University of Alberta

Analyzing the Economic Benefit of Woodland Caribou Conservation in Alberta

by

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Dedication

To my Grandpa. I would have loved to show you this.

Abstract

This thesis seeks to measure the economic benefits of Woodland Caribou conservation in Alberta, Canada. Woodland Caribou are listed as threatened (Environment Canada 2008) both federally and provincially.

Stated preference techniques were used to elicit the public's willingness to pay for caribou conservation using the contingent valuation technique and a form of attribute based choice. Data were collected using a central facility method, audience response systems and the ballot box technique in various locations across Alberta. Conditional logit and random parameters logit models were estimated for both valuation formats individually as well as jointly. A range of benefit estimates were developed.

These benefit data were then compared with cost data (Schneider *et al*. 2010) to examine the economically efficient level of caribou conservation. This study develops economic value measures in the context of both legislation and the comparison of valuation approaches.

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Table of Contents

List of Tables

List of Figures

1 Introduction

The *Species at Risk Act* in Canada represents a commitment by the federal government to provide legal protection for all wildlife species from extinction. This legislation requires that, for any species deemed to be at risk, an action plan for species recovery be created which includes the determination of the socio-economic costs and benefits of recovery. Obtaining information on both the costs and benefits is essential for a complete economic analysis of the situation. This study focuses on the economic benefits of Woodland Caribou (*Rangifer tarandus caribou*) recovery in Alberta, Canada.

Woodland Caribou are declining throughout Canada which has lead to the species being listed as threatened both federally and provincially (Environment Canada 2008). In Alberta, this decline has been attributed at least in part to the effects of resource extraction industries. Thus, there is a tradeoff between preserving various levels of Woodland Caribou habitat in order to meet differing conservation objectives and economic development through conventional oil and gas, oilsands and forestry.

Woodland Caribou are an important species of the boreal forest across Canada. In addition, they are integral to the history and culture of aboriginal peoples which have used caribou for subsistence hunting for thousands of years. Given that caribou are found in low densities over wide areas and are slow to reproduce, they are especially vulnerable to population declines resulting from habitat degradation. As a result, caribou are often seen as an indication of the extent of impact caused by human development on the natural boreal ecosystem (ACC 2006). However, resource extraction industries, especially in Alberta, are also an integral component of its economy, for example contributing approximately 30 percent of the Government of Alberta's revenue in the form of royalties from natural resources in 2009 (Statistics Canada (a)). The demand for natural resources is expected to increase in the future (NEB 2009). Thus, results from a study such as this one is useful for addressing the tradeoff between these two important resources.

This study focuses on the Woodland Caribou herds in Alberta, including both the boreal and the mountain ecotypes. Note that the draft federal recovery strategy (Government of Canada 2011) for Woodland Caribou focuses on the boreal ecotype only.

Schneider *et al*. (2010) provided an assessment of the opportunity costs of conservation strategies for Woodland Caribou. Estimates of the opportunity cost were developed using a spatial dynamic optimization model which incorporated both ecological and temporal objectives. The modeling framework is based on the approach presented in Hauer *et al*. (2010). The opportunity costs for Woodland Caribou conservation depend on land uses and management strategies and are measured as the impact of conservation strategies on the forestry, oil and gas industries in the province. Revenue to the provincial government in the form of royalties from natural resources and corporate taxes are included in the costs. In addition, there are direct costs for caribou conservation which include wolf control and accelerated reclamation. These costs are subject to various capacity, resource and conservation constraints. Results from these models provide a picture of the economic costs of varying levels of caribou conservation.

However, from a policy perspective, it is not enough to know the costs of conservation. It is also necessary to know how much conservation action to engage in which will provide insights into efficient conservation design. This study examines the economic value or benefit of caribou conservation in the province by determining the public's willingness to pay (WTP) for species recovery plans elicited through the use of stated preference techniques. The rationale for using stated preference techniques is that the true value of a species at risk cannot be determined through market behaviour (Freeman 2003). A mixed method stated preference approach is employed that includes a contingent valuation component as well as a form of attribute based choice. Data are collected using a central facility method, termed workshop for the remainder of this study, involving an interactive information presentation with an audience response system. A unique aspect of this value elicitation approach is the integration of detailed information on the interactions between caribou conservation and resource development into the benefit assessment process. Respondents were provided with information from integrated ecological and economic models of the conservation options as background information for the valuation tasks they faced. The household information elicited from the vote and choice tasks was then aggregated to provide the provincial WTP or societal welfare of caribou conservation. This information, coupled with the provincial costs of conservation, can be used in a cost benefit analysis to

determine the optimal or efficient amount of conservation action to engage in. This study makes a contribution to the literature through the development of economic value measures in the context of the *Species at Risk Act* and in the comparison of valuation approaches.

Three unique procedures used during the workshops were group-based surveys, an audience response system and the ballot box technique. However, budget constraints precluded a formal analysis of these innovative procedures using split sample methods. Performing surveys in a group attempted to address many of the challenges of valuation, such as information bias and lack of preformed preferences, as it provided the opportunity for group discussion (Wilson and Howarth 2002, Niemeyer and Spash 2001). Although much of its use in the literature to date has been to enhance student learning in the classroom, audience response systems were chosen as a research tool in order to keep respondents actively engaged in the presentation as well as to promote discussion and ensure that respondents understood the objectives at hand (McCarter and Caza 2009, Solecki *et al*. 2010, Keske and Smutko 2010). It was generally favourably received by participants in each survey. The ballot box technique has had limited use in valuation surveys in the literature but was included in this study as a method to improve authenticity and thus the consequentiality of the survey as well as to reduce comparison of sequential valuation questions by respondents (Leggett *et al*. 2003, Carson *et al*. 1994).

The valuation portion of the survey utilized two different stated preference techniques. The first was the contingent valuation method (CVM) wherein a hypothetical market for some environmental good or service was described and then survey respondents participated by voting for their preferred options thus revealing their monetary preferences for the environmental good or service (Freeman 2003, Grafton *et al*. 2003). The second method was attribute based choice wherein the environmental good or service was defined in terms of various attributes, including cost, and then survey respondents participated by voting for their preferred bundle of attributes (Grafton *et al*. 2003). Attribute based choice traditionally provides respondents with the option to choose the 'business as usual' or status quo strategy wherein there is no associated cost. However, a slightly different form of attribute based choice was utilized in this

study in which respondents were not given a status quo option and thus may only choose between different bundles, each with an associated cost. The rationale for using this method was that the species at risk legislation states that recovery action must be taken once a species is listed, thus not engaging in recovery efforts (or maintaining the status quo) may not be an option.

To determine the appropriate amount of information to present to participants and to establish the most efficient survey design, five focus groups and one pilot workshop were conducted in Edmonton, Alberta. These focus groups included members of government, academia and industry as well as members of the general public. Seven workshops were conducted with members of the general public, including the pilot workshop, in Edmonton, Calgary, Lloydminster and Grande Prairie. Approximately 32 to 43 participants came to each workshop with a total sample size of 257. Descriptive statistics for the sample are very similar to the provincial average for most categories.

Parametric analysis of the CVM data showed that respondents were generally insensitive to the number of herds when making their valuation decisions. In contrast, analysis of the choice data indicated that respondents were sensitive to the number of herds. In both cases, respondents were sensitive to the bid amount. A likelihood ratio test was performed to determine whether both data sets could be pooled because the preferences exhibited in the two data sets were statistically similar. The test established that they could indeed be pooled and the resulting joint model revealed sensitivity both to the number of herds in the conservation strategy and the bid level.

Respondents are willing to pay, on average, approximately $184.02 per household per year for three self-sustaining caribou herds, and approximately $330.36 per household per year for 13 self-sustaining caribou herds. Models incorporating both exogenous and potentially endogenous variables were estimated. A random parameters logit model, used to assess heterogeneity in the preferences of the respondents, confirmed the presence of heterogeneity in the sample across the number of herds, and further indicated that respondents likely feel either positive or negative towards the number of herds in the management strategy. Aggregation of welfare measures over the sample provides information about the economically efficient level of caribou conservation for

society, or the point at which the net benefits of conservation are maximized. For a variety of model specifications this point occurs from approximately four to 11 herds.

This thesis is organized into six chapters: introduction, background information, theory and methods, survey design and data collection, results and conclusions. Chapter 2 presents background information on species at risk legislation, Woodland Caribou and nonmarket valuation. This chapter also outlines the role of resource extraction industries and the tradeoff between economic development and caribou conservation. Chapter 3 delves into the methodology of contingent valuation and attribute based choice which are the two stated preference techniques used in this study. This section also examines the reasons for using a group setting for data collection and provides a review of the relevant literature on species or habitat conservation. Chapter 4 focuses on the development of the survey and the process of data collection. Chapter 5 provides the results from the econometric models. Chapter 6 provides conclusions of this study.

2 Background Information

2.1 Introduction

This chapter provides background information on species at risk legislation, Woodland Caribou and their associated decline. The tradeoff between economic development and caribou conservation is also described in more detail. Economic analysis will proceed through the comparison of both the costs and the benefits of caribou conservation. This cost benefit analysis will be further explained and this chapter will conclude with an explanation of the use of nonmarket valuation in this context.

2.2 Woodland Caribou and species conservation

2.2.1 Legislation for species conservation

The *Species at Risk Act* (*SARA*), passed in 2003, is the federal governments' commitment to provide legal protection for all wildlife species from extinction. *SARA* outlines species recovery plans and encourages the management of our biodiversity. This *Act* applies to all federal lands in Canada and all species designated to be at risk in the country as well as their critical habitat. Created in 1977, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is the official body which produces scientifically sound classifications of wildlife species at risk (COSEWIC 2009). COSEWIC was established within *SARA* as an independent body of experts which may designate species to be at risk (*Species at Risk Act* s. 14). *SARA* then provides the legal protection and specific recovery plans for each species. The risk categories and definitions are depicted in Table 2.1.

This legislation requires that both short term and long term actions be identified for a species recovery plan. In addition, for threatened and endangered species, both the species and their critical habitat must be protected. If these restrictions aimed to protect a species at risk affect individuals, then compensation must also be provided. Finally, any documents or decisions must be made available to the general public through the public registry (GOC 2008a).

Table 2.1 Definitions of General Status Categories for the *Species At Risk Act* in Canada (COSEWIC 2001)

Risk Category	Definition
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not At Risk (NAR)	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)	A species for which there is insufficient scientific information to support status designation.

The process of deeming a species to be at risk and its successful recovery under the federal legislation is as follows (GOC 2008b). First, an inventory of the species is conducted to determine the present population and ecological significance. This report must be updated every five years. A species assessment is then conducted by COSEWIC to assign a federal status designation. Then, a response statement is issued which signals the start of the recovery process. Next, a recovery strategy is created to determine critical habitat and an action plan is formed which outlines the specific actions and their associated timelines which will be required to recover the species at risk. Appropriate economic analyses of the species at risk must be performed in order to produce the action plan. Finally, the response is evaluated on an annual basis to ensure that the *Act* is being administered appropriately and effectively.

Table 2.2 Definitions of General Status Categories for the *Alberta Wildlife Act* in 1996 and 2005 (ASRD 2000)

1996 Rank	2005 Rank	Definition
Red	At Risk	Any species known to be "At Risk" after formal detailed status assessment and designation as "Endangered" or "Threatened" in Alberta.
Blue	May Be At Risk	Any species that "May Be At Risk" of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Yellow	Sensitive	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.
Green	Secure	A species that is not "At Risk", "May Be At Risk" or "Sensitive".
Un-determined	Un-determined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
n/a	Not Assessed	Any species that has not been examined for this report.
n/a	Exotic/Alien	Any species that has been introduced as a result of human activities.
n/a	Extirpated/ Extinct	Any species no longer thought to be present in Alberta ("Extirpated") or no longer believed to be present anywhere in the world ("Extinct").
n/a	Accidental/ Vagrant	Any species occurring infrequently and unpredictably in Alberta, i.e., outside its usual range.

Species at risk in Alberta are protected under the *Wildlife Act*, which was passed in 2000. This legislation ensures that suitable habitat for species at risk is both protected and maintained. Under this *Act*, an Endangered Species Conservation Committee (ESCC) was formed whose purpose is to establish species at risk and to recommend recovery plans for these species (*Wildlife Act* s. 1(6)). The status categories have changed over

time. The status categories for 1996 and 2005 are shown in Table 2.2 and for 2010 are shown in Table 2.3.

Table 2.3 Definitions of General Status Categories for the *Alberta Wildlife Act* in 2010 (ASRD and ACA 2010)

Rank	Definition
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species likely to become endangered if limiting factors are not reversed.
Species of Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Data Deficient	A species for which there is insufficient scientific information to support status designation.

Under this provincial legislation, the process of determining a species to be at risk and its successful recovery is as follows (GOA 2008). First, a general status assessment is completed every five years which is an initial evaluation of species existing in Alberta. Then, a detailed status report is produced for those species which are determined to be threatened or endangered either through the general status assessment or through the similar process at the federal level. Next, the ESCC assesses the general and detailed status reports and determines a legal species designation for each species at risk. This committee also provides recommendations for the management and recovery of that species. Recovery plans must be issued within one year for endangered species and within two years for threatened species. These recovery plans identify short term and long term strategies and actions for recovery and include an opportunity for members of the general public to comment on the plan.

2.2.2 Introduction to Woodland Caribou

Caribou (*Rangifer tarandus*) are found in boreal forest ecosystems throughout western Canada and many parts of eastern Canada. They are medium-sized members of the deer family, which also includes moose, elk, white-tailed deer and mule deer (Dzus 2001). Currently four subspecies of caribou are present in North America: Woodland caribou

which exist primarily across the boreal forests of Canada, Peary caribou which are found in the Arctic islands, Barren ground caribou which are found in the Northwest Territories and Nunavut and Grant's caribou which exist in Alaska and northern Yukon. A fifth subspecies called Dawson's caribou was once found on the Queen Charlotte Islands and were declared extinct in 1984 (Schmidt and Gilbert 1978). For simplicity, Woodland Caribou will be termed a species for the remainder of this paper.

In Alberta, the woodland subspecies (*Rangifer tarandus caribou*) are presently found in the northern regions of the province and represent an integral component of boreal forest ecosystems (Dzus 2001). They are classified into two distinct ecotypes based on differing habitat and behaviour: mountain and boreal. The mountain ecotype migrates during the summer to alpine mountain habitats, whereas the boreal ecotype tends to be located in forested habitat all year long (Edmonds 1991). Both of these ecotypes are found in Alberta.

Woodland caribou prefer large stands of intact mature forest which can take between 60 and 150 years to grow. These stands hold large quantities of lichen which is their main source of food in the winter (ACC 2006). In the summer, caribou rely primarily on forbs, shrubs and other green vegetation.

Caribou select their habitat according to the relative safety from predation by wolves, bears, coyote, wolverine, lynx and cougars (Dzus 2001). These predators also prey on other members of the deer family, such as moose, elk, white-tailed deer and mule deer. Research has suggested that predation is the primary limiting factor for Woodland Caribou (Bergerud and Elliot 1986) and as a result caribou select habitat that is spatially separated from other ungulate species (Dzus 2001, James *et al*. 2004).

Caribou are most easily identified by their cream-colored neck and dark brown pelage. In addition, both genders have large and often elaborate antlers that curve forward and their large hooves, long legs and short extremities are excellent adaptations for survival in harsh winter conditions (Telfer and Kelsall 1984; Klein, Meldgaard and Fancy 1987; Dzus 2001).

Breeding season occurs in early October and calves are usually born in May or June (Edmonds 1988). Caribou are slow to reproduce and only give birth to one calf a year.

They are also generally found in low densities across the landscape (Dzus 2001). Juvenile survival is variable with most mortality occurring during the first 30 days of the calf's life (Stuart-Smith *et al*. 1997); Thomas and Gray (2002) report juvenile survival to be between 30 and 50 percent. Adult survival is less variable; Stuart-Smith *et al*. (1997) report adult survival in the Fort McMurray region to be 88 percent, while McLoughlin *et al*. (2003) found it ranges from 86 to 93 percent in northeastern Alberta.

2.2.3 Population decline

Historic records show that Woodland Caribou range in Alberta once extended throughout the northern region of the province south to approximately Cold Lake and Sundre (Soper 1964). The current distribution of caribou has been reduced from historical records and exists primarily in the northern regions of Alberta as depicted by the shaded areas in Figure 2.1 (ASRD and ACA 2010).

There are 15 Woodland Caribou herds in the province of Alberta (ASRD and ACA 2010). One of these herds resides in Jasper National Park and therefore survives in a protected area. Thus, this study includes 14 herds in the province. These herds are depicted in Figure 2.1 and further explained in Table 2.4 and vary both in terms of number of caribou and in terms of total range size. Yates and Caribou Mountains are the largest herds with approximately 350 individuals each whereas Little Smoky is the smallest herd with approximately 78 individuals. In terms of size of range area, Red Earth has the largest area of approximately 19,977 km^2 whereas Narraway has the smallest area of approximately 1,241 km^2. The total estimated caribou population size included in this study in Alberta is approximately 2,521 to 2,763 individuals and the total range area is approximately 129,995 km^2 (ASRD and ACA 2010).

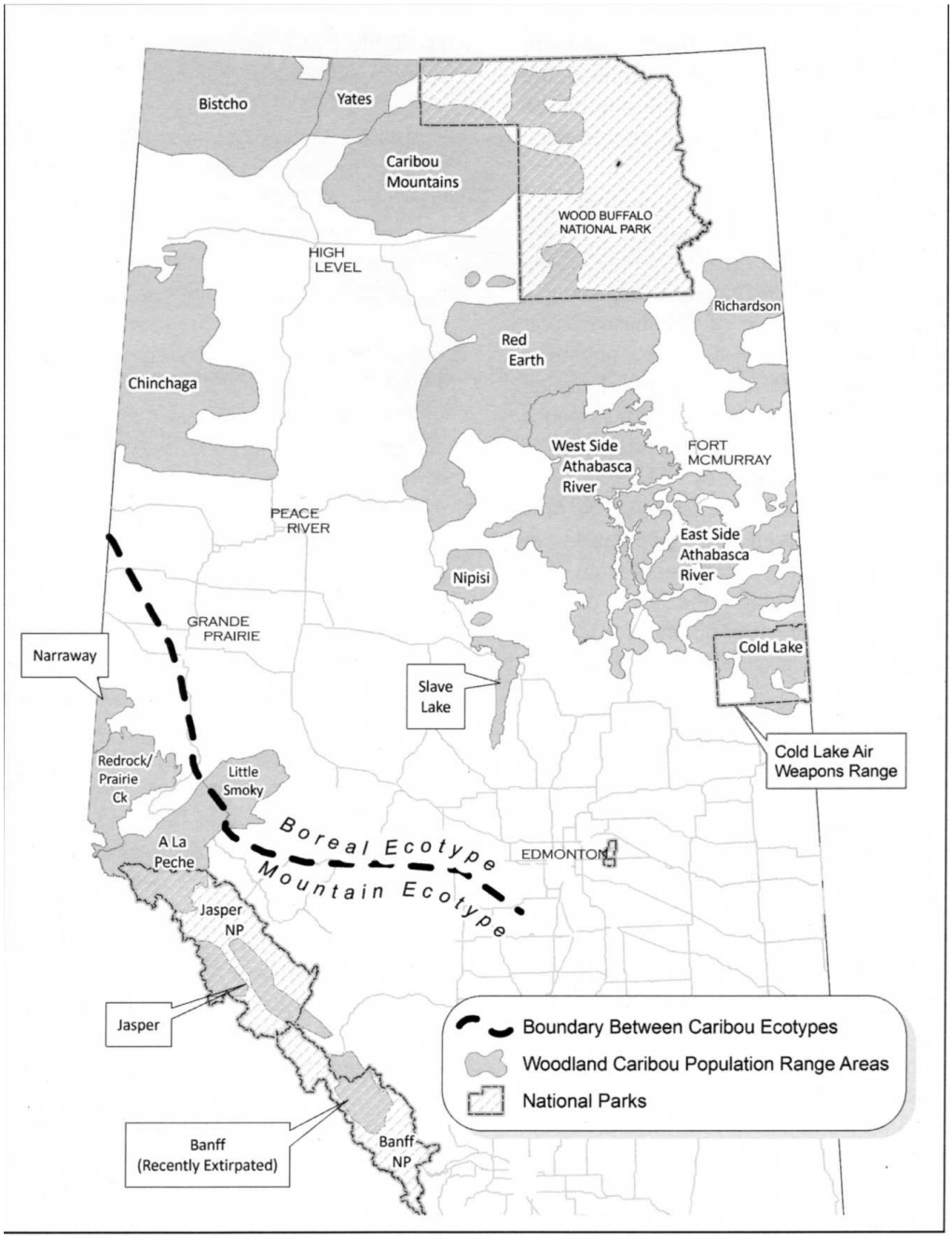

Figure 2.1 Woodland Caribou herd boundaries in Alberta (ASRD and ACA 2010: 3)

Table 2.4 Estimated Population Size and Size of Range Area for Woodland Caribou Populations in Alberta (ASRD and ACA 2010: 10-11, 55)

Caribou Population	Estimated Population Size	Size of Range Area (km^2)
Narraway	100	1,241
Redrock-Prairie Creek	212	4,516
A La Peche	135	5,703
Bistcho	195	13,267
Yates	350	4,489
Caribou Mountains	315-394	15,328
Chinchaga	250	17,517
Slave Lake and Nipisi	120	3,412
Red Earth	172-206	19,977
West Side of Athabasca River	204-272	15,010
East Side of Athabasca River	90-150	14,524
Cold Lake	150	5,538
Richardson	150	6,546
Little Smoky	78	2,927
Total	2,521-2,763	129,995

Woodland Caribou are declining throughout North America which has lead to the species being listed as threatened at the federal level by COSEWIC (COSEWIC 2002). At the provincial level, Woodland Caribou were initially designated as endangered in 1987 under the *Wildlife Act* as there was no distinction made between endangered and threatened at that time. In 1997, the regulations were amended and a distinction was made between these two categories and Woodland Caribou were consequently listed as threatened (ASRD and ACA 2010). The threatened status means that caribou are "likely to become endangered if limiting factors are not reversed" (ASRD and ACA 2010: 86).

2.2.4 Sources of population decline

In Alberta, resource extraction industries such as oil, gas and forestry are rapidly expanding operations over important Woodland Caribou habitat across the northern regions of the province. Caribou will avoid areas used by these industries such as seismic lines, roads and wellsites (Dyer *et al*. 2001, McLoughlin *et al*. 2003, Sorensen *et al*. 2008) and select habitat according to a hierarchical process (Rettie and Messier 2000). Bradshaw, Boutin and Hebert (1998) found that disturbance, such as noise, from petroleum exploration can have significant energetic consequences for caribou. As these industries expand further into caribou habitat, the pressure on caribou populations is increased.

Evidence suggests that predator-prey relationships are the single most consistent limiting factor on the growth of caribou populations (Bergerud and Elliot 1986, McLoughlin *et al*. 2003, Rettie and Messier 2000). Predation occurs primarily by wolves, but also by bears, coyote, wolverine, lynx and cougars. Wolves predominantly prey on hoofed animals such as caribou, moose, elk, white-tailed deer and mule deer. Caribou historically protected themselves by livingin habitats that other wolf prey, such as moose, do not live, but this strategy is no longer very effective (James *et al*. 2004, Stuart-Smith *et al*. 1997). Previous efforts to reduce wolf populations have had positive effects on caribou populations (Bergerud and Elliot 1986; Boertje, Valkenburg and Mcnay 1996).

Caribou have effective strategies for avoiding wolves on natural landscapes where wolves are few. Resource industries create favourable habitat for moose and deer, leading to more wolves by increasing their food supply. The altered landscape also allows wolves to move around more easily. Studies have suggested that wolves avoid areas which receive high traffic volume or human use; however, roads and corridors which do not receive a high volume of traffic may provide easier travel access for the wolves (Thurber *et al*. 1994). Predation by these more numerous and mobile wolves is the most likely cause of Woodland Caribou decline. However, the wolves have become a threat because resource industries have altered large areas of the forest.

Other reasons have been suggested as potential contributing factors to the decline of caribou populations in Alberta. These reasons include wildfire as research has found

that caribou avoid recently burned areas (Sorensen *et al*. 2008, Rettie and Messier 2000), traffic collisions, noise disturbance (Sorensen *et al*. 2008), hunting, disease, parasites, weather and climate change at both local and regional scales (Thomas and Gray 2002).

For thousands of years caribou in the boreal forest have coexisted with predators. Today, however, Woodland Caribou are designated as a threatened species across northern Alberta. This suggests that predation is not the sole reason for the decline in caribou populations and that large-scale human developments in recent years have played a contributing role (McLoughlin *et al*. 2003, Sorensen *et al*. 2008, Schneider *et al*. 2010).

Woodland Caribou habitat covers the majority of northern Alberta. Almost 30 percent of the total value of Alberta's oil, gas and forestry resources occurs in areas used by caribou (Adamowicz *et al*. 2009). Studies have recommended a conservative approach to land use activities in order to maintain caribou populations (Stuart-Smith *et al*. 1997, Sorensen *et al*. 2008, Cameron *et al*. 1992). If Woodland Caribou populations are to be conserved, steps must be taken to minimize and mitigate the effects of industry and resource extraction in important caribou habitat, both now and in the future.

The legislation for species at risk requires that socioeconomic analysis be completed for the creation of action plans for species recovery. This study aims to determine the benefits of Woodland Caribou conservation to help guide the development of action plans.

2.2.5 Resource extraction industries

Resource industries play a significant role in the province's economy. Total government revenue for the province of Alberta from 2005 to 2009 is shown in Figure 2.2. Royalties and taxes from resource extraction industries are two important sources of revenue for the province. Royalties are payments made to the government of Alberta by corporations who have been granted the right to extract natural resources such as forests, oil or natural gas. In 2009, over 30 percent of the Government of Alberta's revenue came from royalties from natural resources (Statistics Canada (a)). Corporate income tax paid to the Government of Alberta by all types of businesses was about $3

billion, which is almost 10 percent of the total revenue collected by the province (Statistics Canada (a)). These royalties and taxes are used to pay for public services such as environmental protection, recreation and culture, health, education, resource conservation and industrial development, social services, transportation and communication and protection of persons and property (Statistics Canada (a)).

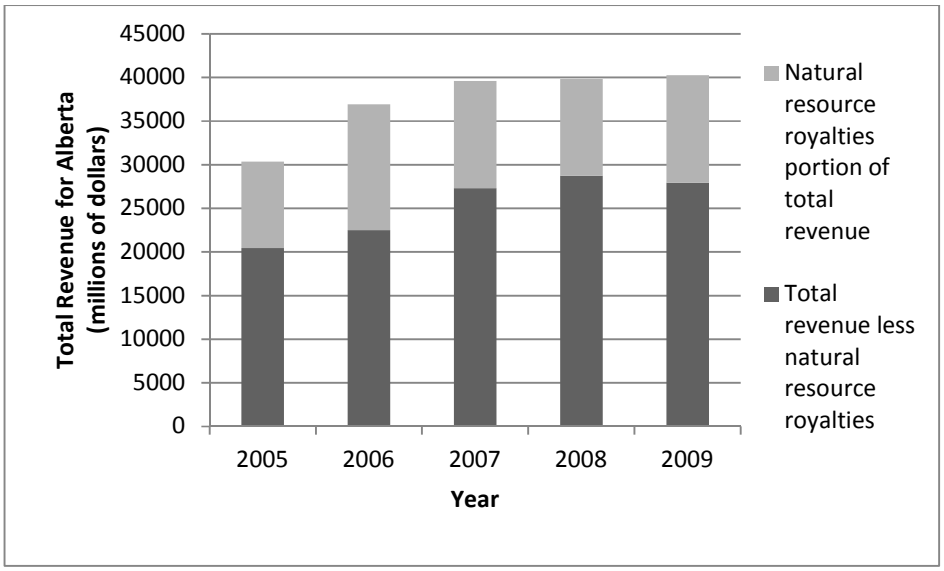

Figure 2.2 Total revenue for the province of Alberta from 2005 to 2009 (Statistics Canada (a))

2.2.6 Significance of caribou and conservation strategies

Woodland Caribou are an important species of the boreal forest and contribute to biodiversity. They are also integral to the history and culture of aboriginal peoples as they have used caribou for subsistence hunting for thousands of years (ACC 2006). This species is often found in low densities across the landscape and are slow to reproduce meaning that they are highly vulnerable to habitat degradation. Therefore, caribou are often used as an indication of the extent of impact on the natural boreal ecosystem caused by human development (ACC 2006). Conservation, in addition to ensuring recovered and stable caribou populations, will also protect old growth stands of forest as well as other natural resources, such as water and other species at risk.

Caribou conservation strategies include predator management or wolf control, restrictions on the places that resource extraction industries (forestry and oil and gas) can operate or restrictions on how quickly these sectors can access the resources and

increased effort in growing forests in areas previously disturbed by energy and forestry industries (Schneider *et al*. 2010). These measures will be costly, and in some cases they will reduce the rate of resource development and thus will reduce tax and royalty revenue collected by the province.

2.3 Cost benefit analysis and welfare measures

Economic analysis will proceed through the comparison of both the costs and the benefits of some proposed policy or project (Carson 2000). This cost benefit analysis involves determining the monetary value of all aspects of the project, and the outcome depends on whether the costs outweigh the benefits, or vice versa. If the benefits of a project outweigh the costs, then the conclusion is that the project has the potential to make society better off as a whole (Hanley and Barbier 2009). For environmental projects, this procedure involves formulating the monetary value of changes in environmental goods and services. However, it is important to note that there may be other considerations besides efficiency, which is the outcome gained from a cost benefit analysis, such as equity, that would mean projects are not undertaken even though the benefits outweigh the costs.

