University of Alberta

Caribou Consumption in Northern Canadian Communities

by

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Abstract

The health of caribou (*Rangifer tarandus*) is impacted by multiple risk factors, which may affect availability of caribou for consumption. From analysis of secondary dietary intake data, consuming caribou was found to be positively related to measures of diet quality—caloric intake and dietary diversity score. Other country foods, beef, or pork may be substituted for caribou with increases in opportunity cost and out-of-pocket costs for obtaining caribou. Caribou consumption levels are predicted to vary across and within regions. Communities with older populations, lower employment rates and access to stores are likely to be impacted more by changes in the health of caribou. Analysis of federal survey data highlights the potential constraints on consumption of country meat and fish—increased household employment activity supports participation in harvesting, but leads to a decreased likelihood of consuming high levels of country meat and fish.

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Chapter 1 Introduction and Background

1.1 Introduction

Food security is the state where "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy lifestyle" (FAO 2013, "Food security statistics"). Food security at the household, community, and regional levels may be defined by five dimensions: i) "availability: sufficient food for all people at all times," ii) "accessibility: physical and economic access to food for all at all times," iii) "acceptability: culturally acceptable and appropriate food and distribution systems," iv) "adequacy: nutritional quality, safety, and sustainability of available sources and methods of food supply," and v) "action: ensuring the social and economic infrastructures are in place to enable action that will ensure the previous four elements of food security" (Growing Food Security Alberta 2013, "What is Food Security in Alberta?"). Each of these components of food security is reportedly threatened in northern Canada, where food sources are comprised of both store-bought foods and food from the land—harvested land and sea mammals, birds, fish, and wild plants.

The availability of and physical accessibility to store foods, and selection and quality of foods, are linked to transportation infrastructure, with many communities lacking year-round road access and having only seasonal waterway access. Economic accessibility to store foods is also of concern, with store foods having higher costs in northern communities than in southern points: according to the Revised Northern Food Basket, a basket of food for a family of four was, on average, $430 in Northwest Territories communities in 2009, $426 in Nunavut communities in 2010, $496 in an isolated Yukon community in 2009, $312 in Labrador communities in 2009, and $346 in Nunavik (Quebec) communities, while an equivalent basket was $254 in Edmonton and $239 in Yellowknife in 2009 (AANDC 2008). Individuals have reported that they cannot afford to purchase food from the store, according to studies conducted with focus groups and socio-cultural questionnaires conducted between 1993-2007 (Chan et al. 2006, Lambden et al. 2006).

In the 1990s, the presence of contaminants such as organochlorines, heavy metals and radionuclides in the food supply were of concern to human health because of the potential for exposure through consumption of country food, especially fish and mammalian organ meats and marine mammal fats (Kinloch, Kuhnlein, and Muir 1992, Van Oostdam et al. 2005). Impacts from a changing climate may be threatening the country food supply, as factors such as northward migration of species, altered ecosystem relationships due to the entrance of invading species, and introduction of new animal-transmitted diseases may lead to threatened availability, accessibility and quality of country food resources (Furgal and Prowse 2008).

Four subspecies of caribou (*Rangifer tarandus*), a member of the Cervidae family, are found in Canada: barren-ground caribou (*R.t. groenlandicus*), woodland caribou (*R.t. caribou*), Peary caribou (*R.t. pearyi*), and Grant's caribou (*R.t. granti*) (Banfield 1961, COSEWIC 2011). Populations of barren-ground, woodland, and peary caribou in the northern territories and Canadian provinces are considered endangered, threatened, or of special concern (Species at Risk Public Registry 2010a, b, c, d, e, f, g, h, i, j). Barren-ground caribou herds are migratory and the methods of delineating a herd may vary and have evolved over time, though the most widely accepted concept is that a herd is defined by shared calving grounds (Fisher, Roy, and Hiltz 2009). Woodland, barren-ground, and Peary caribou ranges are shown in Figure 1-1.

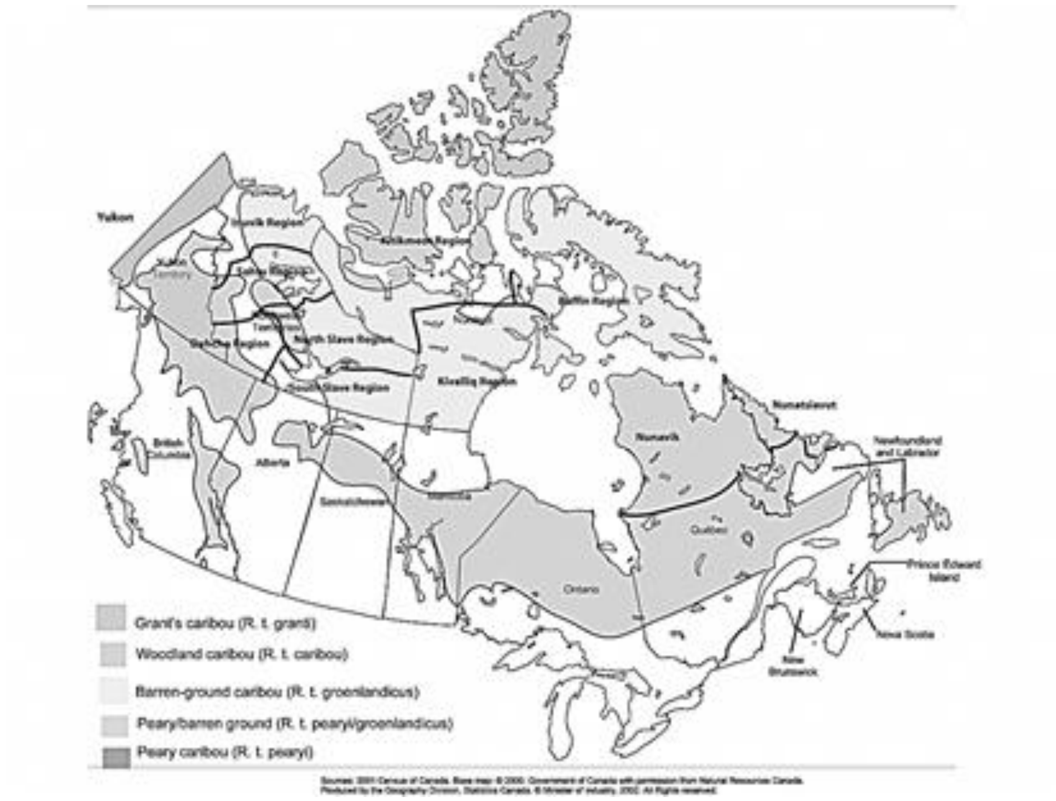

Figure 1-1 Map of Caribou Subspecies Ranges, Territorial Administrative Regions, and Inuit Regions of Canada.[1]

In recent studies, caribou has been shown to be the most frequently consumed food in many communities of the Northwest Territories and Nunavut, while moose is the most frequently consumed food in a few communities in the Northwest Territories and in Yukon Territory (Van Oostdam et al. 2005; Wein and Freeman 1995; Sharma et al. 2010). From archaeological and paleontological evidence, it has been identified that caribou has been a source of food, shelter and clothing for humans for tens of thousands of years (Burch 1972). Involvement in hunting and sharing of caribou harvests fosters kinship and ties to the community, promotes physical activity, and provides a sense of cultural identity (Condon, Collings, and Wenzel 1995, Kuhnlein, Soueida, and Receveur 1996).

Changes in caribou health and migration patterns may affect availability of caribou for household consumption and hence, the overall food security status of

[1] Notes: Administrative regions regions of the Northwest Territories include the Inuvik, Sahtu, Dehcho, North Slave, and South Slave regions, and administrative regions of Nunavut include the

households and communities. A household's ability to obtain meat in the event of scarcity of caribou, or to obtain substitute store foods or other country foods, may be influenced by community economic conditions and individual resources such as access to employment or income. The aim of this research is to explore the impacts of individual- and community-level socio-economic characteristics on country and store food consumption in order to understand which characteristics may influence consumption of caribou and how individuals may respond to changes in availability of caribou.

To understand the economic nature of the food security issues faced by households and provide a context with which to understand households' use of caribou, the physical characteristics, demography, and economic conditions of the North and the nature of the food economy are explained in the next two sections.

1.2 Northern Canada – Land, people and economy

Northern Canada is described under Government of Canada's Northern Contaminants Program as the area of Canada north of the 60^{o} latitude. Politically, the North is often recognized as the territories of Yukon, Northwest Territories (NWT), Nunavut, the Inuit regions of Nunavik in Quebec and Nunatsiavut in Labrador (Furgal et al. 2003). The geographic expanse of these areas is about forty percent of Canada's land mass. The terms "Arctic" and "circumpolar" have been used to describe the region, although "circumpolar" also refers to the regions of Antarctica. The Arctic Monitoring and Assessment Program (AMAP) has delineated the Arctic region as the area north of the treeline (with forest that contains at least 25% crown closure and is at least 5 meters tall at maturity), the 10^{o} July isotherm, and the limit of permafrost (Arctic Monitoring and Assessment Programme (AMAP) 2003). Permafrost is defined as "rock or soil that remains below 0^{o}" (GNWT 2011e, "Permafrost"). The North has also been defined as the area covering the Arctic biome, which occurs in the three territories and the northern parts of Manitoba, Ontario, and Quebec, and the sub-Arctic biome, which occurs in the NWT and the Yukon as well as the northern parts of seven provinces (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Newfoundland and Labrador) (Bone 2009). Furgal et al.'s (2003) definition is adopted for this study. The five regions mentioned covers 106 communities (Statistics Canada 2007d, f, g, h, m)[2].

In 2006, there were 68 thousand persons of Aboriginal identity in the three northern territories, Nunavik (in northern Quebec) and Nunatsiavut (in Labrador) (Statistics Canada 2007b, e, f, g, i, n). Inuit communities in Canada are shown in Figure 1-2.

In the northern territories—Yukon, NWT and Nunavut—about half the population was of Aboriginal identity. The Canadian constitution recognizes Aboriginal peoples as Indians (or First Nations), Métis, and Inuit, where Indians include the Dene (which includes groups that speak Athapaskan languages) in the Northwest Territories and the 14 Yukon First Nations of the Yukon (Van Oostdam et al. 2005, AANDC 2013a).

[2] Although 127 census subdivisions (CSDs) are delineated in the 2006 census (Statistics Canada 2009c), CSDs that are present in the database but have a reported zero population are dropped and not included in the present empirical analysis.

Figure 1-2 Map of Inuit communities

Reference: AANDC 2010b.

Governance structure across the region is diverse; a combination of Aboriginal, regional, territorial/provincial and federal governments control land and resources. Various Dene First Nations groups in the western Northwest Territories ceded control of some of their lands to the government under Treaty 8 (1899) and Treaty 11 (1921), the Inuit in the western Arctic signed the Inuvialuit Final Agreement (IFA) in 1984, the Inuit of the central and eastern Arctic signed the Nunavut Land Settlement in 1995, the Inuit in Labrador signed the Labrador Inuit Land Claims Agreement in 2005, and the Inuit in Quebec signed the Nunavik Inuit Land Claims Agreement in 2008 (AANDC 2011b). These land claims recognize Aboriginal land title, fishing and trapping rights, and financial compensation. For example, the IFA entitled the Inuvialuit the surface rights to 30% of land previously held by the Crown, exclusive harvesting rights for some wildlife species and preferential harvesting rights for others, co-management of wildlife, fisheries, and the environment, and set up the framework for Inuvialuit-controlled economic development institutions. Various groups including the Gwich'in, the Sahtu Dene/Métis, and the Tlicho (Dogrib), and the Yukon First Nations, have also signed self-government agreements, many of which involve the establishment of regional corporations responsible for economic development and the management and settlement of financial claims. Claims with the Akaticho, Dehcho, and Northwest Territory Metis Nation are unsettled and ongoing (AANDC 2011b). The map of Land Claims and Self-Government Areas across Canada is shown in Figure 1-3.

Figure 1-3 Land Claims and Self-Government Areas

Reference: AANDC 2013

Aside from diversity in governance regimes and economic profiles across the regions, there are socio-economic and demographic differences. In the three northern territories, the Yukon has a lower proportion of adults who did not graduate from high school than the national average, while the Northwest Territories and Nunavut have higher proportions (Statistics Canada 2007a, d, h, m). Foreign individuals or migrants from southern Canada tend to live in distinct communities—the 'settlers' stay in industrial or economic centers including

Whitehorse, Yellowknife, and Iqaluit (Young 2008). The population of the entire region is youthful, with between 35 and 52 percent of the populations of the territories being under 25 (Statistics Canada 2007a, d, h, m). Based on current fertility rates, the population of each of the regions of Nunavut is projected to increase through the year 2036 (Nunavut Bureau of Statistics 2010).

In the last 50 years, the North has experienced a transition from a traditional land-based economy to an economy with wage employment, usually in projects for non-renewable natural resources. This economy has been called the “mixed” or “dual” economy (Stabler 1989, Usher 2002). After the Second World War, when the North became a site of military importance as a transportation link between Europe and the United States, new townsites were developed and the federal government encouraged settlement where health, education, and welfare services could be delivered (Young 2008). The construction of the Distant Early Warning (DEW) line, a system of radar stations throughout the North that was used by the Canadian and American governments to detect Cold War threats, brought wage employment opportunities in the 1960s (Usher 2002, Young 2008). Aboriginal peoples moved from seasonal villages and camps for hunting, fishing, and trapping to established communities (Collings, Wenzel, and Condon 1998). Technological change brought new hunting technologies like guns and snow-mobiles, and the use of the dog-team for hunting also declined (Muller-Wille and Pelto 1971, Pavri 2005).

The North has a rich history in exploiting non-renewable resources, beginning with the famous Yukon gold rush in the 1800s. Extracted minerals include metallic minerals such as gold, silver, platinum, lead, copper, zinc, and nickel, non-metallic minerals such as clay, potash, salt, sulphur, and gypsum, structural materials such as gravel, clay, and lime (Bone 2009). More recently, the production of diamonds has comprised a large part of the mineral industry, with the first diamond mine opening in the Northwest Territories in 1998 (GNWT 2011a). As of late 2009, there were four active metal or diamond mines in the NWT (three diamond and one tungsten), one active gold mine in Nunavut, and one active copper and gold mine in the Yukon. Mineral production in the NWT in 2009, composed mainly of diamonds, generated $1500 million of income (NWT & Nunavut Chamber of Mines 2011c). Sand, gravel and stone are also produced in the NWT, but comprise a smaller component of mineral revenues. In the Yukon, metal ore mining accounted for between 15.9 and 28.6 (millions of chained dollars, adjusted for inflation) of GDP in the period 2005-2006 (Yukon Bureau of Statistics 2011). There was no revenue for mining production in Nunavut in 2009, although about $10 million in GDP was generated from exploration activities (NWT & Nunavut Chamber of Mines 2011a, b). The production value of minerals has declined in Nunavut in the period 1990-2009, but the value of mineral exploration has increased significantly (NWT & Nunavut Chamber of Mines 2011a, b). As of 2011, there were 20 exploration sites for metals and 9 exploration sites for diamonds in the NWT and 96 in Nunavut (Falck and Gochnauer 2012, Nunavut Geoscience 2011).

The other major component of the non-renewable resource sector is the exploitation of oil and gas resources. Oil exploration began in 1898, and the first major discovery occurred at Norman Wells on the shores of the Mackenzie River in 1920 (Bone and Mahnic 1984). The deposit supplied oil via the CANOL project pipeline from Whitehorse, YK, to Alaska to assist the U.S. war effort during World War II. Oil production at Norman Wells subsequently stalled until the 1980s, when operations were expanded and a pipeline was built from the Norman Wells oilfield to Zama, Alberta to supply southern markets. The oil price shock in the 1970s led to concerns over domestic oil supply and to heightened exploration activity. Significant onshore and offshore oil and gas discoveries were made in the Mackenzie Delta/Beaufort Sea, including the discovery of 55 trillion cubic feet of likely gas reserves (GNWT 2011c). The Berger Inquiry of 1977 recommended a ten-year moratorium on the construction of a gas pipeline from the Mackenzie region to southern markets in order to settle Aboriginal land claims and address environmental issues and social issues (GNWT 2011c). However, exploration in the Mackenzie Delta and Beaufort Sea continued in the 1980s, encouraged by tax incentives from the Trudeau government under the National

Energy Program (NEP). Mining, oil and gas extraction accounted for 33.8 percent of the GDP (millions of chained dollars) in the Northwest Territories in 2007 and 13.8 percent of the real GDP in Nunavut in 2010 (NWT Bureau of Statistics 2010, Nunavut Bureau of Statistics 2011). In the Yukon, oil and gas extraction accounted for $3.3 million (chained dollars [adjusted for inflation]) of the GDP and the mining and oil and gas extraction sector accounted for 8% of total GDP in 2009 (Yukon Bureau of Statistics 2011).

Industrial projects have had varying impacts on northern communities. Bone, Johnson, and Saku (1992) have categorized northern communities as "resource towns", "government towns", or "native settlements". Employment rates vary from 38.9 (in Tuktoyaktuk, NT) to 80.9 percent (in Norman Wells, NT), while median household income ranged from $28 224 (in Repulse Bay, NU) to $110 135 (in Yellowknife, NT) according to the 2006 census (Statistics Canada 2007c, j, k, l).

The latest large-scale non-renewable resource development projects, including the Mackenzie Valley Pipeline Project, present unique opportunities for northern populations and may contribute to the trend of varied growth and development. A panel evaluating the socio-economic impacts of the Mackenzie Valley Pipeline project suggested that development of the pipeline will result in economic benefits in the form of economic opportunities in the health, education, and government service sectors, as well as improved transport infrastructure (Northern Gas Project Secretariat 2010). The availability of employment opportunities may have varying effects on different socio-economic and demographic groups. For example, the Aboriginal population has not participated in mining activities to a high degree, though participation is growing (Natural Resources Canada 2009).

In summary, the North has physical, demographic, and socio-economic characteristics distinct from the southern regions of Canada. These factors may influence the multiple facets of food security. To understand the present research question, however, it is necessary to further characterize the northern food economy. Historical patterns and current trends are discussed in the next section.

1.3 Food Practices and Policies

1.3.1 Country food harvesting and consumption

For thousands of years, the diet of northern Aboriginal peoples consisted solely of traditional food, also known as 'country' or 'domestic' food (Kuhnlein and Receveur 1996, Myers et al. 2005). Traditional food includes wild animal and plant species, including land and sea mammals and fish, while the "traditional food system" is defined as "all food within a particular culture available from local natural resources and culturally accepted" (Kuhnlein and Receveur 1996, p. 418, Kuhnlein and Chan 2000). "Subsistence"[3] may refer to "the practices of producing such foods and related by-products for use within the household or for exchange with other households" (Myers et al. 2005, p. 24). This term is often used in Alaska to refer to harvested wildlife (Alaska Department of Fish and Game 2011).

Country food species use depends on varied ecological (seasonal and regional) availability and accessibility and cultural preferences (Myers, Powell, and Duhaime 2008, Duhaime et al. 2008). In the Inuvialuit region, people often travel to ice floe edges to hunt seal and polar bears and to set arctic fox traps, while whaling is mainly an open water activity (Usher 2002). Plant species are harvested to a lesser extent than animal species, although berries, including blackberries, blueberries, and cranberries, are harvested and consumed in some regions. Results from ten years of dietary studies in northern communities from 1989 to 1999 conducted under the Northern Contaminants Program show that the most commonly consumed species among the Inuit are caribou, ringed seal, Arctic char and other fish such as whitefish and lake trout, whale, bird species like geese and wildfowl, shell fish, and berries, while moose is the top species hunted in Northwest Territories Dene and Métis and Yukon First Nations communities (Van Oostdam et al. 2005).

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[3] An alternate definition of "subsistence" is "the total outlay or minimum quantity of goods needed to survive" (Deaton and Muellbauer 1980).

Archaeological, ethnographic, and harvest studies have indicated that animal sources have historically been a significant source of energy and protein (Fediuk et al. 2002). This trend has continued to the present day, as dietary surveys from 2008 show that country foods are the top contributor to total protein and iron intake among Inuit and Inuvialuit (Erber et al. 2010b, Hopping et al. 2010a). Often, all animal parts are consumed for nutritional purposes; for example, whale muktuk, whale blubber, and seal blubber have high amounts of monounsaturated and polyunsaturated fatty acids (Kuhnlein and Soueida 1992). Caribou flesh and fat are consumed, along with various parts and organs such as the head, liver, bone and marrow at certain times of the year (Kuhnlein et al. 1994, WMAC North Slope 2009). Country food is a source of important nutrients such as protein, vitamin A (found in marine and land mammal liver and fats), vitamin D, iron, zinc, potassium, phosphorus, selenium and omega-3 fatty acids (Duhaime et al. 2008). A diet consisting of country foods can protect against cardiovascular diseases, and n-3 fatty acids found in marine species can protect against cancer, diabetes, hyperinsulinemia, and birth defects (Duhaime et al. 2008).

Aside from nutritional benefits, the activities of harvesting—hunting and fish, preparing, distributing and eating and sharing country foods—contribute to the cultural, social, and spiritual well being of individuals and communities (Samson and Pretty 2006, Duhaime et al. 2008). Harvesting offers an opportunity for physical activity, for maintaining traditional knowledge and skills and passing them on to younger generations, and maintaining sharing networks (Condon, Collings, and Wenzel 1995).

Restrictions of harvests for certain wildlife species have been implemented with the aim of species conservation, since overharvesting has been linked with the decline of wildlife populations (Bergerud 1974). Harvest quotas have often been set by comparing reported harvests from respondent surveys to the sustainable yield of local wildlife populations, as in the case of muskrat management in the 1940s, walrus hunting restrictions in the 1950s, and the establishment of polar bear quotas in 1967 (Usher and Wenzel 1987). Government harvesting restrictions have not been viewed solely as a tool for wildlife conservation—it has been suggested that they were used primarily as a political means of controlling economic activities of Aboriginal peoples in the 1950s (Sandlos 2007). At the community level, hunters and trappers organizations or committees ('HTO's or 'HTC's) represent community interests and may advise higher-level wildlife managers on local matters and sub-allocate harvest quotas (AANDC 2010a, c, Nunavut Implementation Training Committee 2011).

The availability of country food is related to the status of wildlife populations, which are threatened by contaminants, habitat loss, and factors related to climate change. The physical accessibility of country food is determined by wildlife distribution, seasonal migration patterns and movements that may lead to variability in species and parts of animals used (Duhaime et al. 2008). Economic accessibility to country food is subject to economic factors including having income to purchase equipment like firearms and snowmobiles and amount of time available for harvesting (Condon, Collings, and Wenzel 1995, Duhaime et al. 2008)

Qualitative surveys have indicated that individuals feel the high costs or lack of equipment are barriers to obtaining country food (Condon, Collings, and Wenzel 1995, Chan et al. 2006, Todd 2010). Participation in formal employment has been reported to have varied effects on country food harvesting: households have reported being constrained by time spent in employment, though employed households may have more income with which to purchase costly harvesting equipment like snowmobiles, firearms, ammunition and fuel (Wenzel 1983, Kruse 1991, Condon, Collings, and Wenzel 1995, Todd 2010). The cost of equipment in specific regions has been documented (e.g. Usher 1972, Muller-Wille 1978, Smith and Wright 1989, Smith 1991, InterGroup Consultants Ltd. 2008). Hunter or harvester assistance programs are available in the Northwest Territories, Nunavut, Nunavik, and Labrador and provide funding to individuals for the purchase of fuel, supplies and capital equipment (Gombay 2005, Chan et al. 2006, GNWT 2011b, Aarluk Consulting Incorporated 2011, Nunavut Tunngavik Inc. 2011).

Intra-household factors are also reported to have significant influences on harvesting behavior at the household-level. Duhaime, Chabot, Gaudreault (2002) found that women's consumption of country meat is related not only to income but also to the presence of a male household-head—women in employed households with a male head consumed more country food than those in households without. Todd (2010) found that while some women spent time on the land harvesting, some worked in wage employment while partners harvested and some accompanied partners out on the land.

From the 2006 version of the Aboriginal Peoples Survey (which is used for further analysis in this thesis), it was found that 68% of Inuit adults (74% men and 62% women) 15 and over harvested country food (Tait 2008a). It was reported that 49% of Inuit children ate wild meat at least 3 days per week (Tait 2008b). Though country food is an important component of the diet, northern populations today consume both food from the land and food from the store. There have been declines in country food harvesting and consumption and these changes were first witnessed in the 1960s with settlement and increased availability of imported foods (Schaefer and Steckle 1980, Kuhnlein and Receveur 2007, Duhaime et al. 2008).

1.3.2 Market and store-bought foods

The availability of market or store-bought foods in northern Canada is subject to the availability of road or waterway access and weather conditions like blizzards, high winds, snow, and fog (Green and Green 1987). Only a small proportion of communities have access to road networks, and barge shipment is only available seasonally (Green and Green 1987, Duhaime, Chabot, and Gaudreault 2002).

The cost of store foods is subsidized under the Nutrition North Canada (NNC), a federal program that provides subsidies either directly to retailers, wholesalers, processors and distributors who have entered into agreements with NNC, or individuals or establishments (e.g. hotels, restaurants, schools, and daycares) who place personal orders with southern suppliers (Nutrition North Canada 2013). The new program replaces the Food Mail program, which subsidized the transport of nutritious perishable food and other items to isolated northern communities not accessible year-round by road, rail, or marine service from the late 1960s to March 2011 (AANDC 2012). Under Food Mail, Aboriginal Affairs and Northern Development Canada [formerly Indian and Northern Affairs Canada (INAC)] provided funding to Canada Post Corporation to offer shippers/businesses and individuals reduced postage rates on eligible perishable items, some non-perishable foods, and essential non-food items like clothing and cleaning supplies and personal care products (INAC 2002).

Community subsidy rates are determined by shipping costs and "estimated amounts of eligible products that will be shipped by air to eligible communities," with amounts being revised periodically (Nutrition North Canada 2012b, "Eligible Communities and Subsidy Rates"). Subsidy rates are also divided into Level 1 and Level 2 categories, where Level 1 (high) subsidy foods include "most nutritious, perishable foods" and Level 2 (low) subsidy foods include "other nutritious perishable foods, to non-perishable foods and to non-food items". Under the new program, certain high fat, sugar, and sodium or low nutrient foods were removed, while all non-food and most perishable food items were removed for communities with marine (sealift, ferry, or barge service).

Eighty-four communities (11 in Northern Manitoba, 6 in Northern Labrador, 1 in Southern Labrador, 5 in the Beaufort Delta region of the NWT, 1 in the Deh Cho region of the NWT, 5 in the Sahtu region of the NWT, 13 in the Qikqtaaluk, NU region, 5 in the Kitikmeot, NU, region, 7 in the Kivalliq, NU, region, 8 in Northern Ontario, 14 in Northern Quebec, 7 in the Quebec North Shore region [which are usually only eligible for the subsidy in months without marine service], and 1 in the Yukon) are eligible for higher level (full) subsidies and 19 communities (3 in Northern Manitoba, 3 in the Great Slave Lake region of the NWT, 7 in the Northern Ontario region, 3 in the Quebec North Shore region, and 3 in Saskatchewan) are eligible for lower level (partial) subsidies (Nutrition North Canada 2012b). Community full subsidy rates range between $0.20/kg and

$11.30/kg for Level 1 foods and $0.05/kg and $10.20/kg for Level 2 foods, and partial subsidy rates are $0.05/kg for both Level 1 and Level 2 foods[4]. Twelve nutritious food items at the high NNC subsidy level accounted for more than half of the subsidy (in dollars) (Nutrition North Canada 2012a). Country food shipped accounted for 0.004% of the subsidy applied. In 2008, the majority of shipments (58%) were received by Nunavut and about 7% of total Food Mail shipment volume was composed of personal orders (Dargo 2008). In 2011-2012, it was reported that Nunavut again received the largest proportion of the subsidy (56% of the subsidy), followed by the Nunavik region in Quebec (26% of the subsidy) (Nutrition North Canada 2012a). The NWT received 5% of the subsidy and the Yukon received 0.48%. In 2011-2012, 91% of the volume subsidies was allocated to stores, 4% to individual (personal) orders, 3% to commercial establishments including hotels and restaurants, and 2% to social institutions (Nutrition North Canada 2012a). INAC (2009) reported that average community median individual income and proportion of non-Aboriginal population were each positively associated with per capita shipment volumes in the community in 2007-2008.

Use of store foods has increased in recent years, and the increase has been attributed to increased availability and promotion of store foods through media and popular culture (Myers, Powell, and Duhaime 2004). Household-level economic factors have also been found to have effects on both "healthy" store foods and junk foods. Increased levels of property ownership (material style of life score), increased education, employment participation, and increased income have been found to be associated with higher consumption of fruits and vegetables in communities in the Northwest Territories and Nunavut (Lawn and Harvey 2001, Erber et al. 2010, Hopping et al. 2010).

From dietary surveys in Inuit communities in 2008, it was found that the most frequently consumed store-bought foods were coffee, tea, sugar, syrups, and bread (Erber et al. 2010, Hopping et al. 2010). Lawn and Harvey (2001) found that socio-economic status was not related to the quantities of foods of little nutritional

[4] See Appendix A for a summary of community infrastructure.

value consumed. The purchase of nutritious foods may not only be influenced by food prices and income levels, but also by factors such as tastes, food preparation skills and knowledge. Age has been found to be negatively correlated with increased intake of foods of low nutritional value (Hopping et al. 2010).

An increase in the consumption of store foods has led to concerns about nutritional adequacy of diets and potentially detrimental health effects of inadequate diets and the consumption of high levels of sugar, carbohydrates and saturated fats from store foods. The consumption of these foods has been linked to increased incidence of obesity, heart disease, cancer, and diabetes (Fediuk et al. 2002, Nielsen 2006, Deering et al. 2009, Sharma et al. 2010). On the other hand, it has been found that consumption of some types of store-bought food may have positive effects—perishable store foods have been found to contribute significantly to the diet in terms of calcium, vitamin A, and folacin intake (Lawn and Langner 1994, Fediuk et al. 2002).

1.3.3 Food Sharing

Food sharing is an integral part of Arctic food systems. Sharing is a "core cultural value," and the access and availability of traditional food is important for its continued practice (Myers et al. 2005, p. 24). The most common form of sharing takes place between relatives and friends, though sharing may take place between more socially distant individuals and may involve the exchange of objects or services for food products (Condon, Collings, and Wenzel 1995). Food sharing may also take place between members of different communities, when caribou or other wildlife may be closer to one community than another in a given year (Ford and Beaumier 2011). Even though harvesting has decreased with younger generations, food sharing remains an important practice (Chan et al. 2006, Condon, Collings, and Wenzel 1995, Ford and Beaumier 2011).

It has been demonstrated that income and access to harvesting equipment affect harvest levels and hence the levels of country foods consumed, but sharing enables redistribution or the consumption of country food even by those who do not hunt (Duhaime, Chabot, and Gaudreault 2002). According to Condon, Collings, and Wenzel (1995, p. 41), the household decision to distribute country meat depends on factors such as "1) the amount of meat that has already been harvested and distributed within the community, 2) the amount of meat and fish that the distributor has received from other households, 3) the number or relatives the distributor has, 4) the prospective future harvest of the distributor (i.e., whether he expects to go out and get more), and 5) the level of generosity of the hunter."

Harvesters or their relatives may deliver the meat or fish directly to another household, or neighbours and relatives may watch and help with the butchering of the animal. The remainder of the meat is stored in the house or the community freezer, and family members or friends may be invited to the house for meals (Condon, Collings, and Wenzel 1995). In the Nunavik region of Quebec in 2003, it was reported that nearly 88% of respondents in a country food survey reported getting country foods from the community freezer (Blanchet and Rochette 2008). In 2011, Government of Nunavut announced a commitment to spend $1.7 million to set up community freezers in Nunavut communities (Nunatsiaq News 2011). Todd (2010) reported that in Paulatuk, NT, the community freezer was closed because it was viewed as too costly to run and was replaced by community-provided freezers for individuals, while communities in Nunavut have also reported facing difficulties in maintaining community freezers (Northern News Services 2010). Community hunts where members gather to hunt and then share the meat also take place in many communities (Condon, Collings, and Wenzel 1995, Chan et al. 2006).

The practice of food sharing has been extended to market foods. In food security surveys conducted in 1997, about a third of families in Repulse Bay and half of families in Pond Inlet reported borrowing "basic food" items from family and friends when they ran out of money to buy food (Lawn and Harvey 2001). This type of sharing often takes place between low-income families and those relatively well-off, and it has been suggested that this results in financial strain on the more affluent (Lawn and Harvey 2001).

1.4 Economic Problem

The availability of caribou as a food source is currently threatened by a multitude of factors, including climate change and other environmental factors (Aanes et al. 2002, Post and Forchhammer 2008, Sharma, Couturier, and Cote 2009). Changing snow and ice conditions associated with climate change may restrict access to forage or calving grounds, resulting in calf mortality or low body weight (Nickels et al. 2005, WMAC North Slope 2009). Access to caribou may be influenced by these physical environmental changes. For example, thinner ice poses a risk for overland travel and hunters may have to travel further and in more dangerous conditions to access caribou (Nickels et al. 2005, Wesche and Chan 2010).

Although modern population estimates are available for about the past three decades, the studies may not reflect long-term population cycles that are hypothesized to exist for caribou populations. Studies based on historical records, Aboriginal knowledge of caribou abundance and other ecological methods such as dendroecology suggest that caribou populations fluctuate in a predictable pattern in a cycle of between 40 and 70 years, according to climactic conditions (Ferguson, Williamson, and Messier 1998, Gunn 2003, Morneau and Payette 2000, Nesbitt and Adamczewski 2009, Zalatan, Gunn, and Henry 2006). Despite these findings, the recent literature suggests that current population changes are a direct result of the effects of climate warming and increased temperatures, which have direct impacts on caribou body condition and population changes via changes in forage (e.g. Post and Forchhammer 2008, Sharma, Couturier, and Cote 2009), predator-prey relationships (Dale, Adams, and Bowyer 1994), and snow and ice conditions (Aanes et al. 2002).

Industrial development has also been shown to affect caribou usage of traditional foraging sites (Cameron et al. 2005, Nellemann and Cameron 1998). Community members in the Kitikmeot region have reported both positive and negative effects of climate warming, reporting that thinner ice and lower water levels have resulted in more lush vegetation on which caribou feed, but also that earlier melting has increased the incidence of caribou drowning (West Kitikmeot Slave Study 2001). Dogrib/T'licho elders noted that caribou have adapted to noise and developed areas but were concerned that the caribou would become exposed to contaminated tailings found on industrial sites (West Kitikmeot Slave Study 2001).

From the review of recent population studies, it has been found that many of the caribou populations harvested by northern households are declining[5]. Therefore, northern populations are at risk for food insecurity from restricted supply in the future. The availability of caribou for use as a source of food, shelter, and clothing depends on a dynamic host of factors, both ecological and anthropogenic. However, overall population sizes may not reflect actual consumption of caribou and other species across communities. Harvesting records and other food consumption surveys may illustrate the extent of household harvesting of caribou and other species and therefore how vulnerable households in different communities are to caribou population changes.

Infectious disease also poses a threat to caribou health and human users of caribou. Nematode parasites, toxoplasmosis, and brucellosis have been found in caribou meat; toxoplasmosis been found to be transmissible to humans (McDonald et al. 1990, Pitt and Jordan 1994, Kutz et al. 2001, Tessaro and Forbes 2004, Levesque et al. 2007). Chronic wasting disease (CWD), a degenerative brain disease, has been found in deer and elk in Canada and the United States, and poses a potential disease threat to caribou as suggested by genetic analysis (Happ et al. 2007; Sigurdson 2008). Preferences for caribou as a food source may be influenced by changes in caribou health. In the past, community members have reported being wary of taking meat from animals that appear unhealthy (e.g. have swollen joints or parasite infestations) (Nickels et al. 2005; WMAC North Slope

[5] Caribou population figures and trends are shown in a table in Appendix B.

2009).

Caribou populations may decline significantly in short periods—in a review of declines of twelve reindeer and caribou herds across the circumpolar North over a hundred years, it was found that of thirty one declines, twenty declines were limited to a one-year period (Tyler 2010). Little is known about how communities may respond to sudden changes in caribou populations given the present socio-economic conditions. The impacts of individual- and community-level socio-demographic factors on different types of country and store-bought foods have been examined in previous literature, although these studies do not provide indicators about how households may modify the relative levels of the entire set of foods consumed.

With economic theory, it is posited that individuals maximize their welfare "by trying to attain as much satisfaction or welfare possible given constraints such as their budget, their time, and their information" (Behrman and Oliver 2000, p. 366). The consumer is constrained by the costs of goods in the market and the resources for accessing food such as innate ability, education, wage income, time, or community characteristics. With respect to food, consumers will choose to maximize satisfaction at given levels of income, prices, knowledge of health and nutrition, and taste and preferences (Variyam, Blaylock, and Smallwood 1998).

Within and across communities, there may be significant differences in individual or household access to different food sources. Households where one or more members are involved in employment, whether in or outside the community, may have higher levels of disposable income to spend on food and may choose to develop unique sources of supply of food for their households. This could involve increasing (decreasing) the use of stores within communities and decreasing (increasing) harvesting of caribou and other animals, changing use of personal subsidized food orders, or accessing shared food resources. Within communities where some but not all households have higher incomes due to wage employment, decisions made by employed groups could affect food availability and accessibility for other households within the community, by changing the volumes and types of products required through the local stores. Communities without access to wage employment may have very different food purchasing patterns from communities where a higher proportion of the adults are employed.

Past authors have shown, with either qualitative methods or descriptive statistics, that participation in employment has varied net effects on the time spent harvesting country food (VanStone 1960, Hobart 1981, Wenzel 1983, Kleinfeld, Kruse, and Travis 1983, Wolfe and Walker 1987, Stabler 1990, Kruse 1991, Condon, Collings, and Wenzel 1995, Kerkvliet and Nebesky 1997, Berman 1998, Chabot 2003, Berman and Kofinas 2004, Todd 2010). Employment status, individual income, and community price levels have been found to have statistically significant relationships with consumption of nutrient-dense foods such as fruits and vegetables (Erber et al. 2010, Hopping et al. 2010, Lawn and Harvey 2001). From these studies, however, it is unclear how households may change their relative consumption of country food and store-bought food with an instantaneous change in caribou population.

Duhaime et al. (2004) have used a risk determination process to show the potential impacts of a policy to reduce exposure to pollutants (by changing consumption of marine country food) on household income and total food expenditures. They found that without government subsidies, the increase in store-food purchases and decreased labor income from reduced economic activity in the market for harvesting equipment led to a net decrease of $200 to $256 (1995 dollars) of household income. This analysis does not cover the scenario where consumption of caribou and other country species is changed.

Analysing an economic demand model for different types of foods will provide suggestion about which individual- or community-characteristics most strongly influence demand. From this analysis, elasticities may be computed to show whether consumption of a food will increase or decrease, given changes in prices (or income). Elasticity measures would be important should the need to develop substitutes for caribou arise, since they would also show which foods would currently be acceptable as substitutes by individuals.

Caribou has been shown in numerous studies to be a high contributor of energy (calories), protein, and nutrients such as iron (Van Oostdam et al. 2005, Sharma et al. 2009, Sharma et al. 2010). A change in consumption of caribou or other country foods may influence overall diet quality and household food security status. Specifically, a reduction in consumption of nutrient-dense country foods such as caribou may lead to an increased risk of consuming a nutritionally inadequate diet, if households do not consume other nutrient-dense foods as replacements.

Gaps in understanding with respect to two aspects of the literature may be identified. Firstly, no known study has linked caribou consumption on composite measures of diet quality such as dietary diversity. Huet, Rosol, and Egeland (2012) have implemented the Healthy Eating Index measure on diets in Inuit communities, but do not relate the HEI score to caribou intake. Secondly, it is unclear whether or not replacing caribou with other foods will decrease diet quality, given households' consumption choices and socio-economic characteristics. Pakseresht et al. (2012a, b) calculated food expenditures for six food groups and nutrient-to-price ratios, and found that shifting expenditures from non-nutrient dense foods to country foods would result in no change in calorie consumption, reduced intake of sugar and increases in the intake of specific nutrients. This study, however, does not provide an indication of how increased food expenditure and changing socio-economic characteristics may influence food security status at the household-level. An aim of this study is to understand how consuming caribou may contribute to food security status when other factors that reflect availability and accessibility to other types of food (such as total income or community infrastructure) are accounted for.

1.5 Research objectives

Data on consumption and use of caribou, other country foods, and store-bought foods from dietary recall from four northern communities (Sharma et al. 2009, 2010) and data on harvest participation and country food consumption from the Aboriginal Peoples Survey (Statistics Canada 2003a, b, 2006, 2008b, 2009a, b) are used. A traditional economic framework, where it is posited that individuals and households maximize household utility or satisfaction, is used as a basis on which to i) assign economic values to consumed country foods, and ii) predict changes in either incidence of harvest participation or quantities of store and country foods consumed, according to individual factors such as age, gender, and employment status, and community-level factors such as physical accessibility to stores and community employment rate. The nutritional quality and adequacy of diets is also assessed and their relationship to caribou use and individual- and community-level factors explored. The results from individual- and community-level analysis are used to derive quantitative estimates of caribou consumption across all northern communities to obtain an additional measure of vulnerability to changes in caribou populations.

The primary research objectives are as follows:

1. To determine the economic factors influencing the consumption of caribou in four Aboriginal communities in the Northwest Territories and Nunavut. More specifically, the aim is to determine how opportunity and out-of-pocket input costs of harvesting (e.g. fuel and equipment costs) of caribou and other country foods, individual employment status and community employment rate, and access to food retail locations influence the quantities, types, and sources (harvested or store-bought) of food purchased or harvested and consumed;
2. To determine the socio-economic variables that most influence individual and household harvesting decisions and proportion of country meat and fish consumed (out of total meat and fish consumed) in four regions of northern Canada using the Aboriginal Peoples Survey;

3. To identify the importance of barren-ground caribou in household diets in four northern Aboriginal communities, in terms of dietary quality and food security, in order to understand more about the vulnerabilities of communities to the changing availability and health of this species[6];
4. To develop a model that provides an estimate of the variation in the intake of caribou meat in 106 communities of northern Canada, in order to assess how any shock to the health or availability of caribou might influence relative food security.

The dietary intake of food items by individual households from the dietary data from Sharma et al. (2009, 2010) will be analyzed as cross sectional data, and individual intake of various foods, expressed as expenditures or expenditure shares, will be modeled econometrically as a function of individual- and community-level socio-demographic characteristics. Opportunity costs and out-of-pocket equipment costs of harvesting are used as two types of proxies for the availability of caribou in an econometric demand model. Total calorie intake and dietary diversity, which are measures of diet quality and which have been used as household food security status indicators, will also be developed from the recall data and modeled econometrically as a function of socio-demographic characteristics, and also whether or not a household has consumed caribou.

While consumption expenditure analysis on data from four northern communities may provide a picture of the impacts of employment and other socio-economic characteristics on consumption of caribou and other country foods, detailed survey data from the post-census Aboriginal Peoples Survey 2001 and 2006 (Statistics Canada 2003a, b, 2006, 2008b, 2009a, b) on country food consumption and harvesting and wage employment characteristics—including type of employment (full-time, part-time)—as well as household demographic

[6] While the data available for this thesis is from Inuit regions, where barren-ground caribou is found to be the most abundant, use of woodland and peary caribou are also considered. Consumption of moose, another member of the cervid family, is also identified from the secondary dietary data.

characteristics, are used to further characterize how the household trades time on the land for time in employment.

Analysis of the aforementioned data sets and further examination of the role of socio-economic factors on caribou consumption can allow for the development of caribou dependence indicators for all communities across the North. This determination of caribou dependence can be characterized by a range of economic factors and by historical measures of caribou harvest levels and caribou herd population and accessibility. The potential role of caribou in the diets of households in various communities can be sensitized and examined using Monte Carlo simulation. This analysis can provide the basis of developing a risk management strategy for food security in communities highly dependent on caribou in the face of the instantaneous effects of climate, environmental or disease threats to the population.

The economic models analysed with the dietary data and Aboriginal Peoples Survey sets, and the dependent and explanatory variables examined in each model, are summarized in the following two figures:

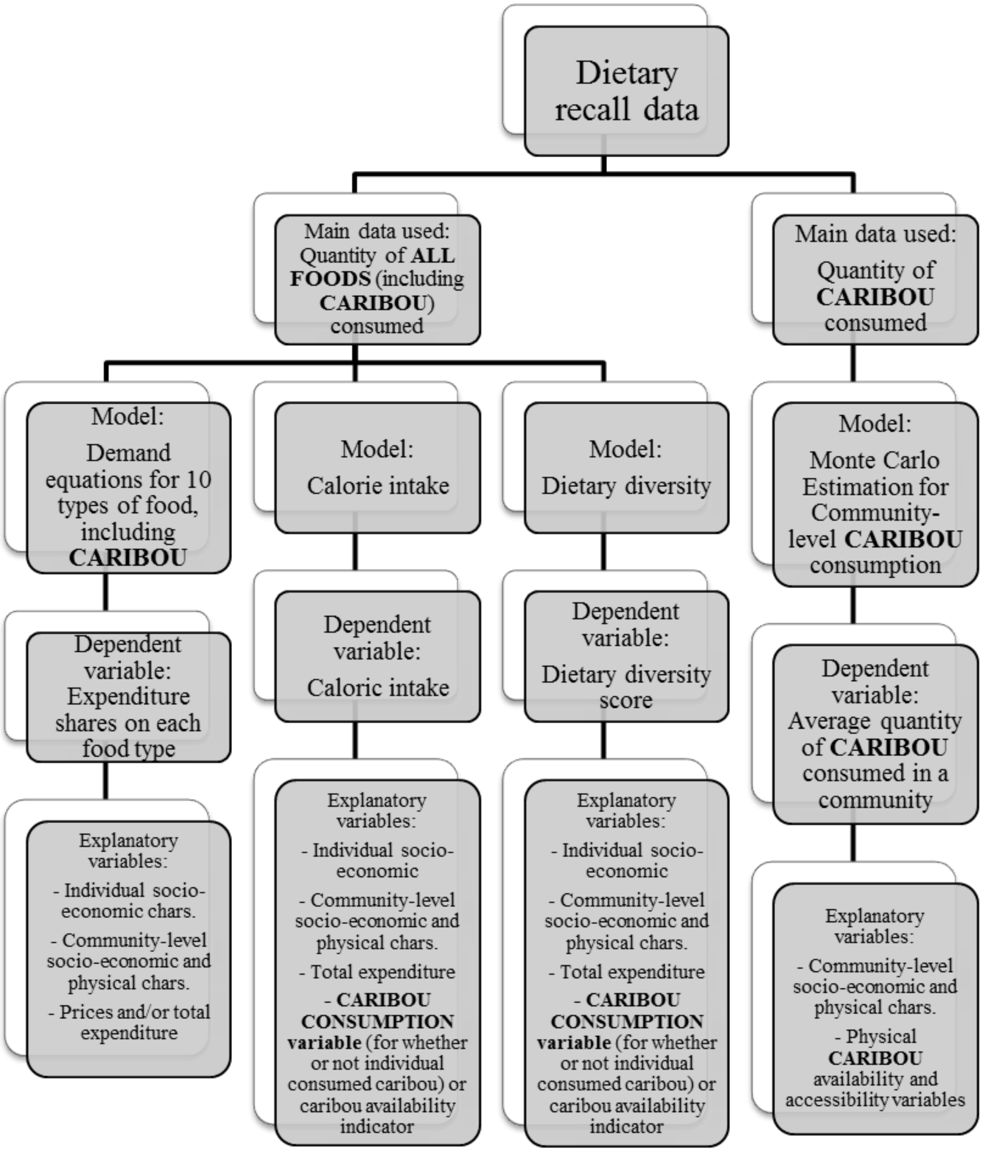

Figure 1-4 Flowchart of dietary data analyses

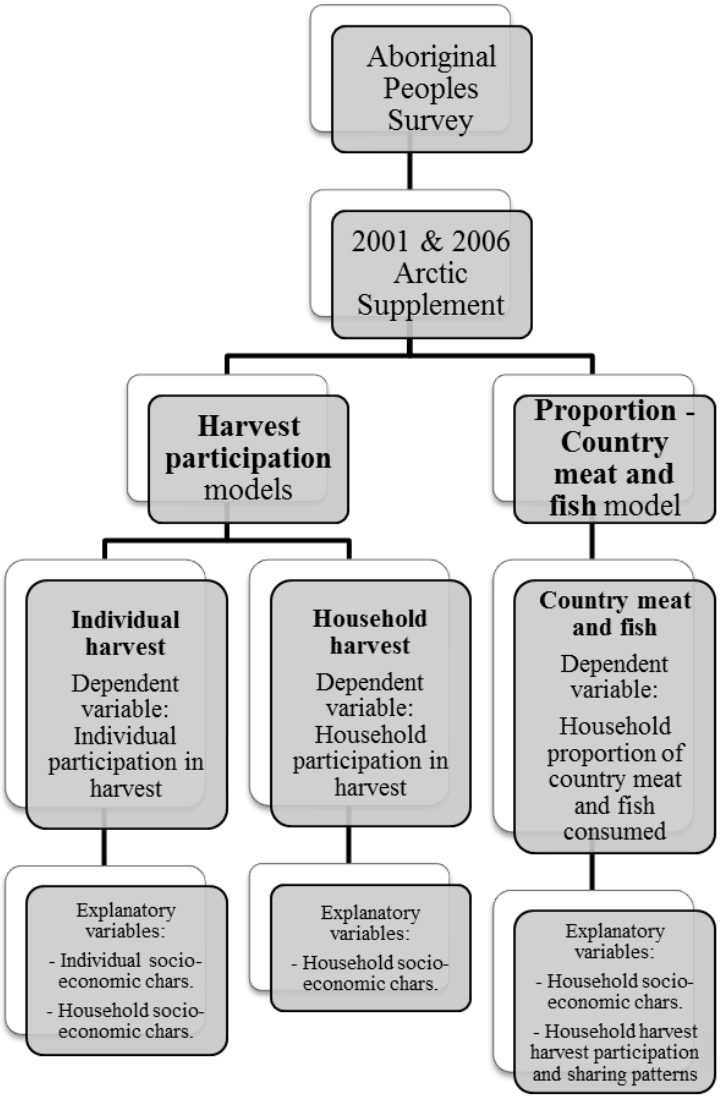

Figure 1-5 Flowchart of Aboriginal Peoples Survey analyses

1.6 Thesis structure

This thesis will be structured in the following manner. Chapter 2 contains a literature review that covers results from pertinent harvest and food consumption studies to provide an understanding of the current usage patterns of caribou, other country foods, and store foods. The results of caribou population studies, which provide information on the current status of caribou species, are also described. Economic theories that explain household behaviour and provide a foundation upon which the analytical methods are developed are also explained. In Chapter 3, the analytical framework and the methods used to address each of the research objectives are described. Results from three distinct analyses (of dietary data, the Aboriginal Peoples Survey, and Monte Carlo simulation) are found respectively in Chapters 4, 5, and 6. Finally, a summary and conclusion are provided in Chapter 7 with reference to policy implications.

Chapter 2 Literature Review

2.1 Introduction

The aims of this research are to examine individual- and community-level food consumption, harvesting behaviour, and food security status in order to assess how households may adapt to changes in wildlife. Changes in the health and population status of historically important country-food species such as caribou may have significant implications for food security in the future.

This chapter will provide background on the conceptual framework for food security and describe tools that may be used for food security analysis, including tools for assessing dietary quality and adequacy. Examples from literature on the North are discussed to provide baseline indicators of harvest and consumption patterns that the present analytical results may be compared to.

Since this study is focused on economic factors such as time use, employment and income on the ability of households to achieve food secure status, economic theory as it relates to household food choices, harvesting, and dietary outcomes are discussed. Understanding economic decisions related to country food consumption involves understanding how goods that are not traditionally sold in the market, such as harvested wildlife, may be valued in economic terms. The theoretical bases and empirical methods for estimating country food prices are discussed.

The chapter concludes with a summary of how the concepts from the literature will be applied to the research objective; the empirical methods and sources of data that will be used will also be identified.

2.2 Food security definitions and methods of measurement

The term "food security" has been described as an issue of concern for northern Canadian populations (Chan et al. 2006; Power 2008; Duhaime 2008). "Food security" is a term that emerged from international discussion of the global food crisis in the 1970s. Food security may be examined as a set of 'dimensions or 'core determinants. The four components listed in Chapter 1 were: i) Availability, ii) Accessibility, iii) Acceptability, iv) Adequacy, v) Action (Growing Food Security Alberta 2013).

A food security indicator is a "summary measure of one or more of the dimensions of food security to demonstrate change or the result of a program activity of a target population" (Riely et al. 1999, p. 36). Chung et al. (1997, p. 10) state: "there is no one indicator that encompasses all dimensions of availability, access, utilization. However, from a practical perspective, a multifaceted food security indicator may not be what is needed." Data for food security indicators may be gathered at the individual, household, community, market, or regional levels. Hoddinott (1999) states that there are 450 indicators of food security, with most of them being indicators for household-level food security.

Existing studies on households and communities in northern Canada have covered each of the dimensions of food security. The next few sections provide an overview of indicators that have been used to collect data and analyse food security in northern Canada, with attention to consumption and harvesting patterns of caribou, other country foods, and store-bought foods.

2.3 Harvest studies

Harvest data are gathered by a variety of sources and for different purposes. In most harvest study surveys, individuals or households are usually asked to report the numbers and general locations of animals, fish, birds, they harvested in the past month (Usher and Wenzel 1987). Harvest studies may be gathered for administrative and monitoring records or for special-purpose by wildlife agencies, government, academic organizations, and Aboriginal land claim organizations. Historical harvest statistics have also been used by biological researchers to determine the abundance of species and as part of socio-economic impact assessments and land claim settlements.

Sources of data accessed for harvest information may include commercial sales data for furs, fur export tax returns, General Hunting License (GHL) tags issued and returned for big game and small game, direct observations of landings and strikings or recall interviews for large marine mammals, fish sales statistics, hunting and fishing license holder reports, questionnaires administered to sport fishing permit holders, game officers' annual reports, and quotas (Usher and Wenzel 1987). The Northwest Territories Act of 1929 also required Aboriginal hunters to report annual numbers of animals they have taken. In recent years, the governments of the Northwest Territories and Yukon have also collected hunter harvest data from non-Aboriginal hunting license holders to monitor harvest levels, composition of the harvest and areas of wildlife use (Carrière 2012, Yukon Environment 2012b).

Usher and Wenzel (1987) note a few pitfalls in using administrative and monitoring records. For records that rely on recall, there may be respondent bias or possibility of misreporting. Statistical sets may not allow for cross comparison if they are designed differently; some may not distinguish between species or may categorize species differently. The design problem may also be present in permit-based reporting systems—data may not be reported in a uniform manner.

The biases that may arise from harvest survey estimates must be noted. Harvest surveys typically rely on respondent recall for harvest estimates; there may be a possibility of misreporting (Usher and Wenzel 1987). The recent harvest studies conducted under land claim agreements, including the Inuvialuit and Nunavut studies as well as the Gwich'in Harvest Study and the Sahtu Harvest Study, are designed to cover all male harvesters or hunters of the relevant Aboriginal groups over 16 years of age, though incomplete land claim enrollment records and other difficulties in defining target respondents posed problems for survey coverage. The Inuvialuit Harvest Study and the Nunavut Harvest Study reports indicate that under-enumeration and over-numeration of harvesters occurred in some communities, since harvester eligibility criteria were not consistently applied, and that there may be a downward bias in the estimates for certain communities (The

Joint Secretariat 2003, Priest and Usher 2004). Non-response errors have been reported to arise in these surveys from declined interviews, incomplete coverage by field workers who are not able to contact respondents, survey avoidance by those who do not have harvests for a period and then drop out of the survey (The Joint Secretariat 2003, Priest and Usher 2004). However, survey response rates may be high enough to minimize the effects of this type of bias in the reported values (The Joint Secretariat 2003). In the Nunavut study, comparison of the response rates suggest that there is no noticeable decline in hunter participation over time in twenty-four out of the twenty-seven communities, so that hunter fatigue is not a significant issue (Priest and Usher 2004).

It has also been hypothesized that the length of the recall period, or the period between the time of the harvest and the time of reporting, may result in recall failure, since the Inuvialuit study allowed recalls of up to a year and the Nunavut survey allowed recalls more than six months old. This problem was mitigated somewhat by the use of harvest calendars in both studies, though Priest and Usher (2004) acknowledge that especially long 'backfill' periods may have resulted in under-estimates in nine Nunavut communities.

Harvest data that involve counts of animals harvested do not provide an exact measure of food available for consumption. Not all harvest statistics are used to measure food availability because not all animals harvested are retrieved and used, and not all animals counted in harvest studies are food sources (Usher and Wenzel 1987). Myers et al. (2005, p. 27) state "there is no direct way to convert harvest values into actual human food intakes, as the fraction of harvest that becomes table food varies by area, by season, and by the proportion of desirable foods in the mix." Harvested volumes reported in harvest surveys may be converted to potential amount consumed by the household, using "standard edible weight" measures, described in the next section (Usher 2000).

2.3.1 Edible weights

From the harvest records it is possible to determine the quantities of caribou consumed relative to other country food species. Comparing counts of different species may not be illustrative of the amount available for human consumption because of the varied size of animals. Counts of animals harvested may be converted to potential weight available as food via standard edible weight values for specific animals. Edible weight values for any species are derived empirically by "collection of an appropriate sample of animals," while "each animal should be butchered according to local method to segregate edible and inedible portions" (Usher 2000, p. 3). Alternatively, whole body weight or carcass weights (the weight of the animal with head, organs, or legs removed) may be multiplied by conversion factors based on other animals of the same or analogous species (Usher 2000). The definition of edible weight may vary due to cultural and local variation in the butchering of wildlife and what is considered edible (Ashley 2002).

The conditions under which data are collected must be considered, as whole body weights of a species may vary by year, season, lifecycle stage, age, sex and geographic location or due to specific conditions such as fat content at the time of year of the measurement, the time of day the measurements are taken (particularly in the case of birds), or amount of material in the digestive tract (Usher 2000, Ashley 2002). The relationship between the body weight and edible weight is not straightforward—season and life-cycle stage may affect what parts of the animals are edible, so that the conversion factor from live to edible weight may also vary across season (Usher 2000).

Components considered when measuring edible weight are meat, bones, fat, organ and viscera and skin. Berkes et al. (1994) calculate protein equivalents instead of edible weight. The problem with using protein equivalents is that the values of other important nutrients are not accounted for. When applying estimated weights to the harvest data, the sex and age preferences of the harvest should also be considered—applying average weights to an aggregate count of the species may not generate values that reflect these differences (Ashley 2002).

For the Inuvialuit Settlement Region, Usher (2000) provides the most recent estimation of edible weights based on raw total body mass and carcass weights from a variety of literature. Usher (2000) calculates 'adopted value', which is an average edible weight value based on the age and sex of animals identified in the actual harvest data. Where edible weight estimates are not available from the same sample as the total body mass estimate, Usher uses a conversion factor from published literature. Usher's edible weight values are calculated by adding the weights of parts that are traditionally eaten by the Inuvialuit. Therefore, edible weight calculations may be specific to different regions or groups. Lu (1972), Gamble (1984), and Pattimore (1985) (as cited in Ashley 2002) have also published edible weights for regions in Nunavut.

Harvest data has been useful for researchers and policy makers to determine the importance of wildlife, particularly in communities that have high levels of country food production and consumption. Using harvest data to determine the amount of country food consumed by a household requires a measure of standard edible weight. On the contrary, dietary records, which are described in a following section, provide direct estimates of harvested food consumed.

2.3.2 Results from harvest studies

2.3.2.1 Edible weights of caribou harvests

From published reports and literature, the harvest levels of different country food species may be examined to determine the relative potential use of caribou and other species in northern Canada. Alton Mackey and Orr (1987) provide edible weight calculations of harvest data from Makkovik in Labrador in 1980-1981. In Makkovik, caribou comprised 38.6% (10960kg/28397kg) of the weight in harvest, greater than that for any other species reported. Land mammals, which included caribou, arctic hare, black bear, beaver, porcupine and lynx, were harvested in the highest proportion in terms of edible weight, comprising a combined 38.8% of the harvest, while fish comprised 30.1%, seals comprised 11.1%, shellfish comprised 0.2%, and birds comprised 18.8% (Alton Mackey and Orr 1987).

A number of harvest surveys have been conducted recently in the study area of interest for this thesis under Aboriginal land claim agreements: the Inuvialuit Harvest Study, the Nunavut Wildlife Harvest Study, the Gwich'in Harvest Study, and the Sahtu Harvest Study. The surveys were carried out with the aim to guide wildlife management decisions and determine whether or not demands of traditional harvesters may be met under management and conservation strategies (McLean 1998, The Joint Secretariat 2003, Priest and Usher 2004, McDonald 2009).

The harvest data is presently examined to determine potential relative use of species across northern communities. Results from the Inuvialuit Harvest Study, the Nunavut Wildlife Harvest Study, and the Gwich'in Harvest Study are compiled and shown[7]. For each species, numbers of animals harvested as shown in data reports are converted to edible weight figures. Averages of edible weights from northern Canada, as found in published literature and compiled by Ashley (2002), are used for calculations. For species not reported in Ashley (2002), average of edible weights from the Inuvialuit Settlement Region, as compiled by Usher (2000), are used.

[7] The edible weight values of harvests of caribou and other country species from the Sahtu Harvest Study have been calculated by McMillan (2012), and are not repeated in this review.

Table 2-1 Estimated weight of wildlife available for consumption in the Inuvialuit Settlement Region (1988-1997)

		% of total country food/community by edible weight					
	Total edible weight (kg)/capita (2006)	Sea mammals[1]	Fish[2]	Large mammals (including caribou)[3]	Caribou	Small mammals and furbearers[4]	Birds[5]
Aklavik	111.63	10%	36%	47%	44%	5%	1%
Holman	315.59	18%	50%	27%	30%	1%	5%
Sachs Harbour	369.06	10%	23%	58%	5%	1%	7%
Inuvik	23.51	23%	32%	35%	32%	8%	2%
Paulatuk	157.29	15%	17%	57%	50%	2%	9%
Tuktoyaktuk	119.36	16%	35%	42%	40%	1%	6%

[1]Seal (various species), Whale
[2]Various species
[3]Polar bear, grizzly bear, caribou, moose, dall's sheep, muskox,
[4]Fox, Hare, Lynx, Marten, Mink, Muskrat, Wolf, Wolverine
[5]Various species

In terms of availability of harvested country meat and fish available per person for each community, values range from 23.48 kg per year in Inuvik, to 366.89 kg per year in Sachs Harbour. Across the 6 communities in the Inuvialuit Settlement Area for the study period, large mammals are the most widely harvested animals in terms of edible weight. The second most widely harvested group is fish. Fish and sea mammals combined, however, are harvested more widely (in terms of edible weight) than land mammals in Holman (Ulukhaktok), Inuvik, and Tuktoyaktuk, harvested in approximately the same proportion as large mammals in Aklavik, and harvested less than large mammals in Sachs Harbour and Paulatuk. In Paulatuk, caribou comprises the majority of the large mammal harvest, while muskox comprises the majority of the large mammal harvest in Sachs Harbour. Some communities may be more dependent on sea animals (mammals and fish) while some are more dependent on land mammals. Caribou is the single most harvested species, by proportion of total edible weight, across all communities in the Inuvialuit Settlement Region, with the exception of Sachs Harbour.

Table 2-2 Estimated weight of wildlife available for consumption in the Nunavut Settlement Area (1998-2001)

		% of total country food/community by edible weight					
	Total edible weight (kg)/capita (2006)	Caribou	Large mammals (including caribou) [1]	Small mammals and furbearers	Sea mammals	Birds	Fish
Baffin Region							
Arctic Bay	183.97	28%	29%	1%	59%	1%	11%
Cape Dorset	93.01	20%	21%	24%	32%	5%	16%
Clyde River	113.97	17%	18%	0%	67%	1%	13%
Grise Fiord	245.62	5%	14%	0%	83%	1%	2%
Hall Beach	153.29	36%	37%	0%	52%	1%	10%
Igloolik	130.06	38%	39%	0%	51%	1%	10%
Iqaluit	121.05	44%	46%	0%	48%	1%	5%
Kimmirut	74.54	28%	30%	1%	11%	4%	12%
Nanisivik	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pangnirtung	284.92	25%	25%	0%	59%	1%	14%
Pond Inlet	161.09	39%	40%	0%	51%	1%	8%
Qikiqtarjuaq	219.96	5%	6%	0%	83%	0%	10%
Resolute	22.38	15%	71%	1%	1%	5%	22%
Sanikiluaq	92.14	2%	6%	0%	58%	14%	23%
Mean	**145.85**	**23%**	**29%**	**2%**	**50%**	**3%**	**12%**
Kitikmeot Region							
Bathurst Inlet	468.73	56%	58%	6%	4%	1%	31%
Cambridge Bay	37.51	66%	70%	2%	6%	2%	21%
Gjoa Haven	51.94	47%	51%	1%	8%	1%	39%
Kugaaruk	122.21	23%	25%	0%	56%	0%	18%
Kugluktuk	103.49	52%	53%	2%	30%	2%	13%
Taloyoak	148.17	26%	28%	0%	44%	1%	28%
Umingmaktok	250.82	67%	67%	5%	7%	1%	20%
Mean	**168.98**	**48%**	**50%**	**2%**	**22%**	**1%**	**24%**
Kivalliq Region							
Arviat	120.79	60%	61%	0%	36%	2%	1%
Baker Lake	70.83	91%	92%	2%	0%	0%	6%
Chesterfield Inlet	139.95	63%	66%	2%	23%	1%	8%
Coral Harbour	116.92	74%	78%	1%	76%	10%	10%
Rankin Inlet	36.69	51%	52%	1%	41%	1%	5%
Repulse Bay	110.70	40%	42%	1%	49%	0%	8%
Whale Cove	127.23	54%	58%	1%	37%	1%	4%
Mean	**103.30**	**62%**	**64%**	**1%**	**37%**	**2%**	**6%**

[1] Polar bear, tundra grizzly bear, black bear, muskox, caribou.

In the Nunavut Settlement Area, total edible weight of harvested animals per capita ranges from 22.25 kg in Resolute Bay to 445.92 kg in Bathurst Inlet. In the Kitikmeot and Kivalliq regions of Nunavut, land mammals are the most widely harvested country animal group in terms of edible weight, while sea mammals are the most widely harvested group in the Baffin region. The majority of the land mammal harvest in the Kitikmeot region is comprised of caribou. From estimated edible harvest figures from previous reports and from present calculations, it is found that there is variation in species use across northern communities.

Table 2-3 Estimated weight of wildlife available for consumption in the Gwich'in Settlement Area (1998-2001)

		% of total country food/community by edible weight					
	Total edible weight (kg)/capita (2006)	Caribou	Large mammals (including caribou	Fish	Sea mammals	Birds	Small mammals and furbearers
Aklavik	232.08	37%	40%	55%	0%	1%	3%
Fort McPherson	719.14	65%	69%	26%	0%	1%	3%
Inuvik	23.53	42%	50%	39%	1%	4%	7%
Tsiigehtchic	1553.50	15%	21%	75%	0%	1%	1%
Mean	632.06	40%	45%	49%	0%	2%	4%

In the Gwich'in Settlement Area, total edible weight of harvested animals per capita ranges from 232.08 kg to 1553.50 kg. In the communities of Fort McPherson and Inuvik, caribou was harvested in a higher proportion (of the total weight of country food harvested) than all other types of country foods. In the communities of Aklavik and Inuvik, fish were harvested in higher proportion than caribou.

2.3.2.2 Numbers of caribou harvested

From the harvest data, it is possible to determine changes in caribou use over the harvest survey periods in terms of aggregate numbers of caribou harvested, as well as numbers of caribou harvested per hunter. Average declines in numbers of caribou harvested were found in the six communities in the Inuvialuit Settlement Region over a ten-year study period (1988-1997). There was a general decline in the numbers of caribou harvested in the Nunavut Settlement Region over the study period 1997-2001. The number of caribou harvested in the five communities in the Gwich'in Settlement Area increased, then decreased, over the five-year study period. Figures for numbers of caribou harvested are shown in Appendix D.

The number of hunters reporting successful harvests is reported on a per-month basis in the Inuvialuit Settlement Region and Nunavut studies. Though the monthly response forms for hunters included the option "hunted—no catch" or "hunted, but not successful," these responses are not included in harvester counts for specific animals in public reports (The Joint Secretariat 2003, Priest and Usher

2004). Numbers of caribou harvested per hunter from the two studies are shown in AppendixD.

The decreases in harvested caribou over the periods of 1988-1997, 1996-2001, and 1995-2001 contrast figures from the period of the 1960s to the 1980s, when harvests of caribou and other large land mammals increased, and where the increase was attributed to an increased availability of caribou (Usher 2002). Hunter effort is recorded as the average number of animals harvested per day or hours on the land and is not reflected in the data; it is not apparent if hunters are spending less time on the land in a given month. However, harvest records from the Inuvialuit Settlement Region and the Nunavut Settlement Area show a general decline in animals harvested per month on average over the respective study periods.

2.3.3 Summary

As calculated with 2006 population values from federal census data, the edible weight of country food harvested ranged between 24 g and 369 g in the Inuvialuit Settlement Region, 24 g and 1553 g in the Gwich'in Settlement Area, and 22 g and 469 g in Nunavut. On average, the harvest (in edible weight) comprised of caribou was higher than that for other categories of country animals —fish, sea mammals, birds, small mammals and furbearers) in the Kitikmeot and Kivalliq regions of Nunavut.

In summary, from the calculation of edible weights of harvested caribou and other country foods, it is found that the proportion of the harvest comprised of caribou is higher than that for other categories of country animals (fish, sea mammals, birds, small mammals and furbearers) in 5 out of 6 of the Inuvialuit Settlement Region communities, 2/13 communities in the Baffin (Qikiqtaaluk) region (Nunavut), 5/7 communities in the Kitikmeot region (Nunavut), 5/7 communities in the Kivalliq region (Nunavut), and 2/4 communities in the Gwich'in Settlement Area. In communities where caribou is not the animal harvested in the highest edible weight, fish, sea mammals, or muskox was. For the Sahtu region, McMillan (2012) has calculated edible weights of animals harvested, and found that in the communities of Colville Lake and Deline, barren-ground caribou comprised the highest proportion of the total edible weight harvested when compared with woodland caribou, moose, small mammals, birds, and fish over the study period of 1999 to 2002. In the community of Fort Good Hope, barren-ground caribou comprised the highest proportion of the total edible weight harvested from 1999 until mid-2001, when moose became the most highly harvested animal and fish became the second most harvested. In the community of Tulita, barren-ground caribou comprised the highest proportion of the total edible weight harvested from 1999 until 2001, when moose became the most highly harvested animal.

From the published harvest study data, it is clear that caribou is potentially a significant food source for northern communities, since it is the most highly harvested species, on average, in terms of relative harvested edible weight, across four regions. As mentioned, all harvest statistics reflect food availability because not all animals harvested are retrieved and used, and not all animals counted in harvest studies are food sources (Usher and Wenzel 1987). Harvest studies illustrate only one aspect of use of country food—potential availability. The next two sections show results from studies in northern Canada involving direct recall of foods consumed and used by individuals and households.

2.4 Direct measurement of food intake

2.4.1 Economic consumption and expenditure surveys

While harvest data may illustrate how much country food has been harvested and potentially used at the individual-, household-, and community-levels, they do not enable analysis of the complete dietary patterns of northern households. As stated in the research objectives of this thesis, the interest of the present study is to examine the economic factors influencing the consumption of caribou and also other harvested and store-bought foods.

While the present analysis employs a dietary survey to address the research objectives, results from a national food consumption survey provide an indication of levels of store-food consumption in select northern communities. Economic consumption surveys typically employ two main ways of collecting data: i) asking direct questions about both the physical quantity consumed by the household and the household's expenditure on the good, or ii) collecting data on expenditures and deflating these figures by the prices of the commodities in question (as obtained in community or price surveys) (Deaton and Grosh 2000). The most common method of collecting data on food intake is the 'food accounts' or 'diary' method, where the household head or respondent records amounts of foods purchased during the survey period, and prices and/or expenditures. Any type of household food consumption data collection methods is subject to design or measurement error. Recall survey methods are usually carried out by interview and rely on the memory of the respondent; they are highly subject to reporting inaccuracy (Deaton and Grosh 2000).

The Canadian Food Expenditure Survey (FES) utilizes the diary method to collect information on the household's purchasing habits and food expenditures, including those incurred if away from home in the previous month, and a questionnaire to gather data on household characteristics including household income (Statistics Canada 2003c). The FES is a periodic supplement of the Survey of Household Spending (SHS) and is used to gather detailed expenditure data on food commodities that are not feasibly collected within the SHS, and was only collected for the 2001 reference year (January –December). It has carried out in households in urban and rural areas in Canadian provinces and in the territorial cities of Whitehorse, Yellowknife, and Iqaluit.

From the published data for the three territories, it is found that food expenditures in Nunavut were, on average, higher than those of Canada and the other territories (NWT and Yukon) (see Figure 2-1). The Northwest Territories have higher expenditures on food than the Yukon across the survey years. The proportion of total expenditures on food items (out of total household expenditure) in the territories is higher than the national average, with Nunavut residents exhibiting the highest proportion food expenditure (see Figure 2-2).

The FES only been carried out in the northern capital cities—the data may not be used to illustrate variations in expenditures across communities. While FES data on specific store food items consumed have been recorded in the survey data on country food consumption or harvesting patterns were not collected. Therefore, the survey results are not useful for carrying out the present research objectives relating to examining the economic trade-off between country and store-bought foods.

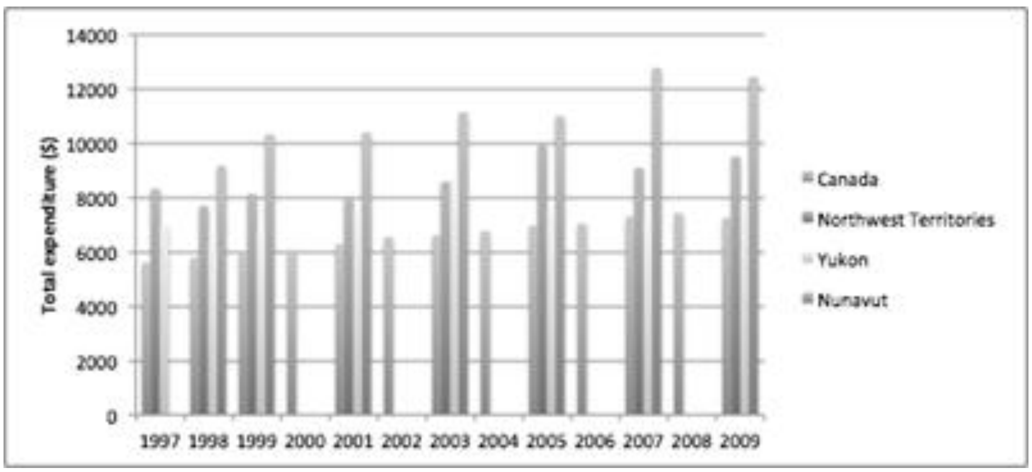

Figure 2-1 Total food expenditures ($), 1997-2009

Reference: Statistics Canada. No date (c, e, g, i).

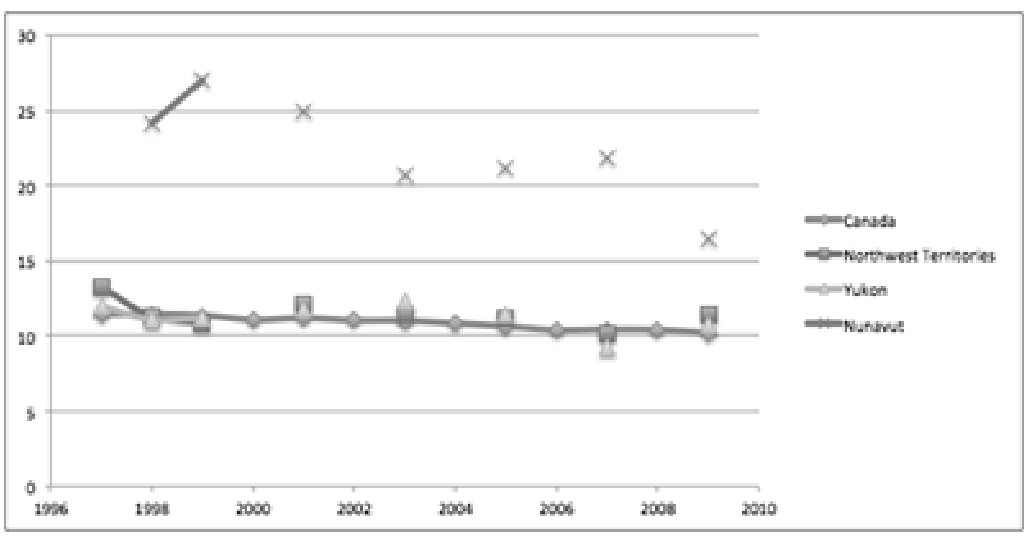

Figure 2-2 Total food expenditures as proportion of total household expenditures - %), 1997-2009

Reference: Statistics Canada, No date (b, c, e, d, f, g, h, i).

2.4.2 Nutritional and dietary surveys

Another source of data for assessing food security and food consumption is nutritional science surveys. Using dietary intake records has a few advantages over harvest studies: dietary studies exclude inedible portions and subtract plate waste, and also account for loss of weight which occurs of cooking meat and fish (Wein and Freeman 1995). In this section, the different types of dietary surveys and related measurement issues are described in detail, since dietary recall data will be used for analysis in this thesis.

Dietary surveys are surveys on "the amounts of different foods consumed" (Burk and Pao 1976, p. 10). These surveys can help the researcher "obtain a picture of the food consumption patterns of individuals in specific groups" (Thomson and Metz 1998 section 2.1.3). These surveys may be self-administered or completed by an observer or interviewer (Burk and Pao 1976). Though data is usually collected for an individual, the respondent may give data for all members of the household (Burk and Pao 1976).

- **24-hour recall**: "A means of obtaining dietary intake whereby subjects, or a proxy, are asked by a trained interviewer to recall their exact food intake during the previous 24-hour period or preceding day. The interviewer records detailed descriptions of all food and beverages consumed in combination with associated preparation and cooking methods, if possible." (Health Canada 2006, Appendix xiii).
- **Food Frequency Questionnaire**: "A food frequency questionnaire (FFQ) aims to assess the frequency with which food items or food groups are consumed during a specified time period. Respondents, or a proxy, are asked to indicate on a well-defined checklist of food and food categories, the associated frequency with which they consume a particular food item (daily, weekly, monthly or yearly). The food list may be extensive or may

focus on specific groups of foods that may or may not be associated with specific events or seasons. The inclusion of portion sizes in the FFQ in addition to improved computerized methods permits researchers to obtain energy and nutrient intakes for the respondent or group being studied." (Health Canada 2006, Appendix xvii). The Quantitative Food Frequency Questionnaire (QFFQ) has also been used. In the QFFQ, portion sizes, three-dimensional food models, household utensils, and standard units (teaspoon and can) are listed on each item line (Sharma et al. 2009).

- **Food Record**: "There are two types of food records: estimated and weighed. In both records, respondent, or a proxy, is asked to record detailed descriptions of all foods, beverages and snacks consumed, including preparation and cooking methods, for a specified period of time. For an estimated food record, food portion sizes are estimated using household measures; for a weighed record, respondents or a proxy are asked to weigh all foods and beverages consumed. In both methods mixed dishes are documented by recording the amount of each raw ingredient used in the recipe, the final weight of the mixed dish and the amount consumed by the subject" (Health Canada 2006, Appendix xvii).
- **Dietary history** is a method of data collection based on recall of usual intake over a period longer than 24 hours or several days, of a period up to a year (Burk and Pao 1976).

2.4.2.1 Measurement issues

Dietary surveys are similar in some ways to the economic food consumption survey formats described in the previous section. Dietary surveys usually involve recording more detail on food items consumed—they usually require information on weights, portion sizes, or ingredients in food items. The recall period (time period covered by the questions of the survey) and the frequency or total number of times the survey is administered may also differ. The 24-hour recall has a recall period shorter than that for other diet survey formats (food record or FFQ) and also for most food consumption/expenditure surveys.

Dietary surveys, when conducted by interview, have a high co-operation rate. The 24-hour recall and FFQ methods depend on the memory of the respondents and thus may be limited in accuracy. The food record format may be more accurate than the other methods but may only be carried out for a short period of time and also requires a high level of co-operation from respondents (Thomson and Metz 1998). Some studies may use two or more of these methods.

Even though the 24-hour recall has a relatively short recall period, it is assumed to represent usual or typical intake of an individual. However, Lawn and Harvey point out some important considerations when using 24-hour recalls. A single 24-hour recall may be sufficient in a cross sectional study but the days of the week should be equally represented (Lawn and Harvey 2001). They also state: "a single assessment of nutrient intake and food consumption can suggest areas of concern for the community, but individual assessment of nutritional status and health would require more than one 24-hour recall" (Lawn and Harvey 2001, p. 29). For the determining adequacy of most nutrients, dietary researchers recommend collecting data from a minimum of two 24-hour recalls administered on non-consecutive days (Wright, Ervin, and Briefel 1994). The FFQ may be more suitable for capturing infrequent or seasonal consumption of foods than the 24-hour recall.

