RURAL ECONOMY

PROJECT REPORT

Department of Rural Economy
Faculty of Agriculture and Forestry
University of Alberta
Edmonton, Canada

Economic Effects of Environmental Quality

Change on Recreation Demand

Alison Coyne
and
Wiktor Adamowicz

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The authors are Research Assistant and Associate Professor respectively, Department of Rural Economy, University of Alberta, Edmonton, Alberta, Canada.

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CHAPTER I INTRODUCTION

A. Study Background and Objectives

In Alberta, there has always been a strong relationship between the province's natural resources and outdoor recreation activities. This relationship is acknowledged in the most recent policy directives issued by government agencies responsible for the legislative and operational aspects of outdoor recreation in Alberta (Alberta Energy and Natural Resources[1], 1984; Alberta Recreation and Parks, 1985). Recent studies conducted on recreational activities show that many of the activities most preferred by Albertans are outdoor activities where the natural environment or resource is a principle component of the activity (Jackson, 1985). This would suggest that changes in the quality of the natural environment could have a significant impact on outdoor recreation activities in Alberta.

Government policies or development programs often have indirect effects on recreation activities even though they are not specifically meant to do so[2]. In Alberta, many natural resources are owned and managed by the Government of Alberta on behalf of the public and decisions regarding the allocation of these resources to various uses is the responsibility of the government. Outdoor recreation represents just one potential use of the

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[1]Since 1986, Alberta Forestry, Lands and Wildlife has been responsible for developing recreation policies and programs relating to Alberta's public lands and wildlife resources.

[2]Natural phenomenon such as fires or floods also lead to changes in environmental quality and can therefore have an impact on recreation activities. This study will primarily be concerned with those changes that can be controlled by natural resource managers.

environment. To some government agencies, such as Alberta Tourism, recreational uses of the natural environment receive high priority. To Alberta Energy the natural environment is a source of oil and gas reserves while Alberta Agriculture is concerned with the suitability of public land for growing crops or grazing cattle. Conflicts between agencies concerning the most appropriate and important uses of Alberta's natural resources exist. This is not to say that any particular use of the natural environment precludes all other uses, but one agency's attempt to achieve its goals is likely to have an effect on the environment as well as on other agencies' efforts to carry out their objectives. In any case, almost all uses of Alberta's natural resources will have either a positive or negative impact on outdoor recreation activities. For this reason, it would be useful to have a means of selecting among various projects or policies causing environmental change.

Benefit-cost analysis is a method of economic analysis that has been used to examine the implications of land and water resource policies including the establishment of government funded recreation areas (Freeman, 1979; McConnell, 1985)[3]. At the most fundamental level, benefit-cost analysis is simply a set of techniques for choosing among alternative policies or projects to achieve stated goals (Johansson, 1987). Benefit-cost analysis provides a set of definitions and procedures with theoretical underpinnings for measuring benefits and costs and can therefore assist in environmental decision making (Freeman, 1979). A project being considered by the government must provide a net benefit to society or the project is not worth undertaking. Unfortunately,

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[3] See Howe (1971) for a detailed description of benefit-cost analysis as applied to water system planning.

recreational activities have often been assigned low values in benefit-cost analyses even though valuation efforts by researchers have shown that these activities contribute significantly to the economy and to the individual participants.

Evaluating the magnitude of the recreation benefits associated with modifications to the environment is an important element of management. Recent theoretical and empirical research in the area has concentrated on measuring the magnitude of the recreation benefits associated with changes in air and water quality (Bockstael et al., 1984). As studies in the United States have shown, a large proportion of the economic benefits associated with improvements in air and water quality result from recreational use of the environment (Bockstael et al., 1984; Freeman, 1979). Air and water quality are two very important components of a general environmental quality. However, there are other aspects of environmental quality which, if altered, could cause changes in recreation benefits. Evaluating these changes can be a challenging task.

The preceding discussion suggests that analysis of the effect of environmental quality on recreation activities is an important element of a sound environmental policy. While several studies in Alberta have analyzed the value of recreation there are few studies that consider the qualitative aspects of the resource and its contribution to economic value. The objective of this study is to develop a methodology which can be used to examine the economic effect of changes in environmental quality on recreation demand and to apply the methodology to an Alberta case study. The particular application to be examined in this study is the case of Bighorn sheep hunting. The two main areas of investigation are (1) determination of environmental variables which may affect hunter demand at Bighorn sheep hunting sites and (2) statistical investigation of the effects of changes in these characteristics on hunter demand at the hunting sites.

B. **Study Plan**

The plan of this study is as follows. Research efforts in the last decade have produced new evaluation techniques and improvements to established evaluation techniques. Chapter II presents a review of the literature on these techniques and includes a discussion of theoretical and empirical models. The discussion will examine the development of theoretical models which incorporate environmental quality. Empirical models used for estimating the impact of environmental quality changes on recreation activities are derived from these theoretical models. The most recent developments in these models, particularly discrete choice models which can be used to incorporate environmental quality into a multiple site framework, are presented..

Chapter III presents a discussion of environmental quality measures. A case study of Bighorn sheep hunting in Alberta will be used to illustrate how quality measures can be incorporated into a discrete choice model. Issues surrounding the data to be used in estimating such a model are also discussed.

In chapter IV, one form of a discrete choice model is estimated and several uses for the results are demonstrated. Conclusions and recommendations for additional research are contained in chapter V.

Before proceeding with the study plan it is useful to have a general understanding of what is meant by recreation benefits and to explain how benefits can be measured. Also, a definition of environmental quality as it is used in this study must be provided. The remaining sections of Chapter I will be concerned with these issues.

C. Benefit Concepts and Measurement

1. Definitions

It is useful to define what is meant by benefits as the terms 'benefits' and 'costs' are often used interchangeably (Feenberg and Mills, 1980; Freeman, 1979). These terms can be examined in the context of recreation benefits and costs. Cost can refer to the value of resources used to bring about an environmental change, for example, construction of a new campground. In this sense, it refers to project costs such as labour and materials and these are valued at market prices.

The distinction between recreation costs and benefits would seem to depend on the choice of a bench mark from which environmental changes are to be measured and on the way in which environmental changes affect various types of recreation. Recreation benefits can be measured by comparing the existing state of the environment with some hypothetical alternative where environmental quality has been improved. Recreation benefits are the gain associated with the improved quality level. Costs would represent what was lost by moving from the improved hypothetical situation back to the original state. Some projects or policies may lead to changes which deteriorate the level of environmental quality thereby impairing recreation activities which make use of the environment. In this case, comparison of the "before" and "after" situations would show a loss in recreation benefits. For purposes of this study, environmental quality changes will be discussed in terms of gains or losses in recreation benefits. Analysis in the study will be concerned with determining if certain policies which modify the environment produce increases in recreational hunting benefits.

2. Benefit Measurement

Measurement of benefits begins with understanding the links between changes in environmental quality and human welfare. Any specific fluctuations in the level of environmental quality depend on the form, place, and time of occurrence of an environmental change (Feenberg and Mills, 1980). However, any change in the environment will influence the existing level of quality. A shift in environmental quality will affect the welfare of individuals in a variety of ways. Environmental changes can affect, either positively or negatively, human health, economic productivity and as mentioned above, recreational uses of the environment. Part of the impacts stemming from environmental quality changes can be measured in economic terms.

In relation to a particular recreation activity, policies which reduce the magnitude of negative effects and increase the size of positive effects of quality changes should be adopted. The values that individuals place on achieving the above are a measure of recreation benefits from environmental alteration.

Assuming that individuals know the effects brought about by quality changes they can form preferences regarding these effects. Individual preferences are the basis for determining the economic benefits from environmental changes. Freeman (1979) defines the benefit of an environmental improvement as "the sum of the monetary values assigned to these effects by all individuals directly or indirectly affected by that action". Estimating these economic values is made difficult by the nature of environmental assets.

Economists describe most environmental assets as public goods. A public good is a good for which consumption by one individual does not prevent consumption by another individual. In the context of environmental management this means that any environmental change will affect all users and not just one individual or group. (Feenberg and Mills, 1980). Also, a public good is often nonexcludable in that a positive price cannot be enforced. For example, it is impossible to force an individual to pay for benefits derived from having a view of a mountain (Just et al., 1982)[4]. Improving the quality of the environment for a particular use requires the expenditure of public or private funds but once the desired level of environmental quality is reached additional users can benefit from the improvements at no extra cost. It would be desirable to determine if the demand for improved environmental quality justifies the expenditure of funds. To estimate demand for private goods for which there is a functioning market economists use price and quantity data[5]. Because there is no market for environmental quality, individual preferences are not revealed, price and quantity data are not available, and techniques used to determine demand for non-market goods must be employed.

D. Environmental Quality and the Recreational Experience

McConnell (1985) defines outdoor recreation as a service which is produced and consumed by an individual using household resources in combination with the natural environment at a particular site. The characteristics of a recreation site can determine an individual's satisfaction with the recreation activities experienced at the site. Thus, the quality of the recreation experience is dependent on the quality of the recreation site. Demand for particular sites is therefore related to the quality of the site. Determination of the demand for recreation services requires an analysis of how individuals allocate resources over recreation

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[4]For a general discussion on the nature of public goods see Just et al. (1982).