Cost benefit analysis aims to determine how best to allocate scarce resources given the unlimited wants of society (Hanley and Barbier 2009). If demands for a certain resource are not limited by costs or constraints, demand will exceed the amount of the resource available for use. In addition, using resources today means they will not be available for use tomorrow, therefore imposing an opportunity cost on society. The merit in using cost benefit analysis is that it allows for the inclusion of ordinary people's preferences into the decision making process of how to best allocate a scarce resource.

Cost benefit analysis can be accomplished on either the basis of total costs and benefits or marginal costs and benefits (Tietenberg and Lewis 2009). Total costs are simply the summation of all the relevant direct costs, including opportunity costs, for the proposed policy or project. Total benefits are defined as the total WTP for the proposed policy or project. Marginal costs and benefits are defined as the additional cost or benefit to obtaining one more unit of the environmental good or service. Comparing either the total costs and benefits or the marginal costs and benefits are equivalent methods of

determining the efficient level of conservation, although the latter is the traditional method. Both the costs and benefits are measured in dollars.

There are several steps in conducting a successful cost benefit analysis which are outlined in Hanley and Spash (1993). The first step is definition of a project which involves defining the resource to be reallocated, those who will gain and those who will lose from the proposed reallocation and the environmental good or service to be valued. The second step is to identify the impacts of the project as a whole. The determination of which of these project impacts are economically relevant, or most efficient, is step three. Step four involves quantifying the costs and benefits of the proposed project. These costs and benefits are then turned into monetary values in step five, and are discounted, or converted into present value terms, in step six. These monetary values are then compared in order to determine if the benefits outweigh the costs in step seven. Step eight provides an indication of how uncertainty may change the results from step seven.

Although the unit of measurement used for a cost benefit analysis is money, ultimately we are defining the change in terms of utility (Hanley and Barbier 2009). Utility is a term which is used in economics to describe how better off or worse off an individual is after some proposed change. In effect, utility explains peoples' preferences. To approximate this utility, individuals are asked how much they would be willing to pay to obtain either more of something desirable or less of something undesirable. Once this willingness to pay (WTP) is known, the compensating variation, or the amount of monetary compensation required to make an individual as well off with the change as they were without the change, can be calculated (Hanley and Barbier 2009). In this context, we are determining the public's WTP for caribou conservation, specified as additional herds conserved, which would leave them as well off as without the additional conservation. This compensating variation can then be aggregated over the province of Alberta to obtain the provincial benefit of varying levels of caribou conservation. These values are then compared to the provincial costs, and the point at which the net benefits are maximized for society is the efficient allocation of conservation.

The species at risk legislation in Canada suggests that cost benefit analysis be conducted for each species that is listed. The *Species at Risk Act* states "community knowledge and interests, including socio-economic interests, should be considered in developing and implementing recovery measures" (*Species at Risk Act* preamble); and "[a]n action plan must include…an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation" (*Species at Risk Act* s. 49(1)). The information derived from the cost benefit analysis is then used to help create an action plan for species recovery. A previous study determined the costs of various conservation strategies for caribou (Schneider *et al*. 2010). This study seeks to establish measures of the benefits, to help determine how much caribou conservation action to engage in.

2.4 Identifying the tradeoff

There is a tradeoff between conserving Woodland Caribou in order to meet differing conservation objectives and economic development through conventional oil and gas, oilsands and forestry (Hauer, Adamowicz and Jagodinski 2010; Adamowicz *et al*. 2009; Hauer *et al*. 2010). Conserving Woodland Caribou will reduce economic development and provincial royalty and tax revenues. Since these decisions involve public resources – caribou and provincial revenues – we are asking the general public for their opinion concerning what level of conservation action to engage in.

In this study, conservation is measured by the number of Alberta's caribou herds which are "self-sustaining" or which have populations that can be maintained over time on their own. An alternative, though equivalent, unit of measurement is the total population of caribou in the province that is in a self-sustaining state; however, performing the analysis at the herd level was chosen as it was generally more favourably received by respondents during the focus groups. These focus groups are described in more detail in the following chapter. Herds are defined as being self-sustaining using the criteria from Schneider *et al*. (2010) which are if the relative growth rate or habitat $\lambda \geq 1.0$ (Sorensen *et al*. 2008) and the population density is above the mean estimated density of caribou in Alberta in 1996 which is 0.045 caribou/km^2 (Alberta Woodland Caribou Conservation Strategy Committee 1996).

The graph depicted in Figure 2.3 represents the costs of achieving various caribou conservation targets and economic development. The horizontal axis represents the

results of different conservation strategies that could ensure that some or up to all 14 of Alberta's caribou herds are self-sustaining or which have populations that can be maintained over the next 50 years and beyond on their own[1]. 50 years was chosen as the time frame for analysis both because it was the time frame used in Schneider *et al*. (2010) and because it will take at least this long to bring most of the herds back to self-sustaining levels. The vertical axis is the present value of the cost of achieving these caribou conservation levels, measured as the cost to the province per year for the next 50 years. The costs include management activities as well as taxes and royalties foregone from the energy and forestry sectors.

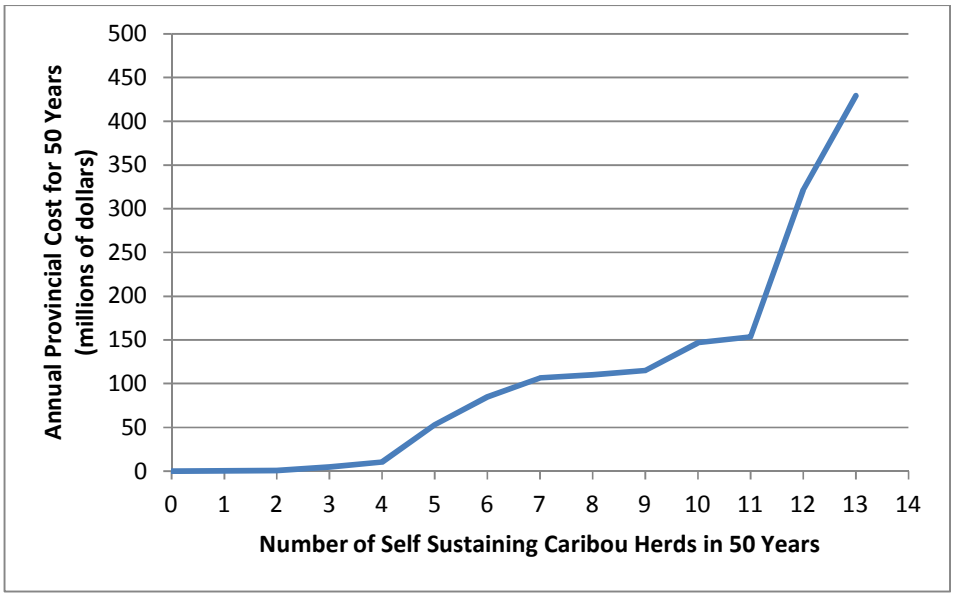

Figure 2.3 The total costs of achieving various Woodland Caribou conservation targets and economic development in Alberta (Hauer *et al*. 2010)

To account for the uncertainty inherent in calculating costs and predicting conservation objectives, a graph is presented (Figure 2.4) with the provincial costs for three different estimates of what energy prices will be the future. The costs associated with caribou conservation will vary depending on: the prices of oil, gas and forest products, the costs

[1] The ASRD and ACA (2010) report have a total of 15 herds in the province. In this study, we are not including herds within the national parks, thus we are including 14 herds. However, in the majority of the cost simulations (Schneider *et al*. 2010), the 14th herd cannot be conserved no matter what stringent conservation practices are put into place. Thus, the analysis in later sections of this study is based on 13 herds.

of energy and forestry extraction and the development of new technologies for energy and forestry extraction. In Figure 2.4, the dashed line is based on low energy price forecasts, the solid line on medium price forecasts and the dotted line on high price forecasts.

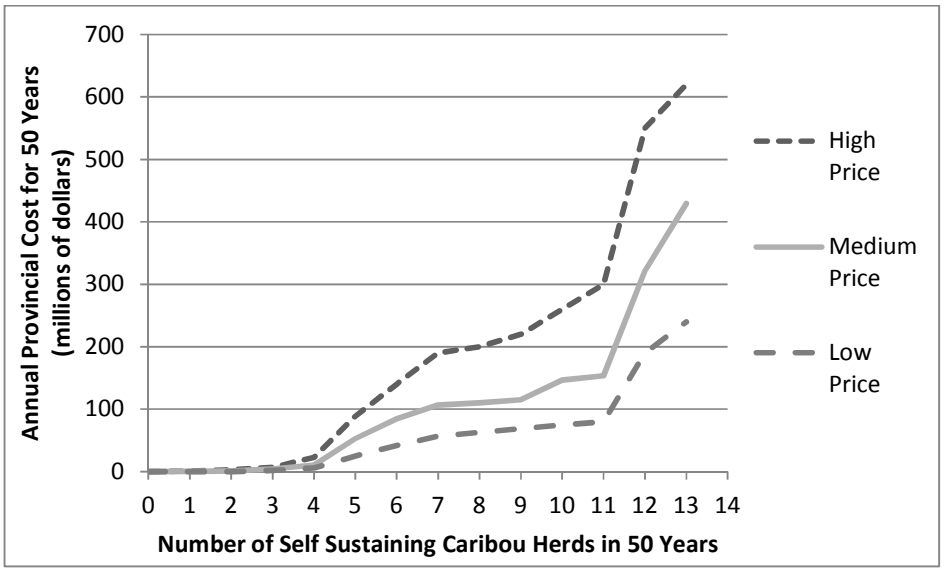

Figure 2.4 The costs of achieving various Woodland Caribou conservation targets in Alberta presented with three different estimates of future energy prices (Hauer *et al*. 2010)

Determination of the opportunity costs of caribou conservation provides necessary information on the cost of differing conservation strategies, but it does not provide insights into how much conservation effort to apply. Thus, this study focuses on the determination of the benefits of caribou conservation to help guide the development of specific action plans for species recovery. These total cost curves can be compared to total benefit curves over the total range of caribou conservation. The economically efficient level of conservation is at the point where net benefits are maximized, or where the marginal benefits equal the marginal costs. For presentation purposes, the remainder of this thesis will illustrate this economically efficient level of conservation using the total costs and benefits curves.

2.5 Nonmarket valuation

The value or benefit of environmental goods and services is relatively easy to determine when it can be captured through market transactions where adequate markets exist. However, the economic benefits of species at risk cannot be determined through such observable behaviour as conventional markets for species valuation do not exist (Hanemann 1994, Grafton *et al*. 2003). Studies have shown that people may value species at risk even if they never expect to see them or for the option to see them in the future. These kinds of values are commonly referred to as either existence, nonuse or passive use values (Freeman 2003). In other words, this is the economic value associated with a change in environmental quality that cannot be observed through behaviour (Adamowicz *et al*. 1998). This value will be determined through nonmarket valuation using stated preference techniques wherein individuals are asked, via a survey instrument, to reveal their willingness to pay (WTP) for alternative caribou conservation programs (Adamowicz *et al*. 1998, Freeman 2003, Grafton *et al*. 2003). More detail on these methods will be presented in the next chapter.

2.6 Conclusions

In conclusion, Woodland Caribou are declining at a rapid rate in Alberta, and the main reason associated with this decline is the linkage between predation and resource industries. Thus, a tradeoff exists between caribou conservation and economic development in the province. Cost benefit analysis is the economic tool which will be used to provide insights into the optimal amount of caribou conservation. Much research to date has been devoted to the determination of the costs of various caribou conservation programs. The aim of this study is to determine how much conservation to engage in, or the benefits of caribou conservation to the general public of Alberta.

3 Theory and Methods

3.1 Introduction

This chapter delves into the contingent valuation method (CVM) and attribute based choice method, which are the stated preference techniques used in this study to determine the value of various caribou conservation programs to Albertans. Specifically, this chapter seeks to outline the guidelines, challenges and reasons for using a group setting for both techniques. In addition, a review of previous studies on either species or habitat conservation is discussed.

3.2 Valuation methods

Two types of stated preference methods will be used in this study. The first, and more traditional approach, is CVM which involves simply asking respondents how much they would be willing to pay for some improvement in environmental quality (Hanley and Barbier 2009). This method first creates a hypothetical market for some environmental good or service and then, through a referendum, determines the WTP for a change in that good or service (Freeman 2003, Grafton *et al*. 2003). Survey respondents participate in eliciting their WTP for hypothetical scenarios thus revealing their monetary preferences for the environmental good or service.

There are six steps involved in CVM survey design (Carson 2000, Grafton *et al*. 2003). The first step is to identify the issue to be considered by respondents. Step two provides a detailed description of both the 'current management strategy' and the 'proposed management strategy' which highlight the environmental change in question. The mechanism for payment, such as an annual household tax, is described in step three. A series of valuation questions occurs in step four, followed by the appropriate debriefing questions to determine the confidence of the respondent in his or her answer in step five. Finally, step six includes several questions designed to elicit the respondents' demographic and attitudinal information.

CVM is the most widely used stated preference technique for valuing environmental goods and services (Boxall *et al*. 1996). This is, in part, due to the absence of any other reliable technique for valuing those goods and services for which adequate markets do not exist, although this has changed in recent years. CVM has been included in this study as it has been previously tested and is a well known valuation technique.

There are two approaches to CVM questioning which are open-ended questions and discrete choice questions (Freeman 2003). Open-ended questions involve simply asking a respondent how much he/she would be willing to pay for some change in an environmental good. The response to this question format is the easiest to interpret as the value stated is simply the respondents' value of the environmental good. However, this format presents respondents with a relatively unfamiliar task (Freeman 2003). In the majority of market settings, individuals are presented with a range of goods or services, each with an associated price, and individuals decide whether or not to purchase the good or service at the specified price. Rarely are they required to choose their own price for the good or service. Discrete choice questions, in contrast, involve having the respondent answer yes or no to some specified WTP amount that is pre-determined by the researcher. Respondents are separated into different subsamples and each subsample is asked a WTP question with a different bid value or price. The response to this question format is used to determine the respondent's indirect utility function. The difficulty with this format is in ensuring that the bid values are an adequate representation of the upper and lower bounds of valuation for the environmental good.

The discrete choice format has several advantages over the open-ended format (Freeman 2003). First, it eliminates the difficulty in determining a one-shot value as in the open-ended question format. Respondents are able to decide "whether or not to purchase the good at the offered price" (Freeman 2003: 167). Second, the choice is relatively simple as respondents are asked only to respond with either a yes or a no. Third, the discrete choice format is generally perceived to be "incentive-compatible" in that respondents are less likely to be strategic in answering the WTP question (Freeman 2003: 167). This is especially the case when the discrete choice is offered as a binding referendum.

The second type of stated preference approach used in this study is attribute based choice. This method defines the environmental good or service in terms of various attributes, including price, and then assesses the respondents' WTP for specific bundles of attributes (Grafton *et al*. 2003). Traditionally, respondents are given a choice of several different bundles, including a bundle which is the 'business as usual' or status

quo option wherein there is no associated cost. A slightly different form of attribute based choice is utilized in this study in which there is no status quo option. The rationale for using this method is that the species at risk legislation states that recovery action must be taken once a species is listed, thus not engaging in recovery efforts (or maintaining the status quo) is not an option.

There are seven steps in attribute based stated choice methods (Grafton *et al*. 2003). The first step is identification of the decision problem. The second step is determining both the number of attributes to be presented to respondents as well as the number of levels of each attribute. Development of the experimental design including construction of the choice task to be presented to respondents occurs in step three. In step four, the rest of the survey is developed and it is decided how the survey will be administered. The data collection itself including consideration of sample size occurs in step five. Estimation of the model is step six, and the seventh step is the calculation of welfare measures for policy analysis and behaviour prediction.

The use of attribute based choice methodology in an environmental context is a relatively recent undertaking compared to the traditional CVM approach (Boxall *et al*. 1996). In the past it has been more widely used in the fields of marketing, geography and transportation (Louviere 1991). However, its use in environmental economics has seen growth over the last decade. The benefit of this method over CVM is that it allows the researcher to value the respondents' preferences for the attributes of the scenario rather than just the scenario itself (Adamowicz *et al*. 1998).

3.3 Contingent valuation

3.3.1 Guidelines for conducting reliable contingent valuation studies

To accurately measure the validity of the estimates obtained from CVM one would have to compare the WTP results with the individuals' true value. However, as there is no way to know what a respondents' true value is, certain validity tests have been developed which may speak to the accuracy of the CVM results. Freeman (2003) outlines four such validity tests: criterion validity, convergent validity, construct validity and content validity.

Criterion validity entails the comparison of the WTP values obtained from the hypothetical CVM survey questions with some appropriate alternative value (Freeman 2003). The most appropriate alternative value would be the respondents' true value, which cannot be observed. Thus, the alternative value is generally simulated instead. Several studies conduct CVM experiments which involve actual market transactions with real consequences for respondents alongside the hypothetical experiments to determine whether or not there exists a significant difference between the real and hypothetical data. However, this strategy necessitates that revealed preference data are available for the environmental good or service being valued, which is not always the case.

Convergent validity involves the comparison of the WTP values obtained from the stated preference method with their revealed preference counterparts (Freeman 2003). The difficulty with this strategy is if a significant difference is found between the stated preference and revealed preference approaches, it could be due to problems in either study, or in the comparison of both.

Construct validity is ensuring that the responses generated from the CVM survey vary in the expected way, as suggested by economic theory (Freeman 2003). For example, theory predicates that WTP values should be an increasing function of income, all else remaining equal. Another form of construct validity is often referred to as the scope test which is determining whether mean values from the sample vary consistently with variations in the proposed scenario. Likewise, irrelevant variations in the scenario should not produce significant changes in the mean sample values.

Finally, content validity is the determination of how well the survey design follows the best practice methods. This process "should involve an examination of the survey instrument, including the scenario specification, the elicitation question – especially its incentive properties – and the payment vehicle, as well as procedural matters, such as sample size and design, and the analysis of data" (Freeman 2003: 178).

3.3.2 Challenges of valuation

Although CVM is the most common stated preference technique, much literature has been devoted to outlining the shortcomings of this method. One such shortcoming is

the limited capacity for information provision, also called 'information bias' (Ajzen, Brown and Rosenthal 1996; Hutchinson, Chilton and Davis 1995). Burgess, Clark and Harrison (2000) state that CVM surveys are unlikely to adequately describe all the characteristics of the environmental good being valued which draws into question the accurateness of the monetary value respondents placed on that good. A CVM survey has been said to put "unrealistic cognitive demands" upon respondents as they are required to digest large amounts of information in a short period of time and then use that information to determine a single monetary value that represents the environmental good (Gregory, Lichtenstein and Slovic 1993: 177).

Furthermore, the theoretical constructs of CVM methodology assumes that people have a pre-conceived preference about the environmental good at hand, and research has proposed that this need not be the case (Sagoff 1998, Christie *et al*. 2006). Schkade and Payne (1994) find evidence to suggest that respondents create their preferences at the time the WTP question is asked. Thus, the valuation of an environmental good may vary with changes in the elicitation procedure, creating uncertainty in the estimates obtained from traditional CVM methodology (Slovic 1995).

One issue with CVM surveys is hypothetical bias which occurs when a participant responds differently to questions depending on whether they perceive them to be real or hypothetical (Cummings and Taylor 1999). One suggested method to reduce this bias is to present respondents with a short script prior to the valuation questions which outlines what hypothetical bias is and what the consequences are for research. This script was first introduced by Cummings and Taylor (1999) and now is present in most valuation studies. In addition, debriefing questions designed to determine how certain participants are in their responses to the valuation questions are included in the survey instrument (Blumenschein *et al*. 1998, Grafton *et al*. 2003).

Hypothetical bias could either be due to social desirability bias or to strategic behaviour. Social desirability bias occurs when participants respond to the survey questionnaire in a manner likely to be favourably viewed by others (Leggatt *et al*. 2003). For example, in this study, participants may perceive that protecting species at risk is socially desirable. A suggested method to reduce social desirability bias in a survey is to have participants place their responses to the valuation questions into a ballot box so as to increase the

anonymity of their responses (Leggatt *et al*. 2003, Harrison 2006). Strategic behaviour occurs when a participant does not feel the survey is credible or consequential and thus the participant behaves strategically when responding to the survey (Grafton *et al*. 2003). For example, if the participant does not feel they will actually have to pay the amount specified, but still want the environmental good or service in question, then they may over-report their WTP. Thus, to reduce the presence of strategic behaviour, respondents must feel they will actually have to pay the amount they report and that their responses will have an impact on policy or will influence provision of the good. Presenting respondents with adequate information on the environmental good or service at hand as well as designing debriefing questions to determine the credibility of the survey are suggested methods of reducing the presence of strategic behaviour.

Insensitivity to scoping and sequencing are two additional concerns with CVM and occur when respondents state their WTP independently of the scope or sequence of the project (Grafton *et al*. 2003). Although each individual respondent may be willing to pay more if more of the environmental good or service is provided, insensitivity to scope is apparent when adding more of the environmental good or service to the valuation question does not seem to change the amount respondents are willing to pay across all individuals in the sample. In other words, the WTP varies significantly with the quantity of the environmental good or service (Hanley and Barbier 2009). The sequencing effect is apparent when changing the order of the programs to be valued changes the WTP estimates. Many CVM surveys now include tests of sensitivity to scope within the design of the survey; however, the degree of either of these concerns is very dependent upon the context of the research (Grafton *et al*. 2003).

A phenomenon arises when respondents tend to vote for a program because of the general cause and not because of the program specifics. This is referred to as the warm glow effect and indicates that the respondent is purchasing moral satisfaction rather than the program itself (Grafton *et al*. 2003). Debriefing questions are again used to determine the extent of this phenomenon.

Focus groups and survey pre-testing are used to determine the optimal bid design to be presented to respondents. It is important that this bid design encompasses the range of potential responses to the WTP question as it contributes to the overall efficiency of

welfare estimates (Haab and McConnell 2002). If the bid levels are either too low or too high, then the valuation question will not be useful in determining how much respondents are willing to pay for the environmental good or service.

Other drawbacks include the large discrepancies reported between WTP and willingness to accept (WTA), although economic theory advocates for their equality (Horowitz and McConnell 2002). In addition, CVM surveys proceeding through conventional modes, such as mail, phone or in-person interviews, generally do not allow the researcher to make assumptions regarding the underlying behaviour of the respondent which led them to answer the survey questionnaire in a certain way (Sagoff 1998).

3.3.3 Contingent valuation in a group

The challenges associated with valuation in this complex setting were outlined in the previous section. To overcome some of these challenges, a group setting was used. This section provides a justification for this approach.

Researchers have suggested the inclusion of deliberation in the CVM process as a means to correct for several shortcomings in the conventional modes of CVM survey administration (Wilson and Howarth 2002). Deliberation in CVM research involves providing information about an environmental good to groups of individuals and then encouraging the group to engage in discussion regarding the valuation of that good (Sagoff 1998, Brouwer *et al*. 1999).

The process of deliberation has its roots in political research as “citizens’ juries” (CJs) or ‘citizen panels’. CJs consist of approximately a dozen people selected to be a representative population of the general public which meet over the course of a few days to discuss some policy question (Aldred 2002). The emphasis here is on the ability of ordinary people to deliberate upon a complex policy and provide suggestions which may be used as inputs into the decision making process (Kenyon, Hanley and Nevin 2001). The deliberation process aims to minimize or eliminate the problem of information provision and the lack of pre-formed preferences as respondents are encouraged to participate in discussions that will ultimately enhance their knowledge of the environmental good.

The integration of a deliberation-based approach, such as citizens' juries, with CVM is called deliberative monetary valuation (DMV) (Niemeyer and Spash 2001). This approach involves "the use of formal deliberation concerning an environmental impact in order to express value in monetary terms for policy purposes, and more specifically as an input to [cost benefit analysis]" (Niemeyer and Spash 2001: 576). DMV provides more detailed information to respondents and has "the ability to recognise silent voices, such as the young, future generations, ecosystems, and non-human entities" (573).

A group-based approach to environmental valuation which has been tested in the socioeconomic field is that of the 'Market Stall' (MS). MS involves several meetings over the course of a couple weeks wherein a group of participants meet to discuss some environmental issue (Macmillan *et al*. 2002). Participants are given time in between sessions to gather additional information and to think and deliberate further with other household members as to their valuation of the environmental good.

Research has also determined some potential problems associated with the MS approach. There exists the opportunity for the development of 'group norms' wherein participants would rather agree with the group or with the dominant persons in the group than voice their own opinion. Additionally, polarization of responses, overestimation of the economic value and small sample sizes are a few of the issues associated with MS (Macmillan *et al*. 2002). Niemeyer and Spash (2001) indicate that recruitment bias may be a potential problem that is more pronounced given the small sample size. They also mention the possibility of strategic responses by individuals within the group setting.

The valuation of rare or complex goods for which the public may have minimal knowledge, such as species at risk, may necessitate a more in-depth methodology than traditional CVM that will provide additional opportunities for the exchange of information and discussion (Christie *et al*. 2006). MacMillan, Hanley and Lienhoop (2006) performed a study which compared both a familiar good and an unfamiliar good using the MS approach and found that "…time to think, additional information and group deliberation all appear to influence mean WTP…" (300) for the unfamiliar good, whereas these requirements did not seem to significantly influence the mean WTP for the familiar good.

In conclusion, incorporation of a group deliberation process into the traditional CVM methodology may enhance the ability of respondents to make an informed decision on the value of the environmental good. Specifically, deliberation may minimize several of the challenges associated with CVM, such as information provision, lack of pre-formed preferences and rare or complex goods.

3.4 Attribute based choice

3.4.1 Challenges of valuation

Many of the challenges of valuation in an attribute based choice context are similar to those in a CVM context. Information bias, pre-conceived preferences, hypothetical bias, strategic behaviour, warm glow, sequencing effect and differences in WTP and WTA are all potential issues in attribute based choice methods (Grafton *et al*. 2003). The scope effect is likely addressed to a certain degree in a choice context given the changing attribute levels.

However, attribute based choice methods involve asking respondents to choose between different scenarios which are described by attributes (Adamowicz *et al*. 1998). Thus, the major difference between CVM and attribute based choice is in choosing an efficient design with the appropriate number of attributes, levels and repetitions (Grafton *et al*. 2003). The process of determining this efficient design involves a combination of both analyst judgement and information collected from focus groups and other survey pre-testing. This process is detailed in the next chapter.

3.4.2 Attribute based choice in a group

Several of the challenges associated with attribute based choice are overcome by using a group setting for valuation, as in the CVM context. These challenges include information provision, lack of pre-formed preferences and rare or complex goods. Incorporating a group deliberation process into the attribute based choice methodology will allow respondents to make more informed decisions with regards to the value of the environmental good.

3.5 Review of previous studies of species or habitat conservation

Stated preference techniques have been used to value a variety of environmental goods and services. Specifically, several studies have been conducted using these techniques

to determine the economic value of species or habitat conservation. Several of these key studies are outlined in this section.

The economic value of 18 marine mammal and bird species at risk was determined in the United States by Loomis and White (1996). The study used CVM via a mail survey to establish a range of WTP values which varied by species; from $6 per household for some fish species to $95 per household for the northern spotted owl. The authors assessed both a one-time payment and an annual lifetime membership.

Using the CVM method, White *et al*. (1997) determined the economic value of the otter (*Lutra lutra*) and the water vole (*Arvicola terrestris*). A telephone survey was administered and the payment vehicle was a one-time increase in taxes. Additionally, the authors find that the public profile of species at risk is as important as other factors, such as species designation, in determining the species' economic value.

Adamowicz *et al*. (1998) conducted a study designed to elicit passive use values of caribou preservation in Alberta. They used both CVM and choice methods and taxes per household were chosen as the appropriate payment vehicle. Welfare measures were calculated for the amount of income required to compensate an individual after a caribou improvement program has been implemented which would make him/her as well off as they would be with the status quo ranged between $75.42 and $217.83 per household per year depending on the functional form chosen for analysis.

Loomis *et al*. (1999) used CVM to determine the economic value of five ecosystem services in a damaged river basin in Colorado, United States. One of these ecosystem services is the protection of habitat for fish and wildlife in the area. The dichotomous choice WTP question was posed as an increase in the respondents' monthly water bill. In-person interviews were conducted and indicate that respondents would be willing to pay approximately $21 US per month for the additional ecosystem services.

Wild geese in Scotland are known to cause damage to farmers' fields, mainly through grazing. However, as wild geese are endangered, the government currently provides compensation to farmers for these damages. Macmillan *et al*. (2002) performed a CVM study to determine if these compensation payments were adequate by eliciting the public's WTP for wild goose conservation. The authors used the MS approach and found

that group deliberation presents important advantages, especially for unfamiliar goods. The WTP estimates using the MS approach were significantly lower than those obtained from the conventional CVM survey.

The benefits of preservation of the Florida manatee (*Trichechus manatus latirostirs*) were determined both through measureable protection benefits such as tourism revenues and through a CVM survey sent to a random sample of the residents of Citrus County, Florida by Solomon, Corey-Luse and Halvorsen (2004). The costs of preservation, measured as the forgone net development benefits, were not calculated, but were estimated as the cost of enforcing boat speed limits. This study employed a mail out survey and the WTP question was posed as the maximum amount that the participant would donate to the manatee protection fund each year. The benefits of manatee preservation were found to exceed the costs by approximately $8.2 to $9 million. This information supported the formation of a safe-minimum standard policy at current manatee population levels.

