UNIVERSITY OF ALBERTA

A RANDOM UTILITY ANALYSIS OF SOUTHERN ALBERTA SPORTFISHING

BY

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ABSTRACT

A Discrete Choice Travel Cost approach is used to develop models of Recreational Sportfishing in Southern Alberta. The data was obtained from a survey administered in 1990 to a randomly selected group of anglers who held fishing licences during that season. The analysis was based on 3465 fishing trips taken to 67 fishing sites in Southern Alberta. Each site was modelled as a bundle of objective environmental quality attributes and a travel cost parameter. Variation in the underlying choice-set assumptions resulted in three distinct Random Utility Models being estimated: the first model is a standard approach where all sites are included in the choice set. Second, a randomly generated choice set of five sites is constructed, and a RUM estimated on this choice set. Finally, the choice set is modified to include only those sites each angler is aware of, and a third RUM is estimated. Once the models are estimated, welfare estimates of selected management policies were evaluated. Among the management policies considered is an examination of the welfare impacts of the Oldman River Dam on Recreational Fishing in Southern Alberta.

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CHAPTER 1 - INTRODUCTION

INTRODUCTION

Sportfishing in Alberta is a major recreational activity. In 1985, anglers fished a total of approximately 5.4 million days and spent approximately $132.5 million on activities and supplies directly connected with this sport (Alberta Forestry, Lands, and Wildlife (AFL&W), 1988). The economic benefits of this activity include the social benefits derived from the consumption of an environmental good.

Every five years, a national survey on Sportfishing is conducted. However, the results of this survey do not adequately address issues of growing economic concern. The survey results identify general environmental quality as the most important factor influencing the enjoyment of recreational sportfishing. However, a detailed economic analysis of the influence of environmental quality attributes, such as water quality , or the impact of environmental policy, for example building the Oldman River Dam, on angler behaviour is not performed. Furthermore, information about trips taken to specific sites is not collected, and the welfare impacts of environmental policies affecting these sites, and the corresponding changes in angler behaviour, are not explored. A regional economic analysis of sportfishing activity incorporating these deficiencies will supplement the general socio-economic results of the national survey and aid policy makers and resource managers in identifying and implementing effective environmental policy.

There are several approaches to address the issues noted above (Clawson and Knetsch 1966, Freeman 1979, McConnell 1985, Madalla 1983). This research will use the Random Utility Model (RUM), where each fishing site will be modelled as a bundle of quality attributes. The underlying assumption with this approach is that an angler will choose one site, site i, over another, site j, only if the utility associated with site i is higher than that associated with site j. RUM analysis allows researchers to model site-choice behaviour among a choice set of sites as well as extending the analysis to address the issue of site *awareness* among anglers. Furthermore, welfare estimates of selected policy initiatives, such as site closures or the impacts of the Oldman River Dam, can be calculated easily once the model is defined.

The standard random utility model incorporates awareness only in the most generalized sense: it is assumed that each angler is aware of all sites included in the model. Incorporating awareness into the model alters the structure of the choice set in that only those sites an angler is aware of are included. As a result, the underlying behavioral linkages in the awareness models are stronger than in the ordinary random utility models. Each alternative in an individual's awareness, or choice, set has some "learning cost" associated with it. In order to expand the set, individuals will investigate new alternatives until either the opportunity cost of learning exceeds some threshold budget level, or until they find a site with attributes leading to a utility value exceeding those already in their choice set. It is in this context that behavioral linkages influence choice sets.

In terms of examining the welfare impacts corresponding to the models with and without awareness, it is expected that there will be a significant difference between models. Consider, for example, an increase in water quality at a particular site, i. In the standard RUM framework, it is expected that there will be some positive welfare change as a result of this quality change. However, once awareness of sites is incorporated into the model, this welfare effect may be quite large for those anglers aware of site i, and zero for those anglers unaware of site i. Hence, a comparison of welfare measures between the random utility models described above may yield some insight as to the behavioral influences of awareness on fishing site choice.

Southern Alberta Sportfishing Study

In 1989, a task force was developed to outline and implement a socio-economic study of recreational fishing in Southern Alberta. Until then, there had not been any socio-economic data collected on the region, and there was a desire to examine the effectiveness of various environmental and fisheries related management proposals (Adamowicz et al, 1992). The main objective behind the study was to examine the socio-economic characteristics of anglers and the recreational fishing experience in Southern Alberta. Several key questions were posed at the beginning of the research process: How many recreational fishing trips are taken in one season? Where do anglers go? Why do they choose those sites? What are the environmental and biological quality factors at each site, and what influence do these factors have on site-choice? What influence does awareness of sites have on site-choice behaviour, and what are the impacts of awareness on welfare estimates? In examining the answers to these questions, information regarding the demand for recreational fishing and the angler's underlying preferences for environmental attributes may be revealed. In turn, this information may provide valuable insight into effective management proposals, and aid policy makers in developing strategies that will yield the highest social returns and improve the quality of the recreational fishing experience.

Objectives and Goals of the Research Project

The research in this thesis is intended to meet a variety of objectives. First, a methodology will be developed to analyze trip information and incorporate objective quality attributes into the economic analysis. An economic model of recreational Sportfishing for 67 sites in Southern Alberta will be developed. The model will be developed as a discrete choice travel-cost model. A Random Utility framework (RUM) will be used so that each site can be modelled as a bundle of physical, biological and environmental quality attributes.

Two separate approaches to estimation of Random Utility Models will be employed: first, a standard RUM will examine site-choice behaviour over 67 sites in the Southern Region, modelling each site as a bundle of quality attributes. In these models, the choice set for every individual will be comprised of all 67 Southern Region sites. In line with this approach, a second Random Utility model will be estimated from a randomly generated site-choice set. It has been suggested by Parsons and Kealy (1993) that when there are a large number of alternatives in a choice set, a randomly generated opportunity set can be used to approximate behaviour. It is anticipated that the results of these two models will closely mirror one another.

Second, a RUM incorporating only those sites that each angler is aware of will be estimated. It is hypothesized that using each angler's awareness set may be a better approximation of behaviour. Again, each site will be modelled as a bundle of quality attributes, but the choice set will encompass only those sites that an angler was aware of.

Once the model structure is defined, an examination of the economic welfare impacts of selected environmental policy initiatives and site closures will be examined and compared between models. Welfare estimates provide economists and resource managers with guidelines as to the relative economic value of a policy proposal. In a Random Utility context, welfare estimation generates market values for non-market goods and services. One application explored in the research in this thesis is an examination of welfare impacts of the Oldman River Dam on recreational fishing in Southern Alberta. Moreover, a comparison of welfare estimates between models may yield useful insight into the underlying behavioral influences of the site-choice assumptions made for each model.

The research will conclude with a brief discussion and summary of the results, conclusions regarding the Random Utility models and welfare measures, and suggestion for continuing research in evaluating the economics of environmental quality changes on recreation.

CHAPTER 2 - BACKGROUND

BENEFIT-COST ANALYSIS

In recent years, a key tool used by managers in the evaluation of environmental policy has been benefit-cost analysis. The overall objective of benefit-cost analysis is to provide a general picture of project viability and environmental impacts in terms of the benefits generated from the investment, and the costs associated with implementation of the project.

Benefit-cost analysis has a wide variety of applications in environmental management. It is most commonly used as a decision making tool. For example, consider a scenario where a wildlife agency wishes to implement a fish stocking policy at a particular lake. If an estimate of the benefits associated with increased fish stocking can be generated, it can be compared with the costs of implementing the project, and an informed decision about this policy can be made by the wildlife agency.

Benefit estimates can be a valuable part of the information base for environmental decision making (Freeman, 1979). In an economic context, there are two key components that should be considered when making policy decisions: efficiency and equity.

Efficiency is a fundamental objective underlying economic analysis: in an ideal market, resources are allocated in accordance with their most efficient or productive use. Discerning use of benefit-cost analysis in evaluating policy alternatives can contribute to more effective resource management. Benefit-cost analysis has the potential to become a useful tool in making decisions towards optimum environmental management. It can provide a set of definitions and procedures for measuring benefits and costs and provide a framework for making policy decisions with the underlying main objective being economic efficiency in resource use.

Incorporating equity considerations into policy decisions accounts for the distributional impacts of environmental policy. There is no direct problem solving approach to address equity issues in terms of benefit-cost analysis. Rather, benefit-cost analysis provides an information base on how to assess equity and distributional issues. Benefit-cost analysis identifies those individuals, or groups of individuals, who gain or lose as a result of implementation of a specific policy. Hence, information of this nature can be used effectively to assess equity and distributional impacts.

In examining the distributional components of environmental policy, two related issues arise: the inter-generational and intra-generational effects of environmental policy. Inter-generational distribution is a dynamic concept. It examines impacts on the current generation as well as giving due consideration for future generations. Intra-generational impacts, on the other hand, relate primarily to the distribution of benefits between current members of society.

Equity considerations in a benefit-cost framework are particularly obvious in an intra-generational perspective. Once the benefits from a particular project or policy are identified, economists can examine the distribution of those benefits among various members of society. For example, consider the benefits associated with building a dam. A water management project of this magnitude can cost significant sums of money, with benefits potentially accruing to a very small proportion of the population. Examination of the distribution of these benefits can aid policy makers in developing policy that not only meets efficiency criteria, but also meets some equity criteria as well.

Inter-generational linkages, however, are somewhat more subtle. These linkages are representative of the long term impacts of environmental policy on future generations. Benefit-cost analysis can identify those individuals, groups of individuals, or regions at a specific point in time that may gain or lose as a result of environmental policy. Capitalized values of these benefits and costs show the value, in perpetutity, of a stream of benefit or costs. However, the introduction of discount rates into the economic analysis can greatly complicate the benefit cost procedure, as, over the long term, discounted values approach zero. Clearly, in this context, the impacts of policy on future generations can not be clearly defined. A judicious evaluation of in inter-generational impacts can provide a valuable piece of information in making overall policy decisions.

BENEFIT MEASUREMENT

One of the foremost issues in the field of benefit estimation is the meaning or interpretation of the term "benefits". There have been several key questions posed in the literature (Freeman 1979, McConnell and Sweeney, 1985, Braden and Kolstad, 1991) that should be addressed in attempting to interpret the term "benefits": What is a benefit? And, of what use are benefit estimates in the formation of public policy?

Welfare Economics

The standard context in which to measure benefits is to evaluate price changes, and hence changes in individual welfare. The basis for determining these values stems from the underlying preference structure of the individual. The economic tools used to estimate these values can be found in the theory of welfare economics. Benefits estimates, or welfare measure, are obtained by converting changes in utility to dollar values.

Consider an individual whose utility is a function of market and environmental goods. Further assume that this individual chooses consumption bundles so as to maximize utility under a budget constraint as follows:

$$\max U = U(X,Q;S) \quad s.t. \quad \sum_{i=1}^{N} P_i x_i = M$$

where U = utility function of the individual, X = a vector of market goods, Q = a vector of environmental goods, S = socioeconomic variables, P_i = market prices of the nth good, and M = money income. The solution to this problem yields a set of ordinary, or Marshallian, demand functions:

$$x_i = x_i(P,Q,M)$$

Suppose one of the prices in the price set changes. Given this demand structure, a welfare measurement, consumer surplus (CS), can be derived as the area between two price lines bounded by the Marshallian Demand curve, ie:

$$CS = \int_{P_0}^{P_1} x_i(P_{x_i},Q,M)\partial P_{x_i}$$

Consider the dual aspect of the optimization problem: assume the individual minimizes expenditure subject to a constant level of utility:

$$\min \sum_{i=1}^{N} P_i X_i \quad s.t. \quad U(X,Q;S) \geq U$$

Solving these equations will yield an expenditure function, ***e=e(P,Q,U)***, and differentiating the expenditure function with respect to any price will yield the Hicks-compensated demand function for that good, where the demand functions are income-compensated:

$$\frac{\delta e}{\delta P_i} = x_i^* = x_i^*(P,Q,U)$$

Again, consider a price change for a market good. How can the well-being of the individual be assessed under the price change without dealing directly with utility, which is unobservable? Under this demand structure, two unique welfare measures are defined: compensating and equivalent variation, CV and EV respectively. Each examines a change in prices, and hence utility, and estimates a money measure of the welfare change associated with the change in prices.

Equivalent variation is a welfare measure defined at the new utility level resulting from the price change. In other words, EV is an income change that could be used in lieu of the price change to yield the same utility after the price change:

$$EV = e(P_1, Q, U_1) - e(P_0, Q, U_1)$$

where $\boldsymbol{P_1}$ and $\boldsymbol{P_0}$ denote the new and old set of prices respectively, and $\boldsymbol{U_1}$ is utility at the new price level. Alternatively, EV can be depicted graphically as the area under the Hicks-compensated demand curve, $\mathbf{x_i^* = x_i^*(P,Q,U_1)}$, between the two price lines:

$$EV = \int_{P_0}^{P_1} X_i^*(P,Q,U_1)\ \delta P_i$$

Compensating variation, on the other hand, is defined at the original utility level, and is the change in income which would make the individual indifferent between the original price set and the new price set. In other words, CV is the quantity of income that compensates consumers for a price change, returning them to their original level of utility. Hence, CV is defined as:

$$CV = e(P_1, Q, U_0) - e(P_0, Q, U_0)$$

where $\boldsymbol{P_1}$ and $\boldsymbol{P_0}$ denote the new and old set of prices respectively, and $\boldsymbol{U_0}$ denotes the original utility level. Again, CV can be depicted graphically as the area under the Hicks-compensated demand curve $\mathbf{x_i^*=x_i^*(P,Q,U_0)}$, between the two price lines:

$$CV = \int_{P_0}^{P_1} X_i^*(P,Q,U_0)\,\delta P_i$$

It has been well documented in the literature that the aforementioned welfare measures, consumer surplus, compensating and equivalent variation, will yield different values given a change in prices. The only situation where equivalent and compensating variation, and consumer surplus will coincide is when the income elasticity of demand for the good is zero. With zero income elasticity, there exists no income effect, and the Marshallian and Hicksian demand curves will coincide.