[5]A private good is one which once consumed by one individual cannot be consumed by another.

sites of varying quality.

There are several dimensions of environmental quality all of which affect the satisfaction derived from a recreational experience. Jackson (1988) has identified four types of interaction between and among recreational activities, the environment and other land uses. These provide a useful framework for examining the dimensions of environmental quality and determining their relationship with the demand for recreation services in a particular area.

Firstly, outdoor recreation interacts with other land uses such as forestry, agriculture, or mining. Outdoor recreation is affected by other land uses[6]. For example, the extraction of gravel from a piece of land could close the area to cross-country skiing if the land is not reclaimed after the extraction process is completed. Also, the land surrounding the area might become less desirable for other recreational uses such as hiking, nature study, or picnicing because of noise and traffic associated with the gravel extraction. In addition, a process such as washing the gravel and draining the sediment into a nearby stream can change the quality of water possibly affecting recreational fishing far downstream from the gravel pit operation. Outdoor recreation can also benefit from other land uses. Forestry operations may lead to increased forage for big game animals increasing animal density and possibly improving hunting success rates.

A second type of interaction involves recreation activities and their affect on the natural environment. Outdoor recreation activities can

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[6]The relationship between outdoor recreation and other land uses is not one way. For example, the operators of the gravel operation described above may be required to fence in the pit area in order to eliminate the potential for injury to recreationists unfamiliar with the area.

affect on the environmental resource influencing current and future uses of the resource. Visitors to recreation areas may litter an area with garbage. Besides reducing the attractiveness of the site, garbage often attracts animals who depend on it as a food source. This may permanently alter the behavioral patterns of the animals and can lead to human/animal conflicts.

A third type of interaction concerns conflict between individuals participating in different recreational activities at the same site. Snowmobilers can destroy cross-country ski trails and motorboat activity may disturb anglers or canoeists on the same lake. Finally, it is possible to have conflicts between recreationists participating in the same activities at one site. Too many hikers on a trail during a one day period may scare off wildlife and inhibit wildlife viewing opportunities.

All of the situations described above involve different dimensions of environmental quality, and all of them can affect the demand for outdoor recreation in a particular area. In the first case, the level of environmental quality is external to the recreation activity. Policies or programs at a particular site alter the physical environment thereby changing the site's attractiveness for recreation activities. In the second example, the recreation activity itself influences the level of environmental quality. The act of using the site for a recreation activity physically or biologically alters the site in some way. The last two examples illustrate the concept of congestion. A site's ecological environment may not have changed but too many people at the site participating in activities may lower the quality of the environment for some activities.

These observations have important implications for modelling the role quality plays in an individual's recreation decisions. There are many aspects to environmental quality and the type of model used in estimating the effects of changes in this quality needs to be appropriate to the situation being analyzed. For purposes of analysis, the quality dimensions used must be measurable. In addition, the recreationists must perceive and respond to the selected quality dimensions.

This chapter has provided background information on the study objectives. As well, benefit concepts and measurement have been discussed and the role of environmental quality in the recreation experience has been examined. Chapter II presents a literature review with emphasis on the development of theories relating to recreation demand models.

CHAPTER II THEORETICAL MODELS AND LITERATURE REVIEW

Extramarket values are values imputed to non-priced goods or activities by a variety of empirical techniques. These values are currently used to evaluate new recreation activity opportunities, to quantify the effects of environmental quality changes and to provide estimates of the economic value of resources not priced in a market. Since the 1950's, estimates of extramarket values have been used to value such "goods" as recreation days, recreation sites, and characteristics of recreation sites such as changes in water quality. The techniques used to derive these extramarket benefits (EMB) can essentially be categorized into two groups, direct and indirect techniques. The only direct technique in use in the "field" is contingent valuation. This technique attempts to reveal values of non-priced goods by asking consumers their willingness to pay for these items. Indirect techniques use existing market transactions to impute values for the non-priced goods. Most often these techniques are used to estimate the value of a recreational site or activity. Recently, however, emphasis has changed to estimating the value of environmental quality changes. Both direct and indirect techniques have been modified to estimate the impact of quality changes on recreational values.

The direct and indirect techniques for valuing non-priced goods can be separated into two further classifications: those techniques which estimate values of sites or recreation activities and those techniques which estimate the value of changes in the quality of a site or environment. The contingent valuation approach can be used for all of these tasks with some modification. The indirect approaches, however, utilize different assumptions, data and empirical techniques to arrive at each of these values. The indirect approach used most often to estimate the value of a site is the travel cost model. The indirect techniques used to evaluate quality changes include the hedonic travel cost model and a variety of discrete choice models. Some travel cost models have been modified to allow estimation the value of quality changes. The discussion below includes a description of the travel cost model, the hedonic travel cost model, contingent valuation models and discrete choice models.

The discussion will outline the theory of nonmarket benefit estimation as it relates to recreational values. First the direct and indirect techniques for valuing sites and recreational activities will be presented and then the modifications made to estimate the impact of environmental quality changes will be discussed.

A. The Travel Cost Model

The travel cost model (TCM) originated in a 1947 letter from Harold Hotelling to the National Park Service. Hotelling essentially proposed that travel costs be used as a surrogate for price in an analysis of trips to a national park. The travel cost method today uses travel (and time) costs as prices which reveal the demand curve for a particular site.

The original idea of the travel cost model is that people in population zones surrounding a recreation site will take trips to the site and that the number of these trips will be a function of the travel costs to the site. Zones further away are expected to have fewer visits per capita, since the price of travel is higher. A statistical relationship is formed which expresses the number of trips per capita as a function of the travel costs to the site and some average socioeconomic characteristics of each zone's population. This relationship is the aggregate visits locus and provides one point on the demand curve for the site. By assuming that individuals would react to a site entrance fee in the same manner as they would react to an increase in travel costs, the demand curve is developed by incrementally adding to the access costs and determining the number of visits in total. The number of visits generated times the increase in the hypothetical site entrance fee (essentially the consumer's surplus) provides the measure of benefits for the site.

More formally, for each zone i, i=1,...I, the travel cost relationship $V_i = V(TC_i, S_i)$ is estimated, where V_i is visits per capita from zone i, TC_i is travel cost for trips from region i and S_i is a vector of socioeconomic characteristics for region i. The total number of visits is: $V = \sum_i POP_i V_i$, where POP_i is the population of zone i. Incremental entrance fees (P) are added to the travel costs to identify the demand curve as $V(P) = \sum_i V(TC_i + P, S_i)$ where P is increased until V(P)=0. This provides a demand curve for the site and the integral of this curve provides the benefit estimate (see Freeman, 1979).

The assumptions of the travel cost model are: (1) Individuals treat the entrance fee and travel costs identically, (2) the main purpose of their trip is recreation at the site, (3) all individuals spend an equal and fixed amount of time at the site (one day for example), (4) there is no utility in travelling to the site, and (5) there are no substitute sites available.

Travel cost models were originally designed to use population zones and aggregate numbers of visits, however, these models may also use individual observations if there is sufficient variation in the number of trips to the particular site. In this case, the demand function is estimated from a group of individuals who each take some number of visits to the site, and the benefit estimate is the consumer's surplus per individual. This is the typical model estimated currently. Most recreation data are collected by individual surveys, thus high quality data are available for individual choices. Estimation of travel cost models from individual data allows the calculation of individual consumer's surplus and more accurate modeling of income and socioeconomic effects.

There are a variety of issues which hamper travel cost models and their estimation. The first of these is the opportunity cost of time. If travel time is valued at some non-zero value then this value must be included in the travel cost estimate. Formulation of a microeconomic model using a household production framework results in the wage rate being the opportunity cost of time (see Smith, Desvousges and McGivney, 1983). However, several authors have argued that due to various constraints on time allocation the wage rate is not an accurate estimate of the value of time. Cesario and Knetsch (1976) suggest that one-third of the wage rate should be used as the value of time. McConnell and Strand (1981) attempt to estimate the fraction of the wage rate that corresponds to the value of time by separating the travel and time cost parameters in a travel cost regression equation. This approach suffers on two accounts. First, the time cost and travel cost variables may be highly correlated. Second, some empirical results provided by Smith and Desvousges (1986) indicate that the value of travel time parameter is negative in some cases and highly positive in other cases, indicating a value of time that is negative and greater than the wage rate respectively. If on-site time is a separate choice variable for the consumer, a simultaneous determination of on-site time and number of trips is indicated, further complicating the issue.

The value of time is a very important factor in the determination of the consumer's surplus from the travel cost model. Bishop and Heberlein (1979) show that valuing travel time at different rates can cause a four fold difference in the benefit estimates. Several new and inventive approaches to valuing time recently have been presented (Wilman, 1980;

Bockstael, Strand and Hanemann, 1987; Smith, Desvousges and McGivney, 1983), but this issue is far from resolved (see Kinsey for a survey of the value of time literature).

A second issue in the estimation of travel cost models is the question of functional form. Most analyses have utilized linear, semi-log or double log functional forms. The majority of recent studies are using a semi-log form based on recommendations by Ziemer, Musser and Hill (1980) and others. There is no basis for a predetermined choice of functional form as theory does not provide us with any guidance in this area. Actually, depending on the fit and the sensitivity of the consumer's surplus estimates to the functional form, the semi-log form may not be a desirable one (Adamowicz, Fletcher and Graham-Tomasi, 1989).