Tisdell, Wilson and Swarna Nantha (2005) determined both the costs and the WTP for the conservation of the endangered mahogany glider (*Petaurus gracilis*) in Australia. Group-based surveys were conducted with approximately 40 individuals in each session. Societal benefits were found to exceed the costs therefore suggesting that a potential management option is the formation of a national park which contains the minimum viable population of the endangered species.

Both the benefits and costs of endangered species and habitat preservation in Denmark were determined by Strange *et al*. (2007). This information was then combined to determine the optimal allocation or the potential welfare economic contribution of implementing a conservation network. A choice experiment was conducted including several attributes which describe various conservation strategies. The authors show that the welfare of each strategy differs significantly and that the strategies can be prioritized accordingly.

Boxall *et al*. (2012) conduct a CVM study to determine the economic value of species at risk recovery plans for several marine mammal species in the St. Lawrence Estuary. Their results suggest that the WTP per household per year for marine mammal recovery

ranged from $82 to $242. The authors discovered that Canadians are willing to pay a substantial amount to move a species from 'endangered' to 'threatened', but are willing to pay less to move a species from 'threatened' to 'not at risk'. This study represents the first attempt to estimate the economic value of marine mammal recovery in Canada.

Stated preference techniques do have their limitations; however, they are still the most common method of determining the economic value for those environmental goods and services for which no markets exist. As Woodland Caribou are not bought or sold in a market, these techniques will be used to determine their economic value in this study. Given the methodology of this study, comparison to the species or habitat valuation studies provided in this section would be difficult and thus will not be attempted.

3.6 Conclusions

In conclusion, this study will use stated preference techniques to determine the value of various caribou conservation programs to the general public in Alberta. Some of the challenges inherent in using these techniques will be overcome through the use of a group setting for the collection of data. Both CVM and a form of attribute based choice will be used to determine the WTP for caribou conservation from residents of Alberta. Although there are several examples of the use of stated preference techniques to determine the value of species at risk or habitat conservation, this study aims to contribute to the literature through the development of economic value measures in the context of the species at risk legislation and in the comparison of valuation approaches.

4 Survey Design and Data Collection

4.1 Introduction

This chapter focuses on the development of the survey and the process of data collection. A detailed explanation of the five focus groups that were conducted in preparation for the creation of the final survey is presented as well as the design of the workshops themselves. Survey administration details and the design of the valuation portion of the survey are also described in this chapter.

4.2 Focus groups

A survey was conducted to collect data from Alberta residents on their opinions on various caribou conservation programs. This survey was designed and pre-tested by conducting five focus groups in Edmonton. The purpose of these focus groups was to determine if the information in both the survey and the presentation were clear and understandable so that the results from this study will be a close estimate of the value of caribou to the general public.

The first focus group was held at the University of Alberta on June 23, 2010 and involved 13 experts from academia, industry, government and non-governmental organisations. This focus group was centered on determining whether the economic costs of caribou conservation options were presented adequately and correctly. Points of discussion included: the best method to summarize and present caribou conservation objectives; the best method to summarize and present the financial and economic implications with various caribou conservation objectives; the time frame of analysis; and whether the metrics presented were scientifically credible and accurate. This meeting also included a brief description of versions of the valuation questions which were to be presented to the public.

The second and third focus groups were held at the polling and market research enterprise Léger Marketing in Edmonton on November 16, 2010 and included 10 members of the public each. Léger Marketing was the recruitment company chosen as they have a facility in downtown Edmonton where we could host the focus groups. Compensation of $50 was given to each participant. These focus groups were used to determine whether the opportunity cost curve, the presentation and the choice questions were clear and understandable. Points of discussion included: whether there

was any additional information which would help to make a more informed valuation decision, whether the presentation or survey was biased and various methods of presenting the valuation questions.

The second and third focus groups aimed to determine the views of participants towards the valuation questions. These groups revealed that several participants were uncomfortable with the valuation question and with making decisions about the fate of certain herds as compared to other herds. However, other participants indicated that they understood that all caribou herds likely cannot be conserved and so concluded that this decision is both a relevant one and an important one.

The fourth and fifth focus groups were held again at Léger Marketing in Edmonton on January 11, 2011 and included 12 members of the public each. Compensation of $50 was given to each participant. Various changes had been made to the presentation and to the survey instrument after the second and third focus groups and thus these focus groups were used to determine if these changes had made the information easier to understand. Points of discussion were very similar to those from the second and third focus groups. Some initial testing of bid amounts was also performed during these focus groups.

4.3 Data collection workshop design

The data collection workshops were organized by first showing participants a 45 minute presentation (Appendix A) outlining the issues surrounding caribou conservation and resource extraction industries in the province. The presentation also included questions which were answered by the participants using audience response systems which allowed the group responses to be displayed after each question. The rationale for using audience response systems was to keep participants engaged in the presentation and to ensure that they understood the information being presented to them. Following the presentation, participants were given some time for discussion and any additional questions. Food and refreshments were also provided. Participants were then given an information package (Appendix B), which summarized many of the points made in the presentation, and then a survey with valuation questions and the associated debriefing questions (Appendix C). This survey was provided to respondents as a series of small booklets to be completed in order, and then dropped in a ballot box once each one was

finished before moving onto the next. The rationale for using a ballot box was to make the vote and choice questions as "real" as possible and to minimize the chance that respondents would compare valuation questions. The final booklet also contained demographic questions (Appendix D). After participants finished filling out this final booklet and had dropped it into the ballot box, they were thanked for participating, paid and were allowed to leave. Participants were paid $100 for participating in the session.

Each respondent was given an audience response system remote at the start of the survey. The identification number on the audience response system was matched with the identification number on the rest of the survey so that audience response system responses could be matched to the appropriate survey responses. Periodically, during the powerpoint presentation (see Appendix A), questions were put on the screen and respondents were asked to choose their response on the remote (a response of A, B, C, D or E). Once all the respondents' had chosen their responses, the group results could be displayed on the screen in a histogram (i.e.; the number of respondents who chose "A" as their response, the number who chose "B", etc.). The responses were entirely anonymous and voluntary and at no point were other people in the workshop able to tell what anyone else in the workshop had responded. For an example of audience response system technology, please see http://www.ctl.ualberta.ca/elearning/click/click_over.php. Audience response systems were not used for the valuation questions and these responses were not shown to others participating in the survey.

Using this technology served two purposes; it attempted to keep respondents engaged in the presentation, and it allowed everyone attending the workshop to get a feel for how other people in the room felt towards certain relevant concepts. With regards to the first purpose, we asked workshop participants at the end of each session whether they thought the audience response system was useful and interesting, and we received favourable reviews. In regards to the second purpose, we had some initial concern that respondents would feel that others around them could see their responses. We did, however, try to make it very clear that using the audience response system was anonymous and voluntary.

Audience response systems have been used in the literature and go by several different names, such as iClickers, audience paced feedback, clicker technology, classroom

communication systems, personal response systems, electronic voting systems, student response systems and voting machines, among others (MacArthur and Jones 2008). They are small electronic devices which allow immediate interaction of the audience with the presenter or researcher and the topic of study. The system has two parts; the remote, and an electronic receiver which records the information and can display the group responses (McCarter and Caza 2009). The collected participant information can then be exported to other software such as Microsoft Excel. Much of the research on audience response systems to date has been on its use in the classroom to further student learning.

Audience response system technology has been used specifically for research purposes in only a few cases. In 2009, McCarter and Caza conducted a study with students using audience response systems to assess its use in research and data collection. The authors found that this technology generally incurs a low cost but produces a relatively high response rate, makes sampling from large groups both convenient and efficient and reduces the potential for error in data entry. Solecki *et al*. (2010) used audience response systems at a nursing education conference and found that that this technology generated discussion and promoted active engagement of participants. Keske and Smutko (2010) used this technology to determine community preferences for recreation and tourism in the United States. The authors found high satisfaction of participants with the audience response systems. In summary, audience response systems have been used in a variety of areas, but to the best of our knowledge this is the first application of this technology to an environmental valuation case.

In addition to audience response systems, this workshop also utilized a ballot box. This approach has been used very few times in the valuation literature. It was first recommended by the NOAA Panel as a method of reducing social desirability bias which occurs when participants in a survey attempt to impress the interviewer by exaggerating certain socially desirable characteristics, such as protecting endangered species (Leggett *et al*. 2003). The ballot box seeks to reduce this bias by providing increased anonymity in participants' survey responses. The first known use of the ballot box in a valuation study was in 1994 with the Exxon Valdez oil spill survey (Carson *et al*. 1994). The authors used two treatments, one with the ballot box and one without, and did not find evidence of a

significant difference between the two treatments thereby providing evidence against the presence of social desirability bias or evidence against the use of the ballot box in reducing this bias. However, Harrison (2006) found that during the ballot box treatment the overall WTP was lower indicating that using a ballot box will provide a more conservative estimate of the total WTP. Leggett *et al*. (2003) found that WTP for a visit to a national monument was significantly higher when the survey was administered face-to-face with a ballot box than when it was self-administered. Although these findings cannot conclusively be attributed to the presence of social desirability bias, the authors suggest that this is a possibility and that using a ballot box did not capture all of the bias.

Although the research to date on the benefit of including ballot boxes in the survey design is mixed, this technique was included in this study. The rationale for this was to make the valuation questions feel more authentic thereby enhancing the consequentiality of the survey. In addition, it was anticipated that by having respondents drop each valuation question into the ballot box once it had been completed, the chance of direct comparison to previous or future valuation questions and changing answers accordingly would be reduced.

The payment vehicle provided to participants in this study was an increase in household income taxes each year for the next 50 years. DuVair and Loomis (1993) state the importance of having a payment vehicle which is both consistent with distribution of the proposed good and relatively emotionally neutral for the participant. Mitchell and Carson (1989) argue that the choice of a payment vehicle is essentially a tradeoff between credibility or realism and payment vehicle rejection; as one increases the likelihood of realism one may also increase the likelihood of payment vehicle rejection. Likewise, if the payment vehicle is not credible, then one can expect to also see payment vehicle rejection. As Woodland Caribou and provincial revenues are both public goods, once the decision has been made to provide them, they are paid for collectively. Thus, a payment vehicle of an increase in income taxes was chosen as it is both coercive and consistent with the distribution of such public goods. Although taxation is generally not considered to be emotionally neutral, this payment vehicle was chosen primarily because it was considered to be the most incentive compatible option.

We chose to use income tax per household as opposed to income tax per individual as the former was well received at the focus groups and is the most common form used in the literature.

4.4 Sample application

A key issue associated with survey design is the extent of the market. This refers to the fact that the chosen participants in a study will have an important impact on the outcome. Since this study involves questions of public resources in Alberta, we chose to ask Albertans what their opinions were on caribou conservation in the province. In order to obtain a close to representative sample of the provincial population, we conducted workshops in Edmonton, Lloydminster, Calgary and Grande Prairie. The difficulty in obtaining a large enough population in an area to support between 30 and 50 respondents per workshop necessitated that multiple workshops be conducted in major city centers such as Edmonton and Calgary. We chose Grande Prairie and Lloydminster for more rural perspectives. In addition, residents of Grande Prairie are expected to be slightly more familiar with Woodland Caribou as there is a herd near this city. Residents of Edmonton, Calgary and Lloydminster were expected to be less familiar with Woodland Caribou.

The survey was administered to 257 members of the public in Alberta from April to June, 2011. The first three workshops were held in Edmonton at the University of Alberta campus; one was held in Lloydminster at the West Harvest Inn; two were held in Calgary at the Olympic Volunteer Center at the McMahon Stadium near the University of Calgary campus; and a final workshop was held in Grande Prairie at the Grande Prairie Regional College. All surveys were held in the evening from 6 to 9 pm.

A market research company called Advanis contacted potential survey respondents by phone and invited them to each workshop. For each workshop, we aimed to get an equal gender and age split, excluding anyone under 18 years old. The recruitment screener is shown in Appendix E.

The first workshop on April 14, 2011 in Edmonton was the pilot workshop. 46 participants were invited to this survey session and 37 people attended. Data from this pilot session were used both to determine an acceptable bid range for the valuation

questions and to create an efficient survey design for the choice portion. The next two workshops were also held in Edmonton on April 26 and 28, 2011. For the workshop on April 26, 39 participants were recruited and 32 were in attendance. For the April 28 workshop, 48 were invited and 35 were in attendance. The workshop held in Lloydminster on May 30, 2011 had 44 recruited with 34 participants in attendance. Two workshops were held in Calgary on June 13 and 14, 2011. On June 13, 49 were invited and 38 were in attendance and on June 14, 50 were invited and 38 were in attendance. Finally, the workshop held in Grande Prairie on June 23, 2011 had 48 recruited and 43 participants who were in attendance. The overall response rate for all the workshops was 79%. More detailed information on confirmed attendance and response rates (number who attended the workshop divided by the number actually recruited) for each workshop is provided in Appendix F.

4.5 Survey design

Both CVM and attribute based choice valuation question formats were used in this survey. Two attributes were chosen which were cost and number of herds. Each attribute then had four levels. For the cost attribute, the four levels were $5, $75, $300 and $600. For the herd attribute, the four levels were 3, 6, 9 and 13. These levels were chosen as a result of both the focus groups and the pilot workshop and aimed to adequately represent the range of possible responses; a large acceptance of the low bid and a small acceptance of the high bid. Each respondent was asked two CVM questions and two choice questions.

The attributes and levels were the same for both the CVM and the choice questions. However, the major difference between these two methods is in the formation of the experimental design. For the CVM portion of the survey, the herd and cost variations were chosen at random, with the obvious elimination of those variations which were identical for both the first and second question.

For the attribute based choice portion of the survey, the attributes and levels were designed to form a universe of 2^4 X 2^4 possible combinations. Constructing the choice set requires choosing a sample from this universe. Ngene software (Choice Metrics 2011) was used to determine an efficient design using priors from the pilot workshop. The resulting sample contained a total of 50 choice sets which were blocked into 25 sets

of two, as each respondent was given two choice questions. As with the CVM, those alternatives which were identical for both the first and second choice questions were eliminated. In addition, the final efficient design rejected those variations which had herds equal for both the first and second question, as well as those variations which had costs equal for both questions. Finally, the efficient design also required the question with the largest number of herds to have the higher cost, and vice versa. Thus, respondents were not given choice questions that had the larger number of herds associated with the smaller cost as that would be a dominant alternative. The final choice design had a D optimality measure of 76.0%. Other design statistics can be seen in Appendix G.

An example of the CVM format is shown in Table 4.1. Respondents are given two choices: the current management strategy, which will occur if no additional action is taken, and various proposed management strategies. In the example, the current management strategy of having two herds which are self-sustaining at the end of 50 years for no cost is compared to the proposed management strategy of having 13 herds which are self-sustaining at the end of 50 years for an annual household cost of $75/year for the next 50 years. The current management strategy was constant for all valuation questions in the survey.

Table 4.1 Example of Referendum or CVM Valuation Question Format Used in Survey Instrument

	Current Management Strategy	Proposed Management Strategy
Number of self-sustaining caribou herds *in 50 years*	2 herds	13 herds
Your household's share of the cost *for the next 50 years* in provincial income taxes	$0/year	$75/year

An example of the attribute based choice format is shown in Table 4.2. Here, respondents are asked to choose between two different management strategies as

legislation requires that some action toward species recovery be taken. In the example, management strategy A of having 13 self-sustaining herds at the end of 50 years for an annual household cost of $600/year for the next 50 years is compared to management strategy B of having 6 herds at the end of 50 years for an annual household cost of $5/year for the next 50 years. Note that participants were not given the option to choose neither alternative as per the legislation guidelines.

Table 4.2 Example of Choice Valuation Question Format Used in Survey Instrument

	Management Strategy A	Management Strategy B
Number of self-sustaining caribou herds *in 50 years*	13 herds	6 herds
Your household's share of the cost *for the next 50 years* in provincial income taxes	$600/year	$5/year

The "cheap talk" script used is shown in Figure 4.1. This script is used to minimize hypothetical bias which occurs when a participant responds differently to questions depending on whether they perceive them to be real or hypothetical (Cummings and Taylor 1999). This script was first introduced by Cummings and Taylor (1999) and is now used in most valuation studies. This script involves discussing what hypothetical bias is and what the consequences of it are for research.

We would like your opinion on the **"tradeoff"** between caribou conservation objectives and economic costs.

The next series of questions asks you to compare the **current management strategy** in Alberta with different scenarios (**proposed management strategy**) about what **could** happen **within the next 50 years** if additional efforts were undertaken to protect woodland caribou habitat.

These scenarios will vary in terms of the following characteristics:

- An estimate of your household's annual cost for the program, which depends on energy prices and other factors
- The number of caribou herds which are self-sustaining

We are asking you to state whether you feel that the conservation program, for the amount of money per household per year that the program will cost, should be undertaken.

After analyzing the differences between the current management strategy and the proposed management strategy, you will be asked to "vote" for or against the proposed strategy.
Some people might choose to vote to keep the current management strategy because they think:

- The proposed management strategy costs too much money for the improvement in caribou population
- There are other things, including other environmental protection options, where my money would be better spent

Other people might choose one of the proposed management strategy options because they think:

- The improvement in caribou populations is worth the money
- This is a good use of money compared to other things provincial government money could be spent on

PLEASE NOTE:

We know that how people vote on a survey is often not a reliable indication of how people would actually vote at the polls. In surveys, some people ignore the monetary and other sacrifices they would really have to make if their vote won a majority and became law. We call this hypothetical bias. In surveys that ask people if they would pay more for certain services, research has found that people may say that they would pay 50% more than they actually will in real transactions.

It is very important that you "vote" as if this were a real vote. You need to imagine that you actually have to dig into your household budget and pay the additional costs associated with the program.

Suppose you were asked to consider the following votes and choices. In each case presented below, imagine that these are the ONLY TWO OPTIONS available to choose from. Each time, please choose INDEPENDENTLY from the other questions – do not compare options from different questions.

Figure 4.1 Cheap talk script used in the survey

An important aspect of survey design is to make sure that respondents both believe they will actually have to pay what they say they will pay, and that they believe their answers to the survey may actually influence future policy. This is called consequentiality and this study aimed to ensure both of these conditions were met. To ensure that respondents believed they will actually have to pay what they say they will pay, respondents were provided with accurate, detailed scenarios for the valuation questions. In addition, the chosen payment vehicle of taxation implied that if a caribou conservation strategy is deemed acceptable by society, participants will not have a choice in whether or not they may contribute to the proposed strategy. To ensure that respondents believed their answers to the survey will actually influence future policy, respondents were told that there were several partners in this research (Appendix A), two of which are the provincial and federal governments (Herriges *et al*. 2010). It is anticipated that these measures would improve the consequentiality of the survey; however, the authors recognize that there is no way to be certain that respondents viewed the survey as being consequential.

4.6 Conclusions

This chapter aimed to provide a detailed description of the focus groups, workshop design, application of the survey and the survey design. Five focus groups were conducted in Edmonton, Alberta prior to implementing the first workshop which facilitated the creation of the final survey. Approximately 35 participants attended each of seven workshops bringing a total of 257 participants to the study. The workshops were performed in Edmonton, Calgary, Lloydminster and Grande Prairie. Two innovative aspects of the workshops were inclusion of audience response systems and the ballot box technique. The valuation portion of the final survey contained two CVM questions and two choice questions.

5 Results

5.1 Introduction

This chapter presents descriptive statistics for the sample and provides details on the econometric analysis performed. Conditional logit and random parameters logit models were estimated. The resulting welfare measures are also calculated. Additional descriptive statistics are provided in Appendix H.

5.2 Demographic statistics for the sample

Some basic demographic statistics are depicted in Table 5.1. Gender was approximately equal and the average age of respondents was 48 years with a minimum of 18 and a maximum of 87 years. The majority of the sample lived in a city or town with more than 1,000 people (urban) and are married. The average household size of the sample was three individuals. Participants had spent, on average, about 33 years in Alberta with a minimum of one year and a maximum of 80 years. The average household income level for the sample was between $80,000 and $99,999. Almost 30 percent of the sample had completed a university undergraduate degree.

Participants were then asked both about their employment status and their employment sector. These results are depicted in Table 5.2. Half of the sample work full time outside the home or are self employed. The most common employment sectors were utilities, construction, manufacturing, educational services, health care and social assistance. However, approximately 25 percent of the sample checked the 'other' category for their employment sector.

Table 5.1 Basic Demographic Statistics for the Sample of Selected Communities in Alberta (Total Sample Size: 257 individuals)

Demographic	Statistic	Frequency	Percent (%)
Gender	Male	122	48.0
	Female	132	52.0
Location	Urban	234	92.1
	Rural	20	7.87
Marital status	Single	78	30.8
	Married	141	55.7
	Common law	34	13.4
Education	Grade school or some high school	7	2.76
	Completed high school	36	14.2
	Post-secondary technical school	33	13.0
	Some university or college	38	15.0
	Completed college diploma	40	15.8
	Completed university undergraduate degree	68	26.8
	Completed post-graduate degree (masters or Ph.D.)	32	12.6
Household income	Less than $20,000	19	7.66
	$20,000 - $39,999	18	7.26
	$40,000 - $59,999	36	14.5
	$60,000 - $79,999	38	15.3
	$80,000 - $99,999	42	16.9
	$100,000 - $119,999	32	12.9
	$120,000 - $139,999	20	8.06
	$140,000 - $159,999	14	5.64
	Greater than $160,000	29	11.7

Table 5.2 Employment Statistics for the Sample of Selected Communities in Alberta

Demographic	Statistic	Frequency	Percent (%)
Employment status	Working full time outside the home or self employed	125	49.2
	Working part time outside the home or self employed	44	17.3
	Student	19	7.48
	Homemaker	14	5.51
	Retired	49	19.3
	Unemployed	15	5.91
Employment sector	Agriculture	13	5.65
	Forestry, fishing, mining, oil and gas	17	7.39
	Utilities, construction and manufacturing	23	10.0
	Transportation and warehousing	12	5.22
	Finance, insurance, real estate and leasing	10	4.35
	Educational services	34	14.8
	Health care and social assistance	29	12.6
	Information, culture and recreation	14	6.09
	Accommodation and food services	12	5.22
	Public administration	9	3.91
	Other	59	25.7

Participants were then asked what environmentally related activities they had engaged in within the last 12 months. These results are depicted in Table 5.3. The most common activities were camping, hiking, wildlife viewing, sightseeing and photographing nature. Over 75 percent of the sample said they watched environmental television sometimes, often or very often.

Table 5.3 Descriptive Statistics on Environmentally Related Activities for the Sample of Selected Communities in Alberta

Demographic	Statistic	Frequency	Percent (%)
Environmental organization	Membership	15	5.91
Environmental activities	Camping	132	52.0
	Hiking	130	51.2
	Cross-country/downhill skiing	61	24.0
	Wildlife viewing	129	50.8
	Sightseeing in natural areas	150	59.1
	Ecotourism	28	11.0
	Photographing nature	114	44.9
	Fishing	63	24.9
	Hunting	25	9.84
	Other	30	11.8
Environmental television	Very often	35	13.8
	Often	64	25.2
	Sometimes	97	38.2
	Rarely	46	18.1
	Never	12	4.72

Table 5.4 depicts the provincial averages for some of the sample demographic statistics for comparison. The sample data closely follows the provincial average for the demographic statistics shown.

Table 5.4 Sample and Provincial Averages for Some Demographic Statistics (Statistics Canada (b))

Demographic	Statistic	Sample Percent (%)	Provincial Percent (%)
Gender	Male	48.0	50.0
	Female	52.0	50.0
Marital status	Single	30.8	34.0
	Married	55.7	50.7
	Common law	13.4	8.60
Employment sector	Agriculture, forestry, fishing, mining, oil and gas	13.0	10.9
	Utilities, construction and manufacturing	10.0	16.9
	Transportation and warehousing	5.22	5.13
	Finance, insurance, real estate and leasing	4.35	5.05
	Educational services	14.8	6.25
	Health care and social assistance	12.6	9.08
	Information, culture and recreation	6.09	3.75
	Accommodation and food services	5.22	6.62
	Public administration	3.91	4.66
	Other	25.7	5.14
Household income	Less than $20,000	7.66	5.14
	$20,000 - $39,999	7.26	14.0
	$40,000 - $59,999	14.5	17.0
	$60,000 - $79,999	15.3	16.5
	$80,000 - $99,999	16.9	14.2
	Greater than $100,000	38.3	33.1

At the beginning of the presentation, participants were asked a series of general attitudinal questions using the audience response systems. First, participants were

asked a series of questions regarding their opinions about some general environmental issues. On average, participants thought Canadians should be doing more for reducing air and water pollution, protecting parks and wildlife reserves, protecting wildlife from extinction, improving roads and highways, encouraging economic growth and jobs, improving health care and improving education. On average, participants thought Canadians should be doing about the same in reducing taxes. These results differ slightly depending on the location. In Edmonton and Calgary[2], participants thought Canadians should be doing about the same for improving roads and highways. In Edmonton, Lloydminster and Grande Prairie, participants thought Canadians should be doing about the same for encouraging economic growth and jobs.

Then, participants were asked several more questions regarding various aspects of the presentation. On average, participants had not heard of the *Species at Risk Act* before this survey, but they had heard of the *Alberta Wildlife Act*. This is to be expected as the latter is an important document for recreational activities such as hunting or fishing. On average, participants reported that it was very important that every possible effort be made to protect all species that are currently at risk. Before this survey, participants were not very familiar with Woodland Caribou and were not aware that this species is at risk in Alberta. The average participant has also not ever observed caribou in nature but is very interested in observing caribou in nature in the future. It somewhat matters to participants if the caribou populations in Alberta and other parts of Canada remain at risk. Participants also somewhat agree that Alberta should take more action to help the caribou populations recover. On average, participants were aware that resource industries played a role in the decline of caribou and that energy and forestry companies made corporate income tax and royalty payments to the government of Alberta based on the resources they extract.

Finally, participants were asked a series of questions regarding their opinions about spending on public services. On average, participants thought funding for health care

[2] Media reports were published in the Calgary Herald regarding the negative impacts of the proposed method of wolf control to conserve Woodland Caribou populations a couple days before we conducted the workshops in Calgary. Despite our initial concern that this information would skew our results, based on discussion at the end of the session it appeared that few of the survey participants had seen or read that article.

and education should be increased somewhat, and funding for environment, recreation, culture, resource conservation and industrial development, social services, transportation and communication and protection of persons and property should stay the same.

5.3 Valuation results for caribou conservation

The results from the descriptive statistics show that residents of Alberta do have concern for caribou, and that they are willing to pay some amount of money to ensure their survival in the future. This section aims to provide a statistical analysis of the willingness to pay (WTP) responses in order to make more definitive conclusions about the degree of caribou concern among residents of Alberta. Nonparametric analysis was completed for the contingent valuation data and is included in Appendix I.

A total of nine respondents did not answer the income question, so the median income value for the sample, which was a category of 5 or $90,000, was used for these respondents. All models were prepared and estimated using *NLOGIT* software (Econometric Software 2011).

5.3.1 Parametric analysis for contingent valuation

The econometric methodology used in this study involved a maximum likelihood estimation of a logit model where the dependent variable is the probability that the respondent answered "yes" to the WTP for caribou conservation survey question. It is based on the economic theory that people make choices in order to maximize their happiness, or their utility (Boxall *et al*. 2012). Thus, when presented with alternative hypothetical caribou conservation strategies, a respondent will choose the strategy that yields the highest utility.

This study utilizes random utility theory wherein utility (U) is assumed to be made up of two components: a systematic component (V) which can be observed and a random component (ε) which cannot be observed (Grafton *et al*. 2003):

$$U_i = V_i + \varepsilon_i \qquad \text{Equation 5.1}$$

Implicit in this model is the assumption that respondents know their preferences (U) whereas the researcher is only able to observe the systematic portion of these preferences (V), which may be a function of various factors, such as the income and

other demographic characteristics of the respondent. The random component of a respondents' preference (ε) is 'latent' or unobservable and thus a representative statistical distribution must be chosen.

In a discrete choice contingent valuation format, utility occurs as a result of the "yes" or "no" response to the contingent valuation question. Respondents are asked to choose between two management strategies; the proposed management strategy at the specified bid level and the current management strategy or status quo. If the respondent votes for the current management strategy, then their response is deemed a "no" and there is no change in their income. If the respondent votes for the proposed management strategy, then their response is deemed a "yes" and their income is reduced by the amount of the bid. The subscript i in the equation above represents this yes or no response, with i = 1 for a "yes" response and i = 0 for a "no" response (Grafton *et al*. 2003). Both responses are shown in the equations below:

$$V_1 = \alpha_1 + \beta(M - t_1) + \varepsilon_1 \qquad \text{Equation 5.2}$$

$$V_0 = \alpha_0 + \beta(M) + \varepsilon_0 \qquad \text{Equation 5.3}$$

Random utility theory and discrete choice contingent valuation propose that in order to understand why a respondent votes for the proposed management strategy, one must examine the difference in utility between the current and the proposed management strategies. This difference depends on the bid amount and on the utility of the management strategies themselves (Grafton *et al*. 2003).

