

Evidence of the Socio-Economic Importance of Polar Bears for Canada

Prepared by ÉcoRessources Consultants

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Prepared by ÉcoRessources Consultants



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ACRONYMS

COSEWIC = Committee on the Status of Endangered Wildlife in Canada

GDP = Gross domestic product

SYMBOLS AND ABBREVIATIONS

\$ = Canadian dollars (unless otherwise indicated, monetary amounts are in 2009 Canadian dollars)

US\$ = American dollars

U/A = unavailable

N/A = not applicable

Glossary

Active-use value – Value that implies a certain use of the resource, direct or indirect, now or in the future (option value).

Anthropocentric value – Value that uses human beings as its reference system (or its assessor).

Benefit transfer – This method is used to transfer values or functions of values originally provided by a particular site (study site) to another site (target site). Some adjustments are made to reflect the various study contexts.

Bequest value – Value assigned to the option of conserving a resource for future generations.

Consumer surplus – Indicates the value of the consumed goods minus the price paid for them (net consumer surplus). The gross consumer surplus includes the price of the goods.

Direct-use value – Direct use involves contact or interaction with the resource. This value can be divided into two additional sub-categories: consumptive direct use, as is the case with hunting, and non-consumptive direct use, as with viewing polar bears in their natural environment.

Existence value – Value assigned to the simple fact that a resource exists, even if it is never used.

Indirect-use value – Indirect use does not involve contact with the resource. This value is gained by using the resource's image or the information that characterizes it (ex.: education value, scientific value, iconic species etc.).

Market-price method – A method that uses the prices of goods and services sold on the market to estimate the value of a resource.

Meta-analysis – Statistical summary of studies on a given topic.

Meta-model – Model developed as part of a meta-analysis, which uses the various studies that have been compiled to build models that clearly explain why the results of these studies varied.

Option value – Value assigned to the option of benefiting from a resource in the future.

Passive-use value – Value that does not involve active use of the resource, only an awareness of animals' well-being and their role in the ecosystem (existence value) and the desire to ensure that they continue to exist in their natural habitat for generations to come (bequest value).

Producer surplus – Indicates the value of the product minus the variable costs incurred to produce it.

Substitute-cost method – Involves identifying products and services that can be substituted for the goods being evaluated and observing their market values. This method is generally used when the goods whose values are being estimated are not commercialized, as is the case with polar bear meat.

Total economic value – All of the active and passive-use values of a particular resource.

Travel-cost method – Method used to estimate the monetary value of a recreational site or of a change in the quality of the site by using the cost of travelling to the site to estimate the recreational demand and the consumer surplus for a visit.

Willingness to pay – Maximum amount that a person is willing to forgo in order to enjoy a good or service.

Executive Summary

The polar bear (*Ursus maritimus*) is an icon of the Arctic environment and Canada's wildlife heritage. Canada is home to approximately 15 000 polar bears representing two-thirds of the global total.¹ The Canadian polar bear population extends to four provinces and three territories within the Arctic marine environment.

The species is of cultural, spiritual and economic significance to Canadians, and particularly to Canada's Northern Aboriginal peoples. As a symbol of the pristine Arctic environment, polar bears are seen throughout the world as a barometer of important environmental issues, especially climate change and pollution.²

As a background analysis in support of the regulatory and future decision-making processes, this document explores evidence of economic values relevant to polar bears as well as economic activities affecting the polar bear and its habitat.

The study is a first attempt to estimate various socio-economic values associated with polar bears in Canada in a comprehensive fashion. The economic values have been estimated using a total economic value (TEV) framework concept.

The first part of the study addresses the evidence of active and passive economic values. The second part focuses on the economic activities that may affect the polar bear population or its habitat. A framework has been developed with the aim of providing decision support for assessing potential trade-offs associated with future policy decisions.

Active values include: subsistence and sport hunting, polar bear viewing in natural settings or in zoos, use of the polar bear image as a symbol, as well as studying polar bears for scientific or educational purposes. These values have been estimated using various economic methods, such as market price for sport and subsistence hunting and travel cost for viewing in the wild. Only some of the aforementioned values could be estimated monetarily. As for the existence value, no primary studies have been conducted on the polar bear, thus a benefit transfer has been used to estimate this passive-use value.

The value of subsistence hunting has been estimated at \$0.6 million, while the sport hunt represents approximately \$1.3 million per year. The highest values of subsistence hunting and sport hunting are found in the Northwest Territories and Nunavut, at \$543,000 and \$923,000, respectively.

The Inuit allocate some of their hunting tags to sport hunting, thus generating economic activities surrounding polar bear hunting. Only 20% of tags are allocated to sport hunting, in spite of the evidence indicating that sport hunting generates greater economic value than subsistence hunting. This indicates that the Aboriginal communities are not seeking to maximize profits associated with

¹ COSEWIC – Committee on the Status of Endangered Wildlife in Canada. 2008. *Assessment and Update Status Report on the Polar Bear (Ursus maritimus) in Canada* (Ottawa, ON: COSEWIC, 2008)

² COSEWIC, vi.

polar bear hunting. Based on the observations made in the settlement of Resolute Bay in Nunavut by Dowsley (2007), the estimated forgone income is approximately \$7,000 per person, which may be an indication of the importance of other values such as preserving cultural, spiritual and traditional values.

In the case of polar bear viewing in its natural habitat, Manitoba has the highest value because Churchill is the most important place for this activity in Canada. The value of polar bear observation in its natural habitat in Churchill, Manitoba, is estimated to be \$7.2 million per year, of which \$2.2 million represents the net revenue of companies who organize viewing expeditions. The remaining \$5 million is attributed to individuals who travel on their own to Churchill to view and photograph polar bears.

Information on passive-use values is typically collected via contingent valuation studies. A review of the literature to date indicates that no such studies currently exist on the polar bear. Based on evidence derived from a meta-analysis, the benefit-transfer technique has been applied to estimate the value Canadians would have placed on the preservation of iconic species such as the polar bear. The value is estimated at approximately \$508 per household and totals \$6 billion annually for Canada. The distribution analysis of this value across Canada is based on household data in each province and territory. However, given the particular relationship between Aboriginal peoples and polar bears, it is possible that the preservation value attributed by Aboriginal peoples to polar bears is higher.

Some values associated with polar bears could not be evaluated monetarily. The value of polar bear viewing in captivity (zoos) is difficult to determine because polar bears are usually just one of many animal species living in zoos. It is only possible to highlight the potential importance of this value. The estimation of the scientific and educational value of the polar bear is also a challenge. Public funds allocated to research on the polar bear in Canada can provide an initial indication of the scientific value, but this indicator is not sufficient to estimate a monetary value. Similarly, it is difficult to estimate the symbolic value of the polar bear because the image of the polar bear is used for a multitude of purposes and there is little data on this subject.

The second part of the report focuses on the analysis of economic activities which could have an impact on the polar bear and its habitat. Activities that could have a potential impact on polar bears include: the mining industry, oil and gas exploration and development, infrastructure for land and air transportation as well as pipeline distribution, marine transportation, production of hydropower, military operations, tourism, hunting, and the development of human settlements notably near maternal denning sites. Moreover, a change in the polar bear population can, in turn, affect activities such as polar bear viewing and hunting.

This study also presents a framework for the analysis of the socio-economic impacts of a change in the population or the habitat of the polar bear. The framework provides necessary elements to help answer the question: "What are the steps to follow to evaluate the costs and benefits of a policy decision affecting the population or the habitat of polar bears in Canada?"

The ultimate aim of the study is to inform the public decision-making process related to the polar bear. The estimated values presented in this report will serve as basic information for future policy making concerning polar bears. However, it has to be noted that this is a first attempt in establishing

economic evidence surrounding the polar bear and more data and analysis are needed. Further studies will thus be necessary for informed decision-making on questions concerning Canada's polar bear population.

Table of Contents

EXECUTIVE SUMMARY	Error! Bookmark not defined.
SOMMAIRE EXÉCUTIF	viii
CHAPTER 1: BACKGROUND AND STUDY OBJECTIVES	1
1.1 BACKGROUND.....	1
1.2 STUDY OBJECTIVES.....	2
CHAPTER 2: SOCIO-ECONOMIC VALUES ASSOCIATED WITH CANADA’S POLAR BEARS	3
2.1 METHODOLOGY	3
2.1.1 <i>Concept of total economic value</i>	3
2.1.2 <i>Economic evaluation methods used in the study</i>	5
2.1.3 <i>Economic indicators of well-being used in the study</i>	8
2.2 ESTIMATE OF THE SOCIO-ECONOMIC VALUES ASSOCIATED WITH POLAR BEARS	10
2.2.1 <i>Active-use values</i>	10
2.2.1.1 Value of subsistence hunting.....	10
2.2.1.2 Value of sport hunting.....	16
2.2.1.3 Value of viewing Polar Bears in their natural habitat.....	20
2.2.1.4 Value of visits to zoos.....	21
2.2.1.5 Iconic value.....	22
2.2.1.6 Scientific and educational value	23
2.2.2 <i>Passive-use values</i>	23
2.2.2.1 Preservation value	23
2.2.3 <i>Cultural, spiritual and social value for Aboriginals</i>	26
2.2.4 <i>Indirect economic benefits relating to the Polar Bear</i>	29
2.2.5 <i>Total economic value</i>	29
2.2.6 <i>Distribution by province and territory</i>	34
CHAPTER 3: HOW CHANGES IN HUMAN ACTIVITIES IN NORTHERN CANADA COULD AFFECT POLAR BEAR HABITAT AND POPULATION	37
CHAPTER 4: FRAMEWORK FOR ANALYZING THE IMPACT OF CHANGES IN POLAR BEAR POPULATIONS AND HABITAT ON THE CANADIAN ECONOMY AND SOCIETY	55
CONCLUSIONS	63
BIBLIOGRAPHY	64
APPENDICES.....	68
APPENDIX 1: CONSUMER SURPLUS, PRODUCER SURPLUS AND COMPENSATING VARIATION.....	69
APPENDIX 2: MAIN STEPS OF THE TRAVEL-COST METHOD (ZONAL TRAVEL-COST APPROACH)	70
APPENDIX 3: MODEL USED TO ESTIMATE PRESERVATION VALUE.....	75
APPENDIX 4: USE OF THE RICHARDSON AND LOOMIS META-MODEL (2008) TO ESTIMATE THE PRESERVATION VALUE OF CANADA’S POLAR BEARS	76

List of Tables

TABLE 1: METHODS USED FOR ESTIMATING THE VARIOUS VALUES ASSOCIATED WITH POLAR BEARS	6
TABLE 2: ESTIMATED ECONOMIC INDICATORS OF WELL-BEING FOR EACH VALUE ASSOCIATED WITH POLAR BEARS	10
TABLE 3: SUBSTITUTE VALUES OF POLAR BEAR MEAT REPORTED IN THE LITERATURE	13
TABLE 4: VALUE OF POLAR BEAR MEAT.....	14
TABLE 5: GROSS VALUES OF A BEAR PELT REPORTED IN THE LITERATURE.....	15
TABLE 6: VALUE OF POLAR BEAR PELTS HARVESTED IN THE 2009 SUBSISTENCE HUNT.....	16
TABLE 7: VALUE OF THE MEAT AND PELT OF POLAR BEARS HARVESTED IN THE 2008–2009 SUBSISTENCE HUNT.....	16
TABLE 8: PRODUCER’S INCOME PER SPORT HUNT.....	18
TABLE 9: PRODUCER’S VARIABLE COSTS PER HUNT.....	19
TABLE 10: TOTAL VALUE OF A SPORT HUNT.....	20
TABLE 11: VALUE OF VIEWING POLAR BEARS IN THEIR NATURAL HABITAT (CHURCHILL, MANITOBA).....	21
TABLE 12: VARIABLES OF THE RICHARDSON AND LOOMIS MODEL (2008), THEIR COEFFICIENTS AND THE VALUES USED FOR ESTIMATING THE PRESERVATION VALUE OF POLAR BEARS	25
TABLE 13: PRESERVATION VALUE OF CANADA’S POLAR BEARS	26
TABLE 14: MONETARY VALUES ASSOCIATED WITH POLAR BEARS IN CANADA (UNIT AND AGGREGATE AMOUNTS).....	33
TABLE 15: VALUES ASSOCIATED WITH THE POLAR BEAR BROKEN DOWN BY PROVINCE AND TERRITORY (\$).....	36
TABLE 16: HUMAN ACTIVITIES THAT COULD HAVE AN IMPACT ON THE POLAR BEAR POPULATION OR ITS HABITAT AND THE IMPACTS.....	39
TABLE 18: ANALYSIS GRID FOR ALL THE IMPACTS OF A POLAR BEAR INTERVENTION STRATEGY.....	60
TABLE 19: AVERAGE TRAVEL COSTS TO WINNIPEG AND NUMBER OF VISITORS BY ZONE.....	72

List of Figures

FIGURE 1: VALUES ASSOCIATED WITH POLAR BEARS.....	5
FIGURE 2: MONETARY VALUES ASSOCIATED WITH POLAR BEARS IN CANADA, BY VALUE CATEGORY (AGGREGATE AMOUNTS FOR CANADA).....	32
FIGURE 3: GDP OF ECONOMIC ACTIVITIES THAT MAY AFFECT POLAR BEARS IN THE AREA WHERE POLAR BEARS ARE LIKELY TO BE PRESENT AND FOR ALL THE TERRITORIES.....	45
FIGURE 4: GDP OF ACTIVITIES, WHICH MAY AFFECT POLAR BEARS, CONDUCTED IN THE AREA WHERE POLAR BEARS ARE LIKELY TO BE PRESENT.....	46
FIGURE 5: MINING EXPLORATION ACTIVITIES AND DISTANCE FROM THE AREA WHERE POLAR BEARS ARE LIKELY TO BE PRESENT IN NUNAVUT.....	47
FIGURE 7: OIL AND GAS EXPLORATION SITES IN THE BEAUFORT SEA.....	49
FIGURE 8: MACKENZIE GAS PIPELINE ROUTE.....	50
FIGURE 9: COMMUNITIES IN NORTHERN CANADA.....	51
FIGURE 10: HUMAN SETTLEMENTS AND THEIR LOCATION WITH RESPECT TO THE AREA.....	52
FIGURE 11: FRAMEWORK FOR ANALYZING THE IMPACTS OF SOCIO-ECONOMIC CHANGES.....	62
FIGURE 12: CONSUMER AND PRODUCER SURPLUS.....	69
FIGURE 13: THE THREE ZONES IDENTIFIED FOR VISITORS FROM CANADA WHO TRAVELLED TO CHURCHILL.....	71
FIGURE 14: THE FOUR ZONES IDENTIFIED FOR VISITORS FROM OUTSIDE CANADA WHO TRAVELLED TO CHURCHILL.....	71
FIGURE 15: VALUE OF POLAR BEAR VIEWING IN CHURCHILL, MANITOBA (CANADIAN VISITORS).....	74
FIGURE 16: VALUE OF POLAR BEAR VIEWING IN CHURCHILL, MANITOBA (FOREIGN VISITORS).....	74

Chapter 1: Background and Study Objectives

1.1 Background

Humans assign a socio-economic value to environmental goods such as species and ecosystems, based on their existence proper and the activities that arise from them. They also have an intrinsic value that is independent of any human consideration. In order to take them into account in the policy-making process, these environmental goods must be evaluated.

Political decisions are based primarily on economic criteria and have long been made without taking environmental factors into consideration. The value of the environment was recognized, but because it had not been estimated, it was not taken into account when calculating the costs and benefits of political decisions: where the value of an environmental good or service had not been estimated, it was deemed to have no economic value.

Placing a value on environmental goods enables the value of these goods to be taken into account when policies are being developed and selected, and helps decision-makers select the most effective options. This assessment provides a rationale for the investment needed to preserve ecosystems or species, by comparing the socio-economic value of these ecosystems or species with the costs that will have to be incurred to protect them.

The polar bear (*Ursus maritimus*) is the largest land carnivore and is at the top of the food chain. It lives in five countries: Denmark (Greenland), Canada (the North), the United States (Alaska), Russia (Siberia) and Norway. The polar bear's hunting ground is the sea ice, where it feeds primarily on seals. Canada is home to approximately two-thirds of the world's polar bear population, which is estimated at approximately 20 000 to 25 000 individuals³. Most of the existing Canadian polar bear population is located in Nunavut (Dowsley, 2009). Several values are associated with the polar bear—values that result from human activities relating to the existence of the species.

Aboriginal people hunt the polar bear for its hide and meat and some peoples, particularly the Inuit, accord it significant cultural, artistic and spiritual values. Inuit beliefs regarding the polar bear are reflected in many legends and are an important source of artistic inspiration. The polar bear is also a tourist attraction in terms of sport hunting and viewing. Inuit guides take Canadian and foreign hunters on dogsleds to participate in polar bear sport hunting in Northern Canada. Polar bear viewing is also of great interest to Canadian and foreign tourists who pay thousands of dollars for polar bear photographic tours. For example, a six-day excursion to Churchill, Manitoba, including a tour of the surrounding area, two days of polar bear viewing and dogsledding costs approximately \$5,000⁴.

³ IUCN/SSC Polar Bear Specialist Group website (<http://pbsg.npolar.no/en/status/>).

⁴ Canada Experience website (<http://www.canadaxperience.com/Manitoba/Nature/Safari-%C3%A0-lours-polaire-6-jours>).

Other values are associated with the polar bear. Aside from the value placed on it by some Aboriginal peoples, such as the Inuit or Cree, the polar bear also has a scientific and educational value. The polar bear is one of the animals studied by the branch of science known as "biomimetics", which draws inspiration from nature to solve technical problems. The polar bear's image is also widely used in advertising campaigns (e.g. Coca-Cola and Nissan), as the emblem on the two-dollar coin and as a symbol for winter festivals. It is, moreover, a charismatic animal whose image has come to symbolize climate change.

The polar bear is particularly vulnerable to overhunting (COSEWIC, 2010), the presence of chemical contaminants in its prey, and the decline in sea ice area caused by global warming. Some human activities such as oil and gas drilling and exploration and eco-tourism can also be stress factors for polar bear populations (IUCN Red List, 2008).

In April 1991 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)⁵ considered the polar bear population level in Canada to be of "special concern." The 2008 reassessment confirmed this status, but the Canadian government has not yet made any decision as to whether it will place the polar bear on the Species at Risk List⁶. In 2008, it was designated a "threatened" species in the United States, and in 2010, an area larger than California was declared a "protected area" in Alaska with the goal of preserving the polar bear's critical habitat. However, the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) rejected the U.S. proposal to provide greater protection for the polar bear by moving it from CITES Appendix II to Appendix I, which lists species threatened with extinction.

1.2 Study objectives

Given that many segments of the Canadian population value the polar bear (consumption, recreation, existence, etc.), the main objective of this study is to estimate these different values to the extent possible. These values refer to the current status of the polar bear population and the various uses of the bear. The study's findings will be used to inform public policy-makers involved in the endangered species decision-making process. The study is an attempt to establish economic values associated with polar bear use through the total economic value approach, despite information and budget constraints. The goal is not to set a price on the polar bear, but to reflect the potential economic compromises associated with the species.

The study's second objective is to provide methodology options and relevant information for a potential future estimate of the costs and benefits of changes in the polar bear population or its habitat as compared to the current situation. In this regard, the study conducts an inventory of the economic activities in Northern Canadian that involve polar bears and their habitat and proposes guidelines for a method to analyze the impact of changes to the polar bear population and habitat on the Canadian economy and society.