Two other problematic issues in the travel cost literature are the fact that the visits variables are truncated (at zero) and the number of days spent on site differs from person to person. In response to the truncation issue several authors have estimated Tobit or Heckman estimators (see Wilman and Pauls, Smith). In the case of different days per trip, Wilman (1987) has recently suggested the use of a recreation repackaging model which translates demands from various lengths of stay into a single length demand function.

A final issue in the estimation of travel cost models is the treatment of substitute sites and quality variables. Travel cost models alone do not take into account substitute sites or quality variables. Several modified travel cost models have been developed which allow for incorporation of these considerations. Travel cost models typically are estimated from cross sectional data and thus quality variables must be spatial (and not temporal) in nature. Also, addition of substitute site prices (travel costs) may best be accomplished in a demand system (Burt and Brewer, 1971).

A model which incorporates alternate sites and quality variables is the generalized travel cost model (Smith and Desvousges, 1986), which is estimated as a two stage model. The first stage estimates the travel cost functions for each of several sites and the second stage estimates a systematic parameter variation component with the parameters of the travel cost model regressed on recreation quality variables. While this technique accounts for quality effects in a travel cost framework, it does not account for entry into or exit from participation in recreation activities due to quality effects.

The travel cost model has been developed sufficiently to constitute a well-accepted model of site specific recreation values. The benefit estimates provided are average consumer's surplus estimates, although estimates of marginal consumer's surplus are also estimable. The technique has been modified to account for quality and substitute effects, although these versions of the travel cost model may not be the most desirable.

B. Contingent Valuation

In order to elicit values for public goods Ciriacy-Wantrup (1968) suggested that individuals be asked direct questions to determine how much they would be willing to pay for units of a public good. Ciriacy-Wantrup's approach was to develop a public goods market demand schedule by eliciting values for "successive additional quantities of a collective extra-market good" (Ciriacy-Wantrup, 1968). This contingent valuation approach was first implemented by Davis (1963). The term contingent valuation (CV) follows from the fact that the questions are asked "contingent" on there being a market for the good in question.

In its most basic form CV entails a single open ended question. More advanced CV approaches ask closed ended questions in the form "would you be wiling to pay X dollars, Yes or No." The value of X is varied for various survey respondents. Analysis of this closed ended CV requires limited dependent variable techniques (Sellar, Stoll and Chavas, 1985). Hanemann (1984) has suggested modifications to the Bishop and Heberlein approach which make it consistent with random utility theory. In particular, the functional forms chosen by Hanemann correspond to those which can be derived from utility theory. A related approach to CV is the bidding game in which respondents are asked closed ended questions, but the payment X is incrementally changed to find the value for which the answer to the question changes from Yes to No (or vice versa).

The use of the CV approach to valuing public goods has grown dramatically in the past 20 years with the sophistication of the survey devices being the major improvement. A number of variants of the simple CV have been developed. The major emphasis in the past few years has been the valuation of environmental quality changes. In order to value water quality improvements a water quality ladder has been employed. This ladder is a method of quantifying water quality levels such that the respondent understands the measures of quality. For example, the water quality ladder may contain steps of "boatable", "fishable", "swimable", etc. This allows the surveyor to ask how much one would be willing to pay for an improvement from one quality level to another. A new approach evaluating quality changes is the contingent ranking technique which asks the consumer to rank various levels of quality and price levels in order of satisfaction. This allows investigation of a gradient of quality and value levels.

Some recent examples of contingent valuation studies include a comparison of bidding game, closed ended and payment card approaches to direct questioning by Boyle and Bishop (1984) and an analysis of closed ended valuation of whooping crane preservation by Bowker and Stoll (1988).

Both studies show that estimates of value are quite sensitive to the technique employed and the method of analysis. Wide ranges in the welfare estimates from the different techniques are commonly found in the literature.

The contingent valuation approach suffers from a variety of theoretical and practical difficulties. The theoretical difficulties stem from the hypothetical nature of the question. There are no actual budget outlays and there is no purchase; thus, some argue that contingent valuation suffers from "hypothetical bias" (for a recent treatment of this issue see Hoehn and Randall, 1987). Samuelson's original article on the provision of public goods (1954) maintained that individuals could not be expected to reveal their willingness to pay for strategic reasons. This has been called "strategic bias". Contingent valuation approaches that use the bidding game technique suffer from "starting point bias" in that respondents may anchor to an initial point in a bidding experiment. When respondents are asked how much in increased taxes they would be willing to pay versus how much they would pay via other methods, the response may be significantly different. This difference in willingness to pay dependent on the method of payment is termed "vehicle bias". Respondents may also change their values depending on the amount of information they are given about the area or situation. For example, if information on present tax expenditures is given, the respondent may provide a different value relative to a case where the respondent is not informed about the tax expenditure. This is termed "information bias".

More recent analyses of the problems (Mitchell and Carson, 1989) in contingent valuation find that many of the "biases" are not truly bias problems but problems in the identification of the commodity and the market mechanism and problems in the information available to the respondent. The question is hypothetical, yet the desire of the researcher is to make the situation realistic and to reveal values as they would be in a market setting. Therefore, responses are not biased due to the hypothetical nature of the question but the respondent may not be able to understand the setting of the commodity being valued. Different levels of information and understanding will (and should) result in different valuations. Hoehn and Randall (1987) present a different approach to hypothetical bias, the approach that the respondent is encountering communications error from the researcher. This approach suggests that the respondent's valuation function is correct, but is subject to a systematic error component. Such an approach also ignores the fact that it is the good and its associated market which are not well perceived by the respondent, not simply a appropriate valuation function affected by systematic error. The hypothetical nature of the questions is related to the information available to the respondent and the structuring of the situation.

The issue of information bias is also unclear. We expect a different valuation from respondents with different levels of information about the good and the market. It is difficult to define the correct amount of information which would provide a correct valuation. Starting point bias may also be related to the information available to the respondent. Without proper information and structuring the respondent may seek out an anchor value and thus reveal what appear as starting point bias. We should expect valuations to change as the good and market become more clearly defined and understood. Vehicle bias may also not be a bias, as such, but a natural response to payment mechanisms. We would expect individuals to offer different valuations depending on the payment vehicle if there are different perceptions about the efficiency of the vehicle or other characteristics of the payment vehicle. The issues identified as biases in the earlier literature raise important questions about the structuring of the contingent value situation but they may not be biases as much as weaknesses in framing and elicitation procedures (see Mitchell and Carson).

A final issue in the elicitation of contingent values is the willingness to pay (WTP) versus willingness to accept (WTA) issue. Generally WTP has been collected in surveys, however, in surveys where WTA has also been collected the WTA values are considerably higher (at times ten times higher) than the WTP figures. There have been several theoretical arguments for WTA to exceed WTP but the debate still continues in an attempt to reconcile these differences (Hanemann, 1985, Cummings, et al., 1986). Two excellent references on the contingent valuation approach are Cummings et al. (1986) and Mitchell and Carson (1989).

C. Hedonic Travel Cost Models

The travel cost and the basic form of the contingent valuation method are both mechanisms used to value recreation activities or recreation sites. The hedonic travel cost technique is one of the approaches used to value recreation quality or site characteristics. The valuation of recreation attributes is important for the estimation of the value of environmental quality changes. The travel cost model cannot value quality changes in its basic form. The hedonic travel cost is a modification of the travel cost model and the hedonic price model popularized in property value studies (Brown and Rosen, 1982).

The essence of the hedonic travel cost model (HTC) is that consumers travel different distances (and thus incur different costs) in order to consume different bundles of recreation characteristics. Since these costs are exogenous and the sites are available in some gradient of characteristic levels, the consumers reveal their demand for site characteristics by choosing some bundle of characteristics for a particular travel cost. As Brown and Mendelsohn (1984, page 427) state, "By observing purchases of a private good (travel) which must be made in order to gain access to the public good (a recreation site), it is possible to observe a price for the public good (the site). Treating heterogeneous sites as if each was a bundle of characteristics, the site price can be decomposed into a set of implicit prices for each characteristic using the traditional hedonic method."

The HTC method divides the area into residence zones and recreation areas. For each residence zone a relationship is estimated between the costs of travel to a site and the levels of characteristics at that site. The travel costs are typically miles times some constant price per mile, but they may also include the costs of travel time. The site characteristics may include such items as fish density, deer population, scenery and congestion. This mileage relationship is estimated for each residence zone as each member of the zone experiences the same array of physically spaced recreation sites. Members of different zones face a different array. The relationship between the travel costs and the site characteristics provides an implicit price for each characteristic and each zone as the derivative of this travel cost function with respect to each characteristic. This provides one set of implicit prices for each residence zone. These prices are then regressed against the level of characteristics actually consumed and a set of socioeconomic variables to provide the inverse demand curve for characteristics.