In the survey, individuals were asked to choose between the proposed management strategy at the specified bid level and the current management strategy. In order to choose between these two strategies, the model assumes that the individual compares his or her level of utility with the proposed strategy and his or her level of utility with the current strategy. However, these 'latent' utilities are not observed. Rather, we observe data on choices and from this data seek to estimate the utility derived from each respondent. For the linear case, the utility levels are defined as:

$$V_{1j} = \alpha_1 z_j + \beta\left(M_j - t_1\right) + \delta(H_1) + \varepsilon_{1j} \qquad \text{Equation 5.4}$$

$$V_{0j} = \alpha_o z_j + \beta M_j + \delta(H_0) + \varepsilon_{0j} \qquad \text{Equation 5.5}$$

where V_{1j} is the indirect level of utility for the proposed strategy for individual j, α is a vector of parameters for each management strategy, z_j is a vector of household characteristics related to individual j, β is the marginal utility of income, M_j is individual j's income, t_1 is the specified bid level or cost for the proposed management strategy, δ is the marginal utility of the number of caribou herds chosen for conservation, H is the number of caribou herds chosen to be conserved in each management strategy, ε is an error term and V_{0j} is the indirect utility function in the current strategy for individual j.

Linear, natural log and quadratic specifications for the herd variable were chosen to describe an individual's preferences[3]. The linear specification was chosen as it is both the simplest and the most common functional form (Boxall *et al*. 2012), whereas the natural log specification was chosen as it is assumed that the utility from caribou conservation increases at a decreasing rate with an increasing number of herds conserved. The quadratic specification was chosen for comparison with the linear and natural log models; the utility from caribou conservation may initially increase with an increasing number of herds, and then eventually decrease. The linear functional form is presented during the theoretical portion of this chapter, whereas both the linear and the natural log form will be presented in the estimation results. The quadratic functional form will appear for comparison purposes in the welfare analysis results; however, estimation results for this functional form, as well as for the linear and natural log functional forms, are depicted in Appendix J.

Thus, the change in the utility level can be defined as:

$$V_{1j} - V_{0j} = \alpha z_j + \beta t_1 + \delta(H_1 - H_0) + \varepsilon_j \qquad \text{Equation 5.6}$$

This equation is a representation of the choice each individual j makes between the proposed and the current strategies which ultimately will determine his or her preferences for caribou conservation. This equation has been normalized by setting

[3] The models which use the natural log specification for the herd variable are termed 'natural log models' for the remainder of this paper. Likewise, the models which use the quadratic specification for the herd variable are termed 'quadratic models'. However, in either case, only the herd variable changes functional form.

$\alpha_o = 0$, thus α_o and α_1 will now be referred to as α which is capturing the value of the program. However, the empirical model employed below defines α as "1" for the status quo and "0" for the proposed strategy; thus α in the results section of this thesis is actually the value of the status quo. In other words, the value of the status quo is the negative of the value of the program. From this equation we can further identify the probability of an individual answering "yes" to the bid amount, or the probability that the utility of yes is greater than the utility of no:

$$Pr(yes_j) = Pr(V_{1j} > V_{0j}) \quad \text{Equation 5.7}$$

$$Pr(yes_j) = Pr(V_{1j} - V_{0j} > 0) \quad \text{Equation 5.8}$$

$$Pr(yes_j) = Pr(\alpha z_j + \beta t_1 + \delta(H_{1j} - H_{0j}) + \varepsilon_j > 0) \quad \text{Equation 5.9}$$

The above three equations relate the probability of answering "yes" as a function of the difference in the utility levels of both the proposed strategy and the current strategy (Gutierrez 2006). A distribution for the errors in this expression must now be chosen.

A logistic distribution is assumed as the dependent variable is a discrete variable representing one choice from a set of mutually exclusive choices. The dependent variable here is the probability of answering "yes" to the specified bid level; it is coded as either a "1" for a "yes" response or "0" for a "no" response. The equation for the logit model relating the probability of individual j answering "yes" to the WTP for caribou conservation is:

$$Pr(yes_j) = \frac{1}{1+exp(-\alpha z_j - \beta t_1 - \delta(H_{1j} - H_{0j}))} \quad \text{Equation 5.10}$$

By constructing the likelihood function of the logit model, the parameters of the utility difference can be estimated using *NLOGIT* software (Econometric Software 2011). Once the parameters have been estimated, the expected or average WTP per herd is calculated as:

$$E(WTP) = \left(\frac{\alpha\bar{z} + \delta}{\beta}\right) \quad \text{Equation 5.11}$$

where α is a vector of estimated parameters from the logit model, δ is the estimated parameter on the herd variable in the logit model, β is the estimated parameter on the bid level variable in the logit model and $\bar{z}$ is a vector of the means of the variables included in the logit model. This value is the amount of money on average an individual would be willing to pay to conserve each caribou herd. Alternatively, it can be defined as the amount of money required to compensate an individual which would leave him or her as well off as without any additional conservation. This definition is referred to as compensating variation and represents the benefit of various levels of caribou conservation to each individual in the sample.

The conditional logit model will be estimated using the bid level and herd variable as explanatory variables. It is expected that the coefficient on the bid level will have a negative relationship with the probability of saying "yes"; respondents will be less likely to contribute to caribou conservation as the amount of this contribution is increased. It is also expected that the coefficient on the number of caribou herds will have a positive relationship with the probability of saying "yes"; respondents will be more likely to contribute to caribou conservation as the amount of herds to be conserved is increased. These models were prepared and estimated using *NLOGIT* software (Econometric Software 2011) and the results are depicted in Table 5.5[4].

The first two models presented in Table 5.5 include all the data, but have changed all the uncertain votes for the proposed strategy to the current strategy in order to reduce the presence of hypothetical bias. The rationale for recoding the data in this fashion is the literature suggests that definitely sure responses are more likely to correspond to the real yes responses (Blumenschein *et al*. 1998). In addition, the recoding will provide a more conservative welfare measure.

In the linear model, the coefficient on the status quo is negative and significant, indicating that respondents generally favoured the proposed management strategy as compared to the current management strategy. Thus, there is value in a caribou

[4] The models presented in this section were chosen based on both the adjusted ρ^2 value and on the theory presented in the literature. Linear and quadratic specifications for the herd variable were also calculated, but they did not seem to contribute any additional explanatory power. All model specifications are presented in Appendix J.

conservation program. The coefficient on the bid level is also negative and significant as is expected. In the log model, the bid level is the only significant variable and it is again negative as expected. Thus, in the CVM portion of the survey, respondents are insensitive to the number of caribou herds presented in the proposed management strategy; respondents are willing to pay the same amount for caribou conservation regardless of the number of herds to be conserved. In other words, participants, on average, feel strongly that caribou should be conserved, but the degree of conservation does not seem to matter. There are 508 observations of two rows each in the data set, and the adjusted ρ^2 value[5] is 0.05 for both models. This adjusted ρ^2 value is typical for models of this type in the literature (e.g. those without random parameters or unobserved heterogeneity).

The third and fourth models presented in Table 5.5 have rejected all those participants who are either not sure or do not feel their responses will have an impact on policy. Literature has suggested that if participants feel their responses to the survey will have an impact on policy, then they are more likely to be responding truthfully (Vossler *et al*. 2010). Less than half the data fits into this group with 209 observations which means that the majority of participants are either unsure or do not think their responses will have an impact on policy. The signs and significance, however, remain the same as in the recoded vote model, again indicating that there is value in caribou conservation programs and that respondents are insensitive to the number of caribou herds presented. The adjusted ρ^2 value is slightly higher than the recoded vote models at 0.06.

[5] The Adjusted R2 value is calculated by $1 - K\left(\frac{Log\ L}{LogL_0}\right)$ where $Log\ L$ is the log likelihood value of the unrestricted model, $LogL_0$ is the log likelihood value of the restricted model and K is an adjustment for the degrees of freedom and is calculated as $\frac{(\sum J_i - n)}{[(\sum J_i - n) - npfree]}$ (Greene 2007).

Table 5.5 Vote Models with Bid Level and both Linear and Natural Log Specifications for the Herd Term

	Recoded for Uncertainty[1]		Negative Policy Implications[2] Rejected	
	Linear	Natural Log	Linear	Natural Log
Status Quo	-0.746**	-0.769	-0.888*	-0.638
	(0.279)	*(0.474)*	*(0.444)*	*(0.757)*
Bid level	-0.002**	-0.002**	-0.003**	-0.003**
	(0.000)	*(0.000)*	*(0.001)*	*(0.001)*
Number of herds	-0.001		0.058	
(linear)	*(0.033)*		*(0.057)*	
Number of herds		-0.018		0.449
(log)		*(0.304)*		*(0.499)*
Observations	508	508	209	209
Log-likelihood	-330.89	-330.89	-124.29	-124.43
Adjusted ρ^2	0.05	0.05	0.06	0.06

* Statistically significant at the 90% level

** Statistically significant at the 99% level

[1] Using all the data in the sample but recoding the uncertain votes for the proposed strategy to the current strategy

[2] Only using the data from those respondents who thought their responses would have an impact on policy

5.3.2 Parametric analysis for attribute-based choice

Parametric analysis for the attribute based choice portion of this study is much the same as in the contingent valuation (CVM) portion in that respondents are maximizing their utility and, thus, random utility theory is utilized. However, respondents are no longer choosing between the current management strategy or status quo and some proposed change in the management strategy. Instead, respondents are asked to choose between two alternative management strategies which can exist simultaneously (Grafton *et al*. 2003). Thus, either management strategy choice will reduce the respondents' income by

the amount of the bid. The systematic or observed component of utility for either response is shown in the equations below:

$$V_1 = \beta(M - t_1) + \delta(H_1 - H_0) + \varepsilon_1 \quad \text{Equation 5.12}$$

$$V_2 = \beta(M - t_2) + \delta(H_1 - H_0) + \varepsilon_2 \quad \text{Equation 5.13}$$

A major difference with the attribute based choice models is that a constant term was not included. The rationale for not including the constant is that there is no status quo option for respondents to choose. In addition, there is no suspected left-right bias in the choice question as variations of the number of herds and cost were randomly placed for each question.[6]

In the linear case, the utility levels for each response are defined as:

$$V_{ij} = \beta\left(M_j - t_i\right) + \delta(H_i) + \varepsilon_{ij} \quad \text{Equation 5.14}$$

where i=1,2 for each management strategy. Thus, the change in the utility level can be defined as:

$$V_{1j} - V_{2j} = \beta(t_1 - t_2) + \delta(H_1 - H_2) + \varepsilon_j \quad \text{Equation 5.15}$$

The probability of an individual choosing management strategy A is:

$$Pr\left(A_j\right) = Pr\left(V_{1j} > V_{0j}\right) \quad \text{Equation 5.16}$$

$$Pr\left(A_j\right) = Pr\left(V_{1j} - V_{0j} > 0\right) \quad \text{Equation 5.17}$$

$$Pr\left(A_j\right) = Pr\left(\beta(t_1 - t_2) + \delta(H_1 - H_2) + \varepsilon_j > 0\right) \quad \text{Equation 5.18}$$

Again, a logistic distribution is chosen and the expected or average WTP per herd is calculated as:

$$E(WTP) = \frac{\delta(H_1 - H_2)}{\beta} \quad \text{Equation 5.19}[7]$$

[6] Models were also estimated which did include a constant term, and the constant was not significant.

[7] If δ or β vary across z parameters, then the resulting compensating variation will be multiplied by these parameters accordingly.

The conditional logit model will again be estimated using the bid level and herd variable as explanatory variables and the same expected relationships apply as in the CVM model. These models were again prepared and estimated using *NLOGIT* software (Econometric Software 2011) and the results are depicted in Table 5.6.

The first two models presented in Table 5.6 contain all the data in the sample. Both the coefficients on the bid level and on the herd variable are significant; the coefficient on the bid level is negative and on the herd variable is positive. Thus, in the choice portion of the survey, respondents are sensitive to both the price and the number of herds presented in the management strategies; respondents have a higher WTP if more caribou herds would be conserved. There are 501 observations and the adjusted ρ^2 value is either 0.11 or 0.12.

Table 5.6 Choice Models with Bid Level and both Linear and Natural Log Specifications for the Herd Term

	All Data[1]		Negative Policy Implications Rejected[2]	
	Linear	Natural Log	Linear	Natural Log
Bid level	-0.003**	-0.003**	-0.003**	-0.003**
	(0.000)	*(0.000)*	*(0.001)*	*(0.001)*
Number of herds	0.049*		0.097*	
(linear)	*(0.025)*		*(0.039)*	
Number of herds		0.491**		0.980**
(log)		*(0.175)*		*(0.274)*
Observations	501	501	207	207
Log-likelihood	-306.49	-304.37	-133.78	-130.06
Adjusted ρ^2	0.11	0.12	0.06	0.08

* Statistically significant at the 90% level

** Statistically significant at the 99% level

[1] Using all the data in the sample

[2] Only using the data from those respondents who thought their responses would have an impact on policy

The third and fourth models presented in Table 5.6 have rejected all those participants who are either not sure or do not feel their responses will have an impact on policy. With the total number of observations at 207, less than half of the sample believes their responses will have an impact on policy. Again, the signs and significance are similar as for the first two models. However, the adjusted ρ^2 value is lower than the first model at either 0.06 or 0.08.

5.3.3 Parametric analysis of joint model

The models in the previous two sections analyzed the vote and choice questions separately. In this section, both the vote and choice questions were analyzed together. The rationale for joint analysis is the ability to work with more data therefore increasing the robustness of model estimates as well as the creation of a single model which contains more information about the preferences of individuals (Adamowicz *et al*. 1998).

The indirect utility functions for the vote and choice models, shown as a subscript of v or c, are defined as:

$$V_v = \alpha_v + \beta_v t + \delta_v H + \varepsilon_v \qquad \text{Equation 5.20}$$

$$V_c = \alpha_c + \beta_c t + \delta_c H + \varepsilon_c \qquad \text{Equation 5.21}$$

These models may reflect the same preferences, and thus can be analyzed jointly, if the parameters between the two models are not significantly different from one another. A likelihood ratio test of H_0: $\beta_v = \beta_c \; and \; \delta_v = \delta_c$ against H_1: $\beta_v \neq \beta_c \; and \; \delta_v \neq \delta_c$ with a chi-squared distribution for the log models was used to determine if the β and δ coefficients are significantly different between the two models. Using two degrees of freedom (the number of restrictions imposed) and a five percent significance level, the calculated test statistic is less than the critical value thus the null hypothesis (H_0) cannot be rejected. We can conclude, therefore, that the vote and choice models reflect the same preferences. The specific calculations from this test are depicted in Appendix K.

The joint model is defined as:

$$V = \alpha + \beta t + \delta H + \mu \qquad \text{Equation 5.22}$$

where α is defined differently for both the CVM and the choice data. For the CVM data, $\alpha = 1$ for the status quo or current management strategy and $\alpha = 0$ for the proposed management strategy. For the choice data, $\alpha = 0$ as there is no status quo.

The conditional logit model will again be estimated using the bid level and herd variable as explanatory variables. However, it will also be estimated using various exogenous and potentially endogenous variables. The additional exogenous variables are income, age, gender and location. It is expected that the coefficient on the income variable would be negative as respondents with higher incomes would be less likely to choose the status quo. Age, gender and location are included to examine whether any other factors affect choice and WTP. Variables which are potentially endogenous are being included as they are used to check whether the responses are consistent with other variables that would likely reflect interest in caribou conservation. The additional endogenous variables are protecting wildlife from extinction, survey responses having an impact on policy and membership in an environmental club. All three of these variables are expected to be negatively related to the status quo; respondents who want to protect wildlife from extinction, who think their survey responses will have an impact on policy and who have a membership in an environmental club will be less likely to choose the status quo. These models were prepared and estimated using *NLOGIT* software (Econometric Software 2011) and the results are depicted in Table 5.7 and Table 5.8.

The first two models presented in Table 5.7 have included all the data, but have changed all the uncertain votes for the proposed strategy to the current strategy. The coefficient on the status quo for both models is significant and negative indicating that respondents generally favoured the proposed strategy as compared to the current strategy. The coefficient on the bid level is again negative and significant for both models and the herd variable is positive for both models but significant for the log model only. Thus, on the whole survey participants are sensitive to both the cost and the number of herds presented in the survey. There are 1009 observations in the sample and the adjusted ρ^2 value for both models is 0.08.

Table 5.7 Joint Vote and Choice Models with Bid Level and both Linear and Natural Log Specifications for the Herd Term

	Recoded for Uncertainty[1]		Negative Policy Implications Rejected[2]	
	Linear	Natural Log	Linear	Natural Log
Status Quo	-0.584** *(0.141)*	-0.385* *(0.185)*	-0.650** *(0.215)*	-0.161 *(0.282)*
Bid level	-0.003** *(0.000)*	-0.003** *(0.000)*	-0.003** *(0.000)*	-0.003** *(0.000)*
Number of herds (linear)	0.026 *(0.018)*		0.088** *(0.028)*	
Number of herds (log)		0.281* *(0.128)*		0.812** *(0.203)*
Observations	1009	1009	416	416
Log-Likelihood	-638.22	-636.88	-258.27	-255.00
Adjusted ρ^2	0.08	0.08	0.08	0.09

* Statistically significant at the 90% level

** Statistically significant at the 99% level

[1] Using all the data in the sample but recoding the uncertain votes for the proposed strategy to the current strategy

[2] Only using the data from those respondents who thought their responses would have an impact on policy

The second model presented in Table 5.7 has excluded all those participants who are either not sure or do not feel their responses will have an impact on policy. Less than half the data are included in this group with only 416 observations which means that the majority of participants are either unsure or do not think their responses will have an impact on policy. The coefficient on the status quo variable is significant only in the linear model, but the coefficients on both the bid level and on the herd variable behave as expected. The adjusted ρ^2 value is slightly higher than the recoded vote model at 0.08 and 0.09.

Table 5.8 presents an exogenous and an endogenous model. All of the variables included, besides the bid level and number of herds, were interacted with the status quo as they are individual specific and not program specific. The variables included in the exogenous model were chosen in part because they are the variables most often included in models of this type in the literature (Boxall *et al*. 2012). The coefficient on the bid level is negative and significant indicating that as the bid level for a certain management strategy increased, the respondents' desire to choose that management strategy decreased. The natural log coefficient on the herd variable is positive and significant indicating that as the number of herds increased for a certain management strategy, the respondents' desire to choose that management strategy also increased. The coefficient on the income variable, which has been interacted with the status quo, is negative and significant indicating that as the income of a participant is increased, the respondents' desire to choose the proposed management strategy is increased as well. All three of these variables performed as they were expected to. The coefficient on the age variable is positive and significant indicating that as the age of the participant is increased, their desire to choose the current management strategy is increased. The location dummies included were Edmonton, Calgary and Grande Prairie, so these results are relative to the omitted location dummy which was Lloydminster. The coefficients on Edmonton and Calgary were not significant, but the coefficient on Grande Prairie is significant and positive indicating that participants from Grande Prairie were less likely to choose the proposed management strategy relative to participants from Lloydminster. This is an interesting result and may reflect the fact that the oil and gas industry is more prevalent in the region surrounding Grande Prairie than in the regions surrounding the other survey locations (Statistics Canada (b)). The coefficient on the gender variable was not significant in the model. These results reflect those found in similar models on species at risk (Boxall *et al*. 2012). There are 991 observations in the sample, and the adjusted ρ^2 value is 0.10.

Table 5.8 Joint Vote and Choice Models with Exogenous and Potentially Endogenous Variables (Recoded for Uncertainty, Natural Log Specification for the Herd Term)

	Exogenous Model	Endogenous Model
Status Quo	-0.983*	0.376
	(0.489)	*(0.247)*
Bid level	-0.003**	-0.003**
	(0.000)	*(0.000)*
Number of herds (log)	0.349**	0.342**
	(0.131)	*(0.131)*
Income (in thousands of	-0.005*	
dollars)	*(0.002)*	
Age	0.021**	
	(0.007)	
Edmonton	-0.342	
	(0.304)	
Calgary	0.058	
	(0.317)	
Grande Prairie	0.733*	
	(0.352)	
Gender (male=1)	0.181	
	(0.199)	
Protecting wildlife from		-0.703**
extinction (do more=1)		*(0.199)*
Your responses will have an		-0.682**
impact on policy		*(0.200)*
Member of an		-0.590
environmental club (yes=1)		*(0.446)*
Observations	991	999
Log-Likelihood	-610.56	-616.41
Adjusted ρ^2	0.10	0.10

* Statistically significant at the 90% level

** Statistically significant at the 99% level

Many of the attitudinal variables which could have been included in the endogenous model are likely strongly correlated with each other. Thus, a correlation matrix was used to determine those variables which had a low correlation and could thus be included in the model. The chosen variables are protecting wildlife from extinction, responses having an impact on policy and membership in an environmental club. Wildlife and policy have a correlation of -0.01, policy and environmental club 0.02 and wildlife and environmental club 0.01 which are all weak correlations.

Table 5.8 also contains results from the model including potentially endogenous variables. The coefficient on the bid level was again significant and negative indicating that as the bid level for a certain management strategy was increased, the respondents' desire to choose that management strategy decreased. The natural log coefficient on the herd variable is positive and significant indicating that as the number of herds increased for a certain management strategy, the respondents' desire to choose that management strategy also increased. Those respondents who thought we should do more to protect wildlife from extinction were more likely to choose the proposed management strategy, as is evident from the negative and significant coefficient on this variable. Likewise, those respondents who thought their responses to this survey would have an impact on policy were also more likely to choose the proposed management strategy. The coefficient on having a membership in an environmental club was not significant in the model. There are 999 observations in this model and the adjusted ρ^2 is 0.10.

Additional models were estimated to explore the significance of the coefficient on the Grande Prairie variable and its potential role in explaining the insensitivity to the number of herds variable in the vote model. From the model in Appendix L, it appears that younger respondents and those who are not from Grande Prairie are sensitive to the number of herds variable in the vote data (and exhibit scope). Interactions with the bid variable were also explored, but no significant differences were found; on average, respondents do not seem to differ in terms of their preferences over bid value or their marginal utility of money.

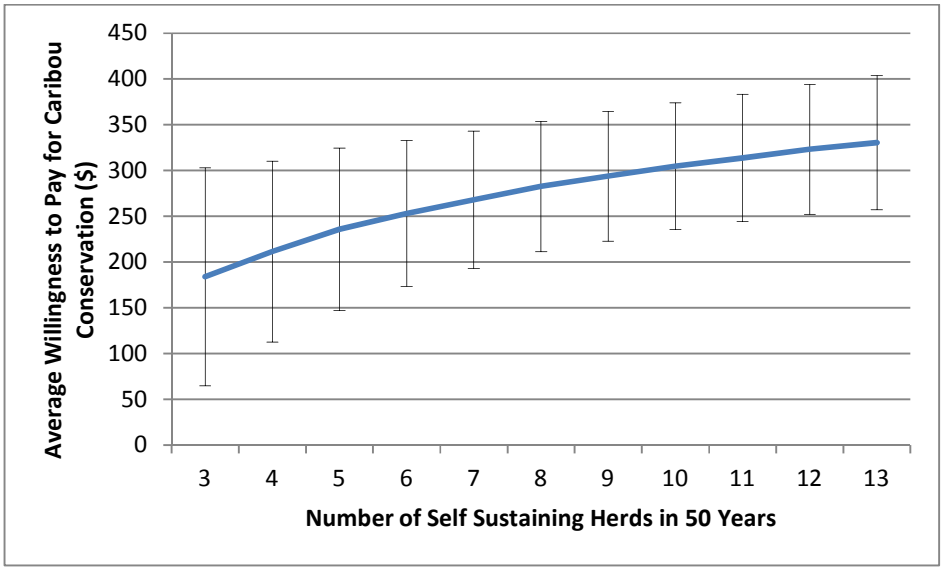

Figure 5.1 Average WTP from the joint model for caribou conservation under each potential conservation strategy (natural log specification for the herd term). The bars provide an estimate of the 95% confidence interval for each estimate of household WTP (based on the Krinsky-Robb 1986 method).

Table 5.9 Mean and Standard Deviation of the WTP Estimates for the Joint Model Recoded for Uncertainty (Natural Log Specification for the Herd Term)

	Movement from 2 to 3 Herds	Movement from 2 to 7 Herds
Mean of WTP estimate	$184.02	$268.17
Standard deviation	$60.73	$38.35

The average WTP and standard deviation for caribou conservation were calculated for the joint model recoded for uncertainty using the bid level and the natural log specification for the herd term. The results are depicted in Figure 5.1 and Table 5.9. The Krinsky-Robb method (Krinsky and Robb 1986) was used to calculate the variances. 5,000 draws from a multivariate normal distribution were taken. The WTP ranges from $184.02 per household per year for three herds to $330.36 per household per year for 13 herds. For a movement from two to three herds, the total WTP is $184.02 per household per year with a standard deviation of $60.73. For a movement from two to

seven herds, the total WTP is $268.17 per household per year with a standard deviation of $38.35.

5.3.4 Random parameters logit model

Random utility models based on the simple type one extreme value error distribution make several fundamental assumptions which can be restrictive when attempting to explain individuals' behaviour (Train 1998). The first is homogeneity, which implies that all individuals have the same tastes or preferences and thus the estimated coefficients will be the same for all individuals in a sample. The second is the property of "independence from irrelevant alternatives" or equal cross elasticities across products. This property necessitates that a change in the attributes of one alternative will change the attributes of another alternative proportionately. Finally, sequential choice decisions made by each individual are assumed to be independent from one another over time. These assumptions can be relaxed by using a random parameters logit (RPL) model. This method assumes a continuous distribution for heterogeneity by allowing the estimated coefficients to vary randomly across individuals in the sample.

The following theoretical description of RPL models relies heavily on the paper by Train (1998). Individual j chooses management strategy i such that his or her utility is obtained by:

$$U_{ij} = \alpha_i + \beta M_j + \delta_j H_{ij} + \varepsilon_{ij} \qquad \text{Equation 5.23}$$

where α_i is the alternative specific constant for the status quo, β is the marginal utility of income which does not vary across individuals, M_j is individual j's income, δ_j is the coefficient on the herd variable which is unobserved and vary randomly representing the tastes of individual j, H_{ij} is the observed number of herds which relate to individual j and management strategy i and ε_{ij} is an unobserved random term that is identically and independently distributed extreme value and is independent of the other variables in the equation. Equation 5.23 can also be written as:

$$U_{ij} = \gamma^{*\prime} x_{ij} + \varepsilon_{ij} \qquad \text{Equation 5.24}$$

where $\gamma^{*\prime}$ is a vector of coefficients that vary randomly across individuals and is not known to the researcher (in this case α_i, β and δ_j), and x_{ij} is a vector of observed

variables (in this case M_j and H_{ij}). The important difference with the RPL specification as compared to the standard logit model explained in the previous sections is that the coefficient $\gamma^{*\prime}$ now varies across individuals rather than being fixed (Train 1998). This variation means that utility is correlated over management strategies. If we focus on the parameter on herds (H), then $\gamma^{*\prime}$ can be decomposed into the summation:

$$\gamma^{*\prime} = bH_{ij} + \eta_j H_{ij} \qquad \text{Equation 5.25}$$

where b is the population mean which can be estimated by the researcher and η_j is the tastes of individual j relative to the average tastes of all individuals in the sample which cannot be observed by the researcher. Thus, utility becomes:

$$U_{ij} = \alpha_i + \beta M_j + bH_{ij} + \eta_j H_{ij} + \varepsilon_{ij} \qquad \text{Equation 5.26}$$

Both $\eta_j H_{ij}$ and ε_{ij} are unobserved terms in the equation above and are therefore correlated over management strategies.

If the researcher knew the preferences of all the individuals in the sample, γ^*, was equal to γ then the choice probability, L_{ij}, for individual j for management strategy i would be:

$$L_{ij} = \frac{e^{\gamma' x_{ij}}}{\sum_j e^{\gamma' x_{ij}}} \qquad \text{Equation 5.27}$$

However, the researcher does not know the preferences of individuals in the sample. The researcher can assume that these preferences vary according to the density of γ represented by $f(\gamma)$. This density is a function of various parameters θ such as the mean and standard deviation of individual preferences in the sample. Thus, we take the integral of Equation 5.27 weighted by $f(\gamma)$ to find the choice probability, $Q_{ij}(\theta)$:

$$Q_{ij}(\theta) = \int L_{ij}(\gamma) f(\gamma|\theta) d\gamma \qquad \text{Equation 5.28}$$

Maximum likelihood estimation of the simple logit model uses the product of the probabilities of each individual's choice or:

$$S_j(\gamma) = \prod_i L_{ij}(\gamma) \qquad \text{Equation 5.29}$$

However, in the case of random parameters logit the probabilities are weighted by the assumed distribution of the random parameters, and the likelihood function becomes Equation 5.29:

$$P_j(\theta) = \int S_j(\gamma) f(\gamma|\theta) d\gamma \qquad \text{Equation 5.30}$$

Maximum likelihood estimation is implemented by running 100 simulations over randomly chosen values for the parameters and taking the average. The models are estimated assuming a normal distribution for the random variable and Halton draws (Greene 2007) using *NLOGIT* software (Econometric Software 2011). The results are depicted in Table 5.10. It is expected that continuous heterogeneity exists in the sample across the number of herds presented in the management strategies.