⁵ COSEWIC is an independent committee of experts whose mission is to conduct assessments and determine whether species are at risk under the *Species at Risk Act*. It produces assessments for the federal Minister of the Environment, who in turn makes recommendations to the Governor General in Council to add identified species to the *Species at Risk Act* list.

⁶ Adding the Polar Bear to the list as a species of "special concern" requires the development and implementation of an action plan that aims to keep the bear from becoming a species at risk.

Chapter 2: Socio-economic Values associated with Canada's Polar Bears

This chapter presents the concept of total economic value, the methods used for estimating the socio-economic values relating to polar bears in Canada, the economic indicators of well-being utilized in the study, and the various values obtained.

2.1 Methodology

2.1.1 Concept of total economic value

A wide range of values characterize environmental goods and services, such as recreational, preservation, cultural, and intrinsic values. The economic estimation of these values is not an easy exercise and, in some cases, still represents a methodological challenge. We also know that some of these values, such as the cultural value that Aboriginal people place on some animals or the intrinsic value of the environment, are very significant, although difficult to quantify.

Figure 1 presents a classification of these values as they relate to polar bears. The table shows the anthropocentric values (i.e. the values assigned by humans) and the non-anthropocentric values. The non-anthropocentric values include the intrinsic value of polar bears, independent of the human value system. Anthropocentric values include the various components of total economic value, as well as values that vary across cultures, as is the case with Inuit cultural, artistic and spiritual values. Anthropocentric values are not part of the total economic value because it is difficult to evaluate them in monetary terms.

Total economic value represents all active- and passive-use values (see Figure 1). Active-use values, also known as *use values*, imply direct or indirect use of a resource now or in the future (*option value*). Direct use involves contact or interaction with a resource and can be divided into two additional sub-categories: consumptive direct use, as is the case with hunting, and non-consumptive direct use, as is the case with viewing polar bears in their natural environment. Indirect use, on the other hand, does not involve contact with a resource, but rather using its image or the information that characterizes it. This is the case of polar bear value as an iconic species, illustrated by Coca-Cola's use of the polar bear's image in its advertisements. Polar bears' educational value and scientific value, and the value of seeing them in zoos, can be included in the same category, even if the last two involve both direct and indirect uses since part of scientific research requires coming into direct contact with polar bears to take various measurements and samples, and zoos provide direct visual contact with the bears, who also happen to be in captivity.

Passive-use values, also known as *non-use values*, do not involve any use of the resource, only an awareness of the animals' well-being and their role in the ecosystem (*existence value*) and the desire to ensure that they continue to exist in their natural habitat for generations to come (*bequest value*).

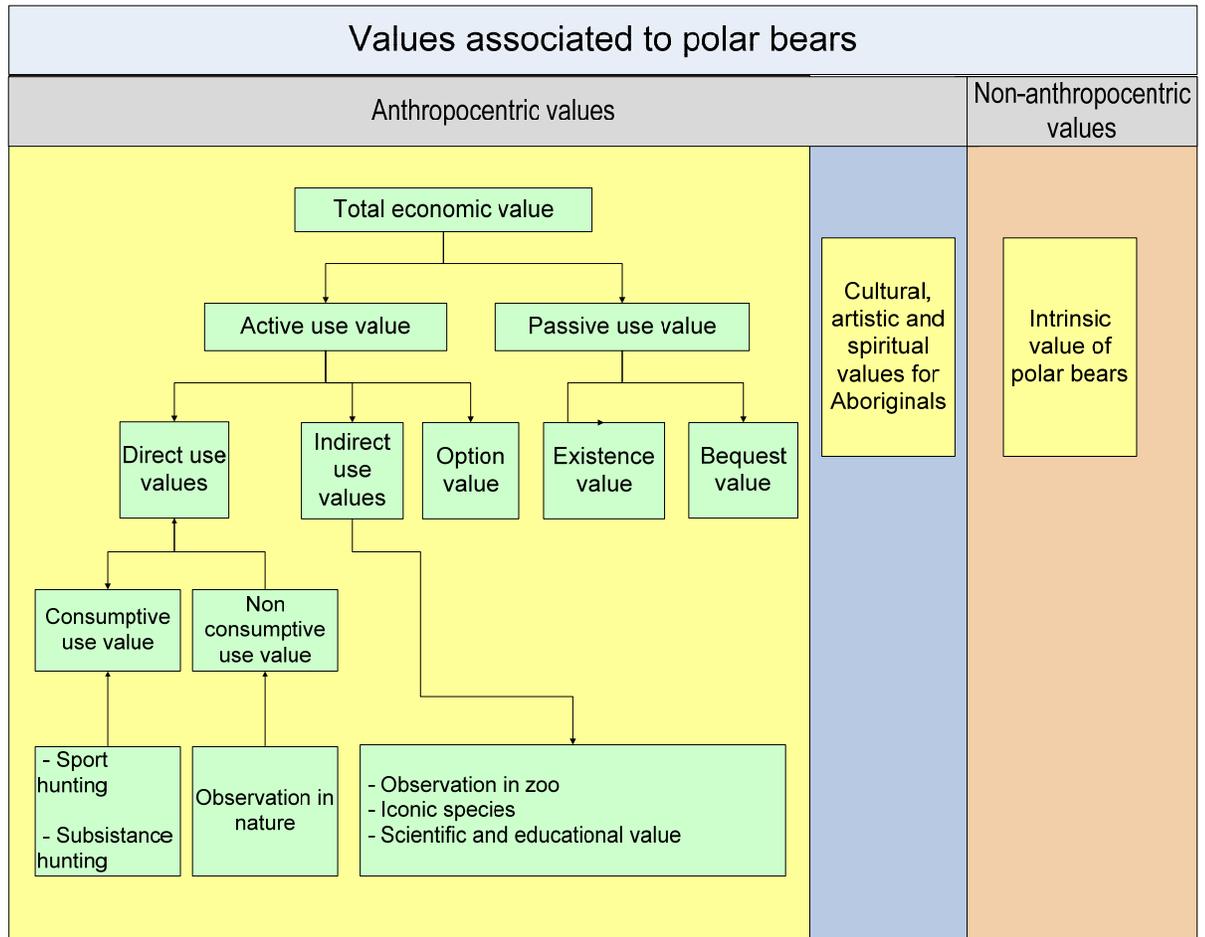
In the case of polar bears, we identified the following anthropocentric values:

1. value of subsistence hunting;
2. value of sport hunting;
3. value of viewing polar bears in the wild;
4. value of viewing polar bears in zoos;
5. iconic species value;
6. scientific value;
7. educational value;

8. option value;
9. existence value;
10. bequest value, and
11. cultural, artistic and spiritual value for the Inuit.

The first eight values are active-use values, while the existence and bequest values are passive-use values. Together, they represent the total economic value of Canada's polar bears. The cultural, artistic and spiritual significance for the Inuit is in a category of its own. It plays an important role in all anthropocentric values relating to Canada's polar bears, but is difficult to assess in monetary terms.

FIGURE 1: VALUES ASSOCIATED WITH POLAR BEARS



Note: The classification of economic values is based on the taxonomy of economic values presented by Asafu-Adjaye et al. (1989).

2.1.2 Economic evaluation methods used in the study

Stated preference methods such as contingent valuation or choice experiment would have been ideal choices for estimating passive-use values (existence and bequest values), especially since these values had not been estimated for polar bears (IEC and Northern Economics, 2010). However, they could not be used because of budgetary constraints and the short duration of the study. This study, therefore, uses the benefit-transfer methods to estimate passive-use values associated with polar bears. For the estimation of the other values methods such as travel-cost, substitute-cost, market-price and benefit-transfer are used (see Table 1 for the values obtained with each method). The choice of these methods was based on the uniqueness of the various values associated with polar bears, the available budget and the duration of the study.

TABLE 1: METHODS USED FOR ESTIMATING THE VARIOUS VALUES ASSOCIATED WITH POLAR BEARS

Method Used	Estimated Value
Travel-cost method	Viewing polar bears in their natural habitat (value assigned by visitors)
Market-price method	Sport hunting (value for the Inuit community) Subsistence hunting (for polar bear pelts)
Substitute-cost method	Subsistence hunting (for polar bear meat)
Benefit-transfer method	Existence and bequest value Sport hunting (value assigned by sport hunters)

Revealed versus stated preferences

Methods for estimating the economic value of environmental services can be divided into two categories: revealed-preference methods and stated-preference methods. The methods in the first category use market information to estimate these values. The hedonic and travel-cost methods belong in this category.

Stated-preference methods are used where there are no markets. These methods use surveys to ask participants openly about their willingness to pay for the environmental services being evaluated, or ask them to choose among several options. Experimental economics, choice experiment and contingent valuation are stated-preference methods.

The benefit-transfer method does not fit into either category since it uses values previously estimated using other methods.

Travel-cost method

This method is based on the idea that travel to recreational sites and the site itself are complementary goods (i.e. they are consumed together). As with all complementary goods, an increase in travel prices not only lowers travel demand, but it also lowers the demand for the recreational site in question. As a result, the cost of travelling to the site can be used to estimate the demand for recreation and the consumer surplus for a visit. Ideally, access rights would be used to estimate recreational demand, but in most cases, there are no access rights or they do not vary enough to reveal visitor preferences.

The travel-cost method can be used to estimate (1) the value of an existing site, or, more specifically, the value of recreational activities related to an existing site and (2) the value of a change in the quality of an existing site. This study examined the first category of values—more specifically, the current value of viewing polar bears in Churchill, Manitoba, and the surrounding area.

Several approaches can be used to implement the travel-cost method, including⁷:

1. A simple travel-cost approach by area, which primarily uses secondary data and gathers simple data through a visitor survey;
2. An individual travel-cost approach that uses data from a detailed visitor survey;
3. A random utility theory approach that involves a survey, secondary data and sophisticated statistical techniques.

We used the first approach for this study because of the project's time and budgetary constraints.

Market-price method

This method uses the prices of goods and services sold on the market to assess the value of a resource as the difference between the price of the demand or supply and its current price on the market (consumer or producer surplus).

Substitute-cost method

This method involves identifying products and services that can be substituted for the goods evaluated and observing their values on the market. This method is generally used when the goods whose values are being estimated are not commercialized, as is the case with polar bear meat.

Benefit-transfer method

This method is used to transfer values originally calculated at a particular site (study site) to another site (target site). Some adjustments are made based on the context. It is used when a sufficient number of primary studies have already been conducted on the resource under study, and budget or time constraints preclude a primary study.

⁷ See the Ecosystem Valuation website: <http://www.ecosystemvaluation.org/travel_costs.htm#OPTIONS>.

The benefit-transfer method can be used in various ways depending on the needs and available information. There are two types of benefit-transfers: (1) the transfer of monetary values and (2) the transfer of functions and meta-models. In this study, we transfer a meta-model to estimate the existence and bequest values, and transfer a monetary value to determine sport hunters' willingness to pay. The transfer of meta-models is considered as having the highest predictive capacity (Genty, 2005), but it could not be used for sport hunting since there are no meta-models for this particular activity.

2.1.3 Economic indicators of well-being used in the study

Several economic indicators of well-being are estimated using various methods: consumer surplus, compensating variation, producer surplus and avoided costs. Except for the compensating variation, which by definition expresses a marginal value (i.e. the value of a change in the goods being evaluated), the other indicators can express both a marginal value or the value of the goods before or after the change. Most of the estimated values in this study characterise the current status of the bear populations rather than a change in their numbers. Marginal values are estimated only for preservation value and sport-hunting value. Since marginal values are often more useful in the public decision-making process, this study can be used as a starting point for estimating marginal values.

The consumer surplus represents the value of the consumed good minus the price paid to obtain it. This is the net consumer surplus. The gross consumer surplus includes the price of the goods. The net surplus is generally preferred to the gross surplus because the price paid for the product reflects a decrease in the consumer budget that generates a decrease in the consumption of other goods and thus a decrease in the whole well-being (Varian, 2006).

Compensating variation, commonly refer to as willingness to pay, is an alternative economic indicator to consumer surplus. Willingness to pay measures how much budgets must be reduced after an environmental improvement is made in order to maintain well-being at its level before the improvement. For more information on the theoretical concepts of producer surplus, consumer surplus and compensating variation, see Appendix 1.

Producer surplus is the value of the product minus the variable costs incurred to produce it. If these costs are not excluded, they will be counted twice since the value of the goods and services used as inputs include the value of other activities that produced them in the rest of the economy. In order to estimate the value of a good or service, both consumer and the producer surpluses must be considered and added.

In the case of environmental goods, the producer is nature, and the value it produces is often captured by various economic agents which, in this study, are the Churchill travel agencies and the Inuit community that organized the sport hunting. In this case, the indicator of well-being called "producer surplus" should be called "surplus accrued by economic agents who benefit from the value created by nature." We use the concept of producer surplus to simplify the presentation and retain the standard language of economic theory.

In the case of the subsistence economy, the consumer and producer surpluses cannot be estimated because there is no market. Instead, we use the avoided cost indicator, i.e. the costs that would have been incurred by the Inuit had they not eaten bear meat and replaced it with another type of meat (such as beef) sold in their village.

Table 2 summarizes the economic indicators of well-being used to estimate the different polar bear use values in monetary terms. The consumer surplus is used to estimate the value visitors assigned to viewing polar bears in their natural environment. We use willingness to pay, estimated by the benefit-transfer method, to define preservation value and the value that sport hunters assigned to polar bear hunting. The avoided costs are used to estimate the value of bear meat consumed by the Inuit. Lastly, the producer surplus is the indicator that provides information on the value of bear pelts harvested by the Inuit, the value of sport hunting to the Inuit community, and the value of viewing polar bears in their natural environment for Churchill travel agencies.

TABLE 2: ESTIMATED ECONOMIC INDICATORS OF WELL-BEING FOR EACH VALUE ASSOCIATED WITH POLAR BEARS

Estimated Value	Economic Indicator of Well-being
Subsistence hunting	Avoided costs (for bear meat) Producer surplus (for bear pelts)
Sport hunting	Willingness to pay (for sport hunters) Producer surplus (for the Inuit community)
Viewing polar bears in their natural habitat	Consumer surplus (for visitors) Producer surplus (for travel agencies)
Preservation value	Willingness to pay (for all households in Canada)

2.2 Estimation of the socio-economic values associated with polar bears

Four values relating to the uses of polar bears in Canada are estimated in monetary terms:

1. Value of subsistence hunting;
2. Value of sport hunting;
3. Value of viewing polar bears in their natural habitat;
4. Preservation value, which includes existence, bequest, option and indirect-use values (e.g. scientific, educational and iconic species values).

2.2.1 Active-use values

2.2.1.1 Value of subsistence hunting

The economy in the Inuit communities of Nunavut and the Northwest Territories is a mixed economy that is based on both the market economy and a subsistence economy. Damas (1972) and Wenzel (2000), in Dowsley (2007, p.120), defined subsistence economies as “ socio-economic systems involving food as the central circulating good” In Inuit communities, the economy is largely based on subsistence hunting (Dowsley, 2007; 2009). The traditional Inuit economy underwent changes in the 20th century influenced by the market economy, and food sources in Inuit communities became more diverse. Despite these changes, the Inuit still practise subsistence hunting, including polar bear hunting. Dogsleds were originally used to practise subsistence hunting, but today, modern, more expensive equipment, such as snowmobiles (used for transportation purposes since the mid-1970s) and firearms are used (Dowsley, 2007). Subsistence hunting is an important economic activity and it also has social and cultural importance (Condon et al., 1995). It provides the Inuit with several non-economic benefits: it enables them to remain connected with the land, provides a relaxing recreational activity, helps perpetuate traditional Inuit practices, and is an element of social integration within the community (Condon et al., 1995).

According to the Inuit, the polar bear hunt is the most highly regarded hunt, and bear hunters are traditionally regarded as role models for the entire community (Sandell and Sandell, 1996). However,

the hunt is highly regulated. In 1973, the five countries with polar bear populations⁸ signed the *Agreement on Conservation of polar bears* (Lentfer, 1974, in Wenzel, 2004) to collectively manage polar bear populations and help preserve them. polar bear hunting is prohibited in Canada, except when carried out or controlled by Aboriginal people, primarily the Inuit. In the Northwest Territories and Nunavut, it is controlled by a quota system that sets annual limits on the number of bears that can be hunted by each community. It is permitted in Quebec and Ontario, where it is conducted by the Cree in particular, although there is no quota system in these two provinces. However, it is illegal in Manitoba. Canadian Inuit are the only people who have a polar bear quota for both subsistence and sport hunting (Wenzel, 2004), unlike the Inupiaq Inuit hunters in Alaska and Greenland, who have quotas for subsistence hunting only. Each Inuit community in Nunavut and the Northwest Territories, whose lands are home to 90% of Canada's polar bear population (Nunavut Department of Environment, year U/A), has an annual quota. Initially, these quotas were established taking into account historical data on the fur trade in each community (Wenzel, 2004), as well as the local polar bear population in each area. In some cases, quotas were also adjusted based on the economic needs of the Inuit communities (Scheweinsberg, 1981, in Dowsley, 2007).

A tag system is used for distributing quotas in each community. Tag management and distribution practices vary from one community to another. The tags are generally given to the community's Hunters and Trappers Organization, which then manages the tags and distributes them to its members. All adults in the Inuit community are entitled to be members of the local HTO (Dowsley, 2007). Hunters who receive a tag are allowed to hunt one polar bear. In some communities, the tags are awarded by lottery and often have a time limit of just a few days. If the hunter has not killed a bear within the time limit, the tag is returned to the lottery and someone else's name is drawn (Dowsley, 2007). For example, in Qikiqtarjuaq, Nunavut, hunters have 24 hours to kill a bear after their names are drawn (Dowsley, 2007). Permit-holders who fail to kill a bear within the allotted time must return their permits, which are then awarded to someone else (Dowsley, 2007).

When a hunter kills a polar bear, the meat is distributed throughout the community, not only within the family circle. Hunters who have killed a polar bear take great pride in their accomplishment. Traditionally, in Inuit society, an experienced hunter who brought in large quantities of game for his community enjoyed great social prestige (Condon et al., 1995). This is still true today. Condon et al. (1995) highlighted the importance in Holman, Nunavut, of sharing game meat from an ideological and economic standpoint and in terms of community inclusion. Wenzel (1995) described the Inuit system of resource sharing (*ningiqtuq*) in Clyde River, Nunavut, as well as its importance in the community's food economy and how it reflected its social structure. In Clyde River, for example, polar bear meat was frequently given to the hunter's in-laws.

Polar bear subsistence hunting, therefore, has a use value, which corresponds to the value of the various parts of the bear that are consumed, and a non-use value, which is the cultural and social value.

The use value of polar bear subsistence hunting consists mainly of the value of the meat consumed and the animal's pelt. The use value also includes the value of the other parts of the bear that can be used (skull, bones, teeth, etc.), but nothing in the literature can be used to estimate the value of these

⁸ Canada, Norway, Denmark, the United States and the Soviet Union.

parts. For example, the Cree decorate polar bear teeth, claws and skulls and sell them to visitors (Lemelin et al., 2010).