Problems associated with the HTC model include accounting for the number of trips made by each consumer, possibly to different sites, within a season. Bockstael, Hanemann and Kling (1985) treat each visit to a different site as a different consumer. Also, each consumer may spend a different amount of time at the site. Brown and Mendelsohn (1984) estimate separate demand curves for categories of length of stay. Smith and Kaoru (1987) identify a number of theoretical and practical issues in the HTC model, including the determination of residence zones and the definition of site characteristics. One of the major problems in the hedonic travel cost model is the fact that many of the prices are negative. Bockstael, Hanemann and Kling and Smith and Kaoru found significant numbers of negative price coefficients. These may be explained as discontinuities in the array of characteristics, however, they cause difficulty in the determination of benefits.

The HTC model has been applied to water quality (Bockstael, Hanemann and Kling, 1985 and Smith and Kaoru, 1987), fishing quality (Brown and Mendelsohn, 1984) and hunting quality (Mendelsohn, 1984a). The major advantage of the approach is its simplicity. Mendelsohn (1984b) has also shown that characteristic prices can be identified for each consumer and these prices are a function of that consumer's level of characteristic consumption.

D. Discrete Choice Models

The valuation of site characteristics and the impact of quality changes on economic welfare can be examined using the hedonic travel cost model. However, the hedonic travel cost model does not explicitly treat site substitution effects or the fact that some users may exit from that recreation activity at some level of environmental quality. The discrete choice class of models is developed to treat models of site substitution and entry and exit from the activity. The discrete choice model is based on the work in travel demand summarized in Domencich and McFadden (1975). These models express the indirect utility received from a site as a function of the characteristics of that site and the income less travel costs to that site. If an individual chooses site A over site B then the indirect utility of site A must be higher. By expressing the indirect utility function as a deterministic function plus a random component, the probability that the utility of site A is greater than site B, given the levels of characteristics and travel costs, can be determined. This relationship usually takes the form of a multinomial logit model with the parameters of the indirect utility function as the coefficients of the logit model. This result is due to the fact that the additive form of the random component and the choice of an i.i.d. extreme value distribution for these random variables results in the logit form (see Feenberg and Mills, 1980).

The consumer (of the recreation activity) faces a set of alternative sites. Each of these sites has different levels of "characteristics". These characteristics include distance to the site, various site quality attributes and perhaps individual perceptions of site attributes. The utility or satisfaction gained by the recreationist ($U(i)$) is composed of two parts, an observable or systematic part ($V(i)$) and a random component ($\epsilon(i)$) where i identifies the site.

$$U(i) = V(i) + \epsilon(i) \qquad (1)$$

The observable component is made up of the attributes that the researcher observes and includes in the model. The random component contains those characteristics or elements of choice that the analyst does not observe. The choice of a particular site (over other sites) could be predicted exactly if the random component did not exist. However, since the random component exists, only probabilistic statements about site choice can be made. That is, using this model one assigns a "probability of choosing site i" to each individual depending on the site attributes, the individual's socioeconomic characteristics and the estimated parameters of the utility function.

More formally, let $V(y-p_i,b_i)$ be the observable component of the utility function with y income, p_i the travel cost to site i and b_i the characteristics of site i. If the individual visits site i and not site j then $V(y-p_i,b_i) > V(y-p_j,b_j)$. If the random component is added to this model in an additive form then site i is visited if $V(y-p_i,b_i) + \epsilon_i > V(y-p_j,b_j) + \epsilon_j$ where ϵ_i and ϵ_j are the mean zero error terms. The probability that site i is visited is (given all other sites j=1,...J):

$$\pi_i = \text{Prob}\ \{\ V(y-p_i,b_i) + \varepsilon_i \geq V(y-p_j,b_j) + \varepsilon_j\ \} \quad \text{for all } j. \qquad (2)$$

McFadden (1976) has shown that if the ε_i's are distributed independently and with an extreme value distribution (Weibull) then the probability that site i is visited takes on the Multinomial Logit form, or

$$\pi_i = \exp\ (V_i)\ /\ \Sigma_j \exp\ (V_j) \quad \text{for } j = 1,\ ...,\ J. \qquad (3)$$

Estimation of this model provides the parameters of the indirect utility function V_i. With the parameters of the model one can predict the probability of any individual selecting site i. Also, given a change in site attributes (eg. environmental quality) the response of individuals can be predicted. Using this model the impact of changes in attributes can be ascertained through the change in the probability of visitation of all sites and the impact of quality changes on expenditures and utility levels. Economic welfare evaluation in this model is relatively straightforward (Bockstael, Hanemann and Kling, 1985).

A number of difficulties arise in the estimation of the multinomial choice model. First, the sites considered (choice set) are usually selected by the researcher and may or may not correspond to those being considered by the individual when making recreation site choice decisions. Second, the model as described above is susceptible to "Independence of Irrelevant Alternatives" (IIA). This characteristic of multinomial choice models requires that the ratio of probabilities of selection of any two sites are independent of the addition or deletion of a third site. Two approaches for treating IIA are available. The first is to select sites that may correspond to this independence assumption in reality. Then a test of the IIA assumption can performed to confirm their independence (Amemiya). Alternately, Bockstael, Hanemann and Kling (1985) overcame the independence of irrelevant alternative assumption implicit in the multinomial logit model by estimating a nested multinomial logit model for beach site choice. Such a model is relatively more complex and requires the specification of a particular nesting scheme which may also restrict behavior.

The estimation of the multinomial logit model can be carried out using any software that has a nonlinear systems solver or a maximum likelihood routine. Some programs have built in multinomial logit algorithms (GAUSS, LIMDEP).

Welfare measurement in this type of discrete choice model was first addressed by Small and Rosen (1982). Further refinements to the theory have been developed by Hanemann (1982) and Hau (1983). Essentially welfare measurement in this case corresponds to measuring how much an individual would have been willing to pay (which may be a negative number) to experience the new level of environmental quality. This willingness to pay is derived from the fact that travel cost (distance to the site times cost per mile) is contained in the model and this cost can be manipulated to provide the same level of utility as before the quality change. The willingness to pay provides a measure of the economic impact of environmental quality changes.

More formally, an individual's welfare change can be estimated from the parameters of the multinomial logit model as

$$\text{Willingness to Pay} = -(1/\mu) \int_{V1b}^{V1a} \pi_1(V_1, V_2, \ldots)\, dV_1 \qquad (4)$$

where μ is the coefficient on travel cost in the multinomial logit model, V_{1a} is the utility after the quality change and V_{1b} if the utility before the quality change (Hanemann, 1982). Since π_1 in the multinomial logit model is defined by equation (3) this calculation reduces to

$$\text{Willingness to Pay} = -(1/\mu)\ [\ln(\Sigma_j \exp(V_j))]\ \Big|_{Q_b}^{Q_a}$$

where Q_a is the quality level after the change and Q_b is the quality level before the change.

The multinomial logit model provides a mechanism to evaluate the benefits of an improvement in site quality. It incorporates substitution effects and allows for varying levels of attributes and various forms of socioeconomic considerations. It requires information on the quality levels at each site and the travel costs to each site. This information is used to estimate the choice probabilities as a function of site attributes. Given a sample of individuals this model can provide the benefits of an improvement in some recreational attribute, the costs of closing a particular site or the benefits of a management change. The model is particularly useful to policy makers who need to evaluate the benefits of various programs. This model is the state of the art in benefit assessment, particularly in cases in which quality changes are being evaluated.

Several examples of the multinomial choice approach have been attempted. Feenberg and Mills (1980) use a discrete choice model to evaluate the impact of water quality on recreational experiences in the U.S. Bockstael, Hanemann and Kling (1985) use this model to evaluate the effect of pollution levels on recreational beach users in the Boston area. Jones (1989) describes a sports fishing model which relates recreational fishing values to pollution levels in the Great Lakes. Carson, Hanemann and Wegge (1989) present a model of recreational fishing in Alaska which uses this approach.

Presently, there are no Canadian examples of studies evaluating the economic impact of environmental quality. The case study presented in this report examines recreational hunting and develops a model of site choice for Bighorn sheep hunters. The model incorporates management variables into the site selection procedure. These management variables include sheep population, ram population, site access indicators and crowding indexes. The variables will be described in detail in Chapter III.

CHAPTER III QUALITY MEASURES AND DATA REQUIREMENTS

Data used to estimate the effects of environmental quality changes on recreation activities are frequently collected using surveys. In the past, some common procedures in data collection involved surveying users at recreation sites or sending out mail surveys to users at the end of the recreation season. Recreationists were asked to provide information on standard socioeconomic variables such as age, income and education. Many early surveys of recreation activities at particular sites were not designed for the purpose of estimating recreation benefits or changes in demand at these sites. These surveys provide a wealth of information on participants' socioeconomic characteristics but are often lacking information on the recreationists' place of residence. This information is needed to calculate travel distance and costs to the recreation site. Travel costs to sites are crucial for estimating recreation benefits or changes in site demand.

Over the past decade, numerous surveys have been administered to recreationists for the specific purpose of collecting information which could be used to estimate recreation demand models. It is now recognized that the environmental quality at the site is an important factor in determining the demand for a specific site. Without data that contain variation in site quality among sites it is not possible to estimate models which predict how site demand will fluctuate with environmental quality changes. It is rare, however, that data on environmental quality have been collected in association with a participant survey[7]. Fortunately,

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[7] In the last three years several studies have been initiated which are collecting quality data in conjunction with user surveys (see Bockstael, Hanemann and Kling, 1985

environmental quality data has been collected for other purposes and this data can sometimes be used with recreation participant surveys to estimate recreation demand models.

