Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2016

Nicholas C. Larter and Danny G. Allaire

Environment and Natural Resources
Government of the Northwest Territories

2017

Manuscript Report No. 268

ABSTRACT

Each of the eight licenced outfitters and Renewable Resource Officers with the Sahtú and Dehcho Environment and Natural Resources (ENR) regional offices collected data on big game harvested in the Mackenzie Mountains during the 2016 hunting season. Harvest data and observations of wildlife from non-resident and non-resident alien hunters (collectively called 'non-resident' for this report) were recorded. This year, big game hunting licences were bought by 389 non-resident hunters, midrange of licenses purchased annually from 1991-2016 (range 321-447). Hunters (n=309) from outside Canada (non-resident aliens) comprised 71% of the outfitted hunters and were primarily from the USA (n=275), with only 44 hunters from other foreign countries. Of the 80 Canadian hunters, whose residency was from outside the Northwest Territories (NWT), 60 were from Alberta or British Columbia. Of the 389 non-resident licence holders, 352 came to the NWT and most spent at least some time hunting.

Hunter satisfaction remains high; 98% of respondents (n=195) rated their experience as either excellent (86%) or very good (12%). The high quality hunting experience, the abundance of wildlife in the Mackenzie Mountains (both game and predators), and the impressive management and stewardship of the land were specifically commented on. Repeat clients (23% of respondents) had returned for a 2nd to 20th hunt, and 92% of respondents indicated they would like to return in future years. We received only 55% of the voluntary hunter observation forms, the lowest since 2000, which is discouraging after returns of >70% in recent years.

Two hundred and fifty-two tags were purchased for Dall's sheep, similar to the average over the past 22 years. This year's harvest of 192 rams (including two by resident hunters) was similar to the average annual harvest of 198 rams from 1991-2016. The mean (±SD) age of rams harvested in 2016 was 11.0±2.3 years, the oldest since records

started in 1967, and the 29th consecutive year the average age has been >9.5 years for rams harvested in the Mackenzie Mountains.

The average right horn length was 89.1 cm, virtually the same as the mean 89.0 cm from the previous 45 years. This consistency is surprising given the increasing age of harvest; the percent broomed horns, 28% left and 23% right was lower than the 20 year average. Hunters reported seeing fewer legal rams (horns at least ¾ curl) than rams with horns <¾ curl during their hunts, average seven legal rams/hunt. Based upon hunter observations, we estimated 49.2 lambs and 80.8 rams per 100 ewes, respectively. Both ratios were slightly lower than average since 1995.

Horn measurements collected by ENR (2002-2016) were used in a study on age structure and horn configuration. Observed age of harvest (average 10.5 years) was near natural mortality of Dall's sheep. The genetic contributions of most harvested sheep had likely been made. DNA from horn cores collected by ENR was used to better delineate the subspecific boundaries of Stone's and Dall's sheep.

In 2016, 319 tags were purchased for northern mountain caribou, more than the average 264, but less than the 347 purchased in 2015. However, the harvest of 191 bull caribou equalled the previous highest harvest in 1993. Hunters observed an estimated 33.4 caribou calves and 41.6 bulls per 100 adult female caribou, respectively. The calf:cow ratio was the lowest recorded since records began in 1995 (range 33-59:100), while the bull:cow was average. Cementum age analysis of 52 teeth from caribou harvested in 1975 and 32 teeth from caribou harvested in 2011-2013 showed striking similarities in age distribution, mean and median ages.

One hundred and twenty-one tags were purchased for moose this year, slightly above average (2005-2016). The harvest of 76 bull moose was higher than the average since 1991, but similar to the average of 74 since 2005. Hunters observed an estimated 30.6

moose calves and 104.6 bulls per 100 adult female moose, respectively. Both ratios similar to the average from 1995-2016. Teeth provided voluntarily from 137 harvested bull moose (2003-2016) have been aged (range 3-15, mean 7.7, median 7.0 years).