Consumer surplus is often used as a welfare estimate because of ease in estimation of Marshallian demand functions. However, it has been noted that Marshallian welfare measures may be inappropriate because of the fact the underlying demand curves are not income compensated. Therefore, price effects are compounded by income effects. Hence, welfare estimates based on consumer surplus are not unique if more than one price changes, or if price and income change simultaneously.

In light of the above criticisms of consumer surplus, compensating and equivalent variation may be more appropriate welfare measures in the context of policy decision-making. Unlike consumer surplus, measures of CV and EV are not path dependent in cases of multiple price changes. Both representations are equally valid, and it is not possible on the basis of the above theoretical framework to discriminate between the two measures of welfare.

It is important, however, to consider the economic and environmental climate when estimating and interpreting measures of compensating or equivalent variation. In this context, two key questions arise: how does this issue relate to the estimation of welfare measures? And, does this factor have some underlying influence on welfare? The derivations discussed above reveal that estimates of CV and EV are based on actual behaviour. Hence, the influence of economic and environmental conditions (for example, a recession or political pressure from an environmental group) implicitly exerts some influence over welfare estimation. It It should therefore be cautioned that welfare estimates based on cross sectional data, such as those generated in this thesis, do indeed reflect the current economic climate.

Environmental Quality

This research attempts to examine benefits, or welfare measures, resulting from changes in environmental quality. Environmental quality is usually considered a public good - typically, these goods exhibit the characteristics of non-exclusion and non-rivalry of use. As a result, market failure frequently follows. Often, benefit-cost analysis does not account for changes in environmental quality because these changes are not reflected in the market via prices. Hence, a measure of welfare that reflects the non-market characteristics of the environmental good must be derived.

In the context of environmental goods, benefits have been interpreted traditionally as a willingness to pay for improvements in environmental quality, or alternatively, a willingness to accept compensation for environmental damage. Given the above framework, and derivations of three measures of welfare estimation, it is clear that incorporating environmental quality into the utility function of the individual can yield useful welfare estimates.

Contemplate, for example, an improvement in an environmental quality attribute, such as the presence of trees at a fishing site. Further assume that an improvement of this nature will yield an increase in utility to an angler fishing at that site. Hence, an hypothesis can be made that an improvement in the forested area around a lake will yield some positive welfare change. It is the objective of the economist to estimate the welfare effect in dollar terms of changes in the quantity of the non-market commodity ie: to provide a money measure of the benefits accruing to an individual (or society as a whole) due to an improvement in environmental quality.

Analogous to the case described above, measures of compensating and equivalent variation can be defined as follows:

$$
\begin{aligned}
CV &= e(P,q'',U_0) - e(P,q',U_0) \\
EV &= e(P,q'',U_1) - e(P,q',U_1)
\end{aligned}
$$

where q' is the initial quality state, q" is the final quality state, and U_0 and U_1 are representative of utility at the original and new levels for compensating and equivalent variation respectively. Note that the price vector for market goods remains constant, hence the change in quality attributes is capturing the non-market aspect of the environmental good.

NON-MARKET GOODS

Value Typology

Benefit-cost analysis is a useful tool for providing economists and policy makers with a reference point in terms of decision making. However, in implementing effective policy, economists must identify the type of benefit desired, and then develop an approach, such as those described above, to measure those benefits. Typically, there are two broad categories of value associated with non-market goods: use values and non-use values (Adamowicz, 1991, and Smith, 1989).

Use values are commonly associated with an activity, such as fishing or hiking. Often, there is some complementary market good that reflects the value of the environmental resource, such as fishing rods or hiking boots. Use values can be further sub-classified into consumptive and non-consumptive uses. Consumptive use can be defined as use that directly affects the resource. For example, a recreational fishing trip has a direct impact on the number of fish available to catch at a particular site. On the other hand, non-consumptive use has minimal impact on the environment. Consider a hiking trip where the main objective is to view nature and experience the "great outdoors". This activity has marginal impacts on the resources required to meet the objectives of the trip.

Non-use value is a value associated with an environmental good just because it is there ie: an existence value. Non-use values typically arise because of the inherent public good characteristic of environmental commodities (Smith, 1993). Because of their elusive nature, non-use values have been difficult, if not impossible to estimate empirically.

The research in this thesis will focus on use values associated with recreational fishing in Southern Alberta. In particular, values of selected environmental policies will be estimated, such as the impact of the Oldman River Dam, and closing selected sites.

Non-market Valuation Techniques

The theoretical framework includes a methodology to estimate the benefits associated with environmental quality, and identifies the type of benefit being estimated. This section will endeavour to examine various approaches used to estimate the demand for recreation (Bockstael et al, USEPA, Fletcher et al, 1990).

There are two key techniques whereby the demand for recreation can be estimated: the direct approach and the indirect approach. The direct approach is a conversational method, and elicits information from respondents about their willingness to pay, or alternatively their willingness to accept compensation, for changes in environmental attributes, or for some other environmental good. In comparison, the indirect approach is a behavioral technique, and allows estimation of the demand for recreation based on the demand for complements and substitutes with market prices. Within these techniques, there exist a variety of methods for deriving demand (Feenburg and Mills 1980, Mitchell and Carson 1989, Freeman 1979). This section will briefly examine two methods commonly used in the literature and in many benefit-cost studies: Contingent Valuation and The Travel Cost Approach.

Contingent Valuation

Contingent Valuation is a direct method of estimating the demand for an environmental good. This approach is most useful when the environmental good being studied is not represented by some complementary market commodity. The standard framework in which contingent valuation studies are done is to "create" a market for an environmental good and, contingent on the existence of this market, solicit information from respondents about their willingness to pay (WTP), or alternatively, their willingness to accept compensation (WTAC), for changes in the supply characteristics of an environmental good (Mitchell and Carson, 1989).

There are some significant advantages associated with the contingent valuation approach (Smith, 1993, Mitchell and Carson, 1989). Foremost is the great flexibility of contingent valuation, particularly in valuing environmental attributes that are difficult to model using other non-market techniques. Furthermore, contingent valuation can be utilized to elicit non-use values. Finally, benefit estimation under the contingent valuation method is straightforward. Welfare measures are easily obtained because respondents are indicating how much they would pay for the increase (or accept for a decline) in an environmental attribute, which, by definition, is a welfare measure.

However, there are some drawbacks associated with this technique (Braden and Kolstad, 1991). First, there is a multitude of problems that arise with survey design and implementation: embedding effects and strategic bias are just two examples. The chief criticism of the contingent valuation approach has been the premise that "hypothetical questions get hypothetical answers", as it is unclear whether respondents can relate to a hypothetical situation.

In summary, the contingent valuation approach is very flexible and allows economists to estimate values for commodities that are difficult or impossible to estimate with standard econometric techniques. However, the criticisms of this approach seem significant. In particular, the fact that welfare estimates are not based on actual behaviour may be a major drawback in terms of policy applications (Adamowicz, 1991, Mitchell and Carson, 1989, McConnell, 1985).

The Travel Cost Approach

The most popular model in the recreation literature that values the non-market aspects of environmental attributes is the travel cost model. The travel cost model is an indirect method of non-market valuation, where the demand for recreation is based on the demand for complements and substitutes priced in the market. In his letter to the US National Park Service in 1947, Harold Hotelling proposed the first travel cost model. He surmised that the time and travel costs required to get to a recreational site act as implicit prices for the environmental attributes and recreational services of that site. It was this fundamental insight, that the consumer must visit a site to consume its services, that sparked the development of travel cost models (Freeman 1979, McConnell 1985, and Braden and Kolstad, 1991).

Travel cost models are designed as a site-specific approach to estimating the value of recreation at a specific site over a period of time. Clearly, demand for recreation in general can not be modelled in the context of standard travel cost models. In a multiple site context, the travel cost model can be parametrized to model substitution between sites. However, within the varying parameters framework, estimation of demand with substitution effects can be computationally difficult to estimate, and the model may be plagued with multicollinearity (Bockstael et al, 1989). However, using the discrete choice approach, the basic theoretical foundation of the travel cost model can be extended to model choice and substitution among a group of sites.

To summarize, the travel cost approach offers qualitative insight into the demand for non-market commodities using observable market behaviour. And, extending the basic travel cost model to a discrete-choice random utility model allows the researcher to model substitution and examine the choice decisions about recreational fishing trips that each individual makes (Coyne and Adamowicz, 1989). This thesis will employ a Random Utility approach to estimate the demand for recreational sportfishing in Southern Alberta.

To date, there is a vast literature on the theoretical aspects of travel cost and random utility models. Additionally, with growing concern for the environment and a desire by policy makers and economists to examine the non-market aspects of the economy, various applications of the travel cost and random utility approaches have been done. These issues will be explored briefly in the theoretical discussion of the following chapter.

SUMMARY

To reiterate, benefit-cost analysis provides a framework for decision making by presenting alternatives and allowing policy decisions to be made on the foundations of equity and efficiency. The theory of welfare economics can provide economists with dollar values of changes in environmental quality, or the impacts of any selected environmental policy initiative. An extension of traditional welfare economics theory to environmental goods shows the interface between the non-market aspects of recreation demand, such as the natural resource requirements and environmental quality, and economic aspects, such as the benefits derived from recreation activity due to changes in environmental quality.

Environmental policy initiatives that have an impact on the non-market aspects of recreation, or change the way in which individuals use the environment, will have economic consequences. Hence, the study of recreation demand and benefit-cost analysis provides environmental economists and policy makers with a tool that can effectively evaluate policy proposals and perhaps shed some insight into the effective and efficient management of recreation-based resources.

CHAPTER 3 - THEORETICAL BACKGROUND

INTRODUCTION

Outdoor recreation is a service produced and consumed by an individual in conjunction with a natural resource, such as fish, or some other environmental good, such as water quality. McConnell (1985) identifies three main characteristics underlying the demand for environmental goods in a recreational context: production, demand, and supply.

The main production characteristic is that the consumer must be transported to the recreation site in order to "consume" the natural resources. Hence, factors such as time and travel cost will come into play in the production analysis. Second, the formation of demand for outdoor recreation requires focusing in on the allocation decisions of the individual. Hence, demand analysis will require development of econometric models designed to incorporate this decision-making process. Third, the key supply characteristic of outdoor recreation is the natural resource requirement. Knowledge of the availability and quality of resources at a recreation site is a crucial factor in estimating models of recreation behaviour.

There exist subtle linkages between the three components described above. The first linkage is embodied in the supply characteristic of recreation demand, and translates ambient quality changes into environmental attributes readily perceived by the recreationist. Qualitative measurement of this linkage is obtained from objective quality measurement of the relevant environmental parameters. The next linkage is a dichotomous one, involving production and demand. This linkage examines the response pattern of the recreationist to perceived changes in environmental quality. The final linkage is the valuation of the recreationist's response, or an estimation of the benefits associated with changes in environmental quality.

In order to measure effectively the recreation benefits associated with a quality change, these linkages must be captured quantitatively (McConnell, 1985). In this research, quantitative analysis will be done within the constructs of a Random Utility Travel Cost Model. The theory of welfare economics provides the tool for quantitative measurement of the final linkage: an estimate of the welfare impacts of changes in environmental quality.

TRAVEL COST MODELS

A travel cost model is formulated on the premise that visits to a site (V_i) are a function of travel costs to the site (C_i), market prices (P), environmental quality attributes of the site (Q_i) and other socioeconomic attributes (S):

$$V_i = f(P, C_i, Q_i; S) \ .$$

Travel costs serve as surrogate prices for the site. In the context of demand for the site, changes in travel cost or changes in an environmental attribute will change visitation rates. The travel cost model can be expanded further to estimate demand for specific attributes associated with a site. In turn, this demand function is used to derive a measure of the willingness to pay for the site, or welfare estimates.

There are two fundamental assumptions underlying travel cost models: weak complementarity and demand homogeneity. The weak complementarity assumption implies that people must trade-off between environmental quality and market goods. Further, this assumption must hold in order to calculate welfare measures. Weak complementarity assumes that there is some choke price above which the willingness to pay for improvements in environmental quality is zero. Hence, weak complementarity bounds the welfare measures. Demand homogeneity is the assumption that all demand parameters are the same across all individuals.