The results from the random parameters logit models are depicted in Table 5.10. The general conclusion from all of these models is that there is evidence of continuous preference heterogeneity in the number of herds across the sample[8]. Although many model specifications were estimated, three of these models were chosen to be presented in this analysis based both on statistical criteria and on the theory presented in the literature. One such criterion used to measure the relative goodness of fit of a statistical model is the Akaike Information Criterion (AIC) which is a log-likelihood criteria with an adjustment for the degrees of freedom and is given by:

$$AIC = 2q - 2\ln(\hat{L}) \qquad \text{Equation 5.31}$$

where q is the number of parameters and $\hat{L}$ is the estimated log likelihood value (Cameron and Trivedi 2005). Smaller AIC values are preferred. The second criterion used is McFadden's Pseudo ρ^2 which is given by:

$$\rho^2 = 1 - \frac{logL_1}{logL_0} \qquad \text{Equation 5.32}$$

where $logL_1$ is the maximum log-likelihood value of the model of interest and $logL_0$ is the maximum value of the log-likelihood function when all parameters, except the

[8] The chosen RPL models specify only the number of herds to be random. It should be noted that the status quo term could also be specified as random. Iterations with both the herd variable and the status quo as random variables were estimated, but did not significantly add to the explanatory power of the model and thus were not included for simplicity.

intercept, are set equal to zero (Verbeek 2007). This criterion gives a higher value for a model with a greater likelihood.

Table 5.10 Random Parameters Logit Models for Vote, Choice and Joint Models (Natural Log Specification for the Herd Variable)

	Vote Model[1]	Choice Model[2]	Joint Model[1]
Status Quo	-0.930		-0.508*
	(0.721)		*(0.260)*
Bid Level	-0.005**	-0.006**	-0.005**
	(0.001)	*(0.001)*	*(0.001)*
Number of herds	0.451	0.679	0.713**
(log)	*(0.512)*	*(0.450)*	*(0.236)*
Standard deviation	1.648**	3.538**	1.864**
of logged herd	*(0.305)*	*(0.670)*	*(0.212)*
Observations	508	501	1009
Log-Likelihood	-309.82	-278.71	-567.55
AIC	1.24	1.12	1.13
McFaddens Pseudo ρ^2	0.12	0.20	0.19

* Statistically significant at the 90% level

** Statistically significant at the 99% level

[1] Using all the data in the sample but recoding the uncertain votes for the proposed strategy to the current strategy

[2] Using all the data in the sample

In the vote RPL model, the coefficient on the bid level and on the standard deviation of the log herd are significant, whereas the coefficient on the status quo and on the log number of herds are not significant. We can thus conclude that there is significant heterogeneity in the preferences over the number of herds. In appears that respondents feel either positive or negative about the number of caribou herds that should be conserved and thus the net effect cancels out (log number of herds). In the choice model, the coefficient on the bid level and on the standard deviation of the log herd are significant, whereas the log coefficient on the number of herds is not significant. Again,

we can conclude that there is significant heterogeneity in the preferences over the number of herds, and respondents feel either positive or negative and that the net effect cancels out. In the joint model, all coefficients on the variables are significant indicating that there is strong continuous heterogeneity in preferences around the number of caribou herds which should be conserved.

5.3.5 Motivations for valuation question responses

After each valuation question, respondents were asked to rate the importance of each attribute in making their final valuation decision. For both question formats, over half of respondents said the number of herds was either very important or extremely important, while almost 75 percent of respondents said the household cost was either very important or extremely important in making their final valuation decision. These numbers are very similar for both the CVM and choice question formats (see Table 5.11). This table illustrates a similar finding as in the vote model where people thought cost was more important than the number of herds in making their valuation decision. Respondents seem to be indifferent more often about the number of herds than they are about the costs.

Table 5.11 Relative Importance of Each Attribute in Final Valuation Decision

Attribute	Relative Importance	CVM (%)	Choice (%)
Number of herds	Not at all important	4.96	4.63
	Somewhat important	41.9	45.7
	Very important	38.3	35.8
	Extremely important	14.9	13.9
Household cost	Not at all important	5.63	3.29
	Somewhat important	23.1	21.8
	Very important	43.1	45.3
	Extremely important	28.2	29.6

Table 5.12 Reasons for Valuation Decision, as a Percentage of the Total Number Who Voted for that Management Strategy

	CVM	Choice
	Current Management Strategy (%, n=199)	Management Strategy with Fewer Herds (%, n=318)
I believe that [the other option] is too much money for the associated improvement in caribou populations	46.7	69.8
There are other things, including other environmental protection options, where my money would be better spent	50.0	52.2
I do not believe the proposed management strategy will actually generate the improvements in caribou populations[9]	31.2	22.3
I do not have enough information to make this decision	19.6	17.0
Other	26.1	20.4

Table 5.12 and Table 5.12 depict the reasons respondents gave for their final valuation decision. The percentages depicted in these tables do not add to 100 percent as respondents were allowed to check all the reasons that applied. Table 5.12 contains percentages for those who voted for the current management strategy (which has fewer herds) in the CVM question and those who voted for the management strategy with fewer herds in the choice question. Of those who voted for the current

[9] Models were estimated without those respondents who rejected the scenario (defined as those who chose this reason). These models are found in Appendix M. However, as respondents were asked in the survey to check all the reasons that applied, rather than just their main reason, using this definition for those who rejected the scenario is likely rather restricting.

management strategy in the CVM question, the two most popular reasons for voting this way were “I believe that is too much money for the associated improvement in caribou populations” and “There are other things, including other environmental protection options, where my money would be better spent”. Of those who voted for the management strategy with fewer herds in the choice question, the two most popular reasons for voting this way were the same as in the CVM question. The household cost seems to be relatively more important in the choice question than in the CVM question.

Table 5.13 contains percentages for those who voted for the proposed management strategy (which has more herds) in the CVM question and those who voted for the management strategy with more herds in the choice question. Of those who voted for the proposed management strategy in the CVM question, the two most popular reasons for voting this way were “The improvement in caribou populations is worth the money” and “I believe the proposed management strategy will actually generate the improvements in caribou populations”. Of those who voted for the management strategy with more herds in the choice question, the two most popular reasons for voting this way were the same as in the CVM question.

Table 5.13 Reasons for Valuation Decision, as a Proportion of the Total Number Who Voted for that Management Strategy

	CVM	Choice
	Proposed Management Strategy (%, n=301)	Management Strategy with More Herds (%, n=159)
The improvement in caribou populations is worth the money	59.5	64.8
We should pay whatever it takes to conserve caribou populations[10]	18.6	25.2
This is a good use of money compared to other things provincial government money could be spent on	43.9	51.6
I believe the proposed management strategy will actually generate the improvements in caribou populations	55.5	57.9
Other	28.2	24.5

5.3.6 Aggregation of welfare measures

As the survey elicited household WTP, the resulting compensating variation calculations are also at the household level. This was aggregated for the province of Alberta by multiplying the figures by the number of households in Alberta in 2006 which was 1,256,190 (Statistics Canada (b)).

[10] In order to eliminate the presence of warm glow, models were estimated without those respondents who chose this reason. These models are found in Appendix M. However, as respondents were asked in the survey to check all the reasons that applied, rather than just their main reason, using this definition for the presence of warm glow is likely rather restricting.

It is important to note that the graphs in this section have a horizontal axis which depicts a maximum of 13 herds to be conserved. This differs from the graphs in previous sections of this thesis in which the horizontal axis goes up to 14. This is because the cost data suggests that the 14th herd cannot be conserved even if recovery actions begin immediately (Hauer *et al*. 2011). Thus, the maximum number of herds to be conserved in the valuation questions was 13.

Three functional forms for the herd variable are shown in the provincial cost and benefit graphs: Figure 5.2 depicts the linear form of the herd term, Figure 5.3 depicts the natural log form of the herd term and Figure 5.4 depicts the quadratic form of the herd term. All three functional forms are presented here for comparison purposes. These graphs show the total costs and benefits as opposed to the marginal costs and benefits since the number of herds is not a continuous variable. Thus, the point at which the net benefits are maximized (maximum distance between the two curves) represents the optimal level of caribou conservation for society. The benefit calculations include the status quo variable.

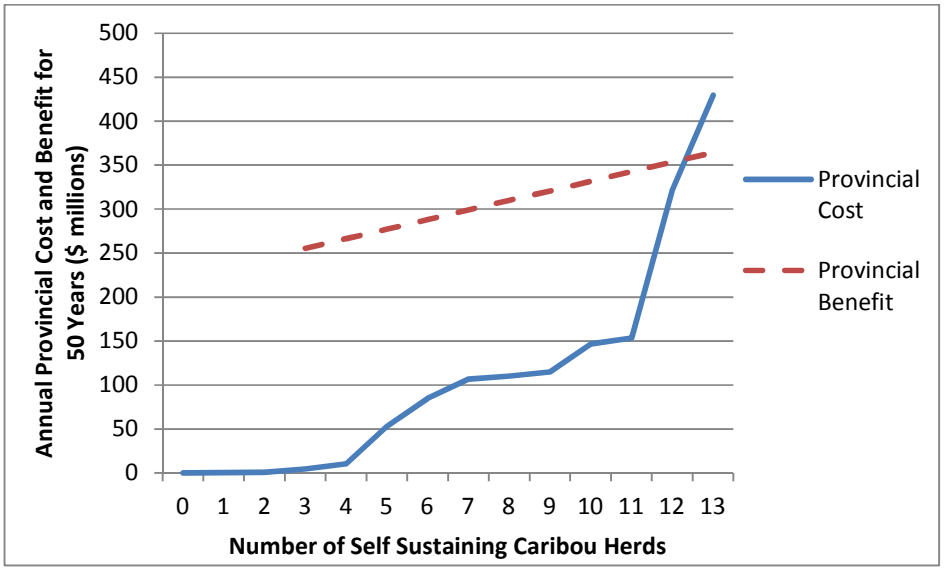

Figure 5.2 Annual provincial cost and benefit (linear specification for the herd term, joint model)

Figure 5.2 shows the annual provincial benefit using the linear functional form for the herd variable. As the smallest number of herds provided to respondents in the choice model was three herds, the total benefits also begin at three herds on the graph. The benefits exceed the costs over most of the range of the graph, and the net benefits of caribou conservation are maximized at four herds at approximately $256 million (benefits of approximately $266 million, costs of approximately $10 million). However, the net benefits of conservation are similar for a range of herd levels; specifically from about three herds to 11 herds. Using the linear functional form is restrictive in that it requires that the amount individuals are willing to pay for each additional herd is held constant; thus, individuals are willing to pay the same amount to move from three to four herds as they are to move from 12 to 13.

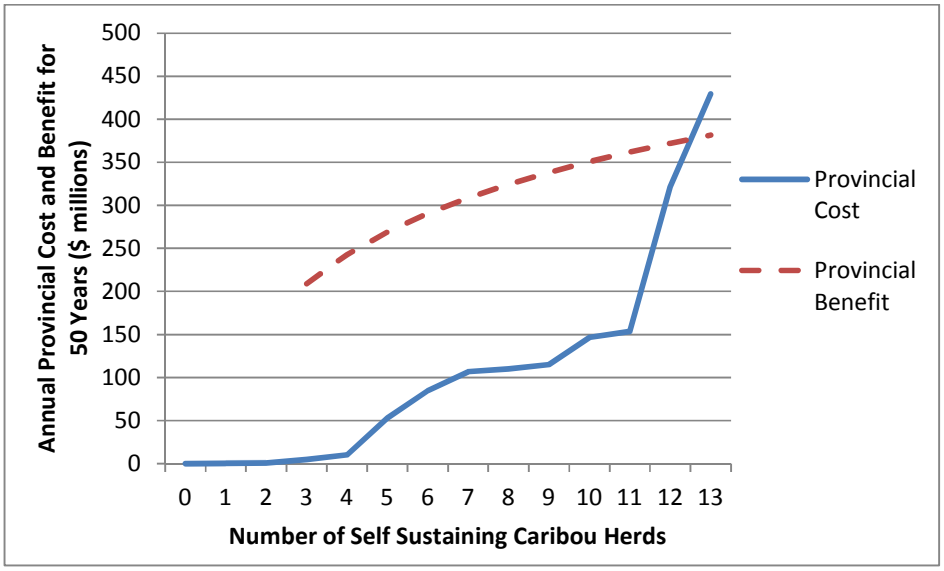

Figure 5.3 Annual provincial cost and benefit (natural log specification for the herd term, joint model)

Figure 5.3 shows the annual provincial benefit using the natural log form for the herd variable. The benefits again exceed the costs over most of the range of the graph, and the net benefits of caribou conservation are maximized at four herds at approximately $232 million (benefits of approximately $243 million, costs of approximately $10 million). However, the net benefits of conservation are similar for a range of herd levels; specifically, from three herds to 11 herds. This functional form is less restrictive in that it allows for diminishing returns to the number of caribou herds conserved; thus, individuals may be willing to pay more to move from three to four herds than they are to move from 12 to 13 herds. Using the log functional form has the additional benefit of maintaining positive economic benefits; conserving more caribou in the province is likely always desirable.

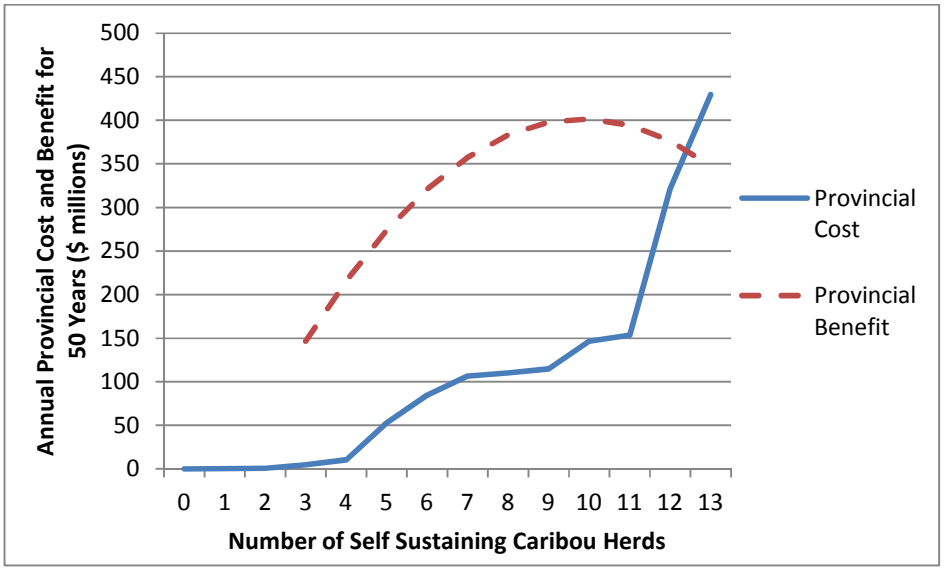

Figure 5.4 Annual provincial cost and benefit (quadratic specification for the herd term, joint model)

Figure 5.4 shows the annual provincial benefit using the quadratic functional form for the herd variable. The benefits exceed the costs over most of the range of the graph, and the net benefits of caribou conservation are maximized at nine herds at approximately $283 million (benefits of approximately $398 million, costs of approximately $115 million). Again, the net benefits of conservation are similar across a range of herd levels; from about four herds to 11 herds. Using the quadratic functional form does allow for decreasing marginal values, as in the log model; however, this model suggests that conserving more caribou in the province is not always desirable as the benefits actually decrease over 10 herds.

5.4 Conclusions

This section outlined the descriptive statistics of the sample which highlighted the concern for caribou among the residents of Alberta. The parametric analysis of the CVM data showed that respondents were generally insensitive to the number of herds when making their valuation decisions. In contrast, the parametric analysis of both the choice data and the joint data indicated that respondents were sensitive to the number of herds. Respondents were willing to pay, on average, approximately $184.02 per household per year for three self-sustaining caribou herds, and approximately $330.36

per household per year for 13 self-sustaining caribou herds. Income and age of the respondents as well as the location of the workshops seem to be variables which help explain the respondents' valuation choice. The random parameters logit model confirms the presence of continuous heterogeneity in the sample across the number of herds, and indicates that respondents feel either positive or negative towards the number of herds in the management strategy. Aggregation of welfare measures over the sample was performed for three different functional forms of the herd variable. The natural log form of the herd variable is preferred as it aligns the closest with expectations of individual perceptions of caribou. The optimal level of conservation for society as a whole occurs at the maximum difference between the benefits and the costs, which occurs from approximately four to 11 herds.

6 Discussion and Conclusions

The aim of this thesis is to determine the willingness to pay (WTP) for Woodland Caribou conservation in Alberta. The federal legislation on species at risk requires that socio-economic analysis be completed to aid in the formation of species recovery plans for those species that are currently listed as being at risk. Combining aggregated WTP with data on the provincial costs of various caribou conservation programs provides information to inform the determination of the optimal level of conservation for the province. It is important to note that this study focuses on the Woodland Caribou herds in Alberta, including both the boreal and the mountain ecotypes. The draft federal recovery strategy for Woodland Caribou (Government of Canada 2011) focuses on the boreal ecotype only.

This survey utilized three unique methods in survey administration: group-based surveys, audience response systems and the ballot box technique. However, research budget constraints precluded a formal analysis of these innovative procedures. Performing surveys in a group addressed many of the challenges of valuation, such as information bias and lack of preformed preferences, as it provided the opportunity for group discussion. Audience response systems have proven in this case to be an exceptional tool for ensuring that participants are engaged in the information presentation. In general, this technology was favourably received at each workshop. The ballot box technique also proved to be a useful method of separating valuation tasks so that participants answered each valuation question independently from the other questions.

This research used both the traditional contingent valuation method (CVM) as well as a form of attribute based choice. The CVM task required participants to choose between the current management strategy and a proposed management strategy. The attribute based choice task required participants to choose between two different management strategies, each with a cost and herd level associated with them. However, respondents were not given an option to choose neither of the management strategies in the choice task. This is to reflect the fact that species at risk legislation requires that some action is taken toward conservation, and that not doing anything is technically not an option.

Thus, the form of attribute based choice in this survey differs from that which is used most often in the literature.

A key conclusion from this research is that residents of Alberta are concerned about Woodland Caribou and are willing to pay for conservation for this species. The average WTP ranged from $184.02 for three herds, to $330.36 for 13 herds and the benefits of caribou conservation exceed the costs for the majority of the management strategy options. The optimal level of conservation for society as a whole occurs at the maximum difference between the benefits and the costs, which occurs from approximately four to 11 herds. The net benefit to the province at this range of herd levels is approximately $200 million per year. This is a conservative estimate as it includes adjustments made for uncertainty.

A potential shortcoming of this research is the inherent complexity in the valuation task. The workshop was long and a great deal of information was presented, much of which would have been new information for participants. In addition, as was determined by the focus groups, some participants felt uncomfortable with the vote and choice tasks in that they were ultimately deciding the fate of some caribou herds as compared to other herds. Every effort was made through the focus groups and during the workshops themselves to ensure that participants understood the valuation task and that they felt free to ask any questions or express any opinions throughout. However, it is still possible that some respondents did not understand the valuation task.

Another shortcoming in this research concerns the representativeness of the sample. Although the sample data are reasonably representative of the Alberta population in that key demographic characteristics are similar to provincial averages (Statistics Canada (b)), we cannot be sure that the data are representative of the Alberta population in terms of environmental attitudes and perceptions.

A potential source of bias in the data which was not expected was the learning that occurred in the researchers themselves, even though every effort was made to keep the material and the presentation relatively consistent across all workshops. We not only became more efficient at doing the workshops over time, but we also learned how to present the information in such a way that common misconceptions or questions were

answered. This learning would potentially mean that the last few surveys may be truer representations of the general public's feelings toward caribou conservation than the first few surveys. The focus groups we conducted to pre-test the survey instrument may help reduce the presence of this bias.

Respondents were provided with two CVM questions and two choice questions in the valuation portion of the survey. The CVM questions always came before the choice questions. Thus, it is possible that there may be an order effect in that respondents may respond to the initial valuation questions differently than the final valuation questions. Models were estimated with results from the first CVM question removed to test for this bias, and the results were not significantly different than when the first CVM question was included in the analysis. Thus, we can reasonably conclude that there is little evidence of such a bias in this data set. However, this is still a potential limitation in this study.

Respondents were provided with a great deal of information during the workshops regarding species at risk in the province. Thus, it is possible that participants were basing their response to the WTP questions on all species at risk in the province. However, every attempt was made to ensure that respondents were aware that the valuation questions were eliciting WTP values for Woodland Caribou conservation only.

This survey sought to determine the efficient outcome for caribou conservation given both the economic costs and benefits. However, there are other concerns than mere efficiency when determining how much conservation action to engage in. These include equity or distribution, the probability of a herds' survival or potential future impacts of climate change (Schneider *et al*. 2010). In addition, there is still considerable uncertainty surrounding, for example, the future price of oil which will affect the estimates presented here. However, the aim of this research is to determine the optimal level of conservation for society as a whole by taking into account as many of the tradeoffs implicit in making such a decision as is possible. The results presented here provide information to be used in the determination of the socially optimal level of conservation.

Additional research in this area should be completed which formally analyses the innovative procedures used in this study. These procedures are audience response systems, the ballot box technique and group based surveys. Participant reactions as well as data analysis suggest that these procedures positively contributed to this study and thus further research on the actual merits of these procedures is warranted.

There are many more species at risk in both Alberta and across Canada. Although performing a cost benefit analysis at this level of detail is not feasible for every species that is listed, emphasis on the socioeconomic component of the legislation has generally been lacking in the creation of a final recovery strategies. Socioeconomic analysis is one important tool, among others, that should be used in the decision making process.

Much of the recovery action to date for the Woodland Caribou has relied on guidelines, restrictions and best practices for resource extraction industries. Despite these actions, caribou are still declining across the country (Environment Canada 2008). The analysis presented here indicates that recovery of the Woodland Caribou, and other species at risk, lies more in difficult tradeoff decisions of how to best allocate scarce resources (Schneider *et al*. 2010).

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Appendix A: Workshop Powerpoint Presentation

Outline

- Species at Risk Legislation
- Background on Woodland Caribou
- Reasons for population decline
- Relationship with resource industries
- Caribou conservation
- Considering caribou conservation options

Partners in this Project

Funded by the Social Sciences and Humanities Research Council of Canada (SSHRC)

Letters of support:

- Alberta Sustainable Resource Development
- Alberta Caribou Committee
- Environment Canada
- Canadian Association of Petroleum Producers
- Alberta Pacific Forest Industries

iClicker Test

Who would you have chosen for best actor in the 2010 Academy Awards?

- Javier Bardem in *Biutiful* (A)
- Jeff Bridges in *True Grit* (B)
- Jesse Eisenberg *in The Social Network* (C)
- Colin Firth in *The King's Speech* (D)
- James Franco in *127 Hours* (E)

Question 1

Before we begin asking questions about Species at Risk we would like to have your opinions about some more general issues. The following slides will list social, economic and environmental issues facing Canadians. Some may not be important to you, others may be. For each issue, would you say **Canadians** should be doing less, about the same or more than we are today?

Question 1 continued

Would you say **Canadians** should be doing less, about the same or more than we are today in reducing air and water pollution?

- Do less (A)
- Do about the same (B)
- Do more (C)
- Not sure (D)

Question 1 continued

Would you say **Canadians** should be doing less, about the same or more than we are today in protecting parks and wildlife reserves?

- Do less (A)
- Do about the same (B)
- Do more (C)
- Not sure (D)

Question 1 continued

Would you say **Canadians** should be doing less, about the same or more than we are today in protecting wildlife from extinction?

- Do less (A)
- Do about the same (B)
- Do more (C)
- Not sure (D)

Question 1 continued

Would you say **Canadians** should be doing less, about the same or more than we are today in improving roads and highways?

- Do less (A)
- Do about the same (B)
- Do more (C)
- Not sure (D)

Question 1 continued

Would you say **Canadians** should be doing less, about the same or more than we are today in encouraging economic growth and jobs?

- Do less (A)
- Do about the same (B)
- Do more (C)
- Not sure (D)

Question 1 continued

Would you say **Canadians** should be doing less, about the same or more than we are today in improving health care?

- Do less (A)
- Do about the same (B)
- Do more (C)
- Not sure (D)

Question 1 continued

Would you say **Canadians** should be doing less, about the same or more than we are today in improving education?

- Do less (A)
- Do about the same (B)
- Do more (C)
- Not sure (D)

Question 1 continued

Would you say **Canadians** should be doing less, about the same or more than we are today in reducing taxes?

- Do less (A)
- Do about the same (B)
- Do more (C)
- Not sure (D)

Background

Species at risk legislation
Description and significance of species
Population trends

Species at Risk

- Legislation provides legal protection and recovery plans for species at risk of extinction
- Canada: *Species at Risk Act* (2003)
- Alberta: *Wildlife Act* (2000)
- Woodland caribou are listed as 'threatened' both federally and provincially (COSEWIC 2002, GOA 2010b)

Requirements of Legislation

www.yfwmb.yk.ca

- Identify both long term and short term actions for a species' recovery plan
- Protect critical habitat for those species which are designated as either threatened or endangered
- Provide compensation to individuals where necessary
- Make documents and decisions available to the general public

Species at Risk Legislation in Alberta

Endangered	Threatened	Special Concern
•Whooping crane (*Grus americana*) •Swift fox (*Vulpes velox*)	•Grizzly bear (*Ursus arctos*) •**Woodland caribou (*Rangifer tarandus caribou*)**	•Sprague's pipit (*Anthus spragueii*) •Harlequin duck (*Histrionicus histrionicus*)

Question 3

Before today, had you heard of the *Species at Risk Act?*

- Yes (A)
- No (B)
- Not sure (C)

Question 4

Before today, had you heard of the *Alberta Wildlife Act?*

- Yes (A)
- No (B)
- Not sure (C)

Question 5

How important is it to you personally that every possible effort be made to protect all species that are currently at risk?

- ❑ Not at all important (A)
- ❑ A little important (B)
- ❑ Very important (C)
- ❑ Extremely important (D)
- ❑ Not sure (E)

Caribou in Canada

- Four subspecies exist:
  - **Woodland Caribou** (Boreal Forests)
  - Peary Caribou (Arctic)
  - Barren Ground Caribou (Alaska, NWT)
  - Grant's Caribou (Alaska, Yukon)
- Fifth subspecies: Dawson's Caribou declared extinct in 1984 (Rothfels and Russell 2005)

cidc.library.cornell.edu

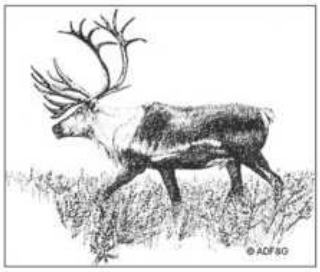
Question 6

Before today, how familiar would you say you were with Woodland Caribou?

- ❑ Not at all familiar (A)
- ❑ Not very familiar (B)
- ❑ Somewhat familiar (C)
- ❑ Very familiar (D)
- ❑ Not sure (E)

Woodland Caribou

- Medium-sized members of deer family
- Feed on lichen, forbs, shrubs
- Live in large stands of undisturbed mature to old forests or peatlands
- Found in low densities
- Low reproductive rate
- Average lifespan 8-10 years
- 2 Ecotypes: Boreal Caribou versus Mountain Caribou (ACC 2006)



adfg.state.ak.us

Question 7

Before today, were you aware that Woodland Caribou in Alberta are at risk?

- Yes (A)
- No (B)
- Not sure (C)

Question 8

Have you ***personally*** ever observed caribou in nature?

- Yes (A)
- No (B)
- Not sure (C)

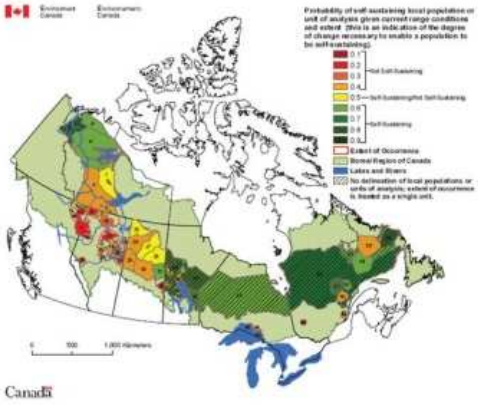
Question 9

How interested are you in observing caribou in nature in the future?

- ❑ Not at all interested (A)
- ❑ Somewhat interested (B)
- ❑ Very interested (C)
- ❑ Extremely interested (D)
- ❑ Not sure (E)

Woodland Caribou in Canada

- Present in boreal forests across western Canada and many parts of eastern Canada
- Boreal forests shaded in light green
- Other colors represent distribution of boreal ecotype of woodland caribou



Environment Canada 2008

Woodland Caribou in Alberta

ASRD and ACA 2010

- There are 15 caribou herds in Alberta
- Exist primarily in northern regions of Alberta (ACC 2006)
- Boreal and Mountain ecotype
- In the past caribou range included approximately all of the area north of the red line (Soper 1964)
- Estimated population as of July 2010: 2,600-2,900 individuals

Question 10

Please indicate the degree to which you agree or disagree with the following three statements.

Question 10 continued

It matters to me personally if the caribou populations in Alberta remain at risk.

- Strongly disagree (A)
- Somewhat disagree (B)
- Somewhat agree (C)
- Strongly agree (D)
- Not sure (E)

Question 10 continued

It matters to me personally if the caribou populations in other parts of Canada are at risk.

- Strongly disagree (A)
- Somewhat disagree (B)
- Somewhat agree (C)
- Strongly agree (D)
- Not sure (E)

Question 10 continued

Alberta should take more action to help the caribou populations recover.