2.4.2.2 Diet quality indicators

Data from nutritional and dietary surveys is typically used to assess dietary quality, which is an aspect of the food security dimension of "adequacy," which involves the assumption that "nutritional quality" must be met in the food supply. The FAO suggests that to achieve a food secure state, the condition of "utilization," defined as "the state of nutritional well-being where all physiological needs are met," must be met (FAO 2001). Thus, the concept of "adequacy" is closely linked with concepts from nutritional science, including dietary quality. Nutritional adequacy refers to the achievement of recommended intakes of energy or other essential nutrients (Ruel 2003, Babu and Sanyal 2009).

Dietary quality may be defined in terms of objective or subjective quality, where objective quality is measured by principles of nutritional analysis, and where subjective quality refers to consumers' perceptions of whether or not their diet meets recommended guidelines or the amount they are willing to pay for a certain level of dietary quality (Drescher 2007). Objective quality indicators are often assessed with either nutrient-based indicators or food-item based indicators, and are discussed in the following two sections. Subjective dietary quality indicators are closely related to food security surveys, and are discussed in a later section on self-perception and qualitative survey instruments.

2.4.2.2.1 Objective dietary quality indicators: Nutrient-based indicators

Dietary and nutrition researchers usually assess diets by converting foods reported in surveys to nutrient composition and then comparing those values to recommended intakes of energy or other nutrients (Babu and Sanyal 2009). Nutrients are comprised of proteins, fats, carbohydrates, vitamins, minerals, and trace elements, as well as water (Thomson and Metz 1998). Thomson and Metz (1998, section 1.2) state that the term "nutritional status" reflects the "net outcome of individual food usage (ingestion, adsorption and utilisation), disease status, and work demand".

The term "nutritional requirement" refers to the quantity of energy and of nutrients, expressed on a daily basis, necessary for a given category of individuals (e.g. by age, sex, body weight, level of activity, physiological status) that will allow these individuals, when in good health, to develop and lead a normal healthy life (Thomson and Metz 1998). "Reference nutrient intakes" (RNIs) or "Recommended Daily Intake" or Recommended Dietary Allowance (RDA) refers to levels of nutrients that are adequate for nearly all individuals in a life stage or gender group (Thomson and Metz 1998, Lawn and Harvey 2001, Health Canada 2006, Babu and Sanyal 2009). The FAO calculates this value (for a given nutrient) as the mean of the range of individual requirements (estimated average requirement or EAR) plus two standard deviations. In the United States and

Canada, Dietary Reference Intakes (DRIs) guidelines, which include the nutrient reference values Estimated Average Requirement (EAR) and Recommended Dietary Allowance (RDA), among other values, have been developed and are used for individuals for nutrient intake assessment (Murphy and Barr 2006, Health Canada 2010a).

The quantities or portions of food recorded are usually converted to calories or nutrients with values from conversion charts from government-published sources. For traditional foods found in the Arctic, Kuhnlein et al. (2002) have published primary results on the content levels of macronutrients, minerals, fatty acids and vitamins for samples of traditional food items reported in food surveys in Yukon and Inuit communities. Country food nutrients have also been published by the Alaska Health Service (Nobmann 1993) and in the 2010 version of the Canadian Nutrient File (Health Canada 2012a). The Canadian Nutrient File (Health Canada 2012a) also contains nutrient data for other food types

"Dietary guidelines" refer to "the linkages for the general public between recommended nutrient intakes and the translation of these recommendations to food based guidelines" (Babu and Sanyal 2009, p. 10). An example of dietary guidelines is Canada's Food Guide, which includes recommendations for quantities of different types of foods that should be consumed by in individual in order for him/her to achieve the recommended daily intakes of nutrients (Health Canada 2010b).

Several measures of dietary quality have been developed to assess the conformity of diets to recommended guidelines. Kant (1996) outlines these indicators, classifying them into three groups: summary measures derived from a select group of nutrients, nutrient-based indexes, and evaluations of energy or single nutrients. A common summary measure involves calculating a mean adequacy ratio (MAR), which involves taking the mean of the NAR and dividing the result by the number of nutrients measured, where NAR is the nutrient adequacy ratio. The NAR is calculated as the ratio of intake of a nutrient relative to its RDA, and each NAR value is truncated at 100 percent to avoid high consumption levels of one nutrient compensating for low intake of another (Kant 1996). This approach has been used by Guthrie and Sheer (1981), Randall et al. (1985), Krebs-Smith et al. (1987), Hatloy, Torhein, and Oshaug (1998).

A problem with summary measures is that they incorporate nutrients at-risk of excess or deficient intake into a single measure. Murphy et al. (1992) calculates an MAR value with nutrients that are under-consumed, where the mean intakes are below 67% of RDA. As cited in Kant (1996), Clark and Wakefield (1975) use the sum of selected nutrients consumed at a level equivalent to at least two-thirds of their RDAs to calculate a nutritional score. As cited in Kant (1996) and Drescher (2007), Hansen (1973) and Sorenson et al. (1976) calculate nutrient densities, which give nutrient supply per unit of energy or calorie content, for several individual nutrients in a food or a diet.

Some studies of dietary quality use intake of single nutrients or energy to draw inferences "regarding the intake of other nutrients given the prevailing food supply and food selection practices in a population" (Kant 1996, p. 786). Nutrients may include the macronutrients protein, carbohydrates, and fat, and selected micronutrients. For example, to assess the dietary adequacy of Inuit and Inuvialuit diets in northern Canada, Sharma et al. (2009, 2010) Hopping et al. (2010), Erber et al. (2010) assess mean and median intakes of energy and a select set of nutrients: energy, total fat, saturated fat, protein, carbohydrate, total sugars, dietary fibre, monounsaturated fat, polyunsaturated fat, omega-3 fatty acid, omega-6 fatty acid, cholesterol, vitamin A, Thiamin, Riboflavin, Niacin, Vitamin B6, Vitamin B12, Vitamin C, Vitamin D, Vitamin E, folate, calcium, iron, and zinc.

Caloric intake, which involves measuring a single nutrient, has often been used as an indicator for food security. Authors have used different benchmarks for food insecurity (or food security) with caloric intakes. Chung et al. (1997) defined households to be "chronically food insecure" if caloric adequacy fell below 70 percent (of recommended intake, adjusted by age and sex) in four of six dietary visits for communities in rural India. Hoddinott (1999) computed both individual- and household- caloric intake for households in Mali categorizes households by whether or not each person has access to 2 030 kilocalories per day. Haddad, Kennedy, and Sullivan (1994) define "food insecurity" as a failure to meet at least 80% of recommended calorie adequacy. Rose and Charlton (2002) regard energy intake as one aspect of food insecurity, along with "food poverty".

Murphy et al. (1992) find positive correlations between calorie intake and select micronutrients from dietary-recall data from the U.S. Nationwide Food Consumption survey. Though these findings suggest that consuming diets high in energy may result in consumption of important nutrients, intake of nutrient-poor and energy-dense foods has also been found to be positively associated with energy intake and inversely related with nutrient density and intake of important micronutrients (Kant and Schatzkin 1994, Andrieu, Darmon, and Drewnowski 2005). It has been found from a number of studies that individuals may select lower-quality diets consisting of high-energy foods to maintain adequate energy intake given low food costs (Dinour, Bergen, and Yeh 2007). Therefore, a calorie intake measure alone may not be sufficient for assessing individual- or household-level food security status. Measurement of intake of other nutrients or use of other indicators may be considered.

2.4.2.2.2 Objective dietary quality indicators: Food item indicators - dietary diversity and composite indices

Another class of objective dietary quality indicators accounts for food items consumed rather than nutrients consumed. This category includes dietary diversity and dietary variety indicators, as well as composite indices that account for both the intake of food items and nutrients. Drescher (2007 p. 18) outlines a few reasons that "food-pattern" indicators may be selected over nutrient indicators: i) nutrient levels may only capture the part of the diet that pertains to the nutrients selected for the analysis (as cited in Dubois, Girard, and Bergeron 2000), ii) dietary quality may not be reflected by only the consumption of nutrients

(Patterson, Haines, and Popkin 1994, as cited in Drewnowski et al. 1996), iii) nutrient studies do not account for interactions between other foods and nutrients and the nutrients under examination (as cited in Maunder, Matji, and Hlathswayo-Molea 2001, Michels and Wolk 2002). Additionally, it is also suggested that consumer demand also focuses on food items rather than individual nutrients (Ogle, Hung, and Tuyet 2001). Thus, food-pattern indicators should be explored as possible tools for assessing dietary adequacy.

Dietary variety is described as the total number of unique food items consumed (de Gwynn and Sanjur 1974, as cited in Kant 1996). Dietary diversity is defined as the number of different food items (or food groups) consumed in a certain period of time, where reference periods are between one and three days, seven days, or up to 15 days (Drewnowski et al. 1997, Ruel 2003). Some studies have used counts of food codes and food ingredients for diversity measures (Foote et al. 2004 as cited in Drescher 2007). Dietary diversity indicators may be used to predict individual-level nutrient adequacy and household-level food security (Ruel 2003).

The most basic measure of food diversity is a simple count of individual food items (e.g. Krebs-Smith et al. 1987, Ferguson et al. 1993, Onyango, Koski, and Tucker 1998) and food groups (e.g. Krebs-Smith et al. 1987, Taren and Chen 1993, Arimond and Ruel 2004). The range of foods consumed may influence the specification of food groups for diversity measures; grouping foods from a limited range may not result in much statistical variability, while defining groups for a wide variety of foods may better facilitate assessment of diversity (Onyango 2003). Mirmiran, Azadbakht, and Azizi (2006) examine diversity within food groups (meat, dairy, whole grain) and find that some within-group diversity scores are strongly correlated with specific nutrient adequacy. Count measures have been very popular in developing countries, perhaps because they are simple to implement (Ruel 2003).

Aside from simple counts of food groups, other variety score types have been constructed. These measures are designed to conform to recommended dietary guidelines. Guthrie and Scheer (1981) develop a "dietary score" where milk products and meat/meat alternative products are assigned two points for each of two recommended servings and fruits/vegetables and bread/cereals are assigned one point for each of four recommended servings. Kant et al. (1991, 1993) specify a 'serving score' measure, which allocates points for a desired number of servings for five food groups (at least two servings each for the dairy, meat, fruit, and vegetable groups, and four servings for the grain group) over a period of 24 hours. Krebs-Smith (1987) use a simple food group count, along with a variety score that assigns points for consumption of six major food groups and one that assigns points for consumption within major food groups. Drewnowski et al. (1996) use a dietary diversity (DD) score that is defined as the mean of the number of food groups consumed across different days in a food frequency questionnaire. Mirmiran et al. (2004) and Raynor et al. (2005) calculate diversity scores by first taking the ratio of foods items consumed in a group to the total number of foods in a specified list for that group. The group-specific score is then weighed by the proportion of points that may be received from that group (out of the maximum score for all groups combined).

Drescher (2007) summarizes the problems with count measures of diversity: i) they do involve considering frequency of food consumption; ii) they do not account for quantities of consumed items; iii) they do account for the ratio of each food quantity to the total quantity of the whole consumption bundle, and iv) they do not involve differentiating healthy from unhealthy food items or food groups. Food variety or diversity may be assessed using statistical tools to measure the distribution of different types of food, or "the relative occurrence of unique items related to their entirety" (Drescher 2007, p. 57).

The Berry Index has been used in economic (Patil and Taillie 1982, Lee 1987, Van Trijp and Steenkamp 1992, Stewart and Harris 2005) and nutrition studies (Katanoda, Kim, and Matsumura 2006) to examine food diversity. While distribution measures account for an additional measure of diversity, they exhibit the highest value when there is an equal distribution of food items, not reflecting the nutritious value of different food groups (Drescher 2007). Moreover, the distribution measure accounts for consumption of all types of foods, so healthy foods and non-healthy foods affect the index the same way. Drescher (2007) and Drescher, Thiele, and Mensink (2007) have developed a Healthy Food Diversity (HFD) index, for which Berry Index values for individual food items are multiplied by an associated "health factor," which is taken as the ratio between the actual and recommended consumption of the food item as specified in the German food pyramid.

Increased dietary diversity has been associated with increased birthweight (Rao et al. 2001), improved anthropometric status (Duyff, Sanjur, and Nelson 1976, Taren and Chen 1993, Onyango, Koski, and Tucker 1998, Hatloy et al. 2000), improved haemoglobin concentrations (Bhargava, Bouis, and Scrimshaw 2001), reduced incidence of hypertension (Miller, Crabtree, and Evans 1992), less macrovascular disease like type II diabetes (Wahlqvist, Lo, and Myers 1989), lower levels of hypertension (Miller, Crabtree, and Evans 1992), reduced risk of cardiovascular disease (Kant, Schatzkin, and Ziegler 1995), reduced risk of various cancers (Fernandez et al. 1996, Franceschi et al. 1995, Kant, Schatzkin, and Ziegler 1995, La Vecchia et al. 1997, Slattery et al. 1997). It has also been found that dietary diversity may be inversely related to mortality from all causes (Kant et al. 1993). There is significant evidence that dietary diversity or variety may contribute to positive health outcomes. Kushi et al. (1985 as cited in Kant 1996) examined the relationship between scores on amount of energy from vegetable or animal protein, starch, or animal fat, on incidence of coronary heart disease, and found that the vegetable score is inversely related with coronary heart disease.

Either nutrient or food-pattern type indicators may be used as broad indicators of food security. Garrett and Ruel (1999), Ruel (2003), and Hoddinott and Yohannes (2002) have considered dietary diversity as a food security indicator in developing countries. In the United States, low intakes of energy, vitamins A, E, C, and B6 and magnesium were reported in households who were categorized as "food-insufficient" based on their response to the question of whether or not there was "sometimes or often not enough to eat" (Rose and Oliveira 1997). Lorenzana and Sanjur (1999) assess the energy content of diets in a group of respondents in Venezuela deemed food insecure by a qualitative food security survey module, and suggested that quantitative and qualitative measures should be used together to assess household food security. Therefore, there have been proven relationships between formal measures of food insecurity and dietary or nutrient adequacy.

Instead of focusing on only nutrient analysis or only on food items consumed, indexes that involve combining information on food item intake and intake of nutrients have also been used as objective indicators of dietary quality. These indexes are based on consumption of all foods or from major or minor food groups, or are derived from patterns of dietary intake extracted from factor analysis (Kant 1996). A few well-known composite-index indicators have been developed, including the Diet Quality Index (Patterson, Haines, and Popkin 1994), the Diet Quality Index Revised (Haines, Siega-Riz, and Popkin 1999), the Diet Status Index (Basiotis et al. 1995), Healthy Eating Index (Kennedy et al. 1995), the Healthy Diet Indicator and the Mediterranean Diet Score (Haveman-Nies et al. 2001), and the Healthy Diet Indicator (Huijbregts et al. 1997).

One composite index score, the Healthy Eating Index (HEI), involves accounting for nutrients, individual food items, and diversity. Scores are assigned based on 10 components, where components 1 to 5 are scores for five food groups, where an individual's score for a food group is based on the recommended servings for his or her age and sex. The 6^{th} component is based on the proportion of total energy intake that is fat, the 7^{th} component is based on the proportion of total energy intake that is saturated fat, and the 8^{th} and 9^{th} components, respectively, were based on milligrams of cholesterol and sodium consumed. The 10^{th} component is a dietary variety measure derived counting the total number of different foods eaten by a person in "amounts sufficient to contribute at least a half serving in any of the food groups" (Kennedy et al. 1995, p. 1105). A maximum score of 10 is given to individuals who report consuming 16 or more different foods, while a score of 0 was given if 6 or fewer distinct foods are consumed. The score for each component ranges from 0 to 10, so the maximum score for the HEI is 100. There is some concern that calculation of the component is arbitrary, as there is a variety of evidence as to how many different foods should be consumed per day to achieve benefits from different nutrients (Carlson and Juan 2004).

There have been attempts to valid composite-index indicators by comparing them to measures of nutrient adequacy or to health outcomes. Dubois, Girard and Bergeron (2000) compared results from the DQI, the HEI, and the HDI with data on a single 24-recall for 2103 individuals in the 1990 Quebec Nutrition Survey. Each of the indicators was adjusted to conform to Canadian recommended intakes, and it was found that the HEI had the strongest correlation with MAR measures (which in itself may be a tool that can be validated) and self-perception of eating habits.

Garriguet (2009) adapted the 2005 revision of the American HEI to Canada's nutritional guidelines, with some components modified to reflect the fact that Canadian recommendations involve numbers of servings rather than proportion of energy intake from nutrients. The index was validated and applied to data from two 24-hour recalls and from questions on fruit and vegetable consumption from the 2004 Canadian Community Health Survey. The results show that for the sample of 35 107 Canadian respondents, the mean HEI was 58.8. To validate the HEI, Garriguet (2009) used simulated diets that follow Canada's food guide and found that they received high scores with the Canadian HEI.

2.4.2.3 Results from dietary studies

From the review of harvest studies, it was found that in terms of estimated edible weight of harvests, caribou is the most harvest species in the majority of communities. From published results of dietary surveys, the relative use of caribou, as measured in quantity of consumption, number of households consuming, or contribution to nutrient intake, may also be described. Results from dietary studies employing survey types such as 24-hour recall, food frequency questionnaires, food records, and dietary history, are described in the following sections, with the aim of illustrating overall dietary patterns and in particular, consumption patterns of caribou.

2.4.2.3.1 Consumption of caribou and other foods

From dietary studies, a range of values has been reported for consumption of caribou and moose meat across the North. The mean or median consumption of caribou meat has been reported to range between 60 g per day to over 250 g per day in Northwest Territories communities and between 70 g and over 150 g in some Yukon communities. For moose, the reported range was 73-169 g for Yukon communities (Wein and Freeman 1995, Batal et al. 2005, Egeland 2010a). In the eastern Arctic, average consumption of caribou has been reported to be between 5 g and 55 g in Nunavik communities, between 31 g and 208 g in Nunavut communities, and around 67 g in Nunatsiavut (Innis, Kuhnlein, and Kinloch 1988, Lawn and Harvey 2001, 2003, Duhaime et al. 2004, Lawn and Harvey 2004b, Egeland 2010b, c). The mean or median values of caribou and moose consumed as shown in recent studies are shown in Appendix E.

Caribou and moose meat were consistently found to be among the top country food species consumed across northern communities since the 1980s, after calculating percentages of respondents consuming (or compiling the percentages, where the values are shown in the published article) and ranking the percentages. The percentages consuming and rankings are shown in Appendix E. In the Northwest Territories and Yukon, caribou meat was found to be among the top 5 (out of lists of 10-28 country foods) or among the top 10 (out of a list of 101 country foods), with percentage of respondents consuming ranging between 4% and 100% across communities or regions and study periods (Kuhnlein et al. 1994, Tracy and Kramer 2000, Batal et al. 2005, Nakano et al. 2005, Egeland 2010a). The studies by Kuhnlein et al. (1994), Batal et al. (2005), and Nakano et al. (2005) show that moose is among the top 5 (out of lists of 15 or 28 country foods) or the top 20 foods (out of a list of 101 country foods) consumed in Dene/Metis communities in the Northwest Territories and Yukon First Nations communities. In the eastern Arctic, caribou was the country food most commonly in Nunavik, the most commonly consumed country food in Nunatsiavut, and either the first or second most commonly consumed country food, on average, across Nunavut communities, with percentage consuming ranging between 6.9% and 98% (Kuhnlein and Soueida 1992, Duhaime, Chabot, and Gaudreault 2002, Egeland 2010b, c, Johnson-Down and Egeland 2010, Gagné et al. 2012).

Caribou was found to be consumed between 1.3 and 3.2 times per week, and moose between 1.6 and 2.7 times per week across the North (Kuhnlein 2002 (pers. com.), as cited in Van Oostdam et al. 2005). Zotor et al. (2012) found that baked, boiled, or roasted caribou was consumed on average 0.18 times a day in a sample of three Inuvialuit communities in 2007 and 2008. Lawn and Harvey (2003, 2004b) found from studies in two Nunavut communities that caribou was consumed between 5.25 and 10.5 times in a month. Blanchet and Rochette (2008) found that 87.4% of respondents reported consuming caribou more than 11 times a year and 11.5% of respondents reported consuming caribou 1-10 times a year in Nunavik in 2004. Wein, Freeman, and Makus (1996) found that from 102 Inuit households (98% of Inuit households) in the community of Sanikiluaq on the Belcher Islands in Nunavut, traditional foods were used by all households on average 1171 ± 852 times a year. The most frequently consumed food type in the study was found to be fish or shellfish, followed by birds, sea mammals, berries, and land mammals.

2.4.2.3.2 Intake of energy and nutrients

In this section, the findings of studies that show how caribou consumption affects indicators of nutritional adequacy are outlined. The impacts of consumption of other country foods and store foods on nutrient adequacy are also discussed.

In previous studies, it has been shown that caribou is a significant contributor to energy intake. From 16 Dene/Metis communities, Receveur, Boulay and Kuhnlein

(1997) report that land mammals in aggregate comprise the largest percentage of energy intake, on average, among all traditional foods. For 44 northern communities, Kuhnlein et al. (2004) found that that 10-36% of adult energy intake was from traditional food, with the average being approximately 22%. From responses to the Quebec Health Survey of the Inuit for a sample of 178 women, Duhaime, Chabot and Gaudreault (2002) found that on average, 12.3% of the diet of the sample was comprised of country food. Sharma et al. (2009) found from a sample of adult Inuit in Nunavut that caribou comprised 5% of total energy intake, being the second highest contributor, behind sweetened juice and drinks. From a sample of adult Inuvialuit in the Northwest Territories, Sharma et al. (2010) reported that caribou soup/stew comprised 3.3% of total energy intake.[8] From surveys in Inuvialuit communities in 2008, Erber et al. (2010) find that caribou and other "large game" comprise 4.1 percent of total energy intake, behind juice, sugar/syrup/honey, carbonated drinks, bread, sweets/desserts, beef, rice/pasta, and crisps/popcorn. From similar surveys in Inuit communities in 2008, Hopping, Mead, et al. (2010) found that caribou and "other game" comprise 7.8% of total energy intake, being the second highest contributor, behind juice.

Caribou and large game have also been found to be the highest contributor to protein intake and iron intake among Inuit and Inuvialuit (Erber et al. 2010, Hopping et al. 2010). Caribou liver is also an important source of vitamin A (Van Oostdam et al. 2005)

2.4.2.3.3 Factors influencing consumption of caribou and other foods, and intake of energy and nutrients

From published dietary studies, it has been reported that use of caribou and other country foods and store-bought foods may depend on demographic characteristics such as age or gender, economic characteristics, and the time of year the respondent consumes the food. As in the case of quantities consumed, intake of

[8] The data sources for Sharma 2009a and 2009b are the same sources used for analysis in this study. However, the data from two regions reported in those studies have been aggregated to form a single data set for the present study. Summary statistics and statistics on caloric intake are shown in Chapter 4.

different nutrients has also been found to vary by these characteristics. Dietary analysis results also illustrate the impacts of types of foods consumed on measures of dietary adequacy or quality, such as intakes of energy or specific nutrients. The results from these studies are described in this section.

From data from 44 Yukon, Dene/Metis, and Inuit communities, Kuhnlein et al. (2004) found that significantly more traditional food was consumed by older respondents than by younger respondents. In the 20- to 40-year old age group, the authors found that men consumed more traditional food on average than women, while this pattern was also found in the 41-60 year old age group in the Inuit respondents (Kuhnlein et al. 2004). Receveur, Boulay, and Kuhnlein (1997) found that interview season (either the March to April or October to November period) had a statistically significant effect on intake of country fish.

From 16 Dene/Metis communities, Receveur, Boulay and Kuhnlein (1997) report that the percentage of energy intake attributed to land animals increases by age for both men and women, with 10.2% average intake for 20-40 year olds, 20.0% average intake for 41-60 year olds, and 24.7% average intake for those over age 61 among women, and 13.3% average intake for 20-40 year olds, 18.1% average intake for 41-60 year olds, and 22.4% average intake for those over age 61 among men. For country fish, the highest average level of contribution to energy intake is in the 41-60 year old category for women, followed by the over-61 category and the 20-40 year old category. The same pattern for women respondents is observed for country birds. For men, average contribution to energy intake from fish increases according to age category. For country birds, however, the group with the highest contribution to overall energy from birds is the 20-40 year old group, followed by the over 61 age group and the 41-60 year age group. It is found that males, on average, derived a greater percentage of their overall energy intake from land animals and country fish than women do. From three communities in Nunavut in 2008, Hopping et al. (2010) found that participants over age 50 consumed country food significantly more frequently (2.3 times per day) than those age 50 and under (1.8 times per day). The older age group was also found to consume foods from the sea and foods from the sky significant more than the younger age group.

Individual characteristics have also been found to influence consumption of store-bought foods. As stated in Chapter 1, Hopping et al. (2010) found that age was negatively correlated with increased intake of foods of low nutritional value. Similarly, with data on 16 Dene/Metis communities Receveur, Boulay, and Kuhnlein (1997) found that older generations consumed less of dairy products, fruits and vegetables, and mixed dishes than younger generations.

Individual employment and income variables have also been found to affect quantities of different food types consumed, as well as nutrient intake levels attributed to different foods. From a food frequency questionnaire survey conducted in three communities in Nunavut, Hopping et al. (2010) found that household participation in employment and being on income support led to higher frequency of country food consumption. Being on household support also leads to increased frequency of consumption of both foods hunted from the land and foods hunted from the sea. Erber et al. (2010) found that having a higher Material Style of Life (MSL) scale score, which represents ownership of material goods, is associated with higher country food intake.

To track the impact in changes of a transport subsidy (and decreased prices) on the consumption of nutritious perishable foods between 1992 and 1997, Lawn and Harvey (2001) used the 24-hour recall methods and FFQ questionnaires to determine changes in actual quantities of the foods. They found that there was no significant relationship between consumption of "foods of little nutritional value" and socio-economic status (as defined by whether or not households receive social assistance and also their income level). The authors also found that the average consumption of fruits and vegetables was over twice as high in Pond Inlet as in Repulse Bay, and attributed this to the fact that cost of perishable fruits and vegetables was about 45% more in Repulse Bay than in Pond Inlet in 2007. In the study, there was no significant relationship between the quantity of country food consumed and socio-economic status.

Lawn and Harvey (2001) found that higher socio-economic status had a positive impact on total energy and folate intakes in 1997 in Pond Inlet, and attributed this to a higher level of fruit and vegetable consumption. The authors did not find a significant relationship between socio-economic status and overall energy intake. Huet, Rosol, and Egeland (2012) found that with data from 33 communities gathered as part of the Inuit Health Survey, lower Healthy Eating Index (HEI) scores were associated with food insecurity (as measured by responses to the USDA food security module), which was in turn found to be associated with a variety of economic factors including living in crowded housing, receiving income support, living in public housing, being in a single adult household, and living in a home needing major repairs.

Duhaime, Chabot and Gaudreault (2002) found that the presence of a male household head and access to an income raised the proportion of country foods in the diet. In terms of country food access, it is both the presence of a male in the household devoted to country food harvesting (and not working in wage labour) and the earning of wage labour by the woman that leads to an increased proportion of country food consumed. If the male is working in wage labour, or if neither the male nor female work, proportion of country food consumed was found to be lower. The authors found no relationship between obtaining food from the community freezer (which contains harvested country foods) and lacking food.

From data from 16 Dene/Metis communities, Receveur, Boulay and Kuhnlein (1997) assessed nutrient intakes as they varied by overall level of traditional food consumed, and found that when a high proportion of the diet is composed of market foods, higher amounts of carbohydrates, fats and sucrose are consumed. Nutrients at risk of inadequate intake include calcium, vitamin A, and folic acid. Traditional foods were consumed on 65.4% of the interview days, and the intakes of iron, zinc, and potassium were significantly higher, and the intake of sodium, fat, saturated fat, and sucrose were significantly lower, on those days than when only market food was consumed. From a study from Inuit living on Baffin Island, it was found that market foods contributed greater amounts of dry weight, energy, fat, carbohydrates, calcium, and sodium for most age groups than traditional foods, and that only 2 out of 10 nutrients studied for nutrient density were found in greater amounts in market food than in country foods (Kuhnlein, Soueida, and Receveur 1996). With data from 44 communities, Kuhnlein et al. (2004) that on days when traditional food was consumed, there was more protein, vitamin A, vitamin D, vitamin E, riboflavin, vitamin B-6, iron, zinc, copper, magnesium, manganese, phosphorus, potassium, and selenium in the diet, and less fat, carbohydrate, and sugar. Egeland et al. (2011) found that for a sample of 3-5 year old children from 16 Nunavut communities, the percent of energy from protein was higher than the percentage of energy from carbohydrates among children who consumed country food in the past day, regardless of their food security status (as determined by a food security module survey). It was also found that a higher proportion of iron deficient children among those who consumed country food than among those who did not (23.2% vs. 13.9%). It was also found that there was a higher proportion of children in the food insecure group that were anemic when they did not consume country food in the past day than if they did consume country food (31.6% vs. 14.9%). From Pakseresht et al.'s (2012a, b) study on six communities in the NWT and Nunavut, it was found that was that households spent the highest amount of food expenditure on non-nutrient dense foods (NNDFs), which includes butter, jam, pizza, sweetened juice, and coffee/tea, followed by replacement meats, traditional foods, fruits and vegetables, grains, and dairy. In percentage terms, households spent about 10% on fruits and vegetables, grains, and dairy, 20% on replacement (store) meats, 17% on traditional foods, and 34% on NNDFs. It was found that men, on average, spent more than women on NNDFs, replacement meats, fruits and vegetables, grains, and dairy, and less traditional foods than women. Age was found to have a negative effect and education was found to have a positive effect on NNDF expenditure.

Additionally, it was found that the nutrient density score (the daily content of a nutrient provided by a given food group to a subject) was higher than the energy cost (as measured in $/[optimal calorie intake]) for traditional foods, grains and diary, and lower than the energy cost for non-nutrient dense foods, replacement meats, grains, and dairy. By shifting expenditures from NNDFs to traditional foods, it was shown that individuals would consume the same number of calories, but reduce intake of sugar and increase intake of iron, zinc, vitamin D, and omega 3. However, it was also shown that vitamin E is supplied in greater quantity per dollar in NNDFs than other food groups. Pakseresht et al. (2012a, b) also found some variation among study regions. Inuit in Nunavut were found to spend more on grains than Inuvialuit in NWT, though they exhibited lower consumption of dietary fibre, folate, zinc, and vitamins C and D.

It is found from dietary study results that country or traditional food is an important source of energy and important nutrients. There is evidence that increased intake of store foods has been associated with inadequate diets and high intake of sugars and fats, while the consumption of country foods coincides with intake of nutrients that are deemed important. It is also found that in some regions, there is variation of amount of country food consumed by season. Country food is found to contribute significantly to overall energy and protein consumed, while non-nutrient dense foods are significant contributors of sugars and fats.

2.4.3 Summary

From a review of dietary study results, it is clear that caribou is a leading country food in northern communities in terms of daily quantity consumed, and as a contributor to total energy, fat, and nutrient intakes. Dietary surveys, mainly 24-hour recalls and food frequency questionnaires, have been administered across northern Canada and have involved the major cultural groups (Inuit, Inuvialuit, Dene/Metis, Yukon First Nations). Much of this data has been used to assess dietary adequacy. In studies conducted in almost all regions, it is found that these populations are deficient in many important macro- and micro-nutrients.

From the surveys it is found that in some regions, there is variation of amount of country food consumed by season. Country food is found to contribute significantly to overall energy and protein consumed, while non-nutrient dense foods are significant contributors of sugars and fats. There is also variation in the impact of age and gender on nutrient adequacy and also types of food consumed.

Some of the dietary studies also directly address socio-economic factors like employment status and use of income support programs on the consumption of different types of foods and on diet quality and adequacy indicators. The impact of a price change was also explored in the Food Mail pilot project review.

The impacts of economic factors such as income and time use on consumption of caribou and diet quality indicators may be further explored. What characteristics influence a household or community's susceptibility to caribou health threats are not readily understood from the published dietary data and harvest data. High costs for hunting equipment and time available for harvesting have been cited as constraints for obtaining country foods, while high costs of store food and lack of high quality food in stores are the major reasons for inability to obtain desirable store foods (Lawn and Harvey 2001, Chan et al. 2006, Chabot 2008, Beaumier and Ford 2010, Todd 2010, Ford and Beaumier 2011). Harvest studies do not routinely collect household-level socio-economic information (Usher and Brooke 2001) so the relationship between harvest activity and household income and employment characteristics may not readily be ascertained. Dietary data, while providing highly detailed information on foods consumed, do not routinely involve collection of data on food prices. An econometric model may illustrate the economic trade-offs a household faces and how the household will respond to changes in both country and store-food prices. Individual intakes of energy may also be calculated from available dietary data and Engel curves used to model consumption of calories at different levels of household expenditures.

2.5 Qualitative surveys

Different types of qualitative surveys, which do not involve recording amounts of foods consumed or expenditures, have been employed to study food consumption in northern communities. As a construct, food security has been measured with indicators developed from specific surveys such as the USDA household food security module. Aside from the USDA module, which has been used in surveys conducted in northern Canada, other types of surveys that involve asking individuals for their perceptions of household food security have also been employed.

In a previous section of this thesis, nutrient-based and food-item objective indicators used for assessing dietary quality were examined. Unlike objective indicators of dietary quality, subjective measures reflect self-perceptions of whether or not diets are meeting measured nutritional guidelines (Drescher 2007). Drescher (2007) states that subjective dietary quality indicators are derived by asking simply asking respondents about self-perceptions, or by measuring consumers' willingness to pay for objectively quantifiable characteristics of food, such as caloric content.

The results, further described in Appendix F, help develop a picture of whether or not households in different regions of northern Canada may be identified as food secure or food-insecure, and to understand what factors may affect food security status. While the results from these studies show general patterns of country food consumption and highlight barriers to acquiring store-bought foods and country food, caribou consumption and harvesting are not specific focuses of the studies.

2.6 Aboriginal Peoples Survey

The Aboriginal Peoples Survey is based on an international survey, The Survey of Living Conditions in the Circumpolar Arctic (SLiCA), which was designed measure and understand living conditions in the Arctic involving indigenous peoples and researchers from the United States, Canada, Greenland, Norway, Sweden, Finland and the indigenous peoples of Kola Peninsula and Chukotka in Russia.

In Canada, the sample frame is based on answers to questions in the Canadian Census. If individuals reported themselves or their ancestors to be Aboriginal, they were included in the Aboriginal Peoples Survey (APS) sample frame. The data from all regions was compiled and processed—open-ended responses were coded and variables created. Delic (2009) suggests that a weakness of the APS is under-coverage and under-representation because of the fact the sampling frame is limited to census respondents.

The Aboriginal Peoples' Survey is collected every five years following the census and focuses on issues such as health, language, employment, income, schooling, housing, and mobility. It is conducted by in-person interviews in the territories (except for Yellowknife) and by a paper questionnaire in other regions of Canada. The APS survey had a response rate of 84.1% in 2001 and 80.1 in 2006 (Statistics Canada 2003a, 2009b). The survey includes questions on country food production and household characteristics, but does not serve as an instrument for gathering detailed information on foods consumed by the household.

The Aboriginal Peoples Survey Arctic supplement is useful for this study because it includes questions focused on consumption and use of country food, as well as detailed questions on socio-economic variables. Summary statistics from the Aboriginal Peoples Survey have been previously published (Tait 2003, 2006, 2007, 2008a, b).

From the 2001 APS, it was found that 71% of Inuit adults reported harvesting country food. At the region level, the highest proportion of respondents reporting harvest of country food was in Nunavik (81%), followed by Labrador (Nunatsiavut) (76%), Nunavut (70%), and the Inuvialuit region (55%). In terms of proportion of total meat consumed that was comprised of country food, the highest proportion reported was in Nunavik (78%), followed by Nunavut (73%), 70% in the Inuvialuit region, and 56% of households in Labrador (Nunatsiavut) (Tait 2007). From the children's survey component from the 2001 survey, it was found that nearly half of all Inuit children in Nunavut, Nunavik, and the Inuvialuit region ate country meat five to seven days a week (48%, 45%, 48%, respectively), while 22% of Inuit children in Nunatsiavut ate country meat that often (Tait 2006, 2007).

It was also reported from the 2001 APS Arctic supplement that participation in harvesting varied by age and gender. It was found that 80% of men harvested country food compared to 63% of women (Tait 2007). Men in the 45 to 54 years age category had the highest level of participation (90%), followed by men in the 25-34 and 35-44 age categories (both 82%), the 55+ age category (77%), and then the 15 to 24 age category (74%) (Tait 2006, 2007). Women in the 45 to 54 years age category had the highest level of participation (69%), followed by women in the 35-44 category (67%), 25-34 category (66%), the 55+ age category (64%), and then the 15 to 24 age category (55% participation) (Tait 2006).

From the 2006 APS Arctic supplement results, participation in harvesting varied by age and gender. It was found that 74% of men harvested country food compared to 62% of women (Tait 2008b). Men in the 35 to 44 years age category had the highest level of participation (81%), followed by men in the 55+ age category (79%), the 45-54 category (77%), the 25-34 category (78%), and the 15 to 24 age category (67%) (Tait 2008b). Women in the 45 to 54 years age category had the highest level of participation (70%), followed by women in the 35-44 category (67%), 25-34 category (66%), the 55+ age category (61%), and then the 15 to 24 age category (53%) (Tait 2008b). From the children's survey component from the 2006 survey, it was found that on average, 49% of all Inuit children ate country food at least 3 days a week, and that differences in consumption across regions was not statistically significant (Tait 2008a).

Since the published analysis does not elucidate relationships between economic variables and country food harvests and consumption, econometric analysis on this topic will be conducted in this thesis. Region- and community-specific data is not available from the APS public use microdata file available for this study. Therefore, analysis is conducted on the entire sample from the Arctic Supplement.

2.7 Economic theory

The first objective of the thesis, as stated in the introductory chapter, is to determine how economic factors such as prices and income, and individual- and community-level demographic and economic factors influence the household's choices of quantities, types, and sources (harvested or store-bought) of food consumed. The second objective is to examine how caribou consumption influences diet quality and overall food security status. Economic theory provides a framework with which to understand how the household may allocate its time and income on different food items and also what factors may influence a household's ability to achieve a food-secure state.

As mentioned in the first chapter, individuals maximize their utility while constrained by their budget and time available. Variyam, Blaylock and Smallwood (1998, p. 3) suggest that four categories of factors influence food consumption behavior—incomes, prices of food and other goods, knowledge of health and nutrition, and tastes and preferences.

In this section, the basic theory is first explained, followed by discussion of the household production model, a form of the basic model where both time and income constraints are modeled. Methods of collecting food prices for expenditure analysis are also explained. Since households in the North participate in country food harvesting, methods of assigning economic values to non-market produced goods in a micro-economic framework are explained.

2.7.1 Basic consumer demand model

Economic theory provides a framework with which to understand why individuals consume the foods they do. In traditional economic theory, it is posited that the consumer engages in behaviour that maximizes his or her "utility" subject to constraints, where utility is viewed as "some measurable level of satisfaction that a consumer gets from consuming a good" (Binger and Hoffman 1997, p. 107).

The consumer's decision-making problem can be represented as a constrained optimization problem. Consumer utility is represented by an ordinal index that assigns ranks to items in a group of consumption goods. The problem is specified:

$$\text{Maximize } U = v(q) \text{ s.t. } x = \sum_{i=1}^{n} p_i q_i \qquad i = 1, 2, \ldots, n,$$

where x is exogenously given income or budget, q is the vector of goods and U is the subjective valuation of the goods, p_i is the price of the ith commodity, and x_i is the quantity of the ith commodity.

Solving the constrained optimization problem for varying levels of utility allows the derivation of demand functions that represent how much of a good a consumer purchases when faced with given prices and a budget (Deaton and Muellbauer 1980). The constrained optimization problem is solved by setting up a Lagrangian function, solving for first order conditions and deriving a set of demand functions. The demand function is specified:

$$q_i = g_i(x, p),$$

where x refers to total expenditures and p refers to price. These functions are the general form of the Marshallian or uncompensated demand function, which shows the quantity of a good demanded by the consumer given prices and income, and under the assumption that prices of other goods and the consumer's income are held constant. The set of goods chosen is the most-preferred consumption bundle; consumers are assumed to rank consumption bundles and choose among them.

The rational economic agent's decision-making is assumed to follow the six axioms of choice (Deaton and Muellbauer 1980).

i. Reflexivity: two identical consumption bundles are ranked the same.
ii. Completeness: the consumer can rank all pairs of consumption bundles either as one preferred to another or one indifferent to another.
iii. Transitivity or consistency: the consumer's choices are consistent.
iv. Continuity: the utility function is differentiable to the first and second degree.
v. Nonsatiation: the bundle with more goods is always preferred to the bundle with less.
vi. Convexity: diminishing marginal rates of substitution among different commodity bundles.

Alternatively, it is possible to find the maximum attainable level of utility given levels of prices and income. This relation is called the indirect utility function, and is shown as:

$$u = \psi(x, p) \qquad \text{i = 1, 2, …, n.}$$

The first consumer problem can be reframed as one where the consumer selects the goods necessary to minimize expenditure at a certain level of utility. This problem is illustrated as:

$$\text{Minimize } \ p \cdot q \qquad \text{s.t. } v(q) = u \ \text{ i = 1, 2, …, n.}$$

where u is the maximum attainable utility level. The solution to this problem yields the demand function:

$$q_i = h_i(u, p) \qquad \text{i = 1, 2, …, n.}$$

These demand functions are called the Hicksian or compensated demand functions, which show quantity purchased as a function of prices and utility, where the prices of other goods and the utility level are held constant.

The optimal quantities of goods demanded under the utility maximization and cost minimization problems are the same:

$$q_i = g_i(x,p) = h_i(u,p)$$

Consumers maximize utility by allocating income so that the extra utility or marginal utility (MU) obtained from spending the last dollar on each good is the same. The following result holds if utility is maximized:

$$\frac{MU_{q_i}}{pq_j} = \frac{MU_{q_j}}{pq_i}, \text{ for all i, j = 1, 2, …, n.}$$

The Marshallian and Hicksian demand functions are derived with a linear budget constraint and exhibit a set of theoretical properties:

- Adding-up: The total value of the Hicksian and Marshallian demand is total expenditure; the budget constraint holds as an equality.
- Homogeneity: The Hicksian demands are homogenous of degree zero in prices, and the Marshallian demands are homogenous of degree zero in total expenditure and prices; if income and prices double, there is no change in demand.
- Symmetry: The cross-price derivatives of the Marshallian and Hicksian demand are symmetric, for all i $\neq$ j, as shown by Young's theorem.
- Negativity: The n by n matrix of cross-price derivatives for the Hicksian demands (called the Slutsky matrix) is negative semi-definite; an increase in price with utility held constant results in demand for the good falling or at least remaining the same.

The Marshallian demand function and the Hicksian demand function are related via the Slutsky equation:

$$\frac{\partial q_i}{\partial p_j} = \frac{\partial h_i}{\partial p_j} - q_j \frac{\partial q_i}{\partial x}$$

The term $\frac{\partial q_i}{\partial p_j}$ is the uncompensated cross-price effect, which can be decomposed into a compensated price effect $\frac{\partial h_i}{\partial p_j}$ and an income effect $q_j \frac{\partial q_i}{\partial x}$. From the Slutsky equation it can be shown that the negativity property does not necessarily apply to

Marshallian demand functions. The own-price version of the Slutsky equation may be written $\frac{\partial q_i}{\partial p_i} = \frac{\partial h_i}{\partial p_i} - q_i \frac{\partial q_i}{\partial x}$. The own-price uncompensated effect may be positive or negative—while the compensated effect is negative, the income effect is positive and can outweigh the compensated effect.

The relationship between the utility maximization problem and the cost minimization problem are shown in the following diagram:

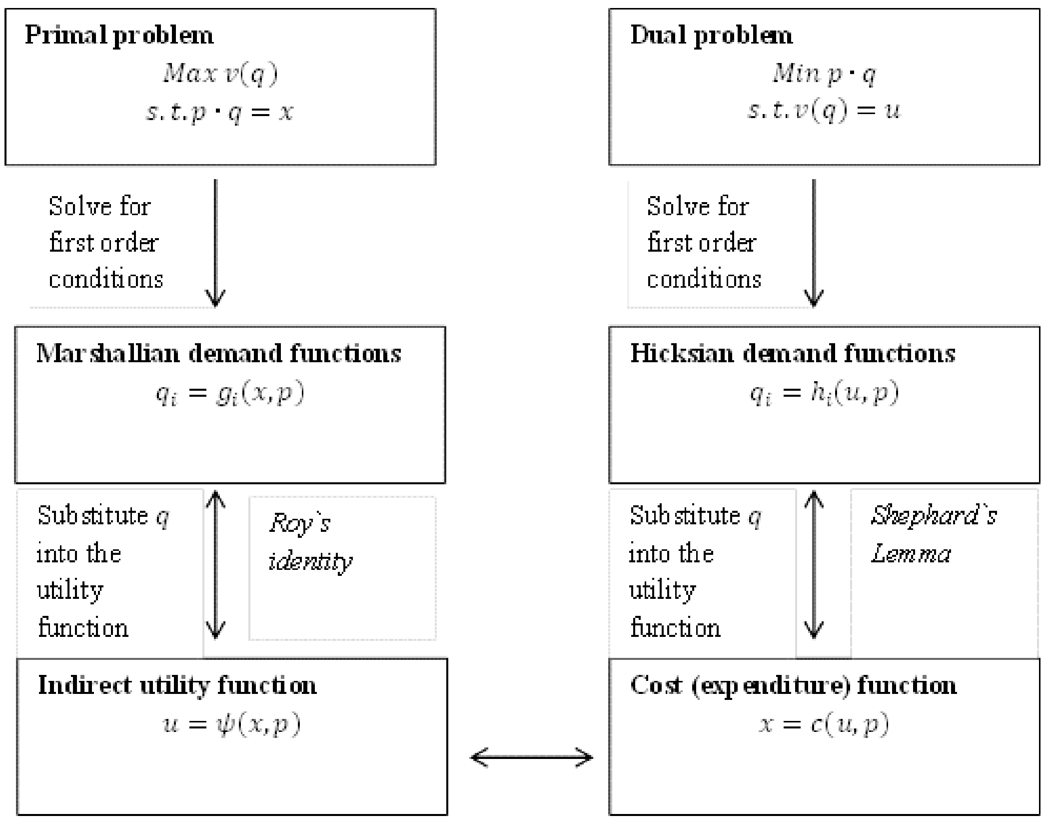

Figure 2-3 Consumer demand framework

Reference: (Deaton and Muellbauer 1980, p. 38).

By taking the derivatives of demand functions, economists can calculate elasticities, or measures in the responsiveness of demand for a good to a change in price of that good, another good, and total expenditure (or income). Elasticities are useful for economists because they are readily understood and dimensionless (Deaton and Muellbauer 1980). The formulas for the main elasticities of interest are:

Own-price elasticity: $e_i = \frac{\partial Q_i}{\partial p_i} * \frac{p_i}{Q_i}$

Cross-price elasticity: $e_{ij} = \frac{\partial Q_i}{\partial p_j} * \frac{p_j}{Q_i}$

Income or expenditure elasticity: $S_i = \frac{\partial Q_i}{\partial x} * \frac{x}{Q_i}$

where Q_i: quantity demanded of ith good, p_i: price of of ith good, x: total income or expenditure.

The own-price elasticity is a measurement of the percentage change in quantity demanded for a given percentage in price. Own-price elasticities are predicted to be negative; as the price of a good increases, the quantity demanded decreases. The Marshallian demand curve is 'elastic' if $e_i < -1$, 'unit elastic' if $e_i = -1$, and inelastic if $0 > e_i > -1$. Cross-price elasticities show the percentage change in quantity demand for a percentage change in price of another good. Positive cross-price elasticities indicate that the two goods in question are gross substitutes, and negative cross-price elasticities indicate that the goods are gross complements.

Expenditure or income elasticity is the percentage change in quantity demanded given a change in income or total expenditure. If $0 < S_i < 1$, the good in question is a normal good, where quantity demanded increases when income or total expenditure increases. If the percentage change in quantity is greater than the percentage change in income ($S_{ii} > 1$), the good is called a luxury. As income increases, the demand for the luxury good increases. If $S_i < 0$, the good is an inferior good, where quantity demanded decreases when income or total expenditure increases.

If prices are absorbed into the functional form of the demand function, the relationship is called the Engel curve, which can be specified as:

$$q_i = g_i^*(x)$$

The Engel relationship may be rewritten by multiplying the equation by p_i, which yields the equation $p_i q_i = p_i \cdot g_i^*(x)$, where p_i faced by all households is the same.

Unlike the Marshallian elasticity of demand, the elasticity of substitution, also known as the compensated or Hicksian elasticity, represents the change in consumption that would occur due to price changes only. The elasticity of substitution is a measure in the percent change in the quantity demanded of good i given a one percent change in the price of good j if the consumer is compensated for the price change—if the consumer's income remains constant while the consumer stays on the same indifference curve.

It is calculated as the percentage change of the ratio of two goods purchased, q_i and q_j, divided by the percentage change in the ratio of their marginal utilities (Hicks and Allen 1934). The larger the elasticity of substitution of good j for i, the more slowly the marginal rate of substitution of j for i increases, and thus the greater the ease with which the two goods may be maintained when substituting j for i (Allen 1967). The ratio of marginal utilities may be represented by the ratio of prices, since the two ratios are equal in equilibrium. The formula for elasticity of substitution is shown, as written by Pigou (1934):

$$\sigma_{ij} = \frac{\partial \frac{q_i}{q_j}}{\frac{q_i}{q_j}} \Bigg/ \frac{\partial \frac{p_i}{p_j}}{\frac{p_i}{p_j}}$$

Rewriting the formula in terms of substitution of good j for good i yields the same result; the measure is symmetrical for any pair of goods. A positive elasticity of substitution implies that the two goods in question are net substitutes, and a negative elasticity of substitution implies that the goods are net complements. Own-price elasticities of substitution are predicted to be negative.

Chalfant, Gray and White (1991) find cross and own elasticities of substitution to range between -0.586 and 0.331 for different meat types consumed in Canada.

Fousekis and Revell (2000) find elasticities of substitution of between -1.002 and 1.172 for different meat types consumed in the UK.

2.7.2 Household production model

While traditional demand analysis involves "goods" or "commodities" purchased in the market, the household production model shows that households may combine time and store-bought goods in order to generate final commodities for consumption while facing resource constraints for available income and time for production of goods (Becker 1965, Gronau 1977, 1986). The household utility function is based on consumption of final commodities Z; the utility maximization problem is specified (Gronau 1977). The consumer maximization problem in the household production model varies from the traditional consumer problem in that a time constraint is explicitly included in the specification.

$$Max\ U(Z)$$

$$s.t.\ \sum_{s=1}^{m} \pi_s Z_s = A + wT = S',$$

where π_s is the price of producing the ith commodity, A is income received from non-wage sources, T represents total time available to the household, w is wage rate, and S' denotes full income.

The maximization problem is solved to yield a commodity demand function:

$$z_i = g^i(\pi, w, A)$$

In terms of food demand, each food consumed may be viewed as a final good z_i, for which demand is based on the time and resources required to produce the good π, the wage rate of work in the market w, and the amount of non-labour income available A.

Pollak and Wachter (1975) suggest that it is possible to estimate the household's technology and the value of home-produced goods π and use the estimated commodity price in the demand estimation for z_i. In order to estimate a traditional Marshallian demand function, which shows the quantity of a good demanded by the consumer given prices and income, a few assumptions must be made about the household's production function, or its ability to convert store-bought goods and time to the home produced item (i.e. country food).

The production function must exhibit constant returns to scale and inputs must be used non-jointly (for the production of only one commodity) (Pollak and Wachter 1975). The unit cost of the *i*th commodity may be written:

$$\pi_i = C^i(P, w, 1),$$

where π_r is a function of only prices of the goods inputs (P) and time (wage rate w). Three methods may be used to estimate the marginal cost π of producing the home good: i) "direct estimation of the production function using data on inputs of goods and outputs of commodities," ii) the calculation of total or unit cost function which yield estimates of commodity prices at various configurations of goods prices, and iii) "constant output factor demand" which show the demand for goods as a function of goods prices and commodity outputs (Pollak and Wachter 1975, p. 261).

A difficulty of empirical estimation of demand for household commodities is specifying the form of π_i while fulfilling the conditions of constant returns to scale and non-joint production. One type of production function that exhibits constant returns to scale is the Leontief fixed proportion production function, as shown by Becker (1965): $\left.\begin{matrix} T_i \equiv t_i Z_i \\ x_i \equiv b_i Z_i \end{matrix}\right\}$, where b_i and t_i are, respectively, vectors of units of time market and goods necessary to produce one unit of z_i, and T_i and x_i are, respectively, the total quantities of time and goods required to produce one unit of z_i. A Leontief production function would imply that for a family with one firearm, for example, a fixed number of hours is required to harvest a specific number of caribou. The implication of this assumption may not be realistic—it is possible that increasing the number of hours spent on the land may lead to increased quantity harvested without any corresponding increases in investment in firearms. Pollak and Wachter (1975, p. 275) suggest that with a fixed coefficient production function, it is possible to use amount of household time as "a proxy for the output of the commodity" where "household time devoted to the production of [the commodity] is proportional to the household's output of [the commodity]". Hence, it is possible to specify fixed proportion production functions with either only time inputs ($\pi_{time} = wT_i$) or only capital equipment inputs ($\pi_{capital} = bX_i$) in production, where w is wage rate and T_i and x_i are, respectively, the total quantities of time and goods required to produce one unit of country food.

It is not unusual to specify the household production function with the cost of harvesting as a function of time only. It is often assumed in the literature that a household's land or capital is fixed in the short term, and that household time is the only input used in the production process with no substitution of goods for time (Gronau 1977, Singh, Squire, and Strauss 1986). In the notation of Gronau (1977), the unit cost of the commodity z_i may be modified and written $\pi_i = C^i(w, 1)$, where the cost of producing the household commodity is a function of time only.

While the discussion so far has focused on the demand function for home-produced goods, demand functions can also be written for the individual inputs used to produce final goods z_i. Pollak and Wachter (1975, p. 268) show that for z_i, the demand functions for inputs goods (x_i) and time (T_c) may be written:

$$x_i = h^i(P, w, A)$$
$$T_c = h^{Tc}(P, w, A),$$

where P is the price of other inputs, w is the price of time, A is non-labour income.

Pollak and Wachter (1975) point out that these demand functions exhibit the same properties as any other demand function for goods and leisure—they are homogeneous of degree zero in (P, w, A), satisfy the budget constraint, and also adhere to Slutsky sign and symmetry conditions.

Pollak and Wachter (1975, p. 268) explain that in the case where goods are separable from leisure, "total expenditure on goods is a function of all goods prices, non-labour income, and the wage rate; but the wage rate and non-labour income influence the demand for goods only through their influence on total expenditure." The demand functions for final home-produced goods z_i and inputs x_i and T_c may also be written in terms of full income S':

$$z_i = g^i(\pi, S')$$

$$x_i = h^i(P, S')$$

$$T_c = h^{Tc}(P, S').$$

Other specifications of the household production model have been shown in the literature. Huskey, Berman and Hill (2004) specify a household for Alaskan households, which face labour, leisure, and harvesting choices similar to those of northern Canadian households. Predictions from the model may be drawn from the specification.

The utility function is specified $U[h(t_h, x_h), x_c, t_l]$ and is maximized subject to constraints for total time $(t_h + t_w + t_l = T)$ and income $y \geq p_c x_c + p_h x_h$ where h: harvested goods, x_c: market consumption goods, x_h: market inputs in harvesting, p_c: price of consumption goods, p_h: price of market inputs to subsistence, t_h: time spent in harvesting activities, t_w: time spent in wage employment, t_l: leisure time, T: total household time, y: total cash income $(y = wt_w + g)$. w: wage rate, g: transfer earnings.

The constrained maximization problem is written:

$$\max V[t_l, t_h, t_w, x_h, x_c, \lambda, \mu] = U[h(t_h, x_h), x_c, t_l] - \lambda[T - (t_h + t_w + t_l)] + \mu[wt_w + g - p_c x_c - p_h x_h],$$

where λ and μ are Lagrange multipliers.

The first order conditions are written:

$$\frac{\partial V}{\partial t_l} = 0 = U_{t_l} - \lambda$$

$$\frac{\partial V}{\partial t_h} = 0 = U_h \frac{\partial h}{\partial t_h} - \lambda$$

$$\frac{\partial V}{\partial t_w} = 0 = -\lambda + w\mu$$

$$\frac{\partial V}{\partial x_h} = 0 = U_h \frac{\partial h}{\partial x_h} - p_h\mu$$

$$\frac{\partial V}{\partial x_c} = 0 = U_{x_c} - p_c\mu$$

Equating the first-order conditions yields the optimal allocation of time: $U_h \frac{\partial h}{\partial t_h} = U_{t_l} = U_h \frac{\partial h}{\partial x_h} \frac{w}{p_h} = U_{x_c} \frac{w}{p_c}$, where the terms represent the marginal utilities, respectively, from time spent in harvesting, time spent in leisure, time spent in work earning money to purchase harvesting equipment, and time spent in work to earn money for consumption goods. The household allocates its time among the four activities so that the respective marginal utilities derived from each activity are the same. A few predicted outcomes from the model are observed.

$$\frac{U_h \frac{\partial h}{\partial x_h}}{U_{X_c}} = \frac{P_h}{P_c} = w$$

$$\frac{\frac{\partial h}{\partial t_h}}{\frac{\partial h}{\partial x_h}} = \frac{w}{p_h}$$

$$\frac{U_{t_l}}{U_{x_c}} = \frac{w}{p_c}$$

$$\frac{U_{t_l}}{U_h} = \frac{\partial h}{\partial x_h}\frac{w}{p_h}$$

$$\frac{U_{t_l}}{U_h} = \frac{\partial h}{\partial x_h}\frac{w}{p_h}$$

Firstly, the wage rate w is equal to $\frac{U_h \frac{\partial h}{\partial x_h}}{U_{X_c}}$ and $\frac{P_h}{P_c}$, marginal rate of substitution and the price ratio of cash inputs in home production and market goods for consumption. The second condition indicates that the marginal rate of technical substitution (MRTS) which represents the number of units that market inputs have to be reduced by for every additional unit of time used so that output remains constant) between time inputs in home production and market inputs in home production ($\frac{\frac{\partial h}{\partial t_h}}{\frac{\partial h}{\partial x_h}}$) is equal to the price ratio between time and price of the market inputs ($\frac{w}{p_h}$). At equilibrium, the marginal rate of substitution of time in leisure and cost of market goods for consumption is equal to the ratio of the wage rate and price of consumption goods $\frac{U_{t_l}}{U_{x_c}} = \frac{w}{p_c}$ and that the marginal rate of substitution of time in leisure and time in harvesting is equal to the ratio of wage rate and price of market inputs, multiplied by the derivative of the home-produced good with respect to the price of the market inputs ($\frac{U_{t_l}}{U_h} = \frac{\partial h}{\partial x_h}\frac{w}{p_h}$).

The indirect utility function is found by substituting the optimality conditions into the utility function and may be written $W(w, g, p_h, p_c, T)$. Therefore, the demand function for harvested wildlife and plants may be specified $Z(w, g, p_h, p_c, T)$ and the demand for store-bought goods may be specified $x_c(w, g, p_h, p_c, T)$. However, the partial derivatives of the demand functions with respect to each of the terms, which show individual responses to changes in economic conditions such as increased government transfers, changes in prices or wages, cannot be predicted, as in the case of the traditional consumer model (without household time), unless the production functions for each commodity with respect to time and goods and the individual's utility function are known. As an example, consider the cost of time, which is approximated by the wage rate w.

If w increases, it is predicted that the individual would substitute time-intensive commodities for goods-intensive commodities, since all commodities are produced with some combination of goods and time (Becker 1965). With an increase in wage rate w, the cost of any unit of t_h would increase relative to the cost of any unit of x_h. If the individual were to produce the same quantity of home commodity, it must substitute t_h with x_h and produce at a different part of the production isoquant, where the MRTS equals the ratio $\frac{w}{p_h}$ where w has increased.

Simultaneously, leisure time x_l has also become relatively expensive, so the individual may substitute leisure with x_c or increase production of h by increasing inputs t_h with x_h, where the marginal utilities from the last dollar spent on all the inputs are the same. Since w has also led to increased total income y, an income effect may occur that will lead to increased consumption of all commodities.

In a model where the only input in home production is time, such as that specified by Gronau (1977), the substitution effect has negative effects on demand for leisure and demand for home-produced commodities, while the income effect leads to increased overall consumption of commodities that is allocated to leisure and market goods (rather than home-produced goods). In a model with two specified inputs, where time and market inputs are included in the home production function, the net effect of wage rate increase on the final demand for x_l, h, and x_c is determined by the magnitudes of the income and substitution effects. If an individual does not participate in the labour market, the model would suggest that the marginal product of home production exceeds the wage rate.

In the household production model, changes in production may be caused by a change in the relative productivities of inputs or a shift in the production function. Most specifications of the model are predicated upon the assumptions that home commodities and store-bought commodities are perfect substitutes and that individuals do not derive utility directly from spending time either in employment or home production (Gronau 1977, 1986, Huskey, Berman, and Hill 2004). Both individual- and community-level factors may affect individual production functions; individuals may have varying physical capabilities and at the community-level, wildlife availability and access to wildlife may differ. Berman (1998) includes harvesting knowledge and exogenous household and community demographic factors as arguments in home production function.

2.7.2.1 Implications of the household production model

Individuals may not readily be able to substitute time on the land for work in wage employment or vice versa in the short run. In the previous versions of the household production model described, households can switch between working at home to spending time in harvesting, and the opportunity cost of time is valued at the wage rate. If individuals are readily able to change their employment schemes, then the short run decision of how much home production to conduct (how much country food to harvest) is conditioned on long-run labor choices.

Bockstael, Strand and Hanemann (1987, p. 296) state "the daily and seasonal recreation choices about which we collect data and develop models can reasonably be treated as short-run decisions conditioned on longer-run labour choices." The basic model may not be realistic in the short term because harvesters are reportedly constrained in employment structure: hunters in Inuvialuit communities have expressed desires to get out on the land, but felt constrained by weekday work and report only being able to hunt on weekends and holidays (Condon, Collings, and Wenzel 1995, Todd 2010). Huskey, Berman, and Hill (2004) indicate that if individuals cannot readily enter the labour force, total income y may enter the utility function along with wage rate, as individuals may make choices to move so that they may seek wage and non-wage income opportunities in other locations.

In modeling decisions of the quantity of recreational services and other commodities to consume, Bockstael, Strand and Hanemann (1987) illustrate a modified budget constraint where an individual may work at a primary job at wage for a fixed work week of forty hours, not work in the market, or work at a secondary or part-time job which pays a lower wage than a full time job. At any interior solution, the individual is assumed to be at an interior solution where he or she may marginally adjust work time so that equal the marginal rate of substitution between goods and leisure. Two different demand functions are derived from this model. In one model, goods may not be substituted for time, and the time and money constraints may not be combined; in the other, which is an interior solution, the individual may trade time for money at the margin in discretionary work, and time spent in additional work is endogenous.

Bockstael, Hanemann and Strand (1987) suggest that both demand specifications may be estimated empirically with data on time and money costs for recreation, individual work time, access to discretionary work and the wage rate for discretionary work, if it is available. However, the authors suggest that if there are separate time and resource constraints and hence two unique constraints, is it not feasible to estimate a Marshallian demand function and derive the expenditure function to measure consumer surplus and arrive at a unique money measure for recreational benefit, since the individual consumes demands fewer commodities (recreation and other goods) than the number of constraints. A single resource that includes time and monetary resources implies that the individual can enter and exit the labour market without costs, and also that the individual values additional employment at the wage rate. The authors point out that when the individual does not participate in discretionary work, and cannot change employment status, the marginal value of the individual's time in alternate activities is not equal to the wage rate he faces. Bockstael, Hanemann and Strand (1987) suggest that the marginal value of time is not zero, but rather that the opportunity cost is not equal to an observable parameter.

Gronau (1986) suggests that the shadow price of time, the cost of a marginal unit of time spent in home production, for a non-employed individual is assumed to not be observable, though he suggests that the value is greater than the wage rate since the individual would participate in the labour market otherwise. Bockstael, Hanemann and Strand (1987) suggest that this case may not be accurate with institutional restrictions on work; an individual may choose unemployment even if the marginal wage rate is lower than the marginal product of leisure if he or she is worse off accepting forty hours of work in a fixed work week. On the other hand, individuals who choose to be employed may gain more utility from a marginal unit of leisure than the value of the wage at a full-time job, but would rather choose forty hours than no hours—the individual would rather choose a fixed work week than an alternative job where the wage may be less than the full-time wage.

Therefore, while it is supposed in the basic household production model that individuals may value the marginal cost of time at the wage rate, and data on individual on wage rates or employment income may be recorded in surveys, the assumption may not be realistic. Measures aside from the wage rate has To estimate the demand for recreational sport-fishing trips, McConnell and Strand (1981) estimate opportunity cost as annual family income multiplied by some proportion *k*, where *k* is estimated, for a given travel site, as a function of out-of-pocket trip costs and time spent valued at average income per hour.

Cesario (1976, p. 34) suggests that opportunity cost should be valued, in the recreational trip context, as the "value of time saved," the amount an individual is willing to pay to save time spent traveling. Cesario (1976), however, suggests that estimating opportunity cost for travel time is not feasible without data on the relative value of leisure and work activities. The value of time saved is explained as the difference between the "commodity value" of time, the value of time in its existing use, and the "scarcity value of time," the value of time in its best alternative use (Wilman 1980). Wilman (1980) values time spent at a recreation site as the "scarcity value" and time spent in travel as the "value of time saved," both of which are derived with survey data on out-of-pocket costs for traveling and being on-site. To estimate the time component of travel cost to recreation sites, Smith, Desvouges and McGivney (1983) suggest that multiple time constraints that account for the respective amounts of time in a day that can be allocated to recreational time and non-recreational time should be modeled. They found that using only predicted wage rates in measures of opportunity cost were not appropriate for recreation sites where on-site time was a significant determinant of demand. In the case of opportunity cost of time spent harvesting country food, data on individual characteristics and time spent in alternative activities would be required to predict individuals' opportunity cost of time if it is assumed that individuals may not easily enter and exit the labour market.

2.7.2.2 Empirical analysis of the household production model

Stabler (1990) adapts a household production model framework specified by Gronau (1977) to determine the impact of wage changes on the time spent in traditional harvesting on adult males in the Northwest Territories. In this model, an increase in the wage rate is not hypothesized to affect the allocation of time of the non-employed but should reduce the time of home work by the employed. The effect of a change of the wage rate on the leisure time chosen by an employed individual depends on both income and substitution effects—the increase in wage rate increases the opportunity cost of being on the land and may lead to a substitution of time spent on the land to time spent in employment, while an increase in wage rate increases overall income that leads to an increase in overall leisure time. It is also hypothesized that those with a lower probability of obtaining a full-time job will reduce participation in harvesting at a lower rate than those with full-time jobs, given a wage rate increase.

As in the Becker model, this model involves making the assumption of non-joint production—time in harvesting and leisure are valued separately by the individual, and the perfect substitutability of home work and market work (or home-produced and market goods). With 1984 Northwest Territories Labour Force Survey Data, Stabler (1990) compares the percentage of Aboriginals participants and non-participants in traditional activities by age, education, and employment status. It was found that harvest participation for people without jobs was substantially higher than for those with jobs, while increased education resulted in increased participation in the wage economy.

Kerkvliet and Nebesky (1997) estimate an econometric model based on household production theory for Inupiat households in Alaska with census data. The utility function is a function of home-produced meals, which is in turn a function of cooking fuel consumption, store-bought grocery consumption, shopping time, ammunition, time spent in camp chores, and whale butchering and distribution. The authors are concerned with the opportunity cost of time spent in harvesting; the dependent variable of the study is the response to the question “During the last twelve-month period, did you spend MORE TIME, about the SAME TIME, or LESS TIME engaged in subsistence activities, than you did at your job?” Time use is not measured discretely; the model estimates the impact of determinants of probabilities of the TIME dependent variable in an index function framework.

The authors test the hypotheses of whether or not labour force efforts are complements or substitutes for subsistence harvests—whether a discrete change to jobless status affects subsistence efforts, and whether or not the number of months worked is exogenous to subsistence participation. If the number of months worked is exogenous to subsistence participation, the data would conform with Becker’s recursive model, where the household makes it labour supply decisions first, and then allocates its subsistence and leisure time. The authors found that the number of months spent working appears to be exogenous to time spent in harvesting—the household makes labour market decisions first and then allocates time to harvesting and leisure.

Berman (1998) employs Alaska North Slope Census data along with detailed harvest records from 100 households across 8 villages. It is found that total household income has positive impacts on i) amount of meat and fish consumed that is from the household’s own harvest, and ii) the total household meat and fish harvest. It is found that increased wage rate has a negative impact on i) average months not working per adult in the household (time available for harvesting), ii) total household members’ hunting and fishing days, and iii) total household members’ caribou hunting days. Increased household income also has a negative impact on percent of meat and fish harvests given away to other households.

A few studies have explored the implications of employment on harvesting behaviour, though not with reference to formal economic household model specifications. Kruse (1991) has found that over a decade of dramatic increases in wage employment participation, harvesting levels in the North Slope of Alaska have actually increased. Wenzel (1983) conducted interviews with Inuit who chose to work outside their communities at a new mine site in Clyde River, NWT, in 1976, finding that many individuals were interested in working to earn income to purchase equipment for harvesting. Condon, Collings and Wenzel (1995) found that those employed individuals are more likely to be active harvesters than those who are not employed. In Paulatuk in the Inuvialuit Settlement Region, Todd (2010) found that those involved in wage employment expressed a desire to harvest more and report being restricted by work schedules. Full-time employees reported that time spent in work creates a barrier for harvesting activities. At the same time, non-employed individuals reported that not having money to purchase equipment prevents participation in harvest activities.

2.7.3 Collecting store price data

Empirical estimation of demand functions, as proposed in this present thesis analysis, necessitates collection of prices. This section involves explanation of methods of price data collection or computation techniques, with details on how prices may be constructed in a manner theoretically consistent with the basic consumer and household production models previously described.

Data on prices may be collected in the individual or household survey, or may be collected separately, either from a price survey conducted by the researcher or taken from government-published price statistics. Government or community-level price statistics have been used in analysis in conjunction with dietary recall data, where price data is not often collected in the individual survey. Guo et al. (2000) applied Chinese state store and published government prices and deflated them to 24-hour recall data in order to calculate price elasticities for 6 food groups. Darmon, Briend and Drenowski (2004) matched national French government prices to dietary data items to estimate the relationship between diet costs and energy density. Cade et al. (1999) matched prices from national food price data and a store shopping catalogue to foods reported in FFQs conducted in the UK in order to determine the association between a healthy diet and food expenditures.

A potential disadvantage to using prices collected in regional or urban surveys is that the prices may not useful for analyses for rural parts of a country where there is great spatial variation in prices (Deaton and Grosh 2000). Additionally, using regional price indices involves the assumption that households actually pay prices that are listed in the index. There are instances where households may not report prices of some items, and where a community-level price list may be useful in obtaining prices of the missing items (Deaton and Grosh 2000).

At both the household- and community-levels, there may be problems obtaining market prices for goods produced in the household, obtained at local markets, or shared with other families. Price data may not exist if the market is not well developed, and haggling or bartering may influence the price (Deaton and Grosh 2000). Prices for these "non-market" goods may be calculated by other methods.

In northern Canada, regional-level prices are collected for isolated northern communities. The Revised Northern Food Basket is a special price survey conducted in 2006-2008 in 8 communities in Newfoundland and Labrador (along with 3 entry points/supply centre communities), 11 communities in Nunavik (along with 3 entry points/supply centre communities), 3 communities in the Côte-Nord region of Quebec (along with 1 entry points/supply centre), 9 communities in Ontario (along with 7 entry points/supply centres), 5 communities in Manitoba (along with 2 entry points/supply centres), 13 communities in the Baffin region of Nunavut (along with 3 entry points/supply centres), 7 communities in the Baffin region of Nunavut (along with 3 entry points/supply centres), 7 communities in the Kivalliq region of Nunavut (along with 3 entry points/supply centres), and 5 communities in the Kitikmeot region of Nunavut (along with 2 entry points/supply centres), 3 communities in Saskatchewan (along with 3 entry points/supply centres), 10 communities in the Northwest Territories (along with 4 entry points/supply centres), and 1 community in Yukon Territory (along with 1 supply centre) (AANDC 2008). The basket contains priority perishable foods for a family of four.

While the price of the Revised Northern Food Basket may reflect relative costs for households in different communities, there are no published prices for individual foods or individual food groups. Thus, prices for individual foods are not available for this study. Campbell (1997) suggests the Northern Food Basket is an incomplete reflection on food availability because it does not incorporate country food. The Regional Inuit Food Basket, which included country foods, was developed by the federal government, but is no longer published (INAC 2007). Prices for country food must be estimated; methods are discussed in the following section.

2.7.4 Estimating the significance of harvested food in the diet

"In an economic world there would be no need to measure these [environmental] values because a set of institutional arrangements would exist that would reveal their value. In a somewhat less ideal world it might be possible to identify the values of environmental quality changes through market transactions" (Grafton et al. 2004). Economic values are values "assigned" by humans to indicate the relative importance or worth of objects (Brown and Burch 1992). From the introductory Economics course it is learned that the equilibrium price, which is an economic value, is based on the intersection of a consumer's willingness to pay for a good and the supplier's marginal cost of producing the good. The market price is often an estimate of the marginal value of a good, or the value of an extra unit in availability of the good.

The establishment of commercial markets for country foods means that commercial prices for country food may be available. In recent years, regional and Aboriginal entrepreneur groups have encouraged the development of commercial caribou and related agri-processing industries in the communities of

Ranklin Inlet and Coral Harbour in Nunavut (Mason, Dana, and Anderson 2007). Kivalliq Arctic Foods (KAF) and the Coral Harbour Development Corporation have developed systems for quality assurance and branding of caribou products with the aim of fostering the regional economic self-reliance and employment. The caribou was sold in to upscale hotels and restaurants in western Canada through 20-30 distributors and exported to the United States and European Union (Mason, Dana, and Anderson 2007). Price comparisons between the marketed caribou and New Zealand deer, with data from a presentation by Kivalliq Arctic Foods at a 2001 Native Investment and Trade Conference, are shown in Mason, Dana, and Anderson (2007). Prices range from $8.51/kg for caribou hips to $19.55/kg for caribou strip loins.

Despite legislative restrictions on the sale of country food in Nunavik, the Makivik Corporation (the regional Inuit development agency) and the government-sponsored Hunter Support Program have successfully marketed country food (Gombay 2006). Under the Nutrition North Canada Program, a federal subsidy is available for commercially-produced country foods shipped by air and produced by any of three approved country food processors: Kitikmeot Foods in Cambridge Bay, NU, Kivalliq Arctic Foods in Rankin Inlet, NU, and Pangnirtung Fisheries Limited in Pangnirtung, NU (AANDC 2011a).

Despite the existence of commercial markets for country food, it may not be practical in many situations to use prices of marketed wildlife for economic analysis. Brown and Burch (1992) state difficulties in relying on commercial prices: i) commercial markets do not exist for many species, ii) if a hunter has a commercial permit and a subsistence permit for hunting, it is difficult to ascertain the quantities allocated to each category, iii) commercial sale may be difficult to distinguish from sharing or bartering.

Market prices for exported goods or goods sold in stores do not provide an accurate reflection of wildlife to local and community members, and therefore may not be very useful in economic estimates unless communities have highly developed institutions for commercial country food exchange. Brown and Burch (Burch 1972) state that "cultural values" such as self-reliance, closeness to nature, and kinship are widely considered held values that are not reflected in economic values but argue that economic values, when properly measured, should reflect all factors involved in an individual's choice. However, they also note that when value is measured in willingness to pay, the accuracy of the estimate is contingent on a certain income distribution (participants are not severely income constrained) and also on the fact that economic exchanges do not reflect impacts from resource changes which is likely applicable in the case of subsistence economies.

2.7.4.1 Substitution cost, input, and output methods

When market prices are not available for a good, the "substitution cost" method and the input and output methods have been used to impute prices. Usher (1976) defines "substitution cost" as the price of a similar market good and usually refers to the case where an environmental good must be replaced by a store-bought good. "Substitution cost" is only relevant in the case where the home or family-produced good is seen to be replaced by a good similar but not identical to the home-produced good, as a market price may exist for the home-produced good. Two approaches to exogenously assign values to non-market goods are: the input approach, where commodities are valued by the land, labour, or capital inputs used in their production and ii) the output approach, where commodities are valued by the price of a similar good in the market (Harvey and Mukhopadhhay 2005).

The output approach has been used to value home-produced or family goods in industrialized countries (e.g. Kinnucan and Sexauer 1978, Caillevet, Nichele, and Robin 1998), agricultural households in developing countries (e.g. Barnum and Squire 1979, Strauss 1984, Delforce 1994) and also in non-agricultural subsistence households. Usher (1976) notes that in Canada, official government records listed values of home-produced goods, where values were represented by price the farmer would have received had the product been sold. This method is more appropriate for developing countries where there are well-established markets for heavily traded commodities like rice and grains or there are nearby local markets.

The "input" method of imputing the cost of country food items involves estimating production cost π, as it has been defined previously in the discussion of the household production model. Methods of estimating π were suggested: computing input or output values for goods from the market, aggregating the costs of equipment used in home production, or estimating the production function of households to derive the prices of harvested animals, other method.

The input method has been used to estimate household demand for home-produced and store-bought goods. The costs of producing home vegetables and the cost of hunting or distance to hunting site are mentioned by a few authors (Caillevet, Nichele, and Robin 1998, Shively 1997, Wilkie and Godoy 2001), but data on household equipment costs are not collected in these studies. In the agricultural literature Delforce (1994) includes an equation for land size and land rotation constraints in an estimation of the household production model. Lau, Lin and Yotopoulos (1978) include costs of fertilizer in their demand system estimations.

The methods suggested previously for estimating input costs of product for home-produced goods are revealed preference methods, where the preferences of consumers are determined by their actual purchases. Revealed preference methods are distinct from stated preference or contingent valuation methods, where preferences are assessed by surveys that contain questions about individuals' "willingness to pay" (e.g. Hanley, Wright, and Adamowicz 1998). Stated preference methods have also been used to "obtain an estimate of the welfare derived from utilizing outdoor recreation resources" (Kealy and Bishop 1986).

Another method of estimating input costs of producing home goods is the travel cost technique, which is a revealed preference method that involves using costs of gaining access or traveling to the site of a non-market resource to obtain a proxy for its market price. The travel cost model involves the assumption that people will make repeated trips to a site in a given season until the value of the last trip is equivalent to the travel costs. The value of the site is estimated with information on how often people visit the site from different distances, and is calculated with the value of all trips, not just marginal ones. To calculate a "price" or "value" per unit of visit, data is needed on number of trips a person takes to the travel site, travel cost (including equipment costs) or entrance fee. Number of trips is usually measured in days (Adamowicz and Phillips 1983). The utility model underlying the travel cost model is the Random Utility Model (RUM) (See Grafton et al. 2004 for full explanation).

Cesario (1976) suggests that studies that only account for the "money" costs of the trip and not the "time costs" are biased, but suggests that there are empirical problems in valuing travel-time; time costs are "highly subjective, varying from individual to individual and from situation to situation" and travel time and travel distance are "usually so highly correlated that it is impossible to distinguish empirically between their separate effects." He suggests that travel time is incorporated in "ad hoc" and "highly arbitrary" ways.

While some empirical studies have added opportunity costs of travelling time to out-of-pocket costs used in travelling to outdoor recreation sites (Cesario and Knetsch 1976, Bishop and Heberlein 1979, Smith, Desvousges, and McGivney 1983), other studies consider only distance and opportunity costs (Berman and Kofinas 2004, Bockstael, Strand, and Hanemann 1987, Emmert 1999, McKean, Johnson, and Walsh 1995). Other studies have added out-of-pocket costs to time and distance measures. Adamowicz and Phillips (1983) use a hedonic approach, estimating days of recreational fishing demanded as a number of fish caught per season, capital expenses, quality and total income. Hagerty and Moeltner (2005) use variables on travel distance and travel time, as well as out-of-pocket automobile use costs, to estimate the demand for recreation sites.

McConnell (1975) suggests that the valuation of travel time should vary by whether the recreationist could have worked for pay during the period of the recreation visit or chosen the number of hours he or she worked. Opportunity time is often measured as functions of individual incomes or wages. As stated in section 2.7.2.1, employment income may not be an appropriate measure of marginal cost of time for individuals who do not participate in the labour market. Bockstael and Strand (1985, as cited in Bockstael Hanemann and Strand 1987) suggest that compensation for a recreational good may be measured as time or money, or any combination of the two.

A travel cost model that measures days spent on the land is applied to data from Alaska and Northern Canada by Berman and Kofinas (2004). With the assumption of random utility, it is possible to measure household welfare—the compensating variation (CV) measure—implied by a change in the timing of freeze-up and differences in work patterns. The definition for compensating variation is as follows: "given a change in prices, CV is the welfare measure of the amount an individual would need to be compensated to maintain the original level of utility. This measure is the change in income needed to make a person as well off as they were before the change" (Berman and Kofinas 2004). The authors choose to measure compensating variation in terms of units of time instead of money because of the importance of the mixed economy in the community. Therefore this study considers the demand for harvesting in "days" and then converts this to opportunity cost based on an assumed value for foregone daily income.