Related to the weak complementarity assumption is the issue of separability in demand (Fletcher et al, 1990). Essentially, the separability issue poses the question: *What parameters should be included in the demand estimation function?* Demand separability can take a variety of forms: goods separability (ie: recreation vs non-recreation goods), spatial separability (ie: how many sites are included in the model), and temporal separability (ie: a planning factor). The separability issue of most concern to the researcher in this thesis is that of spatial separability. Particular emphasis will be placed on the underlying assumptions about the sites included in the model.

There are several distinct advantages that make travel cost models popular among economists. First, travel cost models bring preferences for non-market goods into the arena of observable market relationships (Braden and Kolstad, 1991). In other words, actual behaviour serves as the basis for estimating demand and welfare measures. As a result, studies often can be initiated based on available data without employing the financial and time resources required for contingent valuation studies. Further, welfare estimates are based on what people actually do, rather than what they *say* they will do, and perhaps provide policy makers with more realistic estimates of the true value of the resource. Second, travel cost models are somewhat flexible as they can estimate the value of a specific site, such as a park or fishing site, and value changes in environmental quality attributes, such as improvements in water quality or fish catch rates.

However, there are some notable weaknesses in the travel cost model that deserve comment. First, the approach is limited in that the welfare estimates obtained from the model only reflect use values associated with a specific site. Values that do not entail direct consumption cannot be estimated, hence this approach cannot be used to determine non-use values associated with recreation at a particular site, or for a specific environmental attribute.

Second, travel cost models are usually estimated on cross sectional data ie: data taken at one point in time. As a result, there is typically no variation in quality aspects between observations. Temporal or spatial effects are required to examine effectively the impacts of changes in environmental quality. Also, little consideration is given to incorporating cross-substitution of sites into the demand estimation. If this factor is not accounted for adequately in the model, welfare estimates will be biased, and hence may not reflect the true value of the resource.

As was briefly mentioned in Chapter 2, a discrete choice approach is often used to overcome these limitations. The next section outlines the theoretical framework of the Random Utility Model.

RANDOM UTILITY MODELS

Discrete choice models are models in which the dependent variable assumes discrete values (Madalla, 1983), for example, the site visited on a single fishing trip. Instead of modelling the number of visits, as in the Travel Cost approach, the discrete choice approach models the choice of one of several sites on a single recreation trip.[1] Random utility models provide the economist with useful behavioral insight as they examine the decision-making process of the angler within the context of objective site quality attributes.

In a Random Utility framework[2], the angler is faced with a choice set, denoted $\boldsymbol{C_n}$. By definition, all alternatives within this set are assumed to be mutually exclusive. In this research, the choice set is comprised of recreational fishing sites in Southern Alberta. Each choice, $\boldsymbol{i}$, in the set has associated with it a conditional indirect utility:

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[1] As in the general travel cost model, the assumptions of weak complementarity and demand homogeneity still hold.

[2] The bulk of this discussion is based on Freeman and Peters, 1992, Ben-Akiva and Lerman, 1985, and Maddala, 1983.

$$U_i = f(Y-T_i; Q_i, S)$$

where the utility associated with a visit to each site is a function of income (***Y***), travel cost to the site (T_i), environmental quality of the site (Q_i), and other socioeconomic variables (***S***).

The choice process involves the angler choosing one site over another because the utility associated with visiting that site, say site ***i***, is higher than for any other site. That is:

$$U_i > U_j \quad \forall j \in C_n$$

The underlying indirect utility function is composed of a systematic component, V_i, and a random component, ϵ_i:

$$U_i = V_i + \epsilon_i.$$

The systematic component has its roots in utility theory. It may include attributes of the sites as well as characteristics of the decision maker. The random component accounts for incomplete information, unexplained changes in consumer tastes, and researcher error.

Examining this choice process in a statistical context, the probability that an angler will choose to visit site ***i*** is:

$$\begin{aligned} P(i) &= P(U_i > U_j) \\ &= P(V_i + \epsilon_i > V_j + \epsilon_j) \\ &= P(V_i - V_j > \epsilon_j - \epsilon_i) \end{aligned}$$

If the ϵ's are Type-I extreme value (Weibull) distributed, then the probability of visiting site ***i*** can be denoted as:

$$Pr(i) = \frac{e^{V_i}}{\sum_{j=1}^{N} e^{V_j}}$$

where the denominator is the sum of the exponential of the conditional indirect utilities over all the alternatives in the choice set.

The above theoretical description reveals that site choice is a function of differences in utility between sites. However, in order to estimate the parameters of the utility function, some assumptions must be made about the structure of the systematic component of the utility equation. Ben-Akiva (1985) poses an important question that facilitates the identification of the systematic components of utility: What types of variables can enter these functions? The answer to this question lies in the separability issue introduced in the travel-cost section. There are two key points that will be examined: the effect of including socioeconomic variables in the analysis, and the underlying choice set assumptions.

The systematic component of utility contains variables that the consumer bases his or her decisions on. However, researchers often encounter problems when dealing with some socio-economic variables, such as age, sex, or income. These variables are common to the calculation of the utility for all goods, and their effect will be eliminated when the difference in utility is calculated. For example, consider a simple indirect utility function specified as:

$$V_i = \beta(T_i) + \alpha\text{ (age)}.$$

Calculating the difference in utility between two sites, i and j:

$$V_i - V_j = [\beta(T_i) + \alpha(\text{age}) - \beta(T_j) - \alpha(\text{age})]$$
$$= \beta(T_i) - \beta(T_j)$$

Under the assumption of demand homogeneity, age becomes irrelevant to the analysis. However, the exclusion of these variables could lead to problems with specification error as their effect would then appear in the error terms of the original utility function. One solution to avoid this problem in to interact socio-economic characteristics with attributes of the goods, for example, travel cost divided by income.

A somewhat more thought provoking issue related to separability is that of the underlying choice set assumption. Undoubtedly, the composition of the angler's choice set can have a potentially large influence over site-choice. As more sites are added to the choice set, the probability that any one site will be chosen for the angler's next trip declines. Moreover, a change in the underlying structure of the choice set likely will result in a change of the estimated parameters in the indirect utility function. Hence, the sites that are included in the underlying utility structure can exert influence over the demand estimation and welfare impacts.

To date, many of the Random Utility Models presented in the literature have been estimated based on the assumption of perfect information across individuals. This thesis hypothesizes that incorporating actual awareness of sites into the choice set will capture information effects and provide some insight into the behavioral impact of learning. One of the important issues in this study is whether the respondents' awareness of the available choice opportunities enhances the understanding and prediction of the patterns of spatial behaviour (Perdue, 1987).

Welfare Analysis

Under the assumptions outlined above, welfare estimation in the Random Utility model is fairly straightforward. Small and Rosen (1981) and Hanneman (1980, 1981) derive the compensating variation[3] measure of the change in consumer's welfare as:

$$CV=\frac{1}{\mu}[\ln\sum_{i=0}^{N} e^{V_{i0}}-\ln\sum_{i=0}^{N} e^{V_{i1}}]$$

Because environmental attributes are included in the underlying utility function of the angler, changes in environmental quality or some other attribute at a site (or group of sites) will result in some welfare impact to that angler. In this formula, V_{i0} and V_{i1} represent the utility before and after the quality change at site i, and the impact of the quality change is summed over all sites in the angler's choice set.

It should be noted that μ, the marginal utility of income, is assumed to remain constant. Hanemann (1981, 1982) shows that μ is essentially β_{DIST}, the coefficient on the travel cost parameter estimated in the Random Utility Models. In a generalized sense, the indirect utility function can be represented as:

[3] Note that this derivation of CV estimates welfare impacts ***per trip.***

$$V_i = \beta(Y - TC_i) + \alpha(Q)$$

where β and α are the parameters to be estimated, **Y** is income, $\mathbf{TC_i}$ is travel cost to site i, and **Q** is a vector of quality attributes. The marginal utility of income can be calculated by partially differentiating the utility function with respect to income:

$$\frac{\partial V_i}{\partial Y} = \mu = \beta$$

which yields the coefficient on travel cost. A more in depth discussion of this calculation will be presented in Chapter 6[4].

Once again, the issue of choice set assumptions discussed above will have some influence over welfare estimation. Because welfare estimates for a quality change are summed over all sites in the anglers' choice set, the size and composition of that choice set will have an impact on the magnitude of the welfare estimate. This premise will be discussed in more detail in Chapter 6.

SUMMARY

Quantitative measurements of demand are required if the welfare impacts of changes in environmental quality are to be estimated. This chapter outlines the underlying theory of Travel Cost and Random Utility Models. The advantages and limitations associated with each of these approaches are briefly reviewed, and a brief discussion of some important issues and assumptions, such as separability

[4] Actually, in this thesis, the marginal utility of income is the negative of the coefficient on the travel cost parameter since *B*(TC) is estimated.

and demand homogeneity, are introduced. The chapter concludes with a brief examination of welfare estimation and the underlying assumptions pertaining to the marginal utility of income.

CHAPTER 4 - THE DATA

SOUTHERN ALBERTA SPORTFISHING SURVEY

The primary source of data for this research project was the Southern Alberta Sportfishing survey administered in 1991. The main objective of the survey was to elicit information on fishing preferences, values, and attitudes and further, to obtain information on recreational sportfishing trips taken during the 1990 fishing season. The survey was designed to focus on recreational fishing activity in the Southern region of Alberta. Anglers living in the Southern region will tend to fish in that region. However, anglers from other regions in the province, in particular Central Alberta, also will fish in the Southern region. Hence, the survey was based on a geographical distribution which was expected to account for approximately 95% of the fishing trips taken to sites in Southern Alberta.

The survey was divided into four main sub-components: attitudes and opinions about fishing, awareness of Recreational Fishing sites in Southern Alberta, trip information, and demographics. A brief summary of the results of the survey, and an econometric analysis of the data obtained from the trip information will be discussed in Chapter 5.

A random sample of 5000 names, obtained from copies of fishing licences sold in the Southern or Central regions of Alberta in 1990, was generated for the survey. Further, a smaller sample of 478, taken from a list of 1978 names provided by the Fish and Wildlife Division, was used to verify that the sample of

5000 approximated the population that fished in the Southern region. This smaller sample included individuals residing in all parts of the province

The following table (Table 4-1) summarizes response rates for mailings of the Southern region and Alberta survey. Overall, the effective response rate for the Southern region survey was 48%, with the Alberta Survey response rate at 43%. In both cases, these response rates were quite commendable given the complexity and length of the survey. For more details regarding survey design, mailout procedure, and response rates, refer to Adamowicz et al (1992).

Awareness of Recreational Fishing Sites in Southern Alberta

In examining site choice behaviour among anglers, awareness of Recreational Fishing sites is one of the most important variables to consider, as awareness of recreational fishing sites determines an angler's choice set. Further, the composition of an angler's choice set is one of the fundamental underlying

Table 4-1: Southern Alberta Sportfishing Survey Response Rates

Mailout	Number sent	Effective sample size	Number completed	Effective Percentage
Southern region	5000	4420	2115	48 %
Province wide	478	431	187	43 %

Source: Adamowicz et al, *A Socio-Economic Evaluation of Sportfishing Activity in Southern Alberta*, 1992 structural assumptions when discrete choice econometric analysis is used to describe statistically site-choice visitation.

The map on the following page, Figure 4-1, indicates the location of seventy seven Recreational Fishing sites in Southern Alberta, and Appendix A shows the names of all sites. Of these sites, sixty seven were used for the economic analysis.[5] On average, anglers took five trips to these sixty seven fishing sites during the 1990 fishing season.