This year only 25 tags were purchased for mountain goats, noticeably less than in the past ten years. The drop is not surprising since a large part of mountain goat range falls within the Nahanni National Park Reserve (NPR) boundaries where hunting is now prohibited. Eight goats (six male and two female) were harvested similar to the mean annual harvest prior to 2005. Cementum age analysis of 17 mountain goats harvested in 1972 and 1975 showed a somewhat younger age distribution from the 164 ages of harvested goats from 2005-2016 based upon counting horn annuli: mean 7.9, median 7.5, range 2-16 years. Hunters observed an estimated 67.6 goat kids and 85.3 billies per 100 adult nannies, both ratios higher than the average from 2002-2016.

Wolf tags were purchased by 310 non-resident hunters in the 2016 hunting season, fewer than in the 2015 season but more than in any of the previous 20 years. Twenty-nine wolves were harvested; the greatest annual harvest of wolves since records have been kept. We suspect the recent increase in tag purchases and annual harvest is related to the increasing number and success of winter season hunts. Eight wolves were harvested in zone S/OT/01 in April 2017; the greatest winter season harvest. Hunters observed 221 wolves during 2016/2017. More wolverine tags (190) were purchased in 2016 than in any year since records started; two wolverines were harvested. A total of 23 wolverines were observed in seven zones, including one family group of four. No black bears were harvested from the 18 tags purchased. Only seven black bears have been harvested since 1991. There has been no grizzly bear hunting season for non-residents since 1982. This year observations of adult (n=337), and cub grizzly bears (n=69), were similar to those reported from 1996-2013, down from the >500 adults observed in 2014 and 2015. From 1996-2016 a positive trend in grizzly bear observations remains. One nuisance grizzly bear was killed in 2016.

We continue to use summary meat recording forms in addition to Association of Mackenzie Mountain Outfitters meat forms and for the sixth year we have information about meat distribution for all eight outfitters. An estimated minimum of 23,474 kg (51,751 lbs.) of wild game meat, mostly moose and mountain caribou, was distributed locally this year. Replacement cost of meat from local northern retailers is conservatively estimated at $586,850 using a $25/kg average replacement cost.

This was the first year that hunting was prohibited in outfitter zones D/OT/01, D/OT/02, S/OT/03 and S/OT/05 that fell within the expanded Nahanni NPR and the Nááts'ihch'oh NPR boundaries. A large part of mountain goat range falls within the new boundaries which reduces the area available to hunt mountain goats in the NWT. We anticipate reduced tag purchases, goat harvest, and voluntary goat observations in future years.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

General Background

The 140,000 km^2 (54,000 mi^2) area of the Mackenzie Mountains in the western Northwest Territories (NWT) was first opened to non-subsistence hunters in 1965 (Simmons 1968). Since then, the Mackenzie Mountains have become world-renowned for providing a high quality wilderness hunting experience (Veitch and Simmons 1999, www.spectacularnwt.com/whattodo/hunting/themackenziemountains, www.huntingreport.com), particularly for Dall's sheep and more recently moose. In return, non-resident hunters and outfitters in the Mackenzie Mountains provide about $2.5 million annually to individuals, businesses, and governments in the NWT (Harold Grinde personal communication). The outfitted hunting industry in the Mackenzie Mountains also provides employment for 150-170 outfitters, guides, pilots, camp cooks, camp helpers, and horse wranglers (Werner Aschbacher personal communication). In addition, fresh meat from many harvested animals is provided to a number of local communities including Tulít'a, Fort Good Hope and Norman Wells in the Sahtú and Wrigley, Nahanni Butte, Fort Liard and Fort Simpson in the Dehcho. This meat is distributed among local elders and residents and to health/long term care facilities. The estimated annual replacement value of this meat has ranged from *ca.* $60,000-625,000.