Without widely developed markets for country food across northern communities, the output method may not be appropriate for assigning prices to country foods in the present analyses. The travel cost model may not be employed without specific survey data. Input cost calculation may be specified with a household production framework, and methods employed in this study will be discussed in the next chapter.

2.7.5 Consumer demand for nutrients and dietary quality

While understanding factors affecting the consumption of different types of foods is useful, the consumption patterns for individual types of foods may not be illustrative of individual- and household level food security status across communities. Nutrient measures of dietary adequacy have often been used to assess whether or not individuals are food secure, particularly in terms of the 'adequacy' component of food security. An economic framework based on utility theory may be used to explain how individuals' intake of various nutrients such as calories maybe related to individual characteristics such as employment activity and monetary resources. In this study, as mentioned, it is also of interest to determine the influence of caribou consumption on diet quality and food security indicators. A theoretically consistent way to estimate demand for individual nutrients or units of energy, such as calories, must be identified.

Demand for commodity q_i, the traditional Marshallian demand equation derived from consumer theory $q_i = f_i(p, y)$, where q_i is the consumption of the ith commodity, p is a vector of prices, and y is consumer income. The demand for calories is shown by the relationship $N = \sum_j a_j q_j$, where a_j represents the quantity of nutrients contained in each unit of commodity q_i (Nayga and Capps 1994). By substituting the demand equation into the nutrient equation, the nutrient consumption function is written as $N = g(p, y)$ (Devaney and Fraker 1989, Nayga 1994, Nayga and Capps 1994). This equation has been estimated for calorie demand with prices specified as prices for a single food, such as rice, which serves as a proxy for community prices (Ravallion 1990), a price index (Thomas and Strauss 1992), or prices for specific food groups (Behrman and Deolalikar 1987). Basiotis et al. (1983) estimate demand for different types of nutrients, where weekly availability of a nutrient is regressed on income and other household characteristics and the equations are estimated simultaneously.

Assuming that prices are constant in a cross-sectional data set, the consumption equation for a specific nutrient may be specified $N_i = h_i(y_i, S)$, where N_i refers to the intake of a certain nutrient by individual i, y_i is the income level of the individual i, and S is a vector representing socio-economic and demographic characteristics. Various authors estimate this Engel function for various micronutrients (Devaney and Fraker 1989, Nayga 1994, Nayga and Capps 1994, Fernando 2010) as well as calories (Timmer and Alderman 1979, Ward and Sanders 1980, Wolfe and Behrman 1983, Behrman and Wolfe 1984, Behrman and Deolalikar 1987, von Braun, Puetz, and Webb 1989, Ravallion 1990, Bouis and Haddad 1992, Bouis, Haddad, and Kennedy 1992). Since the intake of calories is of interest for determining individual or household food security status (as discussed earlier in this chapter), a single equation for calorie intake may be estimated.

Bouis, Haddad and Kennedy (1992) compare the results from elasticity estimates using food expenditure data (with food purchases converted to caloric equivalents) and with caloric data from 24-hour recalls, and found that calorie-income elasticities were much higher when estimated with food expenditure data. This has been attributed to measurement error with calculating food consumption from food expenditures and also to the fact that food expenditure diaries do not discount food given away or not consumed by the household members themselves. They suggest that dietary recalls may be more appropriate for estimating calorie-income relationships than using food expenditure surveys that measure food intake indirectly (only by expenditure).

Another measure of objective dietary quality may be used to assess food security. As mentioned earlier in this chapter, aside from individual nutrients, food pattern indicators are another way to assess dietary quality and also reflection of consumption of final food items. The relationship between dietary diversity and food expenditures must be considered. Drescher (2007) suggests that although traditional theory might imply an inherent preference for diversity in that individuals might demand additional goods offered to them, it is also suggested that with homothetic preferences, an individual might not demand additional types of goods. In the case with homothetic preferences, the relative quantities of any two goods will depend on relative prices—an increase in income will result in increases of both types of goods and not necessarily an increase in the number of different types of goods consumed.

Drescher (2007) describes other theories that suggest that increased food expenditures may lead to increased demand for dietary diversity. Jackson's (1984) theory of hierarchy suggests that as income increases, individuals' needs change as income increases; the degree to which individuals change their preferred bundles changes according to relative prices, but also to the fact their needs change at different incomes. The utility maximization by Jackson (1984, p. 9) is written:

$$Max\ u(q) = u(q_1, \dots, q_n)$$

$$s.t. \sum_j p_j = y$$

$$and\ q_j \geq 0,$$

where p_j is the price of the jth commodity and y is income.

The optimality conditions are stated (Jackson 1984, p. 9):

$$q_j \left(\frac{\partial u}{\partial\, q_j} - \lambda\, p_j \right) = 0\ for\ all\ j$$

$$\frac{\partial u}{\partial\, q_j} - \lambda\, p_j \leq 0\ for\ all\ j$$

The Marshallian demand functions may then be written:

$$q_i = q_i(p, y)$$

For given prices and income, the number of commodities demanded may be written:

$$M(y) = \{(i|q_i(p, y))\}$$

If an additive preference function is assumed, the condition $u(q) = \sum_j u_j(q_j)$ holds, so the second optimality condition above may be written:

$$\frac{\partial\, u_j}{\partial\, q_j} - \lambda\, p_j \leq 0\ for\ all\ j.$$

Jackson (1984) points out that $\frac{\partial u_j}{\partial q_j}$ is a decreasing function of q_j, and q_j is a monotonically increasing function of y. The extension from this is that the cardinality of M must be a monotonically increasing function of y. Therefore, it is predicted that with an increase in income, an individual will demand greater diversity in goods.

A problem with this model is that the number of goods demanded increases with income at a decreasing rate, and the demand for a good depends on its hierarchical position (Drescher 2007). Behrman and Deolalikar (1989) suggest that the curvature in individual indifference curves may differ across individuals and that as income increases, individuals may substitute lower-cost calories for higher-cost ones. This is illustrated in the fact that calorie elasticities are often smaller than food elasticities in developing countries (Drescher 2007). Food variety is explained to be related to the degree of curvature and centrality of location of indifference curves, where relative flat indifference curves located close to the axis indicate that low-cost calories are demanded at low incomes (Drescher 2007).

Grossman's (1972) model of health demand suggests that as consumers' income increases, they may allocate more resources to their health. If dietary diversity is a measure of healthy eating, an increase in income may lead to increased demand for health if it is viewed as a normal good. As Drescher (2007) notes, a criticism of Grossman's model is that illustrates a lower demand of health than may be realistic, because it involves the assumption that the consumer is fully informed about his depreciation rate.

2.8 Summary and proposed analysis

This chapter has involved discussion of the literature on different aspects of food security in northern Canada. Different methods of collecting data—dietary surveys, economic consumption and expenditure surveys, and special food security and living conditions surveys have been historically used to measure elements of food security, and have been used by researchers to assess food security in northern Canadian communities.

It has been reported that caribou is a leading food in harvest studies and in dietary recall studies. In every community for which data is available from published studies, caribou has been found to be among the top 5 species consumed from lists of country food species. Harvest numbers for caribou and other animals have also been found to be generally declining. Households in different regions in the North also harvest different quantities of country species—coastal regions consume a higher quantity of sea animals and thus may be less reliant on land animals like caribou. There has also been evidence of dietary change in the northern Canadian territories—households are moving away from consumption of country food and consuming higher quantities of store-bought foods.

The impacts of changes in socio-economic factors, such as employment status and income, on the harvest of caribou and other country foods have been investigated in both quantitative and qualitative studies. For example, employment has been shown to impede harvesting efforts due to increased time constraints, while lack of income has been shown to also lead to difficulties in purchasing equipment. Thus far, however, studies have not specifically addressed how households may trade off country food for store food in the event of a change in availability of country food or caribou, specifically.

In the two-good version of the household production model, where the household is assumed to use both time and store-bought inputs in harvesting, households may trade off time in harvesting for time in work, and vice versa. The theory does not allow for clear predictions of the impact of increased wages or differential impacts wage and non-wage income on amounts of caribou and other country foods consumed, unless more information on the household's economic value of country food is available. This framework, however, has empirical applications because it implies that the cost of producing country food may be estimated.

Among data sources used to examine food security in northern Canada and the relative importance of different types of foods, dietary data has been widely used, and are available for use in this study. This data set, however, has limited information on individual and household characteristics, such as whether or not individuals participate in harvesting. The Aboriginal Peoples Survey is a source of data that contains data on participation in harvesting, and also consumption of country meat and fish. Analysis of demand equations for harvest participation country food consumption with this data set may further elucidate the potential impacts of socio-economic characteristics and economic factors, such as employment and income, on household ability to obtain country food.

While it is of interest to examine what socio-economic characteristics may influence harvest participation and consumption of caribou and other foods, the potential impacts of a change in caribou consumption on individual diet quality should be also be investigated, since these impacts might influence overall community health. From past dietary studies, caribou has been found to a significant contributor of energy, protein, and iron in the diet. The contribution of caribou to individual diet quality when individual characteristics and total food expenditures are accounted for, however, has not been thoroughly investigated.

Calorie intake has been used as an indicator as a broad indicator of food security in developing countries. Presently, a calorie-expenditure relationship may be modeled, as this relationship represents energy intake, a single aspect of diet quality, and more broadly, food security. Since caloric intake may not reflect other aspects of diet quality—intake of important nutrients, a food pattern indicator may also be implemented to determine the impact of caribou on diet quality. Food pattern indicators have been linked to positive physical outcomes in individuals and may be implemented for the dietary data. Specifically, a dietary diversity score measure is developed and a demand equation for dietary diversity estimated, again to help understand the role of caribou consumption in the attainment of a higher quality diet.

The next chapter will outline the theoretical assumptions adopted for the estimation of demand equations for country and store-bought foods, demand for time in harvest participation and for meat and fish (as a group), and demand for calories and dietary diversity. Empirical specification of models and econometric methods employed will also be discussed.

From the dietary studies examined, it is also noted that data on caribou consumption is not published uniformly for all regions across the North. Recent harvest study data has been carried out under land claim agreements in a few areas. Based on the secondary available for this study, statistical analysis may be carried out to make predictions on relative consumption of caribou in all communities across the North. The methods and results employed in this analysis are described in Chapter 6.

Chapter 3 Methodology

3.1 Introduction

The theoretical motivation for the analysis was discussed in the previous chapter. This section will involve discussion of the available data and empirical methods of estimating i) a demand equation model, ii) a calorie intake and dietary diversity model, and iii) harvest participation models and a model for proportion of country meat and fish consumed.

3.2 Theoretical framework

3.2.1 Household production model and the issue of separability

The first thesis objective was to examine the impacts of individual- and community-level demographic and economic factors on types of food consumed. This analysis will follow a traditional economic utility maximization framework where the individual seeks to maximize utility subject to a set of constraints. In northern Canada, there is evidence from the existing literature that country foods produced by the household through harvesting comprise an important part of the diet. In the household production model, an extension of the traditional consumer model, home-produced goods are viewed as final goods to be consumed by the household, where their market prices may be represented by the cost, either in time or goods or both, to produce them.

As explained in Chapter 2, empirical estimation of the price of producing country food π involves the adoption of certain theoretical assumptions. Traditionally, home-produced commodities and store-bought commodities are valued as perfect substitutes and individuals do not derive utility directly from spending time either in employment or harvesting. Time in harvesting is viewed as an input for food production rather than as time for personal satisfaction.

As shown in the previous chapter, the utility maximization problem is solved to yield a commodity demand function for the ith good:

$$z_i = g^i(\pi, Y).$$

Good z_i is a function of the marginal cost of production π and total income S'. Good z_i is assumed to be any food consumed by the household, either store-bought or harvested.

Store-bought foods (meals) are regarded in the household production model as final consumed commodities; it is assumed that the only inputs are store goods in the production of these commodities. The price of a store meal item may be written:

$$\pi_{store} = nr_i,$$

where n is the price of a unit of store good and $r_i = 1$.

In the case of country-harvested foods, π is generated with a production function. As stated earlier, the production function π must exhibit constant returns to scale and no joint production. Fixed proportion production functions exhibit these properties. Two versions of π, one for time and the other for harvesting equipment purchased out-of-pocket, may be specified: $\pi_{time} = wT_i$ and $\pi_{capital} = bX_i$. Not only do these production functions satisfy the desired properties, but T_i and x_i, defined respectively as the total quantities of time and goods required to produce one unit of country food, may be determined with published historical data on numbers of animals harvested and potential time and equipment required for their harvest.

Each of the production function specifications for country food has unique assumptions regarding preferences. As noted by Lecocq (2001), the utility function derived in basic household production theory is weakly separable in the "goods and time used to produce a given commodity," which implies that the marginal rates of substitution the between a pair of inputs for one commodity (e.g. food) is independent of the marginal rates of substitution between inputs used in other commodities. In the 'opportunity cost' specification ($\pi_{time} = wT_i$), a unit of time is valued at the wage rate w, which is also assumed to be the price of leisure time. If the demand for leisure is weakly separable, a change in the price of a unit of leisure, the wage rate, will not affect the allocation of resources among store-bought and harvested foods. A change in the wage rate will only change the relative prices of store-bought and country harvested foods and affect demand for both types of goods via the traditional income and substitution effects. If the demand for leisure were non-separable, demand for household leisure would need to be estimated to derive accurate estimates on the demand for foods consumed. Therefore, it is assumed that demand for leisure time is weakly separable from the demand for different types of food. Under this framework, time spent in harvesting affects household utility only via the effect on country food production.

As discussed in section 2.7.2.1, individuals who do not participate in the labour market may not trade time in harvesting for time spent in employment at the margin. However, the marginal opportunity cost for these individuals is not zero—the opportunity cost of time may be determined exogenously by individual characteristics such as age or education level. Without data on individual wage rates or alternate valuations of an individual's cost of time, it is assumed presently that individuals value their time as time spent in employment, and that community-level potential wage rate represents the opportunity cost of time for all individuals.

With the equipment cost specification for country food ($\pi_{capital} = bX_i$), it is also assumed that demand for leisure is weakly separable from the demand for different types of food. Under this preference structure, the production function is specified so that there is no value to the time spent in harvesting; it is assumed that any time spent in harvesting is viewed by the household as leisure time, and that the only cost faced by the household for harvesting is the cost of market inputs, or equipment. Hunting and fish, preparing, distributing and eating and sharing country foods are said to contribute to the cultural, social, and spiritual well-being of individuals and communities in northern Canada (Samson and Pretty 2006, Duhaime et al. 2008).

It is assumed that the cost for any equipment used in the production of harvested food represents an exogenously determined marginal cost of harvesting. This implies that there is non-joint use of equipment—any equipment used is employed for harvesting only, and for harvesting of the specific country food type in question, as discussed in the next section (section 3.2.2).

The assumed utility trees for the opportunity and out-of-pocket cost model may be shown as follows:

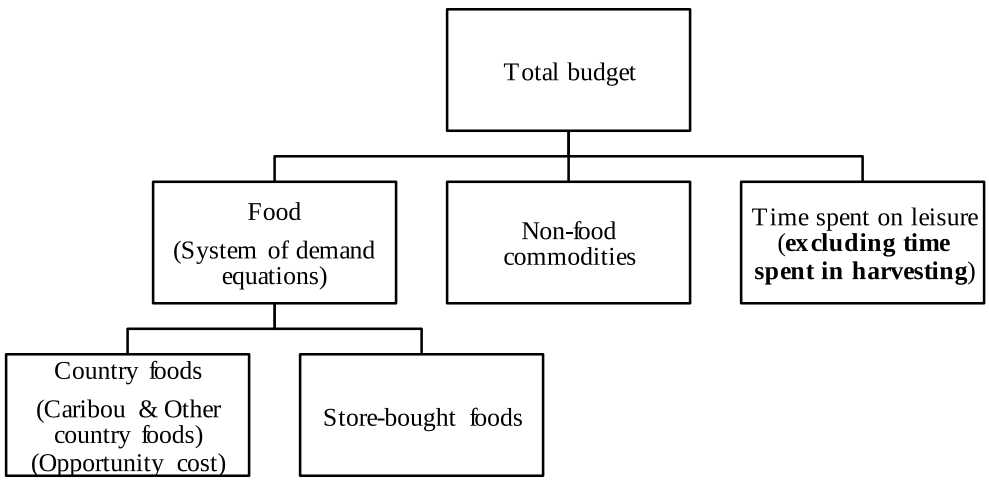

Figure 3-1 Model 1 – Opportunity cost utility model

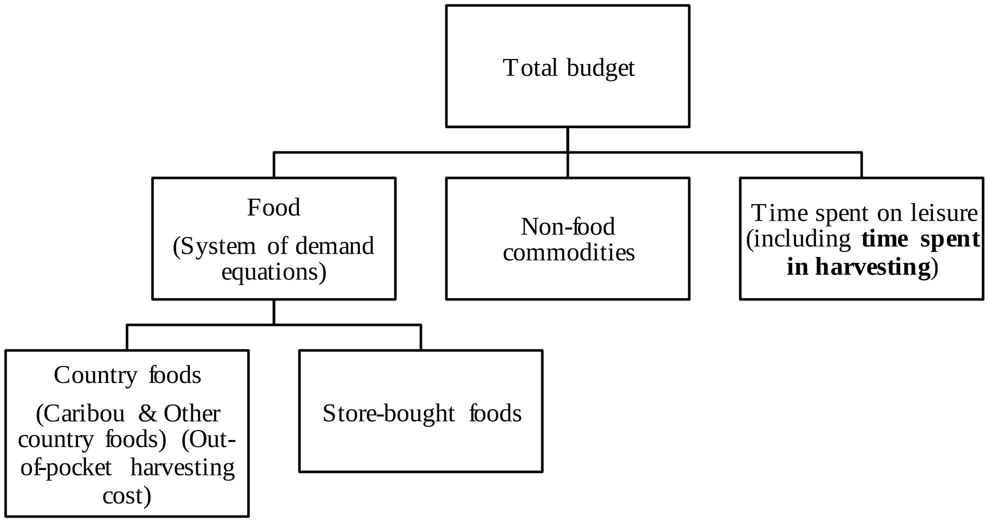

Figure 3-2 Model 2 – Out-of-pocket cost model

3.2.2 Store-bought and country food demand equations

With the assumption that leisure is separable from the demand for food and consumption goods, the demands for harvested food and store-bought foods may be estimated simultaneously. Harvested goods are viewed as home-produced goods with market goods or time as inputs, while store-bought goods are viewed as home-produced goods with store-bought goods as inputs. Though the basic demand model described relates prices and expenditure on quantities of goods demanded, it is necessary to consider other factors such as socio-economic, demographic, sociopsychological factors, and health and nutritional factors, which may influence underlying preferences for different types of foods (Rauniker and Huang 1987). These factors may be incorporated as arguments in the demand function.

Two types of demand equations for different food items may be specified, one with opportunity costs for harvested food and one with out-of-pocket costs for harvested food:

$$z_i = z_i(\pi_{time}, \pi_{store}, Y, \mathbf{K}, \mathbf{J})$$

$$z_i = z_i\left(\pi_{capital}, \pi_{store}, Y, \mathbf{K}, \mathbf{J}\right),$$

where z_i is quantity demand of the ith food type demanded, π_{time}= opportunity cost of harvesting, $\pi_{capital}$: cost of market inputs, Y: total income, **K**: a vector of household demographic characteristics including age, gender, and employment status, and **J**: a vector of community-level infrastructure characteristics including number of stores, availability of road access, and employment rate).

Employment status is used as an explanatory variable in studies of demand for "food-away-from-home," or convenience foods (Prochaska and Schrimper 1973, Redman 1980, Kinsey 1983, Lee and Brown 1986, Nayga 1996, Manrique and Jensen 1997, Mihalopoulos and Demoussis 2001, Chang and Yen 2010, Powell and Han 2011).

Most authors include women's employment status along with a measure of total income as explanatory variables, except for Yen (1993) and Mutlu and Gracia (2006) who use a measure of total income that excludes wife's income and include a dummy variable to indicate whether or not women are employed.

Including both total income (which includes wage and non-wage income) and employment status as explanatory variables for food demand has specific implications for the separability structure of demand. As stated in the previous section, demand for food is considered weakly separable from the demand for leisure. Bryant (1988) examines factors influencing the consumption of durable goods and distinguishes between a conditional and unconditional expenditure function, where a "conditional expenditure function is the expenditure on a good, *i*, when the quantity consumed of some other good, *j*, has been fixed and the consumer is unable to choose it" (Bryant 1988, p. 41). In the conditional case, the wife's hours of paid employment is an "exogenous" variable and total income earned by the family includes the wife's income. The second specification is the unconditional case, where the wife's employment "is not fixed and she can choose her own hours of paid work" (Bryant 1988, p. 41). Bryant (1988) indicates that the conditional demand equation and the unconditional demand equation are equivalent if the consumer chooses the level of fixed good (in this case, employment hours) in both cases. The impact of wives' exogenous employment hours is included in the conditional expenditure function along with income because hours spent in employment may affect tastes of the individual or household for harvested goods and other types of goods. As stated previously, when goods are separable from leisure time, the wage rate affects demands only through its effect on total expenditure. Kerkvliet and Nebesky (1997) have also shown that households make their wage labour decisions first and allocate time between harvesting and leisure after.

For the present analysis, total expenditure on food, which is a proxy for income, and employment status, may both be included as dependent variables in the estimation of conditional food demand equations. As mentioned in Chapter 2, an increase in wage income induces substitution effects on the production of final goods $\boldsymbol{Z}$, where goods requiring more time inputs become expensive relative to those that do not require time inputs. As stated in the previous section, 3.2.1, the price for country food expressed in terms of opportunity cost is $\pi_{time} = wT_i$. Since country foods are valued at the wage rate with this specification, it is assumed that both employed and non-employed households may enter or exit the labour market and earn additional income at the wage rate at any time. Since demand for leisure is weakly separable from the demand for goods, there is no substitution effect between leisure time and time spent in harvesting with a change in the wage rate, only substitution effects between time spent in harvesting country foods, and time spent in work for earning income for purchases of other types of foods. With an increase in individual total expenditure Y, it is expected that a traditional income effect will lead to an increase in the demands for different types of country and store foods.

Accessibility to country food may be influenced by distance to harvesting and health of wildlife populations, and is reflected in the opportunity and out-of-pocket costs calculated for country food. As described, country food prices are specified as $\pi_{time} = wT_i$ and $\pi_{capital} = bX_i$. The variables T_i and X_i reflect the physical availability of wildlife, as they are variables for the rates at which country food may be harvested. The variables w and b reflect market costs for time and out-of-pocket harvesting equipment, respectively. The empirical specifications for the country food price equations are described later in section 3.3.4.

Higher employment rate, education, or income levels may also influence the total supply of country food available in the community for consumption. At the community level, community infrastructure may impact the availability of different types of foods and physical accessibility to different types of foods. For example, the presence of roads, either year-round or seasonal, may increase the types of foods available to be consumed or may influence access to other sites from which food may be purchased. Glanz (2009) suggests that the number, type, location, and accessibility of stores are part of the "community nutrition environment," and suggests that these factors are important for health promotion at the community level and potentially the types of foods chosen and substitution among foods. Other community characteristics including employment rate, median income, family structure, median age, average education level, may also influence the types of foods that are stocked in stores.

In northern Canadian communities, it has been found that there is a lack of variety of types of food available from community stores (Lawn and Harvey 2001, 2003, Beaumier and Ford 2010, Ford and Beaumier 2011, Huet, Rosol, and Egeland 2012). Number of food stores in a community is used as a proxy for availability of store food and is defined as an explanatory variable for demand for caribou. It has been found that the types of foods available in stores are subject to the decisions of store managers (Todd 2010). An increased number of stores may result in an increased variety of available foods.

Dhar, Chavas and Gould (2003) include community-level characteristics such as median age, median household size, household income variables, percentage of Hispanic population, and store concentration ratio as explanatory factors in the estimation of demand for soft drinks in 46 cities. Sharkey and Horel (2008) suggest that distance to food store, which may be viewed as a supply factor, is associated with socioeconomic status and minority composition of communities. Housing characteristics as listed above and access to developed natural resources such as oil are hypothesized to have similar effects, although these factors may be correlated with economic variables such as community employment rate or income.

Community employment rate is included as an explanatory variable as an indicator of availability of country and store food. It is hypothesized that having full-time hunters (who are hence not in wage employment) in a community may affect the level of harvested food available to a household. It has been reported that sharing often takes place among community members and that individuals, particularly women, may pay a hunter to retrieve country food or purchase it from the store (Ford and Berrang-Ford 2009, Beaumier and Ford 2010). Having income with which to purchase fuel and equipment for harvesting affects access to country food at the household-level, but it has also been found in both northern Canada that having a reduced number of full-time hunters in the community influences quantities and species of harvested food available for the entire community (Ford et al. 2006, Ford and Beaumier 2011). In rural African communities, it has been shown that the behaviour of poorer households had an influence on availability of bushmeat for rich households—high proportions of bushmeat harvested by rural households, who had fewer employment alternatives, were sold to urban households (de Merode, Homewood, and Cowlishaw 2004, Bassett 2005, Kümpel et al. 2010). There may be fewer harvesters in communities with higher employment, leading to a decrease in community-level country food supply.

For the present analysis, the number of stores and community-level employment rate are included in the demand function as supply indicators for caribou. The season of interview may also have an impact on intakes of different types of foods, since different animals are harvested in different seasons. For example, Receveur, Boulay, and Kuhnlein (1997) found that interview season (either the March to April or October to November period) had a statistically significant effect on intake of country fish (as mentioned in Chapter 2). However, interview season is excluded from the specification because overall ability to hunt different country food species is already accounted for in the calculation of country food prices.

3.2.3 Aboriginal Peoples Survey equations

As stated previously, this study will involve analysis of the Aboriginal Peoples Survey. From this survey, data on harvesting participation is available. Individuals are asked whether or not they have hunted, fished, gathered, or trapped in the past year, and are asked whether or not anyone in the household has harvested in the past year. Whether or not an individual or household participates in harvesting is indicative of time inputs spent in harvesting.

Participation in harvesting is assumed to be a time variable. As shown previously, the demand function for time used in the production of home goods may be expressed as a function of the price of store-bought goods, wage rate, and non-labour income or full income. It may be assumed that time is the only input in the production of home goods. The demand for time may also be a function of individual demographic variables. If wage rate is not included in the specification, it is assumed that the demands for country and store foods are separable from the demands for leisure (as described previously in section 3.2.2)—the impact of any changes in wage rate are observed through the impacts of changes in income.

The demand function for time spent in harvesting may be written:

$$t_i = f^i(S', \mathbf{K}),$$

where S' is total income, and **K** is the vector of individual demographic variables.

The proportion of country meat and fish consumed (out of total meat and fish consumed) may be represented as a demand equation for a home-produced good. As stated in Chapter 2, the quantity of harvested meat and fish demanded z_i, as measured by an ordinal variable (described later in section 3.5), may be represented:

$$z_i = z_i(S', \mathbf{K}),$$

where, S' is total income, and **K** is the vector of individual demographic variables.

Employment status may be included in the specification, as in the case of the demand equation specification for the system of food demand equations estimated in this thesis (and described in the previous section). If employment status and total income are included in the demand equation, the demand equation estimated is a conditional demand equation, where it is assumed that the decision of whether or not to participate in employment is determined exogenously. Total income influences the demand for time spent harvesting t_i or the amount of country food harvested z_i via a pure income effect.

The demand functions for time and country meat and fish may also include either only employment status variable or only income. If participation in employment has a positive effect on time spent in harvesting, it is assumed that an increase in income from employment results in an increase in all goods demanded due to a pure income effect, and that the production function will increase harvest of country food using higher levels of time input.

If participation in employment has a positive effect on quantity of country meat and fish consumed, this may also be attributed to a pure income effect that results in an increased demand for all goods consumed. The increased demand for country food may be attributed to an increase in production due to an increase in time inputs or out-of-pocket equipment cost inputs. If participation in employment leads to decreased time spent in harvesting, this may imply that even if income is increased by employment income, the individual or household may choose to either consume more store-bought goods, or invest more capital equipment into harvesting activity. If participation in employment leads to decreased levels of consumption of harvested food, this may imply that if income is increased by employment income, the individual or household may choose to either consume more store-bought goods because the production function is such that individual or household is constrained by the production technology—it is not worthwhile for the individual or household to invest more time or out-of-pocket resources in harvesting (and hence increase consumption) given the production technology.

Additional variables on sources of country food, including dummy variables on whether or not the household harvested country food, whether or not country food was received for free, received in exchange for gas, other supplies, or help, or bought from others, may also be included in the demand specification for proportion of country meat and fish consumed.

3.2.4 Caloric intake and dietary diversity equations

It is of interest in this study to identify the potential contribution of caribou to dietary quality indicators, since one of the objectives of this thesis is to explore the contribution of caribou to indicators of food security. As described in a previous section on dietary quality indicators, indicators of nutrient adequacy and food-pattern indicators (or composite indicators) may be used to assess dietary quality. Measures of dietary quality, such as dietary diversity and total calorie intake, have been used to represent aspects of dietary adequacy, and hence, overall food security. Total caloric intake per individual may be computed from the dietary data used for this study.

In Chapter 2, it was found from a review of the literature that caribou was a high contributor of energy (calories), protein, and nutrients such as iron. Consumption of country food generally was found to be related to the intake of important nutrients. The relationship between intake of individual nutrients and income or total expenditure has not been widely explored in the literature on northern Canada. Specifically, the relationship between calories and expenditure has not been modeled while accounting for access to caribou meat.

Additionally, no known studies link dietary quality, as measured by a dietary diversity indicator, to caribou consumption. Huet, Rosol, and Egeland (2012) have implemented the Healthy Eating Index measure on diet from Inuit communities, as previously explained. However, they did not address the relationship between HEI score and caribou intake.

To test the potential effect of caribou consumption on overall energy intake, an indicator for individual caribou consumption or community-level availability of caribou may be included as an explanatory variable in the demand equation for calories. From the dietary data and from published literature, the following indicators of caribou availability may be identified:

Table 3-1 Indicators of caribou access

Variable abbreviation	Caribou indicator	Variable	Source of data
CARIBOUD	Consumption	Binary variable (=1 if consumed caribou in 24-hour recall, 0 otherwise)	Dietary recall
LOWHAR	Availability – community harvests	Low harvest – Minimum harvest level reported from harvest study data	Various harvest study reports for respective communities (see Appendix H)
MEANHAR		Mean harvest - Minimum harvest level reported from harvest study data	
PEAKHAR		Peak harvest - Maximum harvest level reported from harvest study data	
CARIPOP	Availability – population available to community	Continuous – population	Data from caribou populations studies (see Appendix B and Appendix H)

The theoretical demand model as specified by Devaney and Fraker (1989), Nayga (1994), and Nayga and Capps (1994) is adopted for the present theoretical specification for calorie demand. The theoretical specification of the calorie intake model is written:

$$N_i = h_i(Y, \mathbf{K}, \boldsymbol{c_i}),$$

where Y: total income, $\mathbf{K}$: vector of individual or community-level demographic characteristics including age, gender, and employment status, number of stores, community employment rate, and $\boldsymbol{c_i}$ is an indicator on either individual caribou consumption or community availability of caribou.

As stated in Chapter 2, it is predicted from Jackson's (1984) theory of hierarchical demand that dietary diversity increases with expenditure. The demand equation for diversity may be written:

$$D_i = d_i(Y, \mathbf{K}, \boldsymbol{c_i}),$$

where the explanatory variables are the same as those in the calorie demand equation.

As stated in Chapter 2, many types of count measures and distribution measures for dietary diversity have been used. Composite indexes that combine information on intake of foods and intake of nutrients, along with information on nutrient recommendations, have been used to assess diet quality. To select the appropriate measure of dietary diversity, the various measures described previously will be assessed on whether or not they are appropriate for the type of dietary data available presently. Additionally, since an objective of this study is to evaluate the impacts of individual caribou consumption or caribou accessibility and availability on food security indicators, the suitability of the diversity measure as an indicator of food security is also considered. The following table outlines common food diversity measurement methods and their applicability to the present analysis.

Table 3-2 Dietary diversity measures and applicability to present analysis

References	Types of data previously employed	Diversity score method	Appropriateness for dietary recall data from (Sharma et al. 2009, 2010) or for measuring food security
(Jackson 1984, Lee 1987, Ferguson et al. 1993, Nayga and Capps 1994, Fernandez et al. 1996, Slattery et al. 1997, Moon et al. 2002)	Various, including FFQ	Number of different foods a day.	- Many types of junk food consumed would add to count. An increased count may not suggest that diet is of high quality.
(Fernandez et al. 1996, Slattery et al. 1997)	Dietary history, FFQ	Number of different food items within groups: 5 groups—i) vegetables, ii) fruits, iii) meats, iv) carbohydrates, v) other foods – cheese, milk, and eggs in Fernandez et al. (1996); 6 groups—i) meat/poultry/fish/eggs, ii) fruits, iii) vegetables, iv) whole grains, v) refined grains, vi) dairy foods in Slattery et al. (1997); and 6 groups— i) bread and cereal dishes, ii) meat and foods used as meat substitutes, iii) vegetables, iv) fruits, v) sweets, desserts and soft drinks, vi) milk, coffee, tea, sugar, and artificial sweeteners in Franceschi et al. (1995).	- In the measure as specified by Fernandez et al. (1996) and Slattery et al. (1997), "Other" foods that do not fit into the food groups are excluded from analysis; this measure does not account for consumption of foods that may have negative impacts on dietary quality. - Food groups may be defined in different ways (e.g. according to the national food guide) and within-group diversity does not provide an overall measure of dietary quality that may be used as a proxy for food security.
(Kant, Schatzkin, and Ziegler 1995, Haines, Siega-Riz, and Popkin 1999, Hatloy et al. 2000)	24-h recall, 2-day food record	Dietary Diversity Score (DVS) – number of food groups consumed on a daily basis. A minimum portion size is required. Maximum score of 5 (dairy, meat, grain, fruit, vegetable).	- "Other" foods that do not fit into the food groups are excluded from analysis; this measure does not account for consumption of foods that may have negative impacts on dietary quality. - For the present data, establishing a measure for minimum portion consumed is difficult. Portion sizes not provided in the data. Health Canada (2007c) provides serving measures for a few foods but not for all foods consumed.
(Kennedy et al. 1995)		Healthy Eating Index (HEI) variety component. The HEI is based on 10 components, one of which is the dietary variety measure, which is derived by counting the total number of different foods eaten by an individual in "amounts sufficient to contribute at least a half serving in any of the food groups" (Kennedy et al., p.	- For the present data, establishing a measure for serving size consumed is difficult. - As previously stated, Roder (1998, as quoted in Drescher 2007), has criticized the index as not being very sensitive to excess intake. Kennedy et al. also suggest that the upper and lower limits in variety

		1105). A maximum score of 10 is given to individuals who report consuming 16 or more different foods, while a score of 0 was given of 6 or fewer distinct foods are consumed. The food groups specified are grains, fruits, vegetables, milk, and meat.	scores are determined with "little guidance" (1995, p. 1106).
(Kant et al. 1993, Drewnowski et al. 1996)		Dietary Diversity Score [DDS – Kant et al. (1993) or DD – Drewnowski et al. (1996)]: number of food groups (maximum of 5) consumed by each person. Food groups: milk and milk products, meat group, grain group, fruit group, vegetable group. Foods such as carbonated and alcoholic beverages, coffee, candy, high-fat snacks, pastries, were not classified into any of the food groups. In Kant et al. (1993), a minimum of 30g for solid foods with a single ingredient and 60g for all liquids and mixed dishes was required for items reported in the meat, fruit, and vegetable groups, and a minimum of 15g for solid foods with a single ingredient and 30g for all liquids and mixed dishes was required for items in the dairy and grain groups.	- "Other" foods that do not fit into the food groups are excluded from analysis; this measure does not account for consumption of foods that may have negative impacts on dietary quality.
(Drewnowski et al. 1997)	Dietary History	DVS - number of different food items (out of a total of 73 food items)	- Not appropriate for the present data because foods reported are not based on a food list.
(Cox et al. 1997)	2 food records and 24-h recall	Variety Index for Toddler s (VIT) – based on number of servings from 5 food groups in Food Guide Pyramid	- For the present data, establishing a measure for serving size consumed is difficult.
(McCrory et al. 1999)	FFQ	Dietary variety within food groups – percentage of different food types, from a list, consumed within each group. Variety ratio – ratio of variety of vegetables consumed to the variety of sweets, snacks, condiments, entrees and carbohydrates consumed; based on list of foods	Not appropriate for the present data because foods reported are not based on a food list.
(Bernstein et al. 2002)	3-day weighed food record	Food and Vegetable Variety Score - number of different fruits and vegetables consumed in 3 days	- Number of fruits and vegetables alone may not be indicative of food security

(Mirmiran et al. 2004)	Two 24-h recalls	Dietary Diversity Score – each of 5 broad food groups receives a maximum diversity score of 2 from 10 possible score points. Minimum of ½ serving of any item in one of the 23 food subgroups is required to be counted towards the diversity score (over a two day period).	- For the present data, establishing a measure for serving size consumed is difficult. - " Other" foods that do not fit into the food groups are excluded from analysis; this measure does not account for consumption of foods that may have negative impacts on dietary quality.
(Murphy et al. 2006)		Count of 5 Food Guide Pyramid food groups. Count of 22 Food Guide Pyramid Subgroups.	- " Other" foods that do not fit into the food groups are excluded from analysis; this measure does not account for consumption of foods that may have negative impacts on dietary quality.
(Lee and Brown 1989, Jekanowski and Binkley 2000, Moon et al. 2002, Stewart and Harris 2005)	Consumption survey – but usually give list of food items (fixed list of foods)	Simpson/Berry/Herfindahl Index, Entropie Index	- " Other" foods that do not fit into the food groups are excluded from analysis; this measure does not account for consumption of foods that may have negative impacts on dietary quality.
(Drescher 2007)	Consumption data	Healthy Food Diversity: Berry Index multiplied by health factors. Based on counts of food items. Groups: vegetables, wholemeal products, white meal products, potatoes, snacks and sweets, fish and low-fat meat, low-fat diary, dairy, fats and oils	-'Health factors' are based on recommended amounts in the German national food guide. Varies by country. Equivalent factors are not available for the Canadian food guide from published data. - A benefit of the Healthy Food Diversity index score is that it is possible to account for 'unhealthy' food in the diversity score if they are assigned values of 0.

Because serving or portion sizes for foods reported in the dietary data are not reported, and since calculating serving sizes from the weights of foods consumed is a complex task for which conversion factors are not readily available for all foods from sources such as Health Canada, a dietary diversity score based on counts of foods is adopted for this study. Diversity measures where actual portion or serving sizes consumed are used to calculate diversity are therefore not implemented. While portion or serving sizes of foods consumed are not accounted for, portion size estimates may also problematic because they may not reflect nutritional densities.

A simple count measure of the number of different foods consumed, as is used in Ferguson et al. (1993), Fernandez et al. (1996), Slattery et al. (1997), Jackson (1984), Lee (1987), and Moon et al. (2002), is not chosen for this study because the variety of food available for purchase may vary by community since the study communities are geographically isolated, and the study communities have fewer stores than in southern centres. Furthermore, a disadvantage to using the count measure of number of foods consumed is that consuming an increased number of foods that are 'junk' foods or 'unhealthy' foods leads to having a higher diversity score. If many 'junk' or 'unhealthy' foods are consumed, a relatively high diversity score may not mean that an individual diet is of relatively high quality or that an individual is consuming a nutritionally adequate diet. The within-group diversity score measures for different types of foods, as specified by Fernandez et al. (1996) and Slattery et al. (1997), are subject to the same problem as the simple count measure for different foods in that they do not account for the consumption of unhealthy foods.

The food group score developed by Kant et al. (1993) (called the DDS) and Drewnowski et al. (1997) (called the DD) involves counting the different number of food groups in which food items are consumed. This method can be easily implemented for the study data, as the food groups as outlined in Canada's Food Guide for First Nations, Inuit, and Metis (Health Canada 2010b) may be adapted as the food categories to be counted. While Kant et al. (1993) and Drewnowski et al. (1996) specify five food groups to be estimated (milk and milk products, meat, grain, fruit, and vegetable), Canada's Food Guide has four groups (vegetables and fruit, grain products, milk and alternatives, and meat and alternatives). While Kant et al. (1993) and Drewnowski et al. (1996) specify quantity thresholds that the consumed amounts have to fall within in order for a food to be counted, the thresholds are not included in the current calculation because Canada's Food Guide does not include gram weight recommendations for different food groups.

As stated in the literature review of this thesis, there have been attempts to validate diversity count measures with measures of nutrient adequacy, such as caloric intake or mean adequacy ratio, or with physiological outcomes. For the DD score adopted presently, Drewnowski et al. (1996) found that low DD scores were associated with low energy intakes. Kant et al. (1993) found that the DDS score was positively related to intake of energy and dietary fibre. Additionally, the DDS score was found to be inversely related to mortality, even when potential confounders such as age or education were included in a multivariate regression analysis. There is evidence that high DD/DDS scores are positively related to measures of nutrient adequacy and health outcomes; this measure is therefore suitable as a proxy for food security, despite its shortcoming of not accounting for potential consumption of unhealthy foods.

Another potential limitation of food group score measures is that a low food group score may not adequately reflect nutrient adequacy when a range of nutrients may be consumed from country meat and fish. The consumption of a high variety of country meat and fish, including varied parts and organs, has been positively linked to high consumption of important nutrients (Schaefer and Steckle 1980). Consequently, a low food group score may not be fully reflective of nutrient adequacy. Nonetheless, this measure is selected as a broad indicator of diet quality.

3.3 Data set 1: Dietary recall data

This study analyses dietary data from four communities, two in the Inuvialuit Settlement Region in the Northwest Territories and two from the Kitikmeot administrative region in Nunavut, Canada. The model will be based upon household dietary data collected across a number of communities in the Inuvialuit region by Sharma et al. (2009, 2010). As described in Sharma et al. (2009, 2010), twenty-four-hour dietary recalls were conducted among Inuvialuit aged 19 in a study to determine the foods and nutrients to be targeted in a nutritional intervention program. Local interviewers recorded information on time of consumption, types of food or drinks (meat type, brand name, source, and any additions to the food) over the preceding 24-hour period, and quantities of foods based on pre-specified quantity models. The data have been analysed by Sharma et al. (2009, 2010) with a focus on the nutrient content of these foods and the potential effect of various dietary interventions on nutrient intake. In the present study, the dietary intake of food items by individual households will be analyzed as cross sectional data, and intake of various foods and expenditures on individual foods by households can be modeled econometrically as a function of household demographic characteristics.

The study communities vary in population size and economic characteristics, as shown in the following table.

Table 3-3 Dietary Socio-economic characteristics by community

Variable abbreviation	Community characteristics	Sample community			
		1	2	3	4
	Population (2006) (Statistics Canada 2009c)	1477	809	3651	907
	Percentage Change in population (2001/2006) (Statistics Canada 2009c)	10%	10%	10%	-10%
	Population (2001) (Statistics Canada 2009c)	1309	720	3395	999
	Percentage Aboriginal identity (Statistics Canada 2009c)	80%	90%	60%	90%
NSTORES	Number of private or co-operative food retailers Reference: Sources in Appendix A.	2	2	7	1
ROAD	Road access Reference: Sources in Appendix A.	None	None	All-year	Winter only
MAIL	Food mail receiving community Reference: Sources in Appendix A.	Yes	Yes	No	Yes
ERATE	Employment Rate Reference: Statistics Canada.	63.7	40.4	70.8	38.9
Individual characteristics (from dietary data files)					
AGE	Mean age (years)	42.6	52.2	47.8	46.6
GENDERD	% of respondents male	46.8%	50.0%	42%	50%
EMP	% of respondents employed (includes part time and seasonal employment)	51%	10%	44%	30%
	Interview period	Spring (Mar-Apr.)	Spring (Mar-Apr.)	Winter (Nov-Dec.)	Winter (Nov-Dec.)
	Sample size	n=47	n=40	n=45	n=56

Communities vary in population and other demographic characteristics. Only one community has year-round road access, while another only has winter road access. Three of the four communities was a Food Mail-receiving community in 2006. Community 3 is a Food Mail supply centre. As explained in Chapter 1, Food Mail communities receive subsidized shipping rates because they do not have year round transportation access by waterway or road.

3.3.1 Description of dietary recall items

For 188 respondents in the sample, 3185 food entries were reported in the complete set of dietary data. Records of alcoholic beverage or water consumption were excluded from the data—it is assumed that water consumed is from municipal sources. There were two respondents who reported consuming berries from the land. Since the recent major harvest studies have not included data on berry harvesting, store-food prices were used as proxies for the harvested berry item price. Mixed dishes—food items with multiple ingredients listed—are reported in the data and include sandwiches, sauces, stews, stir-fry, and soups.

For some mixed dishes listed, the quantities consumed of component parts are identified in the data. For other dishes, the quantity of each ingredient used in the mixed dish is calculated. In the case of sandwiches where the component parts are described but no quantity value is provided, it is assumed that a sandwich is composed of two slices of bread and an additional item (e.g. ham slice) for which the weight is taken from the average weight consumed by other survey respondents for the same item.

For other mixed dishes where ingredients are listed in the recall entry without associated quantities, the amount of the ingredient used in the dish is assumed to be equal to the total weight of the dish multiplied by fraction representing proportion composition, as derived from published recipes. Recipes for traditional country food dishes (caribou stew, caribou/muskox stirfry, caribou stirfry with rice, caribou soup, fish chowder) published by Health Canada (2007a), Northwest Territories Prenatal Nutrition Program (NWT Prenatal 2012), the Government of Nunavut (Government of Nunavut 2013a, b), and Healthy Alberta (Healthy Alberta 2012) were used to determine the composition for 36 mixed dishes. For each recipe ingredient, gram weights for ingredients used in dishes were found in the USDA Nutrient Database for Standard Reference and the proportion of total weight of each ingredient calculated (USDA Agricultural Research Service 2011).

From the dietary recall, the main ingredients listed for mixed dishes are i) meat, ii) vegetables, and iii) rice or pasta. Therefore, proportions for ingredients are assumed according to classification of the ingredients by these three ingredient 'types.' Proportions obtained from country food mixed dishes are also applied to similar mixed dishes made with store-bought foods (i.e. caribou stew proportions are used for beef stew calculations). For the purposes of calculating mixed dishes, "moisture change," the change in weight due to change in moisture from cooking process (Health Canada 2005), is not taken into account. Therefore, the weights of different raw ingredients assumed to be used in preparing a mixed dish may not be perfectly correlated with the weight obtained by the calculation ([total cooked mixed dish weight] * [proportion of raw ingredient out of total raw ingredient weight]).

For seven types of mixed dishes without country food ingredients, recipes for items with similar ingredients were found in the Canadian Nutrient File database (Health Canada 2012a). Proportions of different ingredients in the cooked dish are shown in the database. It was assumed that these proportions correspond directly to quantities of raw ingredients used, since proportions of raw ingredients used are not reported (see Appendix G).

Aside from mixed dishes with multiple ingredients, single-item ingredients, particularly those prepared by the addition of water, have significantly different weights pre- and post-preparation. Conversion factors were found from published preparation instructions and used to determine the amount of raw ingredient used in the preparation of coffee, tea, powdered beverages and soups (including Kool-Aid, Tang, and Lipton soup mix), rice, spaghetti, pasta, instant noodles, oatmeal, and instant mashed potatoes. In the case of bannock, it was assumed that the price of a piece of bannock is the price of white flour for an equivalent gram weight, since ingredients used are not listed in the recall and it has been reported that flour is used in high quantities in the preparation of bannock (Lawn and Harvey 2003).

3.3.2 Classification of food groups

In this study, food recall data is used to evaluate the impacts of individual- and community-level characteristics i) household food expenditures ii) household food security as measured by dietary quality and nutrient adequacy measures. For both types of analyses it is necessary to disaggregate the food items into groups.

One method of grouping foods is by dietary guideline classifications. Dietary guidelines include recommendations for amounts of different types of foods that should be consumed for an individual to meet nutrient adequacy status. Foods may be classified in groups based on these dietary guidelines. For example, Riccuito, Tarasuk and Yatchew (2006) assign food codes to foods recorded in the Family Food Expenditure Survey (FOODEX) and grouped codes into five food groups—grain products, vegetables and fruit, milk products, meat and alternatives, and 'other' foods.

As in Riccuito, Tarasuk and Yatchew (2006), individual recall items are matched with food codes in the Canadian Nutrient File. Item brand and cooking method are matched to those recorded in the recall as closely as possible. Food codes in the Canadian Nutrient File are classified under 25 groups (as shown in column A in table 3-4). Once classified into these groups, foods were further classified into groups as defined in Canada's Food Guide (shown in column B in table 3-4) [(1) vegetables and fruit, (2) grain products, (3) milk and alternatives, (4) meat and alternatives], in order to calculate the dietary diversity indicator. Group (1) includes wild berries while group (4) includes "traditional meats and wild game."

For the purposes of demand analysis, the groups in the guide are further disaggregated (as shown in table 3-4 column C)—store meat is classified into groups for beef, chicken, pork, processed meat and seafood, while country meat is classified into groups for caribou and other country foods. While foods in the "nuts and seeds" group are usually categorized under "meat and alternatives" in the food guide, they are categorized in the demand analysis groups under the dairy group given that meats are disaggregated for the purposes of demand analysis. Aside from the food groups delineated in the food guide, additional categories are classified for the demand analysis groups: "other foods," which includes fats and oils, sugars, snacks, non-alcoholic beverages, and Food-Away-from-Home. The classified food groups are shown in the following table:

Table 3-4 Food group categorizations for dietary diversity analysis and demand analysis

A. Canadian Nutrient File Food Group Name	**B. Canada's Food Guide (for dietary diversity indicator)**	**C. Demand Analysis Group (for demand analysis)**
Dairy and Eggs	(3) milk and alternatives	(9) Dairy, Eggs, and Alternatives
Spices and Herbs	NA	NA
Babyfoods	NA	NA
Fats and Oils	NA	(10) Other foods
Poultry Products	(4) meat and alternatives	(2) Chicken
Soups, Sauces and Gravies	NA	NA
Sausages and Luncheon meats	(4) meat and alternatives	(4) Processed meat and store seafood
Breakfast cereals	(2) grain products	(8) Grains
Fruits and fruit juices	(1) vegetables and fruit	(7) Fruits & Vegetables
Vegetables and Vegetable Products	(1) vegetables and fruit	(7) Fruits & Vegetables
Legumes and Legume Products	(1) vegetables and fruit	(7) Fruits & Vegetables
Nuts and Seeds	(4) meat and alternatives	(9) Dairy, Eggs, and Alternatives
Beef Products	(4) meat and alternatives	(1) Beef
Pork Products	(4) meat and alternatives	(3) Pork
Finfish and Shellfish Products	(4) meat and alternatives	(4) Processed meat and store seafood
Lamb, Veal and Game	(4) meat and alternatives	(5) Caribou; (6) Other country foods including other land mammals, fish, sea mammals, and birds
Baked Products	(2) grain products	(8) Grains
Sweets	NA	(10) Other foods
Beverages	NA	(10) Non-alcoholic beverages
Fast Foods	Grouped by individual component	(10) Food-Away-From-Home
Mixed Dishes	Grouped by individual component	NA
Snacks	NA	(10) Other foods

The energy intakes (number of kilocalories) from food items in the dietary recall are also converted to calories with values from the Canadian Nutrient File (version 2010) (Health Canada 2010a). When possible, mixed dishes (such as caribou soup) are matched with mixed dishes in the nutrient file, as in the manner of Sharma (2009, 2010) (where nutrient contributions of mixed dishes are derived from measurements for mixed dishes as opposed to individual ingredients).

3.3.3 Store food prices

Store food prices are necessary for calculating individual expenditures. Prices are typically not collected for 24-hour recall data and were not reported at the individual level. Additionally, no published price data is available for food items for the study period and region. For the purposes of expenditure analysis, prices for individual food items as reported in the 24-hour recall were collected by the researcher at a local (Edmonton) retail store in September 2010. The prices collected were for items with matching product type and brand as the items in the recall, where possible. For recall items where no brand is mentioned, store-brand or generic items or the lowest-price for a specific item description was used. The price of chicken breast is used as the price for boneless chicken when no specific chicken cut is mentioned, the average price of striploin and t-bone steaks are used in the case where the type of steak consumed is not specified, and the average of striploin steaks, t-bone steaks, and ground beef are used for beef stews where the beef cut used is not specified.

It is assumed that foods consumed are prepared by the household, unless the dietary entry specifies that an item is consumed away-from-home. Prices for six food-away-from home entries were obtained by speaking with staff at fast food restaurant (Northern Quickstop) in one community via telephone in September 2010 and acquiring prices for items that match the entries in the recall.

Food prices are first adjusted from 2010 to 2006 prices with Alberta index values for individual food categories (Statistics Canada 2012a). The price index values for all-items, food, and categories of food are shown in Appendix G.

As described in the previous section, for the purposes of categorizing foods for demand analysis and for calculation of energy intakes, food entries were categorized according to food codes in the Canadian Nutrient File (CNF). The 22 category labels defined in the Canadian Nutrient File are not identical to the category labels listed in the Consumer Price Index. The CPI categories adopted for adjusting food prices from 2010 to 2006 values in this study are shown in the following table.

Table 3-5 Food group names for demand analysis and corresponding names from Canadian Nutrient File and Consumer Price Index

Demand analysis	Canadian Nutrient File	Consumer Price Index
(1) Beef	Beef Products	Fresh or frozen meat (excluding poultry)
(2) Chicken	Poultry Products	Fresh or frozen poultry meat
(3) Pork	Pork Products	Fresh or frozen meat (excluding poultry)
(4) Processed meat and store seafood	Sausages and Luncheon meats	Processed meat
(4) Processed meat and store seafood	Finfish and Shellfish Products	Fish, seafood and other marine products
(5) Caribou (6) Other country foods	Lame, Veal and Game	NA
(7) Fruits & Vegetables	Fruits and fruit juices	Fresh fruit Preserved fruit and fruit preparations
(7) Fruits & Vegetables	Vegetables and Vegetable Products	Fresh vegetables Preserved vegetables and vegetable preparations
(7) Fruits & Vegetables	Legumes and Legume Products	NA
(8) Grains	Breakfast cereals	Cereal products (excluding infant food)
(8) Grains	Baked Products	Bakery products
(9) Dairy, Eggs, and Alternatives	Dairy and Eggs	Dairy products Eggs
(9) Dairy, Eggs, and Alternatives	Nuts and Seeds	Preserved fruit and fruit preparations
(10) Other foods	Fats and Oils	Other food products and non-alcoholic beverages
(10) Other foods	Soups, Sauces and Gravies	Other food products and non-alcoholic beverages
(10) Other foods	Sweets	Other food products and non-alcoholic beverages
(10) Other foods	Snacks	Other food products and non-alcoholic beverages
(10) Other foods	Fast Foods	Food purchased from restaurants
(10) Other foods	Beverages	Non-alcoholic beverages

To reduce the number of food groups specified in the econometric model, 1) fats and oils, 2) soups, sauces and gravies, 3) sweets, 4) snacks, 5) fast foods, and 6) beverages, as specified in the Canadian Nutrient File, are combined into one group called "Other foods." For the purposes of adjusting food prices, 1) fats and oils, 2) soups, sauces and gravies, 3) sweets, 4) snacks (the food groups as defined for demand analysis) are all adjusted using the aggregated index value for the "Other food products and non-alcoholic beverages" category from the Consumer Price Index.

The adjusted 2006 food prices are then adjusted to community-level prices with values from the Revised Northern Food Basket (RNFB). The RNFB is calculated with the cost of 67 perishable and non-perishable food items in surveyed communities. The costs of perishables, non-perishables, total items, and the respective ratios between the community RNFB measure and Edmonton RNFB measure (AANDC 2008) are shown in the following table.

Table 3-6 Weekly Cost of the Revised Northern Food Basket (RNFB) for a family of four in Edmonton and Study Communities

Community – year	Perishables ($)	Non-perishables ($)	Total ($)	Ratio of Community to Edmonton price
1 – 2006	262	120	382	1.82
2 – 2006	281	143	423	1.94
3 – 2006	196	101	297	1.43
4 – 2006	262	117	379	1.82
Edmonton – 2006	129	73	202	--

The Revised Northern Food Basket is not the only measure of food prices in northern Canada. Consumer price indexes are available for the metropolitan areas and regional centres including Yellowknife, NT, and Iqaluit, NU. The CPI is used as the indicator of the general level of consumer prices and the rate of inflation, and does not show relative cost of goods between regions or communities.

A measure distinct from the Revised Northern Food Basket that shows relative prices in communities is the Living Cost Differential measure computed by Statistics Canada and published by the Treasury Board of Canada Secretariat and National Joint Council to estimate retail and living costs for the purposes of employment compensation schemes (National Joint Council 2012). Although this provides an index measure of relative living costs in the study communities, the

RNFB values used for price adjustments in this study because they provide a measure of cost that only accounts for food. Edmonton prices for 2006 are converted to community-level prices by multiplying by the ratio of the community and Edmonton basket costs. Expenditure on each item is calculated with the relevant price and the community-specific adjustment. Expenditures on items are then aggregated for each individual and subsequently classified by food group.

3.3.4 Country food prices

The production costs per unit of animal harvested, $\pi_{time} = wT_i$ and $\pi_{capital} = bX_i$, are determined by exogenously determined factors such availability of wildlife. To determine the price per unit of country food consumed in terms of either opportunity cost or out-of-pocket equipment cost (time required to harvest), a measure of harvest is necessary. As stated, the variables T_i and X_i, represent the rates at which country food may be harvested.

In the following opportunity cost and out-of-pocket cost specifications, it is assumed that all individuals at the community-level have equal harvest ability. While heterogeneity may exist across individuals in terms of harvest skills, individual level data on harvest effort and catch is not available. Historical community-level rates of harvest per units of time are assumed to capture variation in physical ability to harvest across the study sample.

From published harvest surveys, the number of animals caught on average in a community may be calculated. Without detailed survey data on individual hunting effort and harvest success, data from recent harvest studies in the respective communities are used to approximate harvest effort in terms of the number of animals that may be harvested in a day.

Number of animals and number of harvesters per month for select species are reported for six communities in the Inuvialuit Harvest Study (IHS) (administered 1988-1997) and for twenty-seven communities in the Nunavut Wildlife Harvest

Study (NWHS) (administered for 5 years from 1996 to 2001) (The Joint Secretariat 2003, Priest and Usher 2004).

Time spent in harvesting different species may vary across locations and seasons. Typical harvest seasons are reported in community conservation plans for the 6 communities in the Inuvialuit Settlement region and may represent variations in time spent on the land across different seasons and also in aggregate over the year. On average, caribou were harvested 11 months of the year, sea mammals including seal and whale were harvested 5 months of the year, fish were harvested 9 months of the year, fur-bearers were harvested about 5 months of the year, and birds were harvested 4 months of the year.

It has been suggested that seal, whale or polar bear hunting may be more likely to be carried out by full-time hunters because they required specialized skills and equipment (Kruse 1991, Condon, Collings, and Wenzel 1995, Chabot 2003). Similarly, it was found that found that caribou and muskox hunting activities were undertaken in higher proportions by full-time hunters than part-time hunters from a sample of harvesters in Ulukhaktok, NT (Condon, Collings, and Wenzel 1995). The authors also found that polar bear, seal hunting, trapping, and rabbit hunting were undertaken in greater proportions by active hunters, while rabbit hunting was undertaken mostly by occasional hunters.

Condon, Collings, and Wenzel (1995) also report that duck hunting in June, spring ice fishing, and summer rod and reel fishing were the most popular harvest activities in Ulukhaktok, and involved both part-time and active hunters. Spring fishing and fall fishing involved a greater proportion of full-time hunters than part-time hunters, while summer rod fishing involved approximately equal proportions of part-time and full-time hunters. Duck hunting involved a higher proportion of full-time hunters than part-time hunters. The authors suggest that overall, there is a high level of participation in these activities by both part-time and active hunters because they involve relatively little time investment and knowledge.

While the relevant harvest studies identify catch in a community in a month (in terms of kilograms of meat harvested), the actual number of days spent on the land by hunters in the month is not reported. For this study, it is assumed that different levels of harvest effort are expended for different species that are reported in the harvest studies. It is assumed that full-time hunters devote an average of 20 days per month (the amount of time that may alternatively be devoted to full-time employment) to harvesting. The harvests of fish, small mammals such as rabbits, and birds are assumed to be carried out by part-time hunters, who may spend mainly weekends (8 days a month on average) harvesting.

The number of days required to harvest a unit (kg) of country food is calculated:

$$k_{ij} = \frac{\sum_j (number\ of\ hunter\ months) * \frac{number\ of\ days}{number\ of\ hunter\ months}}{\sum_j \#\ animals * \frac{edible\ weight}{animal}},$$

where $i \in sea\ mammals, birds, j \in community\ (1, 2, 3, 4)$ and number of hunter months refers to the number of hunters in a month summed across all months surveyed.

It is also possible to calculate the number of animals, by species, hunted per day, as follows:

Table 3-7 Number of animals harvested per day - calculations

		Community 1	**Community 2**	**Community 3**	**Community 4**
	Species name*	**# of animals/ day**	**# of animals/ day**	**# of animals/ day**	**# of animals/ day**
	Caribou	0.34	0.28	0.27	0.27
Land mammals	**Moose**	--	--	0.08	--
	Muskox	0.16	0.1	0.08	0.08
	Polar bear	--	N/A	--	--
	Hare (unspec.)	--	--	3.13	2.21
Fish	**Char**	7.88	17.07	9.84	0.56
	Inconnu	--		5.06	7.26
	Loche (Burbot)	--	--	12.88	--
	Trout	3.84	8.07		15
	Herring	--	--	--	30.02 (pacific)

	Whitefish	6.07	7.24	26.69 (broad); 31.37(lake); 3.11 (unspec.)	19.93 (broad); 9.42 (lake); 26.17 (unspec.)
Sea mammals	**Seal**	0.22	0.1 (Bearded); 0.24 (Ringed)	0.05 (bearded)	0.09 (bearded)
	Whale	See comm. 2	0.12 (beluga); 0.12 (narwhal)	0.12 (beluga)	0.07(beluga)
Birds	**Goose**	1.89(Canada); 11 (Snow)	1.76 (Canada); 4.02 (Snow)	2.06(Snow)	3.75(Snow)

*Names of species and subspecies are presented as listed in the Inuvialuit Harvest Study or Nunavut Wildlife Harvest Study

3.3.4.1 Opportunity cost and out-of-pocket cost equations

The opportunity cost of harvesting a unit of animal may be written:

$$o_{ij} = k_{ij} * h_j * x$$ [9],

where o_{ij} is the opportunity cost of harvesting an animal, h_j is the average hourly wage of trades and construction occupations in the community.

The average hourly wage is multiplied by 8 to represent the total daily wages that may be earned by an individual, since most full-time employees are typically paid for eight hours of employment. While not all individuals may access the labour market—this value is assumed to be an average time cost and represents and exogenous time cost in the community for harvesting an animal. Hourly wage figures were not available for all types of occupations, so available published wage figures were used (see Appendix G).

The basic out-of-pocket cost calculation ($/kg) may be stated as:

$$\pi_{ij} = \alpha_{ij} k_{ij} + \beta_{ij} k_{ij} + c_{ij}\, d$$ [10],

[9] Opportunity cost o_{ij} units: $\frac{days}{kg} * \frac{\$}{hours} * \frac{8\ hours}{day}$

[10] Out-of-pocket cost π_{ij} units: (Fuel cost) + (Equipment ownership and depreciation costs) + (Cost of ammunition) $= \left(\frac{\$}{day} * \frac{days}{kg}\right) + \left(\frac{\$}{day} * \frac{days}{kg}\right) + \left(\frac{\$}{kg} * kg\right)$

where $i \in caribou, land\ mammals, fish, sea\ mammals, birds$, $j \in community$ (1, 2, 3, 4), α_{ij}: cost of equipment per day spent harvesting, β_{ij}: cost for fuel per day assuming one trip per day, k_{ij}: days required per kg harvested, c_{ij}: cost per kg harvested, d: kg harvested.

The α_{ij} and β_{ij} terms are:

$$\alpha_{ij} = k_{ij} * (fuel\ costs\ per\ day)$$
$$\beta_{ij} = k_{ij} * (equipment\ ownership\ and\ depreciation\ cost)$$

It is assumed that the cost of fuel per day spent on the land is the cost of one trip to the harvesting site, where harvest distances are determined by measurements with published maps. The term c_{ij} is comprised of ammunition costs, where it is assumed that four bullets are required for seals and whales (Smith and Wright 1989), two shots are required for caribou (Smith and Wright 1989) and one shot per goose.

The community-level out-of-pocket country food cost represents the marginal cost of harvesting when it is assumed that individuals have obtained the set of equipment and materials in the present time period specifically for the purpose of harvesting the country food type in question. In other words, there is non-joint use of equipment. It is also assumed that all individuals in a community access fuel and equipment from the same outlets. In reality, individuals may use different types of equipment for harvesting. However, it is assumed presently that individuals face exogenous community-level prices for a set of market inputs used in harvesting.

Data from published sources on harvesting are used to help define the set of equipment potentially used by households across communities. Households use varied equipment in different seasons and for harvesting different animals. Smith (1991) published operating and depreciation costs per day by species and hunt type (season and type of equipment used) for a sample of 21 hunters in Inukjuak, Quebec. Smith and Wright (1989) published purchasing cost, depreciation period, and annual depreciation cost for various pieces of equipment that may be used in winter or summer harvesting in Holman (Ulukhaktok, NT). While total quantities harvested for each animal type harvested are reported, mean annual cost is not delineated by animal type—i.e., the per-animal cost of harvesting caribou is not reported. Ames et al. (1989) published the cost of equipment of harvesters in Clyde River, NU for three periods between 1971 and 1985, though the costs for different kinds of harvesting are not reported.

The inventory reported by Smith and Wright (1989) is adopted for calculation of the daily cost of using harvest equipment. Prices for snowmobiles, ATVs, boat hulls and motors, firearms and ammunition were found in from online sources, while prices for other equipment were taken from Smith and Wright's (1989) listed prices and adjusted to 2006 prices with the CPI for Yellowknife, NT (Statistics Canada 2012b). The daily cost of each piece of equipment and total equipment cost per day and the variable costs of fuel and ammunition are shown in the following table.

Table 3-8 Equipment costs

Equipment	Cost ($)	Period of depreciation	Adjusted cost (2006)*	Cost per day ($)
Transportation equipment				
Snowmobile and ATV (average)	$10 987 (2012) (Sitiku Sales & Service 2012)	10 (CBSA 2001)	10 908	2.67
Hull of Boat	$3400 (1984) (Smith and Wright 1989)	7 (Smith and Wright 1989)	5299	4.98
Motor of Boat	$3500 (1984) (Smith and Wright 1989)	3 (Smith and Wright 1989)	455	2.07
Vehicle fuel efficiency and fuel costs				
Snowmobile	5.96 km/l (Yamaha 2013)	--	--	Determined by distance travelled
ATV	16.8 km/l (ATV Connection 2013)	--	--	Determined by distance travelled
Boat (assume two-stroke motor)	1.78 km/l (Boattest.com	--	--	Determined by distance travelled

	2013)			
Hunting and Fishing equipment				
Rifle (average of centre fire and summer rifle)	$450 (1984) (Smith and Wright 1989)	6 (Smith and Wright 1989)	701	0.32
Shotgun	$450 (1984) (Smith and Wright 1989)	8 (Smith and Wright 1989)	670	0.23
Fishnet	$270 (1984) (Smith and Wright 1989)	2 (Smith and Wright 1989)	421	0.58
Rifle bullet (assume centre-fire .30-06)	1.50 (Cabela's Canada 2012)	--	1.33	--
Shotgun bullet (assume 12-gauge shotshell)	0.52 (Cabela's Canada 2013)	--	0.46	--
Winter equipment				
Sled	160	4	247	0.17
Tent	120	2	185	0.25
Telescopic sight	200	6	309	0.14
Gas lamp	50	3	77	0.07
Sleeping bag	5	5	8	0.004
Parka	250	3	386	0.35
Mitts	50	2	77	0.11
Shoes	50	1	77	0.21
Duffles	100	1	154	0.42
Wind pants	100	2	154	0.21
Tarpaulins	150	2	232	0.32
Ice chisel	35	8	54	0.02
Shotgun	430	8	664	0.23
Open-water boat	100	6	154	0.07
Traps	1250	15	1930	0.35
Shovel	25	2	39	0.05
Axe	40	2	62	0.08
Snow knife	10	10	15	0.004
Summer equipment				
Controls	800	6	1235	0.56
Tent	350	4	540	0.370
Rain gear	75	75	116	0.004
Boots	50	50	77	0.004
Tarpaulins	100	10	154	0.042
Radio SSB	1700	10	2625	0.72
Gas stove	75	3	116	0.11
Tools	250	2	386	0.53
Gas cans	65	3	100	0.09

The types of transportation equipment and hunting equipment vary by species, which may be classified into hunt "types." The classification and types of equipment involved are shown in the following table.

Table 3-9 Out-of-pocket daily equipment costs by species type

Species type	Equipment list	Total cost per day ($)
Caribou and other land mammals (assume 2 shots for caribou and other land mammals (Smith and Wright 1989)	• Snowmobile, ATV, and boat (average cost) • Rifle • Miscellaneous equipment costs (average of winter and summer costs + year-round cost)	8.51
Sea mammals (assume 4 shots per seal and whale (Smith and Wright 1989)	• Snowmobile, ATV, and boat (average cost) • Rifle • Miscellaneous equipment costs (average of winter and summer costs + year-round cost)	8.51
Fishing	• Snowmobile, ATV, and boat (average cost) • Fishnet • Miscellaneous equipment costs (average of winter and summer costs + year-round cost)	8.76
Birds (assume one shot)	• Snowmobile, ATV, and boat (average cost) • Shotgun • Miscellaneous equipment costs (average of winter and summer costs + year-round cost)	8.42

Fuel prices are assumed to the same across the study area and are based on the price of gas in Yellowknife in 2006 ($1.2/L), since community-level gas prices are not available (GNWT 2006).

Daily cost for using each piece of equipment is calculated as:

$$\beta_{ij} = \frac{\$}{year} * \frac{year}{\frac{365\ days}{year}}$$

The fuel or transportation costs per day may be written as:

$$\alpha_{ij} = \frac{\$1.2}{L} * \frac{L}{8.18\ km} * \frac{km}{day}$$

While the litres of gasoline required to operate a boat and snowmobile vary, an average measure of snowmobile and boat mileage (8.18 km/L) is used. For travel distances, animal range map and community land use maps were used to estimate the distance required to harvest each type of animal (see following table).

Table 3-10 Assumed distances for caribou

	Species name*	Distance (km)	Distance (km)	Distance (km)	Distance (km)
	CARIBOU	**341**	**343**	**267**	**271**
Land mammals	**Moose**	--	--	172	117
	Muskox	140	147	466	411
	Polar bear	--	N/A	--	--
	Hare (unspec.)	--	--	173	--
Fish	**Char**	89	137	161	--
	Inconnu	--	--	--	--
	Loche (Burbot)	--	--	--	--
	Trout	89	137	--	126
	Herring	--	--	--	126
	Whitefish	89	15.92	161	126
Sea mammals	**Seal**	306	281	171	93
	Whale	Used community 2 price with absence of harvest data	191	126	116
Birds	**Goose**	128	119	148	88

Wildlife maps from published government and academic sources are used to estimate potential travel distances for wildlife. It is assumed that individuals from a given community must travel the same distance to harvest different wildlife species. Travel distances are shown in Appendix H.

3.3.4.2 Calculated country food prices

Opportunity and out-of-pocket costs were calculated for groups of species:

Table 3-11 Calculated opportunity cost (opp. cost) and out-of-pocket (pocket cost) country food prices ($/kg) species

		COMMUNITY 1		COMMUNITY 2		COMMUNITY 3		COMMUNITY 4	
	Species name*	**Opp. cost ($/kg)**	**Pocket cost ($/kg)**	**Opp. cost ($/kg)**	**Pocket cost ($/kg)**	**Opp. cost ($/kg)**	**Pocket cost ($/kg)**	**Opp. cost ($/kg)**	**Pocket cost ($/kg)**
	CARIBOU	**10.31**	**3.87**	**12.34**	**4.66**	**16.59**	**4.27**	**16.14**	**4.21**
Land mammals	**Moose**	--	--	--	--	12.74	2.18	15.73	2.04
	Muskox	9.28	1.73	14.63	2.81	22.11	8.57	24.57	8.52
	Polar bear	--	--	N/A	N/A	--	--	--	--
	Hare (unspec.)	--	--	--	--	33.05	5.85	--	--
	AVERAGE	**9.28**	**1.73**	**14.63**	**2.81**	**22.64**	**5.53**	**20.15**	**3.64**
Fish	**Char**	14.64	2.02	6.75	1.23	14.79	2.41	--	--
	Inconnu	--	--	--	--	15.4	2.51	--	--
	Loche (Burbot)	--	--	--	--	11.04	1.80	--	--
	Trout	24.97	3.45	11.87	2.17	--	--	8.04	1.10
	Herring	--	--	--	--	--	--	9.47 (pacific)	3.03(pacific)
	Whitefish	18.99	2.62	15.92	2.91	4.52 (broad); 6.28 (lake); 44.14 (unspec.)	0.74 (broad); 1.02 (lake); 7.18 (unspec.)	6.05 (broad); 20.91 (Lake); 5.24 (unspec.)	0.83 (broad); 2.86 (Lake), 0.72 (unspec.)
	AVERAGE	**19.53**	**2.69**	**11.52**	**2.10**	**16.03**	**2.61**	**9.94**	**1.71**
Sea mammals	**Seal**	27.49	9.29	16.44 (Bearded); 25.31 (Ringed)	5.54 (Bearded); 8.65 (Ringed)	39.41 (bearded)	6.71 (bearded)	22.52 (bearded)	2.56 (bearded)
	Whale	See Comm. 2^	See Comm. 2^	3.7 (beluga) 3.41 (narwhal)	0.65 (beluga), 0.60 (narwhal)	4.77(beluga)	0.66 (beluga)	8.05 (beluga)	1.05 (beluga)
	AVERAGE	**11.53**	**3.56**	**12.22**	**3.65**	**22.09**	**3.68**	**15.28**	**1.80**
Birds	**Goose**	37.32 (Canada); 8.92 (Snow)	6.95 (Canada); 1.94 (Snow)	40.41 (Canada); 24.41 (Snow)	7.19 (Canada); 4.48 (Snow)	59.94 (Snow)	9.83 (Snow)	32.92 (Snow)	3.97 (Snow)
	AVERAGE	**23.12**	**4.23**	**32.27**	**5.53**	**59.94**	**9.36**	**32.92**	**3.81**

*Names of species and subspecies are presented as listed in the Inuvialuit Harvest Study or Nunavut Wildlife Harvest Study; ^ Lack of data in harvest study - Community 2 prices used.

3.4 Data set 2: Aboriginal Peoples Survey

3.4.1 Data description

In Chapter 2, the Aboriginal Peoples Survey (APS) was described as a Canadian survey that incorporates the survey module the Survey of Living Conditions in the Circumpolar Arctic (SLiCA). The dataset available for analysis in this research is the public use microdata file (PUMF) obtained through the Data Liberation Initiative (Statistics Canada 2003b, 2009b).

In this research, food consumption and harvesting patterns of northern Canadians is of interest. In the PUMF releases of the 2001 and 2006 APS, respondents are delineated by geographic categories "Census Metropolitan Area," "the Arctic", "Other rural", or "Other urban". "Arctic" refers to people residing in any of the four Inuit regions—Nunatsiavut, Nunavik, Nunavut, and the Inuvialuit region. An Arctic supplement questionnaire was administered to adults 15 years in these four regions. This supplement included questions on harvesting activities, personal wellness, and community wellness and social participation. The APS PUMF contains individual survey responses for select variables from the census along with APS variables from the core or Arctic questionnaires.

The sampling method used in the Aboriginal Peoples Survey involved stratification of the Aboriginal populations (North American Indian (NAI), Metis, and Inuit) by "domains of estimation," or geographical regions for which estimates with an "acceptable" level of precision are targeted. The geographical regions were separated into Inuit regions and outside Inuit regions. Outside Inuit regions, the targeted geographical units included Census Metropolitan areas (CMAs) and Census Subdivisions (CSDs). Of interest in this research are populations in Inuit regions of Canada where the Arctic supplement was administered. Inuit communities selected for the survey for 2001 (53 communities) and 2006 (33 communities) are listed in Table 3-12 (Statistics Canada 2003a, p. 39-40, 2009b, p. 34). The communities covered are listed, though the PUMF dataset available does not provide data delineated by community.

Table 3-12 Inuit communities surveyed in Aboriginal Peoples Survey 2001 and 2006

	2001 communities	2006 communities
Province/Territory	Community name	Community name
Newfoundland and Labrador	Happy Valley – Goose Bay	Happy Valley – Goose Bay
	Makkovik	Hopedale
	Nain	Nain
	Postville	
	Rigolet	
Quebec	Akulivik	
	Aupaluk	
	Chisasibi	
	Inukjuaq	Inukjuak
	Ivujivik	
	Kanqiqsualujjuaq	Kangiqsualujjuaq
	Kangiqsujuaq	Kangiqsujuaq
	Kangirsuk	
	Kuujjuaq	Kuujjuaq
	Kuujjuarapik	Kuujjuarapik
	Puvirnituq	Puvirnituq
	Quaqtaq	
	Salluit	Salluit
	Tasiujaq	
	Umiujaq	
Northwest Territories	Aklavik	Aklavik
	Holman (Ulukhaktok)	
	Inuvik	Inuvik
	Paulatuk	
	Sachs Harbour	
	Tuktoyaktuk	Tuktoyaktuk
Nunavut	Arctic Bay	Arctic Bay
	Arviat	Arviat
	Baker Lake	Baker Lake
	Bathurst Inlet	
	Cambridge Bay	Cambridge Bay
	Cape Dorset	Cape Dorset
	Chesterfield Inlet	
	Clyde River	Clyde River
	Coral Harbour	Coral Harbour
	Gjoa Haven	Gjoa Haven
	Grise Fiord	
	Hall Beach	Hall Beach
	Igloolik	Igloolik
	Iqaluit	Iqaluit
	Kimmirut	
	Kugaaruk	Kugaaruk
	Kugluktuk	Kugluktuk
	Pangnirtung	Pangnirtung
	Pond Inlet	Pond Inlet
	Qikiqtarjuaq	Qikiqtarjuaq
	Rankin Inlet	Rankin Inlet
	Repulse Bay	Repulse Bay
	Resolute	
	Sanikiluaq	Sanikiluaq
	Taloyoak	Taloyoak
	Umingmaktok	
	Whale Cove	

As stated in Chapter 2, a weakness of the Aboriginal Peoples Survey is that the sampling frame is limited to respondents who were randomly chosen to participate in the Census (Statistics Canada 2003a, 2009b, Delic 2009). Statistics Canada states: "The Aboriginal Peoples Survey is a probabilistic survey, which means that a random sample was selected to represent the target population" (Statistics Canada 2003a, p. 8).

With survey responses obtained with a stratified sampling design, the quality of the estimates is of concern. One concern is that the "persons selected for the APS do not constitute a simple random sample of the target population… the selection of persons was done according to unequal probabilities (Statistics Canada 2009b, p. 5). Since methods of modeling and variance calculation depend on the sampling design and selection probabilities, survey weights are provided with the PUMF to account for over- and under-representation of some groups in the survey. The weights provided with the 2001 and 2006 APS PUMFs are used to indicate the number of persons represented by the estimate and "must be used for all estimations." The weight is adjusted for factors such as non-response and discrepancies between the sample and known characteristics of the target population, as determined by post-stratification adjustment. The number of respondents of the APS 2001 and 2006 and the weighted frequencies (the population size represented by the sample) are shown below for the Arctic and other regions).

Table 3-13 Frequencies and weighted frequencies of respondents in the 2001 and 2006 Aboriginal Peoples Survey

Geography	2001 Frequency	2006 Weighted Frequency	2001 Frequency	2006 Weighted Frequency
CMA (Census Metropolitan Area)	10 258	375 942	9765	536 508
Arctic	2478	8910	2457	26 781
Other rural	8910	171 897	6693	217 847
Other urban	7946	211 648	5453	257 249
Total	29 592	785 777	24 368	1 038 385

To calculate the number or percentage of people in the population targeted by the survey who have a certain characteristic or fall into a defined category, proportions and ratios must be calculated. The steps to calculate the ratio of the form $\frac{\hat{Y}}{\widehat{W}}$ are: (i) sum the final weights of records with the characteristic of interest in the population or in a domain of interest to get $(\hat{Y})$; (ii) sum the final weights of all records in the population or in the same domain of interest in (i) by the result obtained in (ii) to get $\widehat{W}$, and (iii) divide the result obtained in (i) by the result obtained in (ii) to obtain $\frac{\hat{Y}}{\overline{\overline{W}}}$ (Statistics Canada 2009a, p. 15). The weighting procedure will be applied to the data.

3.4.2 Overview of variables

Responses for four questions or series of questions from the Aboriginal Peoples Survey in 2001 and 2006 are used to examine the economic determinants of country food harvesting and consumption. Questions with the phrase "in your household" are used to address household-level activity, while a question on individual participation in harvesting is also used. Corresponding 2001 and 2006 questions are categorized under general variable name headings, although the samples for the variable for individual harvesting status ($IHARVEST$) for the two survey periods are different. The 2006 survey contains a question on whether or not the individual had "ever" participated in the harvesting activity, along with the question of whether or not the individual had participated in the harvesting activity in the previous year. Only respondents in 2006 who answered affirmatively in the first question were included in the sample. Dependent variables used for this analysis are outlined in the following table.