- Strongly disagree (A)
- Somewhat disagree (B)
- Somewhat agree (C)
- Strongly agree (D)
- Not sure (E)

Reasons for Population Decline

Habitat Change
Predation
Other

Habitat Change

www.capp.ca

globalforestwatch.ca

- Oil, gas and forestry
- Create roads, wellsites, seismic lines, cutblocks, noise, etc.
- Caribou avoid areas of human development (Dyer *et al.* 2001)
- Development promotes increased densities of wolves (Fuller and Keith 1980)
- Habitat fragmentation puts increasing pressure on caribou populations

Predation

- Wolves and other predators feed on moose, deer and caribou
- Resource industries:
  - Create favorable habitat for moose and deer
  - Creates access that allows wolves to move around more easily
- Thus, changes in habitat have contributed to more interactions between wolves and caribou – resulting in caribou population decline

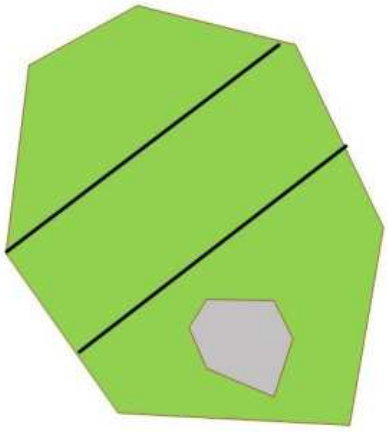
tangischools.org

Other Reasons for Decline

- Fire (Sorensen *et al.* 2005)
- Traffic collisions (Thomas and Gray 2002)
- Spread of agriculture and mining (Dzus 2001)

www.jumpthecurve.net

The Story of Caribou Decline



Energy and Forestry Activity

↓

Increase Moose and Deer

↓

Increase Wolves

↓

Decrease Caribou

Question 11

Before reading this survey, did you know that resource industries played a role in the decline of caribou?

- Yes (A)
- No (B)
- Not sure (C)

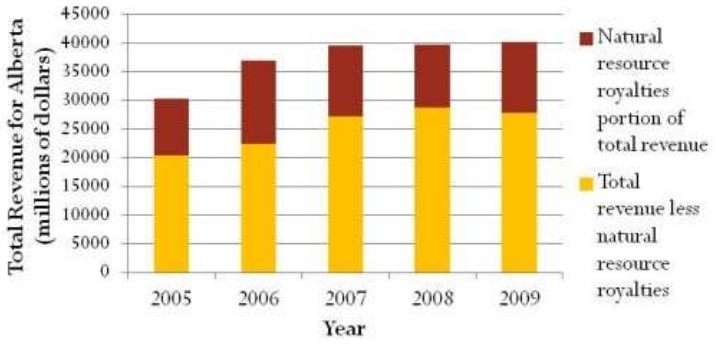
Resource Industries

Alberta's Revenue Sources

Alberta's Expenditures

Alberta's Revenue Sources

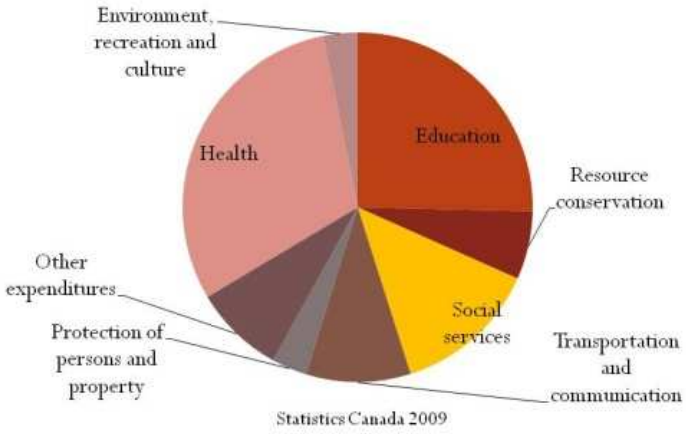
- Royalties: approximately 30% of total revenue
- Corporate income taxes: approximately 10% of total revenue



Statistics Canada

Alberta's Expenditures

- This revenue is used to fund public services:



Statistics Canada 2009

Question 12

Before reading this survey, did you know that energy and forestry companies made corporate income tax and royalty payments to the Government of Alberta based on the resources they extract?

- Yes (A)
- No (B)
- Not sure (C)

Caribou Conservation

Benefits of caribou conservation

Conservation strategies

Benefits of Caribou Conservation

- Iconic species of boreal forest
- Cultural importance for aboriginal peoples
- Biodiversity
- Legal requirements of SARA and *Alberta Wildlife Act*
- Benefits of conservation include:
  - Help recover caribou populations
  - Protect old growth stands of boreal forest
  - Protect other natural resources such as water and other species at risk

www.sararegistry.gc

Conservation Strategies

- Restrictions on the places that resource extraction industries (energy and forestry sectors) can operate, or restrictions on how quickly these sectors can access the resources
- Increased effort in growing forests in areas previously disturbed by energy and forestry activities
- Predator management or wolf control

These measures will be costly, and in some cases they will reduce the rate of resource development and thus will reduce tax and royalty revenue collected by the province.

Considering Caribou Conservation Options

Identifying the tradeoff

The basic story

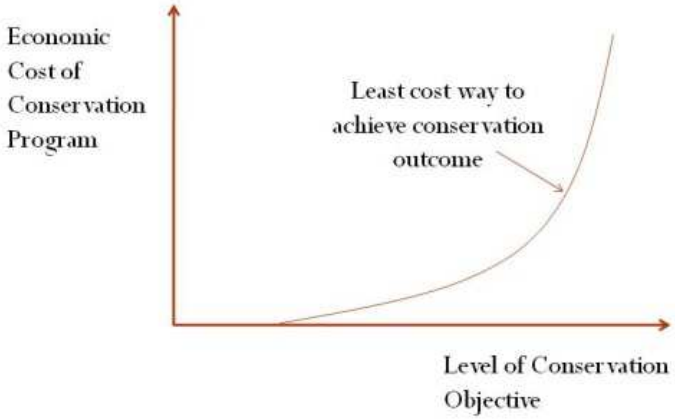
Defining the conservation objectives and costs

Tradeoff

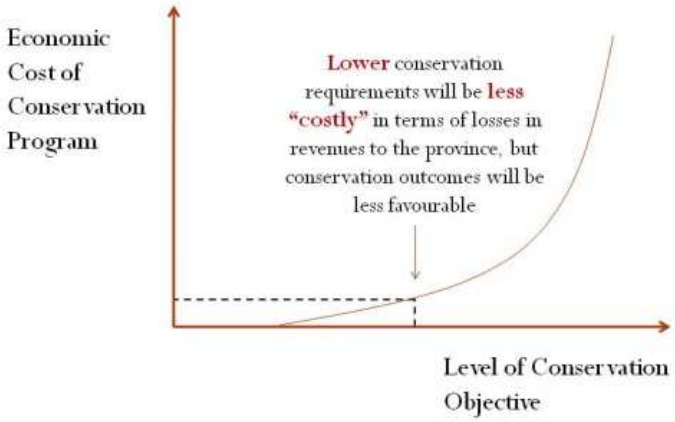
- Decisions will have to be made regarding how much effort to place into caribou conservation and thus how much economic development to postpone
- Conservation actions will reduce economic development through conventional oil and gas, oilsands and forestry
  - Reduction in provincial royalty and tax revenues
- Conversely, the cost of economic development is fewer self-sustaining caribou herds
- This decision involves public resources: caribou and provincial revenues

We want your opinion concerning the best level of conservation action to engage in

The Basic Story



The Basic Story



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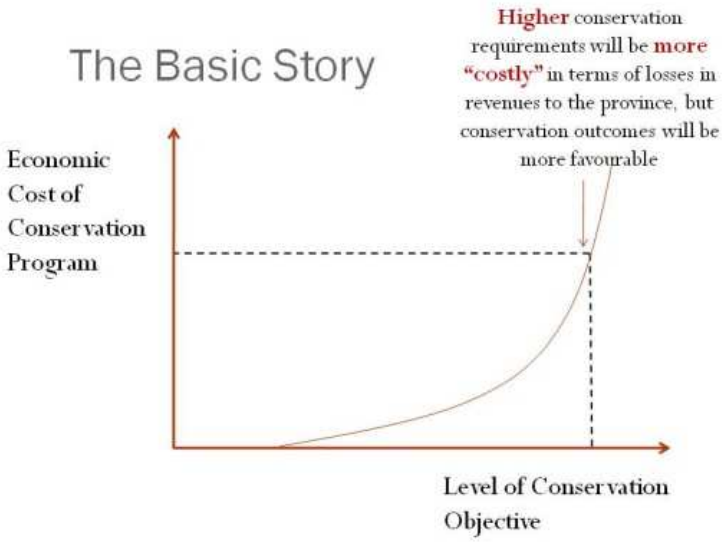
The Basic Story



Defining Conservation Objectives and Costs

- **Finding the 'least cost' way to achieve the conservation outcome involves defining the costs and benefits of various caribou conservation programs**
- "Economic Costs" include:
  - Delayed opportunities for forest harvesting and resource extraction
  - Predator management or wolf control
- "**Conservation objectives**" include:
  - Ensuring there is sufficient habitat for the caribou through time
  - Ensuring that caribou herds in the future are "**self sustaining**" or can survive without human intervention
  - **We measure these as the number of caribou herds, or the number of caribou, that are self sustaining 50 years from now**

Summary: Defining the Costs

- Economic "Cost" of Conservation Program:
  - *The amount of increase in household taxes, per year for the next 50 years, that would be required to maintain revenues and public services ($)*
- Does not include losses in profits that industry will incur

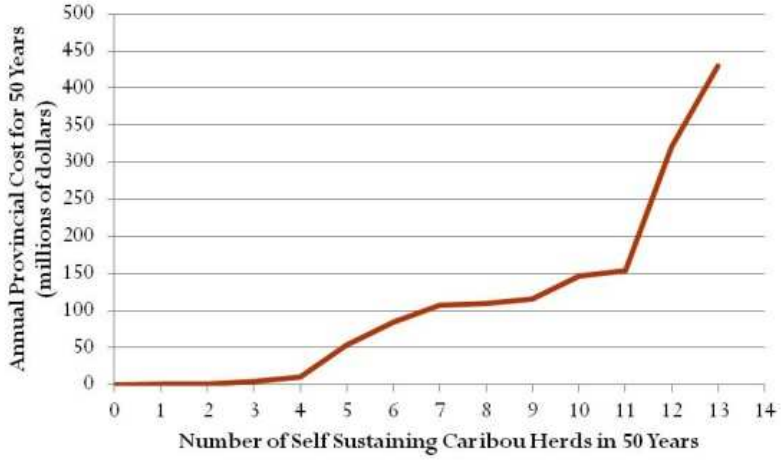
www2.csdm.qc.ca

Further Defining Conservation Objectives

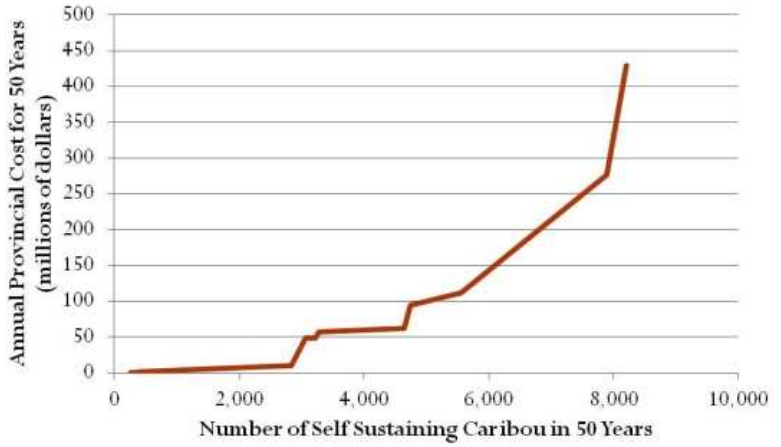
- Level of Conservation Objective:
  - *Number of caribou herds that are nearly guaranteed to be self-sustaining 50 years from now*
  - There may still be caribou in other regions, but the chances of their survival are uncertain

store.wildernesscommitee.org

Identifying the Tradeoff – Herd Numbers



Identifying the Tradeoff – Caribou Population



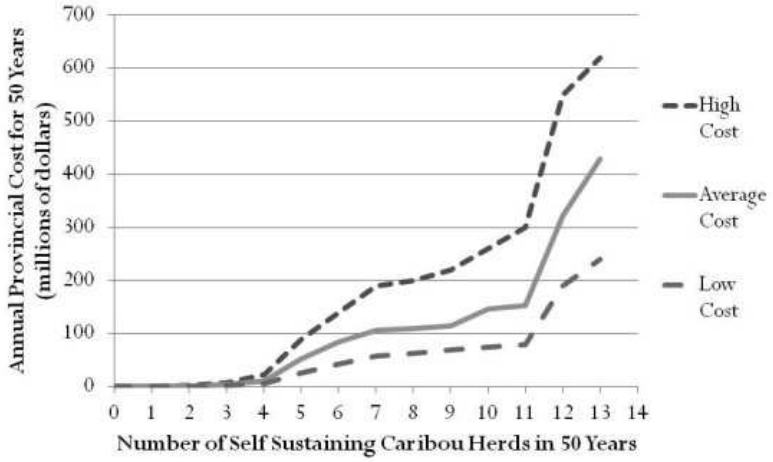
Uncertainty

- Various sources of uncertainty in calculating costs and predicting the results of conservation strategies:
  - Prices of oil, gas and forest products
  - Costs of energy and forestry extraction
  - Development of new technologies for energy and forestry extraction

These curves have been calculated using the best available information. They represent the best estimates we have of the actual costs associated with the conservation objectives.

- There are other tradeoff options besides the one presented here, but they come with their own costs and challenges

Identifying the Tradeoff - Uncertainty



Your Turn!

- We need YOUR input to determine what action is sustainable
- Your voice is very important, both to us and to the development of future policy
- We will have a short discussion and Question / Answer session
- Then we will hand out an information package and a survey for you to complete individually (**no group responses will be displayed**)

	Current Management Strategy	Proposed Management Strategy
Number of self-sustaining caribou herds *in 50 years*	2	6
Your households' share of the cost in provincial income taxes	$0	$9

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Appendix B: Information Sheet, Consent Form and Woodland Caribou Information Package

UNIVERSITY OF ALBERTA
Rural Economy
Faculty of Agricultural, Life and Environmental Sciences

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Economic Analysis of Species at Risk Recovery Plans for Woodland Caribou

Purpose: The purpose of this project is to determine people's views regarding woodland caribou conservation in Alberta.

Methods: You will first be shown a power point presentation and then will be given the opportunity to ask questions in case anything from the presentation is unclear. You will then have a chance to provide us with your input through a survey which will take approximately 30 to 45 minutes. The entire workshop is expected to take 90 to 120 minutes.

Confidentiality: You will be randomly issued a temporary identification number. Your decisions and answers to the survey will eventually be transferred into a computer based on this number. Any personal identification information, including your name, will not be entered into the computer. Only this randomly assigned number will be used as identification on anything that may be written about the survey. Your personal identification, such as your name, will appear only on the ethics consent form and your payment receipt. These will be locked up in a closed cabinet in one of the investigator offices on campus.

Your comments and ideas will not be published or attributed directly to you in any way. Both your comments on the survey and any notes taken will be anonymous. Because other people in the workshop will be hearing your ideas, confidentiality from them cannot be assured but we ask that all participants try to keep the conversations in the workshop confidential and not identify specific individuals and the workshop discussions outside the session.

Benefits: During this workshop, you will learn about the caribou in Alberta and the conservation efforts that are being considered. Should you choose to participate, you will be awarded $100 to compensate you for your time and any other costs you may incur in participating in this workshop.

Risks: There are no known inherent risks from listening to the presentation and filling out the survey. However, as there will be opportunity for discussion, other people in the group will hear your opinions and questions. Confidentiality cannot be guaranteed but we ask for all conversations not to be disclosed to outside parties.

Withdrawal from the Study: Your participation is completely voluntary, anonymous and confidential. You are free to discontinue participation at any time during the workshop.

UNIVERSITY OF ALBERTA
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Use of your Information: The information you provide will be analyzed using statistical techniques and the data will be stored for five years after publication. No one except the investigators will be allowed to see any of the answers to the questionnaire. There are no names on the questionnaire. Only group information will be summarized for any presentation or publication of results. If you withdraw during the workshop, the information you provided will be deleted from the data set as it cannot be used in the analysis. The information obtained from this workshop will be used to write academic papers, reports and graduate theses.

Economic Analysis of Species at Risk Recovery Plans for Woodland Caribou
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In the case of any concerns, complaints or consequences contact:
Dr. Kelvin Jones [Dr. Jones has no direct involvement with this project]
Chair of the Faculty Research Ethics Board
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Rural Economy
Faculty of Agricultural, Life and Environmental Sciences

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Economic Analysis of Species at Risk Recovery Plans for Woodland Caribou

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Please circle your answers.

Do you consent to participating in a workshop about Woodland Caribou in Alberta?

Yes *No*

Do you understand that you have been asked to participate in a research workshop?

Yes *No*

Have you received and read a copy of the Information Sheet?

Yes *No*

Do you understand the benefits and risks involved in taking part in this workshop?

Yes *No*

Do you understand that you can quit taking part in this study at any time? You do not have to say why and it will not affect any payments you receive for participating.

Yes *No*

UNIVERSITY OF ALBERTA
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Has confidentiality been explained to you?

Yes *No*

Do you understand who will be able to see or hear what you say or write?

Yes *No*

Do you know what the information you gave will be used for?

Yes *No*

Do you give us permission to use your data for the purposes specified?

Yes *No*

I agree to take part in the workshop.

_____ _____

Signature Date

Threatened Wildlife Species in Alberta: Background Information

FEBRUARY 2011

A Research Study Funded by the Social Sciences and Humanities Research Council of Canada

Agencies Providing Letters of Support for this Project:

Alberta Sustainable Resource Development

Alberta Caribou Committee

Environment Canada

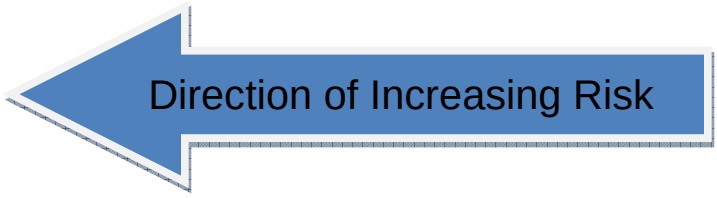
Canadian Association of Petroleum Producers

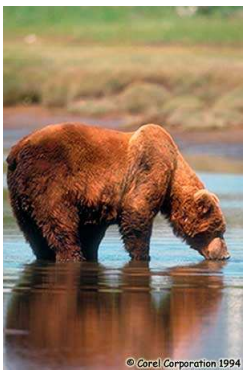
Alberta Pacific Forest Industries

SPECIES AT RISK

A number of species in Canada are listed as species at risk of extinction. Species at risk in Canada are protected under the *Species at Risk Act* (2003). Likewise, species at risk are protected provincially under the *Alberta Wildlife Act* (2000). This legislation provides legal requirements for the protection of species at risk of extinction.

According to these Acts, a species is under **increasing risk** as it passes from not at risk to special concern to threatened to endangered. The figure below provides examples of species currently listed for each class in Alberta.



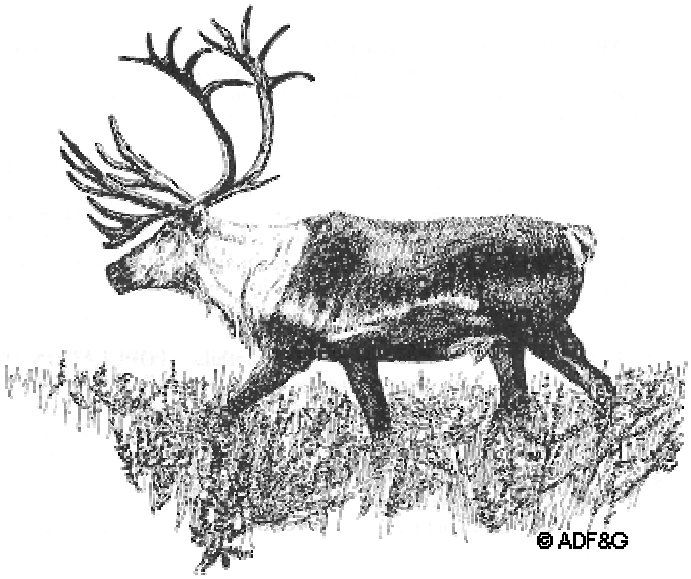
Endangered	Threatened	Special Concern
Swift fox (*Vulpes velox*)	Grizzly bear (*Ursus arctos*)	Harlequin duck (*Histrionicus histrionicus*)
		

Pictures from http://www.sararegistry.gc.ca/sar/index/default_e.cfm

Please see the Appendix at the end of the survey for definitions of each species at risk category.

Caribou are members of the deer family, which also includes moose, elk, white-tailed deer and mule deer. They are most easily identified by their cream-colored neck and large and often complex antlers.

Caribou rely mainly on lichen for food in the winter and on plants, shrubs and other green vegetation in the summer. They prefer large stands of intact mature forest which can take between 60 and 150 years to grow. Caribou are found in low densities over wide areas and are slow to reproduce. This makes them vulnerable to population declines resulting from habitat degradation.

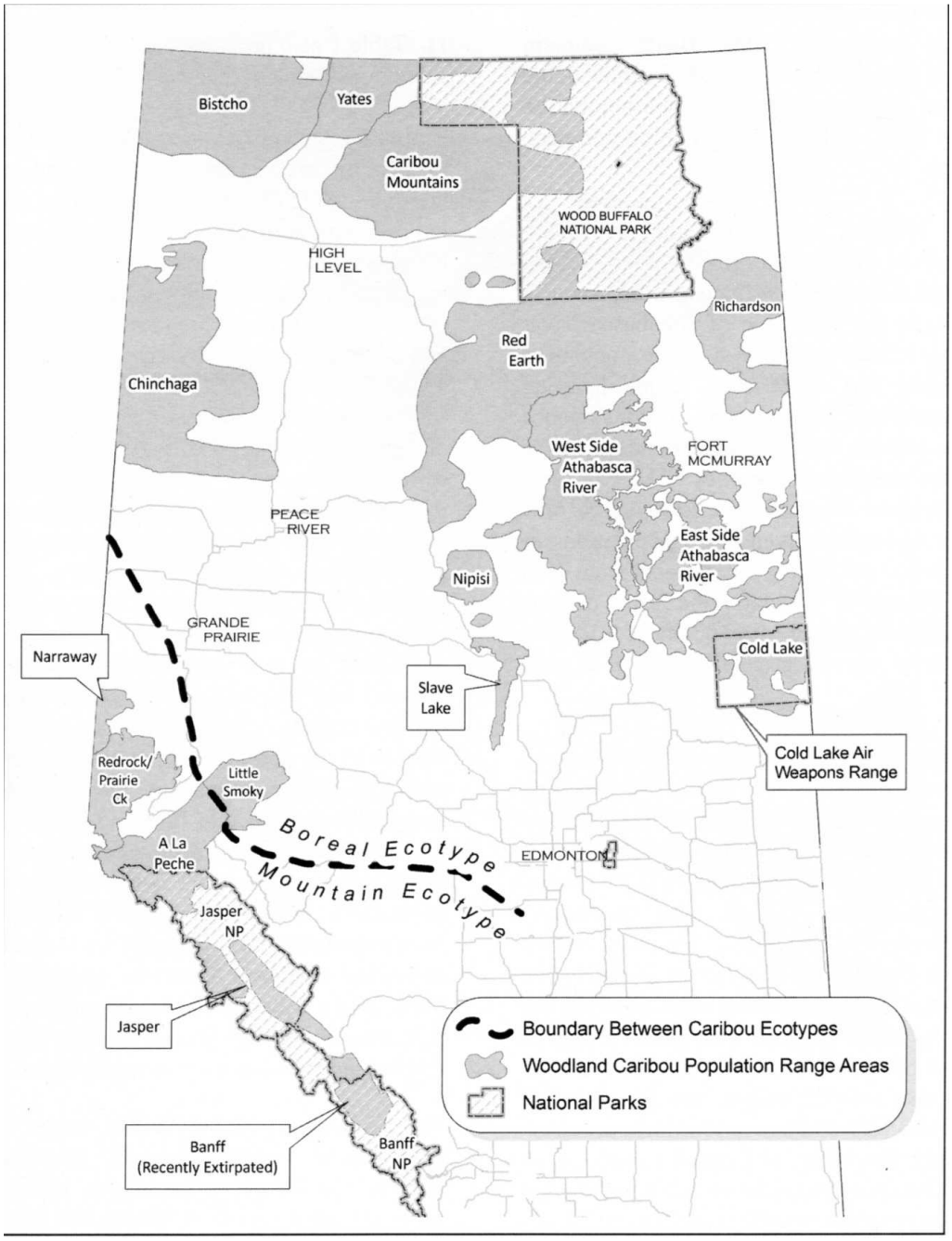


Picture from www.adfg.state.ak.us

Woodland caribou are declining in North America which has lead to the species being listed as **threatened** both at the federal level by the Committee on the Status of Endangered Wildlife in Canada and at the provincial level by Alberta Sustainable Resource Development and the Alberta Conservation Association (COSEWIC 2002, ASRD and ACA 2010).

Woodland caribou habitat covers the majority of northern Alberta. A significant proportion of the total value of Alberta's oil, gas and forestry resources occurs in areas used by caribou (Schneider *et al*. 2009).

In Alberta, caribou of the woodland subspecies (*Rangifer tarandus caribou*) are presently found in the northern regions of the province, denoted by the shaded areas on the map below.



ASRD and ACC 2010

REASONS FOR POPULATION DECLINE

Habitat Change	Predation
	
In Alberta, resource extraction industries such as **oil, gas and forestry** occur in areas which are also important habitat for woodland caribou. Caribou will avoid areas used by these industries. As these industries expand further into caribou habitat, the pressure on caribou populations is increased.	An important factor limiting caribou populations are the **predator-prey relationships** between wolves, caribou, moose and deer. Caribou historically protected themselves by choosing to live in habitats that other animals that wolves eat, such as moose, do not live. However, this strategy is no longer very effective.

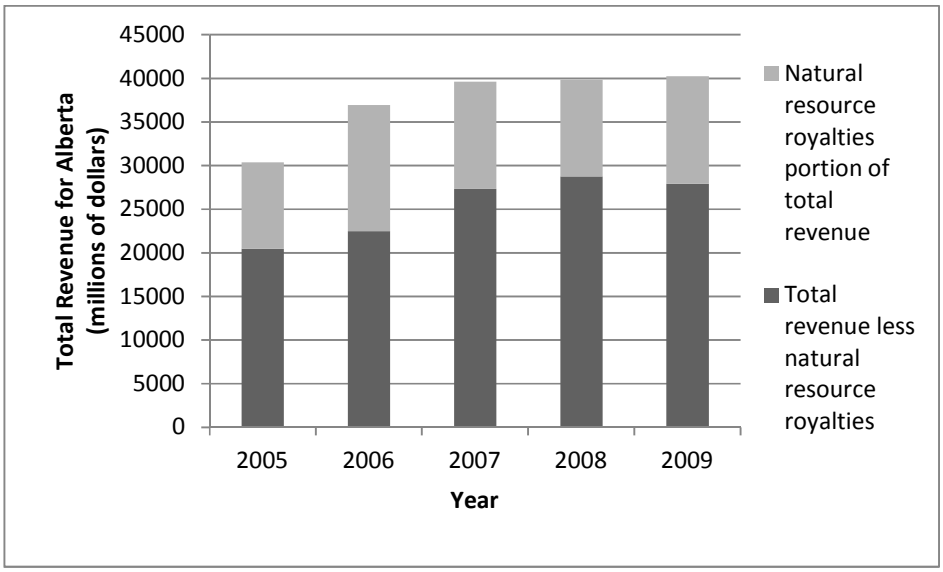
Pictures from www.globalforestwatch.ca and www.tangischools.org

For century's caribou in the boreal forest lived with predators such as wolves. Caribou have effective strategies for avoiding wolves on natural landscapes where there are few wolves. Resource industries create favorable habitat for moose and deer, leading to more wolves by increasing their food supply. The altered landscape also allows wolves to move around more easily.

Predation by these more numerous and mobile wolves is the most likely cause of woodland caribou decline. The wolves have become a threat to caribou because resource industries have altered large areas of the forest.

REVENUE FROM RESOURCE INDUSTRIES

Resource industries play a significant role in the province's economy. Total government revenue for the province of Alberta from 2005 to 2009 is shown in the graph below. Royalties and taxes from resource extraction industries are two important sources of revenue for the province.