Eight outfitters are currently licenced by the Government of the NWT to provide big game outfitting services within the Mackenzie Mountains (Figure 1, Appendix A). Starting with the July 2016 hunting season, no hunting is permitted within the expanded boundaries of Nahanni National Park Reserve (Nahanni NPR) and the newly formed Nááts'ihch'oh National Park Reserve (Nááts'ihch'oh NPR) (Figures 1, 2) except for subsistence harvest by Aboriginal harvested under section 17 of the *Wildlife Act* or NWT general hunting licence (GHL) holders. Under the NWT *Wildlife Act*, each licenced outfitter has the exclusive privilege of providing services within their zone, which enhances the outfitters' ability to practice sustainable harvest through annual allocation of the harvest effort.

The hunting licence year in the NWT runs from 1 July - 30 June and those who desire to hunt big game within the NWT must annually obtain a big game hunting licence and must be at least 12 years old (Environment and Natural Resources 2016). Any youth under the age of 18 must have the consent of a parent or guardian to obtain a licence. There are four classes of licenced big game hunters in the NWT:

1) *General:* only available to Aboriginal people eligible or belonging to an organization listed in the regulations.
2) *NWT Resident:* Canadian citizens or landed immigrants who have been living in the NWT for at least 12 continuous months prior to application for the licence.
3) *Non-resident:* Canadian citizens or landed immigrants who live outside the NWT, or have not resided in the NWT for 12 months prior to application for the licence.
4) *Non-resident Alien:* an individual who is neither a NWT resident nor a non-resident.