Table 3-14 Names, definitions and summary statistics of dependent variables from Aboriginal Peoples Survey used for analysis

Variable name and description	Definition
MEATFISH HH Proportion of total meat and fish eaten in the past year that was country food	Ordinal: 0 = "none", 1 = "less than half", 2= "about half", 3 = "more than half" [2001 and 2006: "Of the total amount of meat and fish eaten in your household during the year ending (December 31st, 2000/December 31st, 2005), how much of this total was country food?" (Variables - 2001: *I11AMFOD*; 2006: *A_IG11*)]
IHARVEST Individual hunted and/or fished and/or gathered wild plants and/or trapped in past year	Binary: =1 If individual hunted and/or fished and/or gathered and/or trapped in past year, 0 otherwise [2001: Binary: If at least one of (*C34HUNT*, *C34FISH*, *C34GATH*, *C34TRAP*) = 1 ("Yes"), then *IHARVEST* = 1, 0 otherwise] [2006: Binary: If at least one of (*CG10A*, *CG11A*, *CG12A*, *CG13A*) = 1 ("Yes"), then *IHARVEST* = 1, 0 otherwise (Sample: Respondents who answered "yes" to corresponding question about having ever hunted/fished/gathered/trapped)]

	Questions by activity: • Hunting: 2001: "In the past 12 months, have you done any of the following activities? Hunting?" (*C34HUNT*) 2006: "Have you ever hunted?" (*CG10*) / "Have you hunted in the past 12 months?" (*CG10A*) • Fishing: 2001: "In the past 12 months, have you done any of the following activities? Fishing?" (*C34FISH*) 2006: "Have you ever fished?" (*CG11*) / "Have you fished in the past 12 months?" (*CG11A*) • Gathering: 2001: "In the past 12 months, have you done any of the following activities? Gathering wild plants such as berries, sweet grass, etc.?" (*C34GATH*) 2006: "Have you ever gathered wild plants such as berries, rice or sweet grass?" (*CG13*) / "Have you gathered wild plants in the past 12 months?" (*CG13A*) • Trapping: 2001: "In the past 12 months, have you done any of the following activities? Trapping?" (*C34TRAP*) 2006: "Have you ever trapped?" (*CG12*) / "Have you ever trapped in the past 12 months?" (*CG12A*)
HHHARVEST HH member harvested in past year	Binary: =1 if at least one household member harvested in past year, 0 otherwise [2001 and 2006: "During the year ending December 31st, 2000, did …harvest country food?" (2001)/ "Did at least one person in the household harvest country food during the year ending December 31st, 2005?" (Variables - 2001: *I08GAT_P*; 2006: *A_IG08H*)]

Individual- and household-level demographic characteristics are collected in the survey cycles. For individuals who report household participation in harvesting, additional questions on whether the household ate food harvested, gave away harvested food for free, gave harvested food away in exchange for gas or supplies, and sold country food, were asked. For households who report a positive proportion of country meat and fish consumed out of total country meat and fish consumed, additional questions on whether or not meat and fish were received for free ($FREE$), received in exchange for gas and supplies ($XCHG$), and bought from the market ($BOUGHT$), were asked. Missing responses from the data are those where the respondent stated "don't know" and "not stated". Responses coded "valid skip", where the question posed is only relevant if the individual responded positively to a previous question, are also considered missing data. The midpoint of the data range is used in analysis for each category defined in value terms

($AGE, ITOTINC, HHINC$). The years of education are approximated and the variable EDU is specified as a continuous variable.

Table 3-15 Names and definitions of explanatory variables in 2001 and 2006 Aboriginal Peoples Survey

Variable abbreviation and description	Definition
Individual non-employment variables	
AGE Age of respondent or proxy	Ordinal recoded as continuous: 15-19 years = 17 years, 20-24 years = 22 years, 25-34 years = 29.5 years, 35-44 years = 39.5 years, 45-54 years = 49.5 years, 55+ = 55 years (**2001**: *AGEGRP*; **2006**: *GDAGEYRS*)
GENDER Gender of respondent or proxy	Binary: =1 male, 0 = female (**2001**: *IDQ06SEX*; **2006**: *GDAGEYRS*)
EDU Highest level of education obtained by respondent	**2001**: Ordinal recoded as continuous: No schooling =0 years, Less than high school diploma =6 years, High school diploma =12 years, Some post-secondary =13 years, Some university =14 years, Bachelor's degree =16 years (**2001**: HLOS) **2006**: Ordinal recoded as continuous: Elementary or less =3 years, Some high school =10 years, Completed high school =12 years, Some post-secondary non-university =13 years, Completed post-secondary non-university =14 years, Some university = 14 years (**2006**: *DHLOSGP*)
Household non-employment variables	
HHSIZE Number of persons in household	Ordinal: 1 = 1 person, 2 = 2 people, 3 = 3 people, 4 = 4 people, 5 = 5 people, 6 = 6 or more people (**2001**: *UNITS*; **2006**: *GNUNITS*)
MAINTAIN Number of persons who pay the rent, or the mortgage, or the taxes, or the electricity, etc., for the dwelling	Binary: 0 = One household maintainer; 1 = More than one household maintainer [**2001**: *NSTIEN*; **2006**: *GNSTIEN*] Definition of maintainer: "Household maintainer refers to the person or persons in the household who pay the rent, mortgage, or the taxes, or the electricity, etc., for the dwelling" (Statistics Canada 2008, p. 41).
CHILDREN	Ordinal: 1 = No children, 2 = One child, 3 = Two children, 4 = Three children, 5 = Four or more children (**2001**: *LFNUMBER*; **2006**: *GLFNUMB*)
Individual employment variables	
ITOTINC	**2001**: Ordinal recoded as continuous: Less than $5 000 = $2500, $5000 - $ 9999 =$7499.5, $10000 - $14999 =$12499.5, $15000 - $19999 =$17499.5, $20000 - $29999 =$24999.5, $30000 - $39999 =$34999.5, $40000 or more = $40000 (**2001**: *TOTINCC*) **2006**: Ordinal recoded as continuous: Less than $5 000 = $2500, $5000 - $ 9999 = $7499.5, $10000 - $19999 =$14999.5, $20000 -

	$29999=$24999.5, $30000 - $39999 =$34999.5, $40 000 or more =$40000 (**2006**: *GTOTINC*)
IANYWORK	Binary: 1 = if any member of the household employed in full-time, part-time or self-employment, 0 otherwise. [**2001**: If *C01WORK* ("Last week, did you work for pay or in self-employment?") = 1 ("Yes"), then *IANYWORK* = 1, 0 otherwise] [**2006**: If *CG01* ("Last week, did you work for pay or in self-employment?") = 1 ("Yes"), then *IANYWORK* = 1, 0 otherwise]
IPTFT	Ordinal: 0 = if individual is not in part-time or full-time employment, 1 = if any member of the household employed in part-time or self-employment and not employed in full-time employment, 2 = if any member of the household employed in full-time employment **2001**: 1=: If (*C01WORK* - "Last week, did you work for pay or in self-employment?"=1); 2 = If (*CG01* – "Last week, did you work for pay or in self employment?" =1) **AND** (*CG08* – "Was this job full time?"), 0 otherwise **2006**: 1=: If (*CG01* - "Last week, did you work for pay or in self-employment?"=1); 2 = If (*CG01* – "Last week, did you work for pay or in self-employment?" =1) **AND** (*CG08* – "Was this job full time?"), 0 otherwise
Household employment variables	
HHINC Household income	**2001**: Ordinal recoded as continuous: Less than $10,000 =$5000, $10000 - $19999 =$14999.5, $20000 - $29999 = $24999.5, $30000 -$39999 =$34999.5, $40000-$59999 =$49999.5, $60000-$79999 =$69999.5, $80000 or more =$80000 (**2001**: *HHINCC*) **2006**: Ordinal recoded as continuous: Less than $20,000 =$10000, $20000 - $39999 =$29999.5, $40000 -$59999 =$49999.5, $60000-$79999 =$69999.5, $80000-$99999 = $89999.5, $100000 or more =$100000 (**2006**: *GHHINC*)
HHEMPANY At least one household member in full-time or part-time employment	Binary: 1 = if any member of the household employed in full-time, part-time or self-employment, 0 otherwise **[2001: If at least one of (*I01G30_P, I02L30_P, I04SEL_P*) = 1 ("Yes"), then *HHEMPANY* = 1, 0 otherwise]** *I01G30_P*:"During the year ending December 31st, 2000, did … have a paid full-time job (30 hours a week or more), not including self-employment?"

	I02L30_P: "During the year ending December 31st, 2000, did….have a paid part-time job (less than 30 hours a week), not including self-employment?" *I04SEL_P*: "During the year ending December 31st, 2000, did…. Receive any income from self-employment, contract work or compensation for attending meetings or sitting on committees?" **[2006: If at least one of (*A_IG01H, A_IG02H, A_IG04H*) = 1 ("Yes"), then *HHEMPANY* = 1, 0 otherwise]** *A_IG01H*:"During the year ending December 31st, 2005, did … have a paid full-time job (30 hours a week or more), not including self-employment?" *A_IG02H*: "During the year ending December 31st, 2005, did….have a paid part-time job (less than 30 hours a week), not including self-employment?" *A_IG04H*: "During the year ending December 31st, 2005, did…. Receive any income from self-employment, contract work or compensation for attending meetings or sitting on committees?"
HHEMPSC	Ordinal: 0 = if no one in household employed in part-time or full-time employment, 1 = if any member of the household employed in part-time or self-employment and not employed in full-time employment, 2 = if any member of the household employed in full-time employment **2001: 1 = If at least one of (*I02L30_P, I04SEL_P*) = 1 ("Yes") AND *I01G30_P* = 2 ("No"); 2 = If (*I01G30_P*) = 1 ("Yes"), 0 otherwise** *I01G30_P* :"During the year ending December 31st, 2000, did … have a paid full-time job (30 hours a week or more), not including self-employment?" *I02L30_P*: "During the year ending December 31st, 2000, did….have a paid part-time job (less than 30 hours a week), not including self-employment?" *I04SEL_P*: "During the year ending December 31st, 2000, did…. Receive any income from self-employment, contract work or compensation for attending meetings or sitting on committees?" **2006: 1 = If at least one of (*A_IG02H, A_IG03H*) = 1 ("Yes") AND *A_IG01H* = 2 ("No"), 2 = If (*A_IG01H*) = 1 ("Yes"), 0 otherwise** *A_IG01H*:"During the year ending December 31st, 2005, did … have a paid full-time job (30 hours a week or more), not including self-employment?" *A_IG02H*: "During the year ending December 31st, 2005, did….have a paid part-time job (less than 30 hours a week), not including self-employment?" *A_IG04H*: "During the year ending December 31st, 2005, did…. Receive any income from self-employment, contract work or compensation for attending meetings or sitting on committees?"
Variables on uses of harvested country meat and fish– For respondents who answered affirmatively to question "During the year ending December 31st, 2000, did … harvest country food?" (Variables - 2001: *I08GAT_P*; 2006: *A_IG08H*)	
EATEN	Ordinal: 1 = if country food harvested was shared or given away to persons outside the household , 0 otherwise (2001: *I10EAT_H*; 2006: *A_IG10A*)

GIVE	Ordinal: 1 = if country food harvested was shared or given away to persons outside the household , 0 otherwise (2001: *I10GIVE*; 2006: *A_IG10B*)
HXCHG	Ordinal: 1 = if country food harvested was given away in exchange for gas, other supplies, or help , 0 otherwise (2001: *I1XCHG*; 2006: *A_IG10C*)
SOLD	Ordinal: 1 = if country food harvested was sold, 0 otherwise (2001: *I10SELL*; 2006: *A_IG10D*)
Variables on sources of country meat and fish– For respondents who did not report "none" for the question "Of the total amount of country meat and fish eaten in your household in the year ending <December 31st, 2000/December 31st, 2005>, how much of this total was country food?"(Variables - 2001: *I11AMFOD*; 2006: *A_IG11*)	
FREE Country food consumed was received from others for free	Ordinal: 1 = if country food received for free, 0 otherwise (2001: *I12FREE*; 2006: *A_IG12A*)
XCHG Country food consumed was received from others in exchange for gas, other supplies, or help	Ordinal: 1 = if country food received in exchange, 0 otherwise (2001: *I12XCHG*; 2006: *A_IG12B*)
BOUGHT Country food consumed was bought from others	Ordinal: 1 = if country food bought, 0 otherwise (2001: *I12BGHT*; 2006: *A_IG12C*)

The econometric model used to estimate the models were discussed in a previous section of this chapter.

3.5 Empirical framework

3.5.1 Demand system specification

3.5.1.1 Single equations vs. demand systems

Demand equations of the form where quantity demanded is a function of total expenditure and prices [$q_i = g_i(x,p)$] can be expressed algebraically in terms of elasticities and budget shares. Expenditure share analysis has been used in economic analysis to assess welfare, where consumption is an approximation to utility (Deaton and Grosh 2000). Budget shares are fractions of total expenditure being spent on each good and are written $w_i = \frac{p_i q_i}{x}$. An equation or a set of equations can be estimated with data on expenditures, prices, and quantities. The previously defined restrictions of demand functions—adding-up, homogeneity, symmetry, and negative (see Chapter 2), can be applied algebraically on particular functional forms or by imposing the restrictions a priori and using standard statistical tests to test their validity.

Economists have used single equations to estimate demand relationships. A benefit of modeling commodity demands individually or equation by equation is that the functional form can be varied and special explanatory variables easily introduced (Deaton and Muellbauer 1980). One example of a single-equation form uses logs because elasticities are given directly in the estimated parameters:

$$log\, q_i = a_i + e_i\, log\, x + \sum_k e_{ik}\, log\, p_k + u_i,$$

where e_i and e_{ik} are, respectively, total expenditure elasticity and cross-price elasticities for goods thought to be closely associated with good i.

This equation can be estimated by ordinary least squares regression. While the homogeneity restriction can be tested by imposing the restriction a priori and using a statistical test to test its validity, the adding-up restriction cannot be accommodated within this double-logarithmic specification unless constant expenditure patterns are observed at all levels of total expenditure (Deaton and Muellbauer 1980). The assumption of constant expenditure patterns is not realistic since it implies that for large values of x, expenditure on a single luxury (where $e_i > 1$) may exceed the total budget and for small values of x, expenditure on a necessity (where $e_i < 1$) may exceed x. An alternative single equation method that satisfies adding-up is the Working-Leser (W-L) model, which is based on the Engel curve, and shown as follows (adapted from Deaton and Muellbauer 1980):

$$w_i = \alpha_i + \beta_i log x + \varepsilon_i,$$

where x is total expenditure; α_i and β_i are parameters to be estimated.

The Working-Leser model reflects Engel's law, which states that the proportion of income spent on food falls as income rises (Deaton and Paxson 1998). The Working-Leser single equation model is easily estimated because only data on expenditure share and quantity consumed are required. Prices do not need to be obtained for estimation. Single equation estimations do not involve imposing cross-equation restrictions (Slutsky symmetry) and so do not account for cross-commodity impact of prices. Properties of demand functions are more easily incorporated into complete demand systems with simultaneous estimation of a set of demand functions. Hazell and Roell (1983) and Ricciuto, Tarasuk, and Yatchew (2006) estimate the Working-Leser model as a single equation for different types of goods. The model is also estimated in a system by Saha, Capps and Byrne (1997) with raw expenditure as the dependent variable instead of expenditure share.

There are two ways to formulate complete demand systems: i) specify a particular direct or indirect utility function and ii) specify the functional form of the demand equations directly and impose the classical and modern theoretical restrictions (Rauniker and Huang 1987). Demand systems of the first type include the Translog, Houthhakker addilog, and Linear Expenditure System (LES). Demand systems of the second type include the Almost Ideal Demand System (AIDS), Rotterdam, constant elasticity demand system, and the Leser and Powell models. The first complete demand system to be estimated, the LES, originates from Stone (1954). The model begins with a general linear formula for demand. The theoretical restrictions of adding up, homogeneity, and symmetry are imposed algebraically in this system. Since the form of the demand function is derived from a direct utility function, homogeneity and symmetry hold at every point and do not need to be statistically imposed. The problem with the LES is that it implies a strict relationship between own-price elasticities and income elasticities that may be unrealistic (Deaton 1974). Demand systems of the type where restrictions are applied parametrically may be more flexible and be applied to a variety of preference structures.

The Almost Ideal Demand System model has been shown to satisfy the axioms of consumer theory, and has been widely used because restrictions like homogeneity and symmetry may easily be imposed within the system. The Almost Ideal Demand System model is derived from maximization of an indirect utility function, which corresponds to minimization of a cost function of the price independent generalized logarithmic (PIGLOG) form, which permits aggregation of demand estimates over consumers (Deaton and Muellbauer 1980). The AIDS model is traditionally estimated with a price index that is not linear in the parameters. Stone's geometric price index is commonly used to approximate the price index in a version of the AIDS model known as the Linear Approximate AIDS (LA/AIDS) model (Green and Alston 1990). The LA/AIDS model may be written:

$$w_i = \alpha_i + \beta_i * \ln(\frac{x}{P}) + \sum_k \gamma_{ij} \ln(p_j) + \varepsilon_i,$$

where w_i is the budget share of the ith good, x is total expenditure, p_j is the price of the jth good, and P is Stone's price index, which is shown as $\ln P = \sum_{i=1}^{n} w_i \log p_i$.

For the AIDS model, the adding-up restriction is satisfied if $\sum_i \alpha_i = 1$, $\sum_i \beta_i = 0$, $\sum_i \gamma_{ij} = 0$, homogeneity is satisfied if $\sum_j \gamma_{ij} = 0$, and symmetry is satisfied if $\gamma_{ij} = \gamma_{ji}$. One equation is dropped from the AIDS estimation to avoid the problem of multi-collinearity because the adding-up condition ($\sum_i w_i = 1$ for all j) must be fulfilled. The parameters of the dropped equation may be recovered via calculations based on the parametric restrictions.

For the present analysis, the aim is to understand how demand for caribou varies relative to demands for other types of country and store-bought foods. For the purposes of this analysis, a system of Working-Leser equations is estimated to help determine which individual- and community-level factors may affect demand while accounting for total expenditures on food. The problem with the Working-Leser model is that it does not account for price differences. Among communities, prices for store foods as well as country foods may differ significantly. Therefore, it is decided to also estimate a model with prices with the AIDS functional form, which is a flexible functional form without strict conditions for preference structures. The LA/AIDS model will be implemented in this study since the linearized parameters can readily be interpreted. The demand restrictions of adding-up, symmetry, homogeneity can also be easily imposed on the parameters.

3.5.1.2 Incorporating demographic characteristics

As stated in a previous section, it is hypothesized that the demand for a type of food is dependent on its own price, prices of other foods, and on individual- and community-level demographic characteristics. Demographic characteristics may be incorporated in demand analysis in a number of ways. The inclusion of these additional variables is more complex for systems of equations than for single equations. Including individual demographic variables such as age, gender, or education may capture differences in preferences among consumers for different foods (McCracken and Brandt 1987, Nayga and Capps 1994, Blaylock and Blisard 1995, Byrne, Capps, and Saha 1998).

A basic way of examining the impact of demographic variables on demand is to estimate separate demand systems or equations for subsamples of households with identical demographic profiles (Pollak and Wales 1992). The drawback to this method is that it does not enable the researcher to draw inferences about consumers with one profile on the behavior of consumers with different profiles (Rauniker and Huang 1987). The most common way to incorporate household characteristics is to include them directly as arguments in the direct or indirect utility function—Parks and Barten (1973) control for the age structure of populations when estimating demand on five classes of goods across a cross-section of countries, and Lau, Lin and Yotopoulos (1978) include a vector of household characteristics to determine demand for an agricultural producing household. Household characteristics are specified as exogenous variables in the utility function and as continuous or discrete variables in the demand equations to be estimated.

Other specialized methods have also been developed for incorporating demographic variables in demand estimation. Pollak and Wales (1981) outline five general procedures that "replaces [the] original class of demand systems by a related class involving additional parameters and postulates that only these additional parameters depend on the demographic variable": demographic translating, demographic scaling, the "Gorman procedure," "reverse Gorman procedure," the "modified Prais Houthakker procedure," and a new generalized quadratic specification that can be applied to the other specifications. Demographic translating involves replacing the original demand equation that is a function of prices and expenditures by a function of household characteristics. It can be interpreted as allowing "necessary" or "subsistence" parameters of a demand system to depend on demographic variables. With the demographic scaling procedure, the demand equation is multiplied by scaling parameters that are functions of demographic variables. Pollak and Wales (1981) apply the five procedures to a single demographic variable, the number of children in the family. All the methods, except for translating, show similar demand impacts of changes in prices, total expenditure and number of children. Translating and scaling have widely been used in the agricultural food demand literature (e.g. Heien and Durham 1991, Perali and Chavas 2000). Lewbel develops a modifying function approach that provides a general case for the procedures detailed by Wales and Woodland (1983), though this approach has had limited empirical applicability (Lewbel 1985, Liu and Chern 2004).

Another method of incorporating demographic variables is the Blundell and Walker (1984) method that is derived explicitly from household production theory. This approach proposes that demographic variables may enter the utility function directly as rationed non-market goods, and is particularly relevant for the cases where household variables like women's employment status and number of children may be endogenous. The authors develop a specification that allows demographic composition to have an additive fixed cost effect on expenditures and marginal budget shares. Their empirical estimates on pooled cross-section/time-series UK budget data show that young children have a large impact on marginal budget shares. Though some studies on FAFH (Nayga 1996, Mutlu and Gracia 2006) include demographic variables in the utility function, they include them as instrumental or exogenous variables and do not apply Blundell and Walker's empirical specification.

Alternatively, the Neoclassical fertility literature regards the number and ages of children in the family as endogenous variables, as fertility and other household variables are simultaneously determined in a life cycle optimization framework (Schultz 1969, Blundell and Walker 1984). In studies on food-away-from home expenditures, the wife's labour hours are considered endogenous and predicted wife's labour hours is used instead (Yen 1993, Jensen and Yen 1996).

Equivalence scale measures have been developed to account for the role that differences in household size have in the transformation of income to welfare and are built upon the idea that any two households of different sizes or compositions but with the same food expenditure share have the same level of welfare (Lazear and Michael 1980, Blaylock 1991). The number, age, and gender of household members are also often specified endogenously as an equivalence scale measure that is derived by assigning different weights to household members according to their age and gender (Gould and Villarreal 2002). They are ideally be specified to account for family type goods, economies of scale, division of labor, voluntary substitutions, etc. (Blaylock 1991). Equivalence scales can be calculated on the basis of individual nutritional requirements, as in the approach used by governments to construct poverty level equivalents, but can also be estimated by a revealed preference approach where equivalence is derived from estimated demand coefficients (Lazear and Michael 1980). Prais and Houthakker (1955) developed such a revealed preference model that became widely used. Agricultural food demand studies have estimated endogenous equivalence scales in censored demand systems for food and types of meat (Gould and Villarreal 2002, Aguero and Gould 2003).

For the present analysis, the basic Working-Leser equation is modified to include demographic variables by using the method of demographic translation, as implemented by Heien and Wessells (1990) and Chern (2002) for systems of equations. Demographic variables can easily be included in estimation without scaling and the adding-up restriction can easily be applied. The modified Working-Leser model is written (adapted from Chern et al. 2002, p. 14)

$$w_i = \alpha_0{}^* + \alpha_i * \log x + \sum_k \gamma_{ik} * D_k + \varepsilon_i,$$

where w_i: expenditure share for a particular food i; x: total expenditure on all goods; D_k: individual- and community-level demographic variables; ε_i is a random disturbance term; $\alpha_0{}^*$ is α_0-$\sum_k \gamma_{ik} * D_k$.

The LA/AIDS model may also be modified to include demographic variables with demographic translating. The modified LA/AIDS model is written (Chern et al. 2002, p. 23):

$$w_i = \alpha_0{}^* + \beta_i * \ln(\frac{x}{P}) + \sum_j \gamma_{ij} \ln(p_j) + \sum_k \gamma_{ik} * D_k + \varepsilon_i,$$

where w_i: expenditure share of a particular food i; x: total expenditure on all goods in the model; P is Stone's price index which is specified $\ln P = \sum_{i=1}^{n} w_i \log p_i$, p_j is price; D_k: individual- and community-level demographic variables; ε_i is a random disturbance term; $\alpha_0{}^*$ is α_0-$\sum_k \gamma_{ik} * D_k$.

As in the basic AIDS model, the adding-up restriction is satisfied if $\sum_i \alpha_i = 1$, $\sum_i \beta_i = 0$, $\sum_i \gamma_{ij} = 0$, homogeneity is satisfied if $\sum_j \gamma_{ij} = 0$, and symmetry is satisfied if $\gamma_{ij} = \gamma_{ji}$. In the present version with demographic variables included, adding-up is fulfilled if $\sum_i \alpha_0{}^* = 1$ and $\sum_k \gamma_{ik} = 0$.

3.5.1.3 Participation equation and two-step estimation

An econometric problem that arises in the estimation of cross-sectional consumption survey data is that of a large number of zeros in the dependent variable. Data with zero observations may be described as i) "truncated," where observations outside a specified range are unobservable, and ii) censored, where values in a certain range are all transformed to (or reported as) a single value and this value may still be related to exogenous variables (Amemiya 1984; Greene 1990). In economics applications, the censored case is more common. For example, incomes below the poverty line might be reported as being at the poverty line. The main reasons for the reported zero values are that: 1) the consumer chooses not to consume the product at current income and price levels (corner solution); 2) the consumer chooses not to participate in the market independently of price and income levels (conscientious abstention), and 3) the specific product has a purchase cycle longer than the survey period length (infrequency of purchase) (Pudney 1988; Mutlu and Gracia 2006).

Econometric models that deal with this type of data include the Tobit model (Tobin 1958), modifications of the original Tobit model, the P-Tobit model and the gamma-Tobit model (Deaton and Irish 1983, Pudney 1988; Atkinson Gomulka and Stern 1990), Cragg's double-hurdle model (1971), the first hurdle dominance and complete dominance models (Jones 1989), Heckman's sample selection model (1979), full-information maximum likelihood method (Amemiya 1974), the quasi maximum likelihood method (Avery, Hansen and Hotz 1983), and the simulated maximum likelihood method (Kao, Lee, and Pitt 2001). Though the general specifications of these models mainly involve a single equation, estimation procedures have been developed for estimation of simultaneous equations (Amemiya 1974; Lee and Pitt 1986, 1987; Wales and Woodland 1983; Heien and Wessells 1990, Shonkwiler and Yen 1990).

The standard Tobit model structure is specified as:

$$y_i^* = x_i'\beta + \varepsilon_i$$

$$y_i = \begin{cases} y_i^* \ if \ y_i^* > 0 \\ 0 \ if \ y_i^* \leq 0 \end{cases},$$

where y_i^* is latent utility. Utility is observed if the response variable is greater than zero. The model is estimated by maximum likelihood estimation, which combines a discrete distribution to investigate why some household have positive unobserved utility and others do not, and a continuous distribution to model the relationship for those with $y_i^* > 0$. The Tobit model assumes that the effect of an explanatory variable on the probability of consumption and the quantity consumed are the same, and does not allow for separate participation and consumption decisions. Therefore, it is assumed that everyone would participate in the market at certain income and price levels—zero consumption implies a corner solution.

Heckman's sample selection problem assumes that there are separate participation and consumption decisions. Heckman's model is illustrated as follows (Green 2003, p. 794):

$$d_i^* = z_i'\alpha + \nu_i,$$

$$y_i^* = X_i'\beta + \varepsilon_i$$

$$[\varepsilon_i, \nu_i] \sim \text{bivariate normal } [0, 0, \sigma^2, p, 1]$$

$$d_i = 1 \; if \; d_i^* > 0$$

$$d_i = 1 \; if \; d_i^* \leq 0$$

$$y_i = d_i y_i^*, (i = 1, 2, \ldots, n).$$

The first equation determines participation and the second equation determines consumption. It is assumed that the two error terms (u_{i} and ν_i) are correlated and joint normal. The problem can be thought of as a sample selection bias problem, where the data that are observed are selected by a systematic process that is not observed. The expected value of y_i^* can be shown as $E[y_i^*|x_i, d_i = 1] = x_i'\beta + E[\varepsilon_i|x_i, d_i = 1] = x_i'\beta + \theta\lambda_i$ where λ_i is referred to as Heckman's lambda or the inverse Mills ratio (IMR). The inverse Mills ratio is specified:

$$\lambda_i = \frac{\phi(z_i'\widehat{a_\iota})}{\Phi(z_i'\widehat{a_\iota})}.$$

In the first stage, y_i^* is regressed upon z_i' by the Probit method to retrieve the parameters of the inverse Mills ratio. In the second stage, the y_i is regressed upon X_i' and λ_i for the individuals with positive consumption. This estimation may be carried out in two steps or by maximum likelihood estimation (Heckman 1979). If z_i' and X_i' are identical, the model is identified only through a nonlinearity of λ_i—the two-stage model can be solved because of assumptions on the distribution of the residuals (Achen 1986, Sartori 2003). However, not having additional variables in the first stage may lead to high multicollinearity and large standard errors in the estimates. Sartori (2003) points out models without additional explanatory variables in the first stage is still estimable, and suggests that theory might dictate that the first stage variables are should be included in the second stage.

The second stage of the Heckman model is estimated only with positive consumption values, as in the Tobit model, since it assumes that individuals who pass the participation hurdle will have positive consumption. The econometric specification for the maximum likelihood function of the Heckman model is also called the First Hurdle Dominance Model (Jones 1989, Garcia and Labeaga 1996). The Complete Dominance model is similar to the Heckman and First Hurdle Dominance models, but assumes that the participation and consumption decisions are independent. It also assumes that individuals who pass the participation hurdle will have positive consumption, and that there will be no corner solution.

Cragg's double hurdle model is similar to the Complete Dominance and Heckman models but allows for censoring at both participation and consumption stages, which are also assumed to be independent. The second stage allows for the possibility that there is a corner solution of zero where the consumer chooses to participate in the market but cannot consume at current prices and income. An extension of Cragg's double hurdle model is the infrequency-of-purchase model, which posits that zero expenditure at the second stage may represent a corner solution or consumption from storage rather than purchase. This model may be applicable for data on foods have a long storage life or non-food durable goods. This model is specified by Blundell and Meghir (1987) and Deaton and Irish (1983) and is used by Blisard and Blaylock (1993), Mutlu and Gracia (2006), and others.

These models have been used to model the demand for labour, food, and non-food goods. Heckman's (1979) model was originally concerned with correcting the sample selection bias that may arise from the estimation of factors that determine wages due to the problem that people with a lower potential for wages may be more likely to be unemployed. Tobin (1958) originally used data for household expenditures on durable goods. To model the demand for food-away-from-home, the Tobit (McCracken and Brandt 1983; Kinsey 1983), a modification of Cragg's double-hurdle model (Yen 1993), and a two-step sample selection model (Lee and Brown 1986; Byrnes, Capp and Saha 1998; Stewart and Yen 2004) have been used. Other zero-consumption models for a single good or a class of aggregated goods have been carried out for butter (Blisard and Blaylock 1993 [Cragg-type estimator]), shellfish and finfish (Cheng and Capps 1988 [Heckman-type estimator]), cheese (Gould 1992 [Cragg-type estimator]), convenience meats (Manrique and Jensen 1997 [Heckman-type estimator]), alcohol (Deaton and Irish 1983 [p-tobit estimator]), tobacco (Deaton and Irish 1983; Jones 1989 [Cragg-type estimator]), clothing (Blundell and Meghir 1987 [Cragg-type estimator]; Pudney 1988 [modified p-tobit estimator and alternative estimators]), and married women's labour supply (Blundell and Meghir 1987), individual meat types (Burton, Tomlinson and Young 1994 [Cragg-type estimator]), and various foods (Haines, Guilkey, and Popkin 1988 [Cragg-type estimator]).

Heien and Wessells (1990) adapt the two-step estimator that is shown by Amemiya (1974) and Lee (1978) to be consistent (though not fully efficient) for a system of equations. As pointed out by Heien and Wessells (1990), the estimator is shown by Lee (1978) to be asymptotically more efficient than estimators developed by Nelson and Olsen (1978) and Heckman (1978). Heien and Wessells (1990) estimate the Almost Ideal Demand System with eleven food items, where the first stage involves estimating probit equations where the dependent variable is a dummy for whether or not the item was consumed in the survey period. In the second stage, all observations are used in the demand system estimation, with the inverse Mills ratio from the first stage used as an instrument in the second stage. Household explanatory variables include percent of meals at home, location, season, region, tenancy, occupation, ethnicity, shopping member of the family, and number of male household members; the same explanatory variables are used in both the first and second stages. The decision of whether or not to consume and quantity consumed are specified the same way as in the Heckman two-stage model. However, in Heien and Wessells's specification, the inverse Mills ratio is calculated, for the *i*th food and the *h*th household, as follows (adapted from Heien and Wessells 1990, p. 369):

$$\lambda_{ih} = \frac{\phi(z'_{ih}\widehat{a_{ih}})}{\Phi(z'_{ih}\widehat{a_{ih}})} \; if d_{ih} = 1,$$

$$\lambda_{ih} = \frac{\phi(z'_{ih}\widehat{a_{ih}})}{1 - \Phi(z'_{ih}\widehat{a_{ih}})} \; if d_{ih} = 0 .$$

Various studies use the Heien and Wessells (hereafter also referred to as HW) procedure but model demand with different demand system models and estimation procedures. Heien and Wessells (1990) use the Seemingly Unrelated Regressions (SUR) method that is a least squares method to estimate the Almost Ideal Demand System (AIDS) model in the second stage estimation, as do Abdelmagid, Wohlgenant, and Safley (1996), to model demand for nursery plants. Gao and Spreen (1994) employ the HW procedure in a hybrid demand system and estimate it using the White robust information consistent algorithm. Nayga estimates a Quadratic Expenditure System and SUR estimation to model demand for disaggregated meat products and fruits and vegetables (1995a; 1995b). Park et al. (1996) use the Linear Expenditure System to model the demand for 12 categories of food consumed by the household. Wang et al. (1996) use Barten's synthetic demand system, the CBS, Rotterdam and AIDS models to estimate demand for three categories of alcohol. They apply the assumption that budget allocation to alcohol expenditures is separable from the allocation to individual alcohol groups. Heien and Durham (1991) estimate the QES using the iterative Three Stage Least Squares method to model the demand for seventeen goods. Wellman (1992) estimates an AIDS model with seven categories of fish using SUR (1992). Salvanes and Devoretz use the LA/AIDS model to estimate demand for meat and fish and test for separability of the groups (1997).

Following the development of the Amemiya (1974) estimator, Wales and Woodland (1983) and Lee and Pitt (1987) developed estimators based on Kuhn-Tucker conditions. These estimators are consistent with demand theory, and the derived full information maximum likelihood estimators require integration of multivariate normal probability density functions. The HW estimation technique and other two-stage methods by Shonkwiler and Yen (1999) and Perali and Chavas (2000) have therefore been developed as more computationally simple techniques. Shonkwiler and Yen (1999) criticize the HW estimators as being inconsistent. Their method is based on the Amemiya estimator, like HW, but uses a vector of maximum likelihood parameters from the first stage in the second stage estimation. Su and Yen (2000) use this method to estimate demand for cigarettes and alcohol, and Yen, Kan and Su (2002) use it for a translog system to estimate demand for five types of fats and oils. Dong, Gould, and Kaiser (2004) suggest that all the two-step methods overlook the adding-up issue embedded in the system of censored share equations because adding-up is only imposed on the latent expenditure shares in these approaches. They formulate an alternative mapping of the observed and latent budget shares and estimate an AIDS model for food demand in maximum using a simulated maximum likelihood technique. Yen, Lin, and Smallwood (2003) address the adding-up problem by using quasi- and simulated-likelihood approaches. Golan, Perloff and Shan (2001) use the generalized maximum entropy approach from information theory to estimate an AIDS model for Mexican meat and fish.

To overcome the zero-consumption problem, econometric solutions including estimating Tobit, double hurdle, and two-step or maximum likelihood models, have been used. For a system of equations, Heien and Wessells' (1990) method (which is based on the single-equation Heckman model) and maximum likelihood procedures such as the Shonkwiler and Yen's (1999) procedure have been used. The method used by Heien and Wessells of modeling participation is commonly used and appropriate for the present study, since it has been shown to be efficient and is not difficult to implement, as is the case with many maximum likelihood estimators.

In the first stage, the participation equation, where the dependent variable is a binary variable for whether or not the good in question is consumed, is estimated by the Probit method to retrieve the parameters of the inverse Mills ratio. In the second stage, all observations are used in the demand system estimation, with the inverse Mills ratio from the first stage used as an instrument in the second stage. The Working-Leser and Almost Ideal Demand System (AIDS) are implemented in second stage estimations. The equations to be estimated in the present study are specified in the next section.

3.5.1.4 Estimated equations and elasticities

The first stage of the two-stage estimation involves estimating the probability that an individual consumes a particular type of food. The probability of observing consumption can be shown as $Prob(y_i = 1|\mathbf{x}) = F(\boldsymbol{x},\beta)$ and the probability of observing zero consumption can be shown as $Prob(y_i = 0|\mathbf{x}) = 1 - F(\boldsymbol{x},\beta)$. The set of parameters β reflect the impacts of $\boldsymbol{x}$, a set of individual-specific attributes like prices or socioeconomic characteristics hypothesized to affect the probabilities of each event. The probabilities are estimated by maximum likelihood estimation (MLE), assuming either a standard normal cumulative distribution function (CDF) [for the Probit model] or a logistic cumulative distribution function (CDF) [for the Logit model]. For this study, the Probit model is used. The marginal effects of variables in $\boldsymbol{x}$, or the impacts of changes in variable in $\boldsymbol{x}$ on the probability, are not equal to the estimated parameters. Marginal effects may be calculated generally by the following formula (Greene 2003, p. 667):

$$\frac{\partial E(y|\mathbf{x})}{\partial \mathbf{x}} = \left\{\frac{dF(\mathbf{x}'\beta)}{d(\mathbf{x}'\beta)}\right\}\beta = f(\mathbf{x}'\beta)\beta,$$

where $f(.)$ is the density function that corresponds to the cumulative distribution, $F(.)$.

For the present analysis, the probability of consuming a food item is stated for the ith food group, jth individual, in time period t, as follows:

$$Pr[y_{ijt} = 1] = \Pr[X'_{ijt}\beta + a_{ijt} + \varepsilon_{ijt} > 0] = \boldsymbol{\Phi}(X'_{ijt}\beta)$$

$$Pr[y_{ijt} = 0] = \Pr[X'_{ijt}\beta + a_{ijt} + \varepsilon_{ijt} = 0] = 1 - \boldsymbol{\Phi}(X'_{ijt}\beta),$$

where

$$X_{iht}'\beta = \beta_0 + \beta_1 * AGE + \beta_2 * GENDERD + \beta_3 * EMP + \beta_4 * NSTORES + \beta_5 * ERATE + \beta_8 \log(x_m) + \varepsilon_i$$

and
AGE: Age of respondent
$GENDERD$: Gender of respondent (=1 if male, 0 otherwise),
EMP: Employment status of respondent (=1 if employed full or part-time, 0 otherwise),
$NSTORES$: Number of food stores in community,
$ERATE$: Community employment rate,
x_m: where *m*=1 when total food expenditures of country food are calculated with opportunity costs (abbreviated $OTOTAL$), and *m*=2 when total food expenditures of country food are calculated with out-of-pocket costs (abbreviated $PTOTAL$).

Based on the specification previously shown, the second stage of the Working-Leser model for estimation specified:

$$w_i = a_0 + a_1 * \log(x_m) + a_2 * AGE + a_3 * GENDERD + a_4 * EMP + a_5 * NSTORES + a_6 * ERATE + \varepsilon_i$$

Based on the specification previously shown, the second stage of the LA/AIDS model is specified:

$$w_i = a_0 + a_1 * \ln(\frac{x_m}{P}) + a_2 * AGE + a_3 * GENDERD + a_4 * EMP + a_5 * NSTORES + a_6 * ERATE + \sum_j \gamma_{ij} \ln(p_j) + \varepsilon_i,$$

where $\ln(P) = \sum_i w_i \ln(p_i)$ and x_m: where *m*=1 when total food expenditures of country food are calculated with opportunity costs (abbreviated $OTOTAL$), and *m*=2 when total food expenditures of country food are calculated with out-of-pocket costs (abbreviated $PTOTAL$).

Total expenditure x is calculated two ways, with opportunity cost and out-of-pocket cost values for country foods. Hence, two versions of the first-stage Probit model are run (one with opportunity costs and one with out-of-pocket costs) and two versions each of the Working-Leser and linearized AIDS models are run.

The Working-Leser expenditure elasticity for good i is calculated as follows (Chern 2002, p. 25):

$$e_{iy} = 1 + \frac{\beta_i}{w_i}$$

The AIDS elasticities are calculated as follows (Green and Alston 1990, p. 444):

$$e_{ij} = \frac{\gamma_{ij} - \beta_j w_j}{w_i} \text{ (Cross-price elasticity)}$$

$$e_{ii} = \frac{\gamma_{ii}}{w_i} - \beta_i - 1 \text{ (Own-price elasticity)}$$

$$e_{iy} = 1 + \frac{\beta_i}{w_i} \text{ (Expenditure elasticity)}$$

The elasticities calculated from the AIDS model from both opportunity-cost and out-of-pocket cost models are traditional Marshallian (uncompensated) demand elasticities.

Chalfant (1987), Green and Alston (1991), Chalfant, Gray and White (1991) show substitution (compensated) price elasticities for the LA/AIDS model, where own- and cross-price elasticities of substitution are written:

$$\sigma_{ii} = 1 + \frac{\gamma_{ii}}{{w_i}^2} - \frac{1}{w_i} \text{ (Own-price)}$$

$$\sigma_{ij} = 1 + \frac{\gamma_{ij}}{w_i w_j} \text{ (Cross-price).}$$

3.5.1.5 Specification tests and goodness-of-fit

For the first-stage of the regression model, the overall significance of each of the equations may be assessed by a likelihood ratio test, with the null hypothesis that the slope estimates are all equal to zero. The null hypothesis is rejected if the Chi-squared test statistic is statistically significant. The goodness-of-fit of a qualitative dependent variable model is assessed by the fit between the calculated probabilities and observed response frequencies or in terms of the model's ability to predict responses (Verbeek 2008). From the TSP 5.1 output, the scaled R-squared statistic may be used to assess general goodness-of-fit (Hall and Cummins 2009).

To test for goodness-of-fit for the second stage of the two-step demand system estimation, the likelihood ratio test is employed to select variables that should be contained in the best fitting model. In the nested test, the Chi-squared test statistic is computed ($\lambda_{LR} = 2[ln(L)_u - (L)_r]$). If the likelihood ratio test statistic is significantly greater than the critical value, the unrestricted model is preferred over the respective restricted models. For the restricted models, each of the individual and community-level demographic variables is assumed to be zero.

The goodness-of-fit of each of the second-stage equations may be assessed by the R-squared estimates. Heteroskedasticity of each of the second stage equations is assessed with the Breusch-Pagan test, which involves testing the statistical significance of the Lagrange multiplier test statistic. To control for potential heteroskedasticity, robust White standard errors are estimated in the second stage.

3.5.2 Calorie and dietary diversity equation specifications

The theoretical specifications of the calorie demand model and the dietary diversity model were explained earlier in this chapter. The empirical models and estimated equations are shown in this section.

3.5.2.1 Calorie demand equation

The estimated calorie consumption equation for the ith individual is specified:

$$N_i = \beta_0 + \beta_1 * AGE + \beta_2 * GENDERD + \beta_3 * EMP + \beta_4 NSTORES + \beta_5 ERATE + \beta_6 CARIBOUD + \beta_7 x_m + \varepsilon_i,$$

where

N_i: Number of calories consumed by individual i in a twenty-four hour period
AGE: Age of respondent
$GENDERD$: Gender of respondent (=1 if male, 0 otherwise),
EMP: Employment status of respondent (=1 if employed full or part-time, 0 otherwise),
$NSTORES$: Number of food stores in community,
$ERATE$: Community employment rate

$CARIBOUD$: Caribou consumption dummy (=1 if consumed caribou in the twenty-four hour period, 0 otherwise),
x_m: where *m*=1 when total food expenditures of country food are calculated with opportunity costs (abbreviated $OTOTAL$), and *m*=2 when total food expenditures of country food are calculated with out-of-pocket costs (abbreviated $PTOTAL$).

The linear calorie demand model is estimated with ordinary least squares (OLS), as is done with linear functions for calorie-income Engel curves in other studies (e.g. Bouis and Haddad 1992; Deaton and Subramanian 1992; Timmer and Alderman 1979; Garcia and Pinstrup-Andersen 1987; Ravallion 1990).

3.5.2.1 Dietary diversity demand equation specification

As stated in section 3.2.4, the DD/DDS measure from Drewnowski et al. (1996) and Kant (1993), based on counting the number of food groups where there is reported consumption, is used in this study as a measure of dietary diversity. The food groups defined in Canada's Food Guide are used to categorize foods.

The estimated equation for dietary diversity for the ith person is specified:

$$M_i = \beta_0 + \beta_1 * AGE + \beta_2 * GENDERD + \beta_3 * EMP + \beta_4 NSTORES + \beta_5 ERATE + \beta_6 CARIBOUD + \beta_7 x_m + \varepsilon_i,$$

where M_i: Dietary diversity score, and other variables are the same as those in the equation for calorie demand, as specified in section 3.5.2.1.

The food group score varies from 0-4. Therefore, a regression method that accounts for the ordinal and integer nature of the dependent variable must be considered. Two types of statistical estimation methods may be employed. The Poisson model is traditionally used for count data and stipulates that each observation is drawn from a Poisson distribution. A drawback to the Poisson model is that it involves the assumption that the probability of an occurrence is constant at any point in time and that the conditional mean and variance are equal. The Negative Binomial model may also be used for count data, and is more appropriate for over-dispersed data, where the variance of the data is greater than the mean (Verbeek 2008). An ordered probit model based on random utility theory, where the dependent variable is ordinal, may also be estimated.

In the ordered probit model, the observed variable can be specified as $y_i^* = \mathbf{x}'\beta + \varepsilon_i > 0$ (Green 2003, p. 736). It is assumed that the individual's actual response y^* is a function of measurable factors $\mathbf{x}$ and certain unobservable factors ε and is assumed to fall within a designated range. The error is assumed to be normally distributed, and the probabilities of the 0, 1, 2, and Jth responses occurring may be specified:

$$
\begin{aligned}
&Prob(y = 0|\mathbf{x}) = \Phi(-\mathbf{x}'\beta),\\
&Prob(y = 1|\mathbf{x}) = \Phi(\mu_1 - \mathbf{x}'\beta) - \Phi(-\mathbf{x}'\beta),\\
&Prob(y = 2|\mathbf{x}) = \Phi(\mu_2 - \mathbf{x}'\beta) - \Phi(\mu_1 - \mathbf{x}'\beta),\\
&\vdots\\
&Prob(y = J|\mathbf{x}) = 1 - \Phi(\mu_{j-1} - X_i'\beta),
\end{aligned}
$$

The marginal effects of the regressors $\mathbf{x}$ on the probabilities are not equal to the estimated parameters. The marginal effects are calculated (Green 2003, p. 738):

$$
\begin{aligned}
&\frac{\partial Prob(y=0|\mathbf{x})}{\partial \mathbf{x}} = \Phi(-\mathbf{x}'\beta)\beta,\\
&\frac{\partial Prob(y=1|\mathbf{x})}{\partial \mathbf{x}} = [\Phi(-\mathbf{x}'\beta) - \Phi(\mu - \mathbf{x}'\beta)]\beta,\\
&\frac{\partial Prob(y=2|\mathbf{x})}{\partial \mathbf{x}} = \Phi(\mu - \mathbf{x}'\beta)\beta.\\
&\vdots
\end{aligned}
$$

As stated earlier in this chapter, the indicator for caribou access may represent caribou consumption, or community-level caribou population or minimum, mean, and peak harvest numbers. Aside from estimating the models with a binary variable for caribou consumption, the models for dietary diversity or calorie consumption are estimated with caribou population and caribou harvest numbers.

3.5.2.2 Specification tests and goodness-of-fit

In the calorie demand model, the Breusch-Pagan test may be used to test for heteroskedasticity. The presence of heteroskedasticity, which means that the variance of the error term varies over observations, leads to unbiased estimators but also leads to inefficiency in the estimators of small samples, and leads to inconsistency in the estimators of large samples. Additionally, it may lead to variance estimates and thus standard errors to be biased. The Breusch-Pagan test, which is a Lagrange multiplier test statistic, may be used to test for heteroskedasticity in a linear regression model (Verbeek 2008). If the Lagrange multiplier test statistic is sufficiently large, the null hypothesis of homoskedasticity is rejected. If heteroskedasticity is detected, the regression may be re-run with variables removed or with transformed variables. Alternatively, estimating heteroskedastic-consistent White (or robust) standard errors results in consistent standard errors for sufficiently large samples. When robust standard errors are computed, the estimated parameters remain the same, but inferences are valid.

As stated previously in the discussion of the first stage of the demand system model, the goodness-of-fit of a qualitative dependent variable model is assessed by the fit between the calculated probabilities and observed response frequencies or in terms of the model's ability to predict responses (Verbeek 2008). For the dietary diversity model, which is estimated by an ordered probit model, the pseudo R-squared generated may be examined to assess generalized goodness of fit. A higher pseudo R-squared indicates a better fitting model. The Wald test may be used to assess whether or not variables are jointly significant—the null hypothesis is rejected when the difference between the vector of parameters is significantly different from a fixed, linearly independent vector (Verbeek 2008). The ordered probit model may also be tested for multiplicative heteroskedasticity, where it is assumed that the error variance is related to a number of exogenous variables (Verbeek 2008). The model will be estimated in LIMDEP with the heteroskedastic ordered probit model, with continuous variables tested for heteroskedasticity.

3.5.3 Aboriginal Peoples Survey equation specification

3.5.3.1 Individual participation in harvesting

The theoretical specification for equations where the dependent variable is time spent in harvest is shown in a previous section of this chapter. For the model on individual participation in harvesting, a binary dependent variable model will be estimated. A binary choice model is based on a set of utility functions, where each utility function represents a choice alternative. This model was explained previously in the section on empirical specification of first-stage model of the demand system estimation. The probability of observing harvesting activity can be shown as $Prob(y_i = 1|\mathbf{x}) = F(\boldsymbol{x},\beta)$ and the probability of observing no harvesting can be shown as $Prob(y_i = 0|\mathbf{x}) = 1 - F(\boldsymbol{x},\beta)$. The set of parameters β reflects the impacts of $\boldsymbol{x}$, a set of individual-specific attributes, such as prices or socioeconomic characteristics, hypothesized to affect the probabilities of each event. The probabilities are estimated by maximum likelihood estimation (MLE), assuming either a standard normal cumulative distribution function (CDF) [for the Probit model] or a logistic cumulative distribution function (CDF) [for the Logit model]. For this study, the Probit model is used. The marginal effects of variables in $\boldsymbol{x}$, or the impacts of changes in variation in $\boldsymbol{x}$ on the probability, are not equal to the estimated parameters. Marginal effects may be calculated by the following formula (Greene 2003, p. 667):

$$\frac{\partial E(y|\mathbf{x})}{\partial \mathbf{x}} = \left\{\frac{dF(\mathbf{x}'\beta)}{d(\mathbf{x}'\beta)}\right\}\beta = f(\mathbf{x}'\beta)\beta$$

As stated previously, two versions of the individual harvest equation may be specified, one model with employment status and income, and one with employment status only. Employment status may be specified as either a binary variable $IANYWORK$ or as a categorical variable $IPTFT$. Therefore, four versions of the individual harvest equation, with data for the ith individual in time period t, are estimated:

$$IHARVEST_{it} = \beta_0 + \beta_1 AGE + \beta_2 GENDER + \beta_3 EDU + \beta_4 HHSIZE + \beta_5 MAINTAIN + \beta_6 CHILDREN + \beta_7 IANYWORK + \varepsilon_i$$

$$IHARVEST_{it} = \beta_0 + \beta_1 AGE + \beta_2 GENDER + \beta_3 EDU + \beta_4 HHSIZE + \beta_5 MAINTAIN + \beta_6 CHILDREN + \beta_7 IPTFT + \varepsilon_i$$

$$IHARVEST_{it} = \beta_0 + \beta_1 AGE + \beta_2 GENDER + \beta_3 EDU + \beta_4 HHSIZE + \beta_5 MAINTAIN + \beta_6 CHILDREN + \beta_7 IANYWORK + \beta_8 ITOTINC + \varepsilon_i$$

$$IHARVEST_{it} = \beta_0 + \beta_1 AGE + \beta_2 GENDER + \beta_3 EDU + \beta_4 HHSIZE + \beta_5 MAINTAIN + \beta_6 CHILDREN + \beta_7 IPTFT + \beta_8 ITOTINC + \varepsilon_i$$

3.5.3.2 Household participation harvesting

The models for household participation in harvesting may also be specified as binary equation. The estimated equation is based on the responses to the question: during the year ending December 31st, 2000, did …harvest country food?" (2001/ "Did at least one person in the household harvest country food during the year ending December 31st, 2005?" (Variables - 2001: I08GAT_P; 2006: A_IG08H)]. As in the case of individual harvesting, two versions of the household harvest equation may be specified, one model with employment status and income, and one with employment status only. Employment status may be specified as either a binary variable $HHEMPANY$ or as the ordinal variable $HHEMPSC$.

The equations to be estimated are stated as follows:

$$HHARVEST_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_2 CHILDREN + \beta_3 HHEMPANY + \varepsilon_i$$

$$HHARVEST_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_2 CHILDREN + \beta_3 HHEMPSC + \varepsilon_i$$

$$HHARVEST_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_2 CHILDREN + \beta_3 HHEMPANY + \beta_4 HHINC + \varepsilon_i$$

$$HHARVEST_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_2 CHILDREN + \beta_3 HHEMPSC + \beta_4 HHINC + \varepsilon_i$$

As in the case of the individual harvesting, this equation is estimated with the binary probit model.

3.5.3.3 Household proportion of country meat and fish consumed

The proportion of country meat and fish out of total meat and fish consumed by the household is measured in the 2001 and 2006 versions of the Aboriginal Peoples Survey with the PUMF variables $I11AMFOD$ in the 2001 survey and A_IG11 in the 2006 survey. This variable is labelled $MEATFISH$ for this study. To estimate an ordered dependent variable model, the ordered probit method, based on a latent regression in the same manner as the binary probit model, will be employed.

The ordered probit is also used in this study to estimate demand for dietary diversity, and has been outlined in a previous section. The observed variable can be specified as $y_i^* = \mathbf{x}'\beta + \varepsilon_i > 0$ (Green 2003, p. 736). It is assumed that the individual's actual response y^* is a function of measurable factors $\mathbf{x}$ and certain unobservable factors ε and is assumed to fall within designated range. For the entire sample of positive and non-positive consumers, the observed y_i^* for proportion of country meat and fish consumed is either 0 for "none," 1 for "less than half," 2 for "about half," or 3 for "more than half." For the entire sample of positive and non-positive consumers, the observed y_i^* for proportion of country meat and fish consumed is either 0 for "none," 1 for "less than half," 2 for "about half," or 3 for "more than half." For only positive consumers, the observed y_i^* is specified either as 0 for "less than half," 1 for "about half," or 2 for "more than half."

The error is assumed to be normally distributed, and the probabilities of the 0, 1, 2, and Jth responses occurring may be specified:

$$Prob(y = 0|\mathbf{x}) = \Phi(-\mathbf{x}'\beta),$$
$$Prob(y = 1|\mathbf{x}) = \Phi(\mu_1 - \mathbf{x}'\beta) - \Phi(-\mathbf{x}'\beta),$$
$$Prob(y = 2|\mathbf{x}) = \Phi(\mu_2 - \mathbf{x}'\beta) - \Phi(\mu_1 - \mathbf{x}'\beta),$$
$$\vdots$$
$$Prob(y = J|\mathbf{x}) = 1 - \Phi(\mu_{j-1} - X_i'\beta),$$

The marginal effects of the regressors $\mathbf{x}$ on the probabilities are not equal to the estimated parameters. The marginal effects are calculated (Green 2003, p. 738):

$$\frac{\partial Prob(y=0|\mathbf{x})}{\partial \mathbf{x}} = \Phi(-\mathbf{x}'\beta)\beta,$$
$$\frac{\partial Prob(y=1|\mathbf{x})}{\partial \mathbf{x}} = [\Phi(-\mathbf{x}'\beta) - \Phi(\mu - \mathbf{x}'\beta)]\beta,$$
$$\frac{\partial Prob(y=2|\mathbf{x})}{\partial \mathbf{x}} = \Phi(\mu - \mathbf{x}'\beta)\beta.$$
$$\vdots$$

As outlined in the data description for the APS, the proportion of meat and fish consumed that is country meat and fish is defined as an ordinal variable. The responses were “none,” “less than half,” “about half,” or “more than half.” Two versions of the equation representing proportion of country meat and fish consumed may be estimated, where one version is estimated with all consumers, and one version is estimated with only positive consumers. For respondents who reported consuming any positive proportion (all responses aside from “none”), the respondent is asked questions about whether or not any country food consumed was received for free, exchange for supplies or help, or bought. The variables representing these questions ($FREE, XCHG, BOUGHT$) are included in the estimation with only positive consumers. Two versions of the equation are specified, one model with employment status and income, and one with employment status only. Employment status may be specified as either a binary variable $HHEMPANY$ or as a categorical variable $HHEMPSC$.

The equations to be estimated for all consumers are specified:

$$MEATFISH_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_2 CHILDREN + \beta_3 HHEMPANY + \beta_4 HHHARVEST + \varepsilon_i$$

$$MEATFISH_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_2 CHILDREN + \beta_3 HHEMPSC + \beta_4 HHHARVEST + \varepsilon_i$$

$$MEATFISH_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_2 CHILDREN + \beta_3 HHEMPANY + \beta_4 HHINC + \beta_5 HHARVEST + \varepsilon_i$$

$$MEATFISH_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_2 CHILDREN + \beta_3 HHEMPSC + \beta_4 HHINC + \beta_5 HHHARVEST + \varepsilon_i$$

The equations to be estimated for positive consumers are specified:

$$MEATFISH_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_3 CHILDREN + \beta_4 HHEMPANY + \beta_5 HHHARVEST + \beta_6 FREE + \beta_7 XCHG + \beta_8 BOUGHT + \varepsilon_i$$

$$MEATFISH_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_3 CHILDREN + \beta_4 HHEMPSC + \beta_5 HHHARVEST + \beta_6 FREE + \beta_7 XCHG + \beta_8 BOUGHT + \varepsilon_i$$

$$MEATFISH_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_3 CHILDREN + \beta_4 HHEMPANY + \beta_5 HHINC + \beta_6 HHHARVEST + \beta_7 FREE + \beta_8 XCHG + \beta_9 BOUGHT + \varepsilon_i$$

$$MEATFISH_{it} = \beta_0 + \beta_1 HHSIZE + \beta_2 MAINTAIN + \beta_3 CHILDREN + \beta_4 HHEMPSC + \beta_5 HHINC + \beta_6 HHHARVEST + \beta_7 FREE + \beta_8 XCHG + \beta_9 BOUGHT + \varepsilon_i$$

3.5.3.4 Specification tests and goodness-of-fit

In this section, the empirical specifications of two models for time spent in harvesting and one model for proportion of country meat and fish consumed were described. The binary dependent variable model used to estimate the first two models may be examined for goodness-of-fit with the pseudo R-squared measure, as in the other binary dependent variable model estimated in this thesis (in the dietary demand analysis). The Wald test may be used to assess whether or not variables are jointly significant—the null hypothesis is rejected when the difference between the vector of parameters is significantly different from a fixed, linearly independent vector (Verbeek 2008). The ordered probit model used for estimation of the model for proportion of country meat and fish consumed will be estimated in LIMDEP with the heteroskedastic ordered probit model, with continuous variable variables tested for heteroskedasticity.

3.6 Summary

In this chapter, the data to be used for analysis were described. The statistical techniques used to estimate specified models were also described. The method of estimating opportunity- and out-of-pocket country food costs was delineated. The relationship between expenditures on different foods, calorie and dietary diversity, and harvesting behavior and individual and household demographic and economic factors will be explored with the results from empirical analysis, presented in the next two chapters. The price of harvesting caribou is between $10.31 and $16.59 for opportunity costs and $3.87 and $4.05 for out-of-pocket costs.

Chapter 4 Analysis of Dietary Recall Data

4.1 Introduction

In this chapter, the results of demand system analysis and analysis of demands for caloric intake and dietary diversity are presented. First, summary statistics will be presented to illustrate the relative consumption of caribou and other types of food, and also to describe calculated country food prices and other data used for the demand analysis. The results of the two demand systems estimated, and elasticity measurements derived from the estimations, are presented. Summary statistics and estimation results for calorie intake and dietary diversity models are presented. A summary of the findings is then provided.

4.2 Summary statistics

In this chapter, the results of demand system analysis and demands for caloric intake and dietary diversity are presented. First, summary statistics will be presented to illustrate the relative consumption of caribou and other types of food, and also to describe calculated country food prices and other data used for the demand analysis. The results of the two demand systems estimated, and elasticity measurements derived from the estimations are represented. Summary statistics and estimation results for the dietary adequacy—calorie intake and dietary diversity models are presented. A summary of the findings is then presented.

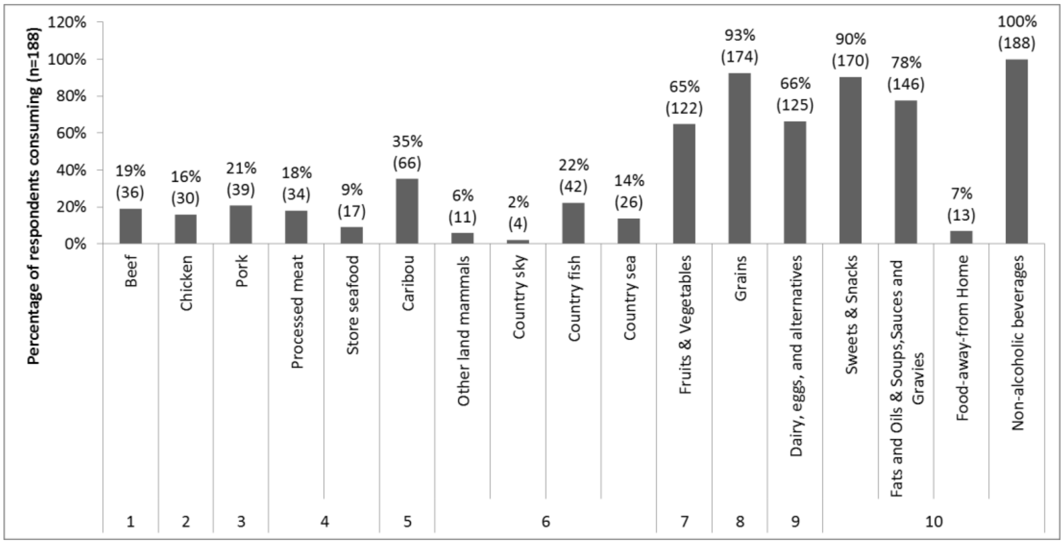

Figure 4-1 Proportion of respondents reporting consumption of different types of country and store food in a 24-hour period

Figure 4-1 shows percentage of individuals consuming caribou and other types of country meat food—other land mammals, sky animals, fish, and sea mammals, fruits and vegetables, grains, dairy products and alternatives, as well as subcategories of the "other foods" group (sweets & snacks, fats and oils & soups, snacks, and gravies, food-away-from-home, and non-alcoholic beverages).

Percent of respondents consuming caribou (35%) is higher than that for each category of store meat (beef, chicken, pork, processed meat, store seafood) as well as any of the other categories of country meat and fish (sky, sea, or other land animals). The second highest consumed country meat (in terms of proportion of respondents consuming) is fish, which is followed by country sea mammals, other land mammals, and sky animals (birds). Of store meats consumed, pork was consumed by the highest proportion of respondents, followed by beef, chicken, processed meat, and store seafood. Of categories of store foods that are not meat or seafood, the category with highest reported consumption is non-alcoholic beverages (with 100% of respondents consuming).

For the demand system analysis, ten food groups are defined (where the classification scheme was explained in section 3.3.2). The food group name and percentage of respondents (in parentheses) consuming each are: [1] beef (19%),

[2] chicken (16%), [3] pork (21%), [4] processed meat and store seafood (25%), [5] caribou (35%), [6] country meat and fish other than caribou (36%), [7] fruits and vegetables (64%), [8] grains (93%), [9] dairy, eggs, and alternatives (66%), [10] other foods (100%).

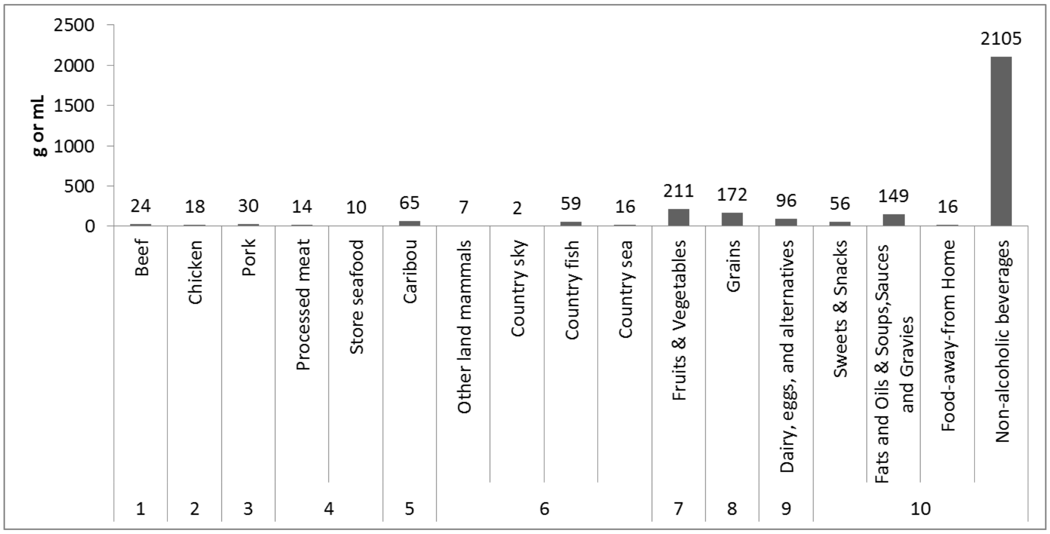

Figure 4-2 Average grams consumed per respondent in a 24-hour period

Figure 4-2 shows average quantity consumed per respondent over the dietary recall sample. Caribou was consumed in the highest quantity on average (65 grams), greater than for each of the store meats (beef, chicken, pork, processed meat, store seafood) and each of the other types of country meat and fish (sky, sea, or other land animals). The second highest consumed country meat (in terms of quantity consumed) was fish, followed by country sea mammals, other land mammals, and sky animals (birds). Of store meats consumed, pork was consumed in the highest quantity, followed by beef, chicken, processed meat, and store seafood. Of categories of store foods that are not meat or seafood, the category with highest consumption was non-alcoholic beverages[11]. While Figure 4-2 shows quantity consumed disaggregated by subgroups for the ten food groups, the average quantities consumed by the sample for the ten food groups are shown later in Table 4-1.

[11] For non-alcoholic beverages made with solid ingredients and water, the weight of the solid ingredients (in grams) was assumed to be the quantity consumed.

The quantities of caribou consumed in this sample reflect patterns found in recent harvest studies, which were described in Chapter 2. Caribou, on average, was found to be the top consumed country food species in terms of proportion of respondents consuming and average quantity consumed. From the literature review, it was shown that caribou was the top country food species harvested (in terms of edible weight) in four out of six communities in the Inuvialuit Settlement Region, while fish is the top country food harvested in the other two communities. It was also shown that caribou was the top country food species harvested (in terms of edible weight) in the Kitikmeot and Kivalliq regions of Nunavut, with caribou being the second most harvested species in the Baffin region. The mean value of caribou found was consumed was 65 g, which is in the approximate range of 60 g – 250 g of caribou per day on average consumed in the Northwest Territories and 31 g – 208 g of caribou consumed per day on average in Nunavut (see Appendix E for values from studies).

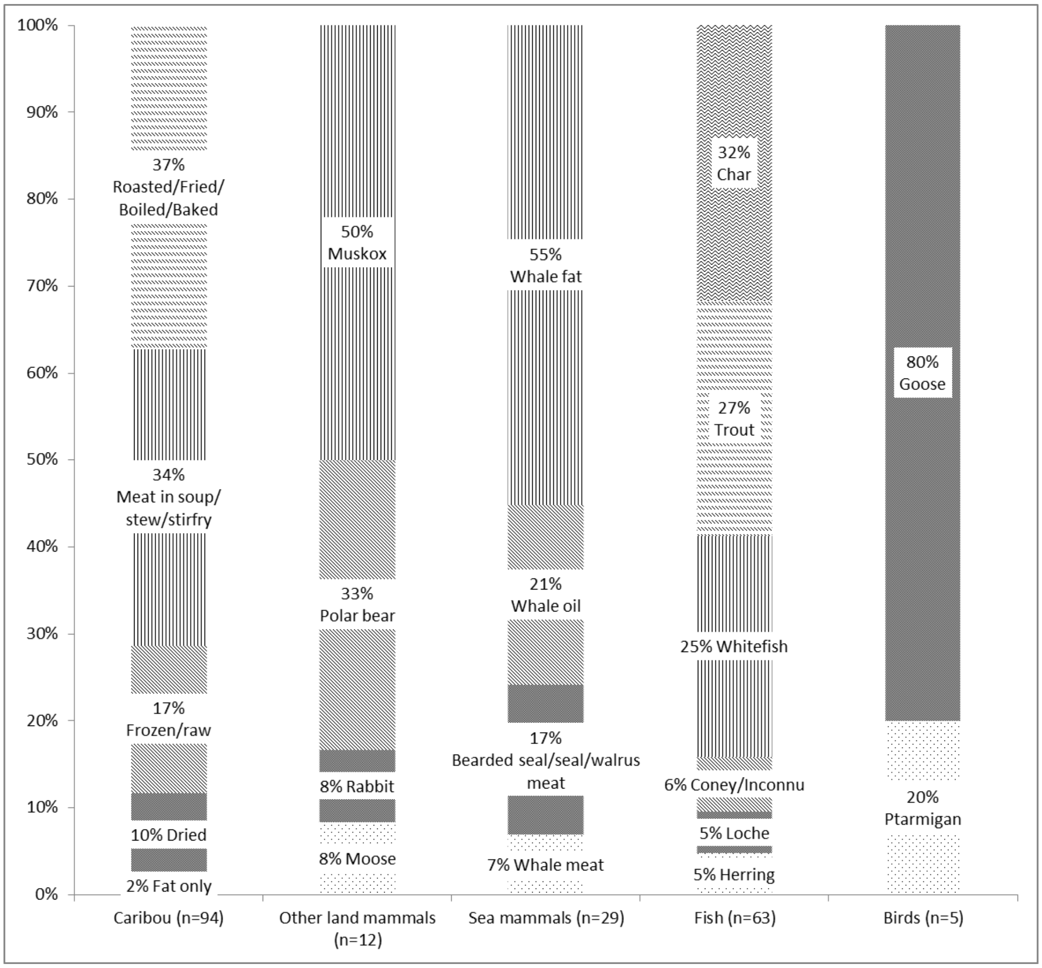

Figure 4-3 Types of country food consumed by proportion (by incidence of consumption), classified by country food group and country food species

In terms of number of meals, the most popular caribou preparation method was caribou cooked by roasting, frying, boiling, or baking. A high proportion of caribou is cooked in soup or stew. In this sample, there is little indication as to what parts of caribou may be consumed, as caribou meat and fat are the only reported caribou parts consumed. Out of the land animals consumed, muskox was consumed the most number of times. Char was the most commonly consumed country food animal of fish, while whale fat (muktuk) was the most highly consumed food from sea mammals. Two species of birds—ptarmigan and goose—were reported to be consumed.

Table 4-1 Mean weight per person, average price, and average expenditure in study communities

	Beef	Chicken	Pork	Processed meat & seafood	Caribou - (opp./pocket)	Country meat other than caribou – (opp./pocket)	Fruits and vegetables	Grains	Dairy	Other	All foods - (opp./pocket)	Store foods only
Average weight consumed (g)											**Sum (g)**	
1	23.58	10.91	63.55	24.59	66.78	90.25	254.32	173.18	101.88	2857.94	3667	
2	13.00	27.45	0.5	32.48	57.95	158.32	219.21	171.29	64.33	2649.79	3394	
3	44.79	11.71	43.15	27.39	65.95	43.24	241.35	178.22	137.97	1988	2782	
4	17.17	23.08	13.49	14.42	67	56.68	141.39	166.37	80.06	1920.01	2501	
All	24.49	18.25	30.34	23.91	64.77	83.48	210.11	171.95	96.03	2326.04	3505	
Average price per kg ($)											**Mean ($)**	
1	18.85	22.34	24.65	30.73	10.31	17.21	8.86	7.08	10.58	19.64	29.43	
					3.87	2.91					24.47	
2	40.78	22.41	27.18	33.97	12.34	19.71	5.66	8.45	9.6	16.73	32.04	
					4.66	3.58					26.43	
3	20.32	15.06	19.6	19.52	16.59	33.74	6.52	9.63	6.51	15.91	29.82	
					4.03	5.99					20.24	
4	15.71	22.52	24.24	26.71	16.14	24.80	7.31	7.36	9.6	24.79	32.98	
					3.97	3.63					25.41	
All	23.24	20.67	23.86	27.54	13.98	23.96	7.16	8.06	9.11	19.67	31.36	
					4.11	4.00					24.16	
Average expenditure per individual per day ($)											**Sum ($)**	
1	0.51	0.21	1.55	0.77	0.69	1.71	2.41	1.11	0.85	5.54	15.35	12.95
					0.25	0.24					13.43	
2	0.56	0.58	0.14	1.05	0.72	1.99	1.04	1.35	0.46	4.03	11.79	9.09
					0.27	0.38					9.74	
3	0.98	0.18	0.83	0.54	1.09	0.84	1.23	1.2	0.59	4.5	12.00	10.06
					0.26	0.16					10.48	
4	0.40	0.55	0.33	0.38	1.08	0.78	0.89	1.29	0.48	3.25	18.4	7.57
					0.27	0.11					7.94	
All	0.60	0.38	0.69	0.66	0.91	1.28	1.39	1.24	0.6	4.29	12.03	9.83
					0.26	0.21					10.31	

As described previously, ten food groups are classified for the purposes of demand analysis. The previous table shows 1) average quantity consumed in grams, 2) average price per kilogram (in $), and 3) average expenditures per individual per day (in $) for each food group by community and across the sample of 188 respondents. Summary statistics are segmented by community specifically to illustrate the different opportunity and out-of-pocket country food costs, as derived in Chapter 3.

To calculate the community- and sample-level summary statistics, total quantity, price, and total expenditures are calculated for each respondent for each of the ten food groups. The price for each food group faced by a respondent is calculated by taking the sum of expenditures on all items in that food group, and dividing by the sum of quantities consumed on all items in that food group.

For the group "other foods," quantity consumed, price, and total expenditure are first calculated for each of the four subcategories ([1] snacks and sweets, [2] fats and oils and soups, sauces, and gravies, [3] food-away-from-home, and [4] non-alcoholic beverages), and then aggregated across the subgroups. Quantities consumed and expenditures are summed across the subgroups for each individual. The price faced by each respondent for "other foods" is calculated by taking the mean of prices calculated for the four subgroups.

Average weight at the community and sample levels is calculated with both positive consumers and those with zero consumption. The average price for each food group at the community-level is calculated by taking the average of prices faced by individual consumers. For consumers with zero consumption, the price is a simple average of the average prices for the food group type faced by all non-zero consumers from the same community. Using prices averaged at the community-level for individuals as approximations for missing prices for individuals involves the assumption that prices, which may be dependent on transportation infrastructure, and the types of products available for purchase, are heterogeneous among communities but relatively homogenous at the community-level. Average expenditure is calculated by taking the sum of expenditures for each individual (for the respective food type), and then taking the average of the individual sums across the community or the entire sample.

In terms of mean weight, more caribou is consumed than other types of country food in communities 3 and 4. The high levels of non-caribou country foods in communities 1 and 2 may be attributed to high levels of consumption of fish, since fish is consumed in high quantities. In terms of opportunity costs, a higher average expenditure is spent on the aggregated group—country foods other than caribou ($1.28) than on caribou ($0.91). A higher average level of expenditure is recorded for caribou than for any of the store meats—beef, chicken, pork, processed meat and store seafood. In terms of out-of-pocket costs, a higher average expenditure is spent on caribou ($0.26) than for country foods other than caribou ($0.21).

Of the store meats, the highest average expenditure was for pork, followed by processed meat and seafood, beef, and chicken. Of the store foods aside from meat, the highest average expenditure is spent on "other foods," followed by fruits and vegetables, grains, and dairy products. Average total expenditure on foods is highest in communities 1 and 3.

Expenditure shares calculated at the individual and community levels for the opportunity cost and out-of-pocket cost specifications are shown in Table 4-2. When expenditure share is calculated as the share of the total expenditure across the sample, expenditure share for caribou is 7.6% with the opportunity cost specification, lower than that for other country foods, and 2.6% with the out-of-pocket cost specification, greater than that for other country foods. For the mean of individual expenditure shares calculated across the sample, caribou has the higher mean expenditure share (13.9%) than other store meat types and other country food in the opportunity cost model. Caribou also has a higher mean expenditure share than other country foods (13.9%), but a smaller expenditure share than chicken, in the out-of-pocket cost model.

Table 4-2 Mean individual expenditure share and total community expenditure share

	Beef	Chicken	Pork	Processed meat & seafood	Caribou	Other country food	Fruits and vegetables	Grains	Dairy	Other
Mean individual expenditure share for Opportunity Cost model (%)										
1	4.9%	4.1%	5.2%	4.6%	9.0%	11.1%	10.5%	10.8%	4.5%	35.2%
2	3.5%	2.1%	10.3%	4.7%	5.9%	9.9%	14.1%	8.8%	4.8%	35.8%
3	4.5%	4.5%	0.2%	7.2%	7.7%	19.1%	8.6%	12.1%	4.3%	31.8%
4	8.6%	1.9%	7.4%	4.4%	7.5%	8.1%	10.3%	10.0%	4.7%	37.2%
Mean (across sample of 4 comms.)	3.3%	7.2%	2.7%	2.7%	13.9%	8.7%	9.1%	12.4%	4.3%	35.6%
Mean individual expenditure share for Out-of-pocket cost model (%)										
1	5.2%	4.4%	5.6%	4.9%	4.1%	3.4%	11.9%	13.1%	5.4%	42.2%
2	4.1%	2.2%	10.6%	4.9%	3.3%	2.8%	15.3%	10.3%	5.2%	41.5%
3	4.8%	5.3%	0.4%	7.9%	4.4%	6.7%	9.3%	15.5%	5.5%	40.4%
4	8.9%	2.0%	8.1%	4.8%	2.9%	2.5%	11.5%	11.5%	5.3%	42.4%
Mean (across sample of 4 comms.)	3.4%	7.4%	3.0%	3.0%	5.7%	2.2%	11.3%	14.9%	5.4%	43.8%
Expenditure share of total community expenditure for Opportunity Cost model (%)										
1	3.3%	1.4%	10.1%	5.0%	4.5%	11.2%	15.7%	7.2%	5.5%	36.1%
2	4.8%	4.9%	0.1%	8.9%	6.1%	16.8%	8.8%	11.5%	3.9%	34.2%
3	8.2%	1.5%	6.9%	4.5%	9.1%	7.0%	10.3%	10.0%	5.0%	37.5%
4	4.3%	5.8%	3.5%	4.0%	11.5%	8.2%	9.5%	13.7%	5.1%	34.5%
Share of exp. for entire sample	5.0%	3.2%	5.7%	5.5%	7.6%	10.7%	11.5%	10.3%	5.0%	35.7%
Expenditure share of total community expenditure for Out-of-pocket cost model (%)										
1	3.8%	1.6%	11.5%	5.7%	1.9%	1.8%	17.9%	8.3%	6.3%	41.2%
2	5.8%	6.0%	0.1%	10.8%	2.8%	3.9%	10.7%	13.9%	4.7%	41.4%
3	9.4%	1.7%	7.9%	5.1%	2.5%	1.5%	11.8%	11.4%	5.7%	42.9%
4	5.1%	6.9%	4.1%	4.7%	3.3%	1.3%	11.3%	16.3%	6.1%	40.9%
Share of exp. for entire sample	5.8%	3.7%	6.7%	6.4%	2.6%	2.1%	13.4%	12.0%	5.8%	41.6%

4.3 Demand system estimation

As described in Chapter 3, two forms of the demand share equations for different types of food will be estimated. A traditional Engel relationship where expenditure share on food is estimated as a function of individual- and community-level characteristics, the Working-Leser model, is estimated, and a version that incorporates prices (the linearized Almost Ideal Demand System) is also estimated. The first stage of both sets of models involves estimation of Probit equations, where estimates show the impacts of individual- and community-level characteristics on the likelihood to consume each of the different types of foods. Following the method of Heien and Wessells (1990), the inverse Mills ratio is retrieved from estimation of the Probit equations and used as instrumental variables in the second-stage estimation of the demand systems. Time Series Processor (TSP) version 5.1 was used for the econometric estimation.