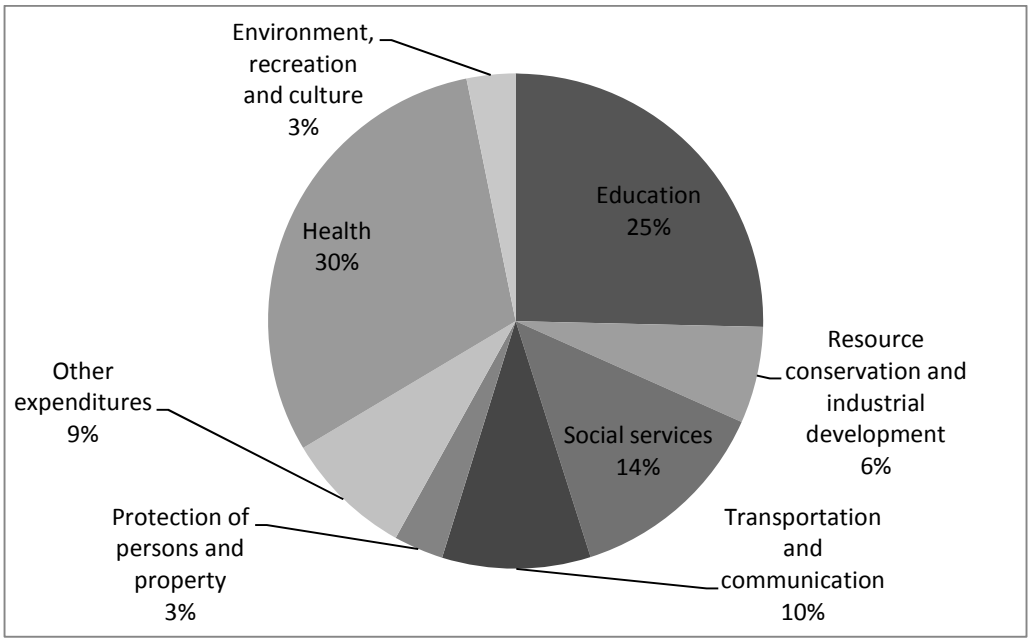


Total revenue for the province of Alberta from 2005 to 2009 (data in millions). Statistics Canada.

Royalties are payments made to the government of Alberta by corporations who have been granted the right to extract natural resources such as forests, oil or natural gas. In 2009, over 30 percent of the Government of Alberta's revenue came from royalties from natural resources.

The taxes that companies pay are called **corporate income taxes**. In 2009, corporate income tax paid to the Government of Alberta by all types of businesses was about $3 Billion, which is almost 10 percent of the total revenue collected by the province.

The taxes and royalties collected by the Government of Alberta are used to pay for public services such as the ones shown in the pie chart below (Statistics Canada).



Expenditure categories for the province of Alberta. Statistics Canada.

APPENDIX – SPECIES AT RISK DEFINITIONS

Definitions of General Status Categories for Canada (COSEWIC 2001)

Risk Category	**Definition**
Extinct (X)	A species that is no longer found anywhere in the world.
Extirpated (XT)	A species that is no longer found in an area where it used to live but remains in the wild somewhere else in the world.
Endangered (E)	A species that may become extirpated or extinct.
Threatened (T)	A species that may become endangered.
Special Concern (SC)	A species that has characteristics which make it particularly sensitive to human activities or natural events.
Not At Risk (NAR)	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)	A species for which there is insufficient scientific information to support status designation.

REFERENCES

Alberta Sustainable Resource Development and Alberta Conservation Association. 2010. Status of the Woodland Caribou (Rangifer tarandus caribou) in Alberta: Update 2010. Alberta Sustainable Resource Development. Wildlife Status Report No. 30 (Update 2010). Edmonton, AB. 88 pp.

COSEWIC. 2001. Canadian Species at Risk. Found online at http://www.sararegistry.gc.ca/virtual_sara/ files/species/clwsa_0501_e.pdf [Assessed June 7, 2010]

COSEWIC. 2002. COSEWIC assessment and update status report on the woodland caribou *Rangifer tarandus caribou* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 98 pp

Schneider RR, Hauer G, Adamowicz WL and S Boutin. 2009. Triage for conserving populations of threatened species: The case of woodland caribou in Alberta. *Biological Conservation* 143, 7: 1603-1611

Statistics Canada. No date. Table 385-0002 Federal, provincial and territorial general government revenue and expenditures, for fiscal year ending March 31, annual (dollars), terminated, data in millions (table). CANSIM (database). Using E-STAT (distributor). Last updated August 27, 2009. http://estat.statcan.gc.ca/cgi-win/CNSMCGI.EXE (accessed October 25, 2010).

For more information you may visit the following web sites:

http://www.srd.alberta.ca/

http://www.albertacaribouCommittee.ca/

Appendix C: Woodland Caribou Valuation Package

Threatened Wildlife Species in Alberta: Your Choices

MAY 2011

V1. We would like your opinions about spending on public services. For each of the publicly-provided services listed below, please indicate if you personally think funding for these services should be reduced substantially, reduced somewhat, not changed, increased somewhat or increased substantially.

	Reduced substantially	Reduced somewhat	Not changed	Increased somewhat	Increased substantially
Health					
Environment, recreation and culture					
Education					
Resource conservation and industrial development					
Social services					
Transportation and communication					
Protection of persons and property					
Other expenditures					

CARIBOU CONSERVATION PROGRAMS

If woodland caribou populations are to be conserved, steps must be taken to minimize and mitigate the effects of industry and resource extraction in important caribou habitat, both now and in the future.

Experts think that the following potential measures, or some combination of these, could be considered as part of a caribou conservation program:

- Predator management or wolf control
- Restrictions on the places that resource extraction industries (energy and forestry sectors) can operate, or restrictions on how quickly these sectors can access the resources
- Increased effort in growing forests in areas previously disturbed by energy and forestry activities

These measures will be costly, and in some cases they will reduce the rate of resource development and thus will reduce tax and royalty revenue collected by the province.

Experts think that a caribou conservation program will:

- Help caribou populations recover to self-sustaining levels
- Protect old growth stands of boreal forest
- Protect other natural resources such as water and other species at risk

There are 15 woodland caribou herds in the province of Alberta. The number of caribou in each herd varies from approximately 80 to 350. Different caribou conservation programs will affect certain caribou herds and will have differing costs.

A caribou conservation program is successful for a given herd if that herd becomes **self-sustaining**. A caribou herd is considered to be **self-sustaining** when its population can be maintained over time on its own.

A more expensive caribou conservation program will likely have more caribou herds which are self-sustaining over time. Similarly, a less expensive caribou conservation program will likely have fewer caribou herds which are self-sustaining over time.

The time frame used in this study is over the next 50 years. Under this time frame, caribou conservation programs will be examined in terms of number of caribou herds that are self-sustaining 50 years from now.

V2. What is the **minimum number** of self-sustaining caribou herds (there are 15 caribou herds in the province of Alberta), 50 years from now, that your household would find acceptable? Please circle your choice below:

0 1 2 3 4 5

6 7 8 9 10

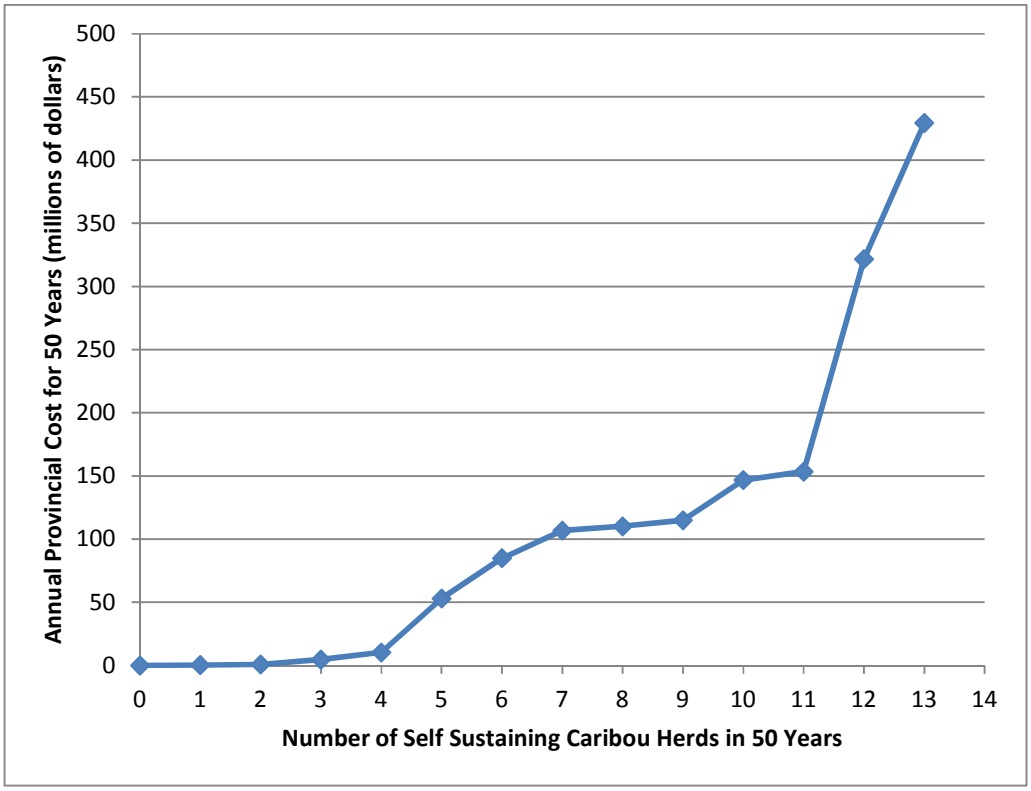
11 12 13 14 15

V3. If caribou conservation requires additional tax funds, what is the **maximum annual increase in taxes** your household would find acceptable for the next 50 years?
$_____/year

PLEASE ANSWER THIS QUESTION, EVEN IF YOU BELIEVE THE MAXIMUM SHOULD BE $0

CONSIDERING CARIBOU CONSERVATION OPTIONS

Conserving woodland caribou habitat will reduce economic development and provincial royalty and tax revenues. Since these decisions involve public resources – caribou and provincial revenues – we are asking for your opinion concerning what level of conservation action to engage in. The following graphs represent an estimate of the "tradeoff" between different levels of caribou conservation and economic development.



The **horizontal axis** represents the results of different conservation strategies that could ensure that some or all 14 of Alberta's caribou herds are "self-sustaining" or which have populations that can be maintained **over the next 50 years and beyond** on their own. These self-sustaining herds are nearly certain to be not at risk. Herds not selected for conservation, including those outside of Alberta, may still have caribou, but the chances of their survival are uncertain.

The **vertical axis** is the cost of achieving these caribou conservation levels, measured as the cost to the province per year in millions of dollars. The costs include management activities as well as taxes and royalties foregone from the energy and forestry sectors. These costs represent the amount the province of Alberta will be required to raise in order to maintain funding of public programs at current levels. This amount would be paid **each year for the next 50 years**.

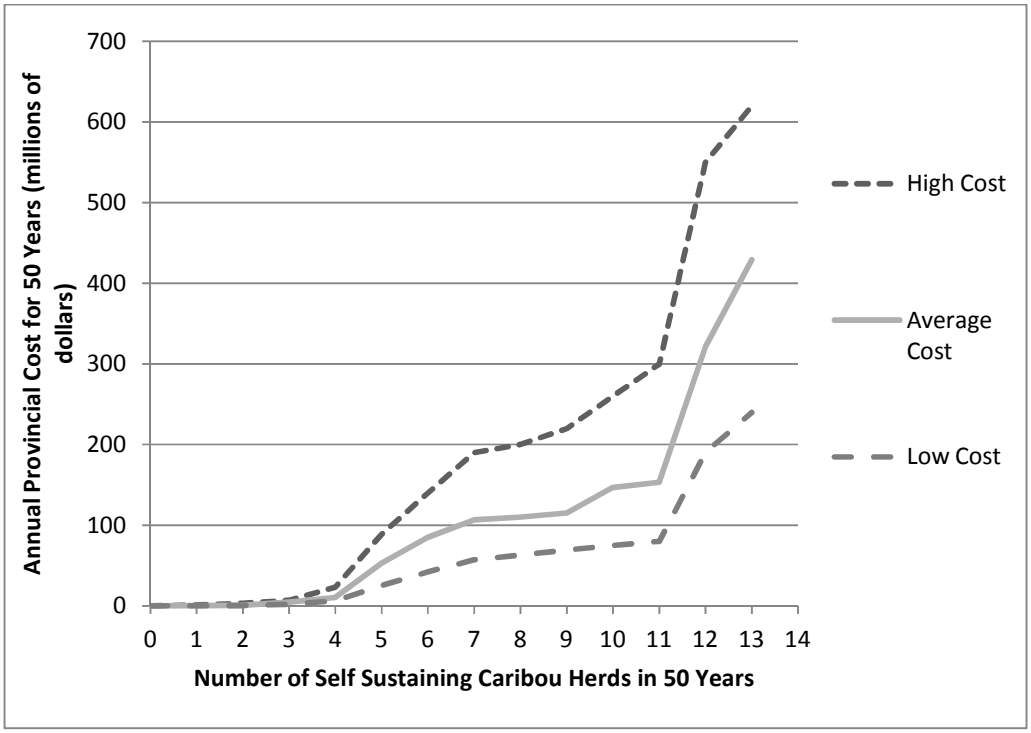
Each point along the curves represents the minimum cost that will achieve a certain conservation objective. Notice that the curve increases slowly at first. This means that the costs of conserving the first few caribou herds are relatively low. As the conservation objective increases to allow for more caribou, the costs begin to rise.

These curves have been calculated using the best available information. They represent the best estimates we have of the actual costs associated with the conservation objectives.

Calculated costs and predicted conservation objectives are uncertain. The costs associated with caribou conservation will vary depending on:

- Prices of oil, gas and forest products
- Costs of energy and forestry extraction
- Development of new technologies for energy and forestry extraction

The curves presented below show the provincial costs for three different estimates of what energy prices will be in the future: the dashed line is based on low energy price forecasts, the solid line on medium or average price forecasts and the dotted line on high price forecasts.



VOTES

We would like your opinion on the **"tradeoff"** between caribou conservation objectives and economic costs.

The next series of questions asks you to compare the **current management strategy** in Alberta with different scenarios (**proposed management strategy**) about what **could** happen **within the next 50 years** if additional efforts were undertaken to protect woodland caribou habitat.

These scenarios will vary in terms of the following characteristics:

- An estimate of your household's annual cost for the program, which depends on energy prices and other factors
- The number of caribou herds which are self-sustaining

We are asking you to state whether you feel that the conservation program, for the amount of money per household per year that the program will cost, should be undertaken.

After analyzing the differences between the current management strategy and the proposed management strategy, you will be asked to "vote" for or against the proposed strategy.

Some people might choose to vote to keep the current management strategy because they think:

- The proposed management strategy costs too much money for the improvement in caribou population
- There are other things, including other environmental protection options, where my money would be better spent

Other people might choose one of the proposed management strategy options because they think:

- The improvement in caribou populations is worth the money
- This is a good use of money compared to other things provincial government money could be spent on

PLEASE NOTE:

We know that how people vote on a survey is often not a reliable indication of how people would actually vote at the polls. In surveys, some people ignore the monetary and other sacrifices they would really have to make if their vote won a majority and became law. We call this hypothetical bias. In surveys that ask people if they would pay more for certain services, research has found that people may say that they would pay 50% more than they actually will in real transactions.

It is very important that you "vote" as if this were a real vote. You need to imagine that you actually have to dig into your household budget and pay the additional costs associated with the program.

Suppose you were asked to consider the following votes and choices. In each case presented below, imagine that these are the ONLY TWO OPTIONS available to choose from. Each time, please choose INDEPENDENTLY from the other questions – do not compare options from different questions.

Suppose you were asked to consider a proposed management strategy versus maintaining the current management strategy as described below.

VOTE 1. Please carefully compare the two alternatives presented in the table below. If you had to VOTE on these two options, which one would you choose?

	Current Management Strategy	Proposed Management Strategy
Number of self-sustaining caribou herds *in 50 years*	2	___
Your household's share of the cost *per year for the next 50 years* in provincial income taxes	$0	$___

PLEASE CHECK ONE RESPONSE ONLY

- ❑ CURRENT management strategy
- ❑ PROPOSED management strategy

VOTE 1a. How certain are you that this is the choice you would make if this was an actual referendum?

PLEASE CHECK ONE RESPONSE ONLY

- ❑ Very Certain
- ❑ Somewhat Certain
- ❑ Neither Certain nor Uncertain
- ❑ Somewhat Uncertain
- ❑ Very Uncertain

VOTE 1b. What percent of Alberta residents do you think would vote for the **PROPOSED** management strategy specified above? _____%

V4. When choosing between the CURRENT management strategy and the PROPOSED management strategy, how important was each of the following to you?

PLEASE CHECK ONE RESPONSE FOR EACH STATEMENT

	Not at all important	Somewhat important	Very important	Extremely important
Number of self-sustaining caribou herds in 50 years				
Your household's share of the cost per year for the next 50 years in provincial income taxes				

V5. When I voted to keep the CURRENT management strategy in the vote above it was because…

PLEASE CHECK ALL THAT APPLY

- ❑ I believe that is too much money for the associated improvement in caribou populations
- ❑ There are other things, including other environmental protection options, where my money would be better spent
- ❑ I do not believe the proposed management strategy will actually generate the improvements in caribou populations
- ❑ I do not have enough information to make this decision
- ❑ Other reason: (PLEASE SPECIFY)

  _____

V6. When I voted for the PROPOSED management strategy in the vote above it was because…

PLEASE CHECK ALL THAT APPLY

- ❑ The improvement in caribou populations is worth the money
- ❑ We should pay whatever it takes to conserve caribou populations
- ❑ This is a good use of money compared to other things provincial government money could be spent on
- ❑ I believe the proposed management strategy will actually generate the improvements in caribou populations
- ❑ Other reason: (PLEASE SPECIFY)

  _____

Now suppose you were asked to consider another proposed management strategy versus maintaining the current management strategy as described below.

VOTE 2. Please carefully compare the two alternatives presented in the table below. If you had to VOTE on these two options, which one would you choose?

	Current Management Strategy	Proposed Management Strategy
Number of self-sustaining caribou herds *in 50 years*	2	___
Your household's share of the cost *per year for the next 50 years* in provincial income taxes	$0	$___

PLEASE CHECK ONE RESPONSE ONLY

- ❑ CURRENT management strategy
- ❑ PROPOSED management strategy

VOTE 2a. How certain are you that this is the choice you would make if this was an actual referendum?

PLEASE CHECK ONE RESPONSE ONLY

- ❑ Very Certain
- ❑ Somewhat Certain
- ❑ Neither Certain nor Uncertain
- ❑ Somewhat Uncertain
- ❑ Very Uncertain

VOTE 2b. What percent of Alberta residents do you think would vote for the **PROPOSED** management strategy specified above? _____%

V7. When choosing between the CURRENT management strategy and the PROPOSED management strategy, how important was each of the following to you?

PLEASE CHECK ONE RESPONSE FOR EACH STATEMENT

	Not at all important	Somewhat important	Very important	Extremely important
Number of self-sustaining caribou herds in 50 years				
Your household's share of the cost per year for the next 50 years in provincial income taxes				

V8. When I voted to keep the CURRENT management strategy in the vote above it was because…

PLEASE CHECK ALL THAT APPLY

- ❑ I believe that is too much money for the associated improvement in caribou populations
- ❑ There are other things, including other environmental protection options, where my money would be better spent
- ❑ I do not believe the proposed management strategy will actually generate the improvements in caribou populations
- ❑ I do not have enough information to make this decision
- ❑ Other reason: (PLEASE SPECIFY)

  _____

V9. When I voted for the PROPOSED management strategy in the vote above it was because…

PLEASE CHECK ALL THAT APPLY

- ❑ The improvement in caribou populations is worth the money
- ❑ We should pay whatever it takes to conserve caribou populations
- ❑ This is a good use of money compared to other things provincial government money could be spent on
- ❑ I believe the proposed management strategy will actually generate the improvements in caribou populations
- ❑ Other reason: (PLEASE SPECIFY)

  _____

In some cases, the Species at Risk legislation requires management action that will be costly. However, the cost will also be related to the conservation outcome selected. Suppose you were asked to consider two management strategies, Management Strategy A and Management Strategy B, as described below. Please assume that these are the only two management strategies available.

CHOICE 1. Please carefully compare the two management strategies presented in the table below. If you had to choose one of these strategies, would you choose Management Strategy A or Management Strategy B?

	Management Strategy A	Management Strategy B
Number of self-sustaining caribou herds *in 50 years*	___	___
Your household's share of the cost *per year for the next 50 years* in provincial income taxes	$___	$___

PLEASE CHECK ONE RESPONSE ONLY

- ❑ Management Strategy A
- ❑ Management Strategy B

CHOICE 1a. How certain are you that this is the choice you would make if this was an actual decision?

- ❑ Very Certain
- ❑ Somewhat Certain
- ❑ Neither Certain nor Uncertain
- ❑ Somewhat Uncertain
- ❑ Very Uncertain

CHOICE 1b. What percent of Alberta residents do you think would choose **Management Strategy A** as specified above? _____%

V10. When choosing between Management Strategy A and Management Strategy B, how important was each of the following to you?

PLEASE CHECK ONE RESPONSE FOR EACH STATEMENT

	Not at all important	Somewhat important	Very important	Extremely important
Number of self-sustaining caribou herds in 50 years				
Your household's share of the cost per year for the next 50 years in provincial income taxes				

V11. If you chose the management strategy **with fewer herds** in the choice above it was because…

PLEASE CHECK ALL THAT APPLY

- ❑ I believe that the management strategy **with more herds** costs too much money for the associated improvement in caribou populations
- ❑ There are other things, including other environmental protection options, where my money would be better spent
- ❑ I do not believe the proposed management strategy will actually generate the improvements in caribou populations
- ❑ I do not have enough information to make this decision
- ❑ Other reason: (PLEASE SPECIFY)

  _____

V12. If you chose the management strategy **with more herds** in the choice above it was because…

PLEASE CHECK ALL THAT APPLY

- ❑ The improvement in caribou populations is worth the money
- ❑ We should pay whatever it takes to conserve caribou populations
- ❑ This is a good use of money compared to other things provincial government money could be spent on
- ❑ I believe the proposed management strategy will actually generate the improvements in caribou populations
- ❑ Other reason: (PLEASE SPECIFY)

  _____

Now suppose you were asked to consider two different management strategies, Management Strategy A and Management Strategy B, as described below. Please assume that these are the only two management strategies available.

CHOICE 2. Please carefully compare the two management strategies presented in the table below. If you had to choose one of these strategies, would you choose Management Strategy A or Management Strategy B?

	Management Strategy A	Management Strategy B
Number of self-sustaining caribou herds *in 50 years*	___	___
Your household's share of the cost *per year for the next 50 years* in provincial income taxes	$___	$___

PLEASE CHECK ONE RESPONSE ONLY

- ❑ Management Strategy A
- ❑ Management Strategy B

CHOICE 2a. How certain are you that this is the choice you would make if this was an actual decision?

- ❑ Very Certain
- ❑ Somewhat Certain
- ❑ Neither Certain nor Uncertain
- ❑ Somewhat Uncertain
- ❑ Very Uncertain

CHOICE 2b. What percent of Alberta residents do you think would choose **Management Strategy A** as specified above? _____%

V13. When choosing between Management Strategy A and Management Strategy B, how important was each of the following to you?

PLEASE CHECK ONE RESPONSE FOR EACH STATEMENT

	Not at all important	Somewhat important	Very important	Extremely important
Number of self-sustaining caribou herds in 50 years				
Your household's share of the cost per year for the next 50 years in provincial income taxes				

V14. If you chose the management strategy **with fewer herds** in the choice above it was because…

PLEASE CHECK ALL THAT APPLY

- ❑ I believe that the management strategy **with more herds** costs too much money for the associated improvement in caribou populations
- ❑ There are other things, including other environmental protection options, where my money would be better spent
- ❑ I do not believe the proposed management strategy will actually generate the improvements in caribou populations
- ❑ I do not have enough information to make this decision
- ❑ Other reason: (PLEASE SPECIFY)

  _____

V15. If you chose the management strategy **with more herds** in the choice above it was because…

PLEASE CHECK ALL THAT APPLY

- ❑ The improvement in caribou populations is worth the money
- ❑ We should pay whatever it takes to conserve caribou populations
- ❑ This is a good use of money compared to other things provincial government money could be spent on
- ❑ I believe the proposed management strategy will actually generate the improvements in caribou populations
- ❑ Other reason: (PLEASE SPECIFY)

  _____

V16. How certain do you think scientists are about the status of caribou populations (threatened, at risk)?

- ❑ Very Certain
- ❑ Somewhat Certain
- ❑ Neither Certain nor Uncertain
- ❑ Somewhat Uncertain
- ❑ Very Uncertain

V17. Did it seem to you that it would take a lot more than 50 years or a lot less than 50 years for the proposed changes in the caribou herds to occur?

- ❑ A lot more
- ❑ A lot less
- ❑ Not sure

V18. Do you feel your responses will have an impact on the policy decisions for caribou conservation?

- ❑ Yes
- ❑ No
- ❑ Not sure

V19. To what extent do you believe that your choices will be used by policy makers?

- ❑ Not at all
- ❑ Weakly
- ❑ Moderately
- ❑ Strongly

V20. Please provide any comments that might help us understand why you voted the way you did.

_____
_____
_____
_____

Appendix D: Demographic Information

We just have a final few questions. Please be assured this information will only be used to report comparisons among groups of people. Your identity will not be linked to your responses in any way.

D1. Are you…?

- ❑ Male
- ❑ Female

D2. What is your age? _____

D3. Do you live in a city or town that has more than 1,000 people?

- ❑ Yes
- ❑ No

D4. How many people live in your household including yourself? _____

D5. How many years have you lived in Alberta? _____

D6. What is your marital status?

- ❑ Single
- ❑ Married
- ❑ Common law

D7. What is your postal code? _____

D8. Which of the following is the highest level of education you have completed?

PLEASE CHECK ONE RESPONSE ONLY

- ❑ Grade school or some high school
- ❑ Completed high school
- ❑ Post-secondary technical school
- ❑ Some university or college
- ❑ Completed college diploma
- ❑ Completed university undergraduate degree
- ❑ Completed post-graduate degree (masters or Ph.D.)

D9. What is your current employment status?

PLEASE CHECK ONE RESPONSE ONLY

- ❑ Working full time outside the home or self employed
- ❑ Working part time outside the home or self employed
- ❑ Student
- ❑ Homemaker
- ❑ Retired
- ❑ Unemployed

D10. Which sector are you employed in?

PLEASE CHECK ONE RESPONSE ONLY

- ❑ Agriculture
- ❑ Forestry, fishing, mining, oil and gas
- ❑ Utilities, construction and manufacturing
- ❑ Transportation and warehousing
- ❑ Finance, insurance, real estate and leasing
- ❑ Educational services
- ❑ Health care and social assistance
- ❑ Information, culture and recreation
- ❑ Accommodation and food services
- ❑ Public administration
- ❑ Other

D11. Are you a member of or associated with any environmental organization (e.g., Greenpeace, Sierra Club, etc.)?

- ❑ Yes
- ❑ No

D12. In which of the following activities have you participated in the past 12 months?

PLEASE CHECK ALL THAT APPLY

- ❑ Camping
- ❑ Hiking
- ❑ Cross-country/downhill skiing
- ❑ Wildlife viewing
- ❑ Sightseeing in natural areas
- ❑ Ecotourism (paid visits for nature viewing)
- ❑ Photographing nature
- ❑ Fishing
- ❑ Hunting
- ❑ None of the above

D13. How often do you personally watch television programs about animals and birds in the wild?

- ❑ Very often
- ❑ Often
- ❑ Sometimes
- ❑ Rarely
- ❑ Never

D14. Which category best describes your total household income (before taxes) in 2010?

- ❑ Less than $20,000
- ❑ $20,000 - $39,999
- ❑ $40,000 - $59,999
- ❑ $60,000 - $79,999
- ❑ $80,000 - $99,999
- ❑ $100,000 - $119,999
- ❑ $120,000 - $139,999
- ❑ $140,000 - $159,999
- ❑ Greater than $160,000

THANK YOU VERY MUCH FOR YOUR COOPERATION

Appendix E: Telephone Recruitment Screener

Hi, my name is _____, from Advantis, a Canada wide market research firm. We are contacting you on behalf of the Department of Rural Economy at the University of Alberta. We are conducting a study about your attitudes surrounding woodland caribou conservation in Canada. We would like to invite you to participate in this study.

The 120 minute session will be held at [fill in city, venue, room, etc.]. Should you choose to attend, we are offering a $100.00 honorarium as a token of our appreciation and to cover any costs for your participation.

This study is to obtain your opinions and is strictly for research purposes. Would you be interested in participating?

Yes	1	**CONTINUE**
No, not interested	2	**THANK AND TERMINATE**

To determine whether your profile matches that of our project, I would like to ask you a few questions to see which group you qualify for.

1. RECORD GENDER

Male	1	**50/50 SPLIT**
Female	2	

2. In which of the following age categories are you?

Under 18	1	**THANK AND TERMINATE**
18 – 34	2	]
35 – 44	3	]
45 – 55	4	] —**OBTAIN GOOD SPREAD***
56 – 65	5	]
Over 65	6	]

Great, then I would like to invite you to participate on (see grid below)...

SESSION	City	RECRUIT	DATE	TIME
1	**Edmonton**	**50 for 40**	April 14, 2011	6 – 9 pm
2	**Edmonton**	**50 for 40**	April 26, 2011	6 – 9 pm
3	**Edmonton**	**50 for 40**	April 28, 2011	6 – 9 pm
4	**Lloydminster**	**50 for 40**	May 30, 2011	6 – 9 pm
5	**Calgary**	**50 for 40**	June 13, 2011	6 – 9 pm
6	**Calgary**	**50 for 40**	June 14, 2011	6 – 9 pm
7	**Grande Prairie**	**50 for 40**	June 23, 2011	6 – 9 pm

Are you interested in participating?

Yes 1

No 2 **THANK AND TERMINATE**

Very good; thank you.

I would like to assure you that your participation will be voluntary and that any information you provide will be kept strictly confidential.