Even though environmental quality data exists, it cannot be assumed that the available measures of environmental quality will be consistent with the goal of estimating a recreation demand model. There are many difficulties involved in measuring environmental quality and in incorporating information about environmental quality into an economic model.

Environmental quality is often examined using scientific techniques which are designed to measure particular quality attributes (Bockstael et al, 1984). Examples of the measured attributes might be the bacteria levels in a water body or the number of developed campsites at a recreation area. These types of quality measures can be used as separate variables in a recreation demand model or they can be combined into an overall index of environmental quality at a particular site. These measures are often referred to as objective measures because they can be used consistently at various sites.

In the 1970's some social scientists recognized that there might be a difference between environmental quality as indicated by the objective measures and individuals' perceptions of environmental quality. Bockstael et al. (1984, pg.199) outline the potential problem resulting from the above observation as it relates to water quality. "...Water quality policy is directed toward changing objective measures whereas benefits from the policy are argued to arise from changes in perceptions. If there is an inconsistency between objective measures and perceptions, then there is a

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and Carson, Hanemann and Wegge, 1989).

major obstacle to valuing the benefits from 'improved' water quality. It is possible that improvements in water quality by objective standards may not be perceived by individuals. Individuals not perceiving the improvement will not alter their behavior, and economists using indirect market methods to measure the benefits will not detect any change."

The statement above indicates the importance of selecting objective measures of environmental quality variables which have a high correlation with individual perceptions of environmental quality. In the case of water quality, objective measures have been used successfully in recreation demand models (Bockstael et al., 1984). They have been statistically significant factors in determining the demand for water based recreation. While much more research is needed in this area, particularly research into perceptions of environmental quality other than water quality, the successes of earlier research would tend to support the continuing use of objective measures of environmental quality in recreation demand models.

The data used in this study come from a number of sources. Data on individual hunters came from a survey conducted in Alberta during 1981. This study also utilizes environmental quality data from the 1981 survey. Other environmental quality data was solicited from the Alberta Fish and Wildlife Division, the agency responsible for wildlife management in Alberta. The remainder of this chapter provides a description of these data sources and a discussion of variables used in this study.

A. Hunter Data

The primary source of data relating information on individual hunters is a 1981 study of big game hunting in the Eastern slopes region of

Alberta[8]. This study provides information on hunters' socioeconomic characteristics such as household income, age, and education. It also provides information on place of residence, hunting site choices, and number of hunting trips associated with individual hunters for the 1981 hunting season.

A subset of data containing socioeconomic and trip information for resident trophy Bighorn sheep hunters was extracted from the main data set. A total of 623 trophy Bighorn sheep license holders responded to the 1981 survey. From this group, a usable set of observations was derived for this analysis. Respondents who took at least one trophy Bighorn sheep hunting trip during the 1981 season were selected[9]. Observations containing missing values were eliminated. This resulted in utilizing observations on 227 resident sheep hunters who took a total of 423 sheep hunting trips to 27 different wildlife management units (WMU's).

1. Hunter Characteristics

Adamowicz (1983) provides a detailed summary and description of statistics relating to sheep hunters used in this study. Table 1 presents some of the socioeconomic characteristics of the sheep hunters. Comparison of these statistics with those from other big game hunters revealed that sheep hunters had characteristics very similar to other hunters in the 1981 study (Adamowicz, 1983). When compared to other ungulate hunters, sheep

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[8]See Adamowicz, W. L., Economic Analysis of Hunting Big Game Species in the Eastern Slopes of Alberta, Unpublished M. Sc. thesis, Department of Rural Economy, University of Alberta, Edmonton, 1983 for a detailed description of study design.

[9]While all selected respondents held trophy sheep licenses not all licenses holders took sheep hunting trips. These respondents were eliminated from the analysis.

hunters had slightly higher levels of income and education and they had more years of big game hunting experience. As was the case with hunters of all other species examined in the 1981 study, nearly all of the sheep hunters were male.

Table 1: 1981 Trophy Sheep Hunter Characteristics

Age	35.02 (10.90)*
Sex (percent male)	98.6
Income (median)	31123
Education (years)	12.70 (2.77)
Big Game Experience (years)	17.68 (11.20)

*Standard deviations are presented in brackets.

2. Hunting Activity

While the socioeconomic characteristics of all big game hunters were found to be similar, hunting activity varied depending on the species sought. Sheep hunters were found to have intense hunting activity levels measured in terms of days hunted, distance travelled to hunt, and number of hunting trips taken. While not all hunting trips were limited strictly to sheep hunting, the data serve to highlight the uniqueness of sheep hunters' activities and reinforce the idea that the sheep hunting experience may be quite responsive to changes in site quality.

The sheep hunters used in this analysis took an average of 1.86 sheep hunting trips to 27 different WMU's during the 1981 season. Hunters took sheep hunting trips to almost all WMU's where sheep hunting was legal in 1981[10]. Table 2 presents the number of hunting trips to each WMU and Figure

[10]The WMU's not visited by the hunters used in this analysis were 328, 429, 446, 414, and 417. In the original sample of 623 respondents hunters did take sheep hunting trips to these areas but the observations were eliminated because of missing values. As these areas lie on the fringe of the

1 indicates the location of these WMU's in Alberta's Eastern slopes region.

These figures reflect a breakdown of trips to administrative units (WMU's). This breakdown does not necessarily correspond to distinct Bighorn sheep hunting sites. These hunting sites will be described in detail in the next chapter.

Table 2: Hunting Trips to Wildlife Management Units

WMU	No. of Trips	WMU	No. of Trips
302	9	426	4
306	1	428	1
308	2	430	7
400	85	432	6
402	85	434	6
404	32	436	3
406	33	438	11
408	43	439	1
410	21	440	9
412	7	441	1
416	11	442	11
418	7	444	1
420	13	445	4
422	9		

Eastern slopes and sheep populations are concentrated closer to the mountains very few trips were made to the WMU's not represented in the analysis.

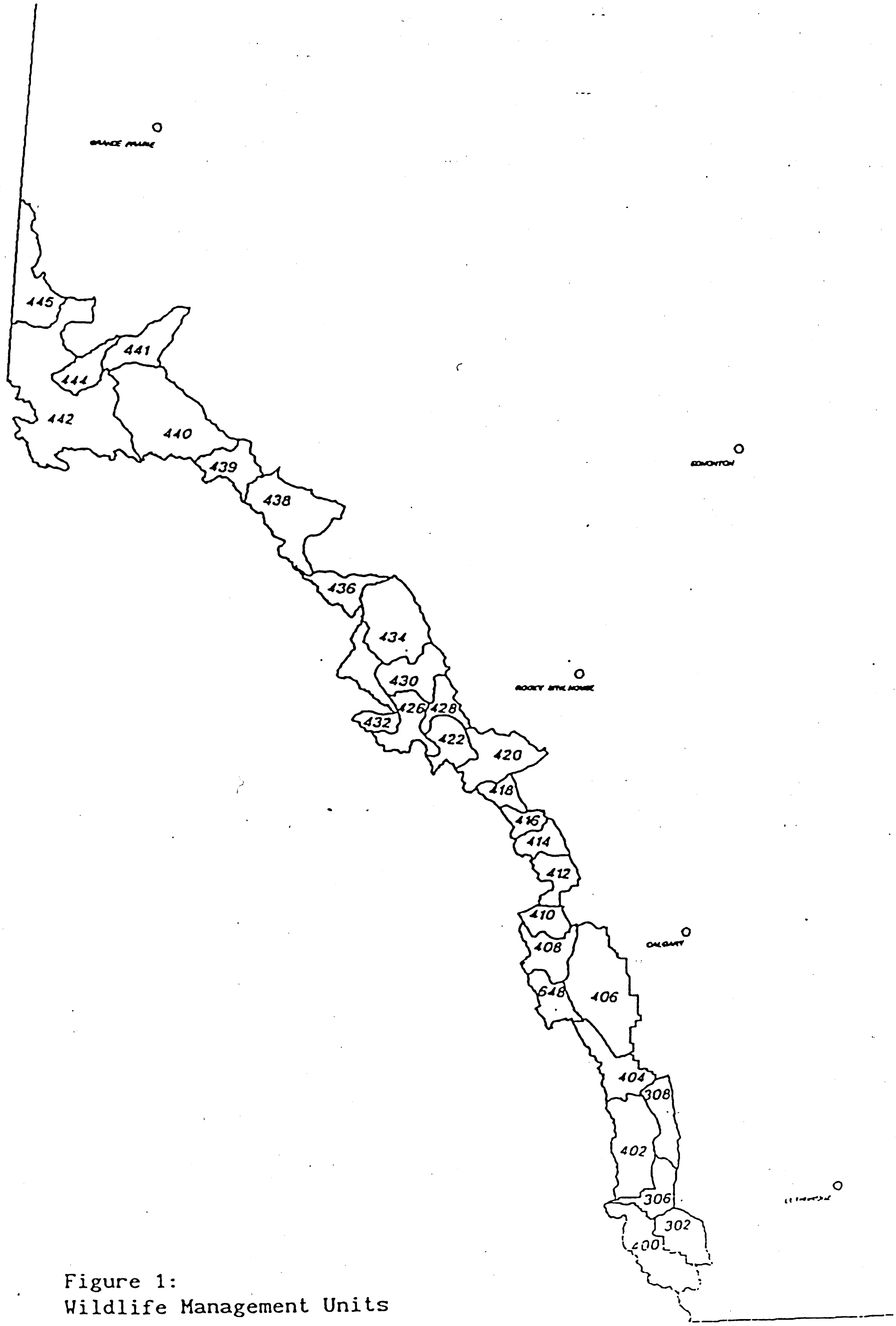

Figure 1:
Wildlife Management Units

B. Site Quality Data

Before collecting site quality data, literature in the recreation and leisure research field was reviewed in an attempt to determine dimensions of site quality for Bighorn sheep hunting. Examination of the literature revealed that while no research has been conducted specifically on sheep hunting, some work has been done on big game hunting in general. This literature guided efforts to select appropriate site quality variables for sheep hunting.