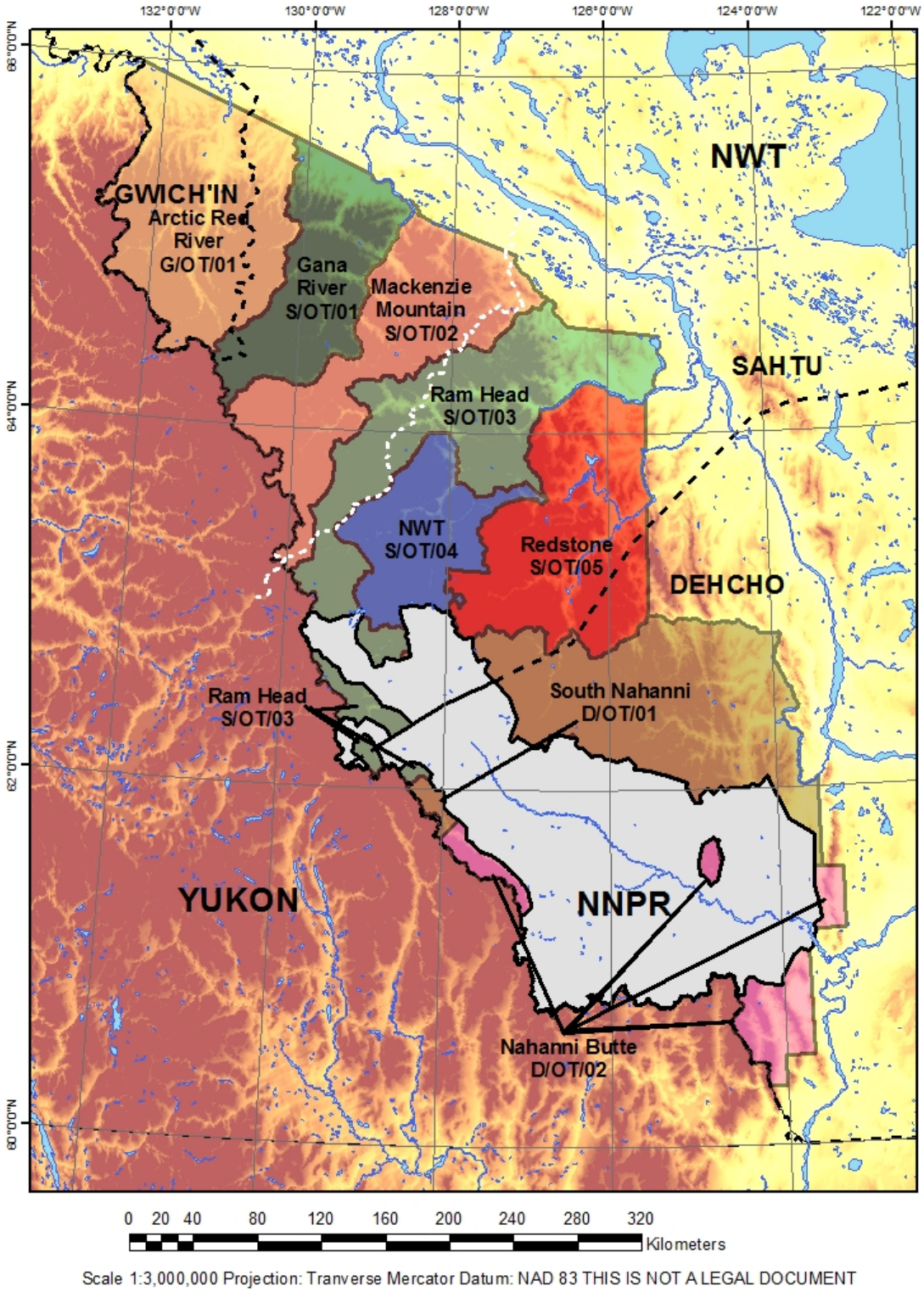

Figure 1: Outfitting zones and land claim areas (black dotted lines) of the Mackenzie Mountains, NWT, with Nahanni NPR expanded boundary and the newly formed Nááts'ihch'oh NPR, indicated. The white hatched line is the Canol road.

Both non-resident and non-resident alien hunters must use the services of an outfitter and must be accompanied by a licenced guide at all times while hunting big game. For simplification in this report, we call both non-resident and non-resident alien hunting licence holders 'non-residents' and combine their harvest statistics. The data from two resident hunters, who harvested Dall's sheep in the Mackenzie Mountains without a guide, have been included in the number of sheep harvested and the age and horn length measurements in this report as indicated.

Individual non-resident hunters are annually restricted to one each of the following big game species (Appendix B): Dall's sheep (male with at least one ¾ curl horn), northern mountain woodland caribou (either sex), moose (either sex), mountain goat (either sex), wolf (either sex)[1], wolverine (either sex), and black bear [adult not accompanied by cub(s)]. Although non-resident hunters are allowed to hunt female moose and caribou they prefer to hunt males for their trophy antlers and the harvest is exclusively males. Non-resident hunting for grizzly bears was closed in 1982 as a result of concerns about over-harvest (Miller et al. 1982, Latour and MacLean 1994). There are currently no restrictions on the total number of each big game species that an outfitter can take within the zone for which they are licenced.

Wildlife management within the Mackenzie Mountains is the responsibility of a variety of government agencies and boards set up as a result of comprehensive land claim agreements. The post-2009 boundaries of Nahanni NPR plus the newly established Nááts'ihch'oh NPR comprise an area of 33,917 km^2 in the south Mackenzie Mountains that is managed by Parks Canada – an agency of the Canadian federal government. Under the terms of the *Sahtú Dene and Métis Comprehensive Land Claim Agreement* (signed in 1993) and the *Gwich'in Comprehensive Land Claim Agreement* (signed in 1992), the main instrument of wildlife management within the two settlement areas lies with the Sahtú

[1]In the Sahtú region, non-resident hunters and non-resident alien hunters are allowed to hunt two wolves from 1 August - 15 April in S/MX/01. Only one wolf can be hunted in the Dehcho and Gwich'in areas.

Renewable Resources Board (SRRB) and the Gwich'in Renewable Resources Board (GRRB), respectively. Approximately 68,000 km^2 of the central and northern Mackenzie Mountains are within the Sahtú Settlement Area and 8,300 km^2 are within the Gwich'in Settlement Area, which encompass the extreme north end of the outfitter areas (Figure 1). However, the GNWT maintains ultimate jurisdiction for management of wildlife and wildlife habitat within each of the claim areas. The Department of Environment and Natural Resources (ENR) is responsible for licencing outfitters, guides, and hunters and for annually monitoring non-resident big game harvest in the Mackenzie Mountains.