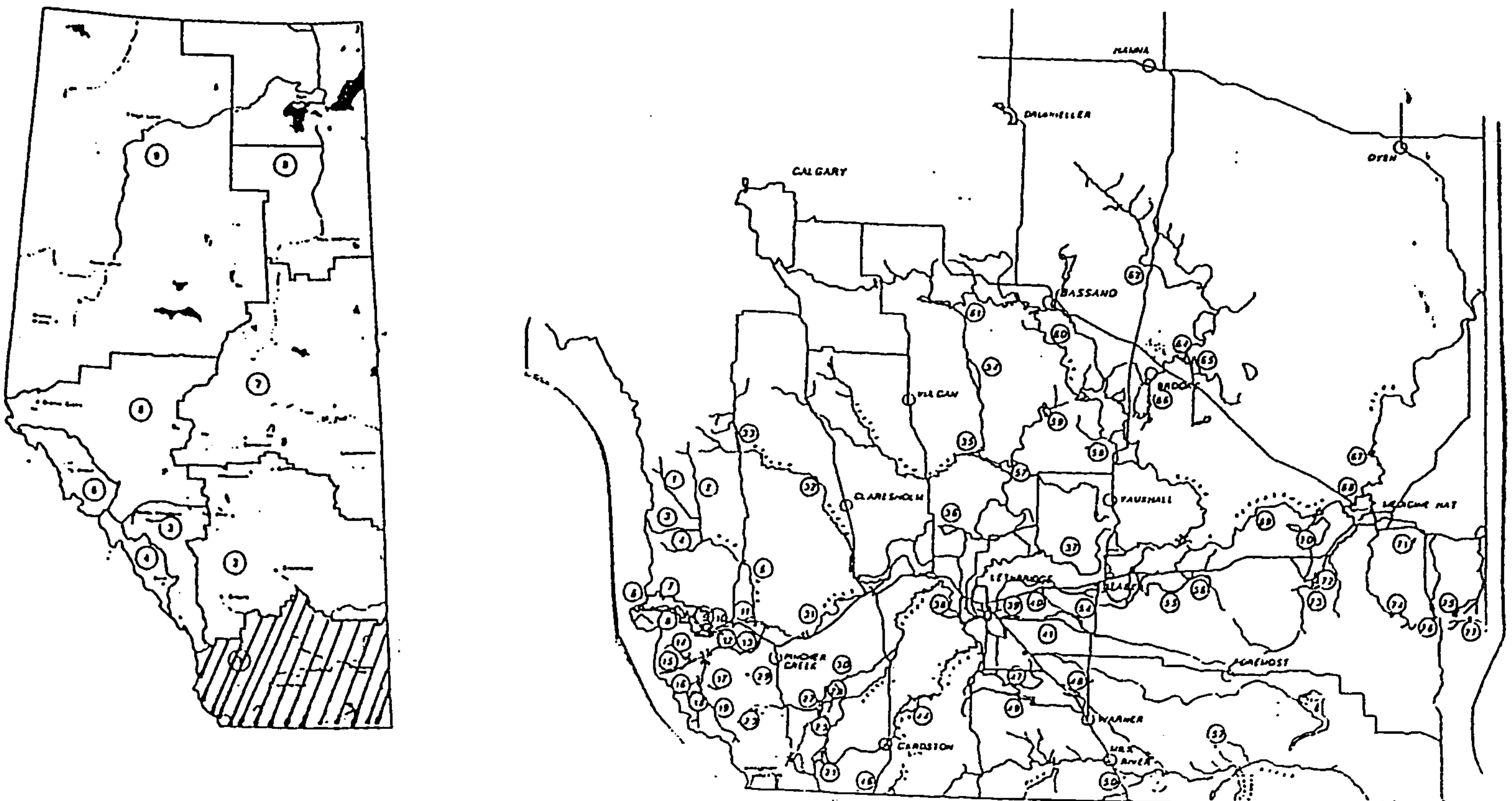
Each survey respondent was shown the map of seventy-seven sites and asked a question about their awareness of these sites. The data obtained from this question were used as the angler's awareness set, or choice set. The seventy seven Southern Alberta Recreational Fishing sites named in the survey were divided into fifteen regional groups. For a description of the awareness question and frequency statistics on awareness for all sites within these fifteen regions, refer to Adamowicz et al (1992).

QUALITY DATA

Data on quality aspects of the seventy seven sites used in the survey were obtained from *Alberta Forestry, Lands, and Wildlife*. The quality aspects of each

[5] Because of a lack of available environmental quality data, and the fact that few trips were taken to these sites, there were 10 sites deleted from the original choice set of 77, resulting in an effective choice set of 67 sites. The deleted sites are: Crooked Creek, Cottonwood Creek, Butcher Lake, Drywood Creek, Belly River, St. Mary River (sites 43 and 45), Milk River (sites 51 and 53), and Brook's Children's Pond.

Figure 4-1: Map of Southern Alberta Fishing Sites



site encompass a wide range of quality parameters, ranging from measures of environmental quality, such as water quality, to more subjective site-specific qualitative measurements such as level of development, to objective physical qualitative aspects such as size of the relevant water body. In total, there were forty different quality variables measured for each site. For a complete listing of the quality data collected, refer to Appendix B.

All forty quality aspects could not be used in the econometric analysis of Recreational Sportfishing in Southern Alberta. Hence, a cross section of quality aspects representative of those preferences and attitudes expressed in the first section of the survey were used. In general, these quality aspects were indicative of overall environmental quality and reflected those site-characteristics related to recreational fishing that anglers deemed most important. In addition, several dummy variables and other quality attributes were included to account for preferences not revealed in the survey and to allow for sufficient breadth of variability of quality attributes. Table 4-2 summarizes the main quality aspects used in the econometric analysis.

The table shows that the main environmental quality indicators used in the modelling are water quality (WATQUAL), pristine wilderness lake (PRISTINE), size of fish caught (SIZECOT), and forested site (TREES). The biological aspects encompassed in the quality variables are catch rates for general fishing and trout fishing respectively (CATCHRT and TROUTCR), and whether a lake is stocked with trout (STOCK). The other quality variables are representative of a cross-section

Table 4-2: Quality Attributes used in Models

VARIABLE	DESCRIPTION	RATING
CAMP	CAMPGROUND	0=ABSENT, 1=PRESENT
CATCHRT	CATCH RATE (GENERAL)	# CAUGHT PER HOUR
WATQUAL	WATER QUALITY	1=POOR, 10=EXCELLENT
PRISTINE	PRISTINE WILDERNESS LAKE	0=NO, 1=YES
DEVELOP	LEVEL OF DEVELOPMENT	1=NO DEV, 10=FULL DEV
SIZECOT	SIZE OF FISH CAUGHT	1=DIFFICULT, 10=EASY
TREES	FORESTED OR TREED	0=NO, 1=YES
INAPARK	IN A DESIGNATED PARK	0=NO, 1=YES
AREAWAT	AREA OF WATERBODY	HECTARES
LENGTH	LENGTH OF STREAM	KILOMETERS
RESERV	RESERVOIR	0=NO, 1=YES
STABLE	STABILITY OF WATER FLOW	1= VERY STABLE 10=FLUCTUATIONS
TROUTCR	CATCH RATE (TROUT)	# CAUGHT PER HOUR
STOCK	STOCKED WITH TROUT	0=NO, 1=YES

of quality factors that are hypothesized to influence an angler's site choice - these variables manifest themselves as the physical attributes of a particular site.

It has been suggested in the literature (Freeman, 1979) that congestion at a recreation site has influence over the estimation of recreation demand and, therefore, any ensuing welfare estimates. Freeman defines congestion of a recreation site as occurring when the number of users is so large that it diminishes the utility of those users.[6] However, in the research contained in this volume, congestion is hypothesized as being endogenous to other quality attributes included in Table 4-2. For example, the variables CAMP and DEVELOP implicitly assume that as the level of development increases, or as campgrounds are built, congestion will increase. Anglers making site-choice decisions will implicitly account for congestion when weighing the quality attributes CAMP and DEVELOP into their decisions. Hence, a congestion variable is not included as one of the quality attributes that Recreational Fishing in Southern Alberta will be modelled on.

DISTANCE DATA

The fundamental premise of a travel cost model is that visits to a site are modelled as a function of travel cost to the site, environmental quality, and other socio-economic variables. The bulk of the discussion thus far has concentrated on the environmental and socio-economic attributes of Southern Alberta anglers. Hence, in order to complete the estimation, a travel cost component must also be included in the analysis. In the sportfishing models developed in this research, DISTANCE will be used as a proxy for price.

Distances to fishing sites were measured using a measuring wheel on maps of the region (Watson et al, 1993). Each respondent indicated in the survey where they were residing, and from this information, distances to the seventy seven

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[6] Freeman further quantifies this definition by stating: "...I ignore the possibility that numbers might increase the utility of users because of enhanced opportunities for social interaction." (page 220, Freeman, 1979)

fishing sites from the respondent's place of residence were calculated. As a note, the distances used in this analysis were estimated in miles, and the distance variable reflects one way travel to the site.

SUMMARY

The Southern Alberta Recreational Sportfishing survey provided an abundance of information regarding the socioeconomic characteristics of Southern region anglers and identified those sites visited during the 1990 fishing season. The survey respondents identified those quality attributes most important to them, and Alberta Fish and Wildlife provided the researchers with objective quality attributes of the seventy seven Southern Region sites. Distance data were calculated and act as price proxies in the models to be estimated.

CHAPTER 5 - RESULTS AND MODEL ESTIMATION

DESCRIPTIVE STATISTICS

Attitudes and Opinions about Fishing

A great deal of attitudinal information is available from the respondents of the survey. This section will summarize briefly only the key points. A more detailed statistical description of the survey responses can be found in Adamowicz et al (1992).

The survey reveals that one of the most important underlying opinions about fishing site choice in Southern Alberta is the environmental quality of the site being visited. Over eighty five percent of the survey respondents identified water quality as being one of the most important factors that influence site choice. Natural beauty of the surroundings, privacy from other anglers, and access to wilderness areas also rank important for the majority of survey respondents. Further, knowing whether a lake is stocked with fish was relatively important for a majority of respondents. Whether this characteristic has a positive or negative influence on site choice will be explored in the next section of this chapter.

When asked what specific things about an angler's *favourite* site are most enjoyed, the responses were consistent with the overall attitudinal preferences except for one notable exception: the specific characteristic most enjoyed by anglers at the favourite fishing site was "good fishing" (high catch rate). Again, the environmental quality characteristics of seclusion and water quality were also very important.

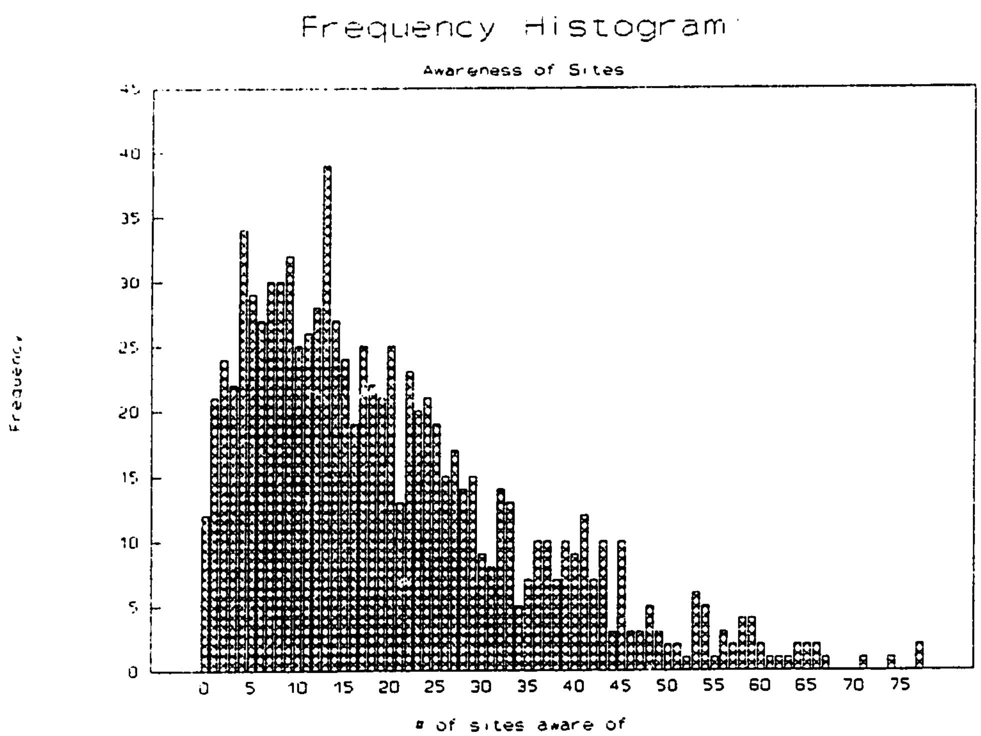
Attitudes and opinions related to accessibility show some interesting results. The respondents indicated that distance from home is another of the most important factors determining visitation to a specific site. However, good road access to the site and access to on-site facilities, such as boat ramps and picnic/camping facilities, did not rate as important for Southern region anglers. This preference structure is consistent with the fact that privacy, natural beauty, and wilderness access all rank most important with anglers.

A Digression on Awareness

The awareness information elicited in the survey provides useful information for discrete choice modelling: the sites respondents indicated as being in their awareness set are the actual sites that the angler is making his or her choice decisions from. In previous studies, statistics of this nature have been unavailable, and economists have had to make choice set assumptions. However, using the data generated from the awareness question, actual choice sets can be constructed and models can be estimated based on a choice set that accurately reflects the real choice set of the angler.

Figure 5-1 below graphically depicts the awareness frequency distribution[7]: the horizontal axis represents the number of sites that an individual is aware of, and the vertical axis depicts the frequencies. The average angler was aware of 33 of the 67 sites used in the econometric analysis. Few respondents are aware of a large number of sites. It is expected that these individuals are avid anglers with many years of fishing experience.

Figure 5-1: Awareness Frequency Distribution



[7] The frequency histogram represents the number of sites each angler was aware of over the entire choice set of 77 sites, rather than the choice set of 67 sites used in the econometric analysis.

One of the most influential factors over the size and composition of an individual's site-choice set is distance, as was indicated in the preferences and attitudes section described above. Besides distance and other environmental quality attributes, there may be some other factors influencing the number of sites in an angler's site choice or awareness set. It is expected that years of fishing experience (YEARS), and amount spent fishing per season ($FISHING) have influence over awareness. That is, an angler with many years of fishing experience who invests a relatively large portion of his or her income in recreational sportfishing is likely to be aware of a broad diversity of sites. Additionally, enjoyment of travel time to site (ENJOY), and length of fishing trip (LENGTH) may also impact on the awareness set. For example, if travel time is enjoyed, the angler may derive utility from exploring potentially new sites. In order to test the hypothesis that these factors have some explanatory power over the number of sites an angler is aware of, an ordinary least squares (OLS) regression testing this hypothesis is estimated. The results are presented in Table 5-1. The dependent variable used in the regression analysis is NUMAWARE and is indicative of the number of sites that an angler is aware of.