One of the most obvious indicators of site quality for hunting is the population of the desired species in the hunting area. Animal populations are important indicators of site quality since research has shown that seeing, shooting, and bagging game are very important to big game hunters. Surveys done by researchers show that these variables are the strongest predictors of hunters overall satisfaction with a hunting trip (Heberlein and Laybourne, 1978; Donnelly and Vaske, 1981; Vaske et al., 1982). It is important to note that it is not necessarily the harvesting of an animal that is important but rather, hunters want to know that there is at least a chance of viewing, shooting, and possibly bagging game. Therefore, sheep populations become a very important measure of the quality of a site for sheep hunting.

While bagging an animal may not always be the most important aspect of hunting big game, it would be an error to assume that the harvesting of game is an insignificant part of the hunting experience. As mentioned above, research has shown that harvest is an important attribute of the hunting experience. Sheep hunters could be expected to return to areas where they had been successful in the past. Sheep hunters may be made aware of other's successes through conversations with fellow hunters and they may go to new hunting areas based on these discussions (Stevenson, 1989). Bighorn sheep harvest is, therefore, another variable which could be used to measure the quality of a site for sheep hunting. While wildlife management agencies may not be able to control harvest directly, they can certainly do so indirectly by changing hunting regulations.

Also related to viewing and bagging game is the issue of access to a hunting area. Game cannot be viewed or hunted if it is impossible to get to areas where the game is found. For most hunting experiences in Alberta this is not a large problem given the extensive network of roads cutting through agricultural and forested areas of the province. Vehicles can be driven into many areas where game can be viewed from or near the vehicle. This is the case in some sheep hunting areas while in others hunters must pack into the area with horses. Such a trip might take three or four days and only then can sheep hunting actually begin (Stevenson, 1989).

Some researchers have examined access issues by looking at the number of miles of certain types of roads and trails in a hunting area (see Langenau, 1979). In these studies, when questioned directly, hunters often state that they are against new roads and trails being put into hunting areas and that they like hunting in natural, undisturbed areas. However, when actual hunter behaviour is examined hunters seem to prefer areas with easier access over areas less accessible (Langenau,1979). This apparent contradiction might be explained in the following way. While hunting in wilderness areas likely adds enjoyment to the overall hunting experience, easier access to the area can increase chances of seeing and shooting game. Also, once an animal has been bagged, it is easier to retrieve in areas with well-developed trail and road systems. In a review of several studies on deer hunting, Langenau found that harvest was higher in areas with trails than in areas without and a large percentage of kills occurred within 600 feet of roads or trails. Access to sheep hunting areas is therefore another measure of site quality which could be related to hunter site choice.

Access to a hunting area may in part determine congestion or crowding at a particular hunting site. The easier it is to get to a site the more people will be tempted to go there. This is especially true if time available for recreation is a factor. It has long been acknowledged that congestion plays a role in site choice for many recreation activities (McConnell, 1985). For many people enjoyment from participating in an activity is diminished if too many other people are at the recreation site.

There does not seem to be a great deal of consensus in the literature as to the effects of crowding on hunter behaviour (Heberlein et al.,1982; Graefe et al., 1984). In part, the effects of crowding seem to depend on the main objective of the recreation activity and the nature of the activity. In the case of hunting the main objective may be to bag an animal. Depending on the species hunted this will require different tactics. As Heberlein and Laybourne (1978) noted, when deer hunting the presence of other hunters is often considered an asset because they may help move deer and increase chances of bagging game.

In comparison, Bighorn sheep are known to utilize the same winter ranges each year. In Alberta, hunting season occurs during the period when the sheep are on or near their winter ranges thus hunters will go to these known areas and scout for a legal ram. Often, even if a hunter has a good shot at one ram he will pass up the chance in hopes that he may have a chance at the "once-in-a-lifetime" ram who is just out of gun range (Stevenson, 1989). This is the type of hunting experience where intrusion of other hunters or hikers into an area could move the game away from one hunter's carefully planned strategic location. It could be hypothesized that a high concentration of other recreationists in a sheep hunting area would not be looked upon favourably.

The foregoing discussion has provided insight into some environmental quality variables which may influence the demand for Bighorn sheep hunting at various sites in Alberta. Not all of the variables discussed can be included in the model. For example, lack of data made it difficult to determine a measure of access to hunting sites. The following sections describe the data used to measure those variables which will be included in the model.

1. Sheep Populations

Conducting inventories of wildlife populations is often a difficult task. Big game animals are spread out over large areas, many parts of which may be inaccessible to man. Many techniques have been used in an attempt to measure big game populations. In Alberta, the most common approach has been to fly aerial surveys over known big game ranges. Aerial surveys are expensive and subject to weather conditions, therefore they cannot usually be carried out in all regions each year. This means that population data for particular species are quite sporadic[11].

For this study sheep population data was required for all sheep ranges in Alberta. Examination of Alberta Fish and Wildlife records indicated that sheep population surveys had been conducted in 1971, 1973, 1975, 1978, and 1979-80. However, closer examination of this data revealed that the 1979-80 survey was the only one where the entire provincial Bighorn sheep range had been flown. In addition, the survey technique had changed

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[11] Since 1984 the Alberta Fish and Wildlife Division has been conducting harvest surveys which can be used to track wildlife populations. See Alberta Fish and Wildlife Division, 1985 for a discussion and example of a harvest survey.

throughout the earlier surveys[12]. The 1979-80 survey was the only one where the same survey technique had been used in all areas of the province. Also, as the hunter data used in this study is from the 1981 hunting season, the 1979-80 sheep population data may best reflect sheep populations around that time.

Table 3 presents the sheep population data as reported by WMU. Some of the data cannot be broken down by WMU as some of the Bighorn sheep ranges extended into more than one WMU. The population survey provided data on total sheep population, total ram population and legal ram population.

As with the hunter data, these figures will be combined to reflect specific sheep hunting sites. It is important to note that limitations of the population survey technique make it unlikely that these figures reflect exact sheep populations. However, they do provide an index of populations and allow relative comparisons between different areas of the province. For the purposes of this study this relative comparison value is extremely important[13].

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[12]See Cook, 1987 for a discussion of survey techniques and limitations.

[13]For wildlife management purposes the population survey would be carried out every few years and over time reliable estimates of actual sheep populations would be derived.

Table 3: Bighorn Sheep Population by Wildlife Management Unit

WMU	TOTAL SHEEP POP	TOTAL RAM POP	LEGAL RAM POP	WMU	TOTAL SHEEP POP	TOTAL RAM POP	LEGAL RAM POP
302, 400	391	65	14	426	58	15	4
306, 308, 402	51	8	2	428	57	14	4
404	242	58	1	432	44	5	1
406	108	34	2	434, 436	183	28	9
408	80	26	0	438	437	148	53
410	144	27	5	439	18	5	1
412	100	35	8	440	285	56	8
416	24	3	0	441, 442	269	64	16
418	298	67	8	444	270	49	16
420	244	66	16	445	135	27	7
422	175	41	16				

2. Harvest Data

The Alberta Fish and Wildlife Division was also the source of Bighorn sheep harvest data. Since the early 1970's Trophy Bighorn sheep hunters have been required to report the location (by WMU) of any harvest of these animals. The total reported Trophy Bighorn sheep harvest between 1971 and 1980 is presented in Table 4.

Table 4: Bighorn Sheep Harvest by Wildlife Management Unit

WMU	TOTAL HARVEST	WMU	TOTAL HARVEST
302	7	426	38
306	9	428	26
308	5	430	56
400	165	432	96
402	96	434	54
404	70	436	16
406	102	438	120
408	106	439	33
410	13	440	142
412	21	441	0
416	25	442	62
418	18	444	19
420	88	445	8
422	94		

3. Crowding

As well as sheep hunting trips, the 1981 hunter survey provides information on the number of goat, elk and moose hunting trips taken in the Eastern slopes region during the 1981 hunting season. The trips were recorded by WMU. It is not possible to determine if these trips were taken at the same time as the sheep hunting trips, but generally speaking these hunting seasons overlap to a great extent (Alberta Fish and Wildlife Division, 1981).