Each year ENR, under the *Wildlife Act* related provisions in the *Wildlife Business Regulations*, requires outfitters to submit an outfitter return on a client hunter success form for each person that purchased a NWT non-resident big game hunting licence (Figure 2). These are known as outfitter return forms and they must be submitted whether or not a client actually hunted, and whether or not any game was harvested. The outfitter return forms allow us to quantify harvest by non-resident hunters to help biologists with the GRRB, SRRB, and ENR to ensure that the harvest of each species is within sustainable limits.

In 1995, the then Department of Resources, Wildlife and Economic Development, requested that all non-resident hunters also fill out a voluntary questionnaire. The questionnaire has evolved through the years based upon suggestions from outfitters, their clients, and government staff. Different questions pertaining to wildlife observations, the quality of the hunting experience, the quality of services related to hunter travel, and specific topics for hunter comment have come and gone. However, one key component of the questionnaire that has remained constant pertains to reporting the different types and numbers of wildlife species seen during their hunts. These data have been recorded and the questionnaire forms have been referred to as hunter observation forms in this report (Figure 3). These data provide valuable time series of observations and are used in assessing mountain caribou herd status (Larter 2012a).

This is the 22nd consecutive year that a summary of the data collected by ENR on non-resident hunters in the Mackenzie Mountains has been made. In the text of this document, data for 1995 are found in Veitch and Popko (1996), for 1996 in Veitch and Popko (1997), for 1997 in Veitch and Simmons (1998), for 1998 in Veitch et al. 2000b, for 1999 and 2000 in Veitch and Simmons (2000, 2002, respectively), for 2001 by A. Veitch and N. Simmons (unpublished data), for 2002-2015 in Larter and Allaire (2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016 respectively). Additionally, Latour and MacLean (1994) summarized data for 1979-1990. This report compiles the harvest data collected during the 2016 hunting season and compares it with available data collected since 1995, and earlier when available.

Department of Environment and Natural Resources
Pursuant to the *WILDLIFE ACT*

Ministère de l'Environnement et des Ressources naturelles
En vertu de la *LOI SUR LA FAUNE*

OUTFITTER RETURN ON CLIENT HUNTER SUCCESS

RAPPORT DU POURVOYEUR SUR LES RÉSULTATS DE CHASSE D'UN CLIENT

OR 017556

INSTRUCTIONS: This form is to be completed as soon as practicable after the big game animal has been killed and is to be submitted before the 10th day of the following month to the Regional Biologist.
Ce formulaire doit être rempli aussitôt que possible après l'abattage du gros gibier et il

RETURN FOR THE PERIOD OF - RAPPORT MENSUEL POUR

Month: / Mois: August 2009

OUTFITTER/CLIENT HUNTER - POURVOYEUR/CLIENT CHASSEUR

Outfitter Name - Nom du pourvoyeur: Gana River Outfitters Ltd

Client Hunter Last Name - Nom de famille du client chasseur: [redacted] First Name - Prénom: [redacted] Init.

Hunting Lic. No. - N° du permis de chasse: [redacted]

BIG GAME HUNTED - GROS GIBIER CHASSÉ (If none killed, complete "No. of Days Hunted" for each species hunted - *Si aucun animal n'a été abattu, remplir la partie «Nombre de jours à la chasse» pour chaque espèce chassée*)