Value of bear meat

The substitute-cost method was used to estimate this value. Table 3 presents the values of bear meat reported in the literature. Bear meat is used by the Inuit for human consumption as well as for dog food. The literature indicated that the price of two possible substitutes can be used to estimate the value of the meat from a bear:

- Imported beef in Inuit communities: Wenzel (2008) cited a price of \$8.50/kg in Resolute (NU) and \$10/kg in Clyde River (NU)⁹. The merits of choosing beef as a substitute are debatable. First, in some communities, imported meat is much less prized than game meat (Condon et al., 1995), which may suggest that using the price of imported beef underestimates the value of polar bear meat for the Inuit, for reasons involving both taste and culture. Second, seal meat or other game meat is actually a more likely substitute for bear meat than imported beef. However, since seal or other game is also obtained through subsistence hunting, and since it has no market price, the price of beef appears to be the most relevant substitute available.
- Dry dog food: a 25-kg bag of dry dog food costs \$60 in Taloyoak (NU) (Wenzel, 2008).

On average, a polar bear yields 140 kg of edible meat (Freeman and Wenzel, 2006; Foote, 1967, in Wenzel, 2008; Freeman, 2003, in Tyrrell, 2006). Polar bear meat is not eaten by the hunter and his family alone; it is distributed more widely within the community, in accordance with Inuit sharing principles. In the 1970s, the parts of polar bears consumed by the Inuit included the legs, ribs and back, which still seems to be the case today (Wenzel, personal communication). The proportion of polar bear meat used for human consumption appears to vary greatly from one community to the next. Some use the meat primarily for human consumption: in Clyde River, bear meat is one of the five main game meats consumed by the Inuit (Wenzel, 1995). In other communities, such as Taloyoak, it is used mainly for animal consumption (Wenzel, 2008). Since more accurate information was not available, it was estimated that approximately 50% of polar bear meat was used for human consumption and 50% was used as dog food.

⁹ The federal government subsidizes the cost of flying food into Northern Canada. Until 2010, the subsidies had been awarded through the Food Mail Program for remote communities, which was replaced by the Nutrition North Canada Program in 2010–2011. Fresh and frozen meat are eligible for the subsidy under both programs (INAC, 2010b).

TABLE 3: SUBSTITUTE VALUES OF POLAR BEAR MEAT REPORTED IN THE LITERATURE

Value of the meat from one bear for human consumption, in current Canadian dollars				Value of the meat from one bear to be used as dog food, in current Canadian dollars
\$800	\$900	\$1,190	\$1,400	\$336
2001	2001	2001	2001	2000
Freeman and Wenzel (2006)	Freeman and Wenzel (2006)	Wenzel (2008)	Wenzel (2008)	Wenzel (2008)
Minimum and maximum values, based on imported beef as a substitute. Estimate based on the local price of imported beef and an average weight of 140 kg of edible meat per polar bear.		In Resolute, NU, based on an average weight of 140 kg per bear and an average price of \$8.50/kg for imported meat (price advertised by the local food co-op in Resolute).	Average value of the meat from one bear in Clyde River, NU, based on a price of \$10/kg for imported meat (price advertised by the local store in Clyde River).	Average value of the meat from one bear in Taloyoak. Replacement used: dry dog food: \$60 for a 25-kg bag.

Based on this information and the number of polar bears killed annually through subsistence hunting (an estimated 367 in 2008–2009), we were able to estimate the value of the meat from all polar bears killed through subsistence hunting in Canada during the 2008–2009 season (Table 4). The number of polar bears killed through subsistence hunting was determined by using the total number of bears killed by people, which was 531 for the 2008–2009 season for all of Canada (Nick Lunn, Environment Canada, personal communication), and assuming that 69.1% were killed through subsistence hunting (Dowsley, 2009)¹⁰. The data shown in Table 6 were used to calculate the minimum and maximum values of the bear meat in 2009 dollars presented in Table 3: (1) the minimum \$800 replacement value for bear meat for human consumption observed by Freeman and Wenzel (2006) in 2001, (2) the maximum \$1,400 replacement value for bear meat for human consumption observed by Wenzel (2008) in 2001, and (3) the \$336 replacement value for bear meat to be used as dog food observed by Wenzel (2008) in 2000.

¹⁰ According to Dowsley (2009), during the 2000–2004 period, on average, 69.1% of Polar Bears killed by humans in Canada were harvested through subsistence hunting; 22.3% were killed through sport hunting, and 8.6% were killed in self-defence. In Nunavut, when a bear is killed in self-defence, none of its parts can be kept for use by the person who killed it, and the hide must be turned in to an officer of the Nunavut Department of Environment (Nunavut Department of Environment, 2010). The value of the parts of bears killed in self-defence was therefore not taken into account in this study.

TABLE 4: VALUE OF POLAR BEAR MEAT

	Minimum Value	Maximum Value	Average Value
	in 2009 Canadian dollars ¹¹		
Value of the meat from one bear	\$662	\$1,010	\$836
Total value of bear meat harvested through subsistence hunting in Canada	\$245,545	\$374,635	\$306,741

Value of polar bear pelts

There is a market for bear pelts and several values have been reported in the literature. The gross value of a polar bear pelt ranges from \$500 (Freeman and Wenzel, 2006; Tyrrell, 2006) to \$1,200 (Freeman and Foote, 2009) (see Table 5).

¹¹ Prices in 2009 Canadian dollars were calculated using the Nunavut consumer price index (and the Northwest Territories consumer price index for years prior to 2002) published by Statistics Canada.

TABLE 5: GROSS VALUES OF A BEAR PELT REPORTED IN THE LITERATURE

Reference	Year of Data	Minimum Value	Maximum Value	Notes
		In current Canadian dollars	In current Canadian dollars	
Freeman and Wenzel (2006)	2006	\$500	\$700	
Freeman and Foote (2009)	2007	\$600	\$1,200	
Tyrrell (2006)	early 2000s (no details)	\$500	\$600	Lower net value if the price of gasoline and the time required to prepare the pelt are deducted
Dowsley (2004)	2002	\$1,000	\$1,000	Sale on the commercial fur market
Minimum and maximum values observed in all references		\$500	\$1,200	Gross value (costs of preparing the pelt are included)

It should be noted that these values were calculated prior to the 2008 U.S. Fish and Wildlife Service ban on importing polar bear pelts. These new regulations may have affected the price of bear pelts in 2008–2009.

Table 6 presents the estimated value of polar bear pelts harvested through subsistence hunting during the 2008–2009 season, calculated by discounting the minimum and maximum values of an untreated pelt shown in Table 5. The total value was obtained by multiplying the value of a bear pelt by the estimated number of bears killed through subsistence hunting during the season (i.e. 367).

TABLE 6: VALUE OF POLAR BEAR PELTS HARVESTED IN THE 2009 SUBSISTENCE HUNT

	Minimum Value	Maximum Value	Average Value
	in 2009 Canadian dollars		
Value of a bear pelt	\$538	\$1,252	\$895
Total value of bear pelt harvested through subsistence hunting in Canada	\$197,566	\$459,657	\$328,612

The use value of subsistence hunting was obtained by adding the value of the meat to that of the bear pelts (Table 7). It ranged from \$440,459 to \$830,246 (Canadian dollars in 2009) for all of Canada for the 2008–2009 season. However, these two amounts (i.e. the minimum- and maximum-use values of subsistence hunting) were underestimated because the value of other parts consumed could not be estimated.

TABLE 7: VALUE OF THE MEAT AND PELT OF POLAR BEARS HARVESTED IN THE 2008–2009 SUBSISTENCE HUNT

	Minimum Value	Maximum Value	Average Value
	in 2009 Canadian dollars		
Value of the meat and pelt from one bear	\$1,200	\$2,262	\$1,731
Total value of bear meat and pelts harvested through subsistence hunting in Canada	\$440,459	\$830,246	\$635,352

These were gross values which did not take into account the costs incurred by hunters to participate in the subsistence hunt. These costs may have included the cost of equipment and gas, and opportunity costs such as the time spent hunting. Tyrrell (2006) identified several aspects of the lottery system used to award tags for the subsistence hunt that could result in opportunity costs for the Inuit. In Arviat (Nunavut), the lottery system does not take into account the professional commitments or types of jobs held by the hunters whose names are drawn. Having their names drawn can cause some of these hunters to lose up to two days' pay, not to mention the cost of food and gasoline (Keith, 2005, in Tyrrell, 2006). As a result, unsuccessful hunters incur losses, strictly from a financial standpoint. Tyrrell also mentioned additional expenses incurred by hunters who manage to kill a bear, such as the cost of preparing the pelt, which is approximately \$300 in Arviat.

2.2.1.2 Value of sport hunting

In Nunavut and the Northwest Territories, Aboriginal people are entitled to give all or part of their quotas to non-Aboriginals for sport hunting (Nunavut Department of Environment, year U/A; Freeman and Wenzel, 2006). In the mid-1980s, the sealskin market collapsed (Dowsley, 2007; Sandell and Sandell, 1996), after which sport hunting became popular. According to Dowsley (2007), this appeared to be a way for the Inuit to offset the financial losses resulting from the collapse of the sealskin market.

Sport and subsistence hunters are both required to have tags. Inuit communities manage the tags and determine how they are to be allocated and the price at which they are to be sold to local outfitting operations or foreign hunters. The hunt is increasingly regulated. Unlike subsistence hunting, all mechanized transport is banned in sport hunting (Dowsley, 2007). Sport hunters can only travel by dogsled or on foot. In addition, in Nunavut, all non-resident hunters who kill a bear must pay a trophy fee to have permission to export all or a part of the animal from Nunavut (Nunavut Department of Environment, 2010). Sport hunters come primarily from the United States, but also from Europe and Canada. Their trips are arranged by specialized travel agencies in the United States and southern Canada. These agencies work in partnership with local outfitters located in the Inuit communities, which welcome the hunters and organize hunting trips by providing escorts (guides and assistants) and dog teams.

Value to the Inuit community

The market-price method was used to calculate the value of sport hunting. The local outfitter that provides the sport-hunting service is the producer, although in reality, the outfitter recovers part of the value created by nature, which is the real producer. Producer surplus was calculated by subtracting the producer's variable costs from its revenues. The local outfitter's revenue was calculated by adding the average price charged by the local outfitters for the polar bear hunt, the tips paid by the hunters and the value of the bear meat, which the hunter usually donates to the Inuit guides and assistants (see Table 8). The value of the meat was counted as profit for the producer, since the producer (the local outfitter) included local hunters and members of the community. In this specific case, it was difficult to distinguish the local outfitter's profits from the community's profits. In fact, Freeman and Wenzel (2006) noted that sport-hunting guides and assistants are among the primary suppliers of game meat, which they donate to the community. They also receive donations in kind, often hunting equipment such as binoculars and guns, from sport hunters. They are also the main beneficiaries of sport hunting in terms of earnings, which enables them to purchase and maintain their often-expensive hunting equipment, which in turn indirectly benefits the entire community.

TABLE 8: PRODUCER'S INCOME PER SPORT HUNT

	Reference	Year of Data	Minimum Value	Maximum Value	Minimum Value	Maximum Value	Community
			Price in current Canadian dollars		Price in 2009 Canadian dollars		
Price charged by local outfitter for a hunt	Wenzel (2008)	2000	\$13,000	\$13,000	\$15,312	\$15,312	Taloyoak, spring 2000
	Dowsley (2004)	2003–2004	\$19,000	\$19,000	\$21,351	\$21,351	Resolute Bay, 2003–2004
	Dowsley (2004)	2003–2004	\$23,750	\$23,750	\$26,689	\$26,689	Clyde River, 2003–2004
	Dowsley (2004)	2003–2004	\$20,000	\$20,000	\$22,475	\$22,475	Qikiqtarjuaq, 2003–2004
Average price charged by the outfitter					\$21,457	\$21,457	
Average value of gratuities in cash	Wenzel (2008)	2000	\$1,500	\$2,300	\$1,767	\$2,709	Per hunt, three Nunavut communities
Average value of gratuities in kind	Wenzel (2008)	2000	\$1,000	\$1,000	\$1,178	\$1,178	In the three communities in Nunavut (Resolute Bay, Clyde River and Taloyoak)
Average total value of gratuities			\$2,500	\$3,300	\$2,945	\$3,887	
Value of polar bear meat from hunts					\$594	\$906	
Total producer income					\$24,995	\$26,249	

Salaries and payment for sport-hunting tags were identified as the producer's main variable costs and are presented in Table 9. Other expenses, such as gasoline, were also part of the variable costs, but were not quantified in the literature.

TABLE 9: PRODUCER'S VARIABLE COSTS PER HUNT

	Reference	Year of Data	Minimum Value	Maximum Value	Minimum Value	Maximum Value	Notes
			Price in current Canadian dollars		Price in 2009 Canadian dollars		
Guide/sled driver's wage	Wenzel (2008)	2000	\$4,700	\$9,000			Wage per hunt, Resolute Bay, Clyde River and Taloyoak (Taloyoak = \$4,700; CR = \$5,100; Resolute = \$9,000)
Assistant's wage	Wenzel (2008)	2000	\$3,800	\$5,000			Wage per hunt, Resolute Bay, Clyde River and Taloyoak (min. value in Taloyoak = \$3,800; max. value in Resolute = \$5,000; Clyde River = \$4,100)
Total wages			\$8,500	\$14,000	\$10,012	\$16,490	
Price of a polar bear sport hunting tag	Tyrrell (2006)	2002	\$2,000	\$2,000	\$2,252	\$2,252	Arviat (Nunavut)
	Dowsley (2004) and Wenzel (2008)	2000	\$2,500	\$2,500	\$2,945	\$2,945	Resolute (NU): 20 tags assigned to the 2000 sport hunt
	Dowsley (2004)	2001	\$2,100	\$2,100	\$2,435	\$2,435	Clyde River (NU): average price of one of 10 tags assigned to the 2001–2002 sport hunt
Average tag price					\$2,544	\$2,544	
Total of producer's variable costs					\$12,555	\$19,033	

The value of sport hunting to the local outfitter, or revenues minus variable costs, ranged from \$5,962 to \$13,694 in 2009 Canadian dollars ¹².

¹² The maximum value of sport hunting for the local outfitter was calculated by subtracting the minimum amount of variable costs from the maximum amount of revenue (\$26,249 – \$12,555). Conversely, the minimum value for the outfitter was calculated by subtracting the maximum amount of costs from the minimum amount of revenue (\$24,995 – \$19,033).

Value for sport hunters

The value of sport hunting for hunters was estimated using a benefit transfer based on Asafu-Adjaye's study (1989), which estimated the willingness to pay for big game and Grizzly Bear hunting in Alberta. In 2009 dollars, the willingness to pay per hunter per year was \$309 for big game and \$229 for Grizzly Bears.

However, it seems likely that willingness to pay for hunting polar bears is higher than these amounts. These are annual amounts because hunters can generally hunt for big game and Grizzly Bears every year. In contrast, polar bear hunting is generally a one-time occurrence. For these reasons, willingness to pay for big game hunting was used to transfer the benefits relating to the willingness to pay for polar bear hunting. Another factor that could have a negative impact on willingness to pay for polar bear hunting is the general public's negative view of the hunt, which has been influenced by the polar bear's charismatic image.

The total value of a sport hunt was calculated by adding the values for the local outfitter and the sport hunters (see Table 10 for results).

TABLE 10: TOTAL VALUE OF A SPORT HUNT

	Minimum Value	Maximum Value	Average Value
Producer's revenues	\$24,995	\$26,249	\$25,622
Producer's variable costs	\$12,555	\$19,033	\$15,794
Value for the local outfitter	\$5,962	\$13,694	\$9,828
Value for hunters (based on willingness to pay for big game hunting)	\$309	\$309	\$309
Total value of a sport hunt	\$6,270	\$14,003	\$10,137

The percentage of tags issued for sport hunting has increased steadily in recent decades. It was less than 1% in the 1970s and reached 15% in the 1990s (Freeman and Wenzel, 2006). Today, about 20% of polar bear hunting quotas held by the Inuit in Nunavut are sold for sport hunting (Dowsley, 2007; Wenzel, 2008). According to Waters et al. (2009), the average number of sport hunting tags sold in Nunavut and the Northwest Territories was estimated at 132 per year between 2000 and 2008. We used this figure to estimate the total value of sport hunting for both territories, which yielded a minimum of \$827,695 and a maximum of \$1,848,368 (2009 dollars). The average value amounted to \$1,338,031. The value of sport hunting is quite low compared to the GDPs of the Northwest Territories and Nunavut. However, Waters et al. (2009) showed that it represented a significant percentage of total income for some communities. This is apparently the case in the Nunavut communities of Grise Fiord, Resolute and Sachs Harbour, where sport hunting makes up 10% to 13% of the residents' average income.

2.2.1.3 Value of viewing polar bears in their natural habitat

Polar bear viewing trips are currently offered by tour companies such as Churchill Wild, Lazy Bear Lodge and Canada Experience, which organize polar bear tours in Churchill, Manitoba, for prices ranging from \$3,000 to \$8,000¹³. Based on discussions with people involved in the industry, polar bear viewing takes place mainly in Churchill. There are other locations, but they are rather marginal because of the number of visitors. There are also organized cruises in the Far North that provide opportunities to view polar bears, but these were not included because polar bear viewing was not one of the main activities offered on these cruises (e.g. whale watching and northern lights).

Two companies that organize polar bear viewing trips in the Churchill area (Churchill Wild and Lazy Bear Lodge) provided us with information on the number of tourists by city of residence. We used this information to extrapolate the distribution of tourists by city of residence to all tourists who travel to Churchill to see polar bears. We used the travel-cost method (area travel-cost approach) to estimate the consumer surplus resulting from viewing polar bears in northern Manitoba. We applied the travel-cost method separately for Canadian and foreign visitors to obtain a specific value for Canadian visitors.

The main steps of the calculation are presented in Appendix 2. The resulting values are \$400/visitor/year for Canadians and \$600/visitor/year for foreigners. The aggregate values are \$1.3 million per year and \$3.5 million per year, respectively (see Table 11). They were obtained by multiplying the individual value by the respective annual numbers of Canadian tourists (3455) and foreigners (5946), in Churchill from October to December. Travel Manitoba provided us with the data, which represented the averages from 2006 to 2008.

TABLE 11: VALUE OF VIEWING POLAR BEARS IN THEIR NATURAL HABITAT (CHURCHILL, MANITOBA)

	Canadian Visitors	Foreign Visitors
Individual value	\$400/visitor/year	\$600/visitor/year
Aggregate value	\$1.3 million/year	\$3.5 million/year

Miller (1995) estimated the gross surplus generated by bear watching in Alaska (Grizzly, Black and Polar bears) at \$485/person/year. This figure included travel costs, but since the population in question consisted mainly of Alaska residents, these expenses were not very high. In 2009 dollars, this amounted to about \$650/person/year, which was close to our estimates (\$400 and \$600/person/year, respectively).

2.2.1.4 Value of visits to zoos

Polar bears are some of the most popular animals in zoos. For example, Knut, who was born in 2006 at the Berlin Zoo, captured the media's attention because he was the first polar bear born in captivity in 30 years. His birth increased the zoo's revenues considerably in the years that followed.

¹³ Canada Experience website (<http://www.canadaxperience.com/Manitoba/Nature/Safari-%C3%A0-lours-polaire-6-jours>).

Estimating the value that people assign to polar bears in zoos is very difficult, given the many species in zoos. The increase in revenues at the Berlin Zoo after Knut's birth could be used as an indicator of this value, but a similar event has never occurred in Canada; moreover, this revenue increase is more reflective of the value of a single extraordinary event than the value of the regular presence of bears in zoos.