4.3.1 First-stage participation estimates for opportunity-cost and out-of-pocket cost models

Probit equations based on the two methods of imputing country food costs, with opportunity costs and out-of-pocket costs, are estimated. The estimation serves as the first-stage model for both the Working-Leser and linearized AIDS estimations. The probability results are shown in Table 4-3 and Table 4-5 and the marginal effects are shown in Table 4-4 and Table 4-6. The overall significance of each of the equation is assessed by a likelihood ratio test, with the null hypothesis that the slope estimates are all equal to zero. For the opportunity cost model, the Probit equations for pork, processed meat and seafood, other country foods, grains, and diary are statistically significant. For the out-of-pocket cost model, the Probit equations for pork, processed meat and seafood, other country foods, fruits and vegetables, and dairy are statistically significant. The lack of significance for Probit equations for some goods suggests that the concavity condition of the underlying log likelihood function is not met, and that the model may not approximate the observed data accurately.

The scaled R-squared value indicates general goodness-of-fit. Scaled R-squared values for each of the ten food groups are 1) 0.046, 2) 0.028, 3) 0.144, 4) 0.069, 5) 0.040, 6) 0.083, 7) 0.055, 8) 0.068, 9) 0.017 for the opportunity cost model, and 1) 0.046, 2) 0.032, 3) 0.160, 4) 0.111, 5) 0.055, 6) 0.093, 7) 0.093, 8) 0.061, 9) 0.166 for the out-of-pocket cost model. In terms of the percent of correct predictions for consumption generated by the Probit equations, the percentage correct was over 90% for grains, over 80% for beef and chicken, over 70% for pork, processed meat and seafood, and dairy, and over 60% for caribou, other country meats, and fruits and vegetables for the opportunity cost model. For the out-of-pocket cost model, the percentage correct was over 90% for grains, over 80% for beef and chicken, over 70% for pork, processed meat and seafood, fruits and vegetables, and dairy, and over 60% for caribou and other country meats.

Table 4-3 First-stage Probit estimates with opportunity cost country food prices

Variables	**Beef**	**Chicken**	**Pork**	**Processed and store seafood**	**Caribou**	**Other country foods**	**Fruits and vegetables**	**Grains**	**Dairy**
C	-2.029***	-0.191	-3.763**	-0.741	-0.607	-0.892	0.130	0.165	-1.320**
	[0.702]	[0.680]	[0.763]	[0.606]	[0.575]	[0.589]	[0.571]	[0.822]	[0.654]
AGE	0.002	0.001	0.006	-0.007	0.010*	0.020***	-0.007	0.017*	0.005
	[0.007]	[0.007]	[0.007]	[0.006]	[0.006]	[0.006]	[0.006]	[0.009]	[0.006]
GENDERD	0.297	-0.303	0.060	0.112	0.180	-0.028	-0.003	0.068	0.386*
	[0.225]	[0.236]	[0.233]	[0.213]	[0.197]	[0.200]	[0.199]	[0.316]	[0.209]
EMP	0.006	-0.234	-0.420*	0.119	-0.009	-0.080	0.085	-0.229	-0.023
	[0.241]	[0.263]	[0.259]	[0.228]	[0.216]	[0.220]	[0.218]	[0.318]	[0.232]
NSTORES	0.023	0.047	-0.077	0.041	-0.048	-0.023	0.072	0.077	0.036
	[0.070]	[0.083]	[0.068]	[0.070]	[0.067]	[0.068]	[0.068]	[0.103]	[0.072]
ERATE	0.018	-0.016	0.050**	-0.006	-0.005]	-0.009	0.003	-0.007	0.006
	[0.013]	[0.014]	[0.013]	[0.012]	[0.011]	[0.012]	[0.011]	[0.016]	[0.012]
OTOTAL	-0.010	0.005	0.018	0.036***	0.006	0.016	0.019	0.074**	0.082***
	[0.016]	[0.017]	[0.015]	[0.014]	[0.013]	[0.014]	[0.014]	[0.033]	[0.021]
Regression statistics									
Schwarz B.I.C.	105.790	98.2509	100.694	117.58	136.422	133.472	135.568	61.9352	121.595
LR (zero slopes)	8.704	5.204	27.235 ***	12.934* *	7.497	15.764**	10.4112	12.442*	33.254***
Scaled R^2	0.046	0.028	0.145	0.069	040	0.083	0.055	0.068	0.173
Correct predictions	80.85%	84.04%	79.26%	73.94%	65.96%	67.55%	65.43%	92.55%	71.28%
# of positive observations	36	30	39	47	66	68	121	174	125
n=188									
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are standard errors.									

Table 4-4 Probit marginal effects with opportunity cost country food prices

Variables	**Beef**	**Chicken**	**Pork**	**Processed meat and seafood**	**Caribou**	**Other country foods**	**Fruits and vegetables**	**Grains**	**Dairy**
CONSTANT	-0.533***	-0.224	-0.948***	-0.229	-0.224	-0.331	0.048	0.017	-0.454**
	[0.177	0.211	0.171	0.185	0.211	0.217	0.211	0.084	0.226
AGE	0.001	0.0048	0.001	-0.002	0.004*	0.007***	-0.003	0.002*	0.002
	[0.002	0.002	0.002	0.002	0.002	0.002	-0.002	0.001	0.002
GENDERD	0.079	0.066	0.015	0.035	0.066	-0.011	-0.001	0.007	0.131*
	[0.060	0.073	0.059	0.066	0.073	0.074	0.074	0.032	0.070
EMP	0.002	-0.003	-0.099*	0.037	-0.003	-0.030	0.031	-0.025	-0.008
	[0.064	0.080	0.057	0.072	0.080	0.081	0.080	0.037	0.080
NSTORES	0.006	-0.018	-0.019	0.013	-0.018	-0.009	0.027	0.008	0.012
	[0.019	0.025	0.017	0.022	0.025	0.025	0.025	0.011	0.025
ERATE	0.005	-0.002	0.013***	-0.002	-0.002	-0.003	0.001	-0.001	0.002
	[0.003	0.004	0.003	0.004	0.004	0.004	0.004	0.002	0.004
OTOTAL	-0.003	0.002	0.005	0.011	0.002	0.006	0.007	0.008**	0.028***
	[0.004	0.005	0.004	0.004	0.005	0.005	0.005	0.003	0.007
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are z-statistics									

Table 4-5 First stage Probit estimates with out-of-pocket country food prices

Variables	**Beef**	**Chicken**	**Pork**	**Processed and store seafood**	**Caribou**	**Other country foods**	**Fruits and vegetables**	**Grains**	**Dairy**
C	-2.208***	-0.283	-3.947***	-0.937	-0.402	-0.543	-0.076	0.217	-1.224*
	0.708	0.683	0.782	0.623	0.580	0.595	0.587	0.814	0.641
AGE	0.004	0.002	0.008	-0.003	0.007	0.015**	-0.004	0.019**	0.007
	0.007	0.007	0.007	0.007	0.006	0.006	0.006	0.009	0.006
GENDERD	0.237	-0.340	0.028	0.066	0.275	0.117	-0.075	0.070	0.391*
	0.224	0.236	0.234	0.215	0.197	0.201	0.201	0.315	0.209
EMP	-0.025	-0.238	-0.458*	0.117	0.018	-0.057	0.068	-0.236	-0.034
	0.242	0.264	0.262	0.233	0.217	0.220	0.221	0.314	0.230
NSTORES	0.036	0.052	-0.070	0.053	-0.065	-0.043	0.084	0.078	0.043
	0.071	0.084	0.069	0.072	0.067	0.068	0.068	0.102	0.072
ERATE	0.014	-0.018	0.048***	-0.009	0.000	-0.003	-0.001	-0.007	0.005
	0.013	0.014	0.013	0.013	0.011	0.012	0.012	0.016	0.012
PTOTAL	0.011	0.017	0.036**	0.059***	-0.026*	-0.029*	0.048***	0.068**	0.082***
	0.017	0.017	0.017	0.015	0.015	0.016	0.017	0.033	0.022
Regression statistics									
Schwarz B.I.C.	105.768	97.8384	99.2181	113.556	134.987	132.533	131.979	62.552	122.325
LR (zero slopes)	8.749	6.029	30.187***	20.982***	10.368	17.641***	17.590***	11.208*	31.794***
Scaled R^2	0.046	0.032	0.1602	0.111	0.055	0.093	0.093	0.061	0.166
Correct predictions	80.85%	84.04%	79.26%	77.66%	64.36%	65.96%	72.34%	92.55%	70.21%
# of positive observations	36	30	39	47	66	68	121	174	125
n=188									
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are standard errors.									

Table 4-6 Probit marginal effects with out-of-pocket country food prices

Variables	Beef	Chicken	Pork	Processed meat and seafood	Caribou	Other country foods	Fruits and vegetables	Grains	Dairy
CONSTANT	-0.579***	-0.066	-0.982***	-0.285	-0.148	-0.201	-0.028	0.023	-0.424*
	-0.177	0.159	0.174	-0.187	0.213	0.219	0.216	0.088**	0.223
AGE	0.001	0.001	0.002	-0.001	0.002	0.005**	-0.001	0.002	0.003
	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.002
GENDERD	0.063	-0.079	0.007	0.020	0.101	0.043	-0.028	0.008	0.134*
	0.059	-0.054	0.058	0.066	0.072	0.075	0.074	0.034	0.071
EMP	-0.007	-0.054	-0.106*	0.036	0.006	-0.021	0.025	-0.027	-0.012
	0.063	0.057	0.056	0.073	0.080	0.081	0.080	0.038	0.080
NSTORES	0.010	0.012	-0.017	0.016	-0.024	-0.016	0.031	0.008	0.015
	0.019	0.020	0.017	0.022	0.025	0.025	0.025	0.011	0.025
ERATE	0.004	-0.004	0.012***	-0.003	1.268E-04	-0.001	-0.001	-0.001	0.002
	0.003	-0.003	0.003	0.004	0.004	0.004	0.004	0.002	0.004
PTOTAL	0.003	0.004	0.009**	0.018***	-0.010*	-0.011*	0.018***	0.007**	0.028***
	0.004	0.004	0.004	0.005	0.006	-0.006	0.006	0.003	0.007
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are z-statistics									

From the probability estimates and corresponding marginal effects for the opportunity cost model, it was found that increased age leads to an increased probability of consuming caribou and country foods other than caribou, with the coefficient for age being statistically significant at the 10% level. Individual employment status and community employment rate were found to have positive impacts on the likelihood of consuming pork. Age was found to have a positive effect on the likelihood of consuming grain products, while being a male increased likelihood of consuming dairy products. Increased total expenditure was found to increase the likelihood of consuming processed meat and seafood, grains, and dairy. For the out-of-pocket cost model, increased age leads to an increased probability of consuming country foods other than caribou, but not caribou. As in the opportunity cost model, participation in employment and higher community employment rate led to an increased likelihood of consuming pork. Increased age also increased the likelihood of consuming grain, and being a male also increased likelihood of consuming dairy. Increased total expenditure was found to increase the likelihood of consuming pork, processed and store seafood, caribou, other country foods, fruits and vegetables, grains, and dairy.

4.3.2 Working-Leser demand system estimates

The proposed empirical model for the Working-Leser demand system estimation was stated in Chapter 3. The likelihood ratio test (LRT) is used to find the best fitting model and is performed by estimating versions of the basic model with each explanatory variable restricted to be zero. The goodness-of-fit is compared between the unrestricted and restricted models. To test for goodness-of-fit for the second stage of the two-step demand system estimation, the likelihood ratio test is employed to select variables that should be contained in the best fitting model. In the nested test, the Chi-squared test statistic is computed ($\lambda_{LR} = 2[ln(L)_u - (L)_r]$). If the test statistic is significantly greater than the critical value, the unrestricted model is preferred over the restricted model (Greene 2003). The degree of freedom is equal to the difference in the number of parameters estimated between the restricted and unrestricted models. Since the explanatory variables for the Working-Leser model are tested one by one, degree of freedom is equal to 1. The likelihood ratios and test statistics for the second-stage of the Working-Leser model for the respective opportunity cost and out-of-pocket cost models are shown in Table 4-7 and Table 4-10.

For the opportunity costs estimation of the Working-Leser model, the null hypotheses that the explanatory variables total expenditure, age, gender, employment status, number of stores, community employment rate, and the Inverse mills ratio each do not have an impact on food group expenditure shares is rejected at the 10% level. Therefore, inclusion of each of the variables improves the fit of the model. Similarly, the null hypotheses that each of the explanatory variables do not have an impact on food group expenditure shares is rejected at the 10% level for the out-of-pocket cost Working-Leser model estimates. The LRTs suggest that all original variables should be retained in the estimations of both versions of the Working-Leser model.

Table 4-7 Likelihood ratio test results for Working-Leser specification with opportunity costs for country food

Model	Likelihood ratio	Test statistic		p-value	Preferred model
Original	1754.299				
Restricting					
Ototal	1741.501	25.596	***		Unrestricted
Age	1731.333	45.932	***		Unrestricted
Gender	1752.628	3.342	**		Unrestricted
Employment status	1748.848	10.901	***		Unrestricted
Number of stores	1742.268	24.062	***		Unrestricted
Employment rate	1725.542	57.515	***		Unrestricted
IMR	1245.308	1017.983	***		Unrestricted

***, **, and * indicate significance at 1, 5 and 10 percent level, respectively

Table 4-8 Likelihood ratio test results for Working-Leser specification with out-of-pocket costs for country food

Model	Likelihood ratio	Test statistic		p-value	Preferred model
Original	1936.061				
Restricting					
Ptotal	1896.417	79.289	***	0.000	Unrestricted
Age	1924.041	24.041	***	0.000	Unrestricted

Gender	1933.019	6.085	***	0.014	Unrestricted
Employment status	1932.006	8.110	***	0.004	Unrestricted
Number of stores	1925.913	20.297	***	0.000	Unrestricted
Employment rate	1910.618	50.886	***	0.000	Unrestricted
IMR	1448.012	976.099	***	0.000	Unrestricted

***, **, and * indicate significance at 1, 5 and 10 percent level, respectively

The results for the opportunity cost and out-of-pocket cost estimations for the second stage of the Working-Leser estimation are presented in Table 4-9 and Table 4-10. The demand system estimates were obtained with the LSQ command in Time Series Processor (TSP) version 5.1. The "other foods" equation was left out of the system estimation and its parameter estimates retrieved by calculations.

In the opportunity cost model, the goodness-of-fit measure, R-squared, was found to be 0.703 for chicken, 0.609 for processed meat and seafood, between 0.588 and 0.597 for country foods other than caribou, beef, caribou, and pork, 0.343 for fruits and vegetables, 0.015 for dairy, and 0.100 for grains. In the out-of-pocket cost model, R-squared was found to be between 0.724 for chicken, 0.637 for pork, between 0.503 and 0.592 for caribou, beef, and processed meat and seafood, 0.461 for country foods other than caribou, 0.359 for fruits and vegetables, 0.128 for grains, and 0.014 for dairy. The Lagrange multiplier test statistic was found to be statistically significant across all equations except for the dairy equation in the opportunity cost model, and the grain and dairy equations in the out-of-pocket cost models, indicating that there is heteroskedasticity. The models were estimated with heteroskedastic-consistent standard errors.

From the opportunity cost version of the Working-Leser estimation, it was found that the inverse Mills ratio for the nine equations estimated were statistically significant at the 10% level, suggesting that using the inverse Mills ratio as an instrumental variable helps account for censored latent variables in the second stage estimation. Age was found to have a positive impact on expenditure share level of country food other than caribou and a negative impact on expenditure share level of other foods (defined as sugars and sweets, fats and oils, soups, sauces and gravies, food-away-from-home). Individual participation in employment was found to have a positive impact on the expenditure share level of beef but a negative impact on the expenditure share level of pork. An increased number of food stores in the community led to an increased expenditure share level for beef, but a decrease in the expenditure share levels for pork and fruits and vegetables. An increased community-level employment rate led to increased expenditure share levels for pork and fruits and vegetables, but decreased levels for chicken and caribou. Increased total expenditure led to an increased expenditure share level for processed meat and seafood, but decreased levels for chicken and caribou.

From the out-of-pocket cost version of the Working-Leser estimation, it was found that the inverse Mills ratio for the nine equations estimated were statistically significant at the 10% level, as in the opportunity cost model. As in the opportunity cost W-L model estimates, age was found to have a positive impact on expenditure share level of country food other than caribou and a negative impact on expenditure share level of other foods (sugars and sweets, fats and oils, soups, sauces and gravies, food-away-from-home). While gender was not found to have a statistically significant impact on any of the food expenditure share levels in the opportunity cost W-L model estimates, it was found that being male led to decreased expenditure share levels for chicken. Individual participation in employment was not found to have a positive impact on the expenditure share level of beef, as in the opportunity cost model, but was also found to have a negative impact on the expenditure share level of pork. As in the opportunity cost W-L model estimates, an increased number of food stores in the community led to an increased expenditure share level for beef, but a decrease in the expenditure share levels for pork and fruits and vegetables. Increased community-level employment rate led to increased expenditure share levels for pork and fruits and vegetables and a decreased level for chicken, as in the opportunity cost W-L model estimates, but increased community-level employment rate is not found to have an effect on the expenditure share level of caribou. Increased total expenditure led to an increased expenditure share level for processed meat and seafood, as in the opportunity cost W-L estimates, but also for pork and fruits and vegetables. Increased total expenditure led to a decrease in caribou share level, as in the opportunity cost W-L estimates, but not for chicken. Additionally, increased total expenditure led to decreases in the expenditure share levels of country foods other than caribou, and grains.

Table 4-9 Working-Leser opportunity cost estimates

Variables	Beef	Chicken	Pork	Processed meat and seafood	Caribou	Other country foods	Fruits and vegetables	Grains	Dairy	Other foods
C	0.025	0.186***	-0.141***	0.013	0.235***	-0.034	-0.004	0.186***	0.028	0.505***
	[0.587]	[5.995]	[-3.356]	[0.399]	[4.475]	[-0.536]	[-0.074]	[3.422]	[0.998]	[4.625]
OTOTAL	4.144E-04	-0.020**	0.007	0.021***	-0.030**	0.004	0.013	-0.004	0.001	0.009
	[0.038]	[-2.559]	[0.644]	[2.603]	[-2.263]	[0.255]	[0.880]	[-0.315]	[1.256]	[0.313]
AGE	2.900 E-04	-4.022 E-04	-3.531 E-05	9.853 E-05	1.103 E-04	0.004***	-4.774 E-05	-1.864 E-04	-2.620E-05	-0.004***
	[0.752]	[-1.442]	[-0.094]	[0.341]	[0.234]	[6.834]	[-0.094]	[-0.383]	[-0.091]	[-3.615]
GENDER D	0.005	-0.011	0.003	-0.002	0.004	-0.007	-0.016	0.007	0.008	0.010
	[0.352]	[-1.151]	[0.256]	[-0.238]	[0.236]	[-0.377]	[-0.958]	[0.442]	[0.781]	[0.324]
EMP	0.029**	-8.804E-05	-0.024*	0.009	0.012	-0.004	-0.013	-0.023	-0.006	0.020
	[2.027]	[-0.009]	[-1.744]	[0.823]	[0.716]	[-0.194]	[-0.683]	[-1.267]	[-0.601]	[0.533]
NSTORES	0.011***	0.001	-0.013***	0.002	0.003	-0.003	-0.011**	0.004	5.126E-05	0.006
	[2.662]	[0.261]	[-3.107]	[0.718]	[0.578]	[-0.552]	[-1.983]	[0.697]	[0.016]	[0.552]
ERATE	-0.001	-0.001***	0.004***	-0.001	-0.002*	-0.001	0.002**	-0.001	1.313E-04	-4.556E-04
	[-0.913]	[-2.691]	[5.777]	[-1.005]	[-1.959]	[-0.528]	[2.445]	[-1.303]	[0.235]	[-0.252]
IMR	0.150***	0.141***	0.139***	0.111***	0.158***	0.170***	0.101***	0.053***	-1.024***	-1.024
	[16.555]	[20.998]	[15.601]	[17.259]	[16.394]	[14.590]	[10.022]	[3.491]	[-28.461]	[-28.461]
Regression Statistics										
Std. Error	0.086	0.062	0.084	0.064	0.105	0.125	0.113	0.108	0.064	
R^2	0.590	0.703	0.597	0.609	0.595	0.588	0.343	0.100	0.015	
LM het. test	81.004 ***	52.956***	74.742***	24.222***	56.464***	45.383***	36.568***	2.745*	0.062	
D-W stat.	2.050	2.211	2.188	2.267	1.933	2.102	2.116	2.099	2.005	
n=188										

***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are t-statistics

Table 4-10 Working-Leser out-of-pocket cost estimates

Variables	Beef	Chicken	Pork	Processed meat and seafood	Caribou	Other country foods	Fruits and vegetables	Grains	Dairy	Other foods
C	-0.005	0.163***	-0.167***	-0.002	0.145***	0.041*	-0.024	0.202***	0.039	0.608***
	[-0.108]	[5.397]	[-4.187]	[-0.051]	[5.024]	[1.691	[-0.405]	[3.509]	[1.198]	[6.610]
PTOTAL	0.013	-0.005	0.020**	0.032***	-0.041***	-0.024***	0.026*	-0.006***	0.001	-0.016
	[1.245]	[-0.698]	[2.066]	[3.831]	[-5.899]	[-4.156]	[1.816]	[-0.427]	[1.320]	[-0.713]
AGE	0.001	-2.479E-04	2.490E-04	3.816E-04	-3.008E-04	0.001***	4.940E-04	4.266E-04	1.913E-04	-0.003***
	[1.214]	[-0.863]	[0.657]	[1.158]	[-1.099]	[4.004]	[0.880]	[0.781]	[0.568]	[-2.885]
GENDERD	-0.003	-0.018*	-2.186E-04	-0.002	0.010	0.004	-0.017	0.004	0.008	0.014
	[-0.195]	[-1.884]	[-0.018]	[-0.170]	[1.079]	[0.484]	[-0.896]	[0.247]	[0.701]	[0.444]
EMP	0.024	-0.002	-0.024*	0.009	-3.002E-04	0.001	0.001	-0.025	-0.007	0.022
	[1.618]	[-0.177]	[-1.741]	[0.802]	[-0.031]	[0.078]	[0.037]	[-1.287]	[-0.542]	[0.644]
NSTORES	0.011**	0.001	-0.012***	0.003	-0.001	-5.581E-05	-0.011*	0.004	0.001	0.005
	[2.330]	[0.435]	[-2.915]	[0.857]	[-0.339]	[-0.022]	[-1.849]	[0.649]	[0.206]	[0.441]
ERATE	-0.001	-0.002***	0.004***	-0.001	-9.292E-05	-4.100E-05	0.002*	-0.002	-1.756E-04	-0.001
	[-0.788]	[-3.183]	[5.567]	[-1.366]	[-0.179]	[-0.093]	[1.872]	[-1.516]	[-0.273]	[-0.535]
IMR	0.155***	0.152***	0.150***	0.118***	0.071***	0.051***	0.114***	0.065	-0.876***	
	[15.960]	[22.275]	[17.114]	[16.120]	[12.729]	[10.576]	[10.240]	[3.869]	[-26.378]	
Regression Statistics										
Std. Error	0.092	0.063	0.082	0.072	0.060	0.051	0.122	0.119	0.073	
R^2	0.583	0.724	0.637	0.592	0.503	0.461	0.359	0.128	0.014	
LM het. test	78.015 ***	49.590 ***	71.256***	18.524***	47.629***	24.402***	36.809***	2.045	0.089	
D-W stat.	2.053	2.173	2.192	2.261	1.761	2.010	2.136	2.160	2.027	
n=188										

***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are t-statistics

4.3.3 Almost Ideal Demand System estimates

The proposed empirical model for the linearized Almost Ideal Demand System (LA/AIDS) estimation was stated in Chapter 3. As in the case of the Working-Leser model, likelihood ratio tests (LRT) are used to find the best fitting model, and are performed by estimating versions of the basic model with each explanatory variable restricted to be zero, in sequential estimations. As in the W-L model results, the Chi-squared test statistic is computed to evaluate whether or not the unrestricted or restricted versions of the model is preferred. Since the explanatory variables for the LA/AIDS model are tested one by one, degree of freedom is equal to 1. The likelihood ratios and test statistics for the second-stage of the LA/AIDS model for the respective opportunity cost and out-of-pocket cost models are shown in the following tables.

For the opportunity costs estimation of the LA/AIDS model, the null hypotheses that the explanatory variables total expenditure, age, gender, employment status, number of stores, community employment rate, and the Inverse mills ratio each do not have an impact on food group expenditure shares is rejected at the 10% level. Each of the explanatory variables tested improves the fit of the model. Similarly, the null hypotheses that each of the explanatory variables does not have an impact on food group expenditure shares are rejected at the 10% level for the out-of-pocket cost LA/AIDS model estimates. The LRTs suggest that all original variables should be retained in the estimations of both versions of the LA/AIDS model.

Table 4-11 Likelihood ratio test results for LA/AIDS specification with opportunity costs for country food

Model	Likelihood ratio	Test statistic		p-value	Preferred model
Original	1562.496				
Restricting					
OTotal	1540.438	44.116	***		Unrestricted
Age	1547.188	30.615	***		Unrestricted
Gender	1557.509	9.973	***		Unrestricted
Employment status	1557.344	10.304	***		Unrestricted
IMR	1327.222	470.547	***		Unrestricted

Number of stores	1554.741	15.509	***	Unrestricted
Employment rate	1550.378	24.236	***	Unrestricted
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively				

Table 4-12 Likelihood ratio test results for LA/AIDS specification with out-of-pocket costs for country food

Model	Likelihood ratio	Test statistic	p-value	Preferred model
Original	1766.706			
Restricting				
PTotal	1738.325	56.761	***	Unrestricted
Age	1734.674	64.063	***	Unrestricted
Gender	1761.266	10.880	***	Unrestricted
Employment status	1762.812	7.788	***	Unrestricted
IMR	1520.651	492.110	***	Unrestricted
Number of stores	1762.968	7.476	***	Unrestricted
Employment rate	1749.930	33.552	***	Unrestricted
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively				

The results for the opportunity cost and out-of-pocket cost estimations for the second stage of the LA/AIDS estimation are presented in Table 4-13 and Table 4-14. The demand system estimates were obtained with the LSQ command in Time Series Processor (TSP) version 5.1. The "other foods" equation was left out of the system estimation and its parameter estimates retrieved by calculations. In the opportunity cost model, the goodness-of-fit measure, R-squared, was found to be 0.721 for beef and 0.713 for chicken, between 0.609 and 0.624 for caribou, country foods other than caribou, and processed meat and seafood, 0.584 for pork, 0.459 for fruits and vegetables, 0.264 for dairy, and 0.059 for grains. In the out-of-pocket cost model, R-squared was found to be 0.733 for chicken, 0.633 for pork and 0.696 for beef, 0.593 for processed meat and seafood, between 0.466 and 0.470 for caribou, fruits and vegetables, and other country foods, 0.288 for dairy, and 0.055 for grains. The Lagrange multiplier test statistic was found to be statistically significant across all equations, indicating that there is heteroskedasticity. The models are estimated were heteroskedastic-consistent standard errors.

From the opportunity cost version of the LA/AIDS estimation, it was found that the inverse Mills ratio for the nine equations estimated were statistically significant at the 10% level, suggesting that using the inverse Mills ratio as an instrumental variable helps account for censored latent variables in the second stage estimation. From the opportunity cost estimates, age was found to have a positive impact on the expenditure share level of country food other than caribou in both the opportunity cost and out-of-pocket cost models. Being male was found to have a positive impact on expenditure share level of beef in the opportunity cost model, expenditure share level of chicken in the out-of-pocket cost model, and a negative impact on expenditure share level of fruits and vegetables in both the opportunity cost and out-of-pocket cost models. Individual participation in employment was found to have a positive impact on the expenditure share level of beef in the opportunity cost model, but no impact on expenditure share levels of any other food types. An increased number of food stores in a community led to decreased expenditure share levels for both beef and caribou in the opportunity cost model and a decrease in expenditure share level of country food other than caribou in the opportunity cost model. An increased community-level employment rate led to increased expenditure share levels for both beef and pork and a decrease in expenditure share level for chicken in both the opportunity cost and out-of-pocket cost models. In the opportunity cost model, increased total expenditure led to increased expenditure share levels for processed meat and seafood, fruits and vegetables, and dairy products, and a decreased expenditure share level for chicken. In the out-of-pocket cost model, increased total expenditure led to increased expenditure share levels for processed meat and seafood, fruits and vegetables and dairy and a decreased expenditure share level for caribou and country foods other than caribou. Own- and cross-price and expenditure elasticities are shown in the following section.

Table 4-13 Almost Ideal Demand System Estimates – Opportunity cost estimates

Variables	Beef	Chicken	Pork	Processed meat and seafood	Caribou	Other country foods	Fruits and vegetables	Grains	Dairy	Other foods
C	0.157**	0.235***	-0.186**	-0.066	-0.111	0.324*	-0.133	-0.131	-0.118**	1.029*
	[2.250]	[3.796]	[-2.014]	[-0.989]	[-0.687]	[1.856]	[-1.300]	[-0.292]	[-2.206	[1.869]
OTOTAL	-0.035***	-0.015*	1.758E-04	0.015*	-0.007	-0.019	0.053***	0.054	0.028***	-0.074
	[-3.547]	[-1.711]	[0.015]	[1.717]	[-0.503]	[-1.102]	[3.706]	[0.820]	[3.671	[-0.997]
AGE	-2.053E-04	-2.574E-04	-9.922E-05	5.453E-05	3.649E-04	0.004***	6.131E-05	3.063E-04	1.485E-04	-0.004
	[-0.627]	[-0.898]	[-0.247]	[0.185]	[0.746]	[6.439]	[0.131]	[0.139]	[0.590	[-1.502]
GENDERD	0.018*	-0.014	0.004	-4.175E-04	-0.002	0.001	-0.035**	-0.010	0.001	0.035
	[1.660]	[-1.437]	[0.335]	[-0.042]	[-0.115]	[0.074]	[-2.184]	[-0.129]	[0.153	[0.485]
EMP	0.024**	-0.001	-0.019	0.015	0.003	0.010	-0.024	-0.013	-0.004	0.008
	[2.020]	[-0.055]	[-1.313]	[1.449]	[0.197]	[0.469]	[-1.381]	[-0.164]	[-0.416	[0.100]
IMR	0.146***	0.133***	0.121***	0.106***	0.136***	0.140***	0.080***	-0.895***	0.034***	
	[19.183]	[20.654]	[12.907]	[16.274]	[14.155]	[12.341]	[8.242]	[-38.669]	[7.229	
NSTORES	-0.017**	0.001	-0.003	0.009	-0.052***	0.040*	0.002	0.008	-0.002	0.013
	[-2.535]	[0.119]	[-0.258]	[1.055]	[-2.623]	[1.853]	[0.344]	[0.340]	[-0.410	[0.484]
ERATE	0.003***	-0.001*	0.003**	-0.001	-0.002	0.002	7.653E-05	-0.002	-8.309E-05	-2.575E-04
	[3.364]	[-1.815]	[2.359]	[-1.557]	[-1.071]	[0.913]	[0.077]	[-0.541]	[-0.150	[-0.057]
PBEEF	0.120***									-0.003
	[7.890]									[-0.232]
PCHICKEN	-0.039***	0.031]								-0.041***
	[-2.745]	[1.022]								[-3.186]
PPORK	-0.056**	0.022	0.221**							-0.023
	[-2.348]	[0.615]	[2.140]							[-1.034]
PPROCESS	-0.048***	-0.003	-0.066	0.157***						-0.049**
	[-2.925]	[-0.115]	[-1.168]	[3.506]						[-2.226]
PCARIBOU	0.024	0.034	-0.107	-0.013	-0.893**					-0.044
	[0.846]	[0.686]	[-0.875]	[-0.165]	[-2.119]					[-1.575]
PNONC	0.037	-0.002	0.039	0.028	1.008**	-1.066***				-0.006
	[1.233]	[-0.043]	[0.318]	[0.369]	[2.453]	[-2.601]				[-0.178]
PFV	-0.011	-0.007	-0.021	-0.008	0.002	-0.043**	0.081***			0.019
	[-1.170]	[-0.731]	[-1.608]	[-0.846]	[0.130]	[-2.352]	[4.921]			[0.775]
PGRAINS	-0.005	-0.001	-0.002	0.002	-0.021**	-0.007	-0.013	0.023		0.020
	[-0.699]	[-0.248]	[-0.253]	[0.262]	[-2.152]	[-0.622]	[-1.318]	[0.513]		[0.628]
PDAIRY	-0.020***	0.006	-0.007	-1.878E-04	0.010	0.012	1.686E-04	0.005	0.004	-0.010]
	[-2.934]	[0.892]	[-0.705]	[-0.026]	[0.790]	[0.875]	[0.023]	[0.981]	0.621	[-0.943]
POTHER										0.134**
										[2.023]
Std. error	0.072	1.940	0.086	0.063	0.104	0.122	0.103	0.490	2.017	
R^2	0.721	0.713	0.584	0.624	0.609	0.618	0.459	0.059	0.264	
LM het. test	84.566***	46.938***	71.999***	29.761***	68.390***	27.808***	58.906***	186.452 **	23.150***	
D-W stat.	1.940	2.285	2.143	2.256	1.859	2.095	1.988	2.017	1.980	
n=188										

***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are t-statistics.

Table 4-14 Almost ideal demand system estimates – Out of pocket costs

Variables	Beef	Chicken	Pork	Processed meat and seafood	Caribou	Other country foods	Fruits and vegetables	Grains	Dairy	Other foods
C	0.131	0.228***	0.175	-0.013	-0.264	0.061	-0.298***	-0.243	-0.077	1.300***
	[1.638]	[2.735]	[0.566]	[-0.119]	[-0.760]	[0.506]	[-2.769]	[-0.614]	[-1.295]	[2.653]
PTOTAL	-0.028	-0.008	0.009	0.020**	-0.017*	-0.015**	0.074***	0.071	0.029***	-0.134**
	[-2.635]	[-0.994]	[0.815]	[2.047]	[-1.961]	[-2.184]	[4.863]	[1.230]	[3.398]	[-2.013]
AGE	-9.414E-05	-1.357E-04	1.197E-04	1.707E-04	1.699E-05	0.001***	0.001	0.001	3.316E-04	-0.003
	[-0.259]	[-0.467]	[0.304]	[0.507]	[0.057]	[4.608]	[1.173]	[0.567]	[1.160]	[-1.370]
GENDERD	0.013	-0.019*	0.002	0.002	0.003	0.002	-0.037**	-0.019	0.001	0.051
	[1.043]	[-1.934]	[0.159]	[0.179]	[0.290]	[0.318]	[-2.145]	[-0.284]	[0.148]	[0.824]
EMP	0.023	-3.214E-04	-0.019	0.016	-0.001	0.005	-0.011	-0.014	-0.004	0.005
	[1.772]	[-0.031]	[-1.356]	[1.341]	[-0.132]	[0.631]	[-0.590]	[-0.199]	[-0.373]	[0.075]
IMR	0.149***	0.142***	0.131***	0.109***	0.065***	0.045***	0.086***	-0.768***	0.040***	
	[17.779]	[21.784]	[14.246]	[14.775]	[10.920]	[9.365]	[8.066]	[-37.471]	[7.179]	
NSTORES	-0.008	0.005	-0.024	0.005	0.007	0.007	-0.003	0.004	4.816E-04	0.008
	[-1.497]	[0.757]	[-1.542]	[0.484]	[0.464]	[0.686]	[-0.565]	[0.181]	[0.134]	[0.359]
ERATE	0.002***	-0.002***	0.005***	-0.001	-0.001	-4.088E-04	2.096E-05	-0.002	-0.001	0.001
	[2.629]	[-3.011]	[4.065]	[-1.319]	[-0.885]	[-0.493]	[0.020]	[-0.652]	[-0.973]	[0.130]
PBEEF	0.113***									0.014
	[7.139]									[1.051]
PCHICKEN	-0.034***	0.035								-0.029**
	[-2.595]	[1.195]								[-2.283]
PPORK	-0.025	0.022	-0.095							-0.019
	[-1.147]	[0.611]	[-0.515]							[-0.954]
PPROCESS	-0.044**	-0.010	-0.088	0.155***						-0.052**
	[-2.534]	[-0.354]	[-1.536]	[2.990]						[-2.133]
PCARIBOU	-0.002	0.015	0.275	0.005	-0.298					-0.043**
	[-0.087]	[0.456]	[1.483]	[0.091]	[-1.282]					[-2.462]
PNONC	0.013	-0.002	-0.036	0.035	0.060	-0.054				-0.004
	[0.893]	[-0.092]	[-0.538]	[0.966]	[0.843]	[-1.030]				[-0.287]
PFV	-0.014	-0.006	-0.025*	[-0.008	-0.007	-0.013*	0.081***			0.004
	[-1.343]	[-0.630]	[-1.909]	-0.768]	[-0.668]	[-1.668]	[4.549]			[0.163]
PGRAINS	-0.002	3.902E-04	-0.001	0.005	-0.014**	-0.005	-0.013	0.034		-0.007
	[-0.315]	[0.066]	[-0.119]	[0.790]	[-2.427]	[-1.096]	[-1.288]	[0.861]		[-0.252]
PDAIRY	-0.020***	0.008	-0.007	0.001	0.009	0.008	0.002	0.003	0.005	-0.008
	[-2.755]	[1.202]	[-0.751]	[0.129]	[1.168]	[1.214]	[0.260]	[0.559]	[0.638]	[-0.726]
POTHER										0.158***
										[2.920]
Std. error	2.91973	1.92052	0.083599	0.072033	0.061863	0.050386	0.112531	0.437693	0.062455	
R^2	0.696054	0.733145	0.632796	0.592872	0.466445	0.470421	0.468206	0.054612	0.288124	
LM het. test	84.046***	47.426***	66.924***	22.462***	45.842***	25.728***	62.876***	185.603***	23.929***	
D-W stat.	1.92052	2.2492	2.13322	2.237	1.83763	2.17456	1.98791	2.03242	2.0394	
n=188										

***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are t-statistics.

4.3.4 Elasticities

As explained in Chapter 2, Marshallian price elasticities and elasticities of substitution are measures of the responsiveness of demand for a good to a change in price of that good or another good, income elasticites are measures of the responsiveness of demand due to a change in total expenditure.

Expenditure elasticites for the Working-Leser model are shown in Table 4-15, price and expenditure elasticities for the LA/AIDS model are shown as follows, and elasticities of substitution, calculated at the sample means of explanatory variables, are shown for both opportunity cost and out-of-pocket cost models.

From expenditure elasticities for the Working-Leser model, it was found that caribou, and grains are all normal goods at the 10% significance level in the opportunity model as well as in the out-of-pocket cost model. With a one percent increase in total expenditure, the quantity demanded of these goods increases less than one percent. Chicken was found to be a normal good at the 10% significance level in the out-of-pocket cost model. The expenditure elasticities for beef, pork, processed meat and seafood, fruits and vegetables are all statistically significant at the 10% level and higher than 1, indicating that a one percent increase in total expenditure leads to an increase in quantity demanded greater than one percent. The "other foods" group exhibits an expenditure elasticity over 1 in the opportunity cost model and an expenditure elasticity close to 1 in the out-of-pocket cost model.

Table 4-15 Expenditure Elasticities for Working-Leser Model

	Opportunity Cost		**Out-of-Pocket Cost**	
	Estimate	**t-statistic**	**Estimate**	**t-statistic**
Beef	1.008***	5.640	1.255***	7.265
Chicken	0.503	1.499	0.884***	3.963
Pork	1.133***	6.646	1.355***	8.862
Processed meat and seafood	1.468***	7.148	1.646***	8.105
Caribou	0.665***	4.289	0.017	0.076
Other country foods	1.037***	6.452	0.274*	1.845
Fruits and vegetables	1.121***	8.176	1.217***	10.148

Grains	0.960***	7.919	0.955***	8.951
Dairy	1.018***	82.917	1.021***	74.332
Other	1.024***	13.117	0.963***	18.561
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively.				

Expenditure elasticities from the LA/AIDS model estimations suggest that there is a one to one relationship between total food expenditure and expenditure on caribou – approximately a 1% increase in total food expenditure is associated with a 1% increase in caribou consumption in both out-of-pocket and opportunity cost models. Expenditure elasticities for country food other than caribou show the same pattern. Opportunity cost expenditure elasticities range from 0.461 to 7.638, and out-of-pocket expenditure elasticities range from 0.069 to 6.902.

From both the opportunity and out-of-pocket cost LA/AIDS estimations, it was found that beef, pork, and processed meat and seafood have positive own-price elasticities that are statistically significant at the 10% level and greater than 1, indicating that a one percent increase in own price leads to an increase in quantity demanded greater than one percent. The positive elasticities for these goods contradict traditional demand theory, where own-price demand elasticities are predicted to be negative. From the opportunity cost estimates, the own-price elasticities of both caribou and other country foods are statistically significant at the 10% level and less than -1, indicating that with a one percent increase in price, quantity demanded decreases by more than one percent. The own-price elasticities of caribou and other country foods in the out-of-pocket cost model are also statistically significant at the 10% level and less than -1, though they are lower in absolute value than the same elasticities in the opportunity cost model. In the opportunity cost model, the own-price elasticities for grain products, dairy products, and other foods are statistically significant at the 10% level and in the inelastic range. In the out-of-pocket cost model, the own-price elasticities for fruits and vegetables, grains grain products, dairy products, and other foods are statistically significant at the 10% level and in the inelastic range.

From opportunity cost estimates, it was found that cross-price elasticities are statistically significant at the 10% level and *negative* for the following pairs of goods: beef and chicken, beef and pork, beef and processed meat and seafood, beef and dairy, chicken and other foods, pork and beef, pork and fruits and vegetables, processed meat and seafood and other foods, caribou and grains, other country foods and fruits and vegetables, fruits and vegetables and pork, fruits and vegetables and grains, dairy and other foods, other foods and chicken, and other foods and processed meat and seafood.

From the out-of-pocket cost estimates, it was found that cross-price elasticities are statistically significant at the 10% level and *negative* for the following pairs of goods: beef and chicken, beef and processed meat and seafood, beef and dairy, chicken and other foods, pork and fruits and vegetables, processed meat and seafood and beef, processed meat and seafood and other foods, caribou and grains, caribou and other foods, other country foods and fruits and vegetables, fruits and vegetables and beef, fruits and vegetables and pork, fruits and vegetables and other country foods, fruits and vegetables and grains, grains and caribou, grains and fruits and vegetables, dairy and beef, other foods and chicken, and other foods and processed meat and seafood.

In summary, grains and other foods, a group that includes fats and oils, sugars, snacks, non-alcoholic beverages, were found to be gross complements for caribou. Fruits and vegetables are found to be gross complements for other country foods. A few pairs of store meat types are found to have gross complementary relationships—in the opportunity cost model, chicken, pork, and processed meat and seafood were found to be complements for beef and beef is found to be a complement for chicken, pork and processed meat and seafood. In the out-of-pocket cost model, processed meat and seafood and chicken were found to be complements for beef and beef is found to be a complement for chicken and processed meat and seafood.

Opportunity cost model cross-price elasticities are statistically significant at the 10% level and *positive* for the following pairs of goods: beef and caribou, beef and other country foods, caribou and other country foods, other country foods and beef, and other country foods and caribou. Out-of-pocket model cross-price elasticities are statistically significant at the 10% level and *positive* for the following pairs of goods: beef and other foods, chicken and dairy, pork and caribou, caribou and pork, other country foods and dairy. To summarize, caribou and other country foods were both found to be gross substitutes for beef, while caribou was found to be a gross substitute for pork. “Other country foods” were found to be a gross substitute for caribou in the opportunity cost model, while pork is found to be a gross substitute for caribou in the out-of-pocket cost model.

Table 4-16 Opportunity cost AIDS elasticity estimates

	Beef	Chicken	Pork	Processed meat and seafood	Caribou	Other country foods	Fruits and vegetables	Grains	Dairy	Other foods	Exp. elast.
Beef	1.491***	-0.763***	-1.102**	-0.950***	0.561*	0.833**	-0.153	-0.018	-0.368**	0.187	0.707***
	[2.950]	[-3.208]	[-2.240]	[-3.277]	[1.741]	[2.165]	[-0.843]	[-0.145]	[-2.135]	[0.628]	[9.273]
Chicken	-0.932***	-0.230	0.562	-0.054	0.857	-0.013	-0.124	0.003	0.165	-0.879**	0.529
	[-3.199]	[-0.178]	[0.907]	[-0.091]	[0.985]	[-0.013]	[-0.668]	[0.021]	[1.328]	[-2.514]	[0.463]
Pork	-1.075**	0.429	3.266*	-1.273	-2.071	0.756	-0.411*	-0.040	-0.135	-0.449	1.001***
	[-2.315]	[0.876]	[1.654]	[-1.063]	[-1.352]	[0.438]	[-1.679]	[-0.318]	[-1.048]	[-0.979]	[21.721]
Processed meat and seafood	-1.069***	-0.076	-1.460	2.414*	-0.305	0.582	-0.215	-0.002	-0.019	-1.180**	1.097***
	[-3.434]	[-0.145]	[-1.077]	[1.813]	[-0.313]	[0.483]	[-1.244]	[-0.015]	[-0.123]	[-2.375]	[22.366]
Caribou	0.273	0.376	-1.183	-0.136	-10.863**	11.156**	0.032	-0.226**	0.111	-0.459	1.008***
	[1.554]	[0.963]	[-1.342]	[-0.275]	[-2.107]	[2.130]	[0.205]	[-2.025]	[0.925]	[-1.472]	[59.305]
Other country foods	0.341**	-0.012	0.362	0.263	9.102**	-10.593**	-0.371**	-0.046	0.115	0.008	1.018***
	[1.974]	[-0.034]	[0.449]	[0.527]	[2.130]	[-2.432]	[-2.456]	[-0.395]	[1.234]	[0.024]	[49.751]
Fruits and vegetables	-0.131	-0.083	-0.228*	-0.101	-0.025	-0.465***	-0.281	-0.173**	-0.021	0.006	1.652***
	[-1.522]	[-1.106]	[-1.946]	[-1.349]	[-0.186]	[-2.904]	[-1.322]	[-2.031]	[-0.313]	[0.024]	[6.583]
Grains	-0.068	-0.034	-0.045	-0.008	-0.241**	-0.121	-0.168	-0.843***	0.024	0.007	3.354
	[-0.971]	[-0.616]	[-0.649]	[-0.147]	[-2.061]	[-0.880]	[-1.548]	[-2.816]	[0.408]	[0.018]	[0.671]
Dairy	-0.462**	0.109	-0.185	-0.032	0.158	0.194	-0.061	0.045	-0.935***	-0.444*	7.638
	[-2.437]	[1.004]	[-1.274]	[-0.207]	[0.663]	[0.850]	[-0.376]	[0.376]	[-7.115]	[-1.722]	[0.813]
Other foods	0.001	-0.108***	-0.055	-0.128**	-0.106	0.007	0.077	0.079	-0.020	-0.535***	0.461
	[0.030]	[-2.951]	[-0.863]	[-2.071]	[-1.336]	[0.076]	[1.089]	[0.886]	[-0.636]	[-2.680]	[0.756]

***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are t-statistics.

Table 4-17 Out-of-pocket cost AIDS elasticity estimates

	Beef	Chicken	Pork	Processed meat and seafood	Caribou	Other country foods	Fruits and vegetables	Grains	Dairy	Other foods	Exp. elast.
Beef	1.216**	-0.629***	-0.445	-0.817***	-0.008	0.266	-0.205	0.025	-0.363**	0.503*	0.752***
	[2.556]	[-3.323]	[-1.176]	[-3.239]	[-0.039]	[1.552]	[-1.096]	[0.198]	[-2.061]	[1.831]	[10.133]
Chicken	-0.768***	-0.187	0.519	-0.211	0.350	-0.045	-0.109	0.034	0.200*	-0.594*	0.763
	[-3.376]	[-0.157]	[0.902]	[-0.379]	[0.659]	[-0.080]	[-0.613]	[0.233]	[1.720]	[-1.681]	[1.192]
Pork	-0.452	0.391	-2.722	-1.593	4.940*	-0.662	-0.469**	-0.039	-0.142	-0.419	0.903***
	[-1.273]	[0.871]	[-0.999]	[-1.504]	[1.816]	[-0.653]	[-2.072]	[-0.336]	[-1.164]	[-1.067]	[4.932]
Processed meat and seafood	-0.909***	-0.212	-1.809	2.129	0.081	0.697	-0.220	0.056	6.929E-05	-1.219**	1.129***
	[-3.401]	[-0.435]	[-1.517]	[1.467]	[0.097]	[1.257]	[-1.227]	[0.460]	[4.618E-04]	[-2.393]	[16.910]
Caribou	-0.017	0.378	6.661*	0.137	-8.183*	1.457	-0.112	-0.292**	0.236	-0.859**	1.056***
	[-0.065]	[0.680]	[1.824]	[0.138]	[-1.805]	[1.121]	[-0.572]	[-1.977]	[1.327]	[-2.143]	[21.872]
Other country foods	0.404	-0.047	-1.058	1.063	1.794	-2.590*	-0.347*	-0.097	0.248**	0.077	1.279***
	[1.523]	[-0.065]	[-0.632]	[1.308]	[1.121]	[-1.859]	[-1.786]	[-0.574]	[2.047]	[0.183]	[5.231]
Fruits and vegetables	-0.150*	-0.075	-0.244**	-0.102	-0.081	-0.134**	-0.397**	-0.193**	-0.016	-0.229	1.915***
	[-1.781]	[-1.110]	[-2.388]	[-1.356]	[-1.162]	[-2.404]	[-2.056]	[-2.297]	[-0.253]	[-1.103]	[6.223]
Grains	-0.046	-0.021	-0.037	0.014	-0.132**	-0.058	-0.166*	-0.808***	-0.004	-0.284	3.065
	[-0.787]	[-0.463]	[-0.691]	[0.283]	[-2.508]	[-1.293]	[-1.770]	[-3.446]	[-0.080]	[-0.958]	[1.069]
Dairy	-0.407**	0.131	-0.167	-0.006	0.144	0.122	-0.025	-0.009	-0.938***	-0.377	6.902
	[-2.352]	[1.441]	[-1.331]	[-0.045]	[1.046]	[1.589]	[-0.174]	[-0.083]	[-7.767]	[-1.660]	[0.880]
Other foods	0.050	-0.056*	-0.028	-0.107*	-0.088**	0.002	0.047	0.024	-0.002	-0.524***	0.069
	[1.565]	[-1.829]	[-0.587]	[-1.860]	[-2.142]	[0.057]	[0.830]	[0.360]	[-0.091]	[-3.747]	[0.115]

***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are t-statistics.

The following tables show elasticities of substitution, which are symmetric for any two goods. In the opportunity cost model, it was found that the following pairs of goods have a substitution relationship at the 10% significance level: beef and caribou, beef and other country foods, caribou and other country foods, fruits and vegetables and other foods, grains and dairy products, and grains and other foods. The following pairs of goods have complement relationships at the 10% significance level in the opportunity cost model: beef and chicken, beef and pork, beef and processed meat and seafood, beef and dairy products, chicken and other foods, and other country foods and fruits and vegetables. Own-price elasticities of substitution are statistically significant at the 10% level and negative, as predicted, for caribou, other country foods, grains, and dairy products. Own-price elasticities of substitution are statistically significant at the 10% level and positive for beef, pork, and processed meat and seafood. Goods with a positive own-price effect are termed Giffen goods, for which quantity demanded increase when price increases. Consumers may associate Giffen goods with quality or luxury with a higher price. However, Jensen and Miller (2008) note that there has been a noted lack of robust empirical examples of the existence of Giffen goods, and find evidence of Giffen good characteristics for staple goods that comprise a high proportion of total food expenditures. For the present model estimation, the presence of Giffen goods may indicate poor model fit.

In the out-of-pocket cost model, the following pairs of goods have a substitution relationship at the 10% significance level: beef and other foods, pork, and caribou, processed meat and seafood and grains, other country foods and dairy products, fruits and vegetables and other foods, grains and dairy products. The following pairs of goods have complement relationships at the 10% significance level in the out-of-pocket cost model: beef and chicken, beef and processed meat and seafood, beef and dairy, and chicken and other foods. Own-price elasticities of substitution are statistically significant at the 10% level and positive for beef, pork, and processed meat and seafood, and negative, as expected, for caribou and other country foods, grains, and dairy products.

Table 4-18 Opportunity cost LA/AIDS elasticity of substitution estimates

	Beef	Chicken	Pork	Processed meat and seafood	Caribou	Other country foods	Fruits and vegetables	Grains	Dairy	Other foods
Beef	1.508***	-18.380***	-20.957**	-20.485***	6.467*	7.782**	-1.171	0.113	-7.821**	0.808
	[3.004]	[-3.144]	[-2.209]	[-3.232]	[1.812]	[2.224]	[-0.680]	[0.097]	[-2.040]	[1.005]
Chicken		-0.204	11.479	-0.541	10.123	0.535	-0.534	0.673	4.272	-1.854**
		[-0.157]	[0.959]	[-0.042]	[1.058]	[0.061]	[-0.292]	[0.553]	[1.622]	[-2.070]
Pork			3.318*	-26.859	-21.874	7.810	-2.898	0.637	-1.957	-0.274
			[1.679]	[-1.027]	[-1.289]	[0.503]	[-1.286]	[0.566]	[-0.698]	[-0.223]
Processed meat and seafood				2.474*	-2.034	6.583	-0.712	1.316	0.909	-2.022
				[1.856]	[-0.189]	[0.604]	[-0.433]	[1.351]	[0.266]	[-1.489]
Caribou					-10.781**	101.485**	1.223	-1.164	3.362	-0.386
					[-2.092]	[2.148]	[0.814]	[-1.150]	[1.265]	[-0.439]
Other country foods						-10.501**	-2.688*	0.407	3.364	0.853
						[-2.409]	[-1.872]	[0.401]	[1.616]	[1.030]
Fruits and vegetables							-0.122	-0.096	1.035	1.520**
							[-0.572]	[-0.131]	[0.700]	[2.267]
Grains								-0.681**	2.026*	1.514*
								[-2.452]	[1.814]	[1.850]
Dairy									-0.862***	0.353
									[-6.510]	[0.514]
Other foods										-0.257
										[-1.364]

***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are t-statistics.

Table 4-19 Out-of-pocket cost LA/AIDS elasticity of substitution estimates

	Beef	Chicken	Pork	Processed meat and seafood	Caribou	Other country foods	Fruits and vegetables	Grains	Dairy	Other foods
Beef	1.246***	-14.007***	-7.567	-16.120***	0.245	8.329	-1.271	0.652	-6.312*	1.641***
	[2.636]	[-3.193]	[-1.107]	[-3.141]	[0.048]	[1.636]	[-0.798]	[0.671]	[-1.908]	[2.654]
Chicken		-0.151	10.151	-3.468	9.269	-0.509	-0.105	1.069	4.545**	-0.599
		[-0.126]	[0.984]	[-0.310]	[0.724]	[-0.031]	[-0.068]	[1.130]	[2.182]	[-0.855]
Pork			-2.658	-31.191	120.593*	-18.479	-2.776	0.871	-1.472	0.172
			[-0.975]	[-1.453]	[1.833]	[-0.613]	[-1.514]	[1.035]	[-0.652]	[0.199]
Processed meat and seafood				2.197	3.376	22.187	-0.445	1.836**	1.405	-1.487
				[1.511]	[0.167]	[1.345]	[-0.292]	[2.084]	[0.503]	[-1.275]
Caribou					-8.157*	43.897	-0.348	-1.639	5.001	-1.444
					[-1.799]	[1.135]	[-0.207]	[-1.479]	[1.504]	[-1.455]
Other country foods						-2.573*	-2.360	-0.193	5.175**	0.734
						[-1.845]	[-1.432]	[-0.158]	[2.247]	[0.793]
Fruits and vegetables							-0.204	0.145	1.323	1.077**
							[-1.046]	[0.243]	[1.142]	[2.263]
Grains								-0.607***	1.464*	0.869*
								[-2.865]	[1.751]	[1.674]
Dairy									-0.856***	0.637
									[-7.004]	[1.274]
Other foods										-0.236*
										[-1.837]

***, **, and * indicate significance at 1, 5 and 10 percent level, respectively; values in square brackets are t-statistics.

In summary, from the elasticities of demand and substitution estimates, other meat types have been found to be potential substitutes for caribou. The Marshallian demand elasticity estimates, which show the gross effect from an increase in the price of a good—from both income and substitution effects—show that other country foods and pork are substitutes for caribou, while grains and other foods are complements. From substitution elasticity estimates that show the pure effect of a price increase of caribou, other country foods and beef are found to be substitutes in the opportunity cost model, while pork is found to be a substitute from the out-of-pocket cost model.

Table 4-20 Summary of substitutes and complements for caribou from LA/AIDS demand system

	Demand elasticities		Elasticities of substitution	
	Opportunity cost model	Out-of-pocket cost model	Opportunity cost model	Out-of-pocket cost model
Substitutes	Other country foods (ε= 11.156)	Pork (ε= 6.661)	Other country foods (σ= 101.485) Beef (σ= 6.467)	Pork (σ= 120.593)
Complements	Grains (ε= -0.226)	Other foods (ε= -0.295)		

The following table shows potential changes in total expenditure, at the community level, with purchasing and consuming substitute foods. In the opportunity cost model, it is assumed that individuals may a combination of other country foods and beef for caribou. For the expenditure calculations, it is assumed that 94% (the proportion of the sum of the respective elasticities of substitution) of the caribou weight consumed by individuals is replaced with other country foods, and 6% of the caribou weight consumed is replaced with beef. In the out-of-pocket cost model, it is assumed that weight of caribou consumed is replaced entirely with pork. The price of the replacement item is calculated from the average prices faced by consumers in the community for the respective item.

When per capita consumption is calculated, average individual food expenditure was found to increase across all communities in both the opportunity cost and out-of-pocket cost models.

Table 4-21 Summary of average individual and total community expenditures per day

	Average individual expenditure				**Total community expenditure**			
Community	Opp. cost ($/day)	Opp. cost - with caribou replacement (**94% Other Country Foods; 6% Beef)** ($/day)	Out-of-pocket cost model ($/day)	Out-of-pocket cost model - with caribou replacement (**Pork**) ($/day)	Opp. cost model ($/day)	Opp. cost model - with caribou replacement (**94% Other Country Foods; 6% Beef)** ($/day)	Out-of-pocket cost model ($/day)	Out-of-pocket cost model - with caribou replacement (**Pork**) ($/day)
1	15.35	15.83	13.43	14.84	721.47	743.78	632.14	697.35
2	11.79	12.29	9.74	11.04	471.70	491.71	389.76	441.69
3	12.00	13.07	10.48	11.46	540.28	587.96	472.22	515.91
4	9.43	9.97	7.94	9.30	527.95	558.41	444.68	520.74
All	12.03	12.67	10.31	11.57	2261.40	2381.86	1938.80	2175.69

The average and total community daily expenditure values may be expressed as annual costs, as shown in the following table:

Table 4-22 Summary of average individual and total community expenditures per year

Community	Average individual expenditure				Total community expenditure			
	Opp. cost ($/year)	Opp. cost - with caribou replacement (**Other country food and beef**) ($/year)	Out-of-pocket cost model ($/year)	Out-of-pocket cost model - with caribou replacement (**Pork**) ($/year)	Opportunity cost model ($/day)	Opportunity cost model - with caribou replacement (**Other country food and beef**) $/year)	Out-of-pocket cost model ($/year)	Out-of-pocket cost model - with caribou replacement (**Pork**) ($/year)
1	5603	5776	4902	5417	263337	271479	230731	254533
2	4303	4487	3555	4030	172171	179475	142262	161217
3	4380	4769	3825	4183	197202	214607	172360	188307
4	3442	3640	2898	3395	192702	203820	162308	190070
All	4391	4624	3763	4223	825411	869381	707662	794127

Differences in annual cost with replacement of caribou are shown in the following table:

Table 4-23 Differences in average individual expenditure ($/year) and total community expenditure ($/year) with replacement of caribou

Community	Average individual expenditure		Total community expenditure	
	Opp. cost - with caribou replacement (**94% Other Country Foods; 6% Beef**) ($/year)	Out-of-pocket cost model - with caribou replacement (**Pork**) ($/year)	Opportunity cost model - with caribou replacement (**94% Other Country Foods; 6% Beef**) ($/year)	Out-of-pocket cost model (**Pork**) ($/year)
1	173	515	8142	23802
2	184	475	7304	18954
3	389	358	17405	15947
4	198	496	11118	27762
All	233	460	43970	86465

If community members to replace caribou entirely with the substitutes pork, or a combination of beef and other country foods, when the price of caribou increases, average individual expenditure may increase between $233 and $460 per year, on average, across all communities.

If it is assumed that there four members in a census family—the average number of persons in a census family was 3.7 persons in Nunavut and 3.2 persons in the Yukon—average annual food expenditure may increase between $932 and $1840 per census family. Given that the median census family income was $49 270 in Nunavut and $86 132 in 2006 (Statistics Canada 2007d, 2007h), the increase in food expenditure can potentially be equal to 2% to 4% of annual family income in

Nunavut, and between 1% and 2% of annual family income in Northwest Territories.

4.3.5 Summary

Various individual- and community-level characteristics, food prices, and total individual expenditures on food were found to have effects on the probability of individuals consuming different types of foods, and the quantities of the foods demanded. For caribou, age was found to have a positive impact on probability of consumption in the opportunity cost specification of the participation equation. For country foods other than caribou (other land mammals, sea mammals and fish, and birds), age was found to have a positive impact on probability of consumption in both the opportunity cost and out-of-pocket cost specifications of the participation equations, and also a positive impact on expenditure share levels in all four specifications of the demand system models. This pattern is consistent with studies that show that older individuals consume country meat, including caribou, either more frequently or and in higher quantities than younger individuals.

An increased community employment rate and a higher number of food stores in a community were found to have negative impacts on expenditure share levels of caribou. This result suggests that the level of economic development in a community may impact the level of caribou consumption. Increased employment levels may decrease aggregate time available to community members for harvesting and hence the total supply of caribou available to the community, assuming that sharing of meat may take place. At the individual level, employment status is not shown to affect the tastes of individuals to consume caribou. In the out-of-pocket cost model for caribou, increased total expenditure has a negative impact on the probability of consuming caribou and a negative impact on expenditure share level in the Working-Leser and LA/AIDS specifications. Therefore, increases in total food expenditure may not lead to increases in the respective expenditure shares on caribou and other country foods.

Expenditure elasticities show that increases in total food expenditure, however, lead to increases in quantity consumed of caribou and other country meat and fish. Own-price Marshallian demand elasticities show that individuals have elastic demands for caribou and other country meat and fish—increases in the price of country foods lead to greater than proportional decreases in demand. Communities where opportunity costs or out-of-pocket costs for harvesting are high—due to relatively high costs for harvesting equipment, high wages, or limited physical accessibility to caribou, individuals may choose to substitute caribou for store-bought foods. From cross-price demand elasticity estimates, it was found from opportunity cost and out-of-pocket cost estimates, respectively, that potential gross substitutes for caribou are other country foods and pork. From elasticity of substitution estimates, it was found from opportunity cost and out-of-pocket cost estimates, respectively, that potential net substitutes for caribou are other country foods and beef, and pork. In a hypothetical scenario where individuals substituted caribou with these foods, average expenditure per individual would increase by between $233 and $460 per year.

A limitation of the results may stem from the fact that non-joint production is assumed in the theoretical specification and empirical methods used to calculate the marginal opportunity costs and out-of-pocket costs of harvesting. It has been assumed that individuals decide the respective amounts of time and out-of-pocket equipment purchases to allocate to the harvest of different types of country food—caribou, other land mammals, sea mammals, birds, and fish. In reality, individuals may combine harvesting activities for different species, and harvest more than one type of country food during a single trip. They may also substitute species or types of country meat and fish harvested in the event of lowered availability of a species. Thus, harvest effort may be over-estimated and lead to biases in the calculated marginal costs of harvesting. In future studies, details on individual allocations of time to harvesting may enable testing of the impacts of species substitution during harvesting activities.

4.4 Calorie intake and dietary diversity models

In this section, summary statistics and model estimates for caloric intake and dietary diversity are shown. The summary values are delineated by gender, by employment status, and by community. Proportions of individuals meeting the recommended calorie intake requirements are shown, where requirements are defined by age and gender categories for sedentary, low active, and active energy levels, by Health Canada (2011). The average diversity scores calculated for the are based on individual diversity scores ranging from 1 to 4.

4.4.1 Summary statistics

In terms of food groups (dietary diversity), about half of the individuals (46%) in the sample reported consuming all four food groups (as shown in Figure 4-6).

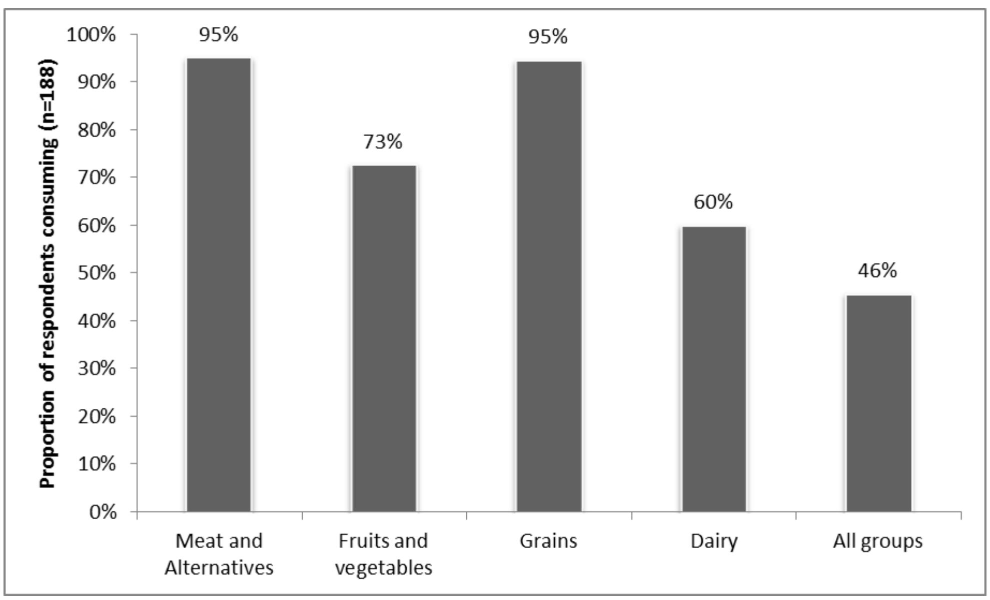

Figure 4-4 Frequency of consumption by food group

Table 4-24 Summary Statistics - Calories and Diversity by Gender

	Calories		Proportion meeting estimated energy requirement			Food group score (Diversity)		
	Mean	S.D.	Sedentary	Low Active	Active	Mean	S.D.	% respondents consuming all groups
Male	2394.63	1338.95	49%	36%	27%	3.28	0.90	52%
Female	1691.09	825.02	42%	30%	21%	3.15	0.83	40%

Total	2024.15	1151.52	46%	33%	24%	3.23	0.83	46%

It was found that males consume more calories than females on average, and have a higher food group score. In terms of energy requirements, more males than females are reaching the recommended energy (calories) intake levels for sedentary activity.

Table 4-25 Summary Statistics - Calories and Diversity by Employment Status

	Calories		Proportion meeting estimated energy requirement			Food group score (Diversity)		
	Mean	S.D.	Sedentary	Low Active	Active	Mean	S.D.	% respondents consuming all groups
Employed	2213.61	1183.32	52%	34%	29%	3.32	0.96	60%
Not employed	1924.06	1126.38	33%	21%	21%	3.08	0.93	38%
Total	2024.15	1151.52	46%	33%	24%	3.23	0.83	46%

Employed individuals were found to consume more calories than the non-employed, and also have higher scores of diversity. A lower proportion of non-employed individuals than employed individuals report meeting the recommended daily intake of energy at the sedentary, low active, and active levels.

Table 4-26 Summary Statistics - Calories and Diversity by Community

Comm.	Calories		Proportion meeting estimated energy requirement			Food group score (Diversity)		
	Mean	S.D.	Sedentary	Low Active	Active	Mean	S.D.	% respondents consuming all groups
1	2299.44	1460.53	55%	40%	34%	3.21	0.83	45%
2	1901.33	939.69	50%	35%	23%	3.08	0.80	35%
3	2285.22	1052.67	56%	42%	31%	3.44	0.81	62%
4	1671.04	976.34	27%	18%	11%	3.18	0.86	41%
Total	2024.17	1151.53	46%	33%	24%	3.23	0.83	46%

From the summary statistics, it was found that about half of individuals (54%) are not meeting estimated energy requirements for their age and gender category at the sedentary activity level. Among the communities, there is heterogeneity in the number of calories consumed. Communities 1, 2, and 3 have at least half of individuals meeting energy intake recommendations, while community 4 is found to only 27%. Food group or dietary diversity score is lowest for communities 2 and 4.

The calorie calculations carried out may be validated with comparison to other Canadian studies on calorie intake and published figures from Sharma et al. (2009, 2010). For example, Garriguet (2007) reports that from a 24-hour recall survey conducted under the 2004 Canadian Community Health Survey 2.2, which was conducted across the 10 Canadian provinces, the daily calorie consumption ranges between 1873 and 2729 for males age 19 and over and between 1514 and 1899 for females aged 19 and over, with calorie consumption for older individuals lower than that for younger individuals, on average. The calculated mean calories for males and females from the present sample fall into the range calculated from the CCHS 2.2 data.

It was also found from CCHS 2.2 data that 5 in 10 women and 7 in 10 men have energy intakes that exceed their energy expenditures (as determined by published Institute of Medicine estimates of energy requirements) (Garriguet 2008, Health Canada 2012c). In the present sample, in terms of consuming enough calories to meet the requirement for a sedentary activity level, men also have higher percentages of adequate intakes than women (49% and 42%, respectively), although these percentages are smaller than that reported for the CCHS 2.2 measure for males and females.

As stated in section 2.4.2.3.2, Sharma et al. (2009, 2010) have reported summary statistics for the data used in the present study. The mean and median values for calorie intake were reported at the region level for the two study regions (Inuvialuit Settlement Region and Nunavut) and categorized by gender. For Nunavut males and females, respectively, the calculated means exceeded the respective values published in Sharma et al. (2010) by 41 and 245 calories. For Inuvialuit males and females, respectively, the calculated means were under the respective values published in Sharma et al. (2010) by 71 and 86 calories. The differences may be attributed to differences in the data treatment, including the dropping of observations, or differences in classification of certain food items. Blanchette and Rochette (2008) found that from 24-recall data for Nunavik adults in 2004, median calorie intake was 1937 calories, with men consuming more calories than women, and with intake decreasing with age for both genders.

Black et al. (1993) also point out drawbacks to calculating calorie intake figures from dietary records. In a study with randomly recruited adults, they found underestimation of food intake with self-reporting of intake, a finding similar to that of previous studies. It was also found that 10% of adults underreported food consumption in the CCHS 2.2 (Garriguet 2008).

There may be relationship between the intake of caribou and overall calorie intake. The following correlation computations show the relationship between the measures of dietary quality chosen as proxies for food security—calorie intake and dietary diversity—and caribou consumption, as modeled by a dummy variable for whether or not caribou was consumed in the dietary recall period.

Table 4-27 Correlation coefficients between caribou consumption and calorie intake and dietary diversity

	Caribou dummy (=1 if consumed caribou, 0 otherwise)	p-value	Weight of caribou consumed	p-value
Calorie intake	-0.017	0.819	0.12	0.106
Dietary diversity	0.05	0.474	0.08	0.253
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				

Caloric intake and dietary diversity scores have positive correlations with the amount (in grams) of caribou consumed, although the correlations are not statistically significant. Dietary diversity has a positive correlation with caribou consumption, while number of calories consumed has a negative correlation with caribou consumption. However, these correlations are not significant at the 10% level. There is some indication that more food secure individuals, as measured by calorie intake and dietary diversity, have higher intakes of caribou. The respective relationships between caribou consumption and calorie intake and dietary diversity are further examined in the econometric models.

4.4.2 Calorie demand model

This section includes results from econometric analysis of the calorie intake demand equations. The empirical model to be estimated was specified in section 3.2.4.

From the model estimates in Tables 4-29 and 4-30, it was found that increased age has a negative effect on calories consumed in both opportunity cost and out-of-pocket cost equations. Being male led to increased consumption of calories at the 10% significance level in both the opportunity cost and out-of-pocket cost equations. Employment status was not found to have an effect on calories consumed. An increased number of stores in the community and increased total expenditure were both found to have positive effects on calorie intake in both specifications at the 10% significance level. The dummy variable for caribou intake was not found to be statistically significant in the opportunity cost model, but was found to be statistically significant in the out-of-pocket cost model.

Table 4-28 Ordinary Least Squares Regression: Calorie intake with opportunity cost expenditure estimates and caribou dummy

Variable	Estimated coefficient	Standard Error	t-statistic	P-value
CONSTANT	1115.290***	337.461	3.305	[.001]
AGE	-13.075***	3.446	-3.794	[.000]
GENDERD	426.633***	115.567	3.692	[.000]
EMP	-191.601	125.184	-1.531	[.128]
NSTORES	73.505*	38.449	1.912	[.057]
ERATE	0.592	6.656	0.089	[.929]
CARIBOUD	19.060	118.576	0.161	[.872]
OTOTAL	94.587***	7.945	11.906	[.000]
R-squared = 0.580194				
LM het. Test = 10.9927 [0.001]				
Durbin-Watson = 1.98295 [<.687]				
n=188				
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively				

Table 4-29 Ordinary Least Squares Regression: Calorie intake with out-of-pocket expenditure estimates and caribou dummy

Variable	Estimated coefficient	Standard Error	t-statistic	P-value
CONSTANT	1000.690***	352.535	2.839	[.005]
AGE	-10.722***	3.637	-2.948	[.004]
GENDERD	440.817***	119.974	3.674	[.000]
EMP	-171.281	129.830	-1.319	[.189]
NSTORES	71.146*	39.909	1.783	[.076]
ERATE	1.295	6.910	0.187	[.851]
CARIBOUD	231.128*	123.995	1.864	[.064]
PTOTAL	99.185***	9.102	10.897	[.000]
R-squared = .547873				
LM het. Test = 19.7178 [.000]				
Durbin-Watson = 1.92718 [<.542]				
n=188				
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively				

From the goodness of fit results, the R-squared value indicates that 58% of the variation in calorie intake may be explained by the explanatory variables for the opportunity cost expenditure estimates, while 55% of the variation in calorie intake may be explained by the explanatory variables for the out-of-pocket cost expenditure estimates. The Lagrange Multiplier (LM) test statistic is statistically significant in both equations, indicating the presence of heteroskedasticity. The models are re-estimated with heteroskedastic-consistent robust standard errors; results are shown in Tables 4-31 and 4-32. It was found that increased age has a negative effect, male gender has a positive effect, and total expenditure has a positive effect, on calories consumed, as in the previous estimations where standard errors are not adjusted. Number of stores was not found to have a statistically significant effect on calorie consumption in both specifications. Consuming caribou was not found to have a positive effect in the out-of-pocket cost model in the version with robust standard errors. Therefore, the results are sensitive in terms of the types of standard errors employed.

Table 4-30 Ordinary Least Squares Regression with Robust standard errors: Calorie intake with opportunity cost expenditure estimates and caribou dummy

Variable	Estimated coefficient	Robust Standard Error	t-statistic	P-value

C	1115.290***	414.915	2.688	[.008]
AGE	-13.075***	3.402	-3.844	[.000]
GENDERD	426.633***	122.471	3.484	[.001]
EMP	-191.601	141.589	-1.353	[.178]
NSTORES	73.505	46.298	1.588	[.114]
ERATE	0.592	8.252	0.072	[.943]
CARIBOUD	19.060	136.143	0.140	[.889]
OTOTAL	94.587***	11.952	7.914	[.000]
R-squared = .580194				
LM het. Test = 10.9927 [.001]				
Durbin-Watson = 1.98295 [<.687]				
n=188				
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively				

Table 4-31 Ordinary Least Squares Regression with Robust standard errors: Calorie intake with out-of-pocket expenditure estimates and caribou dummy

Variable	Estimated coefficient	Robust Standard Error	t-statistic	P-value
C	1000.690**	448.752	2.230	[.027]
AGE	-10.722***	3.980	-2.694	[.008]
GENDERD	440.817***	131.507	3.352	[.001]
EMP	-171.281	146.501	-1.169	[.244]
NSTORES	71.146	46.452	1.532	[.127]
ERATE	1.295	8.037	0.161	[.872]
CARIBOUD	231.128	155.783	1.484	[.140]
PTOTAL	99.185***	14.951	6.634	[.000]
R-squared = .547873				
LM het. Test = 19.7178 [.000]				
Durbin-Watson = 1.92718 [<.542]				
n=188				
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively				

The calorie demand model may also be specified with other indicators of access to caribou. Caribou access may be specified by inclusion of three caribou harvest variables representing low, mean, and peak numbers of caribou harvested as stated in historical harvest data (see Appendix H for harvest numbers). From the two estimations with heteroskedastic-consistent standard errors, it was found that increased age has a negative effect, male gender has a positive effect, and total expenditure has a positive effect, on calories consumed at the 10% significance level. It was found that there is a negative relationship between the low harvest number and calories consumed at the 10% significance level. The peak harvest number was found to be positively related to calories consumed at the 10% significance level.

Table 4-32 Ordinary Least Squares Regression with Robust standard errors: Calorie intake with opportunity cost expenditure estimates and community harvest levels

Variable	Estimated coefficient	Robust Standard Error	t-statistic	P-value
C	1362.540*	691.341	1.971	[.050]
AGE	-12.927***	3.433	-3.765	[.000]
GENDERD	427.286**	124.150	3.442	[.001]
EMP	-195.741	142.407	-1.375	[.171]
MEANHAR	0.472	0.617	0.766	[.445]
LOWHAR	-1.488***	0.454	-3.278	[.001]
PEAKHAR	0.697*	0.362	1.927	[.056]
OTOTAL	94.950***	12.271	7.738	[.000]
R-squared = 0.580				
LM het. Test = 10.6869 [.001]				
Durbin-Watson = 1.98045 [<.681]				
n=188				
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively				

Table 4-33 Ordinary Least Squares Regression with Robust standard errors: Calorie intake with out-of-pocket expenditure estimates and community harvest levels

Variable	Estimated coefficient	Robust Standard Error	t-statistic	P-value
C	1386.430*	720.111	1.925	[.056]
AGE	-10.193**	3.928	-2.595	[.010]
GENDERD	463.790***	130.106	3.565	[.000]
EMP	-168.433	148.439	-1.135	[.258]
MEANHAR	0.301	0.642	0.469	[.640]
LOWHAR	-1.370**	0.502	-2.727	[.007]
PEAKHAR	0.653*	0.376	1.737	[.084]
PTOTAL	96.946***	13.944	6.953	[.000]
R-squared = 0.539				
LM het. Test = 14.3843 [.000]				
Durbin-Watson = 1.90309 [<.476]				
n=188				
***, **, and * indicate significance at 1, 5 and 10 percent level, respectively				

From the goodness of fit results, the R-squared value indicates that 58% of the variation in calorie intake may be explained by the explanatory variables for the opportunity cost expenditure estimates, while 54% of the variation in calorie intake may be explained by the explanatory variables for the out-of-pocket cost expenditure estimates.

The results of the calorie equation estimates suggest that consuming caribou may have a positive impact on individual intake of calories, as the dummy variable coefficient estimate for positive caribou consumption is positive and statistically significant in the out-of-pocket cost specification. Since total food expenditure is included in this specification, the result implies that even if total food expenditure is held constant, consuming caribou would be predicted to have a positive impact on caloric intake. It is noted, however, that the coefficient is not statistically significant in the model estimate with robust standard errors.

4.4.3 Dietary diversity model

This section includes results from econometric analysis of the dietary diversity demand equations. The empirical model to be estimated was specified in Chapter 3. From the summary statistics, it was shown that no respondents had a food group score of 0. Therefore, the dependent variable to be estimated in the ordered probit regression is specified "0": score = 1, "1": score = 2, "2": score = 3, "3": score = 4, as the econometrics software program requires the lowest ordered response to be "0."

From the heteroskedastic ordered probit regression estimates shown in Tables 4-22 and 4-23, it was found that an increased total expenditure has positive effects on dietary diversity in the opportunity cost model at the 10% significance level. From the marginal effects, it was found that total expenditure has a negative effect on the likelihood of having a food group score of 1, 2, or 3, but a positive effect on having a food group score of 4. In the out-of-pocket cost model, caribou consumption and total expenditure were found to have positive effects on diversity at the 10% significance level. From the marginal effects, it was found that caribou consumption and increased total expenditure each have negative effects on the likelihood of having a food group score of 1, 2, or 3, but a positive effect on having a food group score of 4.

