P. 1990. Social and private returns from wetland preservation. p. 553–563 *in* International and Transboundary Water Resources Issues. American Water Resource Association, Washington, D.C. (Sponsoring agency: OMNR)

Wetlands in Southern Ontario are threatened by competition from urban development and agriculture. This paper examined the economics of wetland preservation using a case study method. The marshes on the eastern shore of Lake St. Claire in Dorve Township, Kent County, were chosen for this purpose. These marshes are under great development pressure from agriculture. Two cost-benefit analyses were performed, one from the private owner's point of view and the other from society's point of view. To estimate the net private and social benefits, costs and benefits were calculated for both wetland states (natural and reclaimed).

The results showed that the net private agricultural benefits were higher than the net social agricultural benefits and that this discrepancy was due to drainage subsidies and property taxes, which were included in the private benefits but not in the social benefits. However, the social benefits of wetland preservation far outweighed those of reclamation for agriculture. Over time, the benefits of preservation are expected to grow because of the limited supply of wetlands and the increased demand for their services. Thus, an economic case can be made for wetland preservation in Ontario.

This article incorporated some of the results from Roy (1986). In terms of the methodology and results, this study suffers from the same weaknesses as Roy (1986).

The above review of case studies reveals that a broader range of topics have been covered in Ontario than elsewhere in Canada (see Prins et al. [1990] for an annotated bibliography of Alberta studies). The Ontario case studies provide interesting information in areas where there was no information previously. The primary focus in the Ontario case studies has been on the use values. No attempt has been made to quantify non-use values. Finally, with the exception of Filion et al. (1990), there appear to have been no empirical analyses of the unpriced benefits emanating from Ontario's forest lands.

It can also be noted that the methodological improvements and model refinements that have taken place since the 1970s have generally not been incorporated into non-market valuation studies in Ontario.

SOME ISSUES FOR CONSIDERATION

This report has reviewed the methods for deriving economic values of goods and services that do not pass through markets, and the studies that have taken place in Ontario using such methods. Valuation issues in forestry are profoundly difficult to deal with in a quantitative, dispassionate manner. Even the wood (stumpage) from Ontario's forests is not generally priced through markets; hence, it is difficult to determine whether the stumpage prices set by OMNR reflect proper social values of timber by standard economic criteria. This is one of the reasons for the current debate between Canada and the United States over softwood lumber. Another report in the OMNR's Forest Values Initiative deals with these stumpage, tenure and allocation issues.

Concern over non-marketed goods and services has resulted in the development of numerous techniques to estimate economic values for unpriced goods and services. Economic theory of relevance to public forest management recognizes that such items may have non-zero values—the problem is to actually derive these values for inclusion in comprehensive cost-benefit analyses. Thus, the challenge lies more in application (or practice) than in principle. For example, are existence and bequest values important in Ontario's forests? If so, where, and how would they actually affect management decisions? How much should Ontario's forest cover be manipulated to affect recreation or hunting values? Where are these values most significant?

Despite the progress that has taken place in the development of new methodologies and the refinement of old ones, there are still some problems that plague this type of valuation. Some of these issues were identified in the discussion of the strengths and weaknesses of the major valuation techniques earlier in this report. These include how exceptionally high or low bids should be treated in contingent valuation studies and how to identify the relevant populations to survey for existence values. On this issue, for example, what would Ontario residents be prepared to pay to preserve old-growth forests in British Columbia or tropical forests in Papua New Guinea? In this section, some additional issues are raised that are relevant to a proper understanding of the potential application of the techniques.

The first issue relates to problems of *relevance* and *reliability*. In particular, how relevant are the studies to decision-making? How reliable and robust are the results? Although these issues have been important for a long time, only relatively recently has the academic literature begun to address them. On issue of relevance, Gregory et al. (1989) suggest that the focus of many studies has not been sufficiently narrowly defined to be of use to decision-makers. They reviewed contingent valuation studies of willingness to pay for species preservation (i.e., whooping cranes, blue whales, bald eagles, striped shiners and habitat protection) and commented as follows:

> *"The major drawback of such analysis is the limited ability of present methods to estimate accurately the benefits of preservation. With the development of an adequate protocol, however, economic valuation studies can be used for endangered species policy. Studies completed to date may not be directly applicable to specific policy questions but they clearly illustrate that appropriate values are possible. Species valuation, however, is complicated. It is clear that species protection involves many dimensions including more habitat, large populations, and lower risks of extinction. Valuation questions need to be sensitive to this complexity. For example, if the issue is habitat protection, then the benefits should reflect willingness to pay for habitat and not just the value of any one species in the habitat. Similarly, what people are willing to pay for anticipated changes in the risk of extinction should not be confused with the all-or-nothing value of a species. Finally individuals of a species are often valuable even when there is no risk to the entire species."*

Gregory et al. (1989) highlighted some important considerations for future researchers. In general, only a few studies in the literature have been found to be relevant in a decision-making context. This does not imply that the other studies are not useful to decision-makers. Real-world decision-making is very complex and not all of the ingredients of decision-making are clearly understood. Even if we could understand all the intricacies of decision-making, it would be extremely difficult, if not impossible, to incorporate all the complexities into a single decision support model.

With regards to reliability, a number of points can be made. The first may seem redundant but is probably worth mentioning. Market information is not available to check contingent valuation, travel-cost or hedonic pricing studies, so any inferences about accuracy clearly involve some professional judgment. On the other hand, the importance of the accuracy or reliability of results can only be gauged within the context of the decision. The literature has begun to address reliability in at least four ways:

1) Comparing contingent valuation and/or travel-cost results to results from experimental markets (e.g., Bishop et al. 1983);
2) Comparing contingent valuation and travel cost results for the same service (e.g., Seller et al. 1985);
3) Repeating contingent valuation studies at different times (e.g., Loomis 1989); and
4) Using computers to do studies called Monte Carlo experiments (described below).

In fact, only Monte Carlo experiments can provide independent, known results that reveal the accuracy of a particular scenario. In these experiments the "truth" is incorporated into a computer model that generates data for the analyst. The analysis of the data is also done by the computer. Results of the analysis may differ from the specified "truth" because of stochastic elements in the data generation phase.

Most of this literature has considered the implications of incorrect assumptions on the parameter estimates in travel-cost models. Only relatively recently has this literature begun to address the implications of incorrect assumptions on the results of interest to policy makers—estimates of consumer surplus or willingness to pay. Caulkins et al. (1985) used Monte Carlo techniques to examine the bias of omitted variables in travel cost models. Specifically, they looked at the direction and size of the bias under different sets of assumptions about two recreation sites being complements or substitutes and the degree of correlation between the travel costs to visit the sites. Depending on which set of assumptions was used, estimated consumer surplus values ranged from 30% below the true values to 64% above. Kling (1988) used Monte Carlo methods to examine the reliability of the hedonic travel cost model for estimating the value of water quality at recreational beaches. In her experiments, different functional forms were used to fit the computer-generated data. Underestimation of from 30 to 52% below the true willingness to pay value of $12.04 for improved water quality resulted in all three cases.

Neither of these studies provided a decision context to judge the significance of the errors. Common and McKenney (1992) do so in the context of a forestry application of the hedonic travel cost model. In their study, two forest recreation areas existed that were identical in all respects except for the presence of an "old-growth" stand. Thus, the difference in estimates of consumer surplus between the two sites was, by definition, the recreational value of the old-growth stand. The question was whether the recreational value was greater than the timber value, making "preservation or harvesting" the decision problem. The Monte Carlo experiment was set up so that the true recreation value was about 20% greater than the timber value.

Situations were examined in which the stochastic elements in the computer data-generation phase became noisier, estimates of the number of visitors to each site were incorrect, and measurement errors were present in the travel costs. The results of all these experiments indicated that there was a high lik-''hood of getting answers that would tell the decision-maker to do the wrong thing (i.e., harvest when they should have preserved). Even for situations in which estimates of the number of visitors for one site were just 10% below the true visitor numbers, consumer surplus results were wrong and suggested the incorrect policy option.

It is important to note that it is often difficult to generalize the results of Monte Carlo experiments. This experiment could have just as easily been set up such that harvesting was the correct decision. Strictly speaking, Monte Carlo experiments provide results only for the situation in question. However, Monte Carlo experiments can illustrate that interactions between different sources of error can often produce counterintuitive outcomes. From a policy perspective, the importance of these outcomes can only be gauged in the context of how radically it would change a decision that used the information. Clearly, caution is required when all-or-nothing decisions are being made on the basis of unpriced valuation studies. The study described above illustrated this in a forestry context.