The case of a zoo in Cochrane, Ontario, called the Polar Bear Habitat and Heritage Village, could have been used to obtain an estimate of this type of value since it houses polar bears only. An estimate of the consumer surplus generated by visitors at this particular zoo could have been calculated using the travel-cost method, which was used to perform calculations on polar bear viewing in Churchill. However, the necessary information on the number of visitors per province of residence was not available. As a result, we were limited to highlighting the potential significance of this value.

2.2.1.5 Iconic value

Polar bears have become one of the main symbols of climate change and are portrayed as helpless victims affected by changes in their habitat. Using these types of images may have an indirect value in that it enables the organizations that use them to organize public fundraisers (Wiley-Blackwell, 2010).

The polar bear is the symbol of World Wildlife Fund-Canada's "Arctic Circle" program. In 2010, the "Polar Bears on Thin Ice" campaign, which aimed to raise the Canadian public's awareness of the urgency of fighting climate change, presented the public with an ice sculpture of a polar bear slowly melting away, leaving behind only its metal skeleton¹⁴.

The polar bear's image is used not only to symbolize climate change; it is used in many other situations. Various brands, such as Quebec's *Boréale* beer, use the polar bear as their emblem. Institutions also use the bear's image. The Royal Canadian Mint, for example, features the image of the polar bear on its two-dollar coin, and Nunavut issues polar bear-shaped licence plates. In Quebec, many stores display its image in their windows to attract customers. The posters for the 2011 annual *Fête des Neiges* winter festival, a family event held in Montréal, featured a polar bear hanging from a zipline, and a real bear skin and a bear's head were on display at the festival. Large corporations such as Nissan and Coca-Cola use polar bears in their television commercials. For example, in an advertisement for the 2010 Nissan Leaf, an electric car, a bear faced with climate change leaves the ice pack and makes his way to the city to thank the owner of a Nissan Leaf for choosing an environmentally friendly vehicle.

While it is easy to see that several economic and social stakeholders take advantage of the polar bear's iconic image, it is not as easy to determine the extent of that value. For example, to what extent has using a polar bear in Nissan Leaf advertisements increased the car's market share? Has using an ice sculpture depicting a polar bear in the "Polar Bear on Thin Ice" advertising campaign changed public opinion regarding climate change? The fact that the polar bear's iconic image is widely used reflects its significant value, but quantifying that value remains a challenge.

¹⁴ See the campaign website: <http://www.ourspolaires-glacesephemeres.ca/index.php?lang=en>.

2.2.1.6 *Scientific and educational value*

Because the polar bear is at the top of the food chain, certain information regarding the animal (e.g. tooth growth layer thickness) provides indirect information on habitat status and food-chain productivity. As well, the polar bear is one of the animals studied by the branch of science known as "biomimetics", which draws inspiration from nature to solve technical problems. For example, polar bear fur has fibre-optic properties that assist in efficient heat capture, so research is being conducted on the insulating capacity of polar bear pelts for potential application to buildings. This property also has application for the textile industry, where research is being conducted on producing textiles that mimic the enhanced insulating properties of polar bear fur (Textile Magazine, 2008).

Estimating the polar bear's scientific value is a real challenge. Can the value of all the innovations generated through polar bear research be an indicator of its scientific value, given the fact that the value of an innovation involves a host of other factors? Part of the value of the innovations can be shown by the value of human creativity, for example. Are the funds allocated to polar bear research a better indicator of the scientific value of polar bears? Does the lack of research funding suggest that it has no scientific value?

Given the methodological difficulties involved in estimating its scientific value, we could not estimate this value in monetary terms. However, we will present some information on public funding currently allocated to polar bear research in Canada. The Canadian government is spending \$5 million over the next five years on research directly related to the polar bear¹⁵. The priority areas are:

- The relationship between climate change and polar bear habitat;
- Development of affordable, less invasive techniques for monitoring polar bear populations;
- Improved demarcation of Canadian sub-populations of polar bears;
- Integration of traditional ecological knowledge and Western science.

The amount of \$5 million over five years, which is equivalent to \$1 million/year, assuming the trend continues, could be interpreted as the minimum amount that Canadians are willing to spend through the government that represents them, to improve knowledge relating to polar bears and their contribution to our well-being. The total amount works out to 8¢ per household per year.

The polar bear also has an educational value. Its image is used in many children's books, especially books for young children. It appears in many children's stories, some of which are inspired by Inuit legends. It is often used to illustrate the polar regions in geography books for young people. Moreover, the Millennium Ecosystem Assessment (MEA) ranks educational and scientific values as cultural values (MEA, 2005, in Chevassus-au-Louis et al., 2009).

2.2.2 *Passive-use values*

2.2.2.1 *Preservation value*

In Canada, no decision has yet been made about including polar bears on the Species at Risk List, but the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) believes that the

¹⁵ Environment Canada. 2011, <<http://www.ec.gc.ca/nature/default.asp?lang=En&n=A997D1CC-1>>.

status of Canada's population polar bears of Canada is of "special concern." The 2008 reassessment confirmed this status. The disquieting status of the polar bear has received significant media attention; as a result, most people are somewhat concerned about its future. In 2008, it was designated a "threatened" species in the United States, and in 2010, an area larger than California was declared a "protected area" in Alaska with the goal of preserving the polar bear's critical habitat.

There are no studies on the preservation value of the polar bear (IEC and Northern Economics, 2010). Since the project's budgetary and time constraints precluded a primary study, we used the benefit-transfer method to estimate this value. To be more precise, we used Richardson and Loomis's meta-analysis (2009) because it dealt specifically with species at risk.

It is important to mention that Richardson and Loomis's (2009) model estimates the total economic value of species at risk, whereas our objective was to estimate the preservation value in particular (primarily the existence, bequest and option values). We used the model to eliminate the recreational value by assigning the value 0 to the indicator variable VISITOR, but we could not differentiate among the indirect-use values such as scientific value, educational value or iconic species value. The result therefore included the scientific value, educational value and iconic species value. We nevertheless called this value the "preservation value" because it was the dominant component of the total economic value of species at risk. For a description of the model estimated by Richardson and Loomis (2009), see Appendix 3 .

The detailed calculation of willingness to pay is described in Appendix 4. Table 12 shows the variables of the model, their coefficients and the values used for transferring the value to polar bears. The methodological variables (the survey response rate, \ln RESPONSERATE and the indicator variable MAIL) were given the average metadata value, whereas the other variables were assigned values specific to polar bears, as follows:

- a. The year of the study was set at 2006 because the meta-model was based on values expressed in 2006 dollars;
- b. The variable \ln CHANGESIZE was assigned a value of $\ln(100)$ (i.e. 4,605) because we wanted to estimate Canadians' willingness to pay to preserve the entire existing polar bear population. In other words, we estimated willingness to pay this way in order to avoid a 100% loss of the polar bear population;
- c. Generally, a willingness to pay to avoid a decrease in population was greater than the willingness to pay for an increase in the population. However, the model was not able to distinguish between these two situations;
- d. The variable VISITOR was assigned a value of 0 because we did not want to estimate the value of polar bear viewing. We only wanted to determine the preservation value (passive-use value)¹⁶;

¹⁶ We assigned a value of 1 to the variable VISITOR to compare the value of Polar Bear viewing obtained with the travel-cost method using the results from another approach. Once we removed the preservation value (\$508/household), we obtained \$1,286/person (in 2009 dollars), which was much higher than the values obtained using the travel-cost method (\$400/person and \$600/person, respectively). The difference was attributable to the methods used: generally, the stated-preference methods (meta-analysis used studies based on contingent valuation) yielded higher estimates than did the revealed-preference methods.

- e. The variables FISH and BIRD were assigned a value of 0 because polar bears are not fish or birds. However, the variable MARINE was assigned a value of 1 because the polar bear is considered a marine mammal more often than not. To make the estimated value more specific to polar bears, we should have had a MAMMAL indicator variable, since the value of the polar bear is closer to that of mammals than that of any marine species, including jellyfish, krill, etc. Without this variable, the estimated value actually represented a lower limit of the preservation value, since we expected the preservation value for mammals to be greater than that for marine species in general;
- f. The variable CONJOINT indicated whether the evaluation method used was the choice experiment or standard contingent valuation method. It had an exceedingly positive impact on the estimated value. To eliminate this excessive effect, which was specific to the evaluation method used, the variable CONJOINT was assigned a value of 0;
- g. The variable CHARISMATIC was assigned a value of 1, because the polar bear is a very charismatic species.

TABLE 12: VARIABLES OF THE RICHARDSON AND LOOMIS MODEL (2009), THEIR COEFFICIENTS AND THE VALUES USED FOR ESTIMATING THE PRESERVATION VALUE OF POLAR BEARS

	Model Coefficients (A)	Value of Variables (B)	C = A * B
Constant	-153.231	1	-153.231
ln CHANGESIZE	0.870	4.605	4.006
VISITOR	1.256	0	0.000
FISH	1.020	0	0.000
MARINE	0.772	1	0.772
BIRD	0.826	0	0.000
ln RESPONSERATE	-0.603	3.894	-2.348
CONJOINT	2.767	0	0.000
CHARISMATIC	1.024	1	1.024
MAIL	-0.903	0.851	-0.768
STUDYYEAR	0.078	2006	156.468

The results are presented in Table 13 in 2009 dollars. They indicated that a Canadian household was willing to pay \$508 per year to avoid losing Canada's entire polar bear population. Taking into account all Canadian households, this amount worked out to \$6,320 million/year. This figure might seem high compared to the estimated values for other species at risk. For example, willingness to pay to raise the status of the St. Lawrence Beluga Whale from "threatened" to "special concern" was \$107/household/year (Olar et al., 2007). The difference was partly attributable to the fact that the \$508 figure was for a far more significant change to the species population (avoiding the loss of 100% of the population). If the population change were lowered from 100% to 50%, the willingness to pay would also decrease to about \$278. The difference could be explained by the fact that polar bears receive much more media attention than belugas, even though the beluga is also a charismatic species.

TABLE 13: PRESERVATION VALUE OF CANADA'S POLAR BEARS

Individual value	Aggregate Value in Canada
\$508/household/year	\$6,320 million/year

2.2.3 Cultural, spiritual and social value for Aboriginals

The polar bear (*Nanuq*, in Inuktitut) plays an important role in the culture, art and spirituality of the Inuit people. In Inuit mythology, the bear spirit *Nanuq* is the master of the polar bears and he decides if the hunters have respected the rituals of the polar bear hunt. The polar bear's soul is regarded as particularly powerful and dangerous (Randa, 1986; Germain, 1995). A bear may also be inhabited by the soul of an Inuit.

The relationship that binds the Inuit people to polar bears permeates their legends. Many polar bears in Inuit legends have the gift of speech. Some themes recur regularly in these legends, such as an Inuk adopting a polar bear cub (Bennett and Rowley, 2004). Another legend explains that the Pleiades constellation represents a polar bear surrounded by a pack of dogs. Legends regularly tell how a polar bear is transformed into an Inuk, and vice versa. They are depicted in Inuit art through stone or bone sculptures. Inuit beliefs relating to the polar bear are an important source of artistic inspiration.

The Inuit regard the polar bear as an animal who is man's equal. Like humans, polar bears are at the top of the Arctic food chain and symbolize the bond between humans and their environment (Dowsley, 2009). Its abilities are similar to those of humans. Randa (1986) even suggested that the techniques that polar bears use to hunt and find shelter may have inspired the first Inuit to develop their seal-hunting and igloo-building techniques.

Polar bears and humans communicate with each other, and the bear is said to be able to understand the Inuit and read their minds. It is perceived as having feelings and a conscience, and it is greatly respected by the Inuit people. For example, like man, the bear can decide whether or not to engage in a hunt. This means that the polar bear plays an active role in initiating a hunt, but it can also sense when man or the community fails to respect him, an attitude to which he responds negatively.

The cultural value placed on the polar bear by the Inuit cannot be quantified. Throsby (2003, p. 279) defined culture as “the set of beliefs, traditions, customs, etc. which identify a group and bind its members together.” He noted that the cultural value of a good cannot be identified in relation to individuals, but rather in connection with the group that possesses this culture. The ideological importance of the polar bear for the Inuit is difficult to define (Wenzel, 2004) and is even more difficult to quantify in monetary terms. However, its cultural value is clearly reflected in their hunting practices.

Cultural and social value of hunting for the Inuit

For the Inuit, hunting is a way of maintaining their relationship with polar bears. It is a relationship in which the bears can decide for themselves whether or not to engage in a hunt. The bear-Inuit relationship is based on respect, and traditionally, the Inuit must not kill more bears than they need to subsist (M.A., Quikiqtarjuaq Elder, informal interview, 2004, in Waters et al., 2009). According to Wenzel (2008, p. 88), “the fact that Inuit allocate far fewer animals to the trophy hunt than they could is a clear statement that polar bear hunting has importance for more than the maximum amount of money that a tag can generate.” According to Dowsley (2007), the purpose of subsistence hunting is not purely economic; it may also seek to maintain the relationship between bears and the Inuit and to pass on the knowledge of Inuit hunters from one generation to next. The practice of hunting is also a way for Inuit to maintain social relationships within their own community through sharing (Freeman and Wenzel, 2006; Dowsley, 2007). The cultural value of hunting is not limited to subsistence hunting. The requirement to travel by dogsled and on foot to practise sport hunting is a way of maintaining the Inuit’s traditional knowledge in this area. This requirement led to the reintroduction of dogsled teams in some communities and also helps to pass this knowledge on to younger hunters (Freeman and Wenzel, 2006; Waters et al., 2009).

The transmission of knowledge between generations through the practice of hunting reflects an educational and social value that remains significant despite the economic and social development of Inuit communities in recent decades. Generally speaking, subsistence hunting is not as widely practised by Inuit youth as it is by their elders. Excerpts from interviews conducted by Condon et al. (1995) with elders from the community of Holman showed that the elders deplored this state of affairs. The members of the younger generation often hunted with their fathers when they were children, and even many of those who no longer hunt seem nostalgic when they recall those times, or at least have fond memories of them. Although social hierarchy is increasingly determined by income, the practice of subsistence hunting remains a source of pride. In Holman, the most active hunters are also those who have the best jobs in the community and Condon et al. (1995) seems to suggest that similarly to holding a well-paid job, hunting reflects many positive values for an individual, such as being motivated, engaging in an active lifestyle and being involved in one’s community. Distributing game meat in the community also reinforces the Inuit identity, in addition to sharing nutritious food, which is highly valued culturally (Kishigami, 2008). In this sense, subsistence hunting could be described as a goal in itself and not just a means of subsistence, as proposed by Fienup-Riordan (1983) in Kishigami (2008).

Inuit are entitled to assign all or part of their polar bear hunting quota to non-Inuit hunters from outside of the community who practise sport hunting¹⁷. About 20% of the quotas for polar bear hunting held by the Inuit in Nunavut are sold for sport hunting (Dowsley, 2007; Wenzel, 2008). This percentage is higher in certain communities (i.e. Resolute Bay, Clyde River, NU), where sport hunting has been conducted longer than in other communities where the permit quota is relatively high (Dowlsley, 2007). Thus, in Resolute, the number of tags is high relative to the number of hunters in the community (165 residents and 35 tags in 2001), and Inuit hunters are certain to receive subsistence hunting tags on a regular basis, contrary to what happens in other communities (Freeman and Wenzel, 2006). This may explain the high percentage of tags allotted to sport hunting in this community (20 out of 35 in 2001). In general, according to data on sport hunting in Nunavut and the Northwest Territories mentioned in Waters et al. (2009), from 2003–2004 to 2007–2008, 63% of communities never or rarely provided tags for sport hunting (Waters et al., 2009).

However, communities could decide to sell more tags for sport hunting and would find buyers because there is a waiting list several years long for sport-hunting licences (Wenzel, 2005, in Dowsley, 2007; Waters et al., 2009). Freeman and Wenzel (2006) also reported this excess demand for sport hunting tags relative to the existing supply. They stated that the waiting list could be up to five years and the price of polar bear sport hunting was increasing steadily (in Clyde River, the price rose 21% between 1999 and 2001, but remained undervalued). However, they believed that the number of tags allocated to sport hunting would remain limited because the Inuit were reluctant to reduce their right to subsistence hunting.

The fact that the Inuit decided to allocate only 20% of their quota to sport hunting showed that polar bear hunting had greater cultural value than the economic benefits generated by sport hunting (Wenzel 2008). The research conducted by Dowsley (2007) showed that in Resolute Bay (NU) for example, the average income from subsistence and sport hunting was \$769.85 per person in 2002–2003, while 20 out of 35 tags were allocated to sport hunting. Dowsley calculated that if the community's entire quota were allocated to sport hunting, the average income per person (for a total of 90 potential hunters¹⁸) would be \$7,777.78, which is ten times more. This may suggest that residents of Resolute are forgoing an annual income of \$7,008 per year per adult. With its small number of residents and high hunting quota, Resolute is a distinctive community. In the other two communities studied by Dowsley, Clyde River and Qikiqtarjuaq, the Inuit forgo \$800 of income per adult per year, which is far lower. However, the income forgone in Resolute Bay showed how much value the Inuit placed on subsistence hunting, and that it far exceeded the economic value. It was reasonable to think that the cultural value the Inuit assign to subsistence hunting was the same in Resolute Bay as it was in other Inuit communities. Based on this assumption, the amount of \$7,008 per adult may be an indication of the minimum amount which the Inuit might be willing to forgo in order to practise subsistence hunting. Resolute Bay allocated a greater percentage of tags to sport hunting than did other communities. This led us to believe that the income forgone by the Inuit to practise subsistence hunting was potentially even higher in communities where sport hunting was far less prevalent. It was also true that the number of tags allocated to sport hunting depended on other factors, such as the community's geographic accessibility and the availability of qualified polar bear

¹⁷ In the Northwest Territories, the number of sport hunting tags allocated by an Inuit community may not exceed 50% of the community's quota (Pokiak, 2005 in Freeman and Wenzel, 2006).

¹⁸ The potential number of hunters is equal to the total number of adults in the community. In fact, all the adults in the community, including the women, participate in the lottery used to allocate tags for the Polar Bear hunt.

hunting guides and dogsled drivers (Waters et al., 2009). Tyrrell's (2006) observations in Arviat, moreover, suggested that if the community preferred subsistence hunting to sport hunting, as individuals, hunters whose names were drawn in the tag lottery wanted first and foremost to be able to sell the tag for sport hunting instead of using it themselves for subsistence hunting because of the higher income it provided.

All this suggests that polar bear subsistence hunting has a very high cultural value in the eyes of the Inuit. However, quantifying this value is a very sensitive issue. As Dowsley (2004, p. 5) emphasized, "The decisions made by each community do not show the monetary value of a subsistence hunt to Inuit. Such a calculation is impossible because the value of food and culture is intangible."

2.2.4 Indirect economic benefits relating to the polar bear

Many human activities directly related to polar bears provide indirect economic benefits in other sectors. When tourists come to see polar bears in the wild, many shops and services in the town of Churchill and its surrounding areas receive indirect benefits. The businesses that benefit include restaurants, bars, general grocery stores, etc.

The tanning and taxidermy sectors are examples of sectors that receive indirect benefits from the polar bear hunt. The polar bear pelts harvested during the hunt can be sold raw to taxidermists and tanners who use them to produce various items, mainly clothing (mitts, pants, etc.) and rugs. The value of these crafts varies greatly depending on how they are marketed. The value of a pair of polar bear skin pants can range from \$1,000 to \$1,500, but prices reach \$5,000 in some cases¹⁹. In 2008 and 2010, the average value of a tanned polar bear hide sold at auction by the Fur Harvesters Auction Inc.²⁰ was between \$2,000 and \$3,000, but prices could be much higher. In May 2008, a polar bear pelt was auctioned for \$7,400.