The *a priori* assumptions on this model are that all signs on the coefficients should be positive. Examining the results in table 5-1, the signs on $FISHING and YEARS are consistent with *a priori* expectations. Further, these variables and the constant are significant at the 99% level. However, ENJOY and LENGTH are both negative and insignificant, indicating that the influence of these variables on

Table 5-1: OLS Regression to Estimate Awareness

Dependent Variable: NUMAWARE		
VARIABLE	**B**	**T-STAT**
$FISHING	1.72	4.7
YEARS	0.21	4.7
ENJOY	-0.9	-0.42
LENGTH	-0.3	-0.16
CONSTANT	4.1	10.19

NUMAWARE is not meaningful. The results of this OLS analysis are consistent with intuition: an angler with many years of fishing experience who spends a lot of money on fishing per season is expected to be aware of more sites than an angler who has just started fishing and spends relatively little on this recreational activity. Further, awareness of a particular site does not necessarily imply that the site will be visited, rather one more site is added to the choice set and the angler has an additional site to consider in his or her decision-making process.

SOUTHERN ALBERTA SPORTFISHING MODELS

To model effectively recreational sportfishing in Southern Alberta, a model must attempt to capture the behavioral motivations underlying the choice process that anglers fishing in this region consider when making their site-choice decisions. In an effort to bring behavioral influences in line with econometric theory, three separate random utility models will be estimated. Each model will be based on the same theoretical constructs, but will employ different behavioral assumptions. Specifically, the underlying structure of the angler's choice set will be changed in accordance with the specifications of the modelling approach.

At this point, it may prove useful to make some *a priori* assumptions on the signs of the coefficients[8]. In line with demand theory, it is hypothesized that the sign on the travel cost parameter will be negative. Additionally, consistent with the preferences expressed in the survey, it is hypothesized that signs on the environmental and physical quality attributes will be positive, while DEVELOP will be negative. Recall that anglers indicated *whether a lake is STOCKed* as being an important quality attribute. It is assumed that the overall influence of this attribute on site choice will be positive, however, it should be noted that some anglers may be averse to this attribute. Finally, because of the objective structure of STABLE, it is expected that the sign on this coefficient will be negative; that is, as the instability of the water flow increases, the probability that an angler will choose this site declines.

Table 5-2 summarizes the results of the three random utility models which were estimated. For a summary of the standard errors of the coefficients, refer to Appendix C. The following sections will provide a detailed description of the respective underlying structural assumptions and an economic interpretation of the results.

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[8] Refer to Table 4-2 in Chapter 4 for a summary and description of the quality attributes used in the models.

Basic Random Utility Model

The econometric analysis begins with a standard random utility model, denoted "RUM" in Table 5-2. The structural assumptions underlying this model are as follows: each site will be modelled as a bundle of objective quality attributes

Table 5-2: Random Utility Models

VARIABLE	RUM	RUM-5	AWARE
DISTANCE	-0.045	-0.043	-0.025
CAMP	0.726	0.765	0.217
CATCHRT	0.307	0.357	0.221
WATQUAL	0.0530	0.0428	0.0954
PRISTINE	0.217	0.0477 *	-0.134 *
DEVELOP	-0.0680	-0.0666	-0.116
SIZECOT	0.166	0.131	0.149
TREES	0.808	0.797	0.393
INAPARK	-0.178	-0.225	0.0852 *
AREAWAT	0.000202	0.000200	0.000784
LENGTH	0.00403	0.00380	0.00405
RESERV	0.802	0.656	0.497
STABLE	-0.0329	-0.0487	-0.0508
TROUTCR	1.09	0.878	0.398
STOCK	0.132	0.0191 *	0.0106 *
ρ^2	0.19	0.34	0.08

* denotes insignificant at the 95% level

and a travel cost parameter. In this model, the choice set will be comprised of all sixty seven Southern Region sites. Recall that the dependent variable is the probability an angler chooses to visit site *i*.

Examination of the "RUM" column in Table 5-2 shows all variables to be statistically significant and confirms the hypothesis stated above, with one notable exception. The sign on the coefficient INAPARK is negative. However, this is not a particularly worrisome result. It is suspected that endogeneity exists between INAPARK and other variables included in the model, such as DEVELOP. Sites that are located within the boundaries of a designated Provincial Park may be more developed due to the nature of their location, and the fact that multiple recreational activities, such as swimming and picnicking, are likely occurring at these sites. Additionally, collinearity likely exists between INAPARK and other variables, such as RESERV and CAMP, and INAPARK may be implicitly modelling congestion.

It is reassuring that the signs on the environmental and physical attributes are consistent with those preferences expressed in the survey. A negative travel cost parameter is consistent with demand theory. Moreover, the results of this model indicate that the presence of superior environmental quality increases the probability of choice for that site.

A Modification of the Standard RUM

It has been suggested in the literature (Parsons and Kealy, 1992) that when the number of sites that a recreational angler has to choose from is large, estimation may become burdensome. Hence, it is postulated that a randomly generated choice set drawn from the full set of sites can provide a valid representation of the true behavioral patterns of the angler.

Clearly, an angler likely will be aware of those fishing sites located nearby, or with unique or exceptional quality attributes. Furthermore, anglers also may be aware of other fishing sites, not on a site-by-site basis, but rather in a collective sense. Parsons and Kealy surmise that representing the choice set by a random draw attempts to capture the breadth of awareness of the angler without having to identify specific sites.

The approach taken with the second random utility model is to estimate the model using a randomly drawn choice set of five of the sixty seven Southern Alberta fishing sites. The random draw works as follows: four randomly generated sites are chosen. To that set is added the site actually visited, bringing the total size of the choice set to five. A unique random choice set is generated for each of the 3465 trips taken to sites in the Southern Region.

It is hypothesized that the signs of the coefficients will remain the same as in the standard random utility model described above: the travel cost parameter will be negative, environmental and physical quality attributes will be positive, and STABLE, DEVELOP, and INAPARK will be negative. The column labelled "RUM-5" in Table 5-2 summarizes the results of the model. Note that the variables PRISTINE and STOCK become insignificant. Under the constructs of a randomly generated choice set of five sites, it is likely that there is not enough variability in these attributes to have significant influence over site-choice.

These results of this model are not surprising in light of the premise that a randomly generated choice set will approximate behaviour when the actual choice set is large. Comparing this model with the standard random utility model previously estimated, two things become evident: first, all coefficients are of the expected sign and, second, the model remains relatively robust. However, upon closer examination of both models estimated, it is seen that in all cases there is a relative increase in the standard errors of the coefficients for RUM-5. This result would suggest that in randomly generating a choice set, there is greater variability in the estimated coefficients.

Parsons and Kealy suggest that using information on individual's perceived choice sets may yield some promising results. The next random utility model examines this approach.

Awareness Model

The final model estimated is perhaps the most interesting and potentially insightful model. This modelling approach will estimate behaviour based on the *actual* choice set of each respondent.

Recall that the survey respondents answered a question about their awareness of the seventy-seven sites presented in the survey. The data obtained from this question are used to construct choice sets based on actual awareness. The econometric analysis is set up in such a way that for each trip taken, the angler chooses from among those sites indicated as belonging to his or her choice set. Hence, the choice set varies from one angler to the next.

The column labelled "AWARE" in Table 5-2 summarizes the results of this model. As in RUM-5, the variables PRISTINE and STOCK are statistically insignificant, but INAPARK also becomes insignificant. The signs on the coefficients remain consistent with the previously stated hypothesis. However, an examination of the estimated coefficients reveals significant changes in the magnitude of the coefficients.

There are notable declines in the coefficients on DISTANCE, CAMP, CATCHRT, TREES, RESERV, and TROUTCR; increases in WATQUAL, DEVELOP, AREAWAT, and STABLE; and the coefficients on SIZECOT and LENGTH remain relatively robust. Intuitively, the researcher may expect a decline in magnitude of the travel cost parameter and CAMP. Typically, anglers only may be aware of sites relatively close to home, and therefore may make only day trips to the site. Hence the relative influence that these variables have on the probability of choosing any one particular site may fall.

The awareness model also provides unique insight into behaviour that is not explicitly modeled in this research. The reader may be aware that socio-economic variables, such as age and income, are not included in the random utility analysis.[9] However, the preliminary results indicate that socio-economic variables do indeed exert some influence over the number of sites that an angler is aware of. The composition of the angler's choice set may be an implicit reflection of these socioeconomic variables. As mentioned previously, an angler who spends a large amount of money on fishing, and who has may years of experience likely will be aware of more sites that an angler with less fishing experience. The awareness model captures these effects in tnat choice-behaviour is modeled on the awareness set of the angler.

MODEL COMPARISON

Table 5-2 and the preceding discussion present the results of three random utility models that endeavour to model the choice-process of recreational fishing in Southern Alberta. Each model is based on different assumptions pertaining to the choice set of the individual. Hence, in the context of policy analysis, several key questions arise: What are the strengths and weaknesses of each model? What influence does learning have on behaviour? And what are the policy implications of using one model over another?

The awareness model should most accurately illustrate the behavioral choice process influencing anglers when they make their site visitation choice

[9] Recall from the theoretical discussion in Chapter 3 that socioeconomic variables do not change and, hence, fall out of the utility function.

because the actual awareness set is being used as the choice set. However, the day-to-day activities of anglers have dynamic influences over their choice set. Consider, for example, a situation where an angler visits a fishing site and has a conversation with another angler at that site. He or she may become aware of a new site, and on their next trip, that site will enter into the awareness set. That is, anglers may be making decisions based on choice sets that fluctuate from season to season, or even from trip to trip. Hence, it can be concluded that the awareness model may be best when evaluating the short-term behaviour of recreational anglers.

The general random utility model (RUM in Table 5-2) in a very broad sense, can be interpreted as a long term model. Over the course of many years, or as information is passed on from one generation to the next, the awareness set expands until, theoretically, the angler is aware of all fishing sites in the region. This approach incorporates learning into the awareness, or choice, set. Hence, when evaluating the long term impacts of a policy or environmental quality change, this may be the preferred modelling approach.

The Parsons and Kealy approach is an interesting theoretical experiment that provides a compromise between the two models noted above. This model confirms the researcher's suspicion that, when the number of observations is large, randomly generating a subset of choices closely approximates behaviour.

Of most interest to economists are the welfare measures generated from the random utility models. Recall from Chapter 3 that welfare estimates are a function of the coefficients estimated in the random utility models. Hence, each model will provide economists with different welfare measures. Short-term welfare impacts can be estimated with the Awareness model, and long term welfare impacts can be estimated with either the standard RUM or the Parsons and Kealy approach. This premise will be explored in greater detail in the following chapter.

CHAPTER 6 - WELFARE ESTIMATES

INTRODUCTION

To this point, quality attributes used in the modelling of recreational sportfishing have been discussed, and three random utility models have been derived that reflect different behavioral assumptions underlying the site-choice process. The econometric models provide valuable information to the economist in two key ways: first, general conclusions regarding the site-choice process of anglers can be made, and second, the influence of quality attributes on site choice becomes clear. However, of most use to policy makers are the benefit estimates, or welfare measures, derived from the models.

Welfare measures can be used to provide economists with an estimate of the value of the resource being examined. In the context of benefit-cost analysis, welfare measures provide economists with a reference point from which the benefit component of the decision making process can be analyzed. In this research, welfare measures will be generated to assess the value of a particular policy being considered by a governmental or environmental agency. As a review, the underlying theory regarding welfare estimation was provided in Chapter 2, and a detailed description of welfare estimation in the Random Utility Model was provided in Chapter 3.

At this point, a few important comments regarding the specific procedure used to estimate welfare measures for this research are required. It should be reiterated that the CV-value calculated using the formula in Chapter 3 estimates CV on a per-trip basis. Further, recall from Chapter 3 that the marginal utility of income is a function of the estimated travel cost coefficient in the Random Utility Models. The marginal utility of income was calculated as $\mu = \beta_{DIST} / (2 * 0.48)$, where β_{DIST} is the coefficient on distance in the RUM, and 0.48 is the cost, in cents per mile, to operate a vehicle (Alberta Motor Association, 1993). The cost is multiplied by two because distances in the model reflect only one way distance to the site. In this research, a CV was calculated for each of the 3465 trips taken to Southern Region sites, and the mean CV was used as the per-trip welfare estimate.

An aggregate welfare measure can also be calculated. In order to do this, total annual trips taken to Southern region sites must be estimated. The survey results indicate that the median number of trips an average angler took during the 1991 fishing season was 5.[10] In the Southern region, there were an estimated 66,087 licenses sold to individuals that fished in that region (Adamowicz et al, 1992) It is assumed further that 25% of the angler population is less than 16 or greater than 65 years of age, resulting in an additional 16,522 anglers (AFL&W, 1985 and AFL&W Roundtable discussion, March 1993).[11] Thus, the total

[10] The median number of trips was used rather than the mean because it was statistically more consistent with survey results. The mean number of trips was 9, however, over 50% of the respondents took 5 or less trips during the fishing season.