Another point worth noting is that all valuation techniques are based on orthodox, neoclassical economic theory. This theory is appropriate only for valuation of marginal changes. What happens when changes are not marginal? Economic theory at this stage provides no clear answers on the effects of large changes on economic welfare. In fact, even the definition of a "large change" is problematic in many cases.

Another issue relates to the stability of preferences. If preferences are not systematic and stable over time, what are the implications of using the results of an unpriced valuation study? This issue has not been addressed yet in the literature.

A third issue relates to the aggregation of unpriced values. In particular, when can we and should we add estimated benefits obtained through different methods? For example, if some forest values are estimated by the travel cost method, some by the contingent valuation method and some by the hedonic price method, then how can we meaningfully aggregate these benefits and use the aggregate figures for forest planning? This is still an open question.

Finally, changes in the existing legal and property rights associated with natural resources and the environment may influence preferences. These institutional changes are taking place in Ontario and elsewhere. How will such changes interface with the market economy to generate social values for environmental resources? Is it possible to establish markets for some environmental services that could operate more efficiently than government provision of these services?

The above discussion highlights the fact that our understanding of unpriced values is incomplete and the value concepts and measurement techniques are still evolving. The methods identified in this report are the state-of-the-art techniques in the study of unpriced valuation. These techniques could be used to address a wide range of valuation problems systematically in Ontario forestry.

When coupled to a broader economic framework such as cost-benefit analysis, or perhaps even other methods of planning, the rationale for such studies becomes more obvious. The problems faced by resource managers over relative values are not likely to go away in the near future. The challenge for economists is to contribute in a meaningful way to the resolution of these problems.

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APPENDIX A. A MATHEMATICAL REPRESENTATION OF THE BASIC TRAVEL COST MODEL.

This appendix illustrates the basic mathematical formulation of the travel cost model required to estimate the benefits from moose hunting. Suppose the preference structure of a typical moose hunter can be represented by the following utility function:

$$U = U(x_1, x_2, \ldots, x_n, Q) \tag{A.1}$$

where x_i represents market goods and Q is the number of moose-hunting trips taken. A typical moose hunter maximizes utility subject to a budget constraint such as:

$$\sum_{i=1}^{K} p_i x_i = M \tag{A.2}$$

where M is disposable money income and p_i represents the prices of the corresponding market goods. This constrained maximization process leads to a set of Marshallian demand functions:

$$x_i = x_i(P, M, Q) \tag{A.3}$$

Notice that Q is now an argument in the market goods demand functions.

The "dual" to this utility maximization problem is the expenditure minimization problem subject to a stated level of utility, say U^* (Varian 1984). The solution to this problem gives the following expenditure function:

$$E(P, Q, U^*) = M \tag{A.4}$$

Using Shephard's Lemma, a compensated demand function or marginal willingness-to-pay function for moose hunting trips can be derived as the first derivative of the expenditure function with respect to Q:

$$D_q = -\partial E/\partial Q = E_q(P, Q, U^*) \tag{A.5}$$

This represents a general demand function for moose hunting. The basic travel cost model simplifies this demand function so that it can be applied to a practical situation. For example, if data were collected from each individual hunter about his origin; his expenditure for the permit; the number of trips made that season; the duration of each trip; his income, age, and number of years of hunting experience; and information about other hunting sites etc., then the following demand function could be estimated for "moose hunting":

$$D_q = f(P_q, \Phi) \tag{A.6}$$

Where D_q is the number of moose-hunting trips, of a specified length, to the hunting site; Φ is a vector of exogenous variables that includes hunter income, age, origins, hunting experiences, etc.; and P_q is the cost of the trip, which includes the price of the permit, vehicle-related costs and the cost of the hunter's travel time.

If hunters were coming from "m" different origins to the site, each of which can be indexed based on their distance from the site, then the demand per hunter from the "jth" region is:

$$D_{qj} = f(P_{qj}, \Phi_j) \tag{A.7}$$

The aggregate demand for the jth region is:

$$N_j * D_{qj} = N_j * f(P_{qj}, \Phi_j) \tag{A.8}$$

where N_j is the number of hunters coming from the jth region. Finally, the total benefits to all hunters visiting the site can be computed as the area under the demand curve and above the price line (travel cost in this case) for each hunter, aggregated across all hunters from each region, and then aggregated across all regions. The resulting aggregate benefits can be calculated as:

$$B = \sum_{j=1}^{m} N_j * \int_{P_j}^{P_j^*} f(P_q, \Phi)\, dP_q \tag{A.9}$$

Where P_j is the prevailing travel cost to the site from the region and P_j^* is the price at which nobody from the jth region will travel to the site for hunting[17].