These prices indicate that the total economic value of the polar bear is increased by an indirect value arising from the economic impact of activities relating to the polar bear on other sectors. These indirect benefits are key to providing a comprehensive overview of the importance of polar bears in Canada, but the main purpose of the study was to estimate the total economic value, and more specifically, the values directly relating to the (active and passive) uses of polar bears.

2.2.5 Total economic value

This section presents the aggregate valuation in monetary terms of all four values throughout Canada. Figure 2 presents these aggregate values by value category (active or passive use), while Table 14 provides more details on the distribution of these values among the various economic agents and also presents the unit values (per visitor, bear, hunt or household).

The preservation value is the highest value by far at \$6,320 million/year. This figure indicates that Canadians are willing to pay \$6,320 million/year to ensure that Canada's polar bear population do not

¹⁹ From a personal communication with Environment Canada and an announcement posted on the following website: http://www.foostuff.com/Polar-bear-pants.name.101567.item_id.0.ad_type.ad_details.

²⁰ See: <http://www.furharvesters.com/saleresults.htm>.

disappear. Another study indicates that Canadians are willing to pay \$2,798 million/year to improve the status of belugas, harbour seals and blue whales in the St. Lawrence Estuary (Olar et al., 2006), which represents 44% of the amount estimated for polar bears. As an indication, \$6,320 million is equivalent to 1% of the total income of Canadians in 2005, which was \$625,599 million²¹.

In addition to the preservation value, the amount most likely includes values relating to indirect uses such as the scientific, educational and advertising values, because the meta-analysis used to estimate it is based on the total economic value of the species. The model doesn't estimate hunting value and offers the possibility to eliminate the recreation value, but apart from these two values, it is not possible to differentiate among the various values.

The value of viewing polar bears in their natural habitat in Churchill is estimated at \$7.2 million/year, of which \$2.2 million represent the net income of companies that organized polar bear-watching tours in Churchill, Manitoba, and the remaining \$4.9 million value for Canadian and foreign visitors who travel to Churchill to view and photograph polar bears. The revenues of the travel agencies (\$2.2 million) represent a large part of the Churchill economy, about 10% of its residents' total income²². Most of the value comes from foreign visitors (72%) because they come to Churchill in greater numbers and are willing to pay more than Canadians.

The sport-hunting value is in third place with \$1.3 million/year, a large part of which represents the net incomes of Inuit communities that sell part of their hunting quotas to Canadian, American and European non-residents (\$1.2 million; see Table 14). The value for hunters is much smaller compared to the net revenues of local outfitters (\$0.04 million compared to \$1.2 million), mainly because of the individual sport hunters' low willingness to pay (\$309 per hunter per year). Most likely, this amount is actually higher because our estimate includes the value calculated in the study on big game conducted by Asafu-Adjaye et al. (1989), but we did not make any adjustments for the specific context of the polar bear hunt, which is much more likely to be a once-in-a-lifetime event than an annual activity. In addition, this study took only Canadian hunters into account, but polar bear hunting draws many more foreigners than Canadians and, as is also true for polar bear viewing, these hunters were generally willing to pay more than Canadians.

Subsistence hunting is in last place, with \$0.6 million/year, which represents the value of the bear skins and meat consumed or sold on the market. Compared to the GDP of Nunavut, where most polar bear hunting in Canada takes place, the value of all sport and subsistence hunts represent less than 0.1% of GDP (\$1,497 million in 2008; Statistics Canada, 2009). As for Inuit communities, this value does not represent a significant value in terms of income relative to the community's total

²¹ The income of all Canadians was estimated by multiplying the median income earned by a person aged 15 and over (\$25,615/year) by the number of people aged 15 and over with an income (24,423,165). This data was taken from the Statistics Canada website (2006 Community Profiles. 2006 Census): <<http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/prof/92-591/details/page.cfm?Lang=E&Geo1=PR&Code1=01&Geo2=PR&Code2=01&Data=Count&SearchText=canada&SearchType=Be gins&SearchPR=01&B1=All&Custom=>>>.

²² The income of Churchill's residents was estimated by multiplying the median income for a person aged 15 and over (\$30,459/year) by the number of people aged 15 and over with an income (715). This data was taken from the Statistics Canada website (2006 Community Profiles. 2006 Census): <<http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/prof/92-591/details/page.cfm?Lang=E&Geo1=PR&Code1=01&Geo2=PR&Code2=01&Data=Count&SearchText=canada&SearchType=Be gins&SearchPR=01&B1=All&Custom=>>>.

income²³. Waters et al. (2009) estimated that the revenues from sport hunting ranged from 0% to 5% of the community's income in most Inuit villages. In some cases, this percentage could be as high as 10% to 13% at most.

However, another value seems to demonstrate the importance that the Inuit attach to polar bears. This value, which is very likely cultural, is reflected in the additional revenues from sport hunting, which the community is willing to forgo. It is very difficult to estimate this value in monetary terms because, as we mentioned earlier, the Aboriginal peoples' value system is very different from that of other Canadians. Nevertheless, our research enables us to establish an indication of the lower limit of the interval where this value could lie. The indicator is based on the revenues that Inuit communities give up by not allocating all of their quotas to sport hunting. Despite the fact that they are free to allocate all their quotas to sport hunting and the demand for this activity is very high (there are waiting lists), a significant part remains within the community for subsistence hunting. This meant that the community gives up significant revenues (about \$7,000 per adult in the case of Resolute Bay, according to Dowsley (2007)) because sport hunting is much more lucrative than subsistence hunting. This attitude shows that the polar bear's cultural value within the Inuit community is greater than the \$133 million²⁴ of potential income they forgo.

²³ Government transfers accounted for 11.2% of total income in all Nunavut communities in 2006 (Statistics Canada, 2007).

²⁴ The \$133M figure was calculated by multiplying \$7,000/person by the number of Inuit from Nunavut and the Northwest Territories aged 15 and over (19 040). Likewise, the number of Inuit from Nunavut and the Northwest Territories aged 15 and over was estimated by applying the percentage of Inuit aged 15 and over (66.1% for Nunavut; 2006 Census) to the all Inuit in both territories (28 805; 2006 Census).

TABLE 14: MONETARY VALUES ASSOCIATED WITH POLAR BEARS IN CANADA (UNIT AND AGGREGATE AMOUNTS)

	Subsistence Hunting		Sport Hunting		Viewing in Churchill		Preservation Value			
					Canadian Visitors	Foreign Visitors				
<i>Unit values</i>										
Value for the consumer	N/A		\$309	\$/hunt	\$400	\$/Canadian visitor	\$600	\$/foreign visitor	\$508	\$/household
Value for the service provider			\$9,828	\$/hunt		U/A				N/A
Total	\$1,731	\$/bear	\$10,137	\$/hunt	\$400	\$/Canadian visitor	\$600	\$/foreign visitor	\$508	\$/household
<i>Aggregate value in Canada</i>										
Value for the consumer					\$40,776	\$1,382,000	\$3,567,600			\$6,320,965,092
Value for the service provider					\$1,297,255	\$2,225,681				N/A
Total	\$635,352				\$1,338,031	\$7,175,281				\$6,320,965,092

2.2.6 *Distribution by province and territory*

In many situations, it is useful to know the values associated with natural resources broken down by province and territory of origin. Any decision-making process requires a good understanding of the issues, including a distributional analysis and the impact on the individuals and economic agents involved.

To achieve this distribution, the values are broken down as follows:

- The value for service providers is broken down by supplier location. For example, all of the net revenues of companies that organized polar bear-watching tours in Churchill are allocated to Manitoba, because the agencies are located in this province.
- The value for consumers is broken down by their province of residence. For example, the value associated with Quebec tourists who went polar bear viewing in Churchill is allocated to Quebec.

Table 15 shows the distribution of each of the estimated values by province and territory. The table shows that the preservation value is the only one for which there is a figure in all provinces and territories and the amounts varies in accordance with the population (the amount per household was the same throughout the provinces).

Ontario has the highest polar bear preservation value because it is the province with the largest number of inhabitants. Its value is greater than that of Nunavut and the Northwest Territories, despite the fact that these areas are home to the most polar bears in Canada and Aboriginal peoples have a special relationship with polar bears. As mentioned, the only reason for this difference is the large gap in the number of inhabitants because the value per household was the same for all Canadians. On the other hand, the preservation value that each Aboriginal person assigned to polar bears may have been higher than the value assigned by non-Aboriginal Canadians, but even if that were so, the fact remains that the population of Ontario is 540 times greater than that of both territories combined. It is, therefore, highly likely that there would still be a great difference even if Aboriginal people had assigned a greater value to polar bear preservation than had non-Aboriginals.

As noted earlier, the individual preservation value is deemed identical across Canada, which implies that the value Aboriginals assign to polar bear preservation is the same as that assigned by non-Aboriginals. This assumption can be challenged mainly because the Aboriginal value system differs from that of most other Canadians. However, we could not estimate the specific value for Aboriginals because the meta-model we used to perform the estimate did not provide any information specific to Aboriginals.

However, Nunavut and the Northwest Territories did have the highest values for hunting (\$1.46 million and \$0.42 million, respectively, for all sport and subsistence hunting combined). This finding was consistent with expectations since most polar bear hunting takes place in these areas. In the case of sport hunting, the value for hunters is not broken down by province because we had no information on the Canadian hunters' place of residence.

Manitoba is assigned the highest value for viewing polar bears in their natural habitat (\$2.5 million) because Churchill is Canada's premier polar bear destination. Based on discussions with people involved in the industry, other polar bear-watching sites appeared to be somewhat marginal. Therefore, the value produced by the agencies that organize these tours is entirely allocated to

Manitoba. However, the value for visitors is broken down by the visitors' province of residence, and the table shows that a significant percentage comes from abroad (\$3.6 million).

In addition to a viewing value, foreigners also assign a hunting value and a preservation value to Canadian polar bears. While the foreign hunting value is estimated at \$0.03 million/year, estimating the preservation value that foreigners assign to Canadian polar bears remains challenging, given the disparity of the world's population in terms of income and knowledge about the Canadian polar bear population.

The table shows that the various values associated with polar bears are generated in Northern Canada, but a significant percentage of these values are accrued elsewhere in Canada and abroad. This is the case with polar bear viewing in Churchill, Manitoba, with its \$7.2 million of economic value, of which only 35% is retained by the province, while the rest is spread throughout the rest of Canada (16%) and abroad (49%). Most of the value allocated to Manitoba is represented by the net revenues of the travel agencies that organized polar bear-watching tours (88%). In the case of hunting, however, virtually all of the value remains in the regions where it is generated. For example, the value of subsistence hunting is entirely accrued by the regions where the polar bears live and 98% of the value of sport hunting is accrued by the Northwest Territories and Nunavut.

TABLE 15: VALUES ASSOCIATED WITH THE POLAR BEAR BROKEN DOWN BY PROVINCE AND TERRITORY

	Subsistence Hunting	Sport Hunting	Viewing Polar Bears in Their Natural Habitat	Preservation Value
Alberta	-	-	\$ 238,276	\$ 638,425,367
British Columbia	-	-	\$ 301,816	\$ 835,080,912
Prince Edward Island	-	-	-	\$ 27,004,244
Manitoba	\$ 3,588	-	\$ 2,527,497	\$ 228,078,758
New Brunswick	-	-	-	\$ 150,412,651
Nova Scotia	-	-	\$ 15,885	\$ 191,519,987
Nunavut	\$ 543,255	\$ 923,803	-	\$ 3,992,064
Ontario	\$ 4,784	-	\$ 444,782	\$ 2,314,952,641
Quebec	\$ 23,921	-	\$ 31,770	\$ 1,620,887,400
Saskatchewan	-	-	-	\$ 196,752,107
Newfoundland and Labrador	\$ 5,980	-	-	\$ 100,213,267
Northwest Territories	\$ 53,823	\$ 373,452	-	\$ 7,234,505
Yukon	-	-	\$ 47,655	\$ 6,411,189
Value that Canadians assigned to Canada's Polar Bears	\$ 635,352	\$ 1,300,109	\$ 3,607,681	\$ 6,320,965,092
Value that foreigners assigned Canada's polar bears	-	\$ 37,922	\$ 3,567,600	U/A
Total	\$ 635,352	\$ 1,338,031	\$ 7,175,281	\$ 6,320,965,092

Chapter 3: How Changes in Human Activities in Northern Canada Could Affect Polar Bear Habitat and Population

The development of human activities in Northern Canada may alter the polar bear population or its habitat. Activities that may have an impact on polar bears include exploration and mining, oil and gas drilling and exploration, energy transmission infrastructure, hydro-electric power generation, defence activities, marine transportation, tourism (when the presence of tourists increases within the area in which polar bears are likely to be present), hunting, and the development of human settlements and infrastructure, especially near dens. In addition, some activities may, in turn, be affected by a change in the polar bear population, such as polar bear observation and sport and subsistence hunting.

The potential impact of human activities on polar bears and the potential impact of a change in the polar bear population or status on these activities are intensified when more polar bears are present in an area and these activities are located in areas where polar bears are likely to be present. However, polar bears live primarily on sea ice rather than the adjacent land masses²⁵. Furthermore, according to Environment Canada polar bear expert, Nick Lunn²⁶, polar bear populations do not stay in one location for long, but move based on ice conditions.

Given the time constraints, a detailed analysis of the linkages between human activities and Canada's polar bear population or its habitat could not be completed as part of this study.

To estimate the level of economic activity in the Far North that could have an impact on the polar bear population and vice versa, an indicator was established based the following data:

- In Canada, 90% of the polar bear population lives in the Northwest Territories and Nunavut²⁷;
- The area where polar bears are likely to be present includes 100% of Newfoundland and Labrador, the northern part of Manitoba (25% of the province's total area), Ontario (15% of the province's total area) and Quebec (about 35% of the province's total area), about 90% of the coastal areas of Nunavut, and about 5% of the coastal areas of the Northwest Territories and Yukon²⁸;

The GDP values presented below are an indicator of the area where polar bears are likely to be present. The formula used to perform this calculation is presented below:

$$\text{GDP of an activity} = \{[(\text{GDP of the activity for the Northwest Territories}) \cdot 0.05 + (\text{GDP of the activity for Nunavut}) \cdot 0.9] \cdot 0.9 + 0.1[(\text{GDP of the activity for the Yukon}) \cdot 0.05 + (\text{GDP Newfoundland and Labrador} + \text{GDP Northern Quebec} + \text{GDP Northern Manitoba} + \text{GDP Northern Ontario})] \cdot 0.1\}$$

²⁵ Source: CITES 1973. Online at: <http://www.cites.org/> (accessed August 20, 2010).

²⁶ Personal telephone conversation with Nick Lunn.

²⁷ Northwest Territories Environment and Natural Resources Year N/A. *Polar Bear*. Online at: http://www.enr.gov.nt.ca/_live/pages/wpPages/hunting_Polar_Bear.aspx.

²⁸ See maps of the Polar Bear's habitat: COSEWIC, 2008.

The following table provides a list of economic activities that could have an impact on the polar bear population or its habitat and the impact of the decline in the polar bear population on these activities.

TABLE 16: HUMAN ACTIVITIES THAT COULD HAVE AN IMPACT ON THE POLAR BEAR POPULATION OR ITS HABITAT AND THE IMPACTS THAT THE DECLINE IN THE POLAR BEAR POPULATION MIGHT HAVE ON THESE ACTIVITIES²⁹

Type of Activity	Scope of Activities	Potential Impact on Polar Bears	Potential Impact of a Change in the Polar Bear Population on the Activity
Exploration and mining of metallic and non-metallic minerals	<p>GDP: \$1.4 billion³⁰ out of \$17billion for all the territories, or 8%.</p> <p>In Nunavut and the Northwest Territories, five mining sites are located near the area where polar bears are likely to be present (diamonds and tungsten)³¹.</p> <p>Trends: Activity increasing.</p> <p>Mining exploration projects in Nunavut: 136 in 2007, 214 in 2008 and 122 in 2009³², about a dozen of which are within the area where polar bears are likely to be present³³.</p> <p>Mining exploration projects in the Northwest Territories: 46 projects in 2008³⁴</p>	<p>Impact on polar bears: Not documented</p> <p>Impact on polar bear habitat: Habitat degradation/ fragmentation³⁵</p>	<p>If the polar bear numbers were to drop below a certain threshold, legislation could have an impact on the future development of these activities when they are carried out in areas targeted as inhabited by polar bear populations requiring protection.</p>

²⁹ The GDP values presented are a proxy for the area where polar bears are most likely to be present. Formula used: GDP of an activity = {(GDP of the activity for the Northwest Territories)*0.05 + (GDP of the activity for Nunavut)*0.9}*0.9 + 0.1[(GDP of the activity for the Yukon)*0.05 + (GDP Newfoundland and Labrador + GDP Northern Quebec + GDP Northern Manitoba + GDP Northern Ontario)]*0.1}

³⁰ Source: Statistics Canada and COSEWIC. 2008..

³¹ Source: Northwest Territories Chamber of Mines. 2008.

³² Source: Northern Development Ministers' Forum and Overview and Indian and Northern Affairs Canada. Nunavut. Overview 2009. Mineral Exploration, Mining and Geoscience.

³³ Source: Nunavut Planning Commission. Interactive map. <<http://www.nunavut.ca/en/map?zoom=1&lat=76.24515&lon=-99.58123&layers=BTFTTFFFTTFFFFFFFFFFFFFFFF>>.

³⁴ Source: Mining and Exploration. 2008 Overview. Northwest Territories. Available online: <<http://www.iti.gov.nt.ca/publications/2009/MiningOilGas/MiningOverview2008.pdf>>.

³⁵ Source: National Research Council, 2003.

Type of Activity	Scope of Activities	Potential Impact on Polar Bears	Potential Impact of a Change in the Polar Bear Population on the Activity
Energy transmission infrastructure	<p>GDP⁴⁴: \$0.81M⁴⁵ out of \$20M for all the territories, or 4%.</p> <p>Trends: Activity increasing. Major project for a 1220-km gas pipeline in the Mackenzie River Valley at a cost of \$16.2 billion⁴⁶. Between 6200 and 8200 jobs will be created, depending on the season.</p> <p>The development of energy transmission infrastructure in the Far North has been experiencing strong growth since the 1970s.⁴⁷</p>	<p>Impact on polar bears: According to the environmental impact study, the Mackenzie gas pipeline project would have minimal impact on the polar bear: impact on species that are part of the polar bear's food chain, and sensory disturbances around the Niglintgak site⁴⁸.</p> <p>Impact on polar bear habitat: Not documented</p>	
Electrical power generation and distribution	<p>GDP: \$853M out of \$9.0 billion for all the territories, i.e. 9.5%.</p> <p>Trends: Strong development.</p> <p>In Nunavut, studies are underway to determine the area's hydro-electrical potential, and several potential sites have been identified⁴⁹.</p> <p>In the Northwest Territories, two new hydro-electric power generation projects were planned in 2008⁵⁰.</p> <p>The Eastmain-1-A-Sarcelle-Rupert hydro-electric power generation project in the James Bay area was evaluated at \$4.9 billion.⁵¹</p> <p>Major investments have been made in hydro-electric power generation projects in Northern Manitoba (\$1.7 billion) and Northern Quebec (\$8.2 billion).</p>	<p>Impact on polar bears: The impact studies consulted made no reference to a potential impact on polar bears.</p> <p>Impact on polar bear habitat: Not documented</p>	

⁴⁴ The activities concerned were natural gas transmission and distribution by pipeline.