Species - Espèce	Tag No. N° de l'étiquette	No. of Days Hunted Nombre de jours à la chasse	Guide	Guide Lic. No. N° de licence du guide	Kill Date Date de l'abattage	Latitude	Longitude	Miscellaneous - Divers.
Woodland Caribou Caribou des bois	[redacted]							Right Antler Length: Longueur du bois droit : cm / Left Antler Length: Longueur du bois gauche : cm
Moose Orignal								Widest Antler Spread: Largeur du panache (au plus large) : cm
Mountain Goat Chèvre de montagne								Right Horn Length: Longueur de la corne droit.: cm / Left Horn Length: Longueur de la corne gauche : cm / Sex - Sexe
Polar Bear Ours polaire								Hide Length: Longueur de la peau : cm / Population / Sex - Sexe
Barren-Ground Caribou Caribou de la toundra								Species - Espèce/No. Seen - Quantité aperçue/Sex - Sexe
Other, specify - Autre préciser: Wolf	[redacted]							
Other, specify - Autre préciser: Wolverine								
Other, specify - Autre préciser								
Other, specify - Autre préciser								
Dall's Sheep Mouflon de Dall	[redacted]	8	[redacted]	[redacted]	19 08 09	64 37	129 41	

Plug No. - N° de poinçon: [redacted] Cert. No. - N° de cert.: [redacted] Disc. No. - N° de disque: [redacted] Right Horn Base: Corne droit à la base : cm / Left Horn Base: Corne gauche à la base : cm / Right Horn Length: Longueur de la corne droit: cm / Left Horn Length: Longueur de la corne gauche: cm / Spread - Largeur entre les cornes: / Bloomed - Corne abîmée: Right Droit / Left Gauche / Age

COMMENTS - COMMENTAIRES

We are interested in your observations of quantity and cuality of wildlife observed, their location, condition, age, sex, species, etc. In addition, please comment on any unusual conditions (i.e. scars, behaviour, etc.) on the harvested animals

Nous sommes intéressés par les observations que vous avez faites sur la quantité et la qualité de la faune, sa localisation, sa condition, l'âge, le sexe, les espèces, etc. De plus, vous pouvez faire des commentaires sur les conditions inhabituelles observées sur des animaux abattus (cicatrices, comportement, etc.)

OFFICE USE ONLY - RÉSERVÉ AU BUREAU

Export Permit No. - N° du permis d'exportation: / Export Permit No. - N° du permis d'exportation: / Cites Permit No. N° du permis CITES:

Checked By - Vérifié par: / Date: / Entered By - Inscrit par: / Date: 20

NOTE: This form must be kept up to date and all records relating to the Outfitter Return are subject to inspection by a Wildlife Officer. It is an offence to give false or misleading information in this return.

NOTE: Cette formule doit être à jour. Un agent de la faune a le plein pouvoir de vérifier la justesse de tout ce qui est inscrit sur le rapport du pourvoyeur. Inscrire des renseignements faux ou trompeurs sur ce formulaire constitue une infraction.

[redacted] Date: 04 09 2009

NWT44306/05

Headquaters – Administration Centrale

Figure 2: Example of a completed outfitter return on client hunter success form.

MACKENZIE MOUTAINS, NORTHWEST TERRITORIES
HUNTER WILDLIFE OBSERVATION REPORT – 2007

Dear Hunter: The Department of Environment and Natural Resources request your kind assistance with completing this questionnaire about your NWT hunting experience, in order to assist us with the management of Mackenzie Mountain big game populations. All the requested information is completely voluntary, but your providing it to us is most appreciated.

HUNTER INFORMATION

First Name	Last Name	
Address – number and street, box number	Town, City	Province, State, Country

Hunting License # Outfitter Zone: 6|01|01 Outfitter: ARCTIC RED RIVER

Start Date of Hunt 7/15 2007 End Date of Hunt 7/24 2007 Observations Made Over 10 Days

ESTIMATED NUMBER OF DALL'S SHEEP SEEN			
¾ and Full Curl Rams	Less than ¾ Curl Rams	Ewes	Lambs
25	46	24	17

ESTIMATED NUMBER OF WOODLAND CARIBOU SEEN		
Bulls	Cows	Calves
2	1	Ø

ESTIMATED NUMBER OF MOOSE SEEN		
Bulls	Cows	Calves
Ø	Ø	Ø

ESTIMATED NUMBER OF MOUNTAIN GOAT SEEN			
Billys	Nannys	Kids	Unknown Age
Ø	Ø	Ø	Ø

Other Species						
	Wolf	Wolverine	Black Bear		Grizzly Bear	
			Adult	Cub	Adult	Cub
Number(s) Seen	3	Ø	Ø	Ø	1	Ø

How would you rate your overall hunting experience in the Mackenzie Mountains?
Excellent X Very Good _____ Good _____ Fair _____ Poor _____

How many times have you hunted in the Mackenzie Mountains, **including** this year's hunt? 2

Do you plan to return to hunt in the Mackenzie Mountains again? Yes X No _____

COMMENTS: Excellent Area / outfitter.