The trip data for goat, sheep, elk and moose can be used to determine an index of crowding[14]. The trip data were generated from a sample of the total hunting population. Each respondent to the survey is considered to represent a portion of hunters from the total population and an estimate of

[14]Sheep hunting trips are included since sheep hunters, as well as hunters of other species could have an impact on the sheep hunting experience.

the total number of hunters hunting in each WMU can be calculated[15]. The crowding index provides a means of ranking sites based on the estimated number of hunting trips made to the site. Estimates of the total number of hunting trips to each WMU are provided in Table 5.

This chapter has examined measures of environmental quality which can be incorporated into a recreation demand model for Bighorn sheep hunting in Alberta. Chapter IV will use the data described in this chapter to estimate a model of site choice for Bighorn sheep hunters.

Table 5: Estimate of Total Number of Hunting Trips by Wildlife Management Unit

WMU	NO. OF TRIPS	WMU	NO. OF TRIPS
302	3152	426	538
400	4831	428	16
306	1968	430	3538
308	3572	432	154
402	6940	434	290
404	1843	436	12
406	4421	438	3348
408	1766	439	23
410	2777	440	1618
412	714	441	16
418	284	442	608
420	2416	444	902
422	52	445	274

[15]The crowding index derived from the hunter survey data does not take into account individuals who may have been hunting species other than those identified above. Also, the index does not include information on other activities which may have been taking place in the sheep hunting areas.

CHAPTER IV MODEL ESTIMATION AND RESULTS

The previous chapter described in detail the data to be used in estimation of the model. Before a model of Bighorn sheep hunting demand can be estimated, an important consideration is the definition of the choice set available to hunters. In the case of Bighorn sheep hunting this involves aggregating the data presented in the last chapter into unique Bighorn sheep hunting sites. The first two sections of this chapter provide a description of the choice set and the recreation demand model. The final section of the chapter presents some results obtained from estimation of the model and from application of the model to the analysis of hunters' net willingness to pay for different hunting opportunities. The effects on demand from changing hunting site quality are also presented.

A. Hunting Site Choice Set

A choice set is made up of a set of alternatives and it is the environment of the decision makers which determines these alternatives (Ben Akiva and Lerman, 1985). A decision maker must be aware of an alternative and find it feasible in order for the alternative to be included in the choice set. The feasibility of an alternative can be determined by such factors as physical availability, monetary resources, time constraints or informational constraints. For purposes of this study it is assumed that each alternative in the choice set described below represents a feasible alternative for all resident Bighorn sheep hunters in Alberta.

In this study the alternatives under consideration by Bighorn sheep hunters are hunting sites. All of the data collected for this study have been described in terms of WMU's. Classifying data in terms of WMU's is often useful for administrative purposes, however, WMU's do not necessarily correspond to discrete Bighorn sheep hunting sites.

After consultation with Alberta Fish and Wildlife personnel, the WMU's were aggregated into 10 Bighorn sheep hunting sites (Stevenson, 1989). The sites and corresponding WMU's are presented in Table 6. Figure 2 indicates the location of the hunting sites. Definition of the hunting sites was based on the location of known wintering ranges for Bighorn sheep as well as the need to provide alternatives which are heterogeneous in terms of their attributes. As one of the main objectives of this study is to examine the role that environmental quality plays in recreation site choice it is important to define sites that reflect a difference in quality over the attributes selected for measurement.

Table 6: Bighorn Sheep Hunting Sites

Site 1	WMU's	302 400
Site 2	WMU's	306 308 402
Site 3	WMU	404
Site 4	WMU	406
Site 5	WMU	408
Site 6	WMU	410
Site 7	WMU's	412 416 418 420
Site 8	WMU's	422 426 428 430 432 434 436
Site 9	WMU's	438 439
Site 10	WMU's	440 441 442 444 445

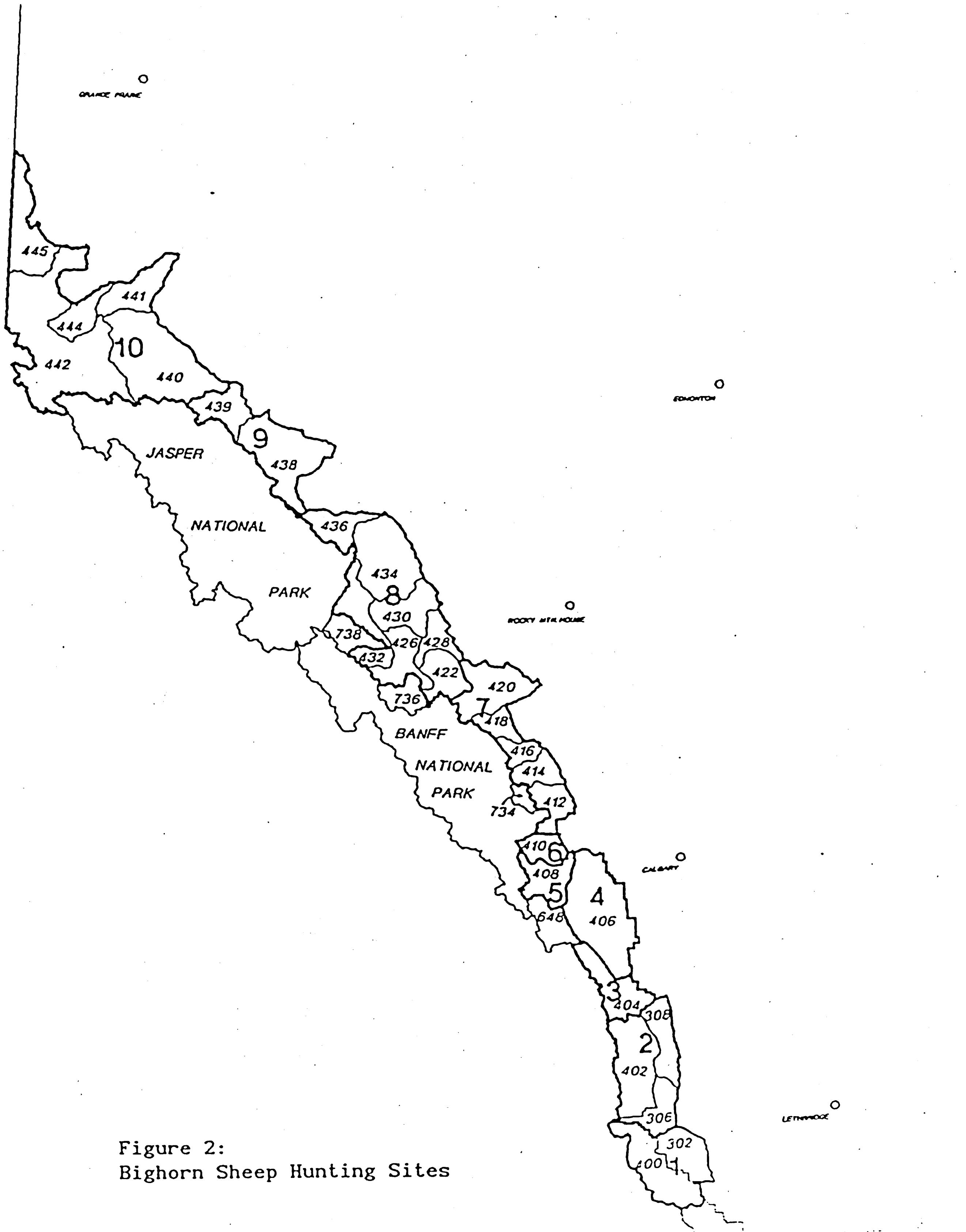

Figure 2:
Bighorn Sheep Hunting Sites

B. Economic Model of Bighorn Sheep Hunting

In this section, a multinomial logit model which is applicable to the discrete choice problem of choosing among Bighorn sheep hunting sites, is described. In this case study, the analytical objective is to estimate the probability of an Alberta resident Bighorn sheep hunter taking a sheep hunting trip to a particular hunting site during the season. Using the multinomial logit model outlined in chapter II and the variables described in chapter III the model used to calculate this probability can be developed.

The general model can be expressed in the following manner.

$$\pi_j = \exp (V_j) / \sum_{k=1}^{m} \exp (V_k) \qquad (6)$$

where π_j is the probability that site j is chosen, V_j is the indirect utility associated with choosing site j and V_k represents the indirect utility associated with choosing sites $k=1, \ldots, m$.

More specifically, the probability that the "t"th hunter chooses the "j"th hunting site is given by

$$\pi_{tj} = \exp (\beta' X_{tj}) / \sum_{k=1}^{m} \exp (\beta' X_{tk}) \qquad (7)$$

The vector of values of the attributes of the "j"th hunting site as perceived by the "t"th hunter is given by X_{tj} and β' is the vector of parameters to be estimated. In this study, the V_k's are linear combinations of variables (X_{tk}) and coefficients (β'). A description of the variables used in estimating the model described above can now be provided.

TCST :Travel cost from each hunter's place of residence to each site k. Distances were extracted from Alberta Transportation distance charts and maps (Alberta Transportation, 1980; Alberta Transportation, 1989). When more than one route to a hunting site was feasible, the shortest distance was used in travel cost calculations. The distances for each hunter to each hunting site were multiplied by a mileage charge of 18 cents per kilometre to determine travel costs[16].