[11] Those anglers less than 16 or greater than 65 years of age are not required to purchase a fishing license, therefore actual licences sold must be adjusted

population of Southern anglers is 82,609. Hence, it is estimated that there were 413,045 trips taken to sites in the Southern Region.[12] The aggregate welfare measures discussed in this section are based on these assumptions.

POLICY PROPOSALS

This thesis will examine the benefits associated with several different policy proposals. The proposals examined were selected to encompass a wide range of current and potential policy objectives: site closures were examined, the benefits of trout stocking and forestry policies were estimated, and the economic impacts of the Oldman River dam on recreational fishing were estimated. This section will briefly outline each of these policies.

The welfare effects of four site closures will be estimated. The sites selected are: McGregor Reservoir, Chain Lake, Reesor Lake, and Beavermines Lake.[13] These sites were selected because they are the four most popular sites among survey respondents, with 31.0%, 23.6%, 20.9%, and 17.3% respectively of respondents visiting these sites during the 1990 fishing season. Moreover, as indicated by the map in Chapter 4, the sites are of a wide geographic distribution

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upwards to account for these anglers.

[12] The angler population of 82,609 each took 5 trips, hence the total number of trips taken is 82,609 x 5 = 413,045.

[13] Referring to the map in Chapter 4, the site numbers are 34, 33, 77, and 17 respectively.

in the Southern region. It is expected that there will be a welfare loss associated with these site closures.

Next, the benefits from a forestry policy will be estimated. The forestry policy changes the TREES attribute in the random utility models and is targeted at sites in the Crowsnest region. The quality change involves foresting sites indicated as being unforested. Those sites affected are Oldman River (site 5), Crowsnest River (sites 8 and 11), and Mami Lake (site 21). The coefficient on TREES in the random utility models is positive, hence it is hypothesized that foresting these sites will yield a positive welfare change.

The trout stocking policy is aimed at Reesor Lake. The variables affected in the random utility model are STOCK, CATCHRT and TROUTCR. It is assumed that this trout stocking policy will increase catch rates (both general and trout) by 10%. All coefficient signs on the affected quality attributes are positive, hence it is speculated that there will be a welfare gain from implementation of this policy.

Finally, the effects of the Oldman River Dam on recreational fishing in Southern Alberta will be estimated. Table 6-1 summarizes the effects of the Oldman Dam on fishing habitat at five sites in the Crowsnest Region. Table 6-1 can be interpreted as follows: the column labelled *%change with dam alone* indicates the percentage change in habitat due just to the presence of the dam. In all, three sites are affected by the dam, and the table shows a habitat loss for all three sites. Similarly, the last column of the table indicates the percentage change in habitat with the presence of the dam *plus* a 75% success rate of

Table 6-1: Habitat Impacts of the Oldman River Dam

Site (#)	% Change with Dam alone	% Change with Dam and 75% mitigation
Upper Oldman River (1)	0	5.7
Oldman River (5)	-81.4	-71.4
Crowsnest River (8)	0	1286.8
Crowsnest River (11)	-45.8	55.67
Castle River (13)	-75.0	-53.1

Source: Watson D. et al (1993), "An Economic Analysis of Recreational Fishing and Environmental Quality Changes in the Upper Oldman River Basin"

mitigation structures built to compensate for the habitat loss.[14] Under this scenario, two sites are still affected with a habitat loss, but there are significant habitat gains at other sites with the mitigation project in place.

There will be two approaches taken to estimate the effects of the dam on recreational fishing: the welfare loss due to the dam alone, and second, the welfare impact of the dam plus mitigation. It is hypothesized that there will be an overall welfare gain in the 75%-scenario. The variables affected by the dam are CATCHRT, TROUTCR, and LENGTH. Catch-rates are assumed to change by the percentages indicated in Table 6-1. It is noted also that LENGTH of three sites

[14] To clarify this statement somewhat, the mitigation scenario can be interpreted as a situation where the dam is in place, and the government builds mitigation structures to compensate for habitat loss due to the dam. However, the mitigation structures are assumed to be 75% successful.

changes as follows: site 5 changes to 17.1 km, site 11 changes to 6.8 km, and site 13 changes to 28.8 km (Watson et al, 1993).

PER-TRIP WELFARE MEASURES

Per-trip welfare estimates of the above noted policy proposals were calculated for all three random utility models estimated in Chapter 5. A comparison of per-trip welfare measures between models may yield some interesting behavioral conclusions regarding the impact of the alternative choice set assumptions of the angler.

Table 6-2 below summarizes the per trip welfare measures. A summary of the minimum, maximum, and coefficient of variation[15] for each estimate can be found in Appendix D. The estimates are in terms of dollars per trip, and the standard deviation for each estimate is indicated in brackets.

RUM and RUM-5 Welfare Estimates

Examining the results for the standard random utility model (RUM) it is seen that all welfare changes are in accordance with *a priori* expectations: there is a welfare loss associated with the site closures, and a welfare gain from the forestry and trout stocking policy. The Oldman River Dam imposes a welfare loss of 13¢ per trip, but when the mitigation structures are built with 75% success, a significant

[15] The coefficient of variation (CoV) for a sample of values is defined by: CoV = S/X, where S is the standard deviation, and X is the sample mean.

Table 6-2: Per-trip Welfare Estimates

Management Policy	RUM ($)	RUM-5 ($)	AWARE ($)
Close McGregor Reservoir	-1.89 (2.06)	-1.80 (1.92)	-6.62 (8.28)
Close Chain Lake	-0.80 (0.91)	-0.63 (0.70)	-0.20 (0.29)
Close Reesor Lake	-0.59 (1.02)	-0.58 (0.99)	-0.13 (0.32)
Close Beavermines Lake	-0.93 (0.92)	-0.76 (0.70)	-0.43 (0.76)
Forest Crowsnest	0.62 (0.51)	0.63 (0.49)	0.10 (0.20)
Trout Stocking	0.10 (0.17)	0.03 (0.05)	0.004 (0.009)
Oldman River Dam	-0.13 (0.11)	-0.14 (0.11)	-0.04 (0.072)
Oldman River Dam (75%)	1.34 (2.89)	2.09 (2.87)	0.34 (0.86)

welfare gain of $1.34 per trip results.

Comparing the welfare measures of the RUM model with those of RUM-5, it is seen that, with a few exceptions, the two closely reflect one another. Closing McGregor Reservoir and Reesor lake, foresting the Crowsnest region, and building the Oldman River Dam impose welfare changes of approximately equal magnitude across models. These results are, of course, expected because as hypothesized in Chapter 5, a randomly generated choice set of five sites should approximate behaviour when the angler is faced with a large choice set.

There are, however, some changes in welfare estimates for four policy proposals between RUM and RUM-5 First, there are relatively large differences in the welfare loss associated with closing Beavermines and Chain Lakes, going from -0.93 to -0.76 and -0.80 to -0.63 respectively. Second, welfare estimates for the trout stocking policy change by 7 cents between RUM and RUM-5. Finally, Table 6-2 reveals that the welfare impact of the Oldman Dam (75%) differs markedly between RUM and RUM-5 from $1.34 per trip to $2.09 per trip.

A difference of means test[16] shows that, in all cases, the aforementioned welfare estimates between models are significantly different. There *should* not be any significant difference between welfare estimates generated from each model, as the random draw approach is theorized to approximate choice behaviour when the number of observations is large. A re-examination of Table 5-2 leads to the conclusion that the difference in magnitude of the estimated coefficients in the random utility models is resulting in notable welfare differences.

With the exception of the two Oldman Dam impacts, the coefficient of variation for the welfare estimates remains relatively robust between models. There is a small decline (from RUM to RUM-5) in the coefficient of variation for the Oldman Dam alone quality changes. However, comparing the minimum and maximum values of the welfare estimated between RUM and RUM-5 for the Oldman Dam (75%) scenario, it is clear that there is less variation in the RUM-5

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[16] Under the null hypothesis H_0: $(\mu_1 - \mu_2) = 0$, a test can be done such that: $z = (\mu_1 - \mu_2) / \sqrt{(\sigma_1^2/n_1 + \sigma_2^2/n_2)}$, where H_0 is rejected at the 95% significance level if $|z| > 1.96$.

estimates, as is indeed reflected in the coefficient of variation. These results suggest that the welfare estimates generated using the RUM-5 model may be more precise than those of the standard RUM.

AWARE Welfare Estimates

Before a discussion of the awareness welfare estimates are presented, it may prove useful to speculate about what impact a change in the structure of the choice set will have on the ensuing welfare estimates. Three key questions can be posed: Will the welfare measures between models be different? If so, what is the expected direction of change? And finally, what impact does this new choice set assumption have on variance?

Freeman (1979) has suggested that if an individual is unaware of a site, then a quality change at that site will have no impact on the individual's welfare. Intuitively, this premise is appealing, and is theoretically consistent with the fact that anglers are choosing sites from their awareness set. Hence, it is expected that there will be some difference in welfare estimates between models. In terms of the direction of change for these welfare estimates, it is expected that they will be smaller than those generated from RUM and RUM-5 (where anglers are assumed to be aware of all sites). Quality changes of policy effects will only affect those anglers aware of the relevant sites, and since not all anglers are aware of all sites, welfare impacts are expected generally to decline.

When considering the variance changes of the welfare measures, two separate effects must be considered. First, for those anglers unaware of a site affected by a quality change, there is no welfare impact. Hence, structural zeros will appear as some angler's welfare estimates. However, consider a situation where an angler is only aware of one site, and that site is closed. The potential welfare impact on this angler may be quite large. Hence, it is expected that there will be larger variation in welfare impacts between anglers due to composition of each individual choice set.

Examining the AWARE column of Table 6-2, it is seen that the welfare estimates from the awareness model are markedly different from the standard random utility models. The only case where the welfare impact increases in absolute value (ie: gets more negative) is closing McGregor Reservoir. This result may not be particularly surprising. McGregor Reservoir is the most popular site visited, and 58% of respondents are aware of it. Hence, closing this site may result in a large welfare loss. Generally though, there is a decline in welfare estimates in accordance with the speculations previously noted.

In examining the minimum and maximum values of the welfare estimates, two interesting details arise: first, in all policy proposals, except one, zero is the minimum (or maximum) welfare measure. The presence of these structural zeros validates the speculation that, for some anglers, there will be no welfare impact due to the change in quality attributes. Second, in the *Oldman Dam (75%)* scenario, there exists some negative welfare impact for at least one angler. In the

RUM and RUM-5 models, all welfare estimates in this scenario are positive. This is expected as the anglers are choosing from all sixty seven sites, and a great deal of substitution possibilities exist. However, the presence of a welfare loss in the awareness model reveals that, even with mitigation structures 75% successful, at least one angler is worse off. It may be the case that, for this angler, the only sites he or she is choosing from are the affected Oldman Dam sites. Recall from Table 6-1 that, even though the overall effect of the mitigation is positive, there are some sites (numbers 5 and 13) that still experience adverse habitat impacts due to the building of the dam. If these sites are the only sites an angler is choosing from, there may be an ensuing welfare loss to this individual.

Further, referring to Appendix D, the coefficient of variation for all quality changes increases. This confirms the hypothesis that there is greater variation in welfare estimates across respondents when site-choice decisions are made from their awareness set.

AGGREGATE WELFARE MEASURES

The per-trip welfare estimates discussed above provided the researcher with some interesting insight into the effect of alternative choice-set assumptions on welfare impacts. However, of most use to policy makers are aggregate welfare measures. The aggregate welfare measures are summarized in Table 6-3. Recall that the estimates were calculated based on 413,045 trips taken to Southern Region sites. Note also that the estimates are annual values. Appendix E shows

Table 6-3: Annual Aggregate Welfare Estimates

MANAGEMENT POLICY	RUM ($)	RUM-5 ($)	AWARE ($)
Close McGregor Reservoir	-780 655	-743 481	- 2 734 357
Close Chain Lake	-330 436	-260 218	-82 609
Close Reesor Lake	-243 696	-239 566	-53 696
Close Beavermines Lake	-384 132	-313 914	-177 609
Forest Crowsnest	256 088	260 218	41 305
Trout Stocking	41 304	12 391	1 652
Oldman River Dam	-53 696	-57 826	-16 522
Oldman River Dam (75%)	553 480	863 264	140 435

the capitalized values of the aggregate welfare estimates at 10% and 5% discount rates.

Aggregate measures are useful to economists because they provide estimates of the overall regional impact of policy implementation. As an example, consider the trout stocking policy: the annual welfare gain associated with stocking Reesor Lake is $41,304 (using the RUM model). If the costs associated with implementation and maintenance of this policy exceed $41,304 per year, then the policy may be an ineffective one. Further, capitalized values reveal the value of the policy in perpetuity, thus accounting for benefits accruing to future generations. Hence, policy makers can examine the long term impacts of policy decisions on future generations.

The discussion in Chapter 5 suggested that different models may best represent the short and long term behavioral influences of anglers. This premise is of crucial importance when using benefit estimates to make informed policy decisions. As is shown in Table 6-3, the aggregate welfare impacts of the selected policy proposals and quality changes are significantly different between the standard random utility models and the awareness model. Therefore, in evaluating the short term impacts of environmental policy, it may be best to evaluate feasibility based on welfare estimates generated from the awareness model.