Thank You! Please give this form to the Officer or Clerk when you are exporting your trophies, or to the guide/outfitter with whom you hunted. We would appreciate receiving this form whether of not you harvested an animal(s).

Figure 3: Example of a fully completed hunter observation report form.

Nahanni National Park Reserve Expansion

Nahanni NPR, encompassing an area of 4,766 km^2 in the southern Mackenzie Mountains, was originally established in 1972, after Prime Minister Pierre Elliot Trudeau canoed down the Nahanni River. The Park was in "reserve" status pending settlement of outstanding Aboriginal land claims in the region, which remain ongoing. On June 9th, 2009, the Canadian government, along with the Dehcho First Nations, announced legislation increasing the area of Nahanni NPR to *ca.* 30,000 km^2 (11,583 mi^2). This newly enlarged boundary includes 91% of the greater Nahanni ecosystem and most of the South Nahanni River watershed in the Dehcho region (www.pc.gc.ca/pn-np/nahanni/ne/ne2-ep.asp).

The area encompassed by the enlarged boundary of the Nahanni NPR plus the newly established Nááts'ihch'oh NPR overlaps four of the eight outfitting zones which were established in the Mackenzie Mountains in 1965: Ram Head Outfitters (S/OT/03), NWT Outfitters (S/OT/04), South Nahanni Outfitters (D/OT/01) and Nahanni Butte Outfitters (D/OT/02). Of the total area of their outfitting zones, 16.3% of Ram Head, 33.2% of South Nahanni, 13.1% of NWT and 79.4% of Nahanni Butte fall within the expanded Nahanni NPR and Nááts'ihch'oh NPR boundaries (Table 1). Since 2009, outfitters have been allowed to harvest within the expanded boundary, while Parks Canada was negotiating with them to end sport hunting in the area. By the end of 2015 Parks Canada had made monetary settlements with two outfitters: Ram Head and Nahanni Butte Outfitters (Dehcho Drum, January 21, 2016), and according to Parks Canada, four commercial outfitters were compensated due to the expansion (www.cbc.ca/news/canada/north/parks-canada-settlements-nwt-1.3391646). Subsequently, starting in 2016 guided hunting by outfitters will be restricted to those areas outside of the Nahanni NPR and Nááts'ihch'oh NPR boundaries. ENR will continue to issue licences, tags, and export permits for harvesting by these four outfitters in the reduced area of their zones.

Table 1: The area (km^2) and percent of outfitting zone that falls within the boundaries of the expanded Nahanni NPR and Nááts'ihch'oh NPR.

Outfitter	Area of Outfitting Zone	Area of Outfitting Zone within NPRs	% of Zone within NPRs
Ram Head Outfitters	19,734.82 km^2	3,218.99 km^2	16.3 %
South Nahanni Outfitters	25,024.16 km^2	8,315.93 km^2	33.2 %
Nahanni Butte Outfitters	21,962.30 km^2	17,441.19 km^2	79.4 %
NWT Outfitters	8,125.57 km^2	1,063.59 km^2	13.1 %

The Prairie Creek mine, established in 1966, now falls completely within the newly expanded boundary of Nahanni NPR. However, the mine and an area of *ca*. 300 km^2 surrounding the site were specifically excluded from Nahanni NPR so that the mine owned by Canadian Zinc was assured of its third party rights to operate and access the mine site. A new bill amending the *National Parks Act* solely for Nahanni NPR was required to assure these third party rights (www.canadianzinc.com).