⁴⁵ Data for the Northwest Territories, Nunavut, Newfoundland and Labrador, and Yukon.

⁴⁶ Source: Mackenzie Gas Project. Project Update 2007. Available online: <http://www.mackenziegasproject.com/theProject/regulatoryProcess/applicationSubmission/Applicationscope/projectupdate2007.html>.

⁴⁷ Source: Socioeconomic Circumpolar Database 2010.

⁴⁸ Environmental Impact Study for Mackenzie Gas Project. Available online:

http://www.mackenziegasproject.com/theProject/regulatoryProcess/applicationSubmission/Documents/MGP_EIS_Vol1_Section_5_S.pdf.

⁴⁹ We have no information on the location of these sites with respect to the Polar Bear's habitat.

⁵⁰ Source: Northwest Territories Power Corporation Annual Report: <http://www.ntpc.com/documents/Annual%20Report_09.pdf>.

⁵¹ Source: Northern Development Ministers' Forum.

Type of Activity	Scope of Activities	Potential Impact on Polar Bears	Potential Impact of a Change in the Polar Bear Population on the Activity
National Defence activities	GDP: \$12.6M ⁵⁹ out of \$110M for all the territories, or 11.5%. No information on the location of defence activities (inside or outside the area where polar bears are likely to be present) Trends: The GDP of defence activities increased approximately 20% between 2000 and 2007.	Impact on polar bears: The effects of noise on polar bears and their prey are not known ⁶⁰ . Possible disturbances in the nursing dens caused by vibrations. Polar bears should be quite tolerant of air and ground traffic near their nursing sites in winter and spring ⁶¹ .	The impact of a change in the polar bear population on these activities is not known.
Marine transportation	Total expenses of the cruise industry in the province of Newfoundland and Labrador (whose polar cruise market is booming): \$5.8M in 2008. Trends: The current level of activity is limited, but developments are expected, particularly because of the impact of climate change on ice melt ⁶² .	Impact on polar bears: Effects on polar bears unknown. Possible negative impacts of icebreakers on the Ringed Seal's breeding habitat ⁶³ . Impact on polar bear habitat: Not documented.	
Observation	GDP: \$2M ⁶⁴ Trends: Marketing activities are currently being conducted in Canada and abroad (United States, Europe, Australia and China) to attract more tourists to Churchill, Manitoba (discussions with industry representatives).	Impact on polar bears: Polar bear observation in itself is not a direct threat to the species. However, in certain situations, negligence or ignorance may result in the death of a polar bear ⁶⁵ .	The decrease in the number of polar bears would have a negative effect on polar bear-observation activities in Churchill if there were no guarantee that visitors would see bears. However, if they saw only one-quarter of the number of bears they see now, tourists would keep coming to Churchill ⁶⁶ .

⁵⁹ Data for the Northwest Territories, Nunavut, Newfoundland and Labrador, and Yukon.

⁶⁰ Source: IUCN. 2009.

⁶¹ Source: Polar Bears International. 2003.

⁶² Source: Laval University. 2006. Le potentiel de trafic maritime dans l'Arctique canadien. Available online:

<http://www.psi.ulaval.ca/fileadmin/psi/documents/Documents/Actes_de_colloques/Actes_TRANSPORT_MARITIME_Comtois.pdf>. and the U.S. Fish and Wildlife Service. 2010. *Economic Analysis of Critical Habitat Designation for the Polar Bear in the United States*.

⁶³ Source: IUCN. 2009.

⁶⁴ Source: Lemelin, 2004.

⁶⁵ Source: IUCN. 2009.

⁶⁶ Source: Dawson et al., 2007.

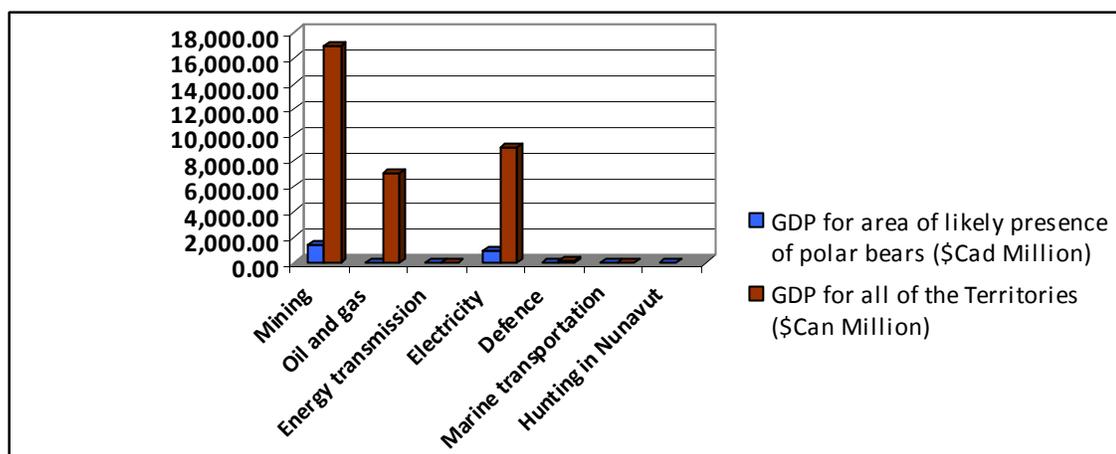
Type of Activity	Scope of Activities	Potential Impact on Polar Bears	Potential Impact of a Change in the Polar Bear Population on the Activity
Hunting (sport and subsistence)	GDP: \$1.2M in Nunavut ⁶⁷ Trends: Quotas are established internationally, distributed to the communities and adjusted in accordance with the local context.	For example, overhunting is the most probable direct cause of the decline in polar bear population in Kane Basin and Baffin Bay ⁶⁸ .	The decrease in the number of polar bears would have a negative effect on hunting by reducing the number of hunting quotas.

⁶⁷ Source: Wenzel, 2008.

⁶⁸ COSEWIC. 2008.

The following figure plots the activities that could have an impact on the polar bear population against the GDP (in millions of dollars) of activities in the area where polar bears are likely to be present and for all the territories.

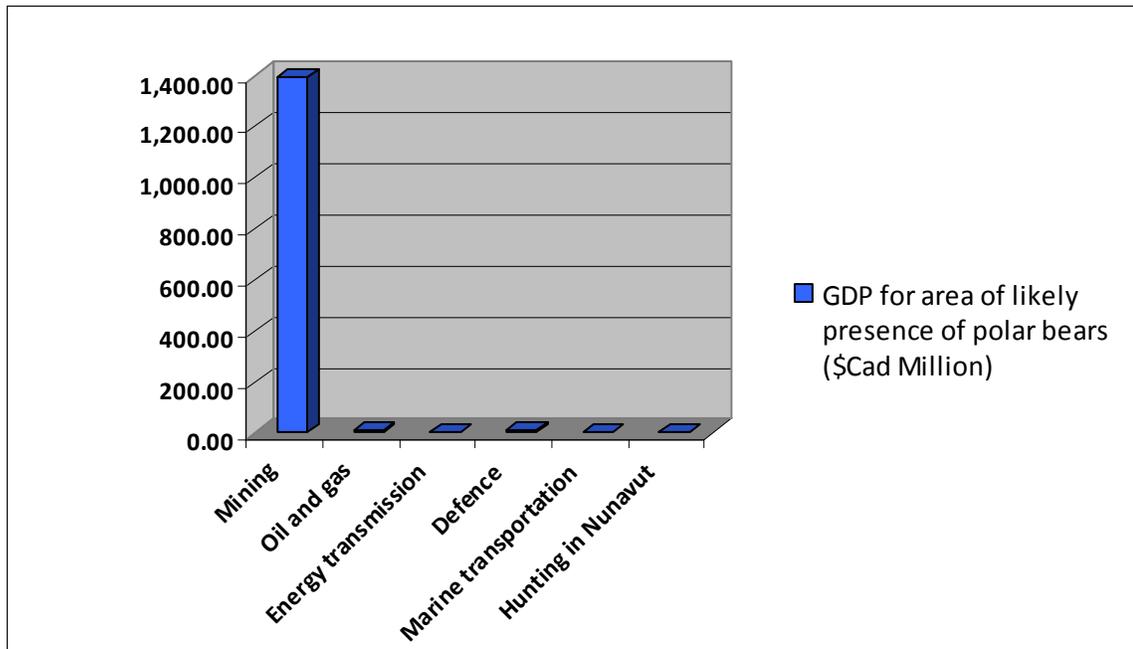
FIGURE 3: GDP OF ECONOMIC ACTIVITIES THAT MAY AFFECT POLAR BEARS IN THE AREA WHERE POLAR BEARS ARE LIKELY TO BE PRESENT AND FOR ALL THE TERRITORIES



Exploration and mining activities produced the highest GDP in the area where polar bears were likely to be present, nearly \$1.4 billion, followed by electrical power generation, \$853M of GDP (in northern Quebec and Manitoba, in particular) and oil and gas drilling (\$10M in the area where polar bears were likely to be present).

The following figure shows the GDP of activities in the area where polar bears were likely to be present. We extracted electrical power generation, because the environmental impact studies that we consulted made no mention of the impact of electrical power generation sites on polar bears.

FIGURE 4: GDP OF ACTIVITIES, WHICH MAY AFFECT POLAR BEARS, CONDUCTED IN THE AREA WHERE POLAR BEARS ARE LIKELY TO BE PRESENT



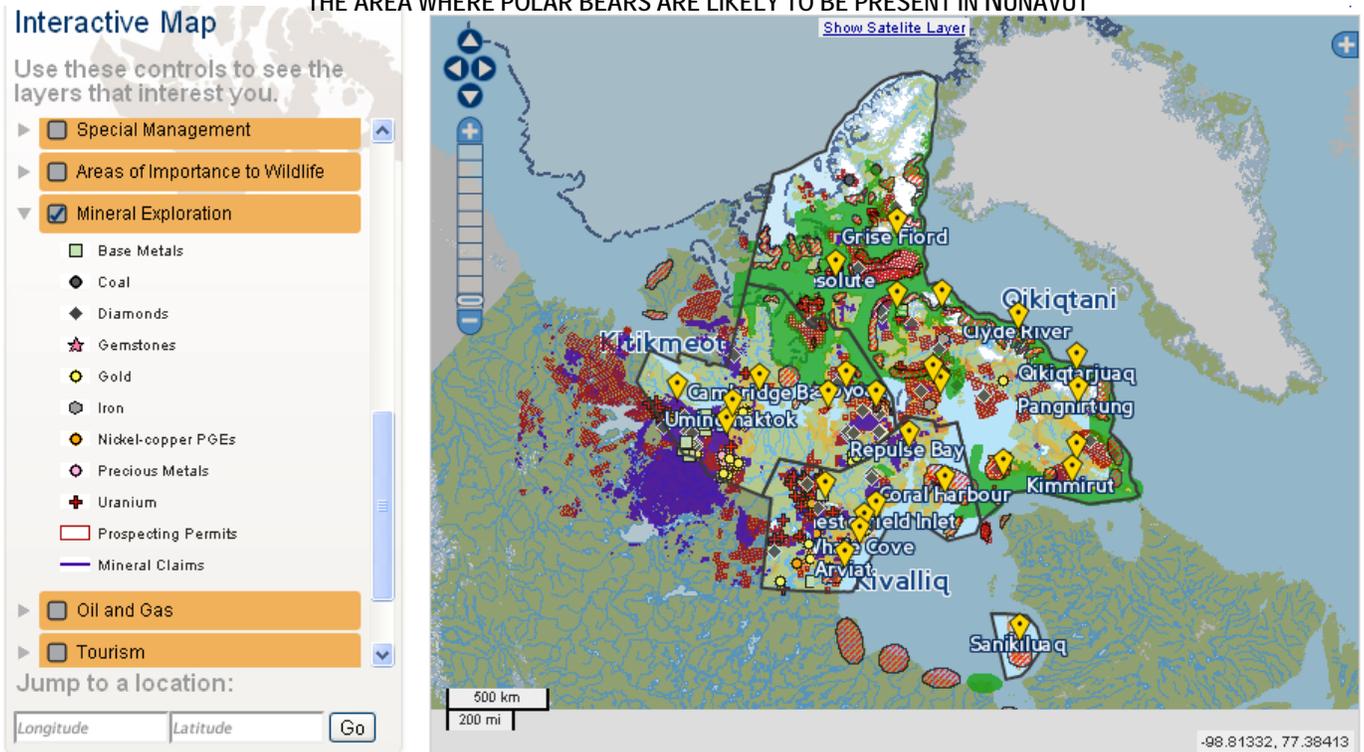
Mining and mining exploration were by far the most important economic activities in the area where polar bears were likely to be present in Canada.

Mining

As mentioned above, mining activity is a very important economic sector near the area where polar bears are likely to be present (there are currently five diamond and tungsten mining sites in the Northwest Territories and Nunavut) and money is being invested in mining exploration. According to the American National Research Council (2003), the potential impact of mining operations and exploration involves polar bear habitat destruction or fragmentation because these sites are located in polar bear habitat.

The following figure shows the mining and exploration sites and their location relative to areas where polar bears are present (green on the map) and the nursing sites (areas with red stripes).

FIGURE 5: MINING EXPLORATION ACTIVITIES AND THEIR LOCATION WITH RESPECT TO THE AREA WHERE POLAR BEARS ARE LIKELY TO BE PRESENT IN NUNAVUT



Source: Nunavut Planning Commission. Interactive map.

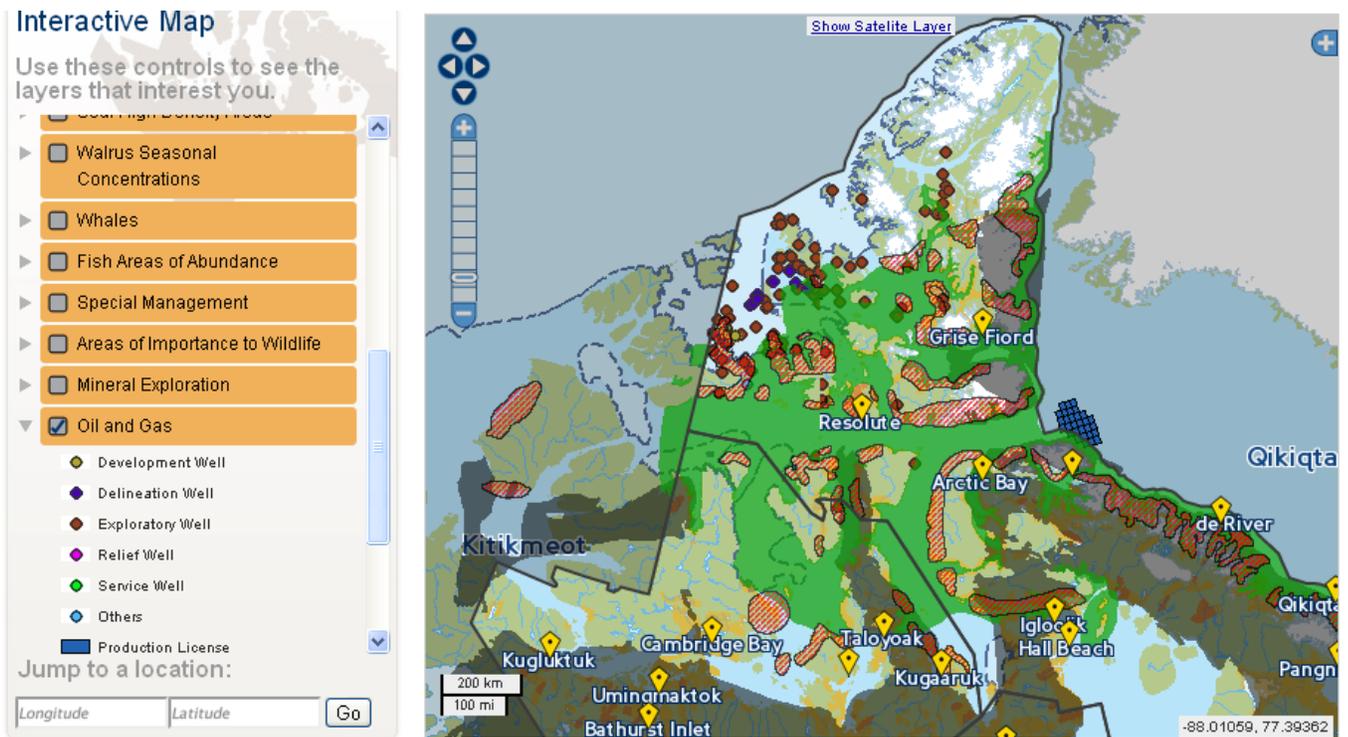
Mining sites in Nunavut are currently located outside of the area where polar bears are likely to be present, but there are about ten mining exploration projects within this area.

Oil and gas activity

Most oil and gas drilling operations are located north of the Mackenzie River Valley, in the area where polar bears are likely to be present. There is currently limited oil and gas activity in Nunavut.

Although production volumes are trending lower because some wells are at the end of their productive lives, oil and gas exploration is booming in the area where polar bears are present. According to the Nunavut Planning Commission (see Figure 6), there are currently about 50 oil and gas exploration sites in the area where polar bears are likely to be present.

FIGURE 6: OIL AND GAS EXPLORATION SITES AND THEIR LOCATION WITH RESPECT TO THE AREA WHERE POLAR BEARS ARE LIKELY TO BE PRESENT IN NUNAVUT



Source: Nunavut Planning Commission. Interactive map.

In the Mackenzie River Valley, the Mackenzie Delta and the Beaufort Sea, six new oil and gas exploration permits were issued in 2008.

The following figure highlights (in yellow) the area occupied by oil and gas exploration sites in the Beaufort Sea (exploration rights granted until 2006) and the calls for bids for implementing oil and gas exploration projects (in green). In 2008, four new exploration permits were granted in the Beaufort Sea. According to the Canadian Association of Petroleum Producers⁶⁹, in May 2010, there were three offshore platforms operating in Atlantic Canada (Nova Scotia and Newfoundland and Labrador). However, there were no platforms operating in the Beaufort Sea at that time.

⁶⁹ See: CAPP Offshore Drilling. <<http://www.capp.ca/CANADAINDUSTRY/OIL/OFFSHORE/Pages/default.aspx#XzRhkw5KHSCo>>.

FIGURE 7: OIL AND GAS EXPLORATION SITES IN THE BEAUFORT SEA



Source: WWF ⁷⁰.

The main potential impacts of these activities on polar bears are the fragmentation and destruction of their habitat, and the risk of accidents (spills), which would be very difficult to deal with, given the climatic conditions in these areas. If there were a spill, the bears might ingest toxic substances which would reduce their fur's insulating properties and cause them to eat more food to increase their caloric intake. However, no consensus has been reached on possible disturbances in nursing dens caused by seismic surveys.