A DIGRESSION ON THE OLDMAN DAM

Of key interest to policy makers in the Southern Region is the economic impact of the Oldman River Dam on recreational fishing. The per trip and aggregate welfare estimates discussed above showed that there are welfare losses associated with building the dam, and when mitigation structures are built and a 75% success rate is assumed, there is an overall positive impact on recreational fishing. However, there are several underlying issues related to mitigation that merit further discussion.

A re-examination of Appendix E shows that the capitalized values of the aggregate welfare gains for the 75% mitigation scenario range from $1.4 million to $8.6 million. At first glance, a welfare gain of this magnitude seems significant, but in comparison to overall cost of the dam, which is approximately $350 million, these gains are small.

Second, it should be reiterated that, in the welfare estimates generated in this thesis, the mitigation structures are assumed to be 75% successful. Under this scenario, Tables 6-2 and 6-3, show that the overall impact of this mitigation is positive. However, as shown in Appendix D, there are some anglers still negatively affected by the dam with 75% mitigation in place. The reconciliation of these mitigation issues lies in the fact that *75% success* was an *ad hoc* assumption. The welfare analysis could just have easily been done on assumed success rates of 25% or 50%. Hence, with the RUM modelling approach taken in this research, greater flexibility in welfare estimation can be introduced.

SUMMARY

Tables 6-1 and 6-2 summarized the per-trip and aggregate welfare estimates for a variety of environmental policies and quality changes at selected Southern Region sites. It is clear that the structural composition of the choice set has influence over the magnitude of the welfare impacts. Under the assumption that the choice set is comprised of only those sites an angler is aware of, there will be no welfare impact to anglers unaware of sites affected by the quality change. Hence it is expected that there will be structural zeros in the set of welfare estimates. Additionally, the potential for negative welfare impacts exists in a multiple-site quality change scenario. Even if the overall effect of the quality change is positive, there may exist some anglers that will not be made better off due to the fact that, because of the structure of their awareness set, the possibilities for site substitution are limited. Finally, welfare estimates generated within an awareness framework show greater variation. Clearly, welfare estimates generated using this approach are likely most suitable for short term policy analysis.

Over the longer term as anglers learn about new sites and add these sites to their choice sets, the welfare impacts associated with these policies increases. This is revealed in the welfare estimates generated from the RUM and RUM-5 models where all sites are assumed to be in the angler's choice set. Even though, in a theoretical context, the random approach is intuitively and computationally appealing, welfare measures generated from this method have been shown to be significantly different from the standard Random Utility approach. This would suggest that a randomly generated choice set may not be behaviorally representative of the underlying choice process of the angler.

CHAPTER 7 - CONCLUSIONS

THE RESEARCH OBJECTIVE

The Thesis

The results of the research contained in this thesis have provided insight into the underlying choice behaviour of recreational anglers, as well as an estimate of the value of selected environmental policy proposals on Recreational Fishing in Southern Alberta. The Random Utility-Travel Cost approach provided an excellent theoretic framework to construct an econometric model representative of choice behaviour. An extension to welfare economics allowed for estimation of the welfare impact of site closures, various environmental-related initiatives and the impact of the Oldman River Dam on Recreational Fishing.

The three Random Utility models estimated revealed that the underlying choice set assumption has significant influence over behaviour. It is clear that incorporating an awareness influence into model estimation resulted in changes in the underlying utility structure influencing an angler's choice decision. Moreover, welfare estimates obtained from these models reflect the influence of awareness of sites in that there is greater variability of impact across anglers, and the overall impact of environmental quality changes is smaller.

This analysis leads to the conclusion that variation in the underlying choice set used in the RUM estimation can be a reflection of short term and long term factors influencing the choice process. The key factors influencing the composition of the choice set are information and time (Perdue, 1987 and Stynes et al, 1985). As information is obtained, and anglers learn about new sites, their choice process changes ie: they have more sites to choose from. Moreover, in a policy context, these results can aid policy makers in evaluating the short and long term impacts of policy initiatives.

Limitations

Despite the appealing nature of the Random Utility approach to model use-value associated with Recreational Sportfishing in Southern Alberta, there are several limitations that deserve comment. First, as mentioned previously, there is a lack of socioeconomic influences in the model. Because of the mathematical structure of the model, socioeconomic variables "fall out" of the estimation equation. However, using awareness sets as choice sets is an attempt at capturing the socioeconomic influences underlying the angler's choice process. Further, the discrete choice modelling approach employed in this thesis does not explicitly incorporate income. However, income effects are tacitly included in the travel cost parameter, and they can be directly included in the model by interacting income with another attribute, such as travel cost. Clearly though, if income effects are explicitly modelled, the marginal utility of income no longer remains constant and estimation of welfare impacts becomes a computationally challenging task.

Second, the random utility technique used in this thesis only models one of a multitude of choices facing the recreationist. In making recreational trip decisions, the individual is faced with a hierarchy of choices: *Do I "recreate" or do something else? Do I go fishing, or camping, or hiking? If I go fishing, will I fish from shore, or in a boat?* In light of this choice structure, nested models may be a more appropriate approach to modelling behaviour (Carson et al, 1989, Parsons and Kealy, 1992, Milon, 1988). However, the presence of several statistical and mathematical obstacles (Maddala, 1983) can make the nested approach difficult and computationally challenging to do.

In the context of welfare estimation, several limitations become evident. First, the welfare benefits estimated in this thesis are not capturing the full spectrum of benefits (or costs). Non-use or existence values are not included in the welfare estimation. Further, only the benefits associated with recreational fishing are estimated. Clearly, there may also be benefits generated as a result of other recreational activities. Second, level information cannot be incorporated into the welfare estimation method of the Random Utility Approach. The addition of a welfare money metric to the modelling technique will require estimation of welfare measures outside the context of compensating or equivalent variation. Finally, it has been suggested in the literature (Blackorby, 1990) that, in using the sum of compensating variations as a welfare estimate, the Pareto efficiency criteria "rests on pretty shaky foundations, and that there are probably very few circumstances in which it can be invoked" in a traditional economic manner. In the context of cost-benefit analysis, Pareto Efficiency criteria provides economists with a framework for decision making. The Kaldor-Hicks compensation test (Feldman,

1980) asserts that if the sum of the compensating variations is greater than zero, that is to say, for any change in state, the "losers" can *potentially* be compensated by the "gainers", then the test is satisfied and the change is Pareto efficient. However, Boadway (Boadway and Bruce 1984, Blackorby 1990) has shown that movement between two competitive equilibria along a Pareto frontier may yield a sum of compensating variations greater than zero. The Boadway paradox reveals that a positive sum of compensating variations is not a sufficient condition for decision making. Hence, in an aggregate sense, using the sum of compensating variations acts as an indicatora, and may not be perfectly accurate.

Future Research

There are a variety of avenues that future research related to this thesis can take. First, continuing research into the role of information and learning on site choice behaviour will provide useful insight into policy implementation and resource management. Moreover, the process whereby individuals become aware of more sites can yield practical wisdom into the underlying marketing principles associated with choice-behaviour. This information can be extended easily to other areas of research and application (Roberts and Lattin, 1991). Related to the issue of learning is that of habit formation. Anglers may choose to visit one site over other sites in their choice set not because of the quality attributes of that site, but rather because of habitual influences. As a result, models of site choice that assume choices are made based on quality attributes may be neglecting the role that habit plays in the choice process. Hence, future research endeavours that examine the factors influencing and composition of choice sets will want to include these effects in their approach.

A second avenue of research presents itself as the role that perceptions play in site-choice decisions. The models developed in this thesis were based on objective quality attributes determined by an external agency (AFL&W), and further it was assumed that the quality attributes of each site were homogeneous from one angler to the next. However, it may not be plausible to assume that anglers have perfect information regarding the quality attributes of sites. It may be more realistic to model site choice behaviour based on perceptions of site quality attributes. Anglers may not have perfect information about the technical and scientific quality attributes of any particular site, and it is reasonable to assume that perceived quality attributes of one site may vary from one angler to another. Hence, constructing a Random Utility Model based on *perceived* quality attributes may better approximate choice behaviour. Further, a comparison of models generated using objective and perceived quality measures may yield useful information to policy makers in terms of aiming their marketing programs and policy initiatives to those areas where discrepancy exists between what is perceived and what is real.

FINAL REMARKS

A new environmental ethic is emerging on a global scale as a result of a growing consciousness about the value of natural resources and the environment. The Brundtland Commission Report, *Our Common Future* (1987), views this modern ethic as an opportunity for a new era of economic growth based on policies that sustain and expand the environmental resource base. Hence, the dawning of an environmental conscience may stem from society's willingness to maintain and improve their environmental assets. On a regional level, the commitment by governments and individuals to maintain and improve these assets is, to some extent, inspired by the belief that better recreational opportunities will ensue as the quality of the environment improves. As a result, the emergence of the environmental movement has created a stimulus to increasing interest in the study of the economic effects of environmental quality changes on recreation (McConnell, 1985).

Economic analysis has grown in importance as a policy tool used in the evaluation of outdoor recreation activities and environmental improvements (Adamowicz et al, 1992, Alberta Forestry Lands and Wildlife, 1988). Economics provides policy makers and natural resource managers with a technique and methodology to place dollar values on outdoor recreation activities and, in particular, to examine the change in economic benefits associated with changes in environmental quality. Hence, studies of recreation demand have developed as an offshoot of applied welfare economics, with particular emphasis on the structure of individual decision-making models. Moreover, judicious use of benefit-cost analysis in public and private decision making can contribute to more effective resource utilization (Freeman, 1979).

Recent studies in the United States and Canada (Coyne 1990, Parsons and Kealy 1992, Freeman 1979, Watson et al, 1993) have revealed the impact that changing environmental quality can have on a recreation experience. In some cases, significant economic benefits can accrue through recreational use of the environment and these welfare estimates have provided economists with useful information regarding the non-market benefits associated with recreation. Results of this nature indicate that further research into the economic impacts of environmental quality changes on recreational sportfishing may yield potentially useful insight into effective environmental policy proposals.

Environmental and economic goals can be made mutually reinforcing, and the ability to anticipate and prevent environmental damage will require a multi-dimensional approach to policy implementation (Our Common Future, 1987). Keeping this in mind, it is clear that the impact of environmental policies, such as improvements in environmental quality, on recreation will not have not only short-term implications, but multi-generational impacts as well. Moreover, study into recreation economics may reveal multi-dimensional relationships between economic and non-economic factors. In this context, research into recreation demand has an important role to play in the development of sustainable environmental policies.

BIBLIOGRAPHY

Adamowicz, W.L. 1991 Valuation of Environmental Amenities, *Canadian Journal of Agricultural Economics*, vol 39, #4, part 1, pp 609-618

Adamowicz, W., P. Boxall, D. Watson, and T. Peters 1992, *A Socio-Economic Evaluation of Sportfishing Activity in Southern Alberta*, Project Report 92-01, Department of Rural Economy, University of Alberta, Edmonton, Alberta

Ben-Akiva, M. and S. Lerman, 1985 *Discrete Choice Analysis: Theory and Application to Travel Demand*, MIT Press, Cambridge Mass

Blackorby, Charles 1990 Economic Policy in a Second-best Environment *Canadian Journal of Economics*, XXIII, No. 4, November 1990, pp 748-771

Bockstael, Nancy E., W. Michael Hanemann & Catherine L. Kling 1987 *Estimating the Value of Water Quality Improvements in a Recreational Demand Framework Water Resources Research,* volume 23 (May), #5, pp 951-960

Bockstael, Nancy E., W. Michael Hanemann, and Ivar E. Strand, *Measuring the Benefits of Water Quality Improvements Using Recreation Demand Models - Volume II of Benefit Analysis Using Indirect or Imputed Market Methods,* United States Environmental Protection Agency

Boadway, Robin W. and Neil Bruce 1984, *Welfare Economics*, Basil Blackwell, Inc, Cambridge Massachesetts

Bockstael N.E., K.E. McConnell, and I.E. Strand, 1989 A Random Utility Model for Sportfishing: Some Preliminary Results for Florida, *Marine Resource Economics*, vol 6, pp245-260

Braden, J.B. and C.D. Kolstad 1991, *Measuring the Demand for Environmental Quality, North Holland*, New York

Brookshire, David S. and V. Kerry Smith 1987 Measuring Recreation Benefits: Conceptual and Empirical Issues, *Water Resources Research*, volume 23 (May), #5, pp 931-935

Carson, Richard T., W. Michael Hanemann, and Thomas Wegge, 1989 *A Nested Logit Model of Recreational Fishing Demand in Alaska*, Paper presented at the Western Economics Association, Lake Tahoe, CA, June 22, 1989

Coyne, A.G. and W.L. Adamowicz 1992 Modelling Choice of Site For Hunting Bighorn Sheep, *Wildlife Society Bulletin*, vol 20, pp 26-33

Coyne, Allison 1991 *Economic Effects of Environmental Quality changes on Recreation Demand* Unpublished MSc Thesis, Department of Rural Economy, University of Alberta, Edmonton, Alberta

Feldman, Allan M., 1980 *Welfare Economics and Social Choice Theory* Martinus- Nijhoff Publishing

Fletcher, Jerald, J., Wiktor L. Adamowicz, and Theodore Graham-Tomasi, 1990 The Travel Cost Model of Recreation Demand: Theoretical and Empirical Issues, *Leisure Sciences,* Volume 12 (January), pp 119-147

Freeman, A.M. III, 1979 *The Benefits of Environmental Improvement: Theory and Practice*, Baltimore: Johns Hopkins University Press, Resources for the Future, 1979

Freeman, Ruth and Tamantha Peters, 1992 *Random Utility Models*, Unpublished project paper, Department of Rural Economy, University of Alberta, Edmonton, Alberta

Feenburg, D and E. Mills, 1980 *Measuring the Benefits of Water Pollution Abatement,* Academic Press, Orlando, Florida

Hanemann, W. Michael, 1981 *Applied Welfare Analysis with Qualitative Choice Models,* Working Paper No. 173, California Agricultural Experiment Station, University of California

Hanemann, W. Michael,1982 *Discrete/Continuous Models of Consumer Demand*, Working Paper No. 198, California Agricultural Experiment Station, University of California

Maddala, G.S., 1983 *Limited-dependent and qualitative variables in Econometrics,* New York: Cambridge University Press

Mendelsohn, R, 1987 Modelling the Demand for Outdoor Recreation, *Water Resources Research*, Volume 23 (May), #5, pp961-967

McConnell, Kenneth E. 1985, The Economics of Outdoor Recreation, Chapter 15 in *Handbook of Natural Resource and Energy Economics*, volume II, edited by A.V. Kneese and J.L. Sweeny, Elseiver Science Publishers B.V.