TPOP :Total sheep population at each site k. Total sheep population was calculated by aggregating the WMU total sheep population data into the hunting sites as defined above. The population figures for each site were then divided by the area of the site. The resulting population index is expressed in terms of sheep population per square kilometre.

RPOP :Total ram population at each site k. Total ram population was calculated by aggregating the WMU ram population data into the defined hunting sites. The ram population figures for each site were divided by the area of the site. The resulting ram population index is expressed in terms of ram population per square kilometre.

LRPOP :Total legal ram population at each site k. This population index is expressed in terms of legal ram population per square kilometre and was calculated in the same manner as the other population indices using the WMU legal ram population data.

CNGEST:A measure of crowding conditions at each site k. This index was computed by aggregating the total number of hunting trips by WMU into the hunting sites as defined above. The trip figures for each site were then divided by the area of the site. This index of congestion is expressed in terms of the number of big game hunting trips per square kilometre.

HVST :A measure of Trophy Bighorn sheep harvests at site k. This index was calculated by aggregating the WMU harvest data into the appropriate hunting

[16]The per kilometre charge was the private vehicle allowance used by provincial government agencies in 1981.

site and then dividing the harvest totals for each site by the area of the site. The harvest index is expressed in terms of total number of Bighorn sheep harvested per square kilometre.

$CNST_k$: A dummy variable taking the value of 1 if hunting site k is chosen and zero otherwise.

C. **Model Estimation and Results**

1. **Results**

The model was estimated using various combinations of the variables described above. Estimations were carried out on an IBM personal computer using the GAUSS MNLOGI2 program. Initially, attempts were made to include all variables in the analysis. Limitations on the size of matrices which can be computed and difficulties in getting the program to converge necessitated estimating a model with selected variables.

Table 7 presents results from the best logit regression. The quality variables which performed the most consistently in the analysis were TPOP and CONGEST. It is possible that TPOP performed better than the other population variables because hunters may have a clearer sense of total sheep populations in an area. Rams are more dispersed and because of their small numbers hunters may not have knowledge of relative population levels at hunting sites. They likely use knowledge of overall sheep populations to make inferences about ram populations.

CONGEST was another significant quality variable in the model although it proved to be more sensitive to model specification. However, results indicate that crowding at sites does affect site choice. The congestion index was derived from data collected during one hunting season. It is possible that sensitivity to model specification would be reduced if the index could be recalculated using several years of hunting trip data for all wildlife species in Bighorn sheep hunting areas.

Table 7: Multinomial Logit Estimates of Bighorn Sheep Hunting Site Choice

Variable	Coefficient	t-Statistic
CNST1	0.7075	3.86
CNST2	2.1180	5.86
CNST3	-1.4350	-4.54
CNST6	-0.6402	-2.29
CNST10	1.2947	4.28
TCST	-65.3705	-13.97
TPOP	7.0778	4.74
CONGEST	-3.6801	-4.36

Log likelihood at convergence -701.7595
Log likelihood at zero -973.9935
Number of cases 423
Number of observations 4230
Likelihood ratio index 0.2795

CNST6 was included in the model because Bighorn sheep hunters are restricted to hunting with bows at this site. CNST1, CNST2 and CNST3 were included because discussions with Fish and Wildlife personnel indicated that Bighorn sheep ranges were extremely easy to reach by vehicle in these areas. CNST10 was included in the analysis since this hunting area includes some of the most inaccessible sheep ranges in the province.

TCST was a highly significant variable in the model results presented above and in all of the other models which were estimated. TCST was consistently significant and of the same sign regardless of model specification.

Results from the model indicate that a hunting site would be more attractive to Bighorn sheep hunters if sheep populations were increased, if crowding was reduced and if the site was less expensive to reach. Sites restricted to bow hunting would be less attractive.

In general, sites that allow easier access to Bighorn sheep ranges would be preferred by hunters. Three sites with easy access were included in the analysis. At two of the sites Bighorn sheep ranges are located within 10 kilometres of a primary highway and the coefficients for the variables representing these sites are positive. At the third site, while vehicle access to Bighorn sheep ranges exists, the ranges are at least 40 kilometres from the nearest highway. The coefficient for the variable representing this site is negative. These results would seem to indicate that there are many aspects to the issue of hunting site access and these will have to be examined carefully in the context of recreation demand modelling.

The coefficient on CNST10 was positive which, given the results described in the preceding paragraph, would seem to be a contradiction. CNST10 was initially included in the analysis because it represents an area where vehicle access is limited. For this reason, it might be predicted that the site would be less attractive to hunters. However, the coefficient in the model results indicates that the attributes of the site represented by CNST10 are attractive to hunters. It is possible that the CNST10 coefficient reflects site quality attributes which have not been explicitly incorporated into the model. For example, many hunters may feel that the remote, pristine wilderness of a site is an important part of the Bighorn sheep hunting experience.

2. Application of Results

A common use of recreation demand models is to estimate the value of a site in terms of consumers' surplus. Consumers' surplus is a measure of net benefits derived from the use of the site for recreational hunting. Using the Bighorn sheep hunting case study as an example, benefits can be measured in terms of the maximum amount of money a hunter would be willing to pay to ensure that a particular Bighorn sheep hunting site is available each time he/she makes a hunting trip site choice. The model estimated above can be used to determine the changes in benefits resulting from fluctuations in hunting site quality, increasing travel costs to a site or closing a site altogether. This type of analysis is referred to as welfare analysis and the techniques outlined in chapter II have been used to derive the results described below.

Estimates of changes in net benefits were carried out for two hypothetical changes in hunting site quality. The first scenario examined the welfare impact of increasing Bighorn sheep populations by 10 percent in all zones. Such a population increase might be brought about by disease eradication programs or restrictions on non-resident hunting. The population change resulted in an increase of $713 in net benefits aggregated over all individual hunters included in the analysis. The amount must be adjusted to reflect the fact that only a portion of Alberta resident Bighorn sheep license holders were included in the analysis. In 1980-81, 2,480 Bighorn sheep licenses were sold thus, the total welfare impact from the increase in sheep populations is $7,790 per season.

A second scenario examined the impact of increased crowding at all hunting sites. If successful, recent efforts to attract more non-resident hunters and wildlife tourists to Alberta could increase crowding at sites. A 10 percent increase in crowding at all Bighorn sheep hunting sites would reduce total benefits received by Alberta resident Bighorn sheep hunters by $9,133 each season.

The welfare impacts of a hypothetical 10 percent increase in travel costs to all hunting zones were also evaluated. Such an increase in travel costs might be brought about by an increase in the price of fuel. This increase in travel costs would lead to a welfare loss of $21,949 each season.

Finally, the impacts of closing a site to Bighorn sheep hunting were examined. The loss in welfare associated with closing one site while all others remain open are presented in Table 8. Closure of site 1 would have the greatest affect on hunter welfare followed by closures of site 2, site 4 and site 10. This type of information could be important to wildlife managers in the event that site closure becomes necessary. Sites closures with the least impact on hunter welfare could be carried out first.

Table 8: Annual Welfare Losses Associated with Site Closure

Site	Total Welfare Loss
1	$27,728
2	$16,050
3	$ 4,173
4	$10,532
5	$ 8,740
6	$ 3,715
7	$ 6,271
8	$ 3,583
9	$ 6,839
10	$ 9,559

It is not reasonable to assume that wildlife management programs or policies could influence all of the hunting site quality variables discussed above. Lack of time and resources to carry out programs will always be a factor in deciding which programs will be implemented but, the discussion provides some examples of the wildlife management applications for recreation demand models.

CHAPTER V CONCLUSIONS

The objective of this research was to develop a methodology which allows for the analysis of the effect of environmental quality on recreation demand and benefits. This project will serve as the basis for a research effort which over time will examine several other national and provincial environmental quality issues. The methodology developed in this study can be used to examine the effect of acid rain damage on lake recreation, off-site effects of soil erosion on recreational fishing or the effects of various species specific hunting regulations on recreational hunting.

A major goal of this study was to contribute to the growing body of knowledge on the link between quality variables actually perceived by recreationists and objective measures used in recreation demand models. Results from this study reinforce the idea that a link between recreationists' perceptions and objective measures does exist. Objective quality measures were used successfully in this study, although it cannot be stressed enough that further research into the relationship is important.

Another goal of the research was to carry out a statistical investigation of the effects of changes in quality variables on recreation demand and benefits. This goal was achieved by utilizing a discrete choice multinomial logit model to analyze the effects of environmental quality changes on Bighorn sheep hunting in Alberta. After a review of alternative recreation demand models, the discrete choice model was chosen for the project because it provided a suitable mechanism to evaluate the benefits of an improvement in site quality. It incorporates substitution among sites as quality changes and it allows for varying site attributes.

The empirical model estimated in this study was simple in form as it was beyond the scope of this research to construct a more intricate recreation demand model. Such a model would have specific data requirements. This data does not exist in Alberta at this time. However, it is encouraging to note that even with this simple model and data limitations the estimated model performed well. Calculations indicated that welfare gains were associated with improvements in environmental quality while welfare losses were associated with increases in travel costs and with site closures.

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