It is clear from equation A.9 that the computation of total benefits from our example of moose hunting in Ontario would require information on: (a) the total number of hunters, stratified by their origins; (b) the number of trips of specified length per hunter; and (c) how the number of trips per hunter responds to changes in travel costs and in exogenous variables.

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[17] On deriving this measure of benefit, it is implicitly assumed that Marshallian (income-constrained) demand functions can be substituted for Hicksian (utility-constrained) demand functions with negligible error. This assumption follows from Willig's (1976) celebrated approximation analysis. Willig's approximation, however, is true only for infinitesimal changes in price and it may not hold for "large" price changes. As well, in natural and environmental economics we are often dealing with unique resources, whose elimination or depletion may generate large welfare effects. Willig's approximation is not helpful in such cases. How can we handle the issue of large changes in well-being in benefit estimation? This question has yet to be resolved. For discussions on this topic, see Hanemann (1980) and Freeman (1985b).

APPENDIX B. DECISION STRUCTURE UNDER THE RANDOM UTILITY MODEL.

In a random utility model, an individual's final decision to take a recreation trip results from two separate choices. The first choice involves whether or not to undertake a specific recreational trip (e.g., deer hunting, fishing, canoeing, etc.) given that he is one of the users of that recreational activity. Once a "yes" decision has been made to the first choice, the second problem is to choose the most preferred site from a set of alternative destinations. By the laws of conditional probability, these two decisions can be put together as:

$$P_{g \cap j} = P_{jg} * P_{g|r} \tag{B.1}$$

Where $P_{g \cap j}$ is the joint probability to take a recreational trip to site j versus the set of alternative sites; P_{jg} in the conditional probability of choosing site j from the set of alternatives given that one has decided to take a trip; $P_{g|r}$ is the probability of taking a trip given that one participates in the type of recreation in question. If person i visits site j, he is assumed to obtain utility, $V_{ij}=V(X_{ij}, Z_i)$, where X_{ij} is a vector of the characteristics of site j perceived by the ith individual (it also includes the travel cost from i's home to the site), and Z_i is a vector of socioeconomic characteristics of the ith person. The utility function U(.) is composed of two parts: one known by the researcher and common to individuals, $V(X_{ij},Z_i)$, and an unobservable component, e_{ij}. The function U(.) is assumed to be a sum of V(.) and e_{ij}. The model is estimated after specifying a functional form for V(.) and under the assumption that e_{ij}'s are normally, identically and independently distributed in the population. These estimates can be used to calculate the probability that an individual with an observed utility level will visit site j. The estimation of the choice probabilities is based on the maintained hypothesis that person i visits site j only if the utility of a visit to j is larger than the utility of visiting any other sites in the choice set. One interesting feature of the random utility model is that it readily incorporates choice among multiple sites in a travel cost model. The attractiveness of a site in relation to other sites that provide a similar type of recreational services influences the probability of a visit in this model.

GLOSSARY

Economic efficiency – A state of the economy in which no one can be made better off without someone else being made worse off. For this to be the case, three conditions must occur: productive efficiency, in which the output of the economy is being produced at the lowest cost; allocative efficiency, in which resources are allocated to the production of goods and services required by society; and distributional efficiency, in which output is distributed in such a way that consumers would not wish to spend their income in any other way given their disposable income and prices.

Embedding effect – A bias associated with the contingent valuation technique. A lower value of benefit is obtained when an environmental resource is valued as a whole than when it is valued in parts.

Free-rider problem – A problem associated with the provision of a public good. Public goods are characterized by jointness and non-rivalry in consumption; i.e., once the provision of a public good is made, excluding individuals from its benefits is generally costly and may not be feasible. Because of this non-excludability, a beneficiary has incentive to not take part in financing the public good. This is called the free-rider problem.

Impure public goods – Public goods that are subject to congestion costs as the number of users increases. For this type of public goods, the condition of non-rivalrous consumption does not hold.

Market-clearing equilibrium – An equilibrium situation in which the total quantity demanded equals the total quantity supplied.

Risk aversion – A characteristic of a consumer making a choice under uncertainty for whom the utility of a lesser, but certain gain is greater than the utility of a much larger, but uncertain gain.

Weak separability – When the preference for one good does not depend on the preference for all other goods, the utility function is called weakly separable.