Table 4-34 Ordered probit coefficient estimates: dietary diversity (Food Group Score – FGS) with opportunity cost expenditure estimates

Parameter	Estimate	Standard	z-statistic	p-value

CONSTANT	0.882	0.786	1.122	0.262
AGE	0.006	0.008	0.750	0.454
GENDERD	-0.098	0.264	-0.369	0.712
EMP	0.102	0.282	0.361	0.718
NSTORE	0.148	0.102	1.456	0.145
ERATE	-0.012	0.016	-0.735	0.463
CARIBOUD	0.364	0.308	1.183	0.237
OTOTAL	0.202***	0.062	3.256	0.001
Wald Chi-squared (df=8) = 42.293				
Prob > chi2 = 0.119E-05				
McFadden Pseudo R-squared = 0.010				
Log pseudo-likelihood = -190.630				
n=188				
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				
Variance function				
TOTAL	0.040**	0.019	2.146	0.032
Marginal effects				
Parameter	y=0 (score = 1)	y= 1 (score = 2)	y= 2 (score = 3)	y= 3 (score = 4)
CONSTANT	-0.021	-0.100	-0.098	0.218
AGE	-0.001E-01	-0.001	-0.001	0.001
GENDERD	0.002	0.011	0.011	-0.024
EMP	-0.002	-0.012	-0.011	0.025
ERATE	-0.004	-0.017	-0.016	0.037
NSTORES	0.003E-01	0.001	0.001	-0.003
CARIBOUD	-0.009	-0.041	-0.040	0.090
OTOTAL	-0.005	-0.023	-0.022	0.050
Var - OTOTAL	0.0073	0.139	-0.185	-0.027

Table 4-35 Ordered probit coefficient estimates: dietary diversity (Food Group Score – FGS) with out-of-pocket expenditure estimates

Parameter	Estimate	Standard	z-statistic	p-value
CONSTANT	0.686	0.826	0.831	0.406
AGE	0.012	0.008	1.487	0.137
GENDERD	-0.092	0.266	-0.346	0.729
EMP	0.213	0.292	0.728	0.467
NSTORE	0.156	0.102	1.538	0.124
ERATE	-0.016	0.017	-0.956	0.339
CARIBOUD	0.588*	0.295	1.992	0.046
PTOTAL	0.252***	0.066	3.827	0.000
Wald Chi-squared (df=8) = 54.700				
Prob > chi2 = 0.000				
McFadden Pseudo R-squared = 0.129				
Log pseudo-likelihood = -184.426				
n=188				
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				
Variance function				
PTOTAL	0.048***	0.017	2.844	0.005
Marginal effects				
Parameter	y=0 (score = 1)	y= 1 (score = 2)	y= 2 (score = 3)	y= 3 (score = 4)
CONSTANT	-0.014	-0.073	-0.079	0.166
AGE	-0.003E-01	-0.013E-01	-0.014E-01	0.003
GENDERD	0.002	0.010	0.011	-0.022

EMP	-0.004	-0.023	-0.025	0.051
ERATE	-0.003	-0.017	-0.018	0.038
NSTORES	0.0003	0.002	0.002	-0.004
CARIBOUD	-0.012	-0.062	-0.068	0.142
PTOTAL	-0.005	-0.027	-0.029	0.061
Var –PTOTAL	0.0073	0.139	-0.185	-0.027

Based on the Wald test, it was found that both dietary diversity demand equations have overall significance—the variables are jointly significant. The coefficients for the opportunity cost total expenditure and out-of-pocket cost total expenditure in the variance function were found to be statistically significant in the respective equations and were retained in the heteroskedastic model estimates.

In both specifications, increased total food expenditure was found to lead to an increased likelihood of having the highest food group score, supporting the theory that increased expenditures or income may lead to higher demand for diversity, as outlined by Jackson (1984). When total expenditure is accounted for, consuming caribou was found to lead to an increased likelihood of achieving a food group score of 4 in the out-of-pocket cost model. Thus, at varied levels of total expenditure, having access to caribou potentially leads to increased overall diet quality, as measured by the dietary diversity indicator. It is noted, however, that the result is not robust to changes in cost specification—the caribou consumption variable is not statistically significant in the opportunity cost model.

4.4.4 Summary

In Chapter 2, it was identified that calorie intake and dietary diversity at the individual-level may reflect dietary quality and hence serve as indicators of food security. The dietary recall data available for this study has been used thus far for expenditure analysis, where expenditure shares of caribou and other foods have been related with certain individual and community-level characteristics, and total food expenditures. In this section, it was found that about half of respondents had a maximum food group score of 4, consuming at least one food item from all of the four food groups. From the Nunavik Inuit Health Survey 2004, Blanchette and Rochette (2008) reported that most respondents met the recommended serving levels for meat and alternatives consumed, but fell below recommended levels for fruits and vegetables, dairy products, and grain products.

Half of respondents met recommended calorie intake levels for sedentary activity. About half of the sample may be deemed food insecure. Comparatively, responses to the food security survey module of the Canadian Community Health Survey (as discussed in Appendix F) showed that 56% of respondents in Nunavut and 28% of respondents in the Northwest Territories were food insecure (Ledrou and Gervais 2005).

The results also show that individuals may be income-constrained in terms of achieving food secure status, as has been suggested in previous studies (e.g. Lambden et al. 2006). From the econometric results, it was found that increased food expenditure levels lead to increased intake of calories and increased dietary diversity scores. Increases in individual incomes may lead to higher levels of food security among individuals. It was also found from the estimation of the calorie models without heteroskedastic-consistent standard errors that increased access to stores in the community led to higher calorie intake.

From the marginal effects from the dietary diversity analysis, it was found that increased expenditures resulted in a decreased likelihood of having a food group score of 3, and an increased likelihood of having a food group score of 4 for both opportunity cost and out-of-pocket cost specifications. Therefore, an increase in income may lead to an increased likelihood of individuals achieving food secure status by shifting from a food insecure state (with food group score of 3) to a food secure state where all food groups are consumed.

The consumption of caribou was found to have a positive influence on calorie consumption in the out-of-pocket cost model where standard errors are not heteroskedastic-consistent, and also in the out-of-pocket cost model specification for dietary diversity. When calorie intake is modeled after different levels of community caribou harvest, harvest levels were found to have varied impacts on calorie intake. There is some evidence from that consuming caribou contributes to overall food security, as measured by energy intake and dietary diversity.

4.5 Summary

This chapter has presented analysis from dietary data from four northern communities. From these data, it has been shown that caribou comprises a significant part of the dietary protein consumed by households. Furthermore, economic factors are shown to have impacts on quantities and incidence of consumption of caribou and other country foods. Negative impacts to caribou populations may have negative impacts on populations in the future, particularly households who may not have monetary resources to participate in harvesting. If access to caribou is constrained, resulting in higher opportunity costs and out-of-pocket costs for harvesting caribou, individuals are likely to decrease their expenditures on caribou and allocate expenditures to substitute goods, which have been found to be other types of meat, either country or store-bought. Since prices have been demonstrated to be higher for other foods, households face higher total food expenditures if caribou is replaced.

In terms of overall dietary outcomes, many households are not meeting recommended guidelines for dietary intake in both energy intake values and in the number of different types of foods consumed. Negative impacts to wildlife may have further consequences for individuals who are already food insecure.

Chapter 5 Analysis of Aboriginal Peoples Survey

5.1 Introduction

Results from the Aboriginal Peoples Survey (APS) are presented in this chapter. As stated, the analysis will address the thesis objective of determining how socio-economic factors influence harvesting behavior and country meat and fish consumption. While the dietary demand analysis in the previous chapter highlighted use of caribou and other country foods, responses to questions from the APS on types of harvesting behavior and amount of country food consumed also provide indicators on the extent to which individuals may depend on country meat and fish as a source of dietary protein.

Results are from the econometric model estimations for i) individual participation in harvesting, ii) household-level participation in harvesting, iii) household-level consumption of country meat and fish, and iv) household purchase of harvesting equipment. The dependent variables for models i), ii), and iii) represent time allocation (individual harvesting, household harvesting, and amount of country meat and fish consumed), while model iv) is used to examine household resource allocation to material inputs for harvesting.

For variables i) and iii), individual harvesting and household consumption of meat and fish, two government reports have reported summary statistics for 2001 data (Tait 2006, 2007) and two for 2006 data (Tait 2008a, b). Econometric modeling has not been conducted for this data. Statistics published in the reports have often been delineated by Inuit region (either Nunavut, Inuvialuit, Nunatsiavut, or Nunavik). For the summary statistics shown as follows for the present analysis, region-level coding is not available in the public use microdata file used and region-level statistics cannot be presented.

The estimated results are presented in the following sections.

5.2 Individual participation in harvesting

5.2.1 Data set-up and descriptive statistics

The Aboriginal Peoples Survey contains questions on individual participation in harvesting activities over the previous year for both the 2001 and 2006 surveys and also over the respondent's lifetime in the 2006 survey.

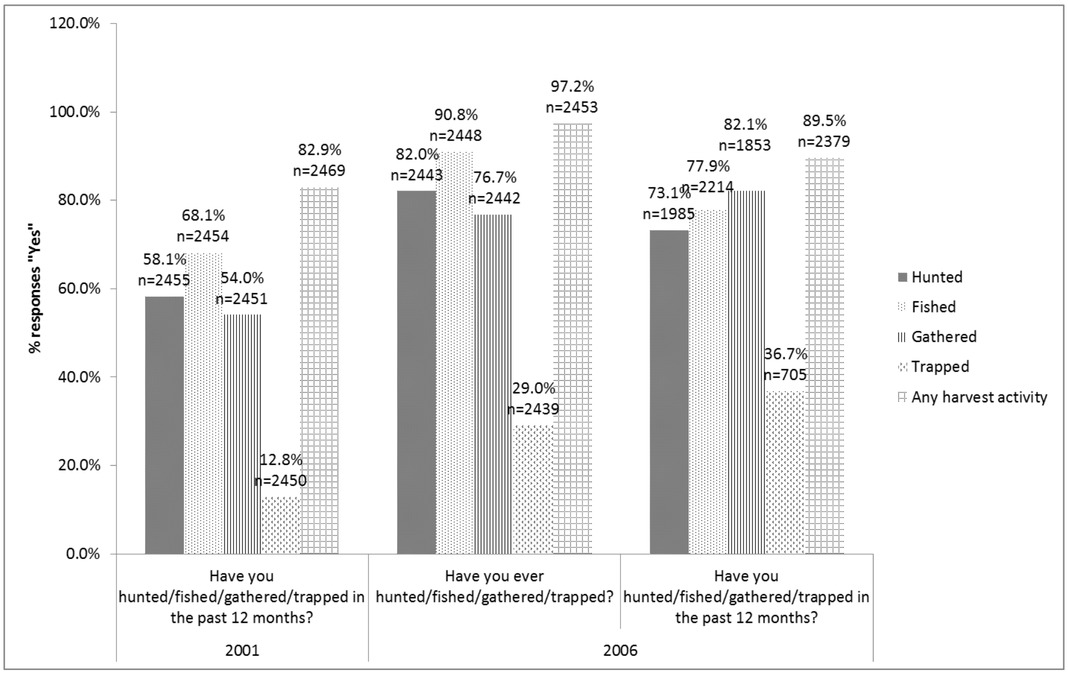

Figure 5-1 Proportion of respondents reporting hunting, fishing, gathering and trapping activity in 2001 and 2006

It was found that in the year before the 2001 survey, the most popular harvesting activity, in terms of percentage of individuals who had affirmative answers to participation (out of total valid responses), was fishing. The second most popular activity was hunting, followed by gathering and trapping.

In 2006, the questionnaire included questions asking if individuals had "ever" participated in harvesting activities. Approximately 97% of respondents reported having participated in one of the four harvest activities. After dropping missing or invalid responses from each of the respective questions on the four different harvesting activities, it was found that fishing was the most frequently conducted activity (when respondents considered whether or not they had "ever" participated in the activity), followed by hunting, gathering, and trapping. For the question about whether or not an activity was carried out in the previous year, gathering was carried out most frequently (in terms of proportion of respondents reporting having "ever" carried out the activity), followed by fishing, hunting, and trapping. While the 2006 results show that fishing and gathering were more popular than hunting in 2006, the 2001 and 2006 questions about having ever participated in activities shows that more individuals have spent time hunting than gathering over their lifetimes.

From the latest harvest survey in the Inuvialuit Settlement Region, as detailed in Chapter 2, the highest proportion of the harvest by edible weight was comprised of sea animals (mammals and fish), with sea animals being the highest harvested animals in four out of six communities. In the Baffin and Kitikmeot regions, the findings of sea animals being the highest harvested category support the results from this data, which suggest that fishing has most recently been the most popular type of harvesting activity. Overall, high levels of participation in harvesting are reported, with 82.9% of individuals harvesting in 2000 and 89.5% of respondents harvesting in 2005.

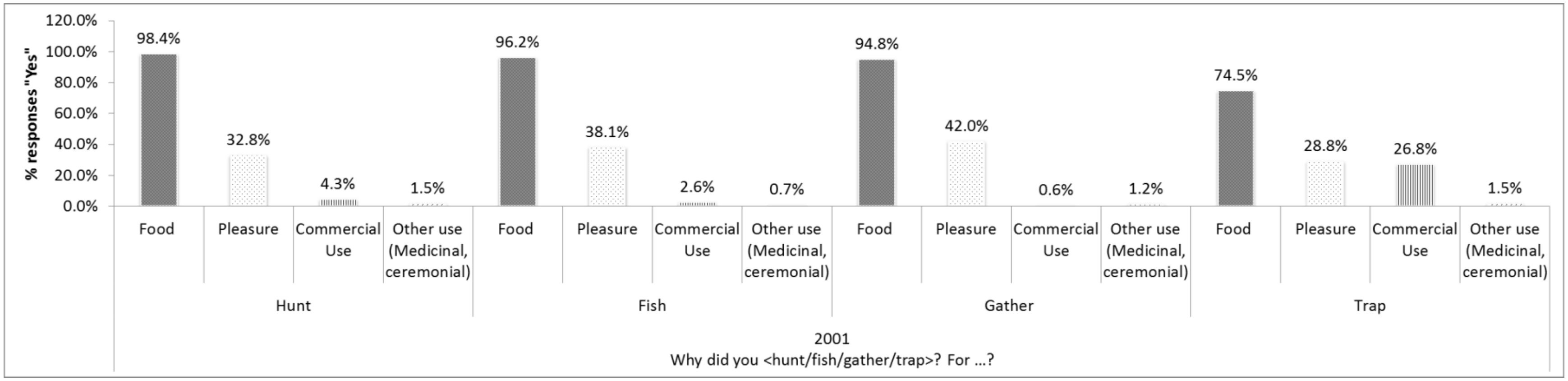

Figure 5-2 Reasons for hunting, fishing, gathering and trapping in 2001

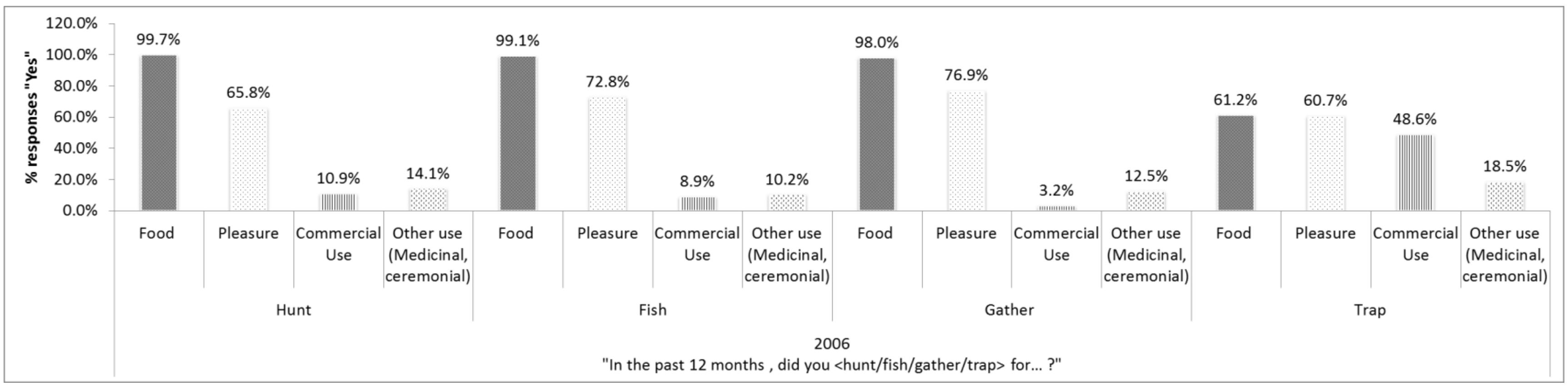

Figure 5-3 Reasons for hunting, fishing, gathering and trapping in 2006

Individuals were asked the reason for engaging in hunting, fishing, gathering and trapping in the previous year (as shown in Figure 5-2 and Figure 5-3). For all four activities in both survey periods, the highest proportion responded that they engaged in the harvesting activity for the purposes of obtaining food, followed by pleasure. A smaller proportion of respondents reported trapping for food than for the other types of harvesting activities, though more respondents trapped to obtain other products for commercial sale than was done for other activities. In both 2001 and 2006, higher proportions of respondents reported hunting for commercial use rather than fishing. In 2006, a higher proportion of respondents reported that they hunt, fish, gather, and trap for pleasure than in 2001.

Table 5-1 Cross-tabulations of variables for individual harvesting model 2001

Dependent variable	Harvested in past year (n=2393)	
Grouped – ANY HARVEST ACTIVITY IN THE PAST 12 MONTHS	Yes	No
Proportion	83%	17%
INDEPENDENT VARIABLES: INDIVIDUAL CHARACTERISTICS (NON-EMPLOYMENT)		
Age *(2001 APS variable name: AGEGRP)*		
15-19 (midpoint:17)	17%	17%
20-24 (midpoint:22)	12%	18%
25-34(midpoint:29.5)	25%	28%
35-44(midpoint:39.5)	22%	15%
45-54(midpoint:49.5)	13%	7%
55+(55)	12%	16%
Gender *(2001 APS variable name: IDQ06SEX)*		
Female	48%	61%
Male	52%	39%
Edu *(2001 APS variable name: HLOS)*		
No schooling (0 years)	8%	11%
Less than high school diploma (6 years)	54%	50%
High school diploma (12 years)	8%	8%
Some post-secondary (13 years)	13%	15%
Some university (14 years)	17%	15%
Bachelor's degree (16 years)	1%	1%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (NON-EMPLOYMENT)		
Household size *(2001 APS variable name: GNUNITS)*		
1 person	4%	6%
2 people	8%	13%
3 people	14%	15%
4 people	16%	16%
5 people	18%	17%
6 or more people	39%	33%
Household maintainer (person who pays rent or mortgage, etc.) *(2001 APS variable name: NSTIEN)*		
One household maintainer	61%	62%
More than one household maintainer	39%	38%
Number of children *(2001 APS variable name: GLFNUMB)*		
No children	40%	51%
One child	17%	16%
Two children	15%	16%

Three children	14%	9%
Four or more children	14%	9%
INDEPENDENT VARIABLES: INDIVIDUAL CHARACTERISTICS (EMPLOYMENT)		
Grouped for analysis (CG01 - "Worked for pay or in self-employment last week & CG08 - "Was this job full time?")		
Did not work last week	48%	60%
Worked part time last week	12%	10%
Worked full time last week	40%	30%
Individual total income *(2001 APS variable name: GTOTINC)*		
Less than $5 000 ($2500)	29%	33%
$5000 - $ 9999 ($7499.5)	14%	18%
$10000 - $14999 ($12499.5)	12%	14%
$15000 - $19999 ($17499.5)	8%	9%
$20000 - $29999 ($24999.5)	13%	12%
$30000 - $39999 ($34999.5)	10%	7%
$40000 or more	14%	7%

Table 5-2 Summary statistics of variables for individual harvesting model 2006

Dependent variable	Harvested in past year (n=2197)	
Grouped – ANY HARVEST ACTIVITY IN THE PAST 12 MONTHS	Yes	No
Proportion	89%	11%
INDEPENDENT VARIABLES: INDIVIDUAL CHARACTERISTICS (NON-EMPLOYMENT)		
Age *(2006 APS variable name: GDAGEYRS)*		
15-19 (midpoint:17)	18%	18%
20-24 (midpoint:22)	16%	21%
25-34(midpoint:29.5)	13%	11%
35-44(midpoint:39.5)	14%	7%
45-54(midpoint:49.5)	5%	10%
55+(55)	6%	18%
Gender *(2006 APS variable name: Q06)*		
Female	49%	58%
Male	51%	42%
Edu *(2006 APS variable name: DHLOSGP)*		
Elementary or less (3 years)	5%	12%
Some high school (10 years)	53%	59%
Completed high school (12 years)	9%	8%
Some post-secondary non-university (13 years)	11%	7%
Completed post-secondary non-university (14 years)	19%	13%
Some university (14 years)	3%	2%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (NON-EMPLOYMENT)		
Household size *(2006 APS variable name: GNUNITS)*		
1 person	4%	10%
2 people	9%	12%
3 people	13%	14%
4 people	19%	18%
5 people	19%	11%
6 or more people	36%	35%
Household maintainer (person who pays rent or mortgage, etc.) *(2006 APS variable name: GNSTIEN)*		
One household maintainer	67%	74%
More than one household maintainer	33%	26%
Number of children (GLFNUMB)		
No children	41%	58%
One child	16%	18%
Two children	16%	10%
Three children	13%	8%
Four or more children	13%	6%

INDEPENDENT VARIABLES: INDIVIDUAL CHARACTERISTICS (EMPLOYMENT)		
Grouped for analysis (CG01 - "Worked for pay or in self-employment last week & CG08 - "Was this job full time?")		
Did not work last week	47%	69%
Worked part time last week	12%	6%
Worked full time last week	41%	25%
Individual total income *(2006 APS variable name: GTOTINC)*		
Less than $5 000 ($2500)	27%	32%
$5000 - $ 9999 ($7499.5)	11%	13%
$10000 - $19999 ($14999.5)	19%	26%
$20000 - $29999 ($24999.5)	12%	13%
$30000 - $39999 ($34999.5)	9%	4%
$40 000 or more ($40000)	22%	13%

5.2.2 Estimation results

Responses for the four harvesting activities (hunting, fishing, gathering, trapping) are combined to determine participation in any harvest activities, as represented by variable $IHARVEST$. Because almost all respondents who report hunting, fishing, trapping, and gathering reported carrying out these activities for the reason of collecting food, it is assumed that individuals who are harvesting are doing so for the purposes of collecting food. For the binary dependent variable $IHARVEST$, it is assumed that respondents who respond affirmatively are harvesting for food in the estimated models.

As stated in Chapter 3, four specifications of the individual harvest model are specified. Both estimations with employment status and income in the specification suffered from multi-collinearity and were not estimable. In the specification with employment status specified as a scale variable with part-time and full-time employment, employment status was not found to be significant for both survey cycle analyses. Only the results for the specification with the binary employment status variable are shown.

From the 2001 results, age was statistically significant; increased age has a negative effect on probability of individual harvesting in two specifications (from coefficient estimates). Being male also increased the likelihood of harvesting across all specifications. An increased number of children had statistically significant and positive effects on an individual harvesting in two specifications. Being involved in any employment (*IANYWORK*) led to a statistically significant and positive impact on likelihood of harvesting. The variables in the specification are jointly significant, with the chi-squared test statistic being statistically significant at the 5% level ($p < 0.05$) for the Wald test for joint significance.

Table 5-3 Individual participation in harvesting model: 2001 Heteroskedastic probit coefficient estimates and marginal effects

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	-0.868	0.547	-1.589	0.112
Age	.0133**	0.006	2.055	0.040
Gender	.511***	0.154	3.327	0.001
Edu	.128*	0.066	1.950	0.051
HHsize	.485**	0.222	2.181	0.029
Maintain	-0.072	0.117	-0.618	0.536
Children	-.455*	0.237	-1.916	0.055
Ianywork	.323***	0.126	2.576	0.010
Wald Chi-squared (df=11) = 88.02888				
Prob > chi2 = 0.0000				
McFadden Pseudo R-squared = .0403542				
Log pseudo-likelihood = -1046.688				
n=2393				
Variance function				
Edu	.068***	0.026	2.662	0.008
HHsize	.178**	0.090	1.979	0.048
Children	-.282***	0.105	-2.700	0.007
Marginal effects				
Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	-.098**	0.048	-2.073	0.038
Age	.002**	0.001	2.352	0.019
Gender	.058***	0.014	4.207	0.000
Edu	-0.002	0.012	-0.151	0.880
HHsize	0.012	0.043	0.287	0.774
Maintain	-0.008	0.013	-0.639	0.523
Children	0.016	0.050	0.327	0.743
Ianywork	.037***	0.013	2.818	0.005
Var - Edu	-0.002	0.012	-0.151	0.880
Var - HHsize	0.012	0.043	0.287	0.774
Var - Children	0.016	0.050	0.327	0.743
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				

From 2006 estimates, it was found that increased age also has a statistically significant and negative effect on the likelihood of an individual participating in harvesting across all three specifications, as in the 2001 estimates. Male gender has a statistically significant and positive effect on likelihood of an individual harvesting, as in the 2001 estimates. The presence of more than one household "maintainer" led to an increased likelihood of harvesting, suggesting that increased household resources, in terms of monetary resources or help in harvesting or household activities, may lead to increased the likelihood of individual harvesting. An increase in the number of children in the household also increased the likelihood of harvesting, suggesting that having children in the household may affect preferences for harvesting, or that individuals with children may have increased time resources available for preparing for harvesting activities. This is a similar result as found in the 2001 analysis, where employment status has a positive effect on likelihood of individual harvesting.

Table 5-4 Individual participation in harvesting model: 2006 Heteroskedastic probit coefficient estimates and marginal effects

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	-0.076	0.541	-0.140	0.889
Age	-0.014**	0.006	-2.310	0.021
Gender	0.492***	0.157	3.144	0.002
Edu	0.060**	0.027	2.174	0.030
HHsize	0.312**	0.146	2.143	0.032
Maintain	0.277	0.170	1.634	0.102
Children	0.342***	0.101	3.370	0.001
Ianywork	0.716***	0.184	3.887	0.000
Wald Chi-squared (df=8) = 102.9508				
Prob > chi2 = 0.0000				
McFadden Pseudo R-squared = .0697535				
Log pseudo-likelihood = -687.5348				
n=2197				
Variance function				
HHsize	0.149***	0.045	3.343	0.001
Marginal effects				
Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	-0.006	0.042	-0.143	0.886
Age	-0.001**	0.001	-2.064	0.039
Gender	0.039***	0.013	3.080	0.002
Edu	0.005**	0.002	2.008	0.045
HHsize	-0.007	0.024	-0.294	0.769
Maintain	0.022*	0.013	1.666	0.096
Children	0.027***	0.007	4.069	0.000
Ianywork	0.057***	0.015	3.838	0.000
Var hhsize	-0.007	0.024	-0.294	0.769
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				

5.3 Household participation in harvesting

This section includes results from the household harvesting equation. Unlike the previous analysis, this model estimates the impacts of factors that affect the likelihood of having someone in the household harvest.

5.3.1 Data set-up and descriptive statistics

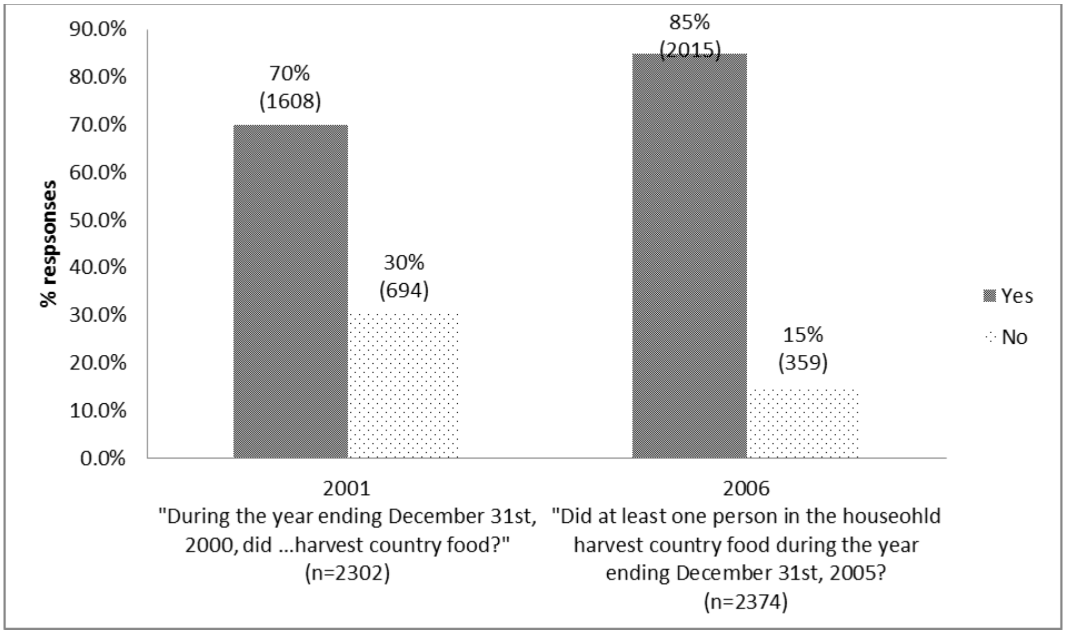

Figure 5-4 Respondents reporting household harvesting of country food (2001 & 2006)

In 2001, 70% of respondents reported that someone in his or her household harvested country food, compared to 85% in 2006. Two specifications of the household-level time allocation model were estimated to determine factors that influence the household-level decision to harvest, each with different specification of household employment status. After dropping the missing values (responses with “don’t know,” “missing”, or “valid skip”), the 2001 survey has 2264 valid responses and the 2006 sample has 2240 valid responses for all three specifications.

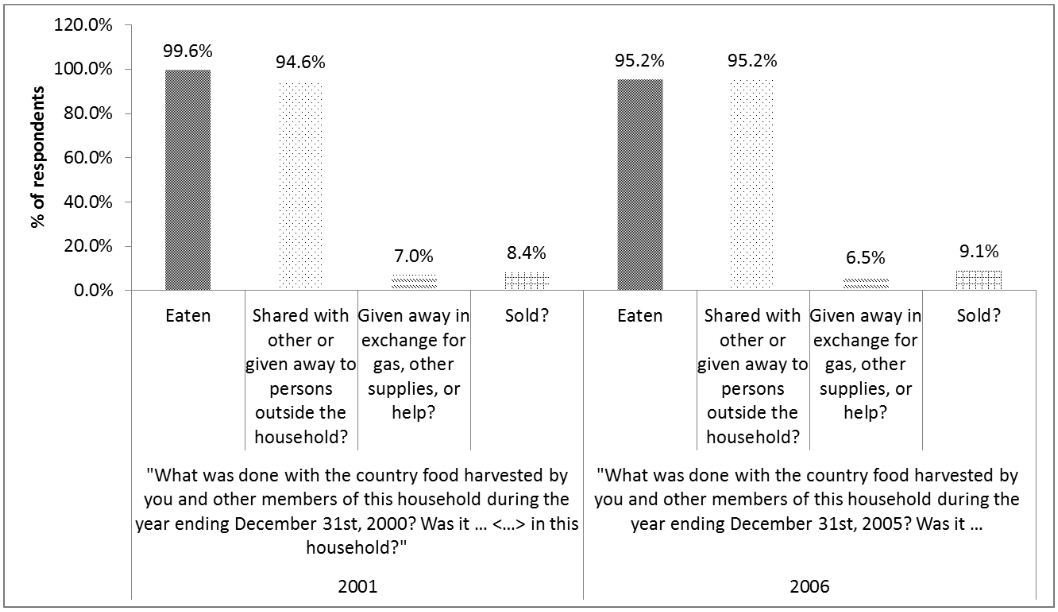

Figure 5-5 Uses of harvested country food (2001 & 2006)

For individuals that reported that at least one person in the household harvested, questions on what the harvested country food was used for were asked. For uses of country food, the category with the highest proportion was that for having eaten country food, followed by having shared country food with others, having sold country food, and having given away country in exchange for other resources.

Table 5-5 Summary statistics of variables for household harvesting model 2001

Dependent variable	At least one person in household harvested in past year (n=2287)	
Did at least one person harvest country food during the year ending <…>? *(A_IG08H)*	Yes	No
	70%	30%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (NON-EMPLOYMENT)		
Household size *(GNUNITS)*		
1 person	4%	6%
2 people	8%	11%
3 people	14%	17%
4 people	16%	17%
5 people	19%	16%
6 or more people	39%	32%
Household maintainer (person who pays rent or mortgage, etc.)(NSTIEN)		
One household maintainer	62%	61%
More than one household maintainer	38%	39%

Number of children (LFNUMBER)		
No children	37%	48%
One child	17%	17%
Two children	16%	16%
Three children	15%	10%
Four or more children	15%	10%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (EMPLOYMENT)		
Household employment status		
No one in the household worked	29%	39%
At least one person in the household worked full-time (A_IG01H)	21%	20%
*At least one person in household worked part-time **or** received income from self-employment (A_IG01H, A_IG02H & A_IG04H)*	w50%	41%
Household total income (HHINCC)		
Less than $10,000 ($5000)	4%	8%
$10000 - $19999 ($14999.5)	10%	15%
$20000 - $29999 ($24999.5)	12%	10%
$30000 -$39999 ($34999.5)	13%	12%
$40000-$59999 ($49999.5)	22%	18%
$60000-$79999 ($69999.5)	16%	14%
$80000 or more ($80000)	23%	22%

Table 5-6 Summary statistics of variables for household harvesting model 2006

Dependent variable	At least one person in household harvested in past year (n=2309)	
Did at least one person harvest country food during the year ending <…>? *(A_IG08H)*	Yes	No
	85%	15%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (NON-EMPLOYMENT)		
Household size *(GNUNITS)*		
1 person	3%	11%
2 people	7%	16%
3 people	12%	18%
4 people	19%	19%
5 people	19%	13%
6 or more people	39%	23%
Household maintainer (person who pays rent or mortgage, etc.)(GNSTIEN)		
One household maintainer	67%	75%
More than one household maintainer	33%	25%
Number of children (GLFNUMB)		
No children	42%	54%
One child	16%	17%
Two children	16%	14%
Three children	14%	6%
Four or more children	13%	9%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (EMPLOYMENT)		
Household employment status		
No one in the household worked	9%	20%
At least one person in the household worked full-time (A_IG01H)	14%	15%
*At least one person in household worked part-time **or** received income from self-employment (A_IG01H, A_IG02H & A_IG04H)*	77%	65%

Household total income (GHHINC)		
Less than $20,000 ($10000)	9%	18%
$20000 - $39999 ($29999.5)	19%	25%
$40000 -$59999 ($49999.5)	19%	17%
$60000-$79999 ($69999.5)	16%	12%
$80000-$99999 ($89999.5)	13%	9%
$100000 or more ($100000)	25%	19%

5.3.2 Estimation results

As stated in Chapter 3, four specifications of the household harvest model are specified. As in the case of the individual harvest models, estimations with employment status and income in the specification suffered from multi-collinearity and were not estimable. Employment status, when specified as a scale variable, was not found to be significant for both survey cycle analyses. Only the results for the specification with the binary employment status variable are included as follows.

From the 2001 results for household participation in harvesting, it was found that household size has a positive and statistically significant influence on likelihood of having someone in the household harvest, across the three specifications. The presence of children also has a statistically significant and positive effect. Involvement in employment also has a positive effect in the first two specifications. Household participation in employment is found to have a statistically significant effect on harvesting. This suggests that even with increased time spent in employment, households may still prefer to spend some time in harvesting.

Table 5-7 Household participation in harvesting model: 2001 Probit coefficient estimates

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	0.133***	0.029	4.604	0.000
hhsize	0.031***	0.008	3.857	0.000
maintain	-0.012	0.009	-1.357	0.175
children	-0.058***	0.008	-7.163	0.000
hhempany	0.032*	0.018	1.835	0.067
Wald Chi-squared (df=5) = 64.47355				
Prob > chi2 = 0.00000				
McFadden Pseudo R-squared = 0.0241101				
Log pseudo-likelihood = -1365.541				
n= 2287				
Variance function				
children	-0.563***	0.090	-6.260	0.000
Marginal effects				
Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	0.176***	0.034	5.227	0.000
hhsize	0.041***	0.009	4.661	0.000
maintain	-0.016	0.011	-1.480	0.139
Children	0.034*	0.053	0.647	0.518
hhempany	0.043**	0.018	2.407	0.016
Var - children	0.034	0.053	0.647	0.518
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				

From the 2006 results, it is found that household size is statistically significant and that increased household size leads to higher likelihood of the household participation in harvesting activity, as in the 2001 results. As in the 2001 estimation results, participation employment (indicated by *HHEMPANY)* has a positive effect on household harvesting. For employed individuals, an increase in income may lead to a net positive effect on harvesting. This suggests that with increased household resources, the household will choose to devote more time into harvesting, and the production ability of the household is such that it can put time into harvesting country food and increase utility, even if the household may be increasing consumption of other types of goods.

Table 5-8 Household participation in harvesting model: 2006 Probit coefficient estimates

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	0.214***	0.075	2.840	0.005
hhsize	0.140***	0.017	8.140	0.000
maintain	0.065**	0.033	1.976	0.048
mhildren	-0.244***	0.017	-13.956	0.000
hhempany	0.157***	0.055	2.860	0.004
Wald Chi-squared (df=5) = 122.1638				
Prob > chi2 = 0.0000				
McFadden Pseudo R-squared = .0620451				
Log pseudo-likelihood = -923.3937				
n=2309				
Variance function				
Children	-0.435***	0.063	-6.930	0.000
Marginal effects				
Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	0.073***	0.027	2.675	0.008
hhsize	0.048***	0.006	8.198	0.000
maintain	0.022**	0.011	2.046	0.041
children	0.018	0.017	1.054	0.292
hhempany	0.054***	0.017	3.216	0.001
Var - children	0.018	0.017	1.054	0.292
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				

5.4 Household proportion of country meat and fish consumed

5.4.1 Data set-up and descriptive statistics

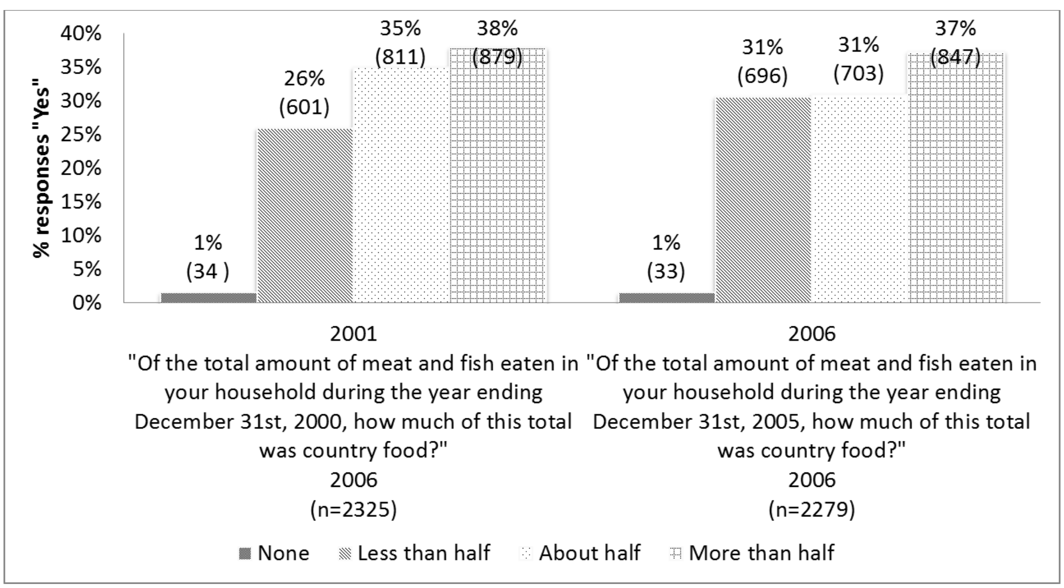

Figure 5-6 Proportion of meat and fish consumed that is country food in 2001 and 2006

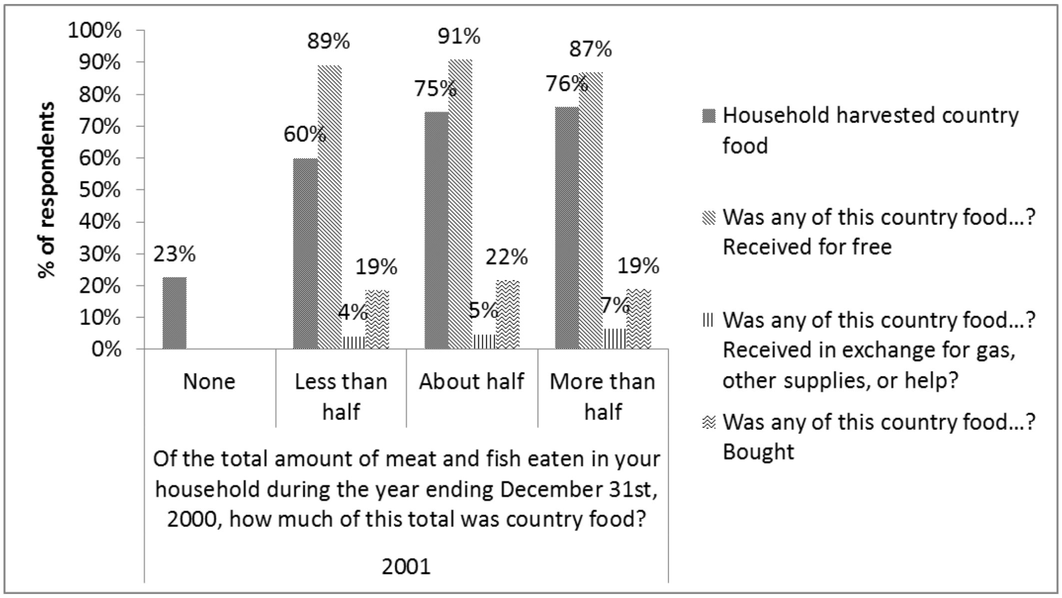

Figure 5-7 Sources of meat and fish consumed (harvested, received for free, received in exchange for other goods, bought) (2001)

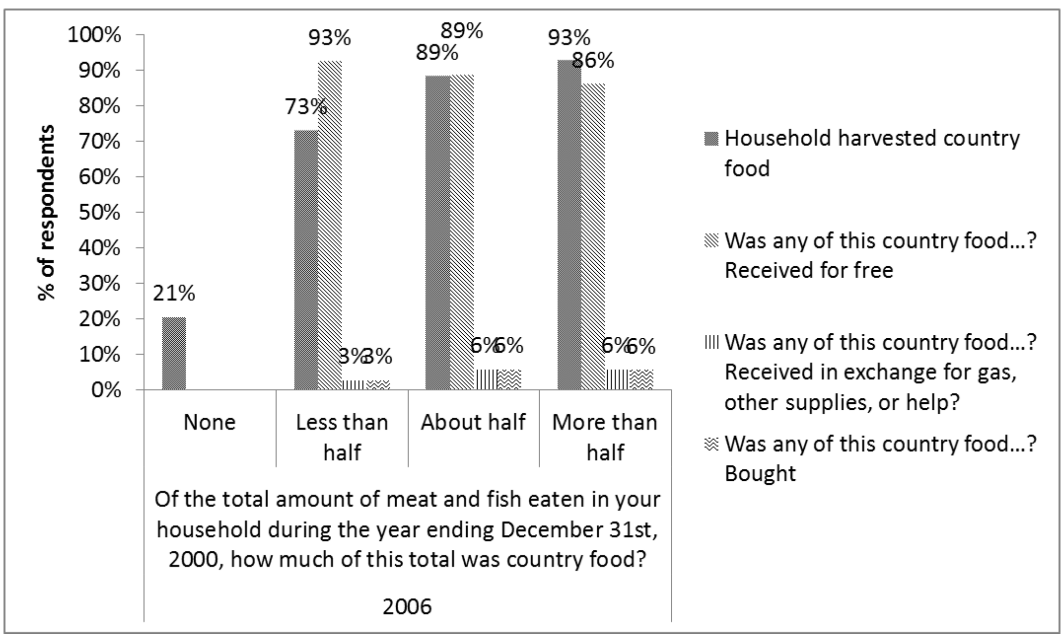

Figure 5-8 Sources of meat and fish consumed (harvested, received for free, received in exchange for other goods, bought) (2006)

Factors affecting the final amount of country food consumed by the household may be examined. For the 2001 data, Tait (2006) shows that 33 percent of individuals report that "about half" of their meat and fish consumption comes from country food, and 38% report "more than half," while proportions of individuals consuming "none" and "less than half" are not reported. For the 2006 data, Tait (2008a) reports that for the respective consumption categories—"none," "less than half" "about half," and "more than half"—the proportion of individuals in each category are 1%, 27%, 29%, and 37%. Discrepancies between the proportions shown in this summary and in published reports (as described in Chapter 2) may be due to different weighing techniques (the application of public use micro data file weights and confidential bootstrap weights in government analysis or presence of rounding in the public file). For both survey cycles, the highest proportion of respondents are in the "more than half" category—the majority of individuals reported their proportions of country meat and fish consumed, out of total meat and fish consumed, to be "more than half."

Table 5-9 Summary statistics of variables for meat and fish consumption model – all consumers 2001

Dependent variable	At least one person in household harvested in past year (n=2196)			
	None	Less than half	About half	More than half
Did at least one person harvest country food during the year ending <…>? *(A_IG08H)*	1%	26%	34%	38%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (NON-EMPLOYMENT)				
Household size *(GNUNITS)*				
1 person	12%	6%	3%	4%
2 people	16%	13%	8%	7%
3 people	31%	19%	12%	14%
4 people	12%	15%	19%	16%
5 people	12%	21%	18%	17%
6 or more people	17%	26%	39%	42%
Household maintainer (person who pays rent or mortgage, etc.) (NSTIEN)				
One household maintainer	62%	56%	63%	64%
More than one household maintainer	38%	44%	37%	36%
Number of children **(*LFNUMBER*)**				
No children	53%	39%	40%	40%
One child	11%	21%	16%	17%
Two children	24%	15%	17%	15%
Three children	6%	15%	13%	14%
Four or more children	6%	11%	14%	15%
INDEPENDENT VARIABLES: INDIVIDUAL CHARACTERISTICS (EMPLOYMENT)				
No one in the household worked (I01G30_P)	41%	26%	33%	35%
At least one person in the household worked full-time (I01G30_P, I02L30P, I04SEL_P)	24%	18%	21%	21%
At least one person in household worked part-time ***or*** *received income from self-employment (I01G30_P, I02L30P, I04SEL_P)*	35%	56%	47%	44%
Household total income *(2001 APS variable name: HHINCC)*				
Less than $10,000 ($5000)	14%	7%	4%	5%
$10000 - $19999 ($14999.5)	15%	13%	10%	11%
$20000 - $29999 ($24999.5)	12%	11%	12%	13%
$30000 -$39999 ($34999.5)	3%	11%	13%	15%
$40000-$59999 ($49999.5)	18%	19%	22%	22%
$60000-$79999 ($69999.5)	16%	17%	15%	14%
$80000 or more ($80000)	23%	23%	24%	21%
HARVESTING (2001 APS variable: *I08GAT_P*)				
Did you or anyone in your household harvest country food in the past year? (I08GAT_P)				
No	77%	40%	25%	24%
Yes	23%	60%	75%	76%

Table 5-10 Summary statistics of variables for meat and fish consumption model – all consumers 2006

Dependent variable	At least one person in household harvested in past year (n=2186)			
	None	Less than half	About half	More than half

Did at least one person harvest country food during the year ending <…>? *(A_IG08H)*	1%	30%	31%	37%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (NON-EMPLOYMENT)				
Household size *(GNUNITS)*				
1 person	13%	6%	4%	3%
2 people	40%	12%	7%	7%
3 people	10%	17%	13%	11%
4 people	15%	21%	21%	18%
5 people	3%	17%	17%	19%
6 or more people	19%	27%	39%	42%
Household maintainer (person who pays rent or mortgage, etc.)(GNSTIEN)				
One household maintainer	78%	68%	66%	69%
More than one household maintainer	22%	32%	34%	31%
Number of children (GLFNUMB)				
No children	63%	45%	45%	41%
One child	16%	17%	14%	17%
Two children	9%	17%	16%	14%
Three children	6%	11%	12%	14%
Four or more children	6%	10%	12%	14%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (EMPLOYMENT)				
No one in the household worked	25%	10%	9%	12%
At least one person in household worked part-time ***or*** *received income from self-employment (A_IG01H, A_IG02H & A_IG04H)*	10%	12%	13%	18%
At least one person in the household worked full-time (A_IG01H)	65%	78%	79%	71%
Household employment (GEMPIN)				
Less than $20,000 ($10000)	9%	12%	10%	9%
$20000 - $39999 ($29999.5)	35%	19%	20%	21%
$40000 -$59999 ($49999.5)	12%	17%	17%	21%
$60000-$79999 ($69999.5)	12%	15%	16%	14%
$80000-$99999 ($89999.5)	22%	10%	11%	14%
$100000 or more ($100000)	10%	27%	27%	21%
HARVESTING				
Did you or anyone in your household harvest country food in the past year?(A_IG08H)				
No	77%	27%	11%	7%
Yes	23%	73%	89%	93%

Table 5-11 Summary statistics of variables for meat and fish consumption model – positive consumers 2001

Dependent variable	At least one person in household harvested in past year (n=2141)		
	Less than half	About half	More than half
Did at least one person harvest country food during the year ending <…>? *(A_IG08H)*	26%	35%	39%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (NON-EMPLOYMENT)			
Household size (GNUNITS)			
1 person	5%	4%	4%
2 people	13%	8%	7%
3 people	19%	12%	14%

4 people	15%	19%	16%
5 people	21%	18%	17%
6 or more people	26%	40%	42%
Household maintainer (person who pays rent or mortgage, etc.) (NSTIEN)			
One household maintainer	56%	63%	65%
More than one household maintainer	44%	37%	35%
Number of children (LFNUMBER)			
No children	39%	40%	40%
One child	21%	16%	16%
Two children	15%	17%	15%
Three children	15%	13%	14%
Four or more children	11%	14%	15%
INDEPENDENT VARIABLES: INDIVIDUAL CHARACTERISTICS (EMPLOYMENT)			
No one in the household worked (I01G30_P)	26%	32%	35%
At least one person in the household worked full-time (I01G30_P, I02L30P, I04SEL_P)	18%	21%	21%
At least one person in household worked part-time **or** *received income from self-employment (I01G30_P, I02L30P, I04SEL_P)*	56%	47%	44%
Household total income *(2001 APS variable name: HHINCC)*			
Less than $10,000 ($5000)	7%	4%	5%
$10000 - $19999 ($14999.5)	13%	10%	11%
$20000 - $29999 ($24999.5)	11%	11%	13%
$30000 -$39999 ($34999.5)	11%	13%	15%
$40000-$59999 ($49999.5)	19%	22%	22%
$60000-$79999 ($69999.5)	17%	15%	14%
$80000 or more ($80000)	23%	25%	21%
Source of meat and fish consumed			
Was any of this country food...received for free (including from other people, from a local hunter and trappers organisation, municipal freezer, or other)? (I12FREE)			
No	11%	9%	13%
Yes	89%	91%	87%
Was any of this country food...received in exchange for gas, supplies or other help? (I12XCHG)			
No	96%	95%	93%
Yes	4%	5%	7%
Was any of this country food... bought?(I12BGHT)			
No	82%	78%	81%
Yes	18%	22%	19%
HARVESTING (2001 APS variable: *I08GAT_P*)			
Did you or anyone in your household harvest country food in the past year?(I08GAT_P)			
No	39%	25%	24%
Yes	61%	75%	76%

Table 5-12 Summary statistics of variables for meat and fish consumption model – positive consumers 2006

Dependent variable	At least one person in household harvested in past year (n=2125)		
Did at least one person harvest country food during the year ending <…>? *(A_IG08H)*	Less than half	About half	More than half
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (NON-EMPLOYMENT)			
Household size *(GNUNITS)*			
1 person	6%	4%	3%
2 people	12%	7%	7%

3 people	17%	13%	11%
4 people	21%	21%	18%
5 people	17%	17%	19%
6 or more people	27%	39%	42%
Household maintainer (person who pays rent or mortgage, etc.)(GNSTIEN)			
One household maintainer	68%	67%	69%
More than one household maintainer	32%	33%	31%
Number of children (GLFNUMB)			
No children	44%	45%	40%
One child	18%	14%	17%
Two children	16%	16%	14%
Three children	12%	12%	14%
Four or more children	10%	12%	14%
INDEPENDENT VARIABLES: HOUSEHOLD CHARACTERISTICS (EMPLOYMENT)			
No one in the household worked	10%	9%	12%
At least one person in the household worked full-time (A_IG01H)	12%	13%	18%
At least one person in household worked part-time ***or*** *received income from self-employment (A_IG01H, A_IG02H & A_IG04H)*	77%	79%	71%
Individual employment income (GEMPIN)			
Less than $20,000 ($10000)	12%	10%	9%
$20000 - $39999 ($29999.5)	19%	20%	21%
$40000 -$59999 ($49999.5)	1%	1%	1%
$60000-$79999 ($69999.5)	31%	32%	34%
$80000-$99999 ($89999.5)	10%	11%	14%
$100000 or more ($100000)	27%	27%	21%
Source of meat and fish consumed			
Was any of this country food...received for free (including from other people, from a local hunter and trappers organisation, municipal freezer, or other)? (A_IG12A)			
Yes	93%	89%	86%
No	7%	11%	14%
Was any of this country food...received in exchange for gas, supplies or other help? (A_IG12B)			
Yes	3%	6%	6%
No	97%	94%	94%
Was any of this country food... bought?(A_IG12C)			
Yes	36%	35%	35%
No	64%	65%	65%

5.4.2 Estimation results

As stated in Chapter 3, four specifications of the meat and fish consumption model are estimated. Two versions for the equation are estimated, one with all respondents included, and one with only positive respondents included. For the 2001 survey cycle, household income was not found to be statistically significant in the version with all consumers. In the 2001 survey cycle model with positive consumers, and the 2006 survey cycle model with all consumers and positive consumers, the results from the equations with only employment status included, and with both employment status and household income included, are shown. Since coefficient estimates from the specifications with the binary household employment variable $HHEMPANY$ and the ordinal household employment variable $HHEMPSC$ (where the household may be categorized as either being unemployed, or participating in part-time or full-time employment) had the same sign, only estimations with the ordinal variable $HHEMPSC$ are shown.

Tables 5-13, 5-14, and 5-15 show the results from the estimations with all respondents, both positive consumers and non-positive consumers, from 2001 and 2006. For the 2006 survey cycle, results with two specifications (one with employment status only, and one with employment status and income), are shown. It was found from all three specifications that household size had statistically significant coefficient estimate. The marginal effects for household size show a negative impact of increased household size on the likelihood of being in the lowest three consumption categories ("none," "less than half, "about half"), and a positive impact on the likelihood being in the high consumption category ("more than half"). In the 2001 estimate (shown in Table 5-13), the coefficient for having more than one household maintainer (earner) is statistically significant. The marginal effects show that having more than one maintainer leads to a decreased likelihood of being in the highest consumption category, but an increased likelihood of being in the lowest three. In the 2001 and 2006 specifications with employment status included and income excluded, employment status has a statistically significant coefficient. The marginal effects show that having higher employment participation leads to a decreased likelihood of being in the highest consumption category, but an increased likelihood of being in the lowest three.

As explained previously in section 3.2.2, when income and employment status are both included in the specification, the theoretical assumption is that the impacts of income from employment are reflected in the income variable, while employment status is included in a demand equation as a taste variable. When income and employment status are included in the specification for the 2006 sample for all respondents, the coefficient estimate for household income is statistically significant and negative, although signs from the marginal effects are not derived from the estimation.

Table 5-13 Meat and fish consumption model – all consumers: 2001 Ordered Probit coefficient estimates and marginal effects

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	1.501***	0.075	19.982	0.000
hhsize	0.071***	0.015	4.876	0.000
maintain	-0.115***	0.038	-3.045	0.002
children	-0.012	0.014	-0.843	0.399
hhempsc	-0.080***	0.022	-3.564	0.000
hharvest	0.312***	0.042	7.423	0.000
Wald Chi-squared (df=6) = 101.0760				
Prob > chi2 = 0.0000				
McFadden Pseudo R-squared = 0.0201674				
Log pseudo-likelihood = -2455.387				
n=2196				
Variance function				
hhsize	-0.047***	0.010	-4.784	0.000
Marginal effects				
Parameter	y= None	y= Less than half	y= About half	y= More than half
Constant	-0.051	-0.561	-0.093	0.704
hhsize	-0.002	-0.026	-0.004	0.033
maintain	0.004	0.043	0.007	-0.054
children	0.000	0.004	0.001	-0.005
hhempsc	0.003	0.030	0.005	-0.038
hharves	-0.010	-0.116	-0.019	0.146
Var - hhsize	0.095	0.211	-0.485	0.179
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				

Table 5-14 Meat and fish consumption model: 2006 Ordered Probit coefficient estimates – all consumers and marginal effects, with employment status

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	1.313***	0.077	16.949	0.000
hhsize	0.082***	0.014	5.971	0.000
maintain	-0.046	0.034	-1.357	0.175
children	0.002	0.012	0.154	0.877
hhempsc	-0.131***	0.029	-4.540	0.000
hhinc	0.683***	0.051	13.452	0.000
hharves	1.313***	0.077	16.949	0.000
Wald Chi-squared (df=6) =214.9659				
Prob > chi2 =0.0000				
McFadden Pseudo R-squared = 0.04427546				
Log pseudo-likelihood = -2406.469				
n=2186				
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				
Variance function				
hhsize	-0.042	0.008	-5.349	0.000
Parameter	y= None	y= Less than half	y= About half	y= More than half
Constant	-0.031	-0.527	-0.034	0.593
hhsize	-0.002	-0.033	-0.002	0.037
maintain	0.001	0.019	0.001	-0.021
children	0.000	-0.001	0.000	0.001
hhempsc	0.003	0.052	0.003	-0.059
hharvest	-0.016	-0.274	-0.018	0.309
Var - hhsize	0.064	0.166	-0.404	0.175
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				

Table 5-15 Meat and fish consumption model: 2006 Ordered Probit coefficient estimates – all consumers and marginal effects, with employment status and income

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	1.431	0.084	17.042	0.000
hhsize	0.0107***	0.015	6.912	0.000
maintain	-0.040	0.038	-1.062	0.288
children	-0.001	0.014	-0.080	0.936
hhempsc	-0.119***	0.034	-3.510	0.000
hhinc	-0.0200E-05***	0.652E-06	-3.063	0.002
hharves	0.0763***	0.054	14.058	0.000
Wald Chi-squared (df=7) =215.5107				
Prob > chi2 =0.0000				
McFadden Pseudo R-squared = 0.0428629				
Log pseudo-likelihood = -2406.196				
n=2186				
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				
Variance function				
hhinc	-0.130E-05**	0.0523E-06	-2.486	0.013
Parameter	y= None	y= Less than half	y= About half	y= More than half
Constant	-0.034	-0.510	-0.038	0.583
hhsize	-0.003	-0.038	-0.003	0.043
maintain	0.095E-02	0.014	0.001	-0.016

children	0.030E-03	0.041E-03	0.030E-03	-0.046E-03
hhempsc	0.003	0.042	0.003	-0.048
hhinc	0.000	0.000	0.000	0.000
hharvest	-0.018	-0.272	-0.020	0.0311
Var - hhinc	0.075	0.179	-0.441	0.186
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				

Tables 5-16, 5-17, 5-18, and 5-19 show the results from the estimations with only positive consumers, or those who reported consumption of country meat and fish in categories other than "none." Tables 5-16 and 5-17 show the results from the 2001 and 2006 estimations with employment status included, while Tables 5-18 and 5-19 show the results from the 2001 and 2006 estimations with employment status and income included.

From all four specifications, increased household size and having more than one household maintainer had statistically significant coefficient estimates and the same signs for marginal effects. The marginal effects indicated a negative impact of increased household size on the likelihood of being in the lower two consumption categories ("less than half, "about half"), and a positive impact of being in the high consumption category ("more than half") category. The marginal effects estimates also indicated that having more than one household maintainer increases the likelihood of being in the in the lower two consumption categories ("less than half, "about half"), and decreases the likelihood of being in the high consumption category ("more than half").

For three out of the four specifications (the 2001 specification with the employment status variable only, the 2006 specification with the employment status variable only, and the 2006 specification with the employment status variable and income), the variables for harvest participation and having received country food for free had statistically significant coefficient estimates and the same signs on marginal effects. Harvest participation was found to lead to decreased likelihood of being in the lower two consumption categories, and an increased likelihood of being in the highest consumption category ("more than half"). Having received country food for free was found to lead to increased likelihood of being in the lower two consumption categories, and a decreased likelihood of being in the highest consumption category ("more than half"). Participating in harvesting was found to lead to decreased likelihood of being in the lower two consumption categories, and an increased likelihood of being in the highest consumption category ("more than half"). Having received country food for free was found to lead to increased likelihood of being in the lower two consumption categories, and a decreased likelihood of being in the highest consumption category ("more than half"). In the 2001 specification with employment rate and income, the coefficient estimates for these two variables are statistically significant, while the marginal effects have opposite signs from those found from the other three model estimations.

Having received country meat and fish in exchange for goods and supplies was found to lead to decreased likelihood of being in the lower two consumption categories, and an increased likelihood of being in the highest consumption category ("more than half") in the two model estimates with employment rate only (shown in Tables 5-16 and 5-18) and also in the 2006 model estimate with employment rate and income included (shown in Table 5-19). In the 2001 specification with employment rate and income, the coefficient estimate for this variable is statistically significant, though the marginal effects have opposite signs.

From the estimations with employment rate only (shown in Tables 5-16 and 5-18), the variables for household employment status had the same significant coefficients and signs on the marginal effects across the survey cycles. Increased employment participation was found to lead to increased likelihood of being in the lower two consumption categories, and a decreased likelihood of being in the highest consumption category ("more than half").

From the estimations with employment rate and income included (shown in Tables 5-17 and 5-19), the variable for household employment status $HHEMPSC$ also has the same sign, though it has been noted that in this specification where income is also included, this variable represents the tastes and preferences associated with being in employment, rather than the impacts of changes in income resulting from employment. Household income has a statistically significant and positive coefficient on proportion of country meat and fish consumed the marginal effects are shown to be zero and the signs not ascertained from the estimates.

Table 5-16 Meat and fish consumption model – positive consumers: 2001 Ordered Probit coefficient estimates and marginal effects, with employment status

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	0.298***	0.085	3.499	0.001
hhsize	0.065***	0.015	4.444	0.000
maintain	-0.126***	0.037	-3.399	0.001
children	-0.012	0.013	-0.905	0.365
hhempsc	-0.089***	0.022	-3.953	0.000
hharves	0.235***	0.042	5.616	0.000
free	-0.102*	0.054	-1.883	0.060
xchg	0.146**	0.074	1.974	0.048
bought	-0.027	0.043	-0.622	0.534
Wald Chi-squared (df=9) = 93.18946				
Prob > chi2 = 0.0000				
McFadden Pseudo R-squared = 0.0201200				
Log pseudo-likelihood = -2267.774				
n= 2141				
Variance function				
hhsize	-0.063***	0.018	-3.431	0.001
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				
Parameter	y= Less than half	y= About half	y= More than half	
Constant	-0.128	-0.023	0.151	
hhsize	-0.028	-0.005	0.033	
maintain	0.054	0.010	-0.064	
children	0.005	0.001	-0.006	
hhempsc	0.038	0.007	-0.045	
hharves	-0.101	-0.019	0.119	
free	0.044	0.008	-0.052	
xchg	-0.062	-0.011	0.074	
bought	0.012	0.002	-0.014	
Var - hhsize	0.063	-0.097	0.034	

Table 5-17 Meat and fish consumption model – positive consumers: 2001 Ordered Probit coefficient estimates and marginal effects, with employment status and income

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	0.318***	0.087	3.656	0.000
hhsize	0.076***	0.016	4.744	0.000
maintain	-0.116***	0.037	-3.111	0.002
children	-0.016	0.013	-1.226	0.220
hhempsc	-0.079***	0.023	-3.456	0.001
hhinc	1.505E-06*	8.157E-07	-1.845	0.065
hharves	0.238***	0.042	5.662	0.000
free	-0.106*	0.054	-1.951	0.051

xchg	0.144*	0.074	1.940	0.052
bought	-0.020	0.043	-0.456	0.648
Wald Chi-squared (df=10) = 96.13388				
Prob > chi2 = 0.0000				
McFadden Pseudo R-squared = 0.0208				
Log pseudo-likelihood = -2267.774				
n= 2141				
Variance function				
hhsize	-0.063***	0.018	-3.432	0.001
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				
Parameter	y= Less than half	y= About half	y= More than half	
Constant	-0.136	-0.025	0.161	
hhsize	-0.032	-0.006	0.038	
maintain	0.050	0.009	-0.059	
children	0.007	0.001	-0.008	
hhempsc	0.034	0.006	-0.040	
hhinc	0.000	0.000	0.000	
hharves	0.045	0.008	-0.054	
free	-0.061	-0.011	0.073	
xchg	0.008	0.002	-0.010	
bought	-0.102	-0.019	0.120	
Var - hhsize	0.067	-0.103	0.036	

Table 5-18 Meat and fish consumption model – positive consumers: 2006 Ordered Probit coefficient estimates and marginal effects, with employment status

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	0.040	0.094	0.423	0.672
hhsize	0.072***	0.013	5.507	0.000
maintain	-0.067**	0.031	-2.204	0.028
children	0.001	0.010	0.072	0.943
hhempsc	-0.128***	0.028	-4.522	0.000
hharves	0.535***	0.056	9.609	0.000
free	-0.236***	0.058	-4.084	0.000
xchg	0.234**	0.097	2.417	0.016
bought	-0.038	0.049	-0.770	0.442
Wald Chi-squared (df=9) = 183.7442				
Prob > chi2 = 0.000				
McFadden Pseudo R-squared = 0.0395800				
Log pseudo-likelihood = -2229.303				
n= 2125				
Variance function				
hhsize	-0.068***	0.015	-4.702	0.000
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				
Parameter	y= Less than half	y= About half	y= More than half	
Constant	-0.019	-0.002	0.020	
hhsize	-0.034	-0.003	0.037	
maintain	0.032	0.003	-0.034	
children	0.000	0.000	0.000	
hhempsc	0.060	0.005	-0.065	
hharves	-0.251	-0.022	0.273	
free	0.111	0.010	-0.120	
xchg	-0.110	-0.010	0.120	

bought	0.018	0.002	-0.019	
Var - hhsize	0.007	-0.012	0.005	

Table 5-19 Meat and fish consumption model – positive consumers: 2006 Ordered Probit coefficient estimates and marginal effects, with employment status and income

Parameter	Estimate	Standard Error	z-statistic	p-value
Constant	0.102	0.110	0.930	0.353
hhsize	0.099***	0.016	6.166	0.000
maintain	-0.071*	0.037	-1.899	0.058
children	-0.002	0.014	-0.132	0.895
hhempsc	-0.131***	0.036	-3.644	0.000
hhinc	1.850E-06***	6.481E-07	-2.855	0.004
hharves	0.640***	0.064	9.997	0.000
free	-0.293***	0.069	-4.220	0.000
xchg	0.283**	0.117	2.425	0.015
bought	-0.051	0.058	-0.872	0.383
Wald Chi-squared (df=10) = 181.4181				
Prob > chi2 = 0.000				
McFadden Pseudo R-squared = 0.0390789				
Log pseudo-likelihood = -2230.466				
n= 2125				
Variance function				
hhinc	1.811E-06**	8.561E-07	-2.115	0.034
***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively				
Parameter	y= Less than half	y= About half	y= More than half	
Constant	-0.039	-0.004	0.043	
hhsize	-0.038	-0.004	0.042	
maintain	0.027	0.003	-0.030	
children	0.001	0.000	-0.001	
hhempsc	0.050	0.005	-0.055	
hhinc	0.000	0.000	0.000	
hharves	-0.246	-0.025	0.271	
free	0.112	0.012	-0.124	
xchg	-0.109	-0.011	0.120	
bought	0.019	0.002	-0.021	
Var - hhinc	0.019	-0.032	0.013	

5.5 Summary

The estimated equations on individual and household participation in harvesting, as well as proportion of meat and fish consumed, show that individual and household level variables have statistically significant impacts on participation in harvesting. Participation in employment leads to increases in likelihood of individual harvesting, while males are more likely to harvest. At the household level, participation in employment also leads to increased likelihood of having someone in the household participate in harvesting.

Participation in harvesting was shown by marginal effects estimates to lead to an increased likelihood of being in the highest-level consumption category for the majority of the ordered Probit models estimated, suggesting that household harvesting is an important source of country meat and fish for the household.

As highlighted in section 2.7.2.2, household participation in employment and community-level development of wage opportunities have reportedly had varied effects on harvest participation. As explained, there is evidence from some communities that employment leads to increased individual time spent in harvesting, while it has also been reported that those involved in employment are restricted by work schedules from spending time harvesting (Condon, Collings and Wenzel 1995, Todd 2010). The ordered probit model estimates show that spending more time spent in employment, as measured by an ordinal variable where households are categorized as non-employed, employed in a part-time job, or employed in a full-time job, has differential effects on final proportion of country meat and fish (out of total meat and fish) consumed. It was found that individuals who worked more were less likely to be in the category with proportion consumption being "more than half."

Although Probit equations for individual and household harvest participation show that employment has a positive impact on participation, these equations do not capture the impacts of employment on frequency of harvesting participation. With an increased amount of time spent work, it is possible that the households face constraints with respect to spending time on the land. Berman and Kofinas (2004) found that full-time employees were more likely than unemployed or part-time employees to go hunting once a season, but were less likely to hunt more often. The results from the Ordered Probit models with the employment status variable included (and total income excluded) suggest that households may face time constraints at high levels of employment. Although households that spend a significant amount of time in employment earn income with which to purchase harvesting equipment, they are less likely to be the highest consumers of country fish. This suggests that income effects may be outweighed by time limitations.

It is noted that in the demand estimation analysis in the previous chapter, the Working-Leser opportunity cost model results show that increased community employment rates may lead to decreased expenditure share of caribou. This finding also suggests that increased time constraints among households at the community-level may limit time spent in harvesting and hence, quantity of country food available for consumption.

The results from the Aboriginal Peoples Survey do not take into account community-level factors, for which data are not available. The present analysis, however, shows that households are largely dependent on country meat and fish sources, with high proportions of individuals reporting harvest activity, and the majority of respondents reporting positive proportions of country meat and fish consumed. Households whose harvesting efforts are threatened by external factors like animal health may have difficulty achieving food secure status.

While the analysis does not involve determining what factors influence caribou harvesting and consumption specifically, the factors that affect overall country food harvesting and consumption behaviour may also reflect use of caribou.

Chapter 6 Consumption of caribou across communities

6.1 Introduction

One of the objectives of this research, as stated in the first chapter, is "to develop a model that provides an estimate of the variation in the intake of caribou meat in 106 communities of northern Canada, in order to assess how any shock to the health or availability of caribou might influence relative food security."

In Chapter 4, demand system estimations showed that individual age, community employment rate, number of stores in the community, and total expenditure level on caribou were found to be related to either the incidence of consuming caribou or expenditure shares on caribou. In terms of dietary quality indicators, consuming caribou was also found to have a statistically significant effect on the intake of calories and dietary diversity in some model specifications. In Chapter 5, it was reported that individual factors such as age and gender, household composition, and employment status were found to influence the likelihood of participation in harvesting and also the amount of country meat and fish that is consumed by a household.

The vulnerability of communities to changes in caribou populations may be dependent on a wide set of environmental and socio-economic characteristics, and significant heterogeneity may exist among communities in terms of use of caribou. With data on caribou consumption from a small set of communities from Sharma et al. [as described in Sharma et al. (2009, 2010)] and data on community-level socio-economic and wildlife characteristics from published government and academic studies, the average weight of caribou consumed by individuals across communities may be predicted. Mean weight of caribou consumed by individuals in a community serves as an indicator for dependence on caribou as a food source, as variations may be observed across communities and regions.

The communities of interest will first be defined, followed by descriptions of the statistical method used and presentation and discussion of results.

6.2 Identification of communities

As stated in Chapter 1, the area in this examination of caribou intake covers the territories of Yukon, Northwest Territories and Nunavut, and the Inuit regions of Nunavik, located mainly in Quebec, and Nunatsiavut, located mainly in Newfoundland and Labrador. All "census subdivisions" defined by Statistics Canada (2009c) are included as communities in the analysis, where census subdivisions with zero populations in 2006 are not included. Data from published studies on consumed and harvested quantities of caribou, and frequency of consumption of caribou, as reviewed in chapter 2 and shown in Appendix E, have not been uniformly gathered across communities. In the present model estimates, cross-community comparisons on caribou dependence—in terms of quantity consumed, may be generated for all communities. Relative caribou dependence at the region level may also be derived from the results.

6.3 Data and Methods

In terms of caribou consumption, the quantity of caribou consumed (in grams) by an individual in a day is available for four communities in data from the dietary data set from Sharma et al. that is used for the analysis in Chapter 4. Community-level socio-economic and wildlife population characteristics for the four communities and the other 102 communities are obtained from published census statistics, as well as from other published and unpublished sources.

For the sample of individuals from four communities, it is possible to identify the quantitative relationships between quantity of caribou consumed, and each community-level variable considered. A linear relationship may be specified as follows and estimated with Ordinary Least Squares regression:

$$wcaribou_{ij} = \beta_{wcaribou} + \gamma_k * x_{ijk} + \varepsilon_{ij},$$

where $wcaribou_{ij}$ is quantity of caribou consumed by individual i in community j, where x_{ijk} is the kth community-level variable and $\beta_{wcaribou}$ is an intercept term.

It is assumed that a set of community-level characteristics affects quantity of caribou consumed. However, with a limited number of degrees of freedom given the sample size (n=188), it is not feasible to estimate an equation of the form $wcaribou_{ijk} = \beta_{wcaribou} + \sum_k \gamma_k * x_{ijk}$, that includes all community-level variable, in order to retrieve a set of k coefficient estimates. Thus, k equations, one for each community-level variable specified, of the form $wcaribou_{ij} = \beta_{wcaribou} + \gamma_k * x_{ijk}$, are estimated.

The dependent variable $wcaribou_{ij}$ is an individual-level variable for quantity of caribou consumed. The γ_k coefficients generated, however, are assumed to be equal to the community-level mean consumption in a community. The mean quantity of caribou consumed in any given community may then be predicted with the following equation:

$$mcaribou_{j_{predicted}} = \beta_0 + \sum_k \gamma_k * x_{jk},$$

The β_0 may be viewed as an error term, which is calculated by subtracting $(\sum_k \gamma_k * x_{jk})$ from the actual mean quantity of caribou consumed. With four data points for the actual quantity of caribou consumption consumed, four values for β_0 may be generated. The errors represent sampling variability among the communities—different mean values are found for the four different communities, which are samples drawn from a single population. The sampling variability may be used to generate predicted values for all communities of interest. Due to limited sampling variability, as there are only four generated errors, a Monte Carlo simulation process is employed to generate repeated samples for each predicted value ($mcaribou_{j_{predicted}}$). Summary statistics may then be computed from the repeated samples.

6.3.1 Monte Carlo simulation

The Monte Carlo method involves generating random samples from a possible range of values while assuming a specific distribution for the range. Kennedy (2003, p. 24) specifies four steps for the Monte Carlo process: "i) model the data-generating process, ii) generate several sets of artificial data, iii) employ these data and an estimator to create several estimates, and iv) use these estimates to gauge the sampling distribution properties of that estimator." The first step involves specifying a model so that the computer can generate real-world data while accounting for stochastic (random) components of the model.

In a study to estimate the number of small scale fishery jobs available in global coastal fisheries, Teh and Sumaila (2013) used Monte Carlo estimation to assign values to the explanatory variable of proportion of people who fish, specifying the parameters of the variable based on a country-level Human Development Index indicator. For northern Canadian data, Hoover et al. (2013) used Monte Carlo simulation to estimate total revenue, total cost, total use value (the difference between total revenue and total cost), and total use value with opportunity cost for beluga and narwhal harvests in the Hudson Bay region. Parameters for each equation were selected randomly from an assigned distribution, with ranges for parameters specified.

The set of j community-level variables x_{jk} in the equation $mcaribou_{j_{predicted}} = \beta_0 + \sum_k \gamma_k * x_{jk}$ must first be specified. In the demand analysis carried out in this study, select individual- and community-level socio-economic variables—number of stores and community employment rate—were hypothesized to affect individual share of expenditures on caribou, while physical access to caribou is reflected in the calculated country food prices.

Although additional community-level socio-economic variables were not included in the demand system estimation due to a limited number of degrees of freedom in the simultaneous equation estimations given the sample size, these additional variables may be related to the average amount of caribou consumed in a community. Berman (2009) has suggested that "place characteristics," which may include total number of people employed in a community, change in employment rate over a ten-year period, and whether or not a community is a regional center, a coastal community, a caribou using community, or a salmon using community, influence the harvest productivity of individuals.

Demands for different store foods have been modeled as functions of community-level explanatory variables such as median age, median household size, household income variables, percentage of neighbourhood population composed of a specific ethnic group, status as a rural, suburban or urban area, store concentration ratio, numbers and types of food stores and location of foods stores (Dhar, Chavas, and Gould 2003, Sharkey and Horel 2008, Powell, Zhao, and Wang 2009). These characteristics may influence the types of foods stocked in stores, which may influence preferences for country foods such as caribou. For example, it has been found that stores in more "advantaged" areas in a rural American county had higher availability of fruits and vegetables (Ball, Timperio, and Crawford 2009).

As suggested previously, households may depend on extended family and community sharing networks for caribou and other harvested food, so the employment patterns of community members have implications for the supply of caribou available, as well as household accessibility to meat (Ford et al. 2006, Ford and Beaumier 2011). Participation in full-time employment, for instance, has been found to lead to lowered willingness to share harvesting equipment with non-employed persons (Wenzel 1995).

6.3.1.1 Community-level variables

Data on socio-economic variables and caribou harvest and population variables are available for all 106 communities. Individual demographic characteristics, household and family demographic characteristics, and employment and time use characteristics, are specified from census data available in Statistics Canada census community profiles (Statistics Canada 2009c). Some variables shown in the community profiles are aggregated—a summary measure is found in the case where multiple variables represent one construct. For example, the marital statuses of community members are accounted for with the percentage of families in the community that are married couple families, although data on numbers of individuals in common-law relationships or who are married is also available. Twenty-three variables are defined from census data. Since values for individual age, gender, and employment status are available from the dietary data, the coefficients generated from regressions (for each of these three variables) are assigned as the coefficients for corresponding community-level variables $MAGE$, $GENDER$, and $ERATE$.

Store and transport infrastructure characteristics, which represent the "food environment" and community food supply factors, are also identified. Variables on access and availability of caribou are derived from harvest and population studies, while distances to caribou harvesting sites are measured with map data. Descriptions of variables are shown in the following table:

Table 6-1 Description of community-level variables

Variable name (for present study)	Description	Source of data
VARIABLES FROM CENSUS DATA		
Demographic characteristics		
GENDER	Calculation: % of total population male	Statistics Canada Community Profile (Statistics Canada 2009c)
POP	"Population in 2006"	Statistics Canada Community Profile - "Population and dwelling counts" (Statistics Canada 2009c)
MAGE	"Median age of the population"	Statistics Canada Community Profile – "Age characteristics" (Statistics Canada 2009c)
FIFTEEN	"% of the population aged 15 and over"	
EDU	Calculation: % of total population aged 15 years and over with a post-secondary degree or diploma	Statistics Canada Community Profile - "Educational attainment" (Statistics Canada 2009c)
IMMIG	% of total population "immigrants"	Statistics Canada – "Immigrant status and period of immigration" (Statistics Canada 2009c)
Housing characteristics		
DWELLV	"Average value of dwellings"	Statistics Canada Community Profile – "Occupied private dwelling characteristics"

		(Statistics Canada 2009c)
MRENT	"Median monthly payments for rented dwellings ($)"	Statistics Canada Community Profile – "Selected household characteristics" (Statistics Canada 2009c)
Household demographic characteristics		
MARCOUPLE	Calculation: % of total number of families that are "married-couple families"	Statistics Canada Community Profile – "Selected family characteristics" (Statistics Canada 2009c)
CENFAM	"Total number of census families"	
LONEPAR	Calculation: % of total number of families that are "lone-parent families"	
FAMSIZE	"Average household size"	Statistics Canada Community Profile – "Selected household characteristics" (Statistics Canada 2009c)
ONEPERSON	Calculation: % total private households that are "one-person households"	
MOVE	Calculation: % of total population that "lived in a different province or territory 1 year ago"	Statistics Canada Community Profile – "Mobility status – Place of residence 1 year ago" (Statistics Canada 2009c)
Employment and income characteristics		
ERATE	"Employment rate"	Statistics Canada Community Profile – "Labour force activity" (Statistics Canada 2009c)
LFORCE	Calculation: % of total population in labour force	
RESJOB	Calculation: % of total "experienced labour force 15 years and over" who work in the following groups: "H – Trades, transport equipment operators, "I – Occupations unique to primary industry," and "J – Occupations unique to processing, manufacturing, and utilities"	Statistics Canada Community Profile – "Occupation" (Statistics Canada 2009c)
UNPAID	Calculation: % of population 15 years and over "reporting unpaid work"	Statistics Canada Community Profile – "Unpaid work" (Statistics Canada 2009c)
FULLYEAR	Calculation: % of population 15 years and over "with earnings who worked full year, full time"	Statistics Canada Community Profile – "Earnings in 2005 (Statistics Canada 2009c)"
OFFSITE	Calculation: % of total employed labour force "working in a different census subdivision (municipality) within the census division (county) of residence"	Statistics Canada Community Profile – "Place of work status" (Statistics Canada 2009c)
TRANSFER	"Government transfers - As a % of total income"	Statistics Canada Community Profile – "Income in 2005" (Statistics Canada 2009c)
MEDINC	"Median income - Persons 15 years and over ($)"	
IMMIG	% of total population "immigrants"	Statistics Canada – "Immigrant status and period of immigration" (Statistics Canada 2009c)
STORE FOOD ACCESS & TRANSPORT ACCESS		
NSTORES	Number of food stores	See Appendix A
COOP	=1 if a Co-operative store is present, 0 otherwise	See Appendix A
MAIL	=1 if Food Mail community in 2006, 0 otherwise	See Appendix A

ROAD	=1 if full-year road access, 0 otherwise	See Appendix A
COASTAL	=1 if coastal (located by sea), 0 otherwise	See Appendix A
CARIBOU POPULATION, DISTANCE, HARVESTS		
NHERDS	Number of caribou herds harvested	See Appendix H
CARIPOP	Sum of caribou from herds harvested	See Appendix H
DCARIB	Distance to caribou	See Appendix H
MEANHAR	Mean harvest of caribou in published studies	See Appendix H
LOWHAR	Minimum harvest	See Appendix H
PEAKHAR	Maximum harvest	See Appendix H

Caribou population values from 2006, when the dietary data was collected, are used. When population figures for 2006 are not available, the value from the most recent population count preceding 2006, are used. For harvest variables, mean, minimum, and maximum values were calculated from published harvest studies at the community-level across years when data is available. For Yukon communities without recent harvest surveys, resident hunter harvest survey results are used and for communities without data, figures derived from other communities in the same region may be used. While individuals may access different harvesting sites, the $DCARIB$ value for a community is the simple average of distances to different herds traditionally accessed by the community, where each distance, to a given herd, is calculated as the of the maximum and minimum distances to the herd (see Appendix H for calculated data). Maximum distances are assumed to be the distance between the townsite and the edge of the range, as shown in maps from government websites or published studies. As noted by Kendrick and Manseau (2008), in a study of harvesters from Arviat, NU, some individuals harvested closer to the town site while others traveled as far as 500km to harvesting areas. The authors also found that over the lifetime of interviewed harvesters, the areas where harvests took place covered most, though not all, of the Beverly and Qamanirjuaq caribou ranges. Harvesters may reach further distances by plane—in Fort Good Hope, NT, community members may charter planes for community hunts for distances 300 km away from town (McMillan 2012).