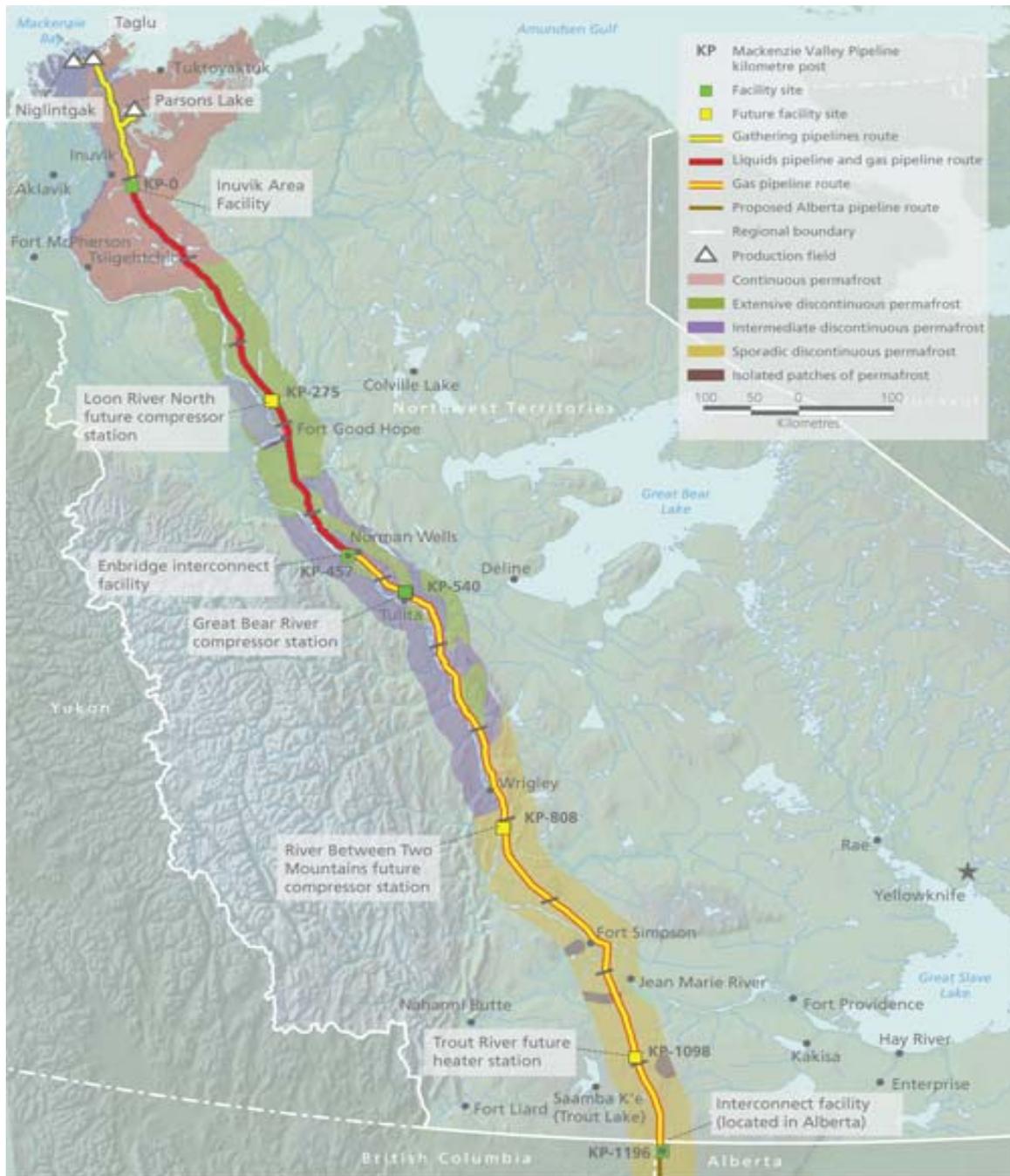
Energy transmission infrastructure

Development of energy transmission infrastructure in the Far North has been experiencing strong growth since the 1970s, particularly in the Mackenzie River Valley, where a gas pipeline project is currently underway.

⁷⁰ See: WWF: Polar Bears. Threats to Polar Bears. <<http://www.worldwildlife.org/species/finder/polarbear/threats.html>>.

The following figure shows the route of the Mackenzie gas pipeline, only the northernmost part of which is located in the area where polar bears are likely to be present.

FIGURE 8: MACKENZIE GAS PIPELINE ROUTE



Source: National Energy Board.2011⁷¹

⁷¹ See: National Energy Board 2011. Mackenzie Gas Project. Reasons for the Decision. Volume 1. Part 3. Transmission pipelines. <<http://www.one-neb.gc.ca/clf-nsi/rthnb/pplctnsbfrthnb/mcknzgsprjct/rfd/rfdv1p3-eng.html>>.

The unavailability of data on defence activities in the Far North prevented us from establishing a clear link between these activities and the polar bear population. According to the IUCN (2009), the effects of noise on polar bears and their prey are poorly understood. According to Polar Bears International (2010), Polar bears should be quite tolerant of air and ground traffic near nursing sites in winter and spring.

Marine transportation

The current level of marine transport in the Far North is limited, but developments are expected, particularly because of the impact of climate change on ice melt. In Nunavut, for example, the number of cruise ships has increased in recent years. In the Northwest Passage and the Beaufort Sea, there were four passages per year in the 1980,s while there were ten per year from 2000 to 2006 (Coast Guard and research icebreakers, cruise ships, ships exploring for oil and gas)⁷³ .

The effects of increased marine traffic on polar bears and their prey are unknown. According to IUCN, icebreakers can have a negative impact on the breeding habitat of Ringed Seals, but these effects are likely to be fairly localized.

Polar bear viewing

Polar bear viewing in itself is not a direct threat to the species. However, in certain situations, negligence or ignorance may result in the death of a polar bear.

Hunting

According to Wenzel (2008), hunting (subsistence and sport) generates \$1.2M in Nunavut. Quotas are established internationally and distributed to the local communities. These quotas are then adjusted in accordance with the local context. For example, the Government of Nunavut has just announced that the number of tags for Baffin Bay residents will be reduced from 105 to 65 until 2014.

Also, hunting can have a negative effect on the polar bear population. For example, according to COSEWIC (2008), overhunting is the most likely direct cause of the declining polar bear population in Kane Basin and Baffin Bay.

The impacts of a change in the polar bear population on economic activities

If the number of polar bears were to drop below a certain threshold, it is likely that legislative amendments would affect the future development of mining and mineral exploration, oil and gas drilling and exploration, electrical power generation, transmission and distribution infrastructure, and the development of human settlements and infrastructure in areas targeted as being inhabited by polar bear populations requiring protection.

We are unable to comment on the potential impact of a change in the polar bear population on defence and marine transportation activities because these issues have not been documented.

⁷³ Source: Arctic Council. 2009.

However, the declining polar bear population will have a direct impact on viewing activities. The declining number of polar bears would have a negative effect on viewing activities in Churchill if there is no guarantee that visitors will see bears. However, the number of people wishing to see polar bears in their natural habitat could increase if polar bears become scarce.

Finally, the declining number of polar bears would have a negative effect on hunting, in that fewer hunting tags would be allocated to the communities.

Chapter 4: Framework for Analyzing the Impact of Changes in Polar Bear Populations and Habitat on the Canadian Economy and Society

This chapter addresses the second objective of the study, which was to design a methodological framework for analyzing the socio-economic impact of a change in the polar bear population or its habitat. Specifically, it provides some answers to the following question: “What steps should be taken to assess the impact of any decision regarding the polar bear population or its habitat?” The flow chart presented in Figure 11 provides the answer to this question.

A wide variety of situations may lead the Government of Canada to address the issue of Canada’s polar bear population or its habitat. If COSEWIC believes that population levels will decline, the government may decide to take measures to avoid or mitigate this type of degradation. However, if the population is increasing (as a result of previous protective measures or other measures), existing constraints may be relaxed or eliminated. The Government of Canada’s decision to intervene is influenced, first, by the status quo scenario developed by COSEWIC for the 13 subpopulations of polar bears in Canada and their habitats, and second, by the various international obligations arising from agreements signed by Canada.

Once the decision to take action has been made and the political objective has been set, an intervention strategy will be adopted. Apart from the desired effects on the polar bear population and its habitat, the strategy will have social and economic impacts that must be taken into account. To determine and put a monetary value on the impacts that the intervention strategy will have on Canada’s society and economy, the habitat and subpopulations involved must first be identified. Is the subpopulation in western Hudson Bay or the one in Baffin Bay involved, or is it another one? What area is affected? Are the areas most affected by climate change the dens, the sea ice used by the bears to hunt seals, or another part of the habitat? Are areas in northern Manitoba, specific areas in Nunavut or other areas involved?

Identifying the areas affected by the measures implemented under the intervention strategy is an essential step in identifying the economic activities and uses affected by these measures. For example, a polar bear intervention strategy may affect viewing of polar bears in their natural habitat, if it specifically targets the western Hudson Bay subpopulation, because most viewing activities are conducted near Churchill, Manitoba. The mining industry may be affected if the mines are located in the target subpopulation’s habitat.

After identifying the areas affected by the intervention strategy, a list of the activities and uses affected by the strategy must be prepared. The uses of polar bears potentially affected by an intervention strategy include sport and subsistence hunting, viewing polar bears in their natural habitat and zoos, scientific research, use of the polar bear’s image as an iconic species, Inuit cultural, artistic and spiritual activities relating to the polar bear and the passive use of preserving the species. Apart from these various uses, some economic activities in Northern Canada may also be affected by an intervention strategy because they take place in the target habitat. These activities include mining, oil and gas drilling operations, energy transmission infrastructure, electrical power generation and distribution, defence activities, marine transportation and human settlements.

Once the uses and activities potentially affected by the intervention strategy have been identified, each use and activity must be analyzed to determine the type of impact and its direction. Table 17 presents the various impacts by activity and use. The plus (+) and minus (-) signs indicate positive and negative impacts. Examples of impacts in the table are fictitious and shown for illustrative purposes only.

TABLE 17: SAMPLE TABLE IDENTIFYING THE POTENTIAL IMPACTS OF A POLAR BEAR INTERVENTION STRATEGY

	Impact 1	Impact 2	Impact 3
Uses of Polar Bears			
Sport hunting	Fewer quotas (-)	Increase in permit price (+ or -)	
Subsistence hunting	More quotas (+)		
Viewing in the wild	Fewer viewing opportunities available (-)	More tourists interested in seeing the bears for the last time (+)	
Passive use (preservation)	More concern for the preservation of the species (+)		
Activities in Northern Canada (other than uses)			
Mining activities	Removal of a development restriction in a specific area (+)		
Energy transmission infrastructure	Minimum distance from a den (-)	Less time allocated to monitoring bear presence (+)	
Human settlements	Development ban (-)		

Estimating costs and marginal benefits

The next step is to estimate the value of the economic impacts that have been identified in Table 17 to which the cost of managing and implementing the intervention strategy must be added. The methods already used for estimating the current values of the direct uses of polar bears may be used to estimate the marginal impact of a future intervention strategy. In the case of activities in Northern Canada, the benefits and marginal costs generated by the intervention strategy will be estimated based on the type of intervention (restrictions or removal of restrictions on activities, bans or removal of bans on the development of certain activities, etc.). In the case of indirect impacts, such as the impact on regional development, a qualitative presentation will replace the monetary estimate because it is difficult to put a monetary value on this type of impact.

The time horizon for estimating costs and benefits will be based on the type of impact. For example, the IEC and Northern Economics study (2010), which estimated the impacts of critical habitat designation for the polar bear in Alaska, used a 30-year horizon because of the impacts on the oil and gas exploration industry. It is expected that this industry will be in its greatest development phase between 2010 and 2039.

The net present value will then be estimated using a discount rate based on the type of benefits and estimated costs. For example, IEC and Northern Economics (2010) used a 7% rate, which is the rate generally used by the Office of Management and Budget (OMB) in the United States. The Government of Canada also uses a 7% rate. However, the Treasury Board of Canada Secretariat recommends that a 3% rate be used instead of a 7% rate when significant intergenerational effects are anticipated (TBSC, 2010). A discount rate sensitivity analysis may also be performed. The IEC and Northern Economics study (2010) performed the sensitivity analysis by comparing the 7% rate with a 3% rate, which assigned a higher present value to future benefits and costs. Environment Canada uses the same approach, which adds the no-discount-rate option to the sensitivity analysis.

The following paragraphs provide guidance on how to estimate each type of impact arising from an intervention strategy on the number of polar bears in Canada or their habitat.

Impacts on the active- and passive-use values of

Chapter 2 of this study estimated the economic value of four uses of polar bears in Canada. Guidelines on estimating the economic value of potential impacts on these four uses were then presented for each use. For uses whose monetary value could not be estimated, general comments were provided on the possible direction of change.

Subsistence hunting

If the intervention strategy changes the number of hunting quotas, an estimate of the higher or lower number of quotas must be performed. Subsequently, updating the average values of a polar bear pelt and one kilogram of bear meat substitute (beef) estimated in this study would be useful if the estimate is performed in the fairly distant future. The final calculation might follow the specific approach described in Section 2.2.1.1.

Sport hunting

Two impacts relating to sport hunting are estimated: the impact on Inuit communities that allocate part of their quotas to sport hunting, and the impact on sport hunters. In the first case, the impact on the number of quotas allocated to sport hunting must be estimated first. Subsequently, the net revenues that a sport hunt generates for the Inuit community must be updated if the estimate is performed later. The total value will then be estimated by multiplying the change in the number of quotas allocated to sport hunting by the net revenues generated by a sport hunt.

In the second case, it is recommended that a literature review be conducted to find out whether more recent studies have estimated a polar bear sport hunter's willingness to pay because this study used a big game hunter's willingness to pay, which is a potentially lower value. To estimate the impact on the value assigned by all sport hunters, the willingness to pay per hunter must be multiplied by the change in the number of quotas allocated to sport hunting, a change whose impact on the Inuit community has already been estimated.

Viewing in the wild

If there is reason to believe that the willingness to pay to watch polar bears in Churchill has changed since the 2010 estimate performed by this study, the same method described in Section 2.2.1.3 can be followed to perform an update. After the intervention strategy has been implemented, the change in the number of visitors must be estimated. To perform the estimate, the latest number of visitors who travel to Churchill specifically to see polar bears must first be obtained from Travel Manitoba or Statistics Canada. Then, an estimate of the percentage change can be performed based on the study conducted by Dawson et al. (2007), which provided guidance on how visitors responded to changes in the number of bears observed (based on a survey conducted in 2007). The change in the aggregate value is calculated by multiplying the individual value by the higher or lower number of tourists.

A second impact that must be estimated is the impact on the net revenues generated by the polar bear-watching industry in Churchill. To perform the estimate, the industry must be contacted because little information is available in the literature. Lemelin (2004) estimated these revenues at \$2M⁷⁴, but this estimate cannot be updated by calculations because it was based on interviews with people in the industry.

Other impacts can be documented to provide a more comprehensive picture of the scope of the changes. Thus, an estimate of the change in the number of jobs in Churchill's polar bear-watching industry may complete the overview.

Preservation value

To estimate the preservation value relating to the anticipated change in the number of bears, Richardson and Loomis's (2009) meta-analysis may be used as it was in Section 2.2.2.1. The only parameter that needs to be adjusted is the percent change in the polar bear population.

⁷⁴ In 2003 Canadian dollars.

Zoo visits, use of the polar bear's image as an iconic species, scientific research and education

It is unlikely that a political decision regarding the number of bears or their habitat will affect these values because a change in these values may occur especially if the species becomes scarce or shows signs of distress. In this case, these values are likely to increase because they are directly related to the degree of scarcity. However, it is difficult to imagine a situation where the government objective will be to allow the species to drop below its viability threshold. Government objectives generally involve enhancing the status of a species or decreasing the number of individuals if the population is too abundant.

Cultural, artistic and spiritual activities

The cultural, artistic and spiritual significance for the Inuit should not change if there is a change in the number of bears or their habitat because this value is not related to the number of bears; rather, it is tied to its charisma, size and ferocity.

Direct impacts on economic activities in Northern Canada

The activities presented in Table 16, other than those associated with the uses of polar bears, may be affected by a polar bear intervention strategy because they take place in polar bear habitat. Depending on the type and level of intervention, there may be restrictions on the scope of these activities and the development of these activities in areas critical to the existence of polar bears, bans on activities already in place or, instead, these types of restrictions and bans may be eliminated.

Restrictions on activities, such as the obligation to comply with minimum setback distances from dens, or the obligation to prevent bears from being present on their sites, may require additional investments or staff assigned specifically to comply with these restrictions. These additional costs must be estimated. If restrictions are lifted, the activity will benefit from a reduction of these costs.

If development of certain activities is banned in a specific area, an opportunity cost, equal to the potential profits that entrepreneurs will forgo, must be calculated. The same type of calculation is used to reflect the closure of existing activities. If bans on development are lifted, a benefit, equal to the future profits of companies that locate their facilities in the area, will be calculated.

Indirect regional impacts

Aside from its direct impacts on the activities of Northern Canada, an intervention strategy may have indirect impacts (i.e. on the entire area). For example, if restrictions are imposed on oil exploration, the oil industry's reluctance to invest in the area may cause investments to flow elsewhere. The impact on employment in the area is significant, especially since the regions in Northern Canada do not offer a wide range of employment opportunities.

From the perspective of the Canadian government, this type of impact primarily involves a transfer of resources from one region to another. However, this information appears relevant given the economic context in the areas that are affected. This type of impact is difficult to express in monetary terms. Therefore, they will be shown descriptively.

Administrative costs of the intervention strategy

Aside from impacts on the uses and economic activities in Northern Canada, a polar bear intervention strategy also has an impact on public spending. Administrative costs are unavoidable, especially those relating to the salaries of the persons responsible for implementing the strategy. Public consultations may also be requested to determine the impact of certain activities on polar bears and their habitat. These consultations involve costs and cause project implementation delays.

Co-benefits

Aside from direct impacts on the use values of polar bears, a potential measure designed to protect their habitat could also produce co-benefits. An example of a co-benefit could be the value of carbon sequestered in the soil, the value of the area's biodiversity or the value of other at-risk species that inhabit the same area as the bears.

Geographical distribution of impacts

Once the various types of impacts mentioned have been estimated, their geographical distribution may be used to refine the analysis and assist in public decision-making at the local, provincial, national and international level.