This study will be held in XXXX. A map will be emailed / faxed / mailed to you before the scheduled discussion.

If you have any questions in advance of the study session or you need to cancel, you may call YYYY at XXXX, or call the Department of Rural Economy at the University of Alberta at (780) 492-4603.

No substitutes are allowed, so please call us if you can't make it so we can try to find another person who qualifies. Please be prompt as we would like to begin and finish on time so that people can get on with their evening/day, so please arrive before the start

time, but no more than 10 minutes early. Late-comers will not be able to take part in the sessions and will not be eligible for the incentive. Please avoid bringing any children to the session as we will need your full attention.

To be able to mail you the [location to be determined] map, may I please have your full name and address?

Name: _____- (FIRST AND LAST)

Phone: _____

Address:_____

City: _____ Postal Code:_____

Fax: _____ Email:_____

We will be calling you the day before your session to confirm your attendance. In case we are not able to reach you at the number you gave, is there another number we might try (e.g. work number)?

Alternate phone # _____

Please remember to bring a driver's licence or other form of photo ID.

That's all the information we need today. We will call you a day before the session as a reminder. Thanks for your time, and we look forward to seeing you.

VERY IMPORTANT TO READ THIS TO THE RESPONDENTS:

As we invite only 50 individuals to participate, your attendance is very important to us. If, for **ANY** reason you are unable to attend, **please call YYYY at XXX-XXXX** (1-8XX-XXX-XXX TOLL FREE) so we can attempt to find a replacement.

Appendix F: Response Rates for Workshops

Table F.1 Response Rates for Each Workshop

City	Date	Number originally recruited	Number confirmed	Number who attended the workshop	Response Rate (Attended/ Recruited)
Edmonton	April 14, 2011	46	29	37	80%
Edmonton	April 26, 2011	39	23	32	82%
Edmonton	April 28, 2011	48	30	35	75%
Lloydminster	May 30, 2011	44	19	34	77%
Calgary	June 13, 2011	49	24	38	78%
Calgary	June 14, 2011	50	22	38	76%
Grande Prairie	June 23, 2011	48	33	43	90%
Total		324	180	257	79%

Appendix G: Ngene Choice Design Statistics

Code:

```
design
;fact
;alts = alt1, alt2
;rows = 36
;block = 18
;model:
U(alt1) = b0 + b1*A[3,6,9,13] + b2*B[5,75,300,600] /
U(alt2) = b1*A[3,6,9,13] + b2*B[5,75,300,600]
;reject:
alt1.A=alt2.A ,
alt1.B=alt2.B ,
alt1.A>alt2.A and alt2.B>alt1.B ,
alt1.A<alt2.A and alt2.B<alt1.B
$
```

MNL efficiency measures

D error	8.5E-05
A error	0.003849
B estimate	100
S estimate	0

Prior	b1	b2
Fixed prior value	0	0
Sp estimates	Undefined	Undefined
Sp t-ratios	0	0

OOD optimality measures

D optimality	75.982844%

Appendix H: Additional Descriptive Statistics

Before participants answered the valuation questions, they were asked two general questions regarding the minimum number of self-sustaining herds and the maximum annual increase in taxes their household would find acceptable. On average, the minimum number of self-sustaining herds deemed acceptable is 10 and the maximum annual increase in taxes is approximately $167.39. The table below provides these estimates by survey location. The frequency of responses for the minimum number of self-sustaining herds across the entire sample is shown in the first figure below; over 20 percent of respondents chose 15 herds as the minimum acceptable number, and approximately 18 percent chose 10 herds. The maximum annual increase in taxes across the entire sample is shown in the second figure below; the cost ranged from $0 to $5,000, with approximately 80% of the sample in the $0 to $100 range.

Table H.1 Minimum Number of Self-Sustaining Herds and Maximum Annual Increase in Taxes by Location for the Sample

Location	Minimum number of self-sustaining herds	Maximum annual increase in taxes ($ per year)
All data	10	167.39
Edmonton	11	177.95
Lloydminster	9	303.39
Calgary	9	102.52
Grande Prairie	9	85.72

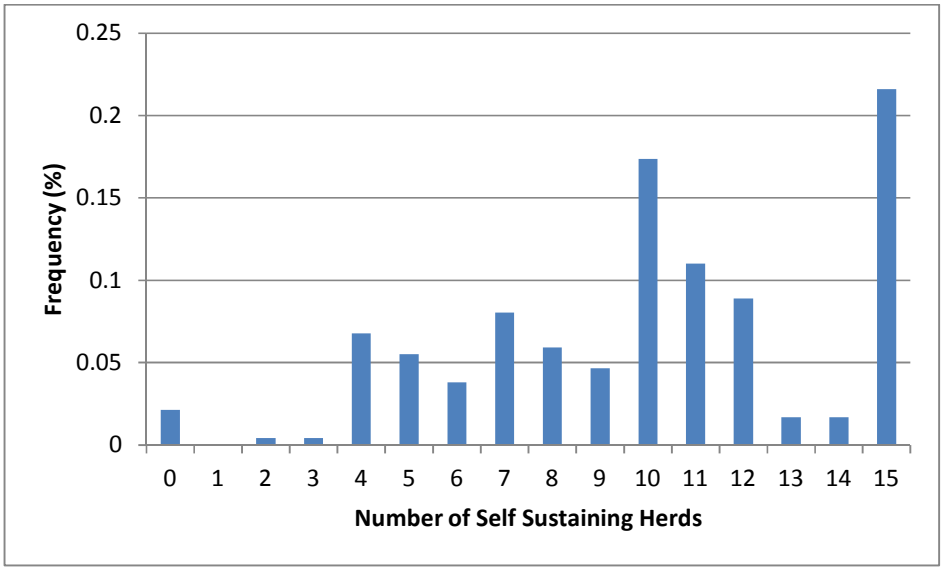


Figure H.1 Histogram of minimum number of self-sustaining herds a household would find acceptable across the sample

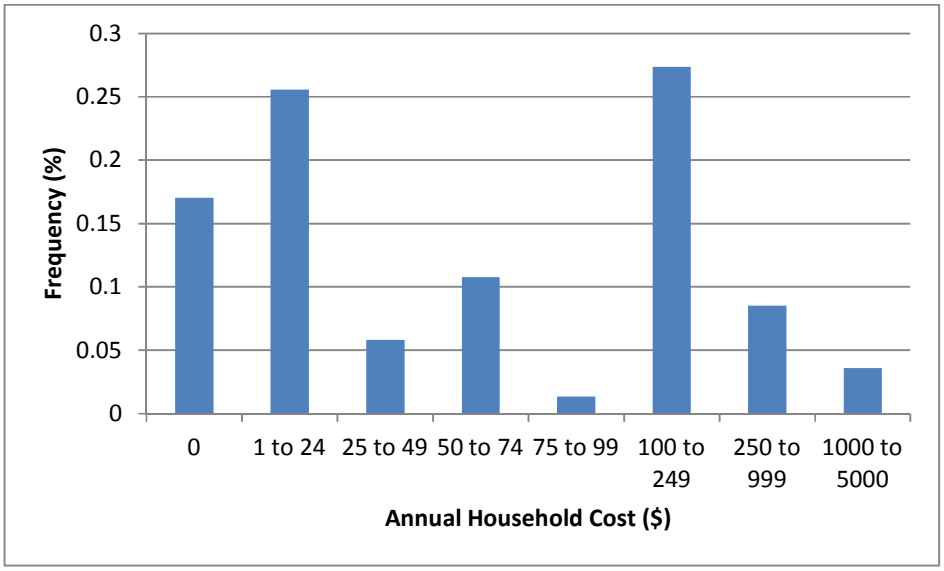


Figure H.1 Histogram of the maximum increase in provincial taxes a household would find acceptable across the sample

Appendix I: Nonparametric Analysis for the Contingent Valuation Data

The following three graphs depict the percentage of respondents who answered "yes" to the valuation question at each bid level for six herds, nine herds and 13 herds.

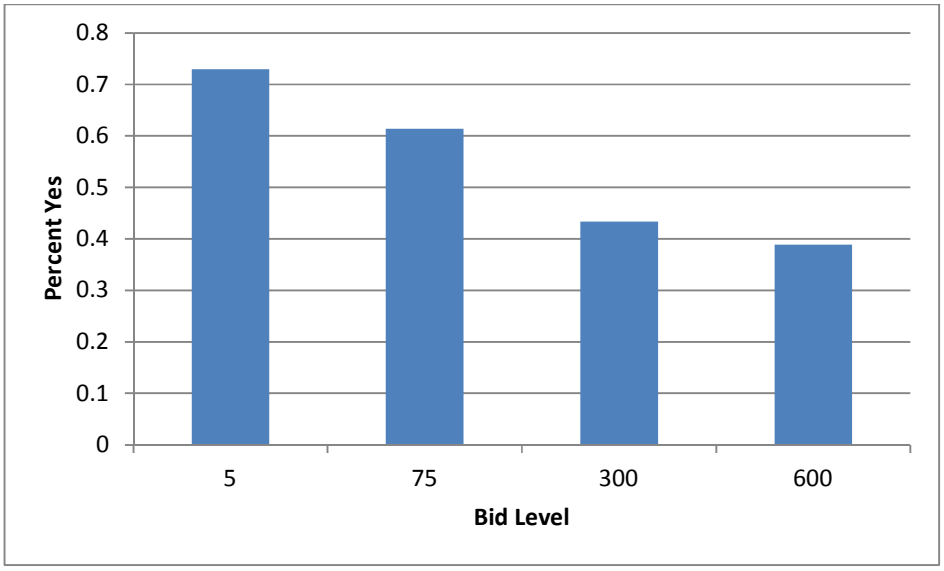


Figure I.1 Percentage of respondents who answered "yes" to the valuation question at each bid level for six herds

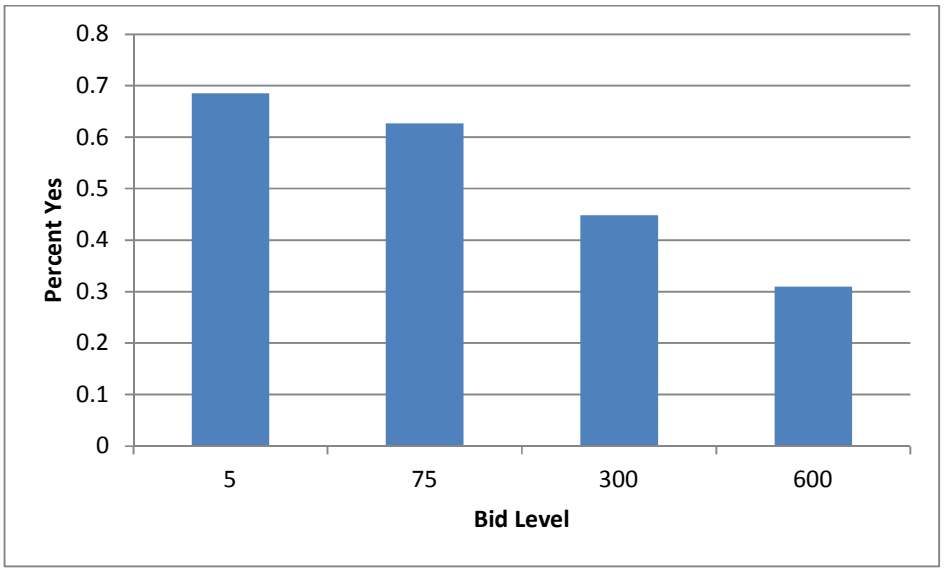


Figure I.2 Percentage of respondents who answered "yes" to the valuation question at each bid level for nine herds

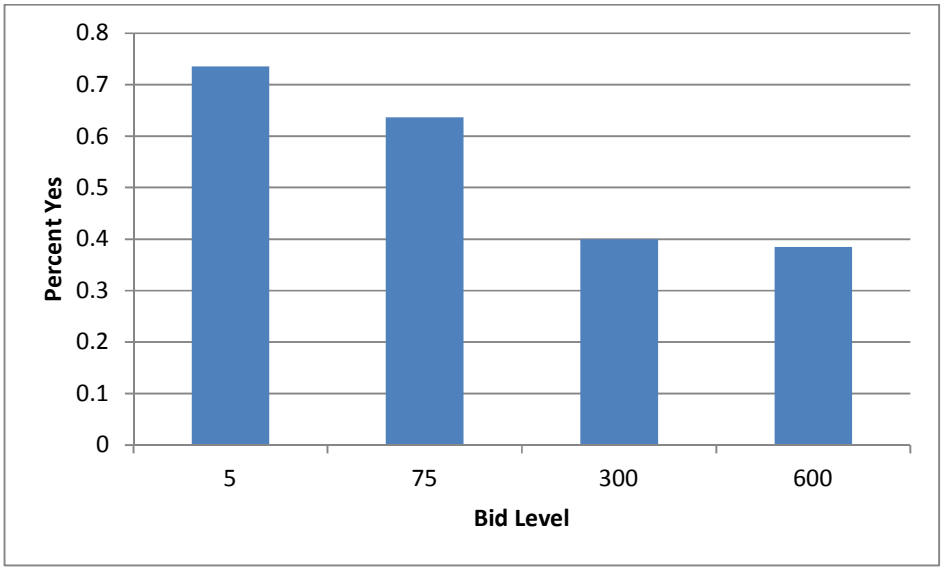


Figure I.3 Percentage of respondents who answered "yes" to the valuation question at each bid level for 13 herds

Approximately 70 percent of respondents answered yes to the lowest bid level, and between 30 and 40 percent of respondents answered yes to the highest bid level for all three herd options.

The non-parametric method used to estimate the mean or expected WTP values for caribou conservation is the Turnbull estimator of the probability density function which does not assume a distribution and imposes monotonicity (Haab and McConnell 2002). This estimator is defined as:

$$f_j^* = F_j - F_{j-1}$$

where f_j^* is the Turnbull estimator for the j^{th} bid level, F_j is the estimated cumulative distribution function (CDF) which is calculated as the number of people who responded "no" to the WTP question divided by the total number of people who participated in the survey for the j^{th} bid level and F_{j-1} is the CDF for the $(j\text{-}1)^{th}$ bid level. The expected value or mean WTP is calculated as:

$$E(WTP) = \sum_{j=0}^{M} t_j f_{j+1}^*$$

where t_j is the j^{th} bid level and f^*_{j+1} is the Turnbull estimator for the $(j+1)^{th}$ bid level for all *j* from *0* to *M*. Thus, this measure of the expected WTP is the lower-bound estimate which ensures that the value is not overstated.

Turnbull estimates for the total WTP are detailed in the table below. The j^{th} bid level is t_j, N_j is the number of people who said "no" to the WTP question for the j^{th} bid level, T_j is the total number of people who participated in the WTP question for the j^{th} bid level, F_j is the unrestricted CDF for the j^{th} bid level and f_j^* is the Turnbull estimator for the j^{th} bid level.

Table I.1 Turnbull Estimates for the Total WTP for Six Herds

t_j	N_j	T_j	F_j	f_j^*
5	10	37	0.270	0.272
75	22	57	0.386	0.116
300	17	30	0.567	0.181
600	22	36	0.611	0.044
600+			1	0.389

Table I.2 Turnbull Estimates for the Total WTP for Nine Herds

t_j	N_j	T_j	F_j	f_j^*
5	17	54	0.315	0.315
75	25	67	0.373	0.058
300	16	29	0.552	0.179
600	29	42	0.690	0.139
600+			1	0.310

Table I.3 Turnbull Estimates for the Total WTP for 13 Herds

t_j	N_j	T_j	F_j	f_j^*
5	9	34	0.265	0.265
75	24	66	0.364	0.099
300	18	30	0.600	0.236
600	16	26	0.615	0.015
600+			1	0.385

Respondents are willing to pay approximately $260.80 for six herds, $241.03 for nine herds and $253.61 for 13 herds. Respondents are willing to pay slightly more for six herds than they are for either nine or 13 herds. This may be indicative of the desire of respondents to conserve caribou in the province without restraining economic development. However, the range between these estimates is small.

Appendix J: Additional Models Estimated

Table J.1 Vote Models with Bid Level and Linear, Log and Quadratic Specifications for the Herd Term

	All Data[1]			Recoded for Uncertainty[2]		
	Linear Model	Natural Log Model	Quadratic Model	Linear Model	Natural Log Model	Quadratic Model
Status Quo	-0.865**	-0.739	-1.075	-0.746**	-0.769	-1.039
	(0.286)	*(0.486)*	*(0.864)*	*(0.279)*	*(0.474)*	*(0.844)*
Bid level	-0.003**	-0.003**	-0.003**	-0.002**	-0.002**	-0.002**
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
Number of herds (linear)	0.023		-0.058	-0.001		-0.113
	(0.034)		*(0.316)*	*(0.033)*		*(0.308)*
Number of herds (log)		0.197			-0.018	
		(0.312)			*(0.304)*	
Number of herds (quadratic)			0.004			0.006
			(0.016)			*(0.016)*
Observations	508	508	508	508	508	508
Log-likelihood	-316.92	-316.95	-316.89	-330.89	-330.89	-330.83
Adjusted ρ^2	0.07	0.07	0.06	0.05	0.05	0.04
WTP for 7 herds	340.92	342.89	339.24	302.31	303.50	299.67

* Statistically significant at the 90% level

** Statistically significant at the 99% level

[1] Using all the data in the sample

[2] Using all the data in the sample but recoding the uncertain votes for the proposed strategy to the current strategy

Table J.2 Vote Models with Bid Level and Linear, Log and Quadratic Specifications for the Herd Term

	Negative Policy Implications Rejected[1]		
	Linear Model	Natural Log Model	Quadratic Model
Status Quo	-0.888*	-0.638	-2.392*
	(0.444)	*(0.757)*	*(0.504)*
Bid level	-0.003**	-0.003**	-0.003**
	(0.001)	*(0.001)*	*(0.001)*
Number of herds	0.058		-0.528
(linear)	*(0.057)*		*(0.504)*
Number of herds		0.449	
(log)		*(0.499)*	
Number of herds			0.031
(quadratic)			*(0.026)*
Observations	209	209	209
Log-likelihood	-124.29	-124.43	-123.60
Adjusted ρ^2	0.06	0.06	0.06
WTP for 7 herds	419.05	427.86	399.08

* Statistically significant at the 90% level

** Statistically significant at the 99% level

[1] Only using the data from those respondents who thought their responses would have an impact on policy

Table J.3 Choice Models with Bid Level and Linear, Log and Quadratic Specifications for the Herd Term

	All Data[1]			Negative Policy Implications Rejected[2]		
	Linear Model	Natural Log Model	Quadratic Model	Linear Model	Natural Log Model	Quadratic Model
Bid level	-0.003**	-0.003**	-0.003**	-0.003**	-0.003**	-0.003**
	(0.000)	*(0.000)*	*(0.000)*	*(0.001)*	*(0.001)*	*(0.001)*
Number of herds (linear)	0.049*		0.337**	0.097*		0.687**
	(0.025)		*(0.100)*	*(0.039)*		*(0.156)*
Number of herds (log)		0.491**			0.980**	
		(0.175)			*(0.274)*	
Number of herds (quadratic)			-0.017**			-0.035**
			(0.006)			*(0.009)*
Observations	501	501	501	207	207	207
Log-likelihood	-306.49	-304.37	-301.92	-133.78	-130.06	-125.29
Adjusted ρ^2	0.11	0.12	0.13	0.06	0.08	0.11
	65.16	124.35	198.72	140.33	241.20	392.11

* Statistically significant at the 90% level

** Statistically significant at the 99% level

[1] Using all the data in the sample

[2] Only using the data from those respondents who thought their responses would have an impact on policy

Table J.4 Joint Models with Bid Level and Linear, Log and Quadratic Specifications for the Herd Term

	All Data[1]			Recoded for Uncertainty[2]		
	Linear Model	Natural Log Model	Quadratic Model	Linear Model	Natural Log Model	Quadratic Model
Status Quo	-0.744**	-0.505**	-0.316	-0.584**	-0.385*	-0.159
	(0.142)	*(0.186)*	*(0.210)*	*(0.141)*	*(0.185)*	*(0.209)*
Bid level	-0.003**	-0.003**	-0.003**	-0.003**	-0.003**	-0.003**
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
Number of herds (linear)	0.040*		0.273**	0.026		0.256**
	(0.018)		*(0.087)*	*(0.018)*		*(0.086)*
Number of herds (log)		0.378**			0.281*	
		(0.129)			*(0.128)*	
Number of herds (quadratic)			-0.014**			-0.013**
			(0.005)			*(0.005)*
Observations	1009	1009	1009	1009	1009	1009
Log-Likelihood	-623.60	-621.80	-619.82	-638.22	-636.88	-634.49
Adjusted ρ^2	0.10	0.10	0.10	0.08	0.08	0.09
WTP for 7 herds	327.94	322.55	345.00	273.74	267.13	295.23

* Statistically significant at the 90% level

** Statistically significant at the 99% level

[1] Using all the data in the sample

[2] Using all the data in the sample but recoding the uncertain votes for the proposed strategy to the current strategy

Table J.5 Joint Models with Bid Level and Linear, Log and Quadratic Specifications for the Herd Term

	Negative Policy Implications Rejected[1]		
	Linear Model	Natural Log Model	Quadratic Model
Status Quo	-0.650**	-0.161	0.173
	(0.215)	*(0.282)*	*(0.320)*
Bid level	-0.003**	-0.003**	-0.003**
	(0.000)	*(0.000)*	*(0.000)*
Number of herds (linear)	0.088**		0.542**
	(0.028)		*(0.133)*
Number of herds (log)		0.812**	
		(0.203)	
Number of herds (quadratic)			-0.027**
			(0.008)
Observations	416	416	416
Log-Likelihood	-258.27	-255.00	-251.92
Adjusted ρ^2	0.08	0.09	0.10
WTP for 7 herds	405.64	391.06	433.05

* Statistically significant at the 90% level

** Statistically significant at the 99% level

[1] Only using the data from those respondents who thought their responses would have an impact on policy

Appendix K: Likelihood Ratio Test Calculations

Null Hypothesis H_0: $\beta_v = \beta_c \; and \; \delta_v = \delta_c$

Alternative Hypothesis H_1: $\beta_v \neq \beta_c \; and \; \delta_v \neq \delta_c$

Table K.1 Likelihood Ratio Test Functions and Values

Model	Function	Log-likelihood Value
Vote	$vote = \alpha_v + \beta_v t + \delta_v \ln(H)$	-330.89
Choice	$choice = \beta_c t + \delta_c \ln(H)$	-304.37
Joint	$joint = \alpha + \beta t + \delta \ln(H)$	-636.88

$LR = 2\left[(x_v + x_c) - x_j\right] = 2[(-330.89 \pm 304.37) \pm 636.88)] = 3.24$

Critical chi-squared value with two degrees of freedom at 5% significance level is 5.99

Since 3.24 < 5.99, the null hypothesis cannot be rejected

Appendix L: Additional Model

Table L.1 Vote Model with Age and Grande Prairie Interacted with the Linear Number of Herds

	Linear Model
Status Quo	-0.660*
	(0.284)
Bid level	-0.002**
	(0.000)
Number of herds (linear)	0.137*
	(0.057)
Age of respondent (interacted with	-0.002**
number of herds)	*(0.001)*
Grande Prairie (interacted with number of	-0.095**
herds)	*(0.033)*
Observations	498
Log-likelihood	-317.30
Adjusted ρ^2	0.06

* Statistically significant at the 90% level

** Statistically significant at the 99% level

Appendix M: Additional Models Corrected for Scenario Rejection and Warm Glow

Table M.1 Vote Model Corrected for Scenario Rejection

	Linear	Natural Log	Quadratic
Status Quo	-1.176**	-0.882	-0.699
	(0.320)	*(0.541)*	*(0.974)*
Bid level	-0.003**	-0.003**	-0.003**
	(0.000)	*(0.000)*	*(0.000)*
Number of herds	0.043		0.230
(linear)	*(0.039)*		*(0.363)*
Number of herds		0.410	
(log)		*(0.352)*	
Number of herds			-0.010
(quadratic)			*(0.019)*
Observations	452	452	452
Log-likelihood	-252.66	-252.60	-252.52
Adjusted ρ^2	0.08	0.08	0.08
WTP for 7 herds	440.65	441.54	445.24

* Statistically significant at the 90% level

** Statistically significant at the 99% level

Table M.2 Choice Model Corrected for Scenario Rejection

	Linear	Natural Log	Quadratic
Bid level	0.072**	-0.003**	-0.003**
	(0.027)	*(0.000)*	*(0.000)*
Number of herds	-0.003**		0.329**
(linear)	*(0.000)*		*(0.105)*
Number of herds		0.624**	
(log)		*(0.184)*	
Number of herds			-0.015*
(quadratic)			*(0.006)*
Observations	443	443	443
Log-likelihood	-274.61	-272.40	-271.29
Adjusted ρ^2	0.07	0.08	0.08
WTP for 7 herds	132.60	259.80	318.36

* Statistically significant at the 90% level

** Statistically significant at the 99% level

Table M.3 Vote Model Corrected for Warm Glow

	Linear	Natural Log	Quadratic
Status Quo	-0.739*	-0.650	-0.808
	(0.300)	*(0.511)*	*(0.906)*
Bid level	-0.003**	-0.003**	-0.003**
	(0.000)	*(0.000)*	*(0.000)*
Number of herds	0.015		-0.011
(linear)	*(0.036)*		*(0.331)*
Number of herds		0.134	
(log)		*(0.329)*	
Number of herds			0.001
(quadratic)			*(0.017)*
Observations	458	458	458
Log-likelihood	-286.93	-286.94	-286.93
Adjusted ρ^2	0.07	0.07	0.07
WTP for 7 herds	271.24	272.25	270.74

* Statistically significant at the 90% level

** Statistically significant at the 99% level

Table M.4 Choice Model Corrected for Warm Glow

	Linear	Natural Log	Quadratic
Bid level	-0.003**	-0.004**	-0.004**
	(0.001)	*(0.001)*	*(0.001)*
Number of herds	0.033		0.265*
(linear)	*(0.027)*		*(0.108)*
Number of herds		0.353*	
(log)		*(0.189)*	
Number of herds			-0.014*
(quadratic)			*(0.006)*
Observations	474	474	474
Log-likelihood	-263.84	-262.81	-261.30
Adjusted ρ^2	0.17	0.17	0.18
WTP for 7 herds	48.06	119.07	191.18

* Statistically significant at the 90% level

** Statistically significant at the 99% level

Table M.5 Vote Model Corrected for both Scenario Rejection and warm glow

	Linear	Natural Log	Quadratic
Status Quo	-1.047**	-0.790	-0.435
	(0.333)	*(0.566)*	*(1.013)*
Bid level	-0.003**	-0.003**	-0.003**
	(0.000)	*(0.000)*	*(0.000)*
Number of herds	0.036		0.274
(linear)	*(0.041)*		*(0.376)*
Number of herds		0.347	
(log)		*(0.368)*	
Number of herds			-0.013
(quadratic)			*(0.020)*
Observations	396	396	396
Log-likelihood	-230.34	-230.28	-230.14
Adjusted ρ^2	0.09	0.09	0.09
WTP for 7 herds	373.56	373.61	379.18

* Statistically significant at the 90% level

** Statistically significant at the 99% level

Table M.6 Choice Model Corrected for both Scenario Rejection and Warm Glow

	Linear	Natural Log	Quadratic
Bid level	-0.003**	-0.003**	-0.003**
	(0.001)	*(0.001)*	*(0.001)*
Number of herds	0.056*		0.253*
(linear)	*(0.028)*		*(0.113)*
Number of herds		0.483*	
(log)		*(0.196)*	
Number of herds			-0.012*
(quadratic)			*(0.006)*
Observations	403	403	403
Log-likelihood	-236.75	-235.63	-235.08
Adjusted ρ^2	0.12	0.12	0.12
WTP for 7 herds	89.60	180.66	220.89

* Statistically significant at the 90% level

** Statistically significant at the 99% level

Table M.7 Joint Model Corrected for Scenario Rejection

	Linear	Natural Log	Quadratic
Status Quo	-0.895**	-0.557**	-0.438*
	(0.153)	*(0.197)*	*(0.223)*
Bid level	-0.003**	-0.003**	-0.003**
	(0.000)	*(0.000)*	*(0.000)*
Number of herds	0.073**		0.328**
(linear)	*(0.019)*		*(0.093)*
Number of herds		0.611**	
(log)		*(0.139)*	
Number of herds			-0.015**
(quadratic)			*(0.005)*
Observations	895	895	895
Log-likelihood	-527.87	-525.21	-523.89
Adjusted ρ^2	0.10	0.11	0.11
WTP for 7 herds	441.43	435.85	453.98

* Statistically significant at the 90% level

** Statistically significant at the 99% level

Table M.8 Joint Model corrected for Warm Glow

	Linear	Natural Log	Quadratic
Status Quo	-0.733**	-0.580**	-0.403*
	(0.152)	*(0.200)*	*(0.227)*
Bid level	-0.003**	-0.003**	-0.003**
	(0.000)	*(0.000)*	*(0.000)*
Number of herds	0.021		0.198*
(linear)	*(0.019)*		*(0.093)*
Number of herds		0.221	
(log)		*(0.138)*	
Number of herds			-0.010*
(quadratic)			*(0.005)*
Observations	932	932	932
Log-likelihood	-550.98	-550.31	-549.11
Adjusted ρ^2	0.12	0.13	0.13
WTP for 7 herds	263.74	260.31	277.82

* Statistically significant at the 90% level

** Statistically significant at the 99% level