6.3.1.2 Prediction equation

In total, thirty-five community-level variable are defined. After estimating k=35 equations of the form $wcaribou_{ij} = \beta_{wcaribou} + \gamma_k * x_{ijk} + \varepsilon_{ij}$, the γ_k parameters may be used for the estimator for community-level mean caribou consumption for all communities:

$$\widehat{mcaribou_j} = \beta_0 + 13.96 * GENDER + (0.99E-03) * POP + 0.30 * MAGE + 0.62 * FIFTEEN + 0.12 * EDU + 0.639 * IMMIG + (0.45E-04) * DWELLV + (0.26E-03) * MRENT + * -1.52 * MARCOUP + (0.39E-03) * CENFAM + 1.23 * LONEPAR + 5.34 * FAMSIZE + 0.71 * ONEPERS + 0.70 * MOVE + -3.12 ERATE + 0.15 * LFORCE + -0.42 * RESJOB + -1.09 * UNPAID + 0.03 * FULLYEAR + 1.12 * OFFSITE + -0.34 * TRANSFER + 0.14 * NSTORES + -3.82 * COOP + -1.56 * MAIL + 3.82 * ROAD + -1.56 * COASTAL + 2.07 * NHERDS + (0.08E-02) * CARIPOP + -0.05 * LDCARIB + (0.17E-02) * MEANHAR + 0.02 * LOWHAR + (0.92E-03) * PEAKHAR$$

The error term β_0 is calculated from the four communities where actual mean quantity of caribou is available. For the prediction of the mean level of caribou consumed at the community level, β_0 is chosen randomly from one of the four error terms. The intercept β_0 is assumed to model the random element of the model, allowing the computer to generate multiple sets of sample data. The "RANDOM" command in Time Series Processor (TSP) 5.1 software is used to generate the random variable, which is drawn from the series of four β_0 values. One thousand sets of data (each with a sample size of N=106) are generated. With the "DRAW" option, the intercepts β_0 are each sampled with ¼ probability.

6.4 Results

For each community, there are 1000 draws from a sampling distribution of the estimator $\widehat{mcaribou_j}$. The expected value of the estimator is calculated as the average of estimates from m=1000 trials: $(\sum_{m=1}^{1000} mcaribou_j)/1000$, and is assumed to be an indicator of caribou dependency in the community. Computed expected values, variance, and minimum and maximum values are shown in the following table:

Table 6-2 Distribution properties of sampling data from Monte Carlo

Region		Comm.	Mean (g)	Variance (g)	Std. Dev.	Minimum (g)	Maximum (g)
NORTHWEST TERRITORIES	Inuvik	1	83.87	143.48	11.98	65.95	96.21
		2	55.29	133.62	11.56	36.74	67.00
		3	65.65	135.32	11.63	46.89	77.16
		4	72.56	139.17	11.80	53.86	84.13
		5	86.95	129.83	11.39	68.00	98.27
		6	71.66	139.71	11.82	53.46	83.72
		7	101.37	135.73	11.65	83.31	113.57
		8	12.59	137.49	11.73	-5.47	24.79
	Regional	**Mean (g)**		**68.74**	**Std. Dev.**		**26.71**
	Sahtu	9	83.87	143.48	11.56	65.95	96.21
		10	55.29	133.62	11.82	36.74	67.00
		11	65.65	135.32	11.60	46.89	77.16
		12	72.56	139.17	11.88	53.86	84.13
		13	86.95	129.83	11.65	68.00	98.27
	Regional	**Mean (g)**		**51.15**	**Std. Dev.**		**29.22**
	Dehcho	14	22.67	133.10	11.54	4.00	34.27
		15	16.52	140.20	11.84	-1.53	28.73
		16	100.85	138.04	11.75	82.49	112.76
		17	33.74	128.02	11.31	14.90	45.16
		18	83.75	139.02	11.79	65.47	95.73
		19	41.80	138.31	11.76	22.94	53.20
	Regional	**Mean (g)**		**33.26**	**Std. Dev.**		**36.91**
	North Slave	20	363.62	128.70	11.34	344.72	374.98
		21	165.03	132.19	11.50	146.43	176.70
		22	181.84	142.34	11.93	163.69	193.95
		23	176.23	127.86	11.31	157.17	187.43
		24	161.96	131.26	11.46	143.65	173.91
		25	122.72	132.38	11.51	104.30	134.56
		26	119.78	132.25	11.50	101.12	131.39
	Regional	**Mean (g)**		**184.45**	**Std. Dev.**		**82.72**
	South Slave	27	21.90	132.74	11.52	3.32	33.58
		28	8.64	135.27	11.63	-9.96	20.30
		29	14.92	137.77	11.74	-3.43	26.83
		30	68.15	138.72	11.78	50.00	80.26
		31	1.48	134.44	11.59	-16.59	13.67
		32	2.26	136.71	11.69	-15.72	14.54
		33	19.41	132.55	11.51	1.03	31.30
	Regional	**Mean (g)**		**19.54**	**Std. Dev.**		**22.85**
NUNAVUT TERRITORY	Qikiqtaaluk	34	74.53	131.92	11.49	55.68	85.94
		35	93.11	138.13	11.75	74.92	105.19
		36	70.03	132.70	11.52	51.56	81.83
		37	99.20	136.33	11.68	81.20	111.46
		38	84.59	135.77	11.65	66.28	96.54
		39	115.98	139.52	11.81	98.14	128.40
		40	185.58	131.34	11.46	166.65	196.91
		41	118.65	134.98	11.62	99.91	130.17
		42	104.93	139.83	11.82	86.45	116.72
		43	81.16	137.08	11.71	63.05	93.31

		44	63.99	131.95	11.49	45.80	76.06
		45	82.04	140.14	11.84	64.05	94.32
		46	45.76	129.28	11.37	26.92	57.18
	Regional	**Mean (g)**		**93.81**	**Std. Dev.**		**34.40**
	Kivalliq	47	137.69	130.21	11.41	118.78	149.05
		48	539.11	138.98	11.79	521.03	551.30
		49	243.58	128.88	11.35	224.27	254.53
		50	227.91	136.63	11.69	209.66	239.93
		51	90.67	137.80	11.74	71.84	102.10
		52	190.04	137.37	11.72	172.23	202.49
		53	100.41	134.14	11.58	81.31	111.57
	Regional	**Mean (g)**		**119.90**	**Std. Dev.**		**60.55**
	Kitikmeot	54	58.54	132.49	11.51	40.25	70.51
		55	59.73	134.89	11.61	41.38	71.64
		56	190.99	134.09	11.580	172.48	202.74
		57	166.96	136.40	11.679	148.82	179.09
		58	123.28	136.35	11.677	104.93	135.20
	Regional	**Mean (g)**		**218.49**	**Std. Dev.**		**153.37**
YUKON TERRITORY	Yukokn	59	16.04	132.45	11.51	-2.85	27.41
		60	5.56	135.81	11.65	-12.75	17.51
		61	66.96	138.68	11.78	48.73	79.00
		62	11.71	134.01	11.58	-6.98	23.28
		63	21.53	131.55	11.47	2.69	32.95
		64	41.33	132.32	11.50	22.67	52.93
		65	32.87	135.31	11.63	15.02	45.28
		66	4.35	140.17	11.84	-13.64	16.63
		67	2.90	134.95	11.62	-15.65	14.62
		68	116.73	132.90	11.53	98.73	128.99
		69	39.39	134.23	11.59	20.95	51.22
		70	34.04	138.57	11.77	15.96	46.22
		71	39.47	133.40	11.55	21.03	51.29
		72	53.15	136.36	11.68	34.58	64.84
		73	118.64	144.60	12.03	101.07	131.33
		74	65.22	137.71	11.73	46.85	77.11
		75	0.71	133.71	11.56	-17.82	12.44
		76	15.55	137.50	11.73	-2.76	27.51
		77	35.08	136.46	11.68	16.42	46.68
		78	38.37	134.82	11.61	19.83	50.09
		79	91.49	129.52	11.38	72.72	102.99
		80	3.63	131.06	11.45	-15.17	15.09
		81	55.95	128.25	11.32	37.08	67.34
		82	87.80	140.23	11.84	69.69	99.95
		83	86.65	127.58	11.29	67.90	98.16
		84	88.26	138.60	11.77	70.25	100.52
		85	2.37	141.02	11.88	-15.66	14.60
		86	42.18	134.79	11.61	23.63	53.89
	Regional	**Mean (g)**		**43.50**	**Std. Dev.**		**35.23**
QUEBEC	Nunavik	87	99.99	133.62	11.56	81.45	111.71
		88	93.72	136.73	11.69	75.17	105.43
		89	153.04	132.37	11.51	133.91	164.17
		90	85.84	146.55	12.11	67.96	98.22
		91	115.48	134.25	11.59	97.17	127.44
		92	138.82	141.80	11.91	120.66	150.92
		93	104.54	138.78	11.78	86.63	116.90
		94	192.41	132.55	11.51	173.49	203.75
		95	147.81	138.94	11.79	129.81	160.07
		96	134.93	138.16	11.75	116.73	146.99

		97	91.29	135.20	11.63	73.33	103.59
		98	108.79	131.37	11.46	89.89	120.16
		99	121.73	134.46	11.60	103.55	133.81
		100	111.47	137.33	11.72	93.21	123.47
	Regional	**Mean (g)**		**121.42**	**Std. Dev.**		**29.35**
LABRADOR	Nunat-siavut	101	160.37	135.98	11.66	142.42	172.69
		102	182.47	136.85	11.70	164.11	194.37
		103	193.19	139.48	11.81	175.52	205.78
		104	150.93	134.50	11.60	131.89	162.15
		105	134.07	133.12	11.54	115.90	146.16
		106	201.34	140.24	11.84	183.98	214.24
	Regional	**Mean (g)**		**170.40**	**Std. Dev.**		**26.16**
All communities		**Mean (g)**		**92.66**	**Std. Dev.**		**77.29**

The region with the highest average predicted community-level mean caribou consumption is the Kitikmeot region of Nunavut, followed by the North Slave region, Nunatsiavut, Nunavik, Kivalliq region, Qikiqtaaluk (Baffin) region, Inuvik region, Sahtu region, the Yukon territory, Dehcho region, and South Slave region. The mean predicted value across communities was 92.66 g (Standard deviation = 77.29).

To assess relative dependence on caribou, the distribution of the expected values of the estimator $\widehat{mcaribou}_j$ may be assessed. The 25th-, 50th-, and 75th-percentile values are delineated, and the number of communities in each region falling into each of the quartiles of the expected values are shown in the following table.

Table 6-3 Number of communities in each quartile of expected values of community-level average quantity of caribou consumed

		1st quartile (<39.94 g)	2nd quartile (39.94 g ≤estimate <84.23 g)	3rd quartile (84.23g ≤estimate <121.24 g)	4th quartile (121.24 ≤estimate <539.11 g)
		Number of communities			
NORTHWEST TERRITORIES	Inuvik Communities: 8	1	5	2	0
	Sahtu Communities: 5	1	4	0	0
	Dehcho Communities: 6	3	2	1	0
	North Slave Communities: 7	0	0	1	6
	South Slave Communities: 7	6	1	0	0
NUNAVUT TERRITORY	Qikiqtaaluk Communities: 13	0	6	6	1
	Kivalliq Communities: 7	0	2	0	5
	Kivalliq Communities: 5	0	0	2	3

YUKON TERRITORY	Yukon Communities: 28	16	6	6	0
QUEBEC	Nunavik Communities: 14	0	0	8	6
LABRADOR	Nunatsiavut Communities: 6	0	0	0	6

In the Northwest Territories, the majority of communities in the North Slave region have an estimated community-level mean consumption of caribou in the 4th quartile. In the South Slave region, however, it was found that all of the communities fall into the first and second quartiles. In Nunavut, a higher proportion of communities in the Kitikmeot and Kivalliq regions have estimated consumption values in the 4th quartile than in the Baffin region. In Nunavik, the highest proportion of communities fall into the 3rd quartile, while all communities in Nunatsiavut fall into the 4th quartile. Therefore, at the territory-level, there is heterogeneity in caribou consumption across regions. The estimates suggest that communities in Nunavik and Nunatsiavut may be the most vulnerable to changes to changes in caribou population due to relatively high current consumption levels, while Yukon communities in general may have a lower dependency on caribou when quantity consumed is considered.

The bias of the expected value of the simulated data sets may be generated for the four dietary study communities by subtracting the expected values, generated from simulation results, from the actual values consumed. The respective errors are, in grams, 8.23, -1.78, -17.92, and 11.71.

Another way of validating the expected value is to compare them to values of caribou consumption, as were described in Chapter 2 and shown in Appendix H. The mean of the expected values for Northwest Territories communities is 80.05g, which is in the approximate range of 60 g – 250 g of caribou per day reportedly consumed by the communities. The mean of the expected values for Nunavut communities is 135.34 g, which is in the approximate range of 31 g – 208 g of caribou per day reportedly consumed in the communities. The mean of the expected values for Yukon communities is 43.50 g, which is outside of the approximate range of 70 g – 250g of consumption per day shown in published studies. The same result is found for the mean of expected values for Nunavik 121.42 g, which falls outside the range literature (5 – 55 g). It is noted, however, that since published caribou consumption values cannot be found for all communities, comparisons between measured real-world values and the simulated community mean values may not be carried out for each community.

6.5 Summary

Results from the Monte Carlo simulation analysis help fill gaps in understanding about consumption of caribou across communities. A set of data generated for all 106 communities in northern Canada may illustrate relative consumption of caribou across communities. From the calculated expected mean values of the Monte Carlo drawings, the communities had a mean caribou consumption level of over 80 grams per day, with the highest community-level mean consumption level being over 500 grams.

The results also suggest that communities in Nunavik and Nunatsiavut are high consumers of caribou, while a high proportion of Yukon communities are low consumers of caribou, and thus less vulnerable to instantaneous shocks that may affect caribou health and population. In the Northwest Territories, the North Slave region is predicted to be the most dependent on caribou relative to other regions, while the South Slave is predicted in the model to be the least affected. In the Inuvik and Sahtu regions, the highest proportion of communities show consumption levels in the 2nd quartile.

Expected values of the simulated sampling data for the Yukon, Nunavik, and Nunatsiavut do not fall in the range of or match consumption values reported in published studies, suggesting that there may be systematic factors not captured by the model. Some communities also have estimated negative values of consumption from the sampling data. At the same time, expected values of the simulated sampling data for the Northwest Territories and Nunavut do fall in ranges of consumption quantities found in published studies. Thus impacts of community-level socio-economic, infrastructure, and caribou harvesting may be included in any further modeling exercises. In future studies, more data points for caribou consumption from primary data collection may enable more accurate estimates of the β_0 in the estimator and better modeling of stochastic effects, leading to smaller errors between simulated and observed values. Coefficient terms for community-level characteristics may also be incorporated as random components of the model to generate a better set of distributions around the estimator.

In this chapter, the mean quantity of caribou consumed in communities is predicted. A drawback to using a quantity indicator is that while it reflects relative potential use of caribou, it does not reflect the availability of other types of country foods that households in communities may choose as substitutes.

An estimator for proportion (by weight or calorie intake levels) of the diet comprised of caribou may better reflect the relative importance of caribou in the diet and be considered for future prediction analyses. Additionally, in the set of explanatory variables, a set of indicators about availability of other types of country food species—other land mammals, sea mammals, birds, and fish, maybe included to account for the impacts of availability of substitute country foods. The results of elasticity calculations the demand system analysis described in Chapter 4 suggest that individuals may access other country foods in the event of lowered availability of caribou

Chapter 7 Conclusion and Discussion

7.1 Summary and conclusions

The continued use of caribou as a food source is threatened by environmental and anthropogenic factors such as industrial development that may affect the habitat and health of the animal, and also the changing socio-economic realities of northern families. Any threat to the health of caribou and supply of caribou for human consumption may negatively impact a household's ability to acquire nutritious country food, potentially increasing household vulnerability to food insecurity. In this study, secondary data have been used to quantitatively characterize usage of caribou and other types of country and store-bought foods. The socio-economic characteristics that influence a household's food choices may influence the ability of households or communities to cope with changes in caribou populations. The impacts of these factors have not been entirely understood from existing population, dietary, and harvest studies.

7.1.1 Demand analysis with dietary data

The first objective of the research was to determine how economic factors, including the opportunity and input costs of harvesting, employment variables, and access to food retail locations, influence consumption of caribou, other country foods, and store-bought foods, in order to understand what characteristics may render individuals or communities vulnerable to instantaneous changes in caribou populations.

Table 7-1 Summary table of impacts of socio-economic factors on caribou consumption

Variables	Caribou expenditure					
	Probit (Marginal effects)		Working-Leser Demand System		LA/AIDS Demand System	
	OC	OP	OC	OP	OC	OP
Individual	AGE (+)					
Community			ERATE (-)		NSTORES (-)	
Total food expenditure		(-)	(-)	(-)		(-)

In the econometric analysis, two decision-making frameworks—one where it is assumed that individuals value time in harvesting as leisure time and costs for harvesting inputs and fuel are imputed, and the other where time spent in harvesting is valued as time spent in food production at a market wage rate—are used to calculate costs of harvesting caribou and other country foods. Both specifications are calculated with data on average community-level harvests.

When foregone wages are taken into account, the average price for caribou faced in the four study communities is lower than the respective average prices for other country foods, in aggregate, and different types of store goods. When opportunity costs are taken into account, the price for caribou is lower than the respective prices for store meats, but higher than the average price for other types of store goods (fruits and vegetables, grains, dairy products, and other foods). The country food prices generated in this study are not directly comparable to those generated in other studies, since the units of inputs and costs reported in other studies are not consistent with the measurement units applied in the present analysis.

Increased age was found to have a positive effect on the incidence of a household reporting caribou consumption in the out-of-pocket cost specification. This finding supports results from previous studies which suggest that increased age has a positive effect on country food consumption in terms of quantity or frequency consumed (Receveur, Boulay, and Kuhnlein 1997, Kuhnlein et al. 2004, Hopping et al. 2010). Community-level characteristics appear to play roles in the determination of the level of caribou consumption consumed—both an increased community employment rate and an increased number of stores available in the community lead to a decreased expenditure share for caribou. The negative impact of employment on caribou consumption level corroborates previous research where it has been suggested that increased time spent in employment leads to decreased time spent in harvesting (Stabler 1990, Todd 2010). An increased community employment rate may restrict the supply of caribou meat available to a given household in a community, since non-employed individuals may harvest meat to be shared with community members.

On the other hand, it is shown from expenditure elasticity measurements that an increase in total food expenditure, which is a proxy for total income, leads to an proportionate increase in the quantity of caribou consumed. Previous authors have suggested that increased income has positive effects on harvesting activity or the consumption of country food (Condon, Collings, and Wenzel 1995, Berman 1998, Erber et al. 2010, Hopping et al. 2010). Therefore, the results suggest that while increased access to overall income at the individual-level may lead to a net increase in the consumption level of caribou, decreased available harvesting time, as indicated by the community-level employment rate variable, may have a simultaneous effect on caribou consumption level.

From the own-price elasticity of demand and substitution estimates for caribou, individuals were found to respond negatively (decrease consumption) in the face of increasing overall monetary costs of harvesting. There is also evidence that individuals may substitute caribou with other protein sources including other country foods (and sea mammals, birds, and fish), and store foods such as pork or beef. This is supported by Ford et al. (2006), who reported with reduced accessibility to hunting areas due to climate change, individuals in Arctic communities have been found to switch locations and species harvested. Grains and other foods were found to be complementary to caribou.

While the summary statistics across communities exhibit patterns consistent with other studies, which find that caribou and other country foods are found to be the type of meats most widely consumed, the econometric analysis indicates that incidence of consumption and quantities of caribou consumed are negatively influenced by a few factors. Individuals with access to increased income, access to more food retailers, and who live in communities with higher employment are more likely to decrease consumption of caribou.

7.1.2 Aboriginal Peoples Survey

The second research objective was related to analysis of the Aboriginal Peoples Survey, which enables modeling of the impacts of individual- and household-level variables not found in the dietary data set. It was found that being a male, having a higher education level, having a larger household, having a child present in the household, and participating in employment led to an increased likelihood of an individual participation in harvesting. An increased household size and household participation in employment were also found to have positive impacts on the likelihood of having at least one household member participate in harvesting, as determined in the 2001 and 2006 model estimations. Having children in the household was found to lead to a decreased likelihood of household harvest participation in harvesting with the 2001 survey data.

Therefore, among individuals and households, demographic factors may significantly influence the decision of whether or not to harvest. Across all models, it was found that increased household size leads to increases in the likelihood of harvesting, suggesting that are there intrahousehold effects on harvesting behavior—household members may divide household tasks and other household members may complete other household tasks that support harvest activity (Duhaime et al. 2004, Todd 2010).

Model estimations for the ordinal response variable for the proportion of country meat and fish out of total household meat and fish consumed suggest that while having access to employment may support positive levels of country food consumption, increased time spent in employment may decrease the likelihood of consuming relatively high levels of country meat and fish.

While dietary demand analysis expenditure elasticity results showed that increased total expenditure leads to increased quantities of caribou and other country foods consumed, the potential tradeoff the household might make between time spent in employment and time spent in harvesting is not illustrated from this result. From the demand analysis, it was assumed that at the margin, individuals could trade time spent earning income to purchase store foods, to time spent in harvesting. The APS results suggest that households may be constrained from harvesting high amounts of country food when they increase employment time.

7.1.3 Calorie and dietary diversity analysis

From the analysis on diet quality indicators, it was found that about half (46%) of respondents reported meeting required energy intake levels and about half (46%) also consuming the recommended number of food groups in a day. As food security indicators, the reported proportions are consistent with findings showing that a smaller percentage of households in northern territories achieve food security status than in southern regions.

From demand analysis for calorie intake and dietary diversity, it was found that a binary variable for caribou consumption, that indicates whether or not an individual has consumed caribou, had a statistically significant on these two indicators of diet quality in some specifications. With out-of-pocket cost calculations for total expenditure, it was found that consuming caribou led to higher caloric intake and higher dietary diversity scores. Therefore, after controlling for total income and also individual and community-level characteristics, the choice of consuming caribou contributes positively to overall diet quality. Therefore, any decreases in availability of caribou may have potential negative impacts on diet quality.

Table 7-2 Summary table of impacts of socio-economic factors on calorie intake and dietary diversity in opportunity cost (OC) and out-of-pocket (OP) cost models

Variables	Caloric Intake		Dietary Diversity Score (Marginal effects)	
	OC	OP	OC	OP
Individual	AGE (-) GENDER (MALE) (+)	AGE (-) GENDER (MALE) (+)		
Community	NSTORES	NSTORES (+)		
Caribou binary variable		(+)		1 food group (-) 2 food groups (-) 3 food groups (-) 4 food groups (+)

Total food expenditure	(+)	(+)	(+)	(+)

From demand analysis results and calculation of elasticities of substitution, potential substitutes for caribou were identified. In Chapter 4, it was predicted from elasticity of substitution estimates that individuals would substitute caribou with other country foods and beef (from opportunity cost model estimates), or pork (from out-of-pocket cost model estimates).

Assuming that individuals substitute caribou for these foods, dietary quality, as measured by individual caloric intake and dietary diversity, may be affected. If households substitute caribou with these foods, dietary diversity scores are assumed to not change, since caribou and the suggested substitutes are meat group items. Supposing that individuals may replace the gram-weight equivalent of caribou consumed with any of the potential substitutes or a combination of substitutes (other country foods and beef, as suggested by opportunity cost substitution elasticity estimates), calories per individual and hence, proportion of individuals falling into different categories for energy intake levels, may be calculated, as shown in the following table. The measure of calories per gram of substitute meat is assumed to be the average cal/g value calculated for the respective meat types and quantities consumed in the community.

	Proportion meeting estimated energy requirement														
				Estimates with substitutes for caribou											
	Estimates with caribou (original)			Beef			Pork			Other country foods			Other country foods (94% of weight) and Beef (4% of weight)		
Community	Sedentary	Low Active	Active	Sedentary	Low Active	Active	Sedentary	Low Active	Active	Sedentary	Low Active	Active	Sedentary	Low Active	Active
1	55%	40%	34%	60%	49%	40%	55%	47%	38%	53%	40%	34%	55%	43%	34%
2	50%	35%	23%	55%	40%	23%	55%	43%	30%	50%	35%	23%	50%	35%	23%
3	56%	42%	31%	58%	47%	33%	58%	47%	33%	56%	42%	33%	56%	42%	33%
4	27%	18%	11%	29%	21%	13%	30%	23%	14%	23%	18%	9%	29%	18%	11%
All	46%	33%	24%	49%	38%	27%	48%	39%	28%	44%	33%	24%	46%	34%	24%

It was found that the proportion of individuals in the sample consuming an energy intake level required for sedentary activity increases with beef and pork substitutes, decreases with other country foods, and remains the same with substitution combination of other country foods and beef.

By substituting caribou with store-bought meats, individual intake of calories may change. In some substitution scenarios—in the cases where caribou is substituted with beef and pork, caloric intake and the predicted proportions of individuals meeting sedentary, low active, and active lifestyle requirements for caloric intake, increase. In the case of substitution with other country foods, where calories per gram consumed is based on the average figure found in the community for country foods in aggregate, calories consumed are predicted to decrease. While substitution with other country foods may lead to inadequate intake of calories, it is noted that the number of calories consumed is not reflective of nutrient densities present in different foods. The ability of individuals to obtain suitable substitutes is contingent on community-level availability of different foods from stores or from the land.

7.1.4 Monte Carlo simulation

In the Monte Carlo simulation analysis, parameters were retrieved from linear modeling with the dietary data and used to model the effects of a wide set of socio-economic, community infrastructure, and caribou-harvesting values on community-level mean consumption of caribou. The results show heterogeneity in caribou within regions, since the expected value of the caribou consumption estimator was found to fall into two or three quartiles of the range of expected values for all regions, with the exception of Nunavik. The differences within region suggest that community-level factors may significantly impact susceptibility to changes in caribou population. Communities with relatively high levels of consumption have strong preferences for caribou, and exogenous shocks to caribou populations, leading to lowered availability of caribou, may be detrimental to household food security status in these communities.

7.2 Implications

From the dietary demand analysis, it was found that there were strong preferences for caribou—it is used by more households than any type of store-bought meat or other country land mammals, country fish and sea mammals, and birds. More caribou meal items were consumed than that for any other type of country meat and fish.

It was found in the demand analysis that some socio-economic characteristics were found to have an effect on either incidence of caribou consumption or expenditure share. Age has a positive effect on whether or not an individual consumes caribou, while community employment rate and the number of food stores available within a community appear to influence the level of caribou meat consumed. Increased individual total expenditure was found to lead to increases in quantity of caribou consumed, indicating that caribou is a normal good. In the face of risks to caribou health, communities with older populations, lower employment rates, and fewer stores may be the most adversely affected in terms of having access to caribou. Communities with smaller family units may also have difficulty procuring a supply of other types of country meat and fish if there is low availability of caribou.

In the event of scarcity of caribou meat, which may result in higher caribou 'prices' since caribou prices depend in part on physical availability of caribou, there is evidence from elasticity of demand and substitution estimates that individuals may substitute caribou with other food types. After calculating the costs of replacing equivalent weights of caribou with beef, pork and other country foods, it was found that average expenditure per individual would increase. While individuals may shift consumption from one country food species to another, country food species other than caribou are also at risk from negative environmental impacts. Consumers may shift expenditures to food types that are more costly than caribou, requiring higher total food expenditures to maintain the same level of utility. Increased subsidies on store foods or country foods aside from caribou, such as those established under the Nutrition North Program, may help offset increases in expenditures faced by households by leading to reduced prices for goods.

Although Lawn and Harvey (2001) found northern community members responded positively to a price decrease in fruits and vegetables in a pilot project, no known studies in the past have involved measuring price elasticities for a demand system. The demand elasticity calculations show that individuals are sensitive to changes in prices caribou and other country foods, as well as prices for store foods such as fruits and vegetables, grains, dairy, and other products. Thus, price subsidies may be useful in promote consumption of specific foods.

The analysis of Aboriginal Peoples Survey data showed that individual-level and household-level employment leads to increased likelihoods of harvest participation. Increased income from employment may facilitate purchase of equipment and support participation in harvesting activities. This result supports findings from expenditure elasticity results that suggest that an increase in total food expenditure leads to increased consumption of caribou and other harvested foods.

At the same time, differential effects of employment participation are noted. From the ordinal response model results, an increased level of employment was found to lead to a decrease in the likelihood of having country meat and fish comprise "more than half" of the total amount of household meat and fish consumed. This finding is in line with previous findings from qualitative and quantitative analyses which suggest that individuals with fixed employment face barriers in having enough time to harvest, and hence have restricted access to harvested foods.

Communities where individuals have access to either employment or non-employment income, for example through government subsidies or harvest assistance programs, may better adapt to changes in caribou populations—increased incomes may lead to increased access to other types of country meat food, either via increases in budgets for harvest equipment, or increases in resources that may be traded harvested food. The finding that trading with other households leads to increased consumption suggests that households with access to existing social networks may also adapt better to changes in caribou populations.

Outside the four dietary study study communities, it was found that other communities may be susceptible to changes in caribou population as well, as determined with results from Monte Carlo analysis. A significant proportion of communities in Nunavik, the Kivalliq and Kitikmeot regions of Nunavut, and the North Slave region of the Northwest Territories, is estimated to have higher-than-average consumption values. It was found that across territories and administrative regions, community-level vulnerability, in terms of level of caribou consumption, varies. In the event of changes in caribou population, community-specific strategies relating to employment, community-infrastructure, or harvesting activities, may be developed to aid in adaptation to population changes. Whether or not communities have access to other species or types of foods may be an important factor in adaptation efforts.

There is evidence that consuming caribou leads to two measures of dietary quality—caloric intake and dietary diversity, given current levels of food expenditure. Caribou consumption has been positively associated with adequate consumption of various nutrients in other studies. To offset adverse effects of declined access to caribou, households may have to replace caribou with other foods, and total household expenditures on food may have to increase significantly for households to achieve nutritionally adequate diets.

The results of this study suggest that changing economic conditions may influence households' abilities to cope with changes to caribou populations. Any significant changes to physical access to caribou may require action to ensure i) access to community-level resources such as food stores, ii) access to monetary income, and iii) access to flexible employment, to ensure that households have time and income resources to achieve adequate diets. Economic levers realted income and price subsidies, or increased access to employment—where employment structure may accommodate harvest activity, may be required to enhance households' ability to deal with changes in access and availability of caribou.

7.3 Limitations and recommendation for further research

This study employed two sources of secondary data, data from 24-hour dietary recall and from the public use microdata file of the 2001 and 2006 Aboriginal Peoples Survey. A limitation with the 24-hour recall data is that data were collected for one day across the four communities in either March-April or October-November. As stated in Chapter 2, at least two recalls are usually recommended to accurately assess food consumption or nutrient intake. As mentioned in Chapter 3, the Aboriginal Peoples Survey is a post-census survey, where the sample is drawn from census responses, and is thus subject to under-representation, as suggested by Delic (2009). A problem with the public use microdata file that is used for the analysis in this thesis is that it does not include region-level or community-level variables. As hypothesized in the food demand models, community-level variables may have an impact on harvesting and food consumption choices. The estimation may suffer from omitted variable bias.

For food demand analysis with dietary data, food item prices from a local (Edmonton) store were collected, adjusted from 2010 to 2006 prices with the Consumer Price Index for Alberta, and then adjusted to reflect community-level price differences with the Revised Northern Food Basket (RNFB) measure. The problem with using the RNFB measure is that the published data do not contain cost data for individual types of foods or food groups. If the price difference among communities is not uniform across all food types, approximated prices used may be biased upwards or downwards.

In the estimation of country food prices used for food demand analysis, individual data on the source of country food and potential harvesting costs were not available. Therefore, the production function or the total cost function for units of country food consumed could not directly be estimated. The estimation of country food prices is based upon calculation of number of animals harvested in a community, edible weights of caribou, distance to caribou, published wages for select occupations, and published prices for harvesting equipment. The wildlife harvest values were collected in periods (1988-1997 for the Inuvialuit Harvest Study in and 1996-2003 for the Nunavut Wildlife Harvest Study 1996-2003) that do not coincide with the dietary recall survey period in 2006. Caribou populations, caribou locations, and accessibility to caribou may have changed, due to environmental factors. With the available data, a linear production function was assumed and estimated with only either time (opportunity cost) or equipment (out-of-pocket) cost components. This functional form may be restrictive—it is possible that individuals exhibit non-linear production functions for harvesting activity. Additionally, individual characteristics may influence individual production functions and ability to harvest, which are assumed in this study to be homogenous at the community-level.

The assumption that individuals may enter and exit the labour force with cost may also be problematic. Additional characteristics of the individual, such as education or training level, may be determined and used to estimate a labour function to determine potential wages an individual may receive in the market. It was also assumed that individuals face an opportunity cost of time equal to a potential wage rate. Detailed data on individual use of time in different activities may enable more accurate estimation of opportunity cost that accounts for heterogeneity among individuals.

It is assumed that leisure is weakly separable from harvesting activities in the utility function. If data on household time use on non-harvesting activities were available, an alternative specification of the utility function may be adopted and the tradeoffs between time spent in harvesting and time spent in leisure estimated empirically, and the results compared to those from the present theoretical specification. Intrahousehold effects are not modeled, since data on household and family structure (e.g. number of household members) is not available.

In order to investigate the impact of caribou consumption on diet quality, two indicators—caloric intake and dietary diversity, were used. A drawback to using an individual caloric intake measure is that it does not account for adequacy of macro- and micro-nutrients. Individuals may be at risk for over-consumption of calories. Further studies may employ measurement of the proportion of individuals in a community that have excessive calorie intake and who are at risk of obesity, versus the proportion of individuals that under-consume calories. While the dietary diversity score measure used takes into account the use of different food types, the score does not account for diversity within food groups or distribution of food groups, both of which may influence the validity of diversity indicators. The meat and alternatives food group, for example, may include a variety of country meat and fish group from which a large set of nutrients may be available from.

Monte Carlo simulation analysis enabled the prediction and sensitization of mean quantities of caribou consumed across communities. Predictions were made based on the sampling variability of a small set of data. In future analyses, additional data on observed quantities of caribou in communities may be included to better model the relationships between consumption and different community-level characteristics. Additionally, equation coefficients for the community-level characteristics may be included as stochastic components in the model.

A recommendation for future research involves collecting detailed dietary or food intake data along with diary records individual purchases of costs of equipment for harvesting. Although data on harvesting costs have been conducted in the past, production functions have not been directly estimated with these data and analysed in conjunction with food consumption data. Furthermore, surveys of this type may also involve gathering detailed data on characteristics of all household members so that intrahousehold effects may be examined, and gathering data on income sources of the household, so that the potentially differential impacts of non-labour income and labour income may be examined.

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Appendix A. Community-level food subsidies and infrastructure data

Table 1. Community-level food subsidies and infrastructure

	Food subsidy data							Community-level Infrastructure			
			Data by Province or Territory and Region (April 1, 2011 to March 31, 2012)				Stores		Transport routes	
	NNC Program Low subsidy or high subsidy~	**Food Mail Program** Receiving Community (RC) or Entry Point (EP) §	$ subsidy ¤	% total $ ¤	kg ¤	% total kg ¤	**# Stores**	**Co-op** 1 = if Co-op present, 0 otherwise	**Road status** 0 = no roads, 1 = if ice road or winter snowmobile trail; 2 = if year round road¢	**Coastal** 1 = along coast of Arctic ocean or Hudson's Bay, 0 otherwise£
Aklavik[1a]	Full	RC	106,958	0%	91,642	0%	1[i]	0	1	1
Fort McPherson[1b]	None	--					2[ij]*	1	2	0
Inuvik[1ab]	None	EP					7[iklm]	0	2	0
Paulatuk[1a]	Full	RC	311,524	1%	94,506	0%	1[i]	0	0	1
Sachs Harbour[1a]	Full	RC	178,358	0%	32,964	0%	1[j]	1	0	1
Tsiigehtchic[1b]	None	RC					1[i]	0	1	0
Tuktoyaktuk[1a]	Full	RC	266,685	0%	143,585	1%	1[i]	0	1	1
Ulukhaktok[1a]	Full	RC	559,210	1%	149,614	1%	2[ij]	1	0	1
Fort Liard[3d]	None	RC					1[i]	0	2	1
Fort Providence[5d]	None	RC					1[in]	0	2	0

Fort Simpson[3d]	None	EP					2[io]	0	2	0
Hay River Reserve[5d]	None	--					1[p]	0	2	0
Hay River[5e]	None	EP					1[i]	0	2	0
Jean Marie River[3d]	None	--					0[q]	0	2	0
Nahanni Butte[3d]	None	RC					1[r]	0	1	0
Trout Lake[3d]	Full	RC	79	0%	30	0%	1[s]	0	1	0
Wrigley[3d]	None	--					1[t]	0	2	0
Colville Lake[2c]	Full	RC	133,431	0%	29,842	0%	1[j]	1	1	0
Deline[2c]	Full	RC	290,098	1%	151,122	1%	2[ij]	1	1	0
Fort Good Hope[2c]	Full	RC	313,059	1%	154,880	1%	2[ij]	1	1	0
Norman Wells[2c]	Full	RC	385,764	1%	235,526	1%	2[iu]	0	1	0
Tulita[2c]	Full	RC	293,013	1%	145,235	1%	1[i]	0	1	0
Enterprise[5d]	None	--					0[v]	0	2	0
Fort Resolution[5e]	None	--					1[i]	0	2	0
Fort Smith[5e]	None	--					3[iw]	0	2	0
Kakisa[5d]	None	--					1[x]	0	2	0
Lutsel'ke[4e]	Partial	RC	3,821	0%	76,416	0%	1[y]	0	0	0
Behchoko[4f]	None	RC					1[i]	0	1	0
Gameti[4f]	Partial	--	0	n/a	0	n/a	1[α]	0	1	0
Wekweeti[4f]	None	RC					1[β]	0	1	0
Whati[4]	Partial	RC	5	0%	100	0%	1[γ]	0	1	0
Detah[4e]	None	--					15[δ]	0	1	0
Yellowknife/N'dilo[4e]	None	EP					15[ε]	0	2	0

NWT total			**2,842,005**	**5%**	**1,305,462**	**5%**					
Arctic Bay[6]	Full	RC	1,787,541	3%	227,062	1%	2[ij]	1	0	1	
Cape Dorset[6]	Full	RC	1,422,088	3%	363,660	1%	2[ij]	1	0	1	
Clyde River[6]	Full	RC	1,630,234	3%	286,953	1%	2[iζ]	1	0	1	
Grise Fiord	Full	RC	555,062	1%	36,277	0%	1[j]	1	0	1	
Hall Beach[6]	Full	RC	781,638	1%	177,379	1%	2[ij]	1	0	1	
Igloolik[6]	Full	RC	2,066,759	4%	471,358	2%	2[ij]	1	0	1	
Iqaluit[6]	Full	RC	5,407,746	10%	3,020,714	11%	3[ijη]	1	0	1	
Kimmirut[6]	Full	RC	555,175	1%	126,606	0%	2[ij]	1	0	1	
Pangnirtung[6]	Full	RC	1,501,598	3%	432,069	2%	4[ij]	1	0	1	
Pond Inlet[6]	Full	RC	3,229,444	6%	435,777	2%	2[ij]	1	0	1	
Qikiqtarjuaq[6]	Full	RC	585,279	1%	156,298	1%	3[ijθ]	1	0	1	
Resolute[6]	Full	RC	786,361	1%	82,717	0%	1[j]	1	0	1	
Sanikiluaq[6]	Full	RC	213,875	0%	207,684	1%	2[ij]	1	0	1	
Cambridge Bay[7]	Full	RC	675,336	1%	619,219	2%	3[ijι]	1	0	1	
Gjoa Haven[7]	Full	RC	1,002,978	2%	381,181	1%	3[ijκ]	1	0	1	
Kugaaruk[7]	Full	RC	675429	1%	208508	1%	1[j]	1	0	1	
Kugluktuk[7]	Full	RC	852,753	2%	447,711	2%	2[ij]	1	0	1	
Taloyoak[7]	Full	RC	858,208	2%	286,054	1%	2[ij]	1	0	1	
Arviat[8]	Full	RC	737,220	1%	810,044	3%	2[ijλ]	1	0	1	
Baker Lake[8]	Full	RC	1,511,453	3%	675,098	3%	2[ij]	1	0	0	
Chesterfield Inlet[8]	Full	RC	304,415	1%	140,518	1%	2[ij]	1	0	1	
Coral Harbour[8]	Full	RC	819,540	2%	242,087	1%	2[ij]	1	0	1	
Rankin Inlet[8]	Full	RC	1,658,683	3%	1,149,551	4%	2[ij]	1	0	1	
Repulse Bay[8]	Full	RC	875,654	2%	251,556	1%	2[ij]	1	0	1	
Whale Cove[8]	Full	RC	252,908	0%	126,558	0%	2[jμ]	1	0	1	

Nunavut Total			**30,747,379**	**57%**	**11,362,641**	**43%**				
Beaver Creek[10]	--	--					0[ν]	0	2	0
Burwash Landing[10]	--	--					1[ς]	0	2	0
Carcross[10]	--	--					1[π]	0	2	0
Carmacks[10]	--	--					1[ρ]	0	2	0
Champagne Landing[10]	--	--					1[ς]		2	0
Dawson[10]	--	--					3[σ]	0	2	0
Destruction Bay[10]	--	--					1[τ]	0	2	0
Faro[10]	--	--					1[υ]	0	2	0
Haines Junction[10]	--	--					1[φ]	0	2	0
Ibex Valley[10]	--	--					6[χ]		2	0
Johnsons Crossing[10]	--	--					0[ψ]		2	0
Keno Hill[10]	--	--					0[ω]		2	0
Lake Laberge[10]	--	--					6[ϊ]		2	0
Mayo[10]	--	--					1[ϋ]	0	2	0
Mount Lorne[10]	--	--					6		2	0
Old Crow[10]	Full	RC	148115	0%	84986	0	1[ό]	0	0	0
Pelly Crossing[10]	--	--					1[ύ]	0	2	0
Ross River[10]	--	--					2[ω]	0	2	0
Stewart Crossing[10]	--	--					0[υ]		2	0
Tagish[10]	--	--					1[ώ]		2	0

Teslin[10]	--	--					1	0	2	0
Teslin Post 13[10]	--	--					1		2	0
Two Mile Village[10]	--	--					2		2	0
Two and One-Half Mile Village[10]	--	--					2		2	0
Upper Liard[10]	--	--					2		2	0
Watson Lake[10]	--	--					2	0	2	0
Whitehorse[10]	--	--					10	0	2	0
Yukon total	--	--	148115	0%	84986	0%				
Akulivik[g]	Full	RC	680,830	1%	178,311	1%	2		1	1
Aupaluk[g]	Full	RC	264,648	0%	67,522	0%	1	1	1	1
Inukjuak[g]	Full	RC	1,224,146	2%	566,977	2%	2	1	1	1
Ivujivik[g]	Full	RC	544,859	1%	114,758	0%	1	1	1	1
Kangiqsulujjuaq[g]	Full	RC	1,002,514	2%	297,092	1%	2	1	1	1
Kangiasujuaq[g]	Full	RC	1,156,905	2%	260,747	1%	2	1	1	1
Kangirsuk[g]	Full	RC	947,852	2%	215,362	1%	4	1	1	1
Kuujjuaq[g]	Full	RC	2,145,000	4%	1,115,996	4%	3	1	1	1
Kuujjuarapik[g]	Full	RC	705,171	1%	790,227	3%	2	1	1	1
Puvirnituq[g]	Full	RC	1,957,511	4%	616,921	2%	2	1	1	1
Quaqtuq[g]	Full	RC	616,175	1%	130,333	0%	1	1	1	1
Salluit[g]	Full	RC	2,151,298	4%	483,094	2%	2	1	1	1
Tasiujaq[g]	Full	RC	366,847	1%	103,814	0%	1	1	1	1
Umiujaq[g]	Full	RC	246,343	0%	189,145	1%	1		1	1
Nunavik total			**14,010,099**	**0.25**	**5,130,299**	**0.18**				
Hopedale[n]	Full	RC	96,967	0%	80,827	0%	3	1	1	1

Makkovik[h]	Full	RC	54,328	0%	54,467	0%	3[q]	1	1	1
Nain[h]	Full	RC	498,754	1%	198,515	1%	5[q]	1	1	1
Postville[h]	Full	RC	33,823	0%	27,405	0%	2[q]	0	1	1
Rigolet[h]	Full	RC	52,078	0%	45,263	0%	1[r]	1	1	1
Happy Valley-Goose Bay[h]	--	EP	--	--	--	--	16[p]	1	2	1
Nunatsiavut total			**735,950**	**0.01**	**406,477**	**0.01**				

*AANDC 2008
** AANDC 2013b
~ AANDC 2013c
§ AANDC 2012b

Land Claims Areas

a: Inuvialuit Settlement Region
b: Gwich'in Settlement Area
c: Sahtu Settlement Region
d: Deh Cho
e: Fort Resolution – Akaitcho Treaty 8
f: T'licho Region
g: Nunavik region (Quebec)
h: Nunatsiavut Region (Newfoundland and Labrador)

Government Administrative Areas

1: Northwest Territories - Inuvik Region
2: Northwest Territories - Sahtu Region
3: Northwest Territories - Dehcho Region
4: Northwest Territories - North Slave Region
5: Northwest Territories - South Slave Region
6: Nunavut – Qikiqtaaluk/Baffin Region

7: Nunavut - Kitikmeot Region

8: Nunavut - Kivalliq Region

9: Yukon

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Appendix B. Caribou population surveys

Population surveys are conducted by photography of animals on calving and post-calving grounds and by radio-collaring animals (Fisher, Roy, and Hiltz 2009, GNWT Environment and Natural Resources 2013b). The accuracy of population studies, such as those for caribou, is subject to survey design issues such as the appropriate classification of populations or herds, the ability to obtain a representative sample and also challenges in statistical modeling which is used to determine overall herd size and demographic composition (Fisher, Roy, and Hiltz 2009). Barren-ground caribou herds are migratory and the methods of delineating a herd may vary and have evolved over time, though the most widely accepted concept is that a herd is defined by shared calving grounds (Fisher, Roy, and Hiltz 2009).

Population studies of barren-ground, woodland, and peary caribou in the Yukon, Nunavut, Northwest Territories, Quebec, and Labrador generally show declines in herds over time. Vors and Boyce's (2009) review of caribou showed declines in international circumpolar herds over the last 10-20 years. However, a few herds have been described as stable or increasing in recent years, as shown in the following table:

Table 1. Population status of barren-ground, woodland, and peary caribou

Population (herds based on calving grounds)	Year	Population Estimate	Range	Method	References	Trend
BARREN-GROUND CARIBOU						
Fortymile	1999	**33110**	N/A	Unknown	(Alaska Board of Game 2000, Harvest Management Coalition 2012)	Declining
	1995		22000-23000	Unspecified		
	1999	**33110**	N/A	Unknown		
	2003	**43375**		Unspecified		
	2010	**51675**		Photocensus		
Porcupine	1989	**178000**	N/A	Photocensus	(Porcupine Caribou Management Board 2010, The Community of Inuvik 2008)	Increasing
	1992	**160000**	N/A	Photocensus		
	1994	**152000**	N/A	Photocensus		
	1998	**129000**	N/A	Photocensus		
	2001	**123000**	N/A	Photocensus		
	2007	**100000 (model estimate)**	N/A	Model estimate		
	2010	**169 000**	N/A	Photocensus		
Tuk Peninsula	2005	**2700**	N/A	Aerial count	(GNWT 2013, Nagy and Johnson 2006, The Community of Tuktoyaktuk 2008)	Declining
	2006	**3078**	N/A	Photocensus		
	2009	**2752**	2480-3010			
	2012	**2200**		Unspecified		
Cape Bathurst	1987	**14529**	1580-2200	Photocensus	(GNWT Environment and Natural Resources	Stable

Population (herds based on calving grounds)	Year	Population Estimate	Range	Method	References	Trend
	1992	**17521**		Photocensus	2010, The Community of Inuvik 2008)	
	2000	**10013**		Photocensus		
	2005	**2400**		Photocensus		
	2006	**1821**		Photocensus		
	2009	**1890; 1934**		Photocensus		
Bluenose-West	1986	--	81470-95270	Photocensus	(CARMA , GNWT Environment and Natural Resources 2010, The Community of Inuvik 2008)	Stable (Giroux: stabilized following declines)
	1987	**98874**	102230-111540	Photocensus		
	1992	**64705**	86790-137930	Photocensus		
	2000	**74273**	62030-90720	Photocensus		
	2005	**20800**	18760-22840	Photocensus		
	2006	**18050**	17520-18580	Photocensus		
	2009	**17897**	16590-19210	Photocensus		
Bluenose-East	2000	**104000**	84 410-126 100	Photocensus	(CARMA 2013, GNWT Environment and Natural Resources 2010, The Community of Inuvik 2008)	Increasing (Giroux: recovering from low numbers)
	2005	**66000**	62 200-70 970	Photocensus		
	2006	**66186**	62 625 - 69 747	Photocensus		
	2010	**98600-102704**				
Bathurst	1970	**259 000**	N/A	Visual	(GNWT Environment and Natural Resources 2012, Gunn, Russell, and Eamer 2011)	Declining (Giroux: stabilized following declines)
	1971	**244 000**	N/A	Visual		
	1974	**251 000**	N/A	Visual		
	1977	**160 000**	N/A	Visual		
	1978	**127 000**	N/A	Visual		
	1980	**140 000**	N/A	Photocensus		

Population (herds based on calving grounds)	Year	Population Estimate	Range	Method	References	Trend
	1982	**174 000**	N/A	Photocensus		
	1984	**384 000**	65 000	Photocensus		
	1986	**472 000**	72 900	Photocensus		
	1990	**352 000**	77 800	Photocensus		
	1996	**349 000**	94 900	Photocensus		
	2003	**186 000**	40 000	Photocensus		
	2006	**128 000**	27 300	Photocensus		
	2009	**31 900**	11 000	Photocensus		
Ahiak (also known as Queen Maud Gulf)	1986	**11265**	1615	*calving ground estimate - not estimate of herd	(CARMA , GNWT Environment and Natural Resources , Gunn, Russell, and Eamer 2011)	Declining [Declined from 1986 to 2006, declined from 2006-2009; signs of increased between 2009 and 2010 (Gunn 2011)]
	1996	**83134**	6298	*calving ground estimate - not estimate of herd		
	1996	**200000**	N/A	*overall herd		
	2006	**123226**	14500			
	2006-2010	**N/A**	N/A	Calving surveys conducted		
Beverly	1982	**164 338**	72332	Photocensus	(Beverly and Qamanirjuaq Caribou Management Board , CARMA , Gunn, Russell, and Eamer 2011)	Declining
	1984	**263 691**	80652	Photocensus		
	1988	**190 000**	71000	Photocensus		
	1993	**87 000**	17900	Photocensus		
	1994	**276 000**	106600	Photocensus		
	1994	**5737**	N/A	*number of breeding		

Population (herds based on calving grounds)	Year	Population Estimate	Range	Method	References	Trend
				females		
	2002	**2629**	N/A	*number of breeding females		
	2007	**189**	N/A	*number of breeding females		
	2008	**93**	N/A	*number of breeding females		
Qamanirjuaq	1970s	**<50000**			(Beverly and Qamanirjuaq Caribou Management Board , CARMA)	Declining
	1980s	**~250000**				
	1994	**496000**				
	2008	**348000**				
George River Herd	1950s	**5000**			(CARMA)	Declining
	1990s	**750000**				
	2001	**385000**				
	2010	**74131**				
Leaf River Herd	1975	**56000**			(CARMA , Couturier et al. 2004, Gunn, Russell, and Eamer 2011)	Declining
	1983	**101000**	43400			
	1986	**121000**	56400			
	1991	**276000**	75900			
	2001	**1193000**	565000/628000			
	2011	**430000**				
PEARY CARIBOU						
Banks Island Peary Caribou	1972	**12000**			(Parks Canada 2009, GNWT Environment and Natural Resources 2013c, Gunn, Russell, and	Declining
	1992	**1018**				

Population (herds based on calving grounds)	Year	Population Estimate	Range	Method	References	Trend
	2002	**1196**			Eamer 2011)	
	2010	**1097**		(Non-calf caribou)		
Northwest Victoria Island	1987	**2600**			(Gunn, Russell, and Eamer 2011)	
	1993	**A few**				
	1998	**95**	35	155		
	2001	**207**	104	307		
	2005	**66**	5	127		
	2010	**150**	46	254		
Bathurst Island population	1961	**3608**	N/A	Unknown	(Jenkins et al. 2011)	
	1997	**78**	N/A	Unknown		
	2001	**<200**	N/A	Visual survey		
	2001-2008	**187**				
Somerset/Prince of Wales Population	1974	**6000**	N/A	Unknown	{Gunn, 2011 #965; Jenkins, 2011 #1037}	
	1995	**60**	N/A	Unknown		
	2004	**No caribou observed**	N/A	N/A		
Devon Island population		**Unknown**	N/A	N/A	(Wildlife Research Section 2007, Gunn, Russell, and Eamer 2011, Jenkins et al. 2011, CARMA)	
	2008	**17**				
West Devon population	2003-2004	**35**	N/A	Visual survey		
	2001-2008	**40**				
North Devon population	2000s	**Low density of caribou**	N/A	Unknown		
All Queen Elizabeth	1961	**25845**	N/A	N/A		

Population (herds based on calving grounds)	**Year**	**Population Estimate**	**Range**	**Method**	**References**	**Trend**
Islands						
Eastern Queen Elizabeth Islands (Ellef Ringnes, Amund ringnes, Devon, Ellesmere, Axel Heiberg Islands, Cornwall, King Christian, Graham)	1961	**1500**				
	2005	**1000**				
Ellesmere and Axel Heiberg	1989	**89**	N/A	Unknown		
Ellesmere Island	2005-2006	**1021**				
Axel Heiberg Islands	2007	**2291**	1636	3208		
Amund Ringnes, Ellef Ringnes, King Christian, Cornall, and Meighen Islands	2007	**282**	157	505		
Lougheed island	2007	**372**	205	672		
All Peary	2001	**8000**			(Gunn, Russell, and Eamer 2011)	Declining; endangered
Nunavut Peary	2001-2008	**4000**				
NWT Peary	2009	**2000**				
Dolphin-Union	1997	**27948**	3363	Photocensus	(Poole et al. 2010)	Declining; COSEWIC Special
	2007	**21753**	2343			

Population (herds based on calving grounds)	Year	Population Estimate	Range	Method	References	Trend
	2007 (maximum)	**27739**	2520			Concern status
Baffin Island Barren-ground caribou	1984	**>60000**	N/A	*South Baffin population	(Wildlife Research Section 2007)	Declining
	1991	**>10000**	N/A	*North Baffin population		
Lorillard and Wager Bay	1983	**119800**	N/A	Unknown	(Campbell 2005, 2007, Wildlife Research Section 2007)	Indeterminate (Giroux: Stable)
	1986	**40000**				
	1995	**73944**	N/A	Unknown		
Wager Bay	2000	**13095**	3532	Reconnaissance survey		Indeterminate (Giroux: Stable)
	2002	**20931**	5296	Reconnaissance survey		
	2004	**28128**				
Lorillard	1999	**13918**	5377	Reconnaissance survey		Indeterminate
	2001	**34520**	17977	Reconnaissance survey		
	2003	**12156**	3697	Reconnaissance survey		
Southampton and Coats Island Caribou (Barren-ground caribou)	1978	**1200**	N/A	Unknown	(Campbell 2006b, Gunn, Russell, and Eamer 2011)	Stable (Giroux: unknown)
	1987	**5400**	N/A	Unknown		
	1990	**9000**	N/A	Unknown		
	1991	**13700**	N/A	Unknown		

Population (herds based on calving grounds)	**Year**	**Population Estimate**	**Range**	**Method**	**References**	**Trend**
	1995	**18275**	N/A	Unknown		
	1996	**30381**	N/A	Unknown		
	1996	**5000**	N/A	*commercial harvest number		
	2003	**17981**	N/A	Photocensus		
	2005	**20582**	(17517-23647)	Photocensus		
Belcher Island/ Sanikiluaq Reindeer	1982	**287**			(Ferguson 1985)	
WOODLAND CARIBOU						
Hart River	1978	**975**		Visual survey	(Yukon Environment, Southern Lakes Wildlife Coordinating Committee 2008)	Unknown
Clear Creek	2001	**900**		Visual survey		Stable
Bonnet Plume	1982	**5,000**		Guess		Unknown
Ethel Lake	1993	**300**		Visual survey		Stable
Moose Lake	1991	**300**		Visual survey		Stable
Tay River	1996	**3,750**		Visual survey		Stable
Redstone	1982	**5-10,000**		Guess		Unknown
Finlayson	1999	**4,130**		Visual survey		Declining
Greater Nahanni	2001	**2000 - 3000**		Visual survey		Unknown
Little Rancheria	1999	**1000 - 1200**		Visual survey		Stable/Increasing
Wolf Lake	1998	**1,400**		Visual survey		Stable
Atlin	1999	**809**	"+/-23%"	Visual survey		Stable
	2007	**777**	"+/17.5%"			
Carcross	2003	**850**		Visual survey		Increasing

Population (herds based on calving grounds)	**Year**	**Population Estimate**	**Range**	**Method**	**References**	**Trend**
		600		Corrected		
	2007	**668**		Visual Survey		
Ibex	2003	**447**		Visual survey		Uncertain
	2007	**615**		Visual Survey		
	2008	**~830**		Visual survey		
Pelly Herds	2002	**1,000**		Visual survey		Unknown
Tatchun	2000	**500**		Visual survey		Stable
Klaza	2000	**650**		Visual survey		Increasing
Aishihik	1998	**1,500**		Visual survey		Increasing
Kluane	2003	**235**		Visual survey		Increasing
Chisana	2003	**720**		Visual survey		Declining
Crow River	2005	**150**		Visual survey		Declining
Horseranch	1999	**600-800**		Visual survey		Stable/Increasing
Aggregate- Northern Mountain population		45000			(GNWT Environment and Natural Resources 2011)	
Aggregate – Boreal population in NWT		6000-70000				

Appendix C. Edible weights

Table 1. Edible weights used for calculations

Species name as listed in harvest stud	Kg of edible weight per animal	Reference and notes
Brant	1	Usher 2000
Canvasback	1	Ashley 2002 - other birds
Crane (Sandhill)	1	Ashley 2002 - other birds
Duck (unspec.)	0.97	Ashley 2000 (Mean value)
Eider (Common)	1.75	Usher 2000
Eider (King)	1.3	Usher 2000
Eider (unspec.)	1.525	Usher 2000 (Mean value)
Goldeneye (Barrow's)	1	Ashley 2002 - other birds
Goldeneye (Common)	1	Ashley 2002 - other birds
Goldeneye (unspec.)	1	Ashley 2002 - other birds
Goose (Canada)	2.24	Ashley 2002
Goose (Greater White-fronted)	1.7	Usher 2000
Goose (Ross)	1	Ashley 2002 - other birds - Ross's geese
Goose (Snow)	1.61	Ashley 2002 (Mean value)
Goose (unspec.)	1.68	Ashley 2002 (Mean value for Geese)
Grouse	0.39	Ashley 2002 (Mean value)
Loon (Common)	1.1	Ashley 2002
Loon (Pacific Arctic)	1.1	Ashley 2002
Loon (Yellow-billed)	1.1	Ashley 2002
Loon (Arctic)	1.1	Ashley 2002 - Pacific arctic loon weight
Loon (unspec.)	1	Ashley 2002 - other birds
Mallard	0.85	Usher 2002
Merganser (Common)	1	Ashley 2002 - other birds
Merganser (Red-breasted)	1	Ashley 2002 - other birds
Merganser (unspec.)	1	Ashley 2002 - other birds
Oldsquaw	0.6	Usher 2000
Owl (Snowy)	1	Ashley 2002 - other birds
Pintail (Northern)	0.65	Usher 2000
Ptarmigan (Rock)	0.35	Usher 2000

Ptarmigan (Willow)	0.5	Usher 2000
Ptarmigan (unspec.)	0.47	Ashley 2002 (Mean value)
Scaup (Greater)	1	Ashley 2002 - other birds
Scaup (Lesser)	1	Ashley 2002 - other birds
Scaup (unspec.)	1	Ashley 2002 - other birds
Scoter (Black)	1	Usher 2000 (use white-winged scoter weight)
Scoter (Surf)	0.65	Usher 2000
Scoter (White-winged)	1.3	Usher 2000
Scoter (unspec.)	0.975	Usher 2000 – use mean value of other scoter weights
Shoveler (Northern)	1	Ashley 2002 - other birds
Shoveler	1	Ashley 2002 - other birds
Swan (Trumpeter)	4.75	Usher 2000
Swan (Tundra)	4.75	Usher 2000
Swan (unspec.)	4.75	Usher 2000 (Mean value)
Teal (Green-winged)	1	Ashley 2002 - other birds
Wigeon (American)	0.55	Usher 2000
Burbot	1.4	Usher 2000
Char (Arctic Anadromous)	1.5	Ashley 2002 (Mean value)
Char (Arctic Land-locked)	1	Ashley 2002 (Mean value)
Char (Land-locked Arctic)	1	Ashley 2002 (Mean value)
Char (Dolly Varden)	1.370588235	Ashley 2002 (Mean value)
Char (Arctic)	1.370588235	Ashley 2002 (Mean value)
Char (unspec.)	1.370588235	Ashley 2002 (Mean value)
Char (Arctic/Dolly Varden)	1.370588235	Ashley 2002 (Mean value)
Char (Land-locked Arctic)	1	Ashley 2002 (Mean value)
Cisco (Arctic)	0.45	Usher 2000
Cisco (Least)	0.3	Usher 2000 - Herring/cisco spp.
Cisco (unspec.)	0.3	Usher 2000 - Herring/cisco spp.
Herring/Cisco (unspec.)	0.3	Usher 2000 - Herring/cisco spp.
Cod (Arctic)	1	Ashley 2002
Cod (Saffron)	1	Ashley 2002
Cod (unspec.)	1	Ashley 2002
Flounder	1	Ashley 2002 – Use cod weight
Grayling (Arctic)	0.9	Ashley 2002
Herring (Lake)	0.3	Usher 2000

Herring (Pacific)	0.7	Usher 2000
Inconnu	2.55	Usher 2000
Pike (Northern)	2.2	Usher 2000
Sculpin (Fourhorn)	0.23	Ashley 2000
Sucker (Longnose)	0.89	Ashley 2000/Berkes et al. 1994
Sucker (White)	0.87	Ashley 2000/Tobias and Kay 1994
Sucker (unspec.)	0.88	Mean value of other suckers
Trout (Lake)	1.65	Ashley 2002 mean
Trout (unspec.)	1.65	Ashley 2002 mean
Walleye (pickerel or dore)	0.44	Ashley 2002 mean
Whitefish (Broad)	1.65	Usher 2000
Whitefish (Lake)	1.015	Ashley 2002 mean
Whitefish (unspec.)	1.36625	Mean of other whitefish
Fish (unspec.)	1.35	Mean of all fish types
Bear (American Black)	95	Ashley 2002
Bear (Grizzly)	73.5	Ashley 2002 (Mean value)
Bear (Polar)	134.7384615	Ashley 2002 (Mean value)
Caribou (barren-ground)	45	Ashley 2002 (Mean value)
Caribou (woodland)	68.9	Ashley 2002 (Mean value)
Moose	184.6615385	Ashley 2002 (Mean value)
Muskox	108	Ashley 2002 (Mean value)
Sheep (Dall)	23	Usher 2000
Beaver (American)	13.5	Usher 2000
Beaver (average)	10.21	Ashley 2002 (Mean value)
Ermine	0.7	Usher 2000 – use muskrat weight
Fox (Arctic)	0.7	Usher 2000 – use muskrat weight
Fox (Coloured)	0.7	Usher 2000 – use muskrat weight
Hare (Arctic)	2.3	Ashley 2002 (Mean value)
Hare (Snowshoe)	1.54	Ashley 2002 (Mean value)
Hare (unspec.)	1.92	Mean of Arctic and Snowshoe hare values
Lynx	3.8	Usher 2000
Marten (American)	0.7	Usher 2000 – use muskrat weight
Mink (American)	0.7	Usher 2000 – use muskrat weight
Muskrat	0.7	Usher 2000
Otter (River)	4.77	Ashley 2000

Porcupine	4.89	Ashley 2000
Squirrel (Arctic Ground)	0.41	Ashley 2000
Wolf	22.75	Adpated from (Wildlife Research Section 2007)
Wolverine	8.29	Adpated from (Wildlife Research Section 2007)
Whale (Beluga)	347	Ashley 2002 (Mean value)
Seal (Bearded)	101	Ashley 2002 (Mean value)
Seal (Ringed)	26	Ashley 2002 (Mean value)
Seal (unspec.)	47	Ashley 2002 - mean of bearded and ringed seal
Walrus	252.308	Ashley 2002 (Mean value)

Appendix D. Numbers of caribou harvested

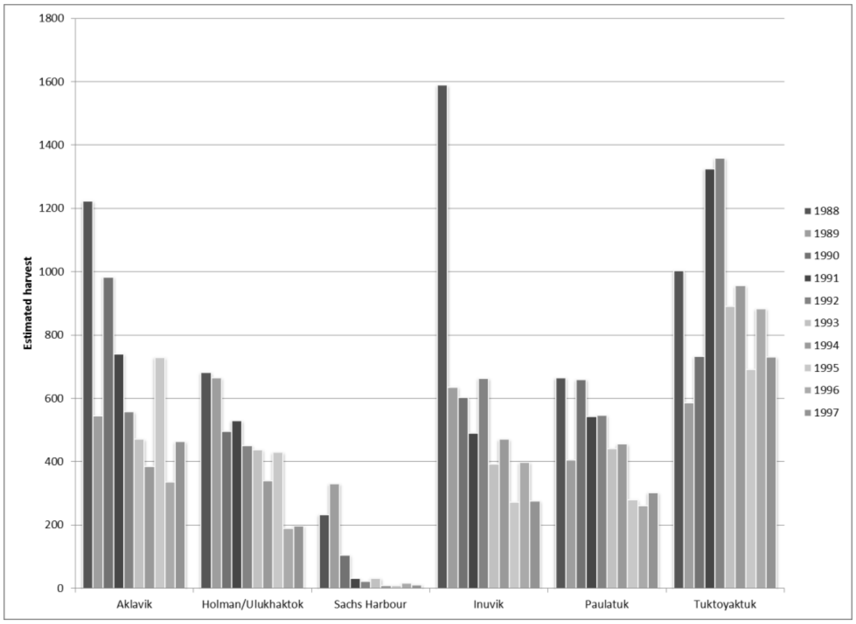

Figure 1.Numbers of caribou harvested in the Inuvialuit Settlement Region, 1988-1997 (Joint Secretariat 2003)

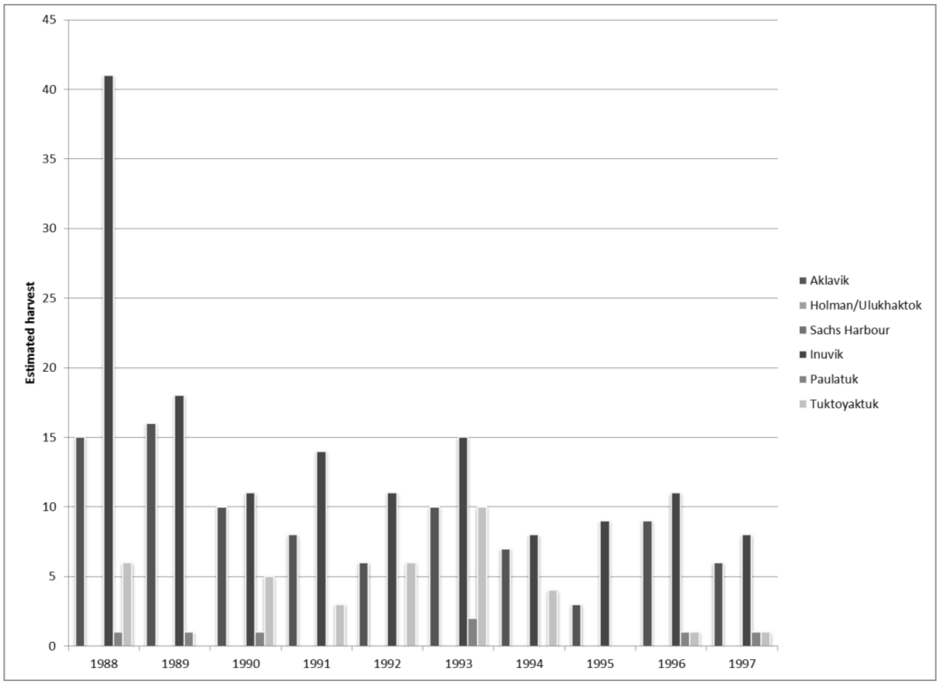

Figure 2. Numbers of caribou harvested in the Inuvialuit Settlement Region by community, 1988-1997 (Joint Secretariat 2003)

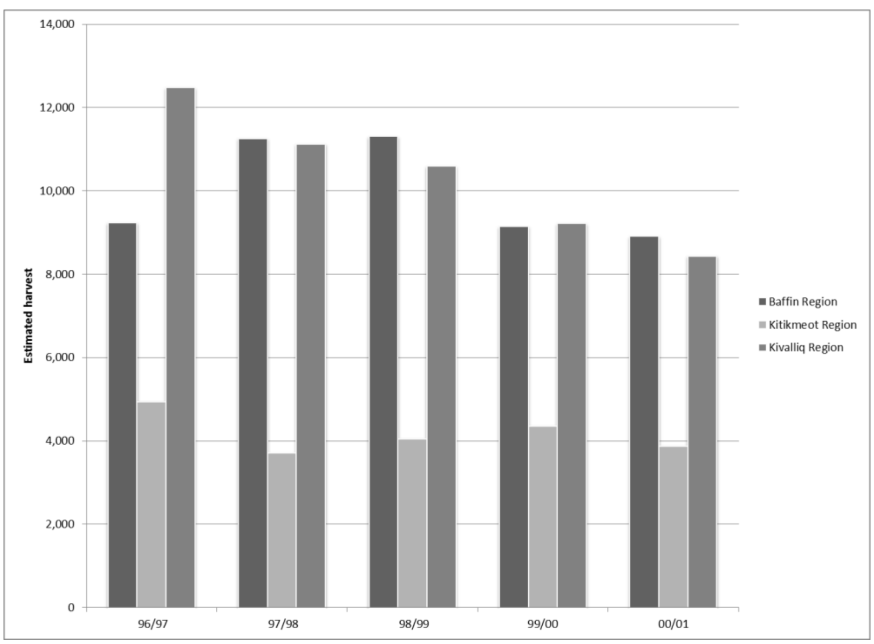

Figure 3. Number of caribou harvested in the Nunavut Settlement Area by region, 1996-2001 (Priest and Usher 2004).

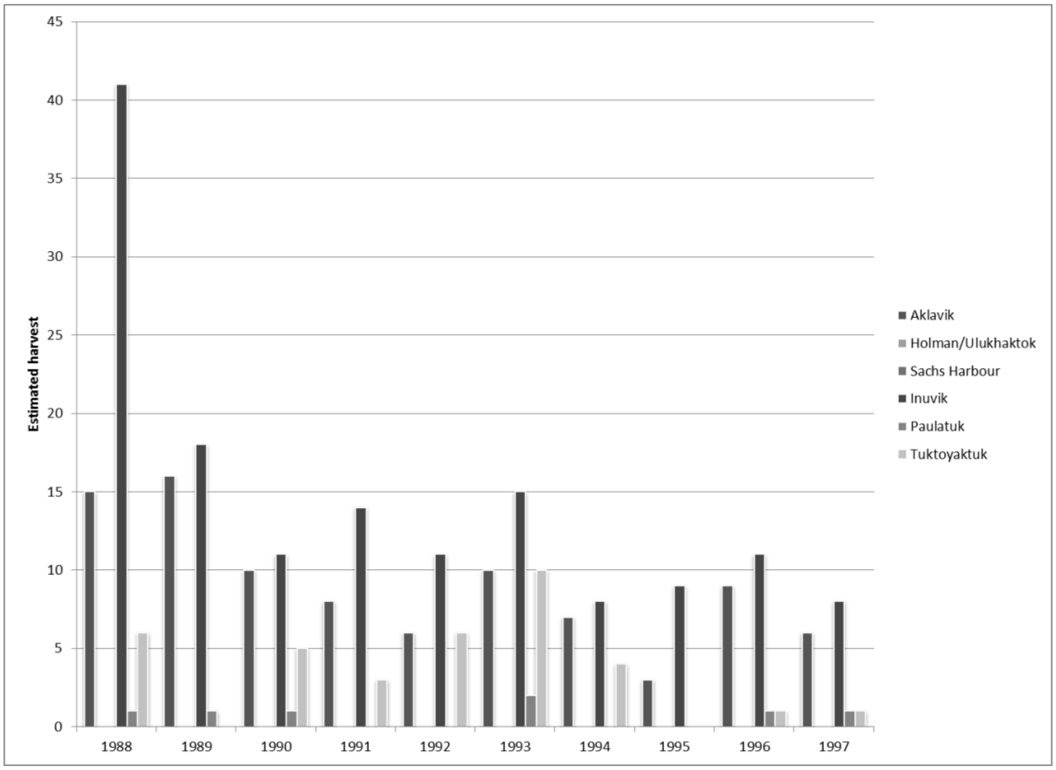

Figure 4. Numbers of caribou harvested in the Gwich'in Settlement Area, 1995-2001

Hunter effort is recorded as the average number of animals harvested per day or hours on the land is not reflected in the data; it is not apparent if hunters are spending less time on the land in a given month. Therefore, only number of caribou harvested per successful hunter (hunter with positive harvests) may be determined from the published harvest data. From the Gwich'in Harvest Study, numbers of caribou harvested per month and classified by herd or type ('Bluenose,' 'Porcupine,' and 'Woodland') are shown, though the number of hunters harvesting each species or type of animal is not available.

From the Inuvialuit and Nunavut data, the number of caribou per successful hunter ranges from 2 to around 9 on average across study communities. Jingfors (1986) found that in the Kitikmeot region of Nunavut in 1983-1984, successful hunters harvested, on average, 3.5 caribou a month. Caribou harvests in aggregate and per successful hunter appear to have declined over the survey periods for both the Inuvialuit and Nunavut surveys. In the Sahtu Harvest Study conducted in the period 1995-2001, average numbers of caribou per successful hunter per month ranged from 3.2 to 7.5 caribou, with the peak caribou harvesting month being October.

From the Gwich'in harvest survey data, it is found that the number of caribou harvested per hunter ranges from zero to 2. However, it is noted that the numbers of hunters harvesting are not listed in the report by species—not all hunters may be harvesting caribou and so the number of caribou per hunter harvesting caribou may be higher than the figure given.

Table 1. Number of caribou harvested per successful hunter, Inuvialuit Harvest Study 1988-1997 (Joint Secretariat 2003).

ISR	Number of caribou harvested/Number of hunters harvesting caribou successfully											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1988	6.2	6.8	5.9	4.7	3.8	2.9	3.7	4.4	6.9	7.2	9.1	8.5	5.8
1989	6	4.6	4.5	3.3	4.1	2.7	3.7	3.6	4	6.4	6.6	4	4.5
1990	5	4.4	4.3	3.6	4.4	3.1	2.1	4.2	4.4	5.2	6.3	5.8	4.4
1991	4.7	5.5	4.8	4.8	2.4	2.7	2	4.6	5.5	5.1	5.3	5.3	4.4
1992	4.4	5.1	5.2	3.8	3.5	2.3	1.5	4.4	4.4	6.1	5.1	3.7	4.1
1993	3.8	4.5	5	4.6	3.2	4.1	3	4.1	5.1	4.1	4.3	4.1	4.2
1994	4.2	6	4.4	3.4	3	4.1	4	4.6	5.1	5.1	4.6	4.4	4.4
1995	4.8	5.6	3.4	3.7	3.3	3.5	2.8	3.7	6.6	8.3	5.3	4	4.6
1996	4.8	5.3	5.8	3.4	4	4.4	3.4	4.4	5.8	6.4	6.5	7.8	5.2
1997	4.5	4.2	4.5	3.7	3.4	2.8	2.6	4	3.4	5.6	5.7	4.9	4.1
Mean	4.8	5.2	4.8	3.9	3.5	3.3	2.9	4.2	5.1	6	5.9	5.2	4.6

Table 2. Number of caribou harvested per successful hunter, Nunavut Wildlife Harvest Study 1997-2001 (Priest and Usher 2004).

Nunavut	Number of caribou harvested/Number of hunters harvesting caribou successfully											
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Mean
1996-1997	4.9	3.7	5.9	6.7	7.5	5.9	5.7	5.5	5.2	4.8	5.1	4.7	5.5
1997-1998	3.6	3.9	4.4	5.3	6.1	5.4	4.4	3.9	4.3	4.6	4.3	4	4.5
1998-1999	3.3	3.8	5	5.3	6	4.6	4.5	5	4.9	4.7	5	4.1	4.7
1999-2000	3.2	3.4	4.8	5.2	6.2	4.7	5	4.4	4.2	4	4.1	4.2	4.5
2000-2001	3.3	3.2	4.1	5	5.4	5	5.3	4.8	5.2	4.5	5.2	4.6	4.6
Mean	3.7	3.6	4.9	5.5	6.2	5.1	5	4.7	4.8	4.5	4.8	4.3	4.8

Table 3. Number of caribou harvested per hunter, Gwich'in Harvest Study 1995-2001 (MacDonald 2009)

Gwich'in	Number of caribou harvested/Number of hunters interviewed											
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Mean
1995-1996	0.29	0.44	0.69	0.34	0.55	1.34	0.63	1.29	0.99	0.09	0.03	0.04	0.56
1996-1997	0.22	0.68	0.44	0.22	0.60	0.46	1.22	1.09	0.89	0.02	0.00	0.01	0.49
1997-1998	0.42	0.15	1.54	0.88	0.57	1.73	2.04	0.79	0.45	0.00	0.00	0.00	0.71
1998-1999	0.13	0.38	1.56	0.29	0.25	0.34	0.23	0.35	0.83	0.07	0.04	0.00	0.37
1999-2000	0.11	0.60	0.57	0.12	0.08	0.20	0.22	0.09	0.12	0.09	0.00	0.00	0.18
2000-2001	0.18	3.14	0.82	0.33	0.16	0.42	0.58	0.65	2.31	0.11	0.00	0.08	0.73

Table 4. Number of caribou harvested per hunter, Sahtu Harvest Study

Sahtu	Number of caribou harvested/Number of hunters harvesting caribou successfully												
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Mean
95/96	4.9	3.7	5.9	6.7	7.5	5.9	5.7	5.5	5.2	4.8	5.1	4.7	5.5
96/97	3.6	3.9	4.4	5.3	6.1	5.4	4.4	3.9	4.3	4.6	4.3	4	4.5
97/98	3.3	3.8	5	5.3	6	4.6	4.5	5	4.9	4.7	5	4.1	4.7
98/99	3.2	3.4	4.8	5.2	6.2	4.7	5	4.4	4.2	4	4.1	4.2	4.5
99/00	3.3	3.2	4.1	5	5.4	5	5.3	4.8	5.2	4.5	5.2	4.6	4.6
00/01	3.7	3.6	4.9	5.5	6.2	5.1	5	4.7	4.8	4.5	4.8	4.3	4.8

From the Inuvialuit and Nunavut data, the number of caribou per successful hunter ranges from 2 to around 9 on average across study communities. Jingfors (1986) found that in the Kitikmeot region of Nunavut in 1983-1984, successful hunters harvested, on average, 3.5 caribou a month. Caribou harvests in aggregate and per successful hunter appear to have declined over the survey periods for both the Inuvialuit and Nunavut surveys. In the Sahtu Harvest Study conducted in the period 1995-2001, average numbers of caribou per successful hunter per month ranged from 3.2 to 7.5 caribou, with the peak caribou harvesting month being October.