Impact report

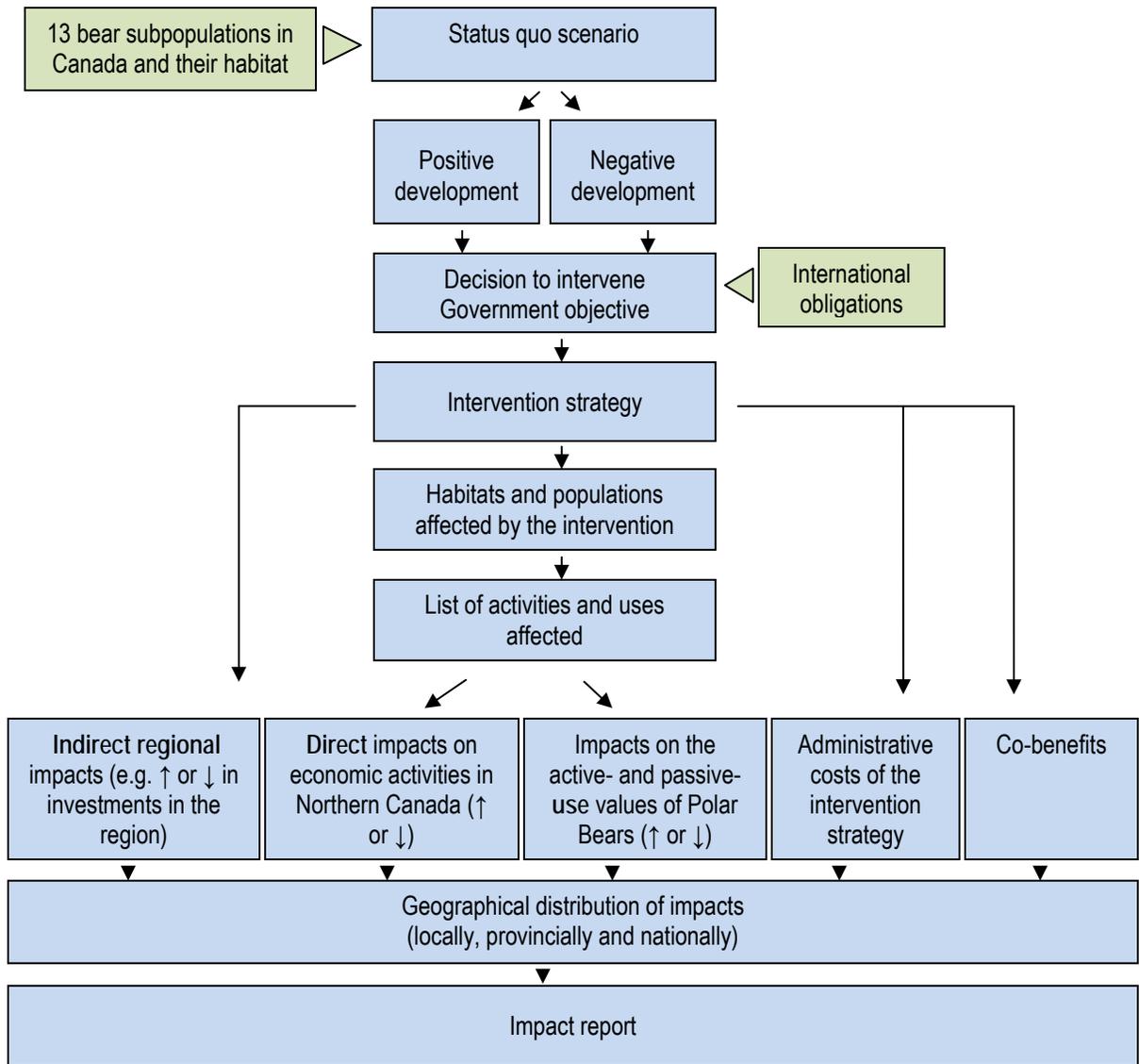
Finally, a report will determine whether the positive impacts outweigh the negative. The report can be produced using a grid like the one presented in Table 18.

**TABLE 18: ANALYSIS GRID FOR ALL THE IMPACTS OF A POLAR BEAR INTERVENTION STRATEGY
(FICTITIOUS EXAMPLE)**

	Impacts on the active- and passive-use values of polar bears	Direct impacts on Northern Canada's economic activities	Indirect regional impacts	Administrative cost of the intervention strategy	Co-benefits
Positive Impacts	More subsistence hunting (\$Xmillion)	Development activities after the lifting of existing restrictions (\$Xmillion)	Increased number of jobs	N/A	Carbon sequestration
	Increased polar bear sightings (\$Xmillion)				Protection of biodiversity
Negative Impacts	Less sport hunting (\$Xmillion)	Higher oil exploration costs	Decrease in investments in the area	\$Xmillion	N/A

		(\$Xmillion)			
			Fewer jobs		

FIGURE 11: FRAMEWORK FOR ANALYZING THE IMPACTS OF SOCIO-ECONOMIC CHANGES ON THE POLAR BEAR POPULATION AND ITS HABITAT



Conclusions

Several studies have estimated the value of Canada's natural capital, but as far as we know, none of them have reported the value of Canada's polar bears, which represent two-thirds of the world polar bear population. Sport and subsistence hunting are well documented, but there was not enough economic information available to estimate other values, such as viewing polar bears in their natural environment, preservation value, iconic species value or cultural value for the Inuit.

This study represented an initial attempt to estimate the various use values of polar bears in Canada. It estimated the monetary value of subsistence hunting, sport hunting, viewing polar bears in their natural environment and preservation. It also provided relevant information about the values that could not be estimated in dollars, such as the polar bear's scientific value, iconic species value or its cultural value to the Inuit, to complete the overall picture of the importance of polar bears in Canada.

Preservation value was by far the most significant value estimated in monetary terms. It amounted to \$6,320million/year for all of Canada. The value of viewing polar bears in the wild came in second at \$7.2million/year, sport hunting was third at \$1.3million/year and subsistence hunting was fourth at \$0.6million/year. Despite its apparent low monetary value, Aboriginal communities regarded subsistence hunting as very important especially because of its cultural value. Apart from values directly relating to polar bears, a potential measure designed to protect their habitat could also produce co-benefits such as the value of carbon sequestered in soil or the value of other species that inhabit the same area as the polar bear.

Another interesting finding produced by the study was the geographic distribution of these values. Although Nature created these values in the Far North, they were accrued throughout Canada and even abroad. For example, 49% of the value of viewing polar bears in the wild was attributed to foreign tourists who travelled to Churchill, Manitoba, and 16% was attributed to Canadian visitors from outside Manitoba. Hunting was an exception because the two territories that are home to the greatest number of bears, Nunavut and the Northwest Territories, recovered more than 98% of the total value of hunting.

Apart from estimating the different values associated with polar bears, the study also presented economic activities in Northern Canada that could affect polar bears and which could also be affected by an intervention strategy targeting the number of bears or their habitat. These activities included exploration and mining, oil and gas drilling and exploration, energy transmission infrastructure, hydro-electric power generation, defence activities, marine transportation, tourism, hunting and the development of human settlements and infrastructure, especially near breeding sites.

Finally, guidelines were presented on how the impacts of an intervention strategy on the number of bears or their habitat can be estimated. The study provided a structured, flexible analytical framework that can be used in a wide variety of intervention strategies.

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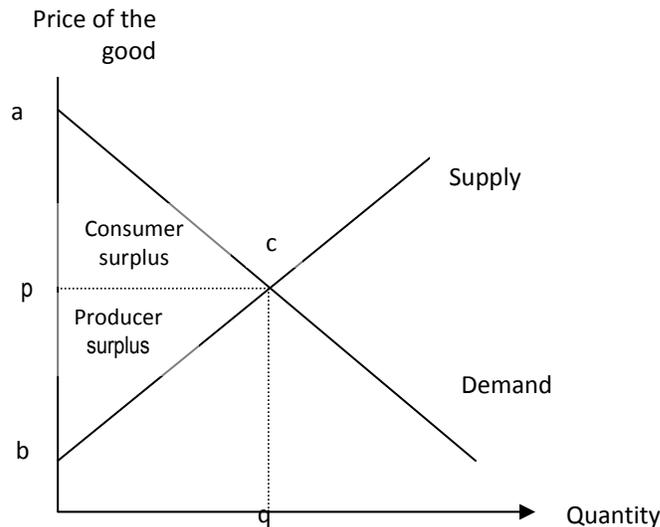
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Appendices

Appendix 1: Consumer Surplus, Producer Surplus and Compensating Variation

Consumer surplus is calculated as the area above the market price up to the demand curve (area of triangle apc ; see Figure 12). Producer surplus is estimated as the area below the market price down to the supply curve (area of triangle bpc).

FIGURE 12: CONSUMER AND PRODUCER SURPLUS



An economic indicator that is even better than consumer surplus from a theoretical standpoint is compensating variation (or compensating surplus, in the case of public goods), commonly called “willingness to pay”⁷⁵. Willingness to pay measures how much a person’s budget must be reduced *after* an environmental improvement has been made in order to maintain his well-being at the level it was prior to the improvement. Thus, assuming that people would like polar bear populations to increase, they will be happier once the proposed program has been implemented. To maintain the same utility level that they had before the increase in the number of polar bears, the additional well-being should be withdrawn via a decrease in their income. This decrease in income is willingness to pay. A greater willingness to pay indicates a greater appreciation of an improvement in polar bear populations.

⁷⁵ Compensating variation is equivalent to the concept of “willingness to pay” only if the assumption that people appreciate environmental improvements is true. If an environmental improvement decreases their well-being, compensating variation is equivalent to the concept of “willingness to receive.”

Appendix 2: Main Steps of the Travel-cost Method (Zonal Travel-cost Approach)

The travel-cost method (zonal travel-cost approach) was used to estimate the value of viewing polar bears in Churchill. The main steps of this method are described below.

- 1) Estimating the cost of travelling from the city of residence to Winnipeg for each city of residence of both companies' clients:

To determine the zones that made a difference in terms of the price paid to travel to Churchill, we estimated only the cost of travelling to Winnipeg because the cost of travelling from Winnipeg to Churchill was generally included in the packages offered by travel agencies. However, to determine the relationship between the travel costs and the number of visitors (step 3), the price of the package was added to the cost of travelling to Winnipeg (\$5,500).

The travel costs included the price of gasoline, airfare and the opportunity cost of time, which was estimated at 33% ⁷⁶ of the average hourly wage. The hourly wage used for Canadian visitors varied by province, and was specific to individuals aged 55 and over because according to certain studies, most tourists who visit Churchill are seniors (Dawson et al., 2007).

More than 100 cities of residence were taken into account. Travel cost information was accessed on airline websites for airfare, maps.google.com for distances and shortest travel routes, and various other sites for the price of gasoline and hourly wages.

- 2) Identifying zones with similar costs:

Three zones were identified for Canada, and four were identified for foreign visitors, based on travel costs to Winnipeg (see Figure 13). For Canada, the first zone (the least expensive) was in Manitoba, more specifically in the Winnipeg area. The second zone included major cities in Canada with reasonably priced flights to Winnipeg (Toronto, Montreal, Vancouver, Calgary, Edmonton, etc.). The major cities in the Maritime Provinces and territories were not included in this zone. These cities were part of the third zone, which represented the rest of Canada.

The four following zones were identified for foreign visitors (see Figure 14):

- Zone 1 (least expensive): States bordering Manitoba (Minnesota and North Dakota);
- Zone 2: Rest of the United States;
- Zone 3: Western Europe;
- Zone 4 (most expensive): Australia, New Zealand, South Africa, and Indonesia.

⁷⁶ Transport Canada generally uses 50% of the hourly wage to estimate the opportunity cost of time spent travelling to work. Instead of 50% we used 33%, which was the factor used in the study by Amoako-Tuffour et al. (2008), because this was time spent travelling to a recreational destination, and therefore a smaller percentage of this time was perceived as a cost (the remaining 67% was considered recreation).

FIGURE 13: THE THREE ZONES IDENTIFIED FOR VISITORS FROM CANADA WHO TRAVELLED TO CHURCHILL



FIGURE 14: THE FOUR ZONES IDENTIFIED FOR VISITORS FROM OUTSIDE CANADA WHO TRAVELLED TO CHURCHILL



- 3) Econometric estimate of the relationship between the number of visitors and the average travel cost per zone:

The average cost per zone included the average cost of travel to Winnipeg and the amount of \$5,500, which represented the average price of an all-inclusive trip from Winnipeg. Table 19 presents the average travel costs to Winnipeg by zone for Canadian visitors and foreign visitors and the average number of visitors.

TABLE 19: AVERAGE TRAVEL COSTS TO WINNIPEG AND NUMBER OF VISITORS BY ZONE

	Average Travel Cost	Number of Visitors
Canadian visitors		per 100 000 residents
Zone 1 (Winnipeg area)	\$97	85
Zone 2 (major cities in Canada with reasonably priced flights to Winnipeg)	\$591	16
Zone 3 (rest of Canada)	\$1,005	3
Foreign visitors		per 1 000 000 residents
Zone 1 (states bordering Manitoba: Minnesota and North Dakota)	\$263	447
Zone 2 (rest of the United States)	\$826	135
Zone 3 (Western Europe)	\$1,196	31
Zone 4 (Australia, New Zealand, South Africa, and Indonesia)	\$2,530	3

In both cases (foreign visitors and Canadian visitors), we obtained a semi-logarithmic relationship with a 5% level of significance:

- For Canadian visitors: $\ln(\text{number of visitors}) = 25.04698 - 0.0036732 * \text{cost}$
- For foreign visitors: $\ln(\text{number of visitors}) = 18.71221 - 0.0022118 * \text{cost}$

- 4) Estimated demand curve:

Several points along the demand curve were estimated based on the relationship obtained in Step 3. The demand curve related the number of visitors and the visitors' willingness to pay beyond the costs incurred to view polar bears. This was the net surplus for each visitor.

5) Estimated net consumer surplus:

The area below the demand curve represents the net consumer surplus. To calculate this figure, we estimated the area based on the area of a triangle. The line that best approximates this area intersects the Y-axis at \$800 for Canadian visitors and \$1,200 for foreign visitors (see Figure 15 and Figure 16).

We used the following formulas:

- Net surplus for Canadian visitors = $(800 * 3455)/2$
- Net surplus for foreign visitors = $(1200 * 5946)/2$

The figures 5946 and 3455 represent the number of foreign and Canadian visitors to Churchill, respectively, from October to December (average from 2006 to 2008). Travel Manitoba provided us with this data.

FIGURE 15: VALUE OF POLAR BEAR VIEWING IN CHURCHILL, MANITOBA (CANADIAN VISITORS)

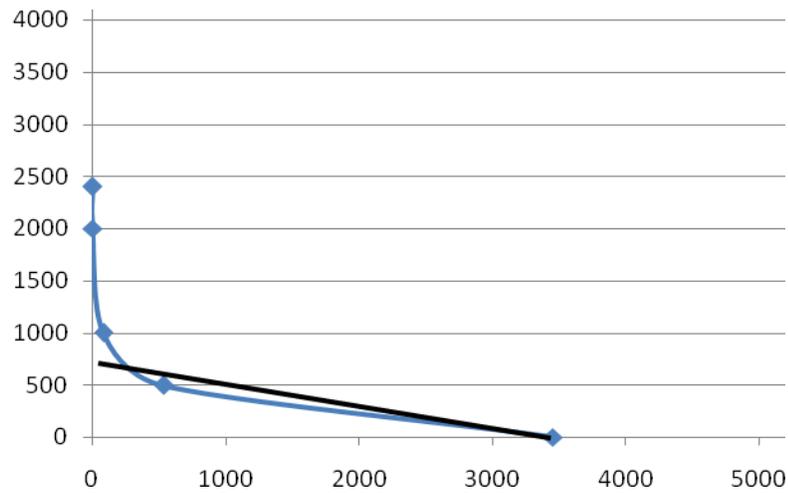
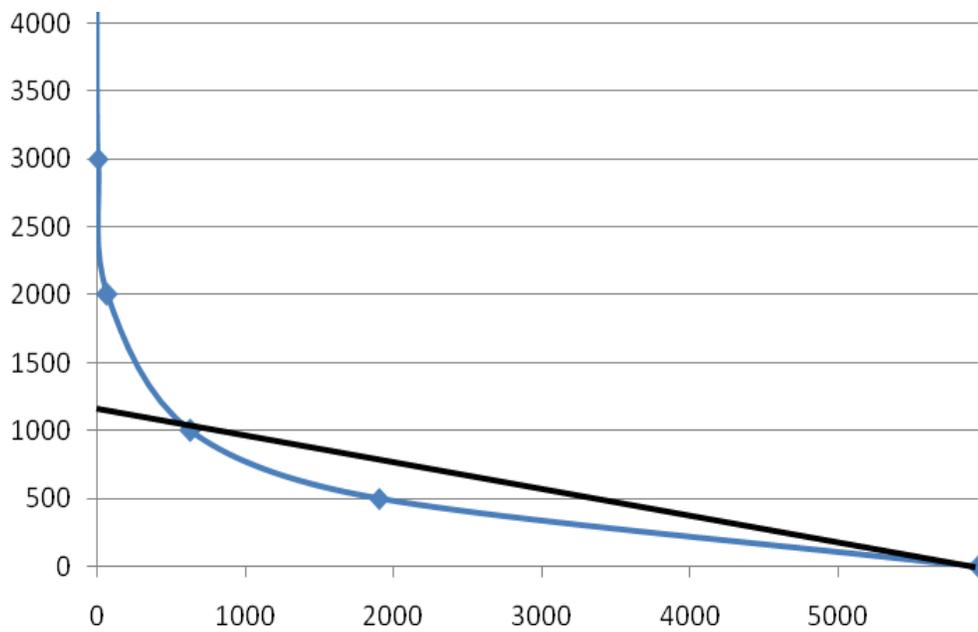


FIGURE 16: VALUE OF POLAR BEAR VIEWING IN CHURCHILL, MANITOBA (FOREIGN VISITORS)



Appendix 3: Model Used to Estimate Preservation Value

The Richardson and Loomis meta-model (2009) is a semi-logarithmic model in which several variables linked to the study's design, the socio-economic context and the resource were used to estimate the logarithm of willingness to pay (WTP) per household and per year.

$$\ln(WTP) = \text{intercept} + \sum(\text{coefficient}_i)(\text{variable}_i) + e \quad (1)$$

where e represented the error term.

The following formula was used to estimate willingness:

$$WTP = \exp(\text{intercept} + \sum(\text{coefficient}_i)(\text{variable}_i) + \sigma_e^2/2) \quad (2)$$

where σ_e^2 represented the error term variance.

To estimate the polar bears' preservation value using this model, two key steps must be followed:

- 1) Assign values to all the explanatory variables:

In general, methodological variables (those that characterize the methodology used in baseline studies) are assigned the metadata's average value, except where there are specific reasons for using specific values. However, variables that characterize the resource or the socio-economic context are generally assigned values that are specific to the target site and its socio-economic context;

- 2) Apply the formula (2) to estimate WTP using the meta-model's estimated coefficients, the values chosen for the explanatory variables and the estimated error term variance.

Appendix 4: Use of the Richardson and Loomis Meta-model (2009) to Estimate the Preservation Value of Canada's Polar Bears

	Model Coefficients (A)	Value of Variables (B)	C = A * B
Intercept	-153.231	1	-153.231
In CHANGESIZE	0.870	4.605	4.006
VISITOR	1.256	0	0.000
FISH	1.020	0	0.000
MARINE	0.772	1	0.772
BIRD	0.826	0	0.000
In RESPONSERATE	-0.603	3.894	-2.348
CONJOINT	2.767	0	0.000
CHARISMATIC	1.024	1	1.024
MAIL	-0.903	0.851	-0.768
STUDY YEAR	0.078	2006	156.468

Total column C (D) = 5.9230

Error term variance σ_e^2 (E) = 0.2694

Willingness to pay (WTP) per household and per year (2006 US\$) = 427

(F = $e^{D+E/2}$) =

Exchange rate \$/US\$ (2006 average) (G)⁷⁷ = 1.1341

WTP per household and per year (2006\$) (H = F*G) = 485

Consumer price index in 2009 compared to 2006 (I)⁷⁸ = 114.4/109.1

WTP per household per year (2009\$) (J = H*I) = 508

Number of households in Canada (K)⁷⁹ = 12,437,470

WTP in Canada per year (2009\$) (N = J*K) \$ **6,320,965,092**

⁷⁷ Bank of Canada website, 2008: <<http://www.bankofcanada.ca/en/rates/exchange-avg.html>>.

⁷⁸ Statistics Canada 2010. Consumer price index, historical summary: <http://www40.statcan.gc.ca/l01/cst01/econ46a-eng.htm>.

⁷⁹ Statistics Canada 2010, 2006 Census, 2006 Community Profiles: <<http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/prof/92-591/details/page.cfm?Lang=E&Geo1=PR&Code1=01&Geo2=PR&Code2=01&Data=Count&SearchText=canada&SearchType=Beings&SearchPR=01&B1=All&Custom=>>>.