Milon, J. Walter 1988 A Nested Demand Shares Model of Artificial Marine Habitat Choice by Sport Anglers, *Marine Resource Economics*, Volume 5, pp 191-213

Parsons, George R. and Mary Jo Kealy, 1992 Randomly Drawn Opportunity Sets in a Random Utility Model of Lake Recreation, *Land Economics*, February 1992, 68(1), pp 93-106

Perdue R.R., 1987 The Influence of Awareness on Spatial Behaviour in Recreational Boating, *Leisure Sciences*, vol 9, pp 15-25

Roberts, John H. and James M. Lattin, 1991 Development and Testing of a Model of Consideration Set Composition", *Journal of Marketing Research*, volume XXVIII, November, pp429-40

Small, K.A. and H.S. Rosen, 1981 Applied Welfare Economics with Discrete Choice Models, *Econometrica*, vol 49

Smith, V. Kerry, 1989 *Can We Measure the Economic Value of Environmental Amenities?*, Discussion Paper QE90-06, Resources for the Future

Smith, V. Kerry, 1993 Nonmarket Valuation of Environmental Resources: An Interpretive Appraisal, *Land Economics,* 69(1), February 1993

Stynes, Daniel J., Daniel M. Spotts, and John R. Strunk 1985 Relaxing Assumptions of Perfect Information in Park Visitation Models, *Professional Geographer*, 37(1), 1985

Watson, D., W.L. Adamowicz and P.C. Boxall 1993, *An Economic Analysis of Recreational Fishing and Environmental Quality Changes in the Upper Oldman River Basin,* Project Report 93-01, Department of Rural Economy, University of Alberta, Edmonton, Alberta

APPENDIX A:

SITE NAMES AND NUMBERS

UPPER OLDMAN RIVER AREA

1 ___ Upper Oldman River (NW Branch)
2 ___ Livingstone River
3 ___ Dutch Creek
4 ___ Racehorse Creek
5 ___ Oldman River-Hwy 22 Bridge to Peigan Reserve

CROWSNEST RIVER AREA

6 ___ Crowsnest Lake
7 ___ Allison (Chinook) Lake
8 ___ Crowsnest River-Headwaters to Blairmore (Legion Bridge)
9 ___ Crowsnest River-Blairmore to Passberg Bridge (Byron Cr.)
10 ___ Crowsnest River-Passberg Bridge to Lundbreck Falls
11 ___ Crowsnest River-Lundbreck Falls to mouth (Blairmore-Pincher Creek Areas)
12 ___ Burmis Lake
13 ___ Castle River

CASTLE RIVER AREA

14 ___ Lynx Creek
15 ___ Carbondale River
16 ___ West Castle River
17 ___ Beavermines Lake
18 ___ Barnaby (Southfork) Lake
19 ___ South Castle River

WATERTON LAKES AREA

20 ___ Crooked Creek
21 ___ Maini (Paine) Lake
22 ___ Cottonwood Creek

PINCHER CREEK AREA

23 ___ Bathing Lake
24 ___ Butcher Lake
25 ___ Dipping Vat Lake
26 ___ Drywood Creek
27 ___ Waterton Reservoir
28 ___ Cochrane Lake
29 ___ Beauvais Lake
30 ___ Waterton River
31 ___ Oldman River-near Fort MacLeod

CLARESHOLM AREA

32 ___ Willow Creek
33 ___ Chain Lake

VULCAN AREA

34 ___ McGregor Reservoir
35 ___ Travers Reservoir

LETHBRIDGE AREA

36 ___ Keho Lake
37 ___ Oldman River-Monarch to Forks
38 ___ Nicholas Sheran Park Lake (in the city of Lethbridge)
39 ___ Henderson Lake (in the city of Lethbridge)
40 ___ Stafford Reservoir
41 ___ McQuillan Lake

CARDSTON AREA

42 ___ Belly River
43 ___ St. Mary River-Upper to Reservoir
44 ___ St. Mary Reservoir
45 ___ St. Mary River-Below Reservoir
46 ___ Police (Outpost) Lake

MILK RIVER-WARNER AREA

47 ___ Cross Coulee Reservoir
48 ___ Tyrrell Lake
49 ___ Milk River Ridge Reservoir
50 ___ Goldsprings Park Pond
51 ___ Milk River - mouth of the N. Milk River to Miners Coulee Creek
52 ___ Heninger Reservoir
53 ___ Milk River -Miners Coulee Creek to Montana Border

TABER AREA

54 ___ Chin Reservoir
55 ___ Sherburne Reservoir
56 ___ Unnamed Lake South of Burdett

VAUXHALL AREA

57 ___ Little Bow Reservoir
58 ___ Stonehill Lake
59 ___ Badger Reservoir

BASSANO AREA

60 ___ Bow River-Bassano Dam to mouth
61 ___ Bow River-Carseland to Bassano
62 ___ Red Deer River-Finegan to Dinosaur Provincial Park

BROOKS AREA

63 ___ Brook's Childrens Pond
64 ___ Cowoki Reservoir
65 ___ Tilly B Reservoir
66 ___ Lake Newell

MEDICINE HAT AREA

67 ___ S. Saskatchewan River-Rattlesnake to Saskatchewan Border
68 ___ Echo Dale Regional Park Pond (in the city of Medicine Hat)
69 ___ South Sask[illegible]an River-Forks to Rattles[illegible]
70 ___ Rattlesna[illegible]r Reservoir
71 ___ Cavan L[illegible]
72 ___ Michell [illegible]
73 ___ Murray [illegible]
74 ___ Bullshead [illegible]oir
75 ___ Spruce Coulee Reservoir
76 ___ Elkwater Lake
77 ___ Reesor Lake

APPENDIX B:

QUALITY ASPECTS OF SOUTHERN REGION SITES

QUALITY ASPECT	MEASUREMENT
Recreation / Facilities	
Playgrounds	Presence/Absence
Campgrounds	Presence/Absence
Toilet Facilities	Presence/Absence
Parking	Presence/Absence
Level of Development	1=none; 10=full
Boat Launch	Presence/Absence
Level of Congestion	1=little ; 10=extreme
Access Road Paved	Yes/No
Fish Cleaning Facilities	Presence/Absence
Swimmable	Yes/No
Boating Regulations	Presence/Absence
Access Fees	Yes/No (amount)
Public Access	Presence/Absence
Fishing Regulations	
Bait Ban	Presence/Absence
Size Restrictions	Presence/Absence
Catch & Release Only	Presence/Absence
Restrictions on Limit	Presence/Absence
Special License Required	Yes/no
Special Seasonal Limitations	Presence/Absence
Biological Aspects	
Trout Fishery	Yes/No
Walleye Fishery	Yes/No
Stocked with one species of trout	Yes/No

Biological Aspects (con't)	
Stocked with >1 species	Yes/No
Catch Rate	Number caught per hour
Aquatic Vegetation Problem	Presence/Absence
Water Quality	1=poor; 10=excellent
Natural Reproduction Present	Yes/No
Stability of Water Flow or Stock	1=stable; 10=fluctuating
Number of sport fish species	Number of Species
Winter Kills Frequently	Yes/No
Locational Aspects	
Dugout or Slough	Yes/No
Pristine Wilderness Lake	Yes/No
In a Designated Park	Yes/No
Located Close to Metropolitan Area	Yes/No
Reservoir	Yes/No
Forested or Treed Around Site	Yes/No
Subjective Quality Aspects	
Frequency of Presence of Fish and Wildlife Staff	1=seldom; 10=frequent
Ratings bv Fisheries Staff of site in terms of Size of Fish Caught (ie; how easily can an average angler catch a big fish?)	1=difficult to catch large fish; 10 = easy to catch large fish
Other Characteristics	
Area of the Waterbody	Hectares
Length of Reach of Stream	Kilometers

APPENDIX C:

STANDARD ERRORS OF ESTIMATED RUM COEFFICIENTS

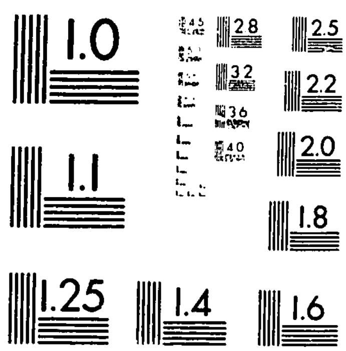
VARIABLE	RUM	RUM-5	AWARE
DISTANCE	0.00083	0.0011	[illegible]088
CAMP	0.064	0.081	0.066
CATCHRT	0.090	0.11	0.089
WATQUAL	0.018	0.022	0.018
PRISTINE	0.11	0.13	0.11
DEVELOP	0.011	0.016	0.013
SIZECOT	0.014	0.018	0.015
TREES	0.056	0.072	0.061
INAPARK	0.056	0.076	0.059
AREAWAT	0.000014	0.000020	0.000014
LENGTH	.00066	0.00086	0.00072
RESERV	0.076	0.096	0.078
STABLE	0.0095	0.012	0.0097
TROUTCR	0.1252	0.16	0.13
STOCK	0.049	0.064	0.051

APPENDIX D:

COEFFICIENT OF VARIATION AND MIN/MAX OF PER TRIP WELFARE ESTIMATES

Management Policy	RUM	RUM-5	AWARE
Close McGregor Reservoir	-1.09 -12.74/-0.009	-1.07 -0.01/-11.91	-1.25 -40.70/0
Close Chain Lake	-1.14 -2.93/-0.004	-1.11 -2.23/-0.0005	-1.45 -2.11/0
Close Reesor Lake	-1.73 -7.04/-0.003	-1.71 -6.77/-0.003/	-2.57 -3.49/0
Close Beavermines Lake	-0.98 -4.16/-0.02	-0.92 -3.21/-0.02	-1.75 -5.49/0
Forest Crowsnest	0.82 0.01/2.50	0.77 0.019/2.35	1.83 0/1.35
Trout Stocking	1.70 0.004/1.07	1.67 0/0.30	2.50 0/0.09
Oldman River Dam	-0.85 -0.49/-0.003	-.79 -0.53/-0.004	-2.00 -0.47/0
Oldman River Dam (75%)	2.16 0.03/149.05	0.72 0.06/119.34	2.52 -0.14/9.59

2 of/de 2



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

APPENDIX E:

CAPITALIZED ANNUAL AGGREGATE WELFARE ESTIMATES

DISCOUNT RATE = 10% :

MANAGEMENT POLICY	RUM ($)	RUM-5 ($)	AWARE ($)
Close McGregor Reservoir	-7 806 550	-7 434 810	-27 343 570
Close Chain Lake	-3 304 360	-2 602 180	-826 090
Close Reesor Lake	-2 436 960	-2 395 660	-536 960
Close Beavermines Lake	-3 841 320	-3 139 140	-1 776 090
Forest Crowsnest	2 560 880	2 602 180	413 050
Trout Stocking	413 040	123 910	16 520
Oldman River Dam	-536 960	-578 260	-165 220
Oldman River Dam (75%)	5 534 800	8 632 640	1 404 350

DISCOUNT RATE = 5% :

MANAGEMENT POLICY	RUM ($)	RUM-5 ($)	AWARE ($)
Close McGregor Reservoir	-15 613 100	-14 869 620	-54 707 140
Close Chain Lake	-6 608 720	-5 204 360	-1 652 180
Close Reesor Lake	-4 873 920	-4 791 320	-1 073 920
Close Beavermines Lake	-7 682 640	-6 278 280	-3 552 180
Forest Crowsnest	5 121 760	5 204 360	826 100
Trout Stocking	826 080	247 820	33 040
Oldman River Dam	-1 073 920	-1 156 520	-330 440
Oldman River Dam (75%)	11 069 600	17 265 280	2 808 700

END

17-05-94

FIN