From the Gwich'in harvest survey data, it is found that the number of caribou harvested per hunter ranges from zero to 2. However, it is noted that the numbers of hunters harvesting are not listed in the report by species—not all hunters may be harvesting caribou and so the number of caribou per hunter harvesting caribou may be higher than the figure given.

Appendix E. Dietary study results on caribou

Results from dietary studies where individual species are identified and values pertaining to cervid animals (woodland caribou, barren-ground caribou, and moose) are compiled and shown in the following table. In Kuhnlein (1994), it is shown that in Fort Good Hope, NT, moose is the most meat highly consumed food (delineated by species, animal part and cooking method) in terms of an average weighted score and barren-ground caribou meat is the third-most highly consumed food out of 101 country foods listed in the survey. In Fort Good Hope, it is found that barren-ground caribou meat is the most highly consumed food. Kuhnlein and Soueida (1992) also report an average weighted score for foods consumed by households in Broughton Island (now Qikiqtarjuaq) out of 35 delineated foods. Caribou is the second most highly consumed food, behind ringed seal. In Nunavik, it is found that caribou is the most popular foods, with 3.6% of respondents consuming. Batal et al. (2005) shows that in Denendeh communities in the Northwest Territories, barren-ground caribou is the most highly consumed food in terms of percentage of respondents consuming, while moose is more popular in the Yukon communities surveyed. Nakano et al. (2005) show that barren-ground caribou is most highly consumed food in among Dene/Metis and Yukon children across 5 communities. From the Inuit Health Study survey, reports that caribou is the most highly consumed food, in terms of proportion of respondents consuming, in the Inuvialuit Settlement Region, Nunatsiavut, and Nunavut (Egeland 2010a, b, c). While precise values are not reported, Tracy and Kramer (1999) found that in each of 5 communities (Baker Lake, NU, Rae-Edzo (now Behchoko, NT), Old Crow, YK, Aklavik, NT, and Fort McPherson, NT), over 95% of respondents reported consuming caribou meat from a 1989-1990 questionnaire.

Table 1. Woodland and barren-ground caribou and moose: Percentage of respondents consuming (%) and rank of relative frequency of consumption

Period	Season	Location	Woodland Caribou		Barren-ground Caribou		Moose		Source
			Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)"	Rank of proportion consuming (out of total number of foods listed) §	
1986-1987	Fall-early winter (Aug-Nov 1986); Spring-summer (Apr – Aug 1987) (n=120)	Fort Chipewyan, Alberta, and Fort Smith, NWT (combined) [*only proportion of sample consuming fat and organ meets reported*]	40.8% [bone marrow]		[*Type of caribou not specified; barren-ground and woodland combined*]		45.0% [bone marrow]	(Full species list not available)	(Wein, Sabry, and Evers 1991)
			32.5% [heart]				44.2% [heart]		
			31.7% [tongue]				44.2% [tongue]		
			21.7% [liver]				31.7% [kidney]		
			21.7% [kidney]				30.0% [liver]		
			5.0% [head]				11.7% [fat]		
			4.2% [fat]				5.8% [head]		
			3.3% [stomach and intestines]				5.0% [stomach and intestines]		
1988-1990	Summer (n=76),	Fort Good Hope, NWT	26.3% [Meat – cooked]	41/101	63.2% [meat – cooked]	8/101	93.4% [Meat – cooked]	1/101	(Kuhnlein et al. 1994)
			21.1%[Meat – dried]	50/101	51.3% [meat – dried]	18/101	56.6% [meat – dried]	13/101	
			18.4% [unspecified parts]	53/101	42.1% [unspecified parts]	29/101	51.3% [meat – unspecified parts]	18/101	
			14.5% [meat smoked]	56/101	25% [Liver]	43/101	40.8% [meat – smoked]	30/101	
			13.2% [liver]	63/101	22.4% [meat – smoked]	47/101	39.5% [liver]	56/101	
					3.9% [head]	73/101	31.6% [blood]	35101	
							2.6% [heart]	75/101	
1988-1990	Winter (n=68),	Fort Good Hope, NWT	39.7% [meat-cooked]	13/101	60.3% [meat-cooked]	4/101	82.4% [meat cooked]	3/101	

Period	Season	Location	Woodland Caribou		Barren-ground Caribou		Moose		Source
			Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)"	Rank of proportion consuming (out of total number of foods listed) §	
			33.8% [meat – dried]	16/101	35.3% [meat – dried]	16/101	60.3% [meat – dried]	4/101	
			5.9% [liver]	53/101	13.2% [liver]	34/101	20.6% [liver]	28/101	
			5.9% [head]	53/101	10.3% [head]	45/101	19.1% [blood]	30/101	
			4.4% [meat – smoked]	60/101	7.4% [heart]	50/101	16.2% [unspecified parts]	32/101	
			2.9% [heart]	66/101	7.4% [unspecified parts]	50/101	14.7% [heart]	33/101	
			2.9% [stomach – bible]	66/101	5.9% [meat - smoked]	53/101	13.2% [head]	35/101	
			2.9% [kidney]	66/101	4.4% [kidney]	60/101	13.2% [kidney]	35/101	
			2.9% [unspecified parts]	66/101	2.9% [stomach – bible]	66/101	8.8% [meat- smoked]	48/101	
					2.9% [intestine]	66/101	5.9% [intestine]	53/101	
							4.4% [stomach]	60/101	
							2.9% [lung]	66/101	
							2.9% [brain]	66/101	
							1.5% [hoof]	80/101	
1988-1990	Spring (n=93)[**]	Fort Good Hope, NWT	36.6% [meat – cooked]	14/101	57.0% [meat – cooked]	5/101	62.4% [meat – cooked]	4/101	
			18.3% [meat – dried]	22/101	44.1% [meat – dried]	7/101	37.6% [meat – dried]	12/101	
			7.5% [meat – smoked]	33/101	12.9% [meat – smoked]	26/101	16.1% [meat – smoked]	23/101	
			3.2% [liver]	47/101	11.8% [head]	27/101	10.8% [heart]	29/101	
			3.2% [head]	47/101	9.7% [liver]	30/101	8.6% [liver]	32/101	
			2.2% [heart]	51/101	9.7% [heart]	30/101	7.5% [head]	33/101	
			1.1% [kidney]	67/101	4.3% [unspecified parts]	44/101	4.3% [blood]	44/101	
					1.1% [stomach – bible]	65/101	4.3% [unspecified parts]	44/101	
					1.1% [intestine]	65/101	1.1%	65/101	

Period	Season	Location	Woodland Caribou		Barren-ground Caribou		Moose		Source
			Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)"	Rank of proportion consuming (out of total number of foods listed) §	
							[stomach]		
							1.1% [lung]	65/101	
1987-1988	Summer (n=11),	Colville Lake, NWT			81.8% [meat-cooked]	2/101	18.2% [meat-cooked]	10/101	
					18.2% [meat-smoked]	10/101	18.2% [meat – dried]	10/101	
					18.2% [meat-dried]	10/101	9.1% [liver]	16/101	
					9.1% [liver]	16/101			
					9.1% [unspecified parts]	16/101			
1987-1988	Winter (n=11)	Colville Lake, NWT	27.3% [meat – dried]	16/101	63.6% [meat-cooked]	2/101	63.6% [meat – cooked]	2/101	
			18.2% [liver]	26/101	63.6% [meat-dried]	2/101	54.5% [meat-dried]	8/101	
			9.1% [meat – cooked]	43/101	27.3% [stomach – bible]	16/101	18.2% [meat-smoked]	22/101	
			9.1% [unspecified parts]	43/101	18.2% [meat – smoked]	22/101	18.2% [liver]	22/101	
					18.2% [liver]	22/101	18.2% [blood]	22/101	
					18.2% [heart]	22/101	18.2% [heart]	22/101	
					18.2% [unspecified parts]	22/101	18.2% [head]	22/101	
					9.1% [kidney]	42/101	18.2% [stomach]	22/101	
							9.1% [hoof]	42/101	
							9.4% [unspecified parts]	42/101	
1987-1988	Spring (n=10)**	Colville Lake, NWT	10% [meat-cooked]	22/101	80% [meat-cooked]	4/101	30% [meat – cooked]	16/101	
			10% [meat-dried]	22/101	70% [meat – dried]	6/101	10% [meat – smoked]	22/101	
					30% [meat-smoked]	16/101	10% [meat – dried]	22/101	

Period	Season	Location	Woodland Caribou		Barren-ground Caribou		Moose		Source
			Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)"	Rank of proportion consuming (out of total number of foods listed) §	
					10% [head]	22/101	10% [heart]	22/101	
1987-1988	All – data taken every two months (Avg. of 67 households across survey periods)	Broughton Island (now Qikiqtarjuak, Nunavut	--	--	86.6% [Meat – raw or cooked]	2/35	--	--	(Kuhnlein and Soueida 1992)
				--	49.3% [Fat]	6/35		--	
				--	38.1%[Various – bone marrow, stomach, lungs, heart, liver, tongue, brain, stomach contents]	8/35		--	
1991-1992	Fall (1991)/Summer (1992)	Four Yukon Communities (Haines Junction, Old Crow, Teslin, Whitehorse)			64.8% [Caribou]	5/79	99.2% [Moose]	1/79	(Wein and Freeman 1995)
1987-1988	All seasons – data taken every two months (n=178)	Comms. in Nunavik, Quebec	--	--	3.60% [All caribou]	1/6	--	--	(Duhaime, Chabot, and Gaudreault 2002)
1989-1990	Survey included question about current week, winter, and summer	Baker Lake (n=241)	[*Type of caribou not specified*]		96.5%	1/18			(Tracy and Kramer 2000)
		Rae-Edzo (n-336)			96.8%	1/18			
		Old Crow (n=64)			100%	1/18			
		Aklavik (n=102)			97.9%	1/18			
		Fort McPherson (n=96)			96.3%	2/18			
1992/19	Aug.	Holman			45% [percentage of	1/7			(Condon, Collings,

Period	Season	Location	Woodland Caribou		Barren-ground Caribou		Moose		Source
			Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)"	Rank of proportion consuming (out of total number of foods listed) §	
93	1992-Jul. 1993 (n=16)	(Ulukhaktok), NT			evening meals that contain caribou]				and Wenzel 1995)
1994	Late Sep. (Female n = 299; Male n = 309)***	Eight Denendeh communities in the NWT	8.6%[Meat – baked]	5/13	55.4%[Meat – baked]	1/13	24.0%[Meat – baked]	3/13	(Batal. 2004)
			--	--	29.8%[Meat – dried]	2/13	3.5% [Meat – smoke/dried]	8/13	
			--	--	5.8%[Fat - raw]	6/13	--	--	
1995	Late February (Female n = 401; Male n = 309)***	Ten First Nations Comms. in Yukon	3.6% [Meat – baked]	3/13	0.9%[Meat – baked]	6/13	36.8%[Meat – baked]	1/13	
			--	--	0.3%[Meat – dried]	8/13	4.8% [Meat – smoke/dried]	2/13	
			--	--	0%[Fat -raw]	--	--	--	
			--	--	3.6%[Meat – dried]	--	--	--	
2000-2001; 2002	Nov.-Jan.; Aug.-Oct. (n=409)	Five comms. Dene/Metis and Yukon (Old Crow, Fort McPherson, Tulita, Fort Resolution, Carcross)	--	--	28 %[Meat – fried]	1/28	6.4%[Meat – Fried]	3/28	(Nakano et al. 2005)
			--	--	24%[Meat – boiled]	2/28	6.4%[Meat – boiled]	4/28	
			--	--	5.9%[Meat – dried]	5/28	1.5% [Meat – roasted]	13/28	
			--	--	5.5% [Ribs – cooked]	6/28	0.5% [Meat – baked]	20/28	
			--	--	2.0%[Heart – cooked]	10/28	0.5% [Bone marrow – cooked]	23/28	
			--	--	1.5%[Meat – Baked]	11/28	--	--	
2007-2008	Survey data from 12 months preceding survey (n=266)	Inuvialuit Settlement Region (Aklavik, Inuvik, Tuktoyaktuk, Sachs Harbour, Paulatuk,	--	--	95.9% [fresh meat]	1/10	--	--	(Egeland 2010a)
			--	--	77.2% [meat dried]	3/10	--	--	
			--	--	54.1% [heart]	10/10	--	--	

Period	Season	Location	Woodland Caribou		Barren-ground Caribou		Moose		Source
			Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)"	Rank of proportion consuming (out of total number of foods listed) §	
		Ulukhaktok)							
2008	Survey data from 12 months preceding survey (n=310)	Nunatsiavut (Nain, Hopedale, Postville, Makkovik, Rigolet)			98.1% [fresh meat] 84.0% [caribou ribs] 72.5% [caribou marrow] 66.8% [caribou meat (dried)] 62.6% [caribou heart]	1/10 4/10 5/10 7/10 10/10			(Egeland 2010b)
2007-2008	Survey data from 12 months preceding survey (n=1569)	Nunavut (Baffin – 13 communities; Kivalliq – 7 communities; Kitikmeot – 5 communities)			96.2% [fresh meat] 74.5% [meat dried] 70.5% [tongue]	1/10 3/10 6/10			(Egeland 2010c)
2007-2008	Late summer and fall in 2007 and 2008 (n=388 children 3-5y)	16 out of 25 communities of Nunavut			84.3%	1/30			(Johnson-Down and Egeland 2010)
2006-2010	(n=217) October and December	10 Nunavik communities			6.9% [Meat – baked] 3.2% [Meat - fried] 2.3% [Meat - boiled] 2.3% [Meat - raw] 0.9% [Meat - frozen]	1/34 3/34 5/34 6/34 14/34			(Gagné et al. 2012)

Period	Season	Location	Woodland Caribou		Barren-ground Caribou		Moose		Source
			Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)§	Rank of proportion consuming (out of total number of foods listed) §	Proportion consuming (%)"	Rank of proportion consuming (out of total number of foods listed) §	
					0.5%[Meat - dried]	23/34			
2006	(n=83)	Two Nunavut communities			32% [Caribou]	1/10			(Sharma et al. 2010)
					8% [Caribou soup/stew]	4/10			
					2% [Caribou fat or seal fat]	8/10			

§ Calculations by present author based on data reported in published article, unless otherwise specified
*Rank: Rank of proportion consuming (%) out of total number of foods listed
***Male and female average shown for present calculations

Table 2. Mean daily consumption (grams) of caribou per day from published literature

Period	Season data collected/method of estimation	Region/community	Mean or Median daily intake of caribou (g)			Source
			Woodland Caribou	**Barren-ground caribou**	**Moose**	
1967-1968	Based on body burden measurements of radio-cesium*** [*surveys "carried out in conjunction with community x-ray surveys… which were done routinely at that time"*]	Baker Lake, NU (n=190)		146		(Tracy and Kramer 2000)
		Rae-Edzo, NT (n=84)		142		
		Old Crow, YK (n=49)		194.5		
		Fort McPherson, NT (n=61)		116.5		
		Aklavik, NT (n=40)		64.5		
		Reindeer Station (n=55)		128.5		
		Rae Lakes (Gameti), NT (n=28)		259		
		Fort Good Hope, Fort Norman (Tulita), Fort Franklin (Deline), NT (n=114)		111.5		
		Colville Lake, NT (n=66)		560.5		
		Snowdrift (Lutsel'ke), NT (n=31)		178		
		Lac La Martre (Whati), NT (n=29)		112.5		
1989-1990	Based on body burden measurements of radio-cesium [*voluntary participation in survey*]	Baker Lake, NU (n=255)		53		
		Rae-Edzo, NT (n=341)		36.5		
		Old Crow, YK (n=64)		32		
		Fort McPherson, NT (n=107)		36.5		
		Aklavik, NT (n=96)		17.5		
1988	Sep. 1985 n=312	Broughton Island (Qikiqtarjuaq), NU		31		(Innis, Kuhnlein, and Kinloch 1988)
1987-1988	All seasons – data taken every two months	Communities in Nunavik, Quebec	--	54.5	--	(Duhaime, Chabot, and Gaudreault 2002)
1994	Late September (Female n = 299; Male n = 309) ***	Eight Denendeh communities in the NWT	337[Meat – baked]	271 [Meat – baked] 90 [Meat – dried] 58 [Fat]	253.5 [Meat – baked] 56.5 [Meat – smoke/dried]	(Batal et al. 2005)
1995	Late February (Female n = 401; Male n = 309) ***	Ten First Nations Communities in Yukon	36 [Meat – baked]	168.5[Meat – baked] 90.5[Meat – dried] 17.5 [Fat]	73 [Meat – baked] 10.5 [Meat – smoke/dried]	

Period	Season data collected/method of estimation	Region/community	Mean or Median daily intake of caribou (g)			Source
			Woodland Caribou	Barren-ground caribou	Moose	
2001	Spring (n=74)	Kugaaruk, NU		35	--	(Lawn and Harvey 2003)
2002	Spring (n=77)	Kangiqsujuaq, QC		5	--	(Lawn and Harvey 2004b)
2002	Spring (n=66)	Fort Severn, ON		33	--	(Lawn and Harvey 2004a)
1992	Spring (n=62)	Repulse Bay, NU		120	--	(Lawn and Harvey 2001)
1997	Spring (n=71)			93	--	
1992	Spring (n=116)	Pond Inlet, NU		169	--	
1993	Spring (n=123)			145	--	
1997	Spring (n=136)			112	--	
2007-2008	Survey data from 12 months preceding survey (n=266)	Inuvialuit Settlement Region communities (Aklavik, Inuvik, Tuktoyaktuk, Sachs Harbour, Paulatuk, Ulukhaktok)		66.7 [fresh meat]; 30.2 [meat dried]; 7.0 [heart]		(Egeland 2010a)
2008	Survey data from 12 months preceding survey (n=310)	Nunatsiavut (Nain, Hopedale, Postville, Makkovik, Rigolet)		67.3 [fresh meat]; 14.1 [caribou ribs]; 6.6[caribou marrow]; 30.8 [caribou dried]; 58.5 [caribou heart];		(Egeland 2010b)
2007-2008	Survey data from 12 months preceding survey (n=1569)	Nunavut (Baffin – 13 communities; Kivalliq – 7 communities; Kitikmeot – 5 communities)		96.2 [fresh meat]; 74.5 [meat dried]; 70.5 [tongue]		(Egeland 2010c)

***Male and female average

Appendix F. Self-perception and qualitative surveys

A special class of surveys that involves reporting of self-perceptions has been developed to measure food security, not only dietary quality specifically. The objective of this study is not to assess the impact of caribou consumption on food security, so it is useful to examine this type of survey tool. These food security surveys have been called "subjective-qualitative" tools—they involve gathering information on how individuals express their own or their household members' perceptions and responses to food insecurity in a structure framework, where the responses are used to calculate specific measures (Webb et al. 2006).

One of these survey types allows households to be categorized as food secure/insecure based on a scale measure. The most widely used of this survey type is the USDA's Household Food Security Survey Module (HFSSM), developed by the USDA based on work by Kathy Radimer at Cornell University (Bickel et al. 2000, Radimer 2002).

The core survey module asks a set of 18 questions about the following topics, as outlined by the USDA (Bickel et al. 2000):

- Anxiety that the household food budget or food supply may be insufficient to meet basic needs.
- The experience of running out of food, without money to obtain more.
- Perceptions by the respondent that the food eaten by household members was inadequate in quality or quantity.
- Adjustments to normal food use, substituting fewer and cheaper foods than usual.
- Instances of reduced food intake, or consequences of reduced food intake, for children in the household.

The conditions expressed in the questions reflect various experiential or behavioural stages of food insecurity. The first stage involves "inadequacy in food supplies and food budgets" and anxiety about meeting basic needs and adjusting the food budget and types of food purchased, the second stage involves adults reducing food intake so children have food, and the next stage involves children beginning to reduce food (Bickel et al. 2000). This model of behaviour was developed based on researchers' gathered accounts of how individuals in the United States perceived and responded to food insecurity (Campbell 1991, Bickel et al. 2000).

The responses to the questions can be combined into a continuous, linear scale called the food security scale. To compute the food security score, it is first necessary to categorize or code household responses. Affirmative responses to questions are given a score of "1"; the maximum number of points is 18 for households with children and 10 points for households without children. Based on the sum of affirmative responses, households may be assigned a score between 0 and 10, where 0 indicates that the household is food secure, and 10 indicates food insecurity status. The computational method used by the USDA to relate the number of affirmative responses to the scale score is the Rasch measurement method based on Item-Response Theory (IRT), which involves the assumption that the probability of a household affirming a specific item depends on the relative severity (of food security) of the household and the severity the item reflects (detailed in Bickel et al. 2000). Most applications of the USDA HFSSM assign scores based on the guide compiled by the USDA rather than computing raw scores with Rasch measurement software. The core module of the survey contains 18 questions, but for time-constrained situations, a 6-question subset can also be used to identify a scale score. In 2004, Health Canada (2012b) adopted the 18-question module in its national survey and calculated separate scores for adult and children in order to identify the levels of food security in each population.

This single numerical value indicates "the degree of severity of food insecurity/hunger experienced by a household," with the full scale spanning the range of severity experienced (Bickel et al. 2000). The USDA uses the scores to place households into one of four categories, each of which represents a range of severity: *high food security*, *marginal food security*, *low food security*, and *very low food security* (USDA 2012). Prior to 2006, the categories described food insecurity either with or without "hunger" (USDA 2012). This classification scheme was abandoned because various government agencies came to recognize more clearly "hunger" as an individual level phenomenon that is subjective and cannot be measured very well with the module. Health Canada (2012b) adjusts these thresholds—a fewer number of affirmative responses is required to place a household in a 'food insecure' category. The three categories of food insecurity defined by Health Canada are: '*food secure*', '*food insecure – moderate*', '*food insecure – severe*'.

The developer of the module, the USDA, suggests that the module questions work systematically together to indicate the level of severity of food insecurity experienced in the household; although individual questions may represent certain indicators of the condition, they should not be taken alone as meaningful measures of food insufficiency or food insecurity (Bickel et al. 2000). Despite this, users of the HFSSM typically show proportions of affirmative responses to illustrate trends in some of the underlying behaviours in a population (e.g. Lawn and Harvey 2001, Melgar-Quinonez et al. 2006). The numerical scores or food security status categories may be coded as variables and used in regression analysis to show how the food security measure is correlated with socio-demographic characteristics such as income, type of employment or individual measures such as whether or not the person is obese or overweight.

The USDA HFSSM was viewed as an improved measure of food security status in the United States from the previously used measures of income and poverty levels (Bickel et al. 2000). Radimer (2002) states that the scale measure reflects "sufficiency of household food as perceived by the household and not the nutritional adequacy of diets as a nutritionist would measure it." In addition, questions do not address all aspects of the food insecurity "phenomenon," including food safety, nutritional quality of diets, and "social acceptability" of food sources (Bickel et al. 2000). For example, while a higher household food security score may suggest the household is consuming a nutritionally adequate diet, this may not be confirmed by looking at the scale score. What the scale measure more closely identifies is the household's food *economic accessibility* (as defined as a component of food security). The operational definition of food security in the HFSSM is stated: "Access by all people at all times to enough food for an active, healthy life. Food security includes at a minimum: (1) the ready availability of nutritionally adequate and safe foods, and (2) an assured ability to acquire acceptable foods in socially acceptable ways (e.g., without resorting to emergency food supplies, scavenging, stealing, or other coping strategies)." As such, households classified as "food insecure" face the condition as it results from "financial and resource constraint" (Bickel et al. 2000). Each of the module questions is asked in way that assures that the reported behavior or condition occurred as a result of financial limitations by including phrases such as "because we couldn't afford that" or "because there wasn't enough money for food," and not out of voluntary behavior (Bickel et al. 2000; Campbell 1991).

An advantage of this using the food security module survey is that it captures the periodicity or frequency of food insecure episodes, and can also provide an assessment of household food security for the relatively long period of one year. This type of instrument has been widely used in developed countries since it has been recognized that the methods of measuring welfare in terms of expenditures on goods and services and measuring nutritional outcomes at certain price and income levels may not be relevant for households that are not in extreme poverty like those in economically undeveloped regions (Webb et al. 2006). Though the questions ask if the household has enough food or money to meet its basic needs, the survey may or may not ask for data on potential correlates such as household income. Therefore, the scale score itself is not useful for showing how household behaviours may change with changes in their budget or resource constraints.

Although this method was designed in the United States, it has been used in other developed countries like Canada, where it has been incorporated into the National Population Health Survey (NPHS) and the Canadian Community Health Survey (CCHS). It has also been administered in remote communities in Northern Canada (Lawn and Harvey 2001, 2003, 2004a, 2004b) with some modifications to the wording of questions to be more meaningful to Aboriginal populations.

It has also been used in developing countries such as Bolivia, Burkina Faso, the Phillippines, Brazil with some modification of the questions (Melgar-Quinonez et al. 2006, Melgar-Quinonez et al. 2007). More recently, a few international agencies have developed and tested an instrument called the Food Access Survey Tool (FAST) that is a 9-question tool based on the USDA module (Coates et al. 2003). This tool also asks questions on perception but is designed to fit the observed behaviours in developing countries.

Another approach that asks about household perceptions of food security is the coping strategies approach. The coping strategy approach was developed by Maxwell (1996) and involves asking the following questions:

Question: Because **food is not enough, or money to buy food is not enough**, in the past month, how often have you had to (*REPEAT FOR EACH QUESTION*)	
1. Rely on less preferred and less expensive foods?	Every day/ 3-6x per week / 1-2x per week / <1x per week/ Never
2. Borrow food, or borrow money to buy food?	Every day/ 3-6x per week / 1-2x per week / <1x per week/ Never
3. Purchase food on credit?	Every day/ 3-6x per week / 1-2x per week / <1x per week/ Never
4. Rely on help from relative or friend outside household (including remittance for 'chop' money)?	Every day/ 3-6x per week / 1-2x per week / <1x per week/ Never
5. Limit portions at mealtimes?	Every day/ 3-6x per week / 1-2x per week / <1x per week/ Never
6. Ration the little money you have to household members to buy street foods?	Every day/ 3-6x per week / 1-2x per week / <1x per week/ Never
7. Limit your own intake to ensure child gets enough?	Every day/ 3-6x per week / 1-2x per week / <1x per week/ Never
8. Reduce number of meals eaten in a day?	Every day/ 3-6x per week / 1-2x per week / <1x per week/ Never
9. Skip whole days without eating?	Every day/ 3-6x per week / 1-2x per week / <1x per week/ Never

Maxwell first classified types of strategies. As explained by Babu and Sanyal (2009), this approach involves developing a food security score for the household, which can be calculated using values for the frequency of each strategy and a severity weighting factor based on an ordinal ranking. This method was used by Chabot (2008) in Northern Canada (Kuujuaq, Nunavik).

This section outlined a few instruments which involved using data on self-reported perceptions of food security. Babu and Sanyal (2009) refers to the scaling and coping strategy approaches as methods "in vogue" that contrast more traditional approaches such as expenditure surveys, nutrition surveys, or regional food balance sheets. However, Bickel et al. (2000) outline some important uses of scale survey responses: i) they can be used to identify regions of food insecurity and help target food assistance efforts, or track the impact of economic changes, ii) changes in food security scores can help assess whether or not income or other assistance programs are working, and iii) the measures can be included in measures of overall food security status of a community. A limitation to the USDA instrument is that it was developed in an American context, though modifications can be made. Special considerations on the linguistics, cultural translation, and characteristic patterns of perception and response for any non-American population must be made (Bickel et al. 2000).

The USDA food security module has frequently been used by the government and other researchers to study food security in northern Canada. The food security module questions were employed in a few Indian and Northern Affairs food and nutrition studies: 1992 and 1993 surveys in Nunavut (Pond Inlet, Arctic Bay, Repulse Bay, Coral Harbour and Gjoa Haven), Labrador (Nain and Davis Inlet) and Ontario (Fort Severn), repeat 1997 surveys in Repulse Bay and Pond Inlet, 2001 survey in Kugaaruk, Nunavut, 2001 survey in Kangiqsujuaq, Nunavik, and 2001 survey in Fort Severn, Ontario (Lawn and Langner 1994, Lawn and Harvey 2001, 2003, 2004a, 2004b). The household food security module was also incorporated into a few cycles of the Canadian Community Health Survey (CCHS). CCHS cycles 1.1, 2.1, 3.1, and 4.1 were administered in northern Canada, with region-level statistics published in Ledrou and Gervais (2005). Aside from traditional consumption surveys, dietary surveys, and specialized food security instruments, patterns of food consumption and harvesting in northern Canada may be analysed from responses to government surveys.

The USDA food security module was modified slightly in the surveys to make the questions more culturally acceptable in northern Canada (the questions were deemed by a researcher of the USDA not to affect the scale measure). Additional perception questions not in the original module were added in the INAC studies. In the 1997 surveys, respondents were asked about their ability to feed their family compared to five years previously, and were also asked whether or not they felt if "most people in [the] community can afford to buy enough food to feed their families," and whether "most families who are on social assistance in the community can afford to buy enough food to feed their family." The INAC surveys in Kugaaruk, Kangiqsujuaq, and Fort Severn also included additional questions in the food security portion of the study on specific reasons households could not afford food.

Egeland, Faraj, and Osborne (2010) administered the 18-question food security module to families with children in 16 communities in Nunavut in 2007 and 2008. From the responses, households were placed into categories of whether or not children in the household are food insecure (and whether moderately or severely). The authors compared the responses to each of the 18 questions among these groups. The authors combined the food security survey results to the body masses of children in the household. Ford and Berrang-Ford (2009) administered the 18-question module in Igloolik, Nunavut, in 2007 and reported the percentage of the respondents in each of the four food insecurity categories outlined by the USDA.

To develop a coping strategy survey, a list of possible coping strategies must be developed. Chabot (2008) adapts Maxwell's list to a Canadian Arctic setting. The analysis was carried out in Kuujjaaq, Nunavik. A coping strategy question was also included in the food security questionnaire in the INAC studies. The question asked how households coped with not having food and asked if they used the following strategies: "ask social assistance for more money," "ask store manager for more credit," "borrow basic food from family/friends," "go hunting or fishing," "ask help from doctor or nurse," "do without," and "make carving or craft to sell."

This approach enables researchers to understand short-term food insufficiency but does not address longer term aspects of food insecurity (Babu and Sanyal 2009).

However, the coping strategies approach is useful for determining factors that might influence household food choice and allow further modeling of those factors.

A number of surveys with qualitative questions have been undertaken by researchers to understand perceptions regarding economic and physical accessibility, availability of country and market foods, and other factors affecting food security in the North. Some of these surveys also collect demographic and socio-economic data. Lambden, Receveur and Kuhnlein (2007) ask a set of question in order to examine observed changes to traditional food systems and the perceived advantages and health benefits of traditional food and traditional food preferences. Lambden et al. (2006) also use qualitative questions to assess perceptions on household access to traditional and market foods in the Arctic.

These surveys may be analysed with basic statistical tools like descriptive statistics. These surveys may address topics that are addressed by other survey instruments by asking questions related to household vulnerability, coping strategies, and views on nutrition. They may not be extremely useful in any advanced statistical or economic analysis, which typically require data from quantitative responses. However, Lambden et al. (2006) argue that the "socio-cultural questionnaire" is useful in helping to identify issues surrounding the use of traditional foods because "it is questionable whether [national surveys like the NPHS and CCHS] are useful in understanding the role traditional foods may have in food security for Arctic populations." Therefore, qualitative surveys may be implemented by researchers who wish to focus on specific topics that are not addressed by government surveys.

This section outlined various types of surveys that address household food security. Though the described questionnaires differ from traditional consumption surveys that record quantities of food consumed and expenditures, they are useful in capturing both social and economic factors related to household food security. Bickel et al. (2000) outline some important uses of scale survey responses: i) they can be used to identify regions of food insecurity and help target food assistance efforts, or track the impact of economic changes, ii) changes in food security scores can help assess whether or not income or other assistance programs are working, and iii) the measures can be included in measures of overall food security status of a community. A limitation to the USDA instrument is that it was developed in an American context, though modifications can be made. Special considerations on the linguistics, cultural translation, and characteristic patterns of perception and response for any non-American population must be made (Bickel et al. 2000). In Canada, the food security responses in the INAC and other surveys have illustrated disparities in food security levels between northern and other regions of Canada. The USDA household food security module has been widely administered in the study area of Northern Canada, with results generally suggesting a prevalence of food insecurity

As noted in section Chapter 2, cycles 1.1, 2.1, 3.1, and 4.1 of the Canadian Community Health Survey (CCHS) were administered in northern Canada, with food security survey results showing that the prevalence of food insecurity is higher for the northern territories than for Canada as a whole—56% of respondents in Nunavut, 28% in the Northwest Territories, and 21% in the Yukon reported to be food insecure, compared with a national average of 14.7% (Ledrou and Gervais 2005).

Table 1. Qualitative and other (non-dietary) food security studies in northern Canada

Communities	Citation	Objectives/concepts	Data	Analysis and Results
Inuit, Dene/Metis, and Yukon across three territories.	Lambden, J., O. Receveur, J. Marshall, and H. V. Kuhnlein. 2006. Traditional and Market Food Access in Arctic Canada Is Affected by Economic Factors. International Journal of Circumpolar Health 65(4): 331-340.	Evaluate access of Indigenous women to traditional and market foods.	Used data from cross-sectional survey of Yukon First Nations, Dene/Metis, and Inuit women in 44 Arctic communities. Survey of 1771 women stratified by age. 7 open-ended response questions on sociocultural aspects and the ability to obtain food.	Regional variation in ability to afford adequate food and variation in the percentage of those who could afford or had access to hunting and fishing equipment. 40% to 60% said they could afford adequate food, up to 50% said they had inadequate access to fishing and hunting equipment, and 46% said they could not afford to go hunting or fishing. Among Dene/Metis, age affected access and affordability of fishing and hunting equipment, with elderly having more limited access. Among the Inuit, the middle-income range had greatest access to traditional foods.
Nunavik, Quebec.	Chabot, M. 2008. Assessing Food Insecurity in the Arctic: An Analysis of Aboriginal Household Coping Strategies - A Case Study in Nunavik.	Hypothesizes that lack of monetary resources is a key factor in food insecurity, even in places with widespread sharing.	Community: Kuujjuaq, Nunavut. Data collected on income, expenditures, production, savings, taxes, and food intake for each household member. Interview Guide and questionnaire on coping strategies used. Randomly selected sample of low income households. 29 households represented.	Coping strategies to food insecurity include "borrowing money," "going to the community freezer," "asking for food," "eating less," "asking a housemate for money," "cutting back on food expenditures"
Inuit, Dene/Metis, and Yukon across three territories.	Lambden, J., Receveur, O., and H.V. Kuhnlein. 2007. Traditional Food Attributes Must be Included in Studies of Food Security In the Canadian Arctic	Address "understudied" characteristics of Arctic food security: changes in traditional food systems, advantages and benefits of traditional food and traditional food preferences.	Used data from cross-sectional survey of Yukon First Nations, Dene/Metis, and Inuit women in 44 Arctic communities. 5 qualitative questions with open ended responses on role of traditional foods and culture of harvesting and using traditional foods.	This research reported the foods that women in each region feel are "especially good for health." The Inuit reported caribou fish, and seal as the top foods. Traditional food is perceived to be healthy despite concerns about changing quality of food (38.2% of the sample noticed changes in quality or health of food).
Inuit communities in Nunavut.	Chan, H.M., Fediuk, K., Hamilton, S., Rostas, L., Caughey, A., Kuhnlein, H., Egeland, and E. Loring. 2006. Food Security in Nunavut: Barriers and Recommendations.	To assess community perceptions about availability and accessibility of traditional market foods in Nunavut, Canada.	Qualitative study with focus groups conducted in 6 communities in Nunavut in 2004.	Factors affecting food security include income, living and hunting costs, societal changes in terms of diet, lifestyle, cultural practice. Participants dissatisfied by the cost, quality and variety of food in stores. Food security can be gained through increased wages for workers, economic support for community hunts, freezers, and education programs.

	International Journal of Circumpolar Health 65(5): 416-430.			
Fort Severn, Ontario.	Lawn, J., and D. Harvey. 2004. Nutrition and food security in Fort Severn, Ontario: baseline survey for the food mail pilot project.	In Janaury 2003, rate for shipping for Priority Perishables to Fort Severn reduced from $0.80 to $0.30 per kilogram plus $0.75 per parcel. Goals of study: i) to evaluate food purchasing patterns and food security status of households in Fort Severn prior to implementation. ii) To assess nutrient intakes and the general health status of First Nation women of child-bearing age in Fort Severn.	Assessment tools: Household questionnaire (questions on where they had purchased foods, where certain foods were purchased, perception of quality of certain Priority Perishable Foods, reasons for not buying fresh fruit and vegetables and milk, 18-item US Food Security Survey module, sociodemographic factors, and other),	Families on social assistance or working poor significantly more food insecure than well-off families. No statistically significant relationship between food security status and socio-economic group and mean intakes of calcium, folate and vitamin A.
Two Inuit communities—Repulse Bay, NU, and Pond Inlet, NU.	Lawn, J., and D. Harvey. 2001. Changes in Nutrition and Food Security in Two Inuit Communities, 1992 to 1997.	To determine if changes to Northern Air Stage Program (Food Mail Program) have resulted in increased consumption of nutritious perishable foods and affected nutrition, food security, and health of Aboriginal people in isolated communities. Also examination of other factors that may have contributed to changes in food security.	Survey of Inuit women aged 15 to 44 in 1997 in Repulse Bay and Pond Inlet. Same communities had participated in INAC surveys in 1992. Survey includes 24-hour recall, food frequency questionnaire, questions regarding food security and changes in food affordability compared to five years before study, and a questionnaire on heatlh, lifestyle and socioeconomic conditions.	Food Security module results: Approximately half respondents felt that most people in the community could not afford to purchase enough food for their families. In 1997, half of women in households reported not enough to eat in past month. Repulse Bay in 1992 over 2/3rds reported this problem. Pond Inlet in 1993over 2/3rds reported this problem. Therefore there has been improvement between 1992 and 1997 as shown in food security indicators. Lack of a strong relationship between energy intake and socio-economic status. This is attributed to the fact that more well-off families may share with lower-income families. Relatively well-off families reported running out of money for food less often.
Inuit in Igloolik, Nunavut.	Ford, J.D. and L. Berrang-Ford. 2009.	Exploratory study of food security in Igloolik,	Stratified cross-sectional food security survey administered to 50 participants	Food insecurity among sample greatly exceeds national average. Prevalence and severity of food insecurity differed, with those obtaining

	Food Security in Igloolik, Nunavut: An Exploratory Study. Polar Record 45(234): 225-236.	Nunavut. Identifying high risk groups, identify conditions facilitating and constraining food security. Focus on individual perception of ability to access food, availability of food, and quality of food which is accessible and available. Identify key trends and variables related to food security within study population. Igloolik has both wage economy (from administration and tourism) and subsistence hunting.	in July 2007. Interview length between 15 and 45 minutes. Participants selected based on quota sampling, a non-probabilistic approach to finding a sample that seeks to reproduce a distn of characteristics relevant to research problem. Survey of 4 sections with 5 close ended questions. Section 4 of the survey built upon U.S. Department of Agriculture's (USDA) food security survey.	their food from the store at greatest risk of food insecurity. Consumption of traditional foods associated with increased food security. Participants who hunt for a living more likely to be food secure than those engaged in the waged sector. Food security status not shown to different significantly by age, unlike some other studies which suggest that young Inuit have changing dietary patterns and less interest in hunting.
Inuit in Igloolik, Nunavut.	Ford, J.D. and M. Beaumier. 2010. Feeding the family during times of stress: experience and determinants of food insecurity in an Inuit community. The Geographic Journal 177(1): 44-61.	To characterize determinants of food insecurity in the community of Igloolik, Nunavut.	Semi-structured interviews (n=66), focus groups (n=10) and key informant interviews (n=19) conducted in Fall 2008. Participatory mapping was used to identify changes in hunting patterns, and location and operation of hunting camps.	Widespread food insecurity reported; those who are presently food secure reported experiencing food insecurity—experiences of constrained access, availability, and quality of food—in the recent past. Food insecurity attributed to: "food affordability and budgeting, food knowledge and preferences, food quality and availability, environmental stress, declining hunting activity, and costs of harvesting." Food sharing is also reportedly weakened, with younger generations and non-hunters less inclined to share with others, and some individuals asking for money for country foods.
Inuit women in Igloolik, Nunavut.	Beaumier, M. and J.D. Ford. Food Insecurity among Inuit Women Exacerbated by Socio-economic Stresses and Climate Change. Canadian Public Health Association 101(3): 196-201.	To characterize determinants of food insecurity among Inuit women in the community of Igloolik, Nunavut.	Semi-structured interviews (n=36), focus groups (n=5) and key informant interviews with health profesionals (n=13) conducted in Fall 2008 and Winter 2009.	The respondents reported the follow barriers to achieving food security: price, availability and quality of store food, poverty and not being able to pay for daily needs, knowledge on store foods, gambling and substance addictions, high hunting costs, budgeting skills and running out of money for food when other expenses such as power bills or house rental payments are due, environmental conditions relating to transport of store food (flight delays), access to hunting areas, which are influence by ice trail conditions, from November to July.

Inuit in 36 communities in Inuvialuit Settlement Region, Nunavut, and Nunatsiavut	Huet, C., R. Rosol, and G.M. Egeland. 2012. "The Prevalence of Food Insecurity Is High and the Diet Quality Poor in Inuit Communities." Journal of Nutrition 142(30):541-547.	To relate food security survey module and Healthy Eating Index (HEI) scores to indicators such as BMI, waist circumference, and percent body fat, household crowding, income support, public housing, being in a single adult household, having a home in need of major repairs, and having an active hunter in the home	24-hour recall, 18-item USDA food security survey module. 2796 households approached and 1901 participating households, with 2595 individuals participating.	Food insecurity was found in 62.6% of households. Adults from food insecure households had a significantly lower HEI score, lower consumption of vegetables and fruit, grains, and dairy products, higher percent of energy from high-sugar foods than adults from food secure households. Food security was associated with household crowding, income support, public housing, single adult houesholds, and having a home in need of major repairs, while households identified as "food insecure" had a lower prevalence of having an active hunter.

Appendix G. Detailed data for expenditure analysis

Table 1. Consumer Price Index

Consumer Price Index	2006	2010
	2002=100	
All-items	112.3	122.7
Food	107.8	121.8
Food purchased from stores	106.5	120.4
Meat	103.9	114.4
Fresh or frozen meat (excluding poultry)	100.7	108.6
Fresh or frozen poultry meat	107.1	121.2
Processed meat	105.3	116.3
Fish, seafood and other marine products	93.4	104.3
Fish	97.8	112.2
Seafood and other marine products	.	.
Dairy products and eggs	113	130.9
Dairy products	113	131.3
Eggs	113.2	126.3
Bakery and cereal products (excluding infant food)	112.8	136.8
Bakery products	118.9	148.1
Cereal products (excluding infant food)	104.4	121.1
Fruit, fruit preparations and nuts	99	110
Fresh fruit	95.9	101.4
Preserved fruit and fruit preparations	103.5	120.7
Nuts	.	.
Vegetables and vegetable preparations	96.6	106.4
Fresh vegetables	92.8	99.6
Preserved vegetables and vegetable preparations	109.1	128.4
Other food products and non-alcoholic beverages	109.4	121.3
Sugar and confectionery	119.4	138
Fats and oils	109.7	132.5
Coffee and tea	110.1	119.4
Condiments, spices and vinegars	.	.
Other food preparations	.	.
Non-alcoholic beverages	100.4	112.4
Food purchased from restaurants	110.4	124.7

Reference: Statistics Canada 2012a. CANSIM series 321-0001.

Table 2. Wage Rates ($/hour) for Northwest Territories and Nunavut - Wage Rates as of May 25, 2006.

Reference: (Human Resources and Skills Development Canada 2009a, 2009b)

Northwest Territories	**($/hour)**	**Nunavut**	**($/hour)**
Electricians	$28.77	Plumbers	$23.61
Plumbers	$29.82	Carpenters	$21.18
Carpenters	$24.88	Plasterers, Drywall Installers, Finishers and Lathers	$19.36
General Welder/CWB	$24.78	Truck Drivers	$18.25
Plasterers, Drywall Installers, Finishers and Lathers	$26.56	Operators of Heavy Equipment (Excluding Cranes, Graders, Asphalt Paving Machinery Operators)	$19.87

Painters	$22.2	Trade Helpers and Labourers (Excluding Asphalt Layers, Flag Persons, Form Setters and Jackhammer Operators)	$16.94
Heavy Duty Equipment Mechanics	$27.84		
Truck Drivers	$20.23		
Operators	$23.66		
Heavy Equipment (Except Cranes, Graders, Asphalt and Paving Machines)	$16.80		
MEAN per hour	$24.55	MEAN per hour	$19.87
MEAN wages per day	$196.43	MEAN wages per day	$158.95

Table 3. Mixed Dish Recipes

Recipe name and ingredients	Gram weight	Percentage of total dish weight in kg or mL (%)	Percentage by food group	**Dietary recall mixed dishes**
Caribou Stew (No rice)				
1 tbsp oil	13.6	1%	**Caribou meat**	Caribou and beef stews: Meat sauces made withv vegetables; Other dishes – meat mixed with vegetables
1½ pounds caribou meat	679.95	25%	25%	
1 large onion, chopped	150.00	6%	**Vegetables**	
2 stalks of celery, chopped	80.00	3%	32%	
½ cup turnip, chopped	65.00	2%	**Tomato sauce**	
3 small carrots, chopped	150.00	6%	11%	
2 medium potatoes, chopped	416.00	15%		
3 cups water	709.80	26%		
1 can tomato or cream of mushroom soup or 1 envelope soup mix	294.00	11%		
2 tbsp flour or cornstarch	15.63	1%		
½ cup cold water	118.30	4%		
salt and pepper to taste	--	--		
Caribou/Muskox Stirfry				
1 kg musk-ox (or Caribou), sliced against the grain	1000.00	45%	**Caribou meat**	Caribou and beef stirfrys (without rice)
¼ cup soy sauce (Kikkoman)	63.75	3%	45%	
1 tsp vegetable oil	4.50	0.2%	**Vegetables**	
1 tsp powdered ginger	1.80	0.1%	50%	
1-2 tsp minced garlic	4.20	0.2%		
1 tbsp vegetable oil	13.60	1%		
1 onion, sliced into long strips	110.00	5%		
½ kg frozen vegetables (broccoli, Asian, California mix – whatever is on hand)	500.00	23%		
1 can baby corn	482.00	22%		
1 tbsp corn starch	8.00	0.4%		
1 tbsp water	14.79	1%		
Caribou/Muskox Stirfry (with Rice)				
Water – ½ cup	125	3%	**Caribou meat**	Caribou stirfry with rice
Cornstarch – 2 tbsps	16	0.40%	25%	
Soya sauce – 3 tbsps	48	1%	**Vegetables**	
Oil – 3 tbsps	40.8	1%	19%	
Caribou/Muskox or other lean meat – 1 kilogram/2 pounds	1000	25%	**Rice**	
Frozen mixed vegetables – 750 gram bag	750	19%	50%	
Rice – 4 cups of dry rice	1000	25%		
Water for instant rice – 4 cups	1000	25%		
Hamburger/Caribou Soup				
Carrots – 4 cut small	244.00	6%	**Caribou/beef**	Caribou, rabbit, ptarmigan ground beef, chicken soup with vegetables or rice; rice mixed with meat and/or vegetables
Pepper – 1/8 tsp or 0.5 ml	0.50	0.01%	18%	
Hamburger/caribou – 1.5 lbs or 0.7 kg	700.00	18%	**Vegetables**	
Water – 4 cups or 1 litre	1000.00	25%	29%	
Onion – 1 cut small	110.00	3%	**Barley**	
Celery stalks – 2 cut small	80.00	2%	6%	
Bay leaf – 1 leaf	0.60	0.02%		
Beef Stock – 2 cups or 500 ml	500.00	13%		
Tomatos and liquid, cut medium – 19 oz can or 796 mL can	796.00	20%		

Recipe name and ingredients	Gram weight	Percentage of total dish weight in kg or mL (%)	Percentage by food group	**Dietary recall mixed dishes**
Parsley 1 tsp or 5 mL	5.00	0.13%		
Tomato Soup – 10 oz or 284 mL can	284.00	7%		
Thyme – ½ tsp or 2mL	2.00	0.1%		
Barley, uncooked – ½ cup or 125 mL	250.00	6%		
Fish Chowder				
Oil – 2tbsp	27.2	1%	**Char**	Char chowder
Onion – 1 chopped	110	2%	33%	
Carrots – 4 chopped	244	5%	**Vegetables**	
Celery – 4 stalks chopped	160	4%	29%	
Flour – 2 tbsps	15.625	0.35%		
Water – 4 cups	1000	22%		
Cream of mushroom soup – 1 can	303	7%		
Evaporated milk – 1 can	369	8%		
Potatoes - 3 cubed	639	14%		
Frozen or kernel corn – 1 cup	136	3%		
Pepper – 1 tsp	2.3	0.05%		
Bay leaves – 2 leaves	1.2	0.03%		
Arctic char – Small to medium, or around 1.5kg (3lbs) of another fish	1500	33%		
Mixed dishes, spaghetti with meatballs and sauce, frozen				
TOMATOES, RED, RIPE, BOILED	--	35%	**Meat**	Various pasta dishes: spaghetti with tomato sauce, meat and vegetables; macaroni salad with vegetables and meat
PASTA, SPAGHETTI, ENRICHED, COOKED	--	36%	14%	
MILK, FLUID, SKIM	--	6%	**Vegetables**	
PEAS, GREEN, BOILED, DRAINED	--	5%	6%	
BEEF, GROUND, LEAN, BROILED, WELL DONE	--	14%		
SWEETS, SUGARS, GRANULATED	--	1%		
WATER, MUNICIPAL	--	1%		
MARGARINE, TUB, UNSPECIFIED VEGETABLE OILS	--	1%		
GRAINS, CORNSTARCH	--	0.25%		
CHEESE, CHEDDAR	--	0.25%		
ONIONS, BOILED, DRAINED	--	0.25%		
CARROTS, BOILED, DRAINED	--	0.25%		
SALT, TABLE	--	1%		
Mixed Dishes, Chili con carne with beans, canned				
BEEF, GROUND, MEDIUM, BROILED, WELL DONE	--	19%	**Meat**	Sauce with beef, tomato, and chili powder (Sloppy Joe Sauce)
ONIONS, RAW	--	7%	19%	
CELERY, RAW	--	4%	**Tomato Sauce**	
SPICES, CHILI POWDER	--	0.33%	47%	
SALT, TABLE	--	0.39%		
TOMATOES, SAUCE, CANNED	--	8%		
BEANS, KIDNEY, DARK RED, CANNED, SOLIDS AND LIQUID	--	28%		
TOMATOES, RED, RIPE, CANNED, STEWED	--	30%		
VEGETABLE OIL, CANOLA	--	3%		
SWEETS, SUGARS, GRANULATED	--	2%		
MIXED DISHES, PASTA WITH MEATBALLS IN TOMATO SAUCE, CANNED				

Recipe name and ingredients	Gram weight	Percentage of total dish weight in kg or mL (%)	Percentage by food group	**Dietary recall mixed dishes**
PASTA, SPAGHETTI, ENRICHED, COOKED	--	18%	Meat	Kraft dinner with canned meat
CHEESE, PARMESAN, GRATED	--	2%	6%	
BEEF, GROUND, LEAN, BAKED, WELL DONE	--	3%	Vegetables	
PORK, FRESH, SHOULDER, PICNIC (ARM), LEAN, BRAISED	--	3%	4%	
EGG, CHICKEN, WHOLE, FRESH/FROZEN, RAW	--	1%	Tomatoes	
BREAD CRUMBS, DRY, GRATED, PLAIN	--	3%	40%	
GRAINS, WHEAT FLOUR, WHITE, ALL PURPOSE	--	0.41%		
SPICES, PARSLEY, DRIED	--	0.70%		
GARLIC, RAW	--	0.14%		
ONIONS, RAW	--	4%		
TOMATOES, RED, RIPE, CANNED, WHOLE	--	32%		
TOMATO PASTE, CANNED	--	8%		
PEPPERS, SWEET, GREEN, RAW	--	0.07%		
MILK, FLUID, PARTLY SKIMMED, 2% B.F.	--	3%		
VEGETABLE OIL, OLIVE	--	2%		
SALT, TABLE	--	1%		
SWEETS, SUGARS, GRANULATED	--	0.35%		
WATER, MUNICIPAL	--	18%		
Potato salad				
Fresh potatoes, as purchased	2126.21	65%	**Chopped vegetables**	Potato salad
Fresh celery, chopped	255.146	8%	11%	
Fresh onions, chopped	106.311	3%		
Sweet pickle relish, undrained	85.0486	3%	**Eggs**	
Fresh large eggs, hard-cooked, peeled, chilled, chopped (optional)	300	9%	9%	
Reduced calorie salad dress OR lowfat mayonnaise	368.844	11%		
Salt	9	0.28%		
Ground black or white pepper	1.15	0.04%		
Dry mustard	3	0.09%		

References: Health Canada (2007a), NWT Prenatal 2012), Government of Nunavut (Government of Nunavut 2013a, b), Healthy Alberta 2012, USDA Agricultural Research Service 201

Table 4. Recipe Conversions

Food name	Raw ingredient weight	Final cooked weight	Reference and notes
Coffee	5g	177ml	Folgers Coffee. 2012. "How to measure coffee." Accessed August 5, 2013. http://www.folgers.com/coffee-how-to/how-to-measure-coffee/index.aspx
Tea	1bag	300ml	Assume volume of 1 mug and 1mL=1grams
Kool-Aid	1 pkg	8 servings (assume cups) or 2L	Kraft Foods. 2013. "Kool-Aid Powdered – Soft Drink Mix – Peach Mango Unsweetened". Accessed August 5, 2013. http://www.kraftrecipes.com/Products/ProductInfoDisplay.aspx?SiteId=1&Product=4300004582
Tang	100g	979	Kraft Foods. 2013. "Tang Flavour Crystals". Accessed August 5, 2013. http://www.kraftcanada.com/en/products/s-u/tangflavourcrystals.aspx
Bannock			Weight in white flour
Lipton Soup Mix (Chicken or Onion)	1 package	1000ml	Knorr. 2012. "Lipton Soup Mix" Access October 2012. http://www.knorr.ca/en/products/ProductInfo.aspx?ENCSUQ9bHAwMDE=
Rice	125g	250ml (assume 250 g final weight)	NWT Prenatal. 2011. "Recipes." Accessed August 2011. http://www.nwtprenatal.ca/recipes
Spaghetti	450g	1.5L (assume final weigh 1.5 kg)	NWT Prenatal. 2011. "Recipes." Accessed August 2011. http://www.nwtprenatal.ca/recipes
Macaroni/pasta	125g	250 ml (assume final weight 250g)	NWT Prenatal. 2011. "Recipes." Accessed August 2011. http://www.nwtprenatal.ca/recipes
Oatmeal	100g	593	PepsiCo Canada. 2012. "Quaker Instant Oatmeal Regular." Accessed October 2012. http://www.quakeroats.ca/en/products/oatmeal/instant-oatmeal/regular.aspx
Instant Mashed Potato	75g	341g	Idahoan. 2012. "Instamash." Access October 2012. http://www.idahoanfoodservice.com/products/value-advantage/idahoan-instamash; eHow . 2013. "How to Make Instant Mashed Potatoes." Accessed August 5, 2013. http://www.ehow.com/how_5374855_make-instant-mashed-potatoes.html; for weight of 1 cup cooked potato used in conversion, assume average of weights derived from USDA food database

Appendix H. Caribou herds harvested and distances to caribou

Table 1. Distances to caribou sites

	Min distance to any herd (km)	Minimum of average distances to herds (km)	Average of average distances to herds (km)
Northwest Territories			
Aklavik	0	221	304
Fort McPherson	0	190	332
Inuvik	17	186	267
Paulatuk	0	224	344
Sachs Harbour	0	139	307
Tsiigehtchic	56	244	338
Tuktoyaktuk	0	118	271
Ulukhaktok	150	233	332
Fort Liard	14	182	182
Fort Providence	0	139	139
Fort Simpson	8	126	126
Hay River Reserve	0	181	181
Hay River	0	181	181
Jean Marie River	6	98	98
Nahanni Butte	3	132	132
Trout Lake	6	171	171
Wrigley	4	214	278
Colville Lake	0	214	461
Deline	0	266	304
Fort Good Hope	10	295	311
Norman Wells	0	272	323
Tulita	0	314	365
Enterprise	0	174	174
Fort Resolution	0	231	434
Fort Smith	0	294	445
Kakisa	0	138	138
Lutsel'ke	0	170	316
Behchoko	7	247	297
Gameti	0	276	282
Wekweeti	0	209	470
Whati	76	308	337
Detah	0	189	421
Yellowknife/N'dilo	0	189	421
Nunavut			
Arctic Bay	494	611	611
Cape Dorset	137	349	349
Clyde River	172	260	260
Grise Fiord	42	172	410
Hall Beach	118	442	442
Igloolik	118	442	442
Iqaluit	34	261	261
Kimmirut	122	360	360
Pangnirtung	93	245	245
Pond Inlet	356	456	456
Qikiqtarjuaq	256	380	380
Resolute	96	432	432
Sanikiluaq	0	48	48

Cambridge Bay	0	273	341
Gjoa Haven	0	329	354
Kugaaruk	134	319	319
Kugluktuk	0	297	330
Taloyoak	67	343	343
Arviat	0	513	513
Baker Lake	0	176	361
Chesterfield Inlet	26	161	364
Coral Harbour	8	111	111
Rankin Inlet	0	571	571
Repulse Bay	0	259	296
Whale Cove	0	545	545
Yukon[1]			
Beaver Creek	20	490	490
Burwash Landing	0	423	423
Carcross	0	335	335
Carmacks	5	358	358
Champagne Landing	25	363	363
Dawson	50	297	470
Destruction Bay	8	391	391
Faro	0	283	283
Haines Junction	40	403	403
Ibex Valley	25	333	333
Johnsons Crossing	0	303	303
Keno Hill	60	395	395
Lake Laberge	0	318	318
Mayo	10	337	370
Mount Lorne	0	328	328
Old Crow	0	150	150
Pelly Crossing	13	374	374
Ross River	8	259	259
Stewart Crossing	15	388	388
Swift River	0	345	345
Tagish	0	321	321
Teslin	10	325	325
Teslin Post 13	10	325	325
Two Mile Village	0	375	375
Two and a Half Mile Village	0	375	375
Upper Liard	0	383	383
Watson Lake	0	383	383
Whitehorse	3	316	316
Quebec			
Akulivik	107	228	518
Aupaluk	95	276	302
Inukjuak	52	244	421
Ivujivik	78	266	573
Kangiqsulujjuaq	186	248	351
Kangiasujuaq	72	190	385
Kangirsuk	14	204	292
Kuujjuaq	83	233	305
Kuujjuarapik	167	311	595
Puvirnituq	5	179	403
Quaqtuq	134	294	379
Salluit	69	187	477
Tasiujaq	21	227	284
Umiujaq	102	261	441
Newfoundland and Labrador			
Hopedale	95	205	205
Makkovik	81	176	176

Nain	63	164	164
Postville	149	295	295
Rigolet	18	212	212
Happy Valley-Goose Bay	255	308	308

[1]It is assumed that Yukon residents have access to the entire population of Northern Mountain caribou, though distances to caribou sites are calculated with distances to the closest herds, since distinct herds are delineated by Yukon Government

References for maps: Cape Bathurst - (Nagy and Johnson 2006); Bluenose-West - (Advisory Committee for the Cooperation on Wildlife Management 2011, Nagy and Johnson 2006, The Community of Inuvik 2008); Bluenose-East - (Advisory Committee for the Cooperation on Wildlife Management 2011, The Community of Inuvik 2008); Bathurst maps - (GNWT Environment and Natural Resources 2013a, Gunn, D'Hont, and Williams 2005, The Bathurst Caribou Management Planning Committee); Ahiak - (CARMA , GNWT Environment and Natural Resources , Gunn, D'Hont, and Williams 2005); Tuktoyaktuk Peninsula - (Nagy and Johnson 2006, The Community of Inuvik 2008); Porcupine - (Gunn, Russell, and Eamer 2011, Russell, Martell, and Nixon 1993); Beverly and Qamanirjuaq - (Beverly and Qamanirjuaq Caribou Management Board); Banks Island Peary - (The Community of Sachs Harbour 2008); Dolphin-Union - (Dumond 2007, Poole et al. 2010); Lorillard and Wager Bay - (Campbell 2005); Baffin Island Barren-Ground - (Ferguson, Williamson, and Messier 1998, Nunavut Planning Commission 2011); Prince Albert Sound - (The Community of Ulukhaktok 2008); Southampton and Coats Island - (Campbell 2006b); George River and Leaf River - (Couturier et al. 2004, Government of Newfoundland and Labrador , Government of Quebec); Peary - (Campbell 2006a, Jenkins 2008); Yukon Woodland - (Yukon Environment); NWT Woodland - (Gunn et al. 2004, Larter and Allaire 2010, Canadian Wildlife Service 2012, McDonald, Hrynkiw, and Guthrie 2010); Sanikiluaq – (Google Map

Table 2. Caribou harvests

	Mean harvest	Low harvest	Peak harvest	Notes and references
Northwest Territories				
Aklavik	704	384	1222	Barren-ground harvests 1995-1997(McDonald 2009) (only 1995-1997 values were used as the values from the Gwich'in Harvest Study for these years were summed with the 1995-1997 values shown in the Inuvialuit Harvest Study); 1988-1997 (Joint Secretariat 2003)
Fort McPherson	1149	373	1663	Barren-ground harvests 1995-2000(McDonald 2009)
Paulatuk	456	260	665	Barren-ground harvests 1988-1997 (The Joint Secretariat 2003)
Inuvik	662	392	1589	Barren-ground harvests 1995-1997(McDonald 2009) (only 1995-1997 values were used as the values from the Gwich'in Harvest Study for these years were summed with the 1995-1997 values shown in the Inuvialuit Harvest Study); 1988-1997 (Joint Secretariat 2003)
Sachs Harbour	79	9	330	Barren-ground harvests 1988-1997 (The Joint Secretariat 2003)
Tsiigehtchic	131	15	250	Barren-ground harvests 1995-2000 (McDonald 2009)
Tukotyaktuk	915	586	1358	Barren-ground harvests 1988-1997 (Joint Secretariat 2003)
Ulukhaktok	562	189	1207	Barren-ground harvests 1982-1983 (Jingfors 1984 unpublished report, as cited in Wong 1985); 1988-1997 (Joint Secretariat 2003)
Fort Liard	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Fort Providence	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Fort Simpson	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Hay River Reserve	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Hay River	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Jean Marie River	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Nahanni Butte	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Trout Lake	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Wrigley	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Colville Lake	186	43	355	Woodland and barren-ground harvests (in the calculation of the mean, maximum, and minimum values across survey years, values for different years are summed for both types of caribou in years where data for both are reported. 1998-2003 (Sahtu Renewable Resources Board 2011)
Deline	1259	274	1812	1974 (Rushforth 1977, as cited in Coad 1994); Woodland and barren-ground

				harvests (in the calculation of the mean, maximum, and minimum values across survey years, values for different years are summed for both types of caribou in years where data for both are reported. 1998-2003 (Sahtu Renewable Resources Board 2011)
Fort Good Hope	417	741	43	Woodland and barren-ground harvests (in the calculation of the mean, maximum, and minimum values across survey years, values for different years are summed for both types of caribou in years where data for both are reported. 1998-2003 (Sahtu Renewable Resources Board 2011)
Norman Wells	56	123	20	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979); Woodland and barren-ground caribou harvests 1998-2003 (Sahtu Renewable Resources Board 2011)
Tulita	213	378	47	Woodland and barren-ground caribou harvests 1998-2003 (Sahtu Renewable Resources Board 2011)
Enterprise	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Fort Resolution	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Fort Smith	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Kakisa	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Lutsel'ke	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Behchoko	3957	1981	5425	Harvest numbers for 1988-1993 adapted from Boulanger and Gunn (2007)[2]
Gameti	3957	1981	5425	Harvest numbers for 1988-1993 adapted from Boulanger and Gunn (2007)[2]
Wekweeti	3957	1981	5425	Harvest numbers for 1988-1993 adapted from Boulanger and Gunn (2007)[2]
Whati	3957	1981	5425	Harvest numbers for 1988-1993 adapted from Boulanger and Gunn (2007)[2]
Detah	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Yellowknife/N'dilo	107	62	163	Harvest numbers for 1963-1974 adapted from Dickinson and Herman (1979)[1]
Nunavut				
Arctic Bay	819	463	1226	Barren-ground harvests 1981-1984 (Donaldson 1983, 1984 and Anon 1983 unpublished reports, as cited in Wong 1985);1997-2001 harvests (Priest and Usher)
Cape Dorset	1107	373	2260	Barren-ground harvests 1981-1984 harvests (Donaldson 1983, 1984 and Anon 1983 unpublished reports, as cited in Wong 1985);1997-2001 harvests (Priest and Usher)
Clyde River	529	222	992	Barren-ground harvests 1978 (Finley and Miller 1980 unpublished report, as cited in Wong 1985) 1981-1984 harvests (Donaldson 1983, 1984 and Anon 1983 unpublished reports, as cited in Wong 1985);1997-2001 harvests (Priest and Usher)
Grise Fiord	42	74	29	Barren-ground harvests 1978 (Finlay and Miller 1980 unpublished report, as cited in Wong 1985) 1981-1984 harvests (Donaldson 1983, 1984 and Anon 1983

				unpublished reports, as cited in Wong 1985);1997-2001 harvests (Priest and Usher)
Hall Beach	1025	665	1677	Barren-ground harvests 1981-1984 harvests (Donaldson 1983, 1984 and Anon 1983 unpublished reports, as cited in Wong 1985);1997-2001 harvests (Priest and Usher)
Igloolik	1663.4	2060	913	Barren-ground harvests 1981-1984 harvests (Donaldson 1983, 1984 and Anon 1983 unpublished reports, as cited in Wong 1985);1997-2001 harvests (Priest and Usher)
Iqaluit	2241	1446	4365	Barren-ground harvests 1981-1984 harvests (Donaldson 1983, 1984 and Anon 1983 unpublished reports, as cited in Wong 1985);1997-2001 harvests (Priest and Usher)
Kimmirut	382	282	550	Barren-ground harvests 1974 (Kemp 1975 unpublished report, as cited by Coad 1994);1984 harvests (Donaldson 1983, 1984 and Anon 1983, as cited in Wong 1985);1997-2001 harvests (Priest and Usher)
Pangnirtung	1874	960	2640	Barren-ground harvests 1978 harvest (Finley and Miller 1980 unpublished report, as cited in Wong 1985); 1997-2001 harvests (Priest and Usher 2004)
Pond Inlet	1718	590	2534	Barren-ground harvests 1997-2001 harvests (Priest and Usher 2004)
Qikiqtarjuaq	272	41	586	Barren-ground harvests 1997-2001 harvests (Priest and Usher 2004)
Resolute	66	6	201	Barren-ground harvests 1976 (Kemp 1975 unpublished report as cited by Coad 1994);1981-1984 harvests (Donaldson 1983, 1984 and Anon 1983 unpublished reports, as cited in Wong 1985);1997-2001 harvests (Priest and Usher 2004)
Sanikiluaq	16	0	38	Barren-ground harvests 1981-1984 harvests (Donaldson 1983, 1984 and Anon 1983 unpublished reports, as cited in Wong 1985);1997-2001 harvests (Priest and Usher 2004)
Cambridge Bay	1207	359	2234	Barren-ground harvests 1982-1983 (Jingfors 1984 unpublished report, as cited in Wong 1985); 1997-2001 (Priest and Usher 2004)
Gjoa Haven	864	398	1567	Barren-ground harvests 1982-1983 (Jingfors 1984 unpublished report, as cited in Wong 1985); 1997-2001 (Priest and Usher 2004)
Kugaaruk	541	274	887	Barren-ground harvests 1982-1983 (Jingfors 1984 unpublished report, as cited in Wong 1985); 1997-2001 (Priest and Usher 2004)
Kugluktuk	1606	1355	1913	Barren-ground harvests 1982-1983 (Jingfors 1984 unpublished report, as cited in Wong 1985); 1997-2001 (Priest and Usher 2004)
Taloyoak	925	288	1636	Barren-ground harvests 1982-1983 (Jingfors 1984 unpublished report, as cited in Wong 1985); 1997-2001 (Priest and Usher 2004)
Arviat	3509	1990	4036	Barren-ground harvests 1981-1984 (Gamble 1984, 1987a as cited in Wong 1985; Gamble 1987b as cited in Coad 1994); 1997-2001 (Priest and Usher 2004)
Baker Lake	3702	2507	6431	Barren-ground harvests 1981-1984 (Gamble 1984, 1987a as cited in Wong 1985;

				Gamble 1987b as cited in Coad 1994); 1997-2001 (Priest and Usher 2004)
Chesterfield Inlet	513	151	941	Barren-ground harvests 1981-1984 (Gamble 1984, 1987a as cited in Wong 1985; Gamble 1987b as cited in Coad 1994); 1997-2001 (Priest and Usher 2004)
Coral Harbour	1063	89	1940	Barren-ground harvests 1981-1983 (Gamble 1984, 1987a as cited in Wong 1985; Gamble 1987b as cited in Coad 1994); 1997-2001 (Priest and Usher 2004)
Rankin Inlet	1290	411	2076	Barren-ground harvests 1981-1984 (Gamble 1984, 1987a as cited in Wong 1985; Gamble 1987b as cited in Coad 1994); 1997-2001 (Priest and Usher 2004)
Repulse Bay	958	464	1413	Barren-ground harvests 1981-1984 (Gamble 1984, 1987a as cited in Wong 1985; Gamble 1987b as cited in Coad 1994); 1997-2001 (Priest and Usher 2004)
Whale Cove	608	344	1097	Barren-ground harvests 1981-1984 (Gamble 1984, 1987a as cited in Wong 1985; Gamble 1987b as cited in Coad 1994); 1997-2001 (Priest and Usher 2004)
Yukon[3]				
Beaver Creek	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Burwash Landing	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Carcross	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Carmacks	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Champagne Landing	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Dawson	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Destruction Bay	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Faro	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Haines Junction	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Ibex Valley	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Johnsons Crossing	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Keno Hill	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Lake Laberge	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Mayo	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Mount Lorne	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Old Crow	1043	873	1211	Adapted from Wein and Freeman 1995
Pelly Crossing	227	114	329	Yukon Resident Hunter Harvest report
Ross River	991	991	991	Dimitrov and Weinstein 1984 unpublished report, as cited in Coad 1994
Stewart Crossing	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Swift River	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Tagish	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Teslin	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Teslin Post	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Two Mile Village	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)

Two and One-Half Mile Village	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Upper Liard	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Watson Lake	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Whitehorse	227	114	329	Yukon Resident Hunter Harvest 2007-2010 (Yukon Environment 2011)
Quebec				
Akulivik	94	94	94	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Aupaluk	178	178	178	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Inukjuak	891	891	891	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Ivujivik	31	31	31	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Kangiqsulujjuaq	1011	1011	1011	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Kangiasujuaq	171	171	171	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Kangirsuk	191	191	191	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Kuujjuaq	1310	1310	1310	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Kuujjuarapik	242	242	242	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Puvirnituq	493	493	493	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Quaqtuq	47	47	47	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Salluit	31	31	31	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Tasiujaq	330	330	330	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Umiujaq	567	567	567	Barren-ground harvests 1980 (CRRABJNQ 1989 report, as cited in Coad 1994)
Newfoundland and Labrador				
Hopedale	184	184	184	Barren-ground harvests 1978 (Usher 1982 unpublished report, as cited in Coad 1994)
Makkovik	226	226	226	Barren-ground harvests 1978 (Usher 1982 unpublished report, as cited in Coad 1994)
Nain	1010	1010	1010	Barren-ground harvests 1978 (Usher 1982 unpublished report, as cited in Coad 1994)
Postville	106	106	106	Barren-ground harvests 1978 (Usher 1982 unpublished report, as cited in Coad 1994)
Rigolet	8	8	8	Barren-ground harvests 1978 (Usher 1982 unpublished report, as cited in Coad 1994)
Happy Valley-Goose Bay	307	307	307	Barren-ground harvests 1978 (Usher 1982 unpublished report, as cited in Coad 1994)

[1]Calculated from caribou harvests 1963-1974 (Dickinson and Herman 1979). Since values on harvests are not available in all communities of the Deh Cho and South Slave regions, the average value calculated across 7 (Gwich'in, Dehcho, and South Slave) communities in the Dickinson and Herman (1979) study are assumed to be the harvest values for all Deh Cho and South Slave communities.

[2] Since values on harvests are not available in all communities of the T' licho region, the average value calculated across 4 communities as reported in Adamczewski et al. (2009) study are assumed to be the harvest values for all T' licho communities.
[3] For communities for which harvest data is not found, resident hunter harvests for the territory are assumed as the harvest value for the community.

Table 3. Herds harvested by communities

	Herds traditionally harvested	Number of herds or types traditionally harvested
Northwest Territories		
Aklavik	Cape Bathurst Bluenose-West Porcupine Tuktoyaktuk Peninsula	4
Fort McPherson	Bluenose-West Porcupine	2
Inuvik	Cape Bathurst Bluenose-West Porcupine[1] Tuktoyaktuk Peninsula	4
Paulatuk	Bluenose-West Bluenose-East Porcupine Tuktoyaktuk Peninsula Peary caribou	5
Sachs Harbour	Bluenose-Wet Porcupine Banks Island caribou Tuktoyaktuk Peninsula Peary caribou	5
Tsiigehtchic	Bluenose-West Porcupine	2
Tuktoyaktuk	Cape Bathurst Bluenose-West Porcupine Tuktoyaktuk Peninsula	4

Ulukhaktok	Bluenose-West Porcupine Tuktoyatuk Peninsula Prince Albert Sound	6
Fort Liard	Woodland caribou	1
Fort Providence	Woodland caribou	1
Fort Simpson	Woodland caribou	1
Hay River Reserve	Woodland caribou	1
Hay River	Woodland caribou	1
Jean Marie River	Bathurst caribou[2] Woodland caribou	2
Nahanni Butte	Woodland caribou	1
Trout Lake	Bathurst caribou[2] Woodland caribou	2
Wrigley	Bluenose-East Woodland caribou	2
Colville Lake	Bluenose-West Bluenose-East Woodland caribou	3
Deline	Bluenose-West Bluenose-East Woodland caribou	3
Fort Good Hope	Bluenose-West Bluenose-East Woodland caribou	3
Norman Wells	Bluenose-West Bluenose-East Woodland caribou	3
Tulita	Bluenose-West Bluenose-East Woodland caribou	3
Enterprise	Woodland caribou	1
Fort Resolution	Woodland caribou	1
Fort Smith	Woodland caribou	1
Kakisa	Bathurst caribou Woodland caribou	2
Lutsel'ke	Bathurst	3

	Ahiak Beverly	
Behchoko	Bluenose-East Bathurst	2
Gameti	Bluenose-East Bathurst	2
Wekweeti	Bluenose-East Bathurst	2
Whati	Bluenose-East Bathurst	2
Detah	Bluenose-East Bathurst	2
Yellowknife/N'dilo	Bathurst Woodland caribou	2
Nunavut		
Arctic Bay	Baffin-Island barren-ground	1
Cape Dorset	Baffin-Island barren-ground	1
Clyde River	Baffin-Island barren-ground	1
Grise Fiord	Baffin-Island barren-ground	1
Hall Beach	Baffin-Island barren-ground Wager Bay	2
Igloolik	Baffin-Island barren-ground Wager Bay	2
Iqaluit	Baffin-Island barren-ground	1
Kimmirut	Baffin-Island barren-ground	1
Pangnirtung	Baffin-Island barren-ground	1
Pond Inlet	Baffin-Island barren-ground	1
Qikiqtarjuaq	Baffin-Island barren-ground	1
Resolute	Baffin-Island barren-ground	1
Sanikiluaq	George River Sankiluaq reindeer	3
Cambridge Bay	Ahiak Dolphin-Union	2
Gjoa Haven	Ahiak Wager Bay Beverly	3
Kugaaruk	Ahiak	3

	Wager Bay Beverly	
Kugluktuk	Bluenose-East Bathurst Dolphin-Union	3
Taloyoak	Ahiak Lorillard Wager Bay	3
Arviat	Qamanirjuaq	1
Baker Lake	Ahiak Lorillard Wager Bay Beverly Qamanirjuaq	5
Chesterfield Inlet	Lorillard Wager Bay Qamanirjuaq	3
Coral Harbour[3]	Lorillard Wager Bay Qamanirjuaq Southampton and Coats Island	4
Rankin Inlet	Qamanirjuaq	1
Repulse Bay	Ahiak Lorillard Wager Bay	3
Whale Cove	Qamaniruaq	1
Yukon[4]		
Beaver Creek	Woodland caribou	1
Burwash Landing	Woodland caribou	1
Carcross	Woodland caribou	1
Carmacks	Fortymile Woodland caribou	2
Champagne Landing	Woodland caribou	1
Dawson	Fortymile Woodland caribou	2
Destruction Bay	Woodland caribou	1
Faro	Woodland caribou	1

Haines Junction	Woodland caribou	1
Ibex Valley	Woodland caribou	1
Johnsons Crossing	Woodland caribou	1
Keno Hill	Woodland caribou	1
Lake Laberge	Woodland caribou	1
Mayo	Fortymile Woodland caribou	2
Mount Lorne	Woodland caribou	1
Old Crow	Porcupine	1
Pelly Crossing	Woodland caribou	1
Ross River	Woodland caribou	1
Stewart Crossing	Woodland caribou	1
Swift River	Woodland caribou	1
Tagish	Woodland caribou	1
Teslin	Woodland caribou	1
Teslin Post 13	Woodland caribou	1
Two Mile Village	Woodland caribou	1
Two and a Half Mile Village	Woodland caribou	1
Upper Liard	Woodland caribou	1
Watson Lake	Woodland caribou	1
Whitehorse	Woodland caribou	1
Quebec[5]		
Akulivik	George River	1
Aupaluk	George River	1
Inukjuak	George River	1
Ivujivik	George River	1
Kangiqsulujjuaq	George River	1
Kangiasujuaq	George River	1
Kangirsuk	George River	1
Kuujjuaq	George River	1
Kuujjuarapik	George River	1
Puvirnituq	George River	1
Quaqtuq	George River	1
Salluit	George River	1
Tasiujaq	George River	1
Umiujaq	George River	1

Newfoundland and Labrador[5]		
Hopedale	Leaf River	1
Makkovik	Leaf River	1
Nain	Leaf River	1
Postville	Leaf River	1
Rigolet	Leaf River	1
Happy Valley-Goose Bay	Leaf River	1

[1]Although not all communities are documented in reports to harvest Porcupine caribou, Porcupine is assumed to be a herd that maybe harvested by members of all Inuvialuit communities because Inuvialuit beneficiaries have preferential rights to harvest Porcupine caribou (WMAC North Slope)

[2]Dehcho communities have been documented to harvest woodland caribou. For the communities of Trout Lake and Jean Marie River, Bathurst caribou is is assumed to be an additional herd harvested for modeling purposes. Model estimates generated with only woodland caribou yielded negative values and so population and herd counts were replaced with augmented values.

[3] Although Southampton Island caribou is documented to be main source of caribou for Coral Harbour, for modeling, it is assumed that community members also harvest Lorillard and Wager Bay caribou.

[4] It is assumed that Yukon residents have access to the entire population of Northern Mountain caribou, though distances to caribou sites are calculated with distances to the closest herds.

[5] Distances from Quebec and Labrador communities to George River and Leaf River herds are based on the most recent satellite telemetry map from the Government of Quebec map showing caribou movements, since these maps provide a high level of detail, with community locations and caribou movement locations identified.

References:

(Campbell 2005, 2007, Wildlife Research Section 2007, The Community of Inuvik 2008, The Community of Sachs Harbour 2008, The Community of Tuktoyaktuk 2008, The Community of Ulukhaktok 2008, Nesbitt and Adamczewski 2009, Advisory Committee for the Cooperation on Wildlife Management 2011, Gunn, Russell, and Eamer 2011, Giroux et al. 2012, Trondek Heritage 2012, GNWT Environment and Natural Resources 2013a, WMAC North Slope)