METHODS

General Background

Prior to the start of the 2016 hunting season, each outfitter in the Mackenzie Mountains received sufficient copies of the outfitter return and hunter observation forms for all their clients for the year. The *Wildlife Business Regulations* requires outfitter return forms to be returned by the tenth day of the month following the month of the hunt – e.g. for a hunter that was in the field in July, a form must be submitted by the tenth of August. Those forms were submitted to the senior biologist in the Dehcho or Sahtú region, whether or not a client actually hunted and whether or not harvest occurred. In co-operation with ENR Renewable Resource Officers and the outfitters, persistent attempts were made to obtain outfitter return forms for every non-resident that held a big game hunting licence through a Mackenzie Mountain outfitter in 2016.

Data from both the outfitter return forms and hunter observation forms were entered into Microsoft Excel (Microsoft Corporation 2010) spreadsheets. Data were cross-checked with the records of sequentially numbered, unique identifier plugs inserted in the horns of legally harvested rams found in the Licence Information System-IntraNet (LISIN) data management system maintained by ENR offices across the NWT, and also with GNWT wildlife export permit forms, to ensure that all data were verified and the spreadsheets contained all appropriate available data required for analyses.

We distributed new hunter observation forms in 2016 for consistency and recorded all observations directly from these hunter observation forms. If we did not receive a hunter observation form, but wildlife observation data were recorded on the outfitter return form, we used these wildlife observation data. If observation information differed between the hunter observation form and the outfitter return form for the same client, we used the data from the hunter observation form. Occasionally we received identical observation data from forms of different hunters. These hunters had the same guides and lengths of hunts, and obviously had hunted together. We recorded forms with data that had been provided, but for the wildlife observation analyses only one set of observations was used.

All descriptive statistical analyses were performed using Microsoft Excel. We present means ± standard deviation (SD). Some additional statistical analyses were performed using Minitab 7.2 software (Minitab Inc. 1989).

RESULTS AND DISCUSSION

Hunters

In 2016, big game hunting licences for the Mackenzie Mountains were bought by 389 non-resident hunters from ten countries (Table 2). A drop from last year (most purchased) to slightly above the average of 373 purchased in a year from 1991-2016 (range 321-447; Figure 4, Appendix F). Of those 389 hunters, 352 came to the NWT and spent some time hunting. The remaining 37 either cancelled their hunts, decided not to hunt for themselves but participated with other hunters they knew, or decided not to hunt due to unforeseen complications after arriving in the NWT. Fourteen of these 37 were guides. Guides often purchase licences every year but rarely have the opportunity to hunt themselves.

In 2016, licence sales to residents of countries other than Canada and the United States (n=34) represented only 9% of sales, down noticeably from the *ca*. 17% in 2013. Non-resident Canadians purchased 21% (n=80) of licenses, the lowest proportion in all but one year (2015) since 2005. Hunters from the United States (US) purchased 71% of licenses, the greatest proportion since 2005 (Table 2, Figure 5). Sales of licenses to US hunters were *ca.* 60% from 2006-2013 but have increased each year since 2013. Hunts are marketed in American dollars. In years when the Canadian dollar has averaged $0.80 or more against the US dollar (2005-2014) *ca.* 40% of hunters were from other than the US. Whereas in years when the Canadian dollar averaged below $0.80 US hunters predominated (70-80%; 2015-2016 and 2002-2004; www.canadianforex.ca).

Table 2: Province, state and/or country of origin of the 389 non-residents who purchased licences for hunting in the Mackenzie Mountains, 2016.

Canada		United States		W. Europe		Other	
Yukon	**5**	Eastern States[1]	**124**	Germany	**12**	Mexico	**8**
British Columbia	**21**			Austria	**5**	Russia	**2**
Alberta	**39**	Western States[2]	**151**	Belgium	**2**	Australia	**2**
Saskatchewan	**7**			Switzerland	**2**	New Zealand	**1**
Manitoba	**2**						
Ontario/Quebec	**6**						
Total	**80**		**275**		**21**		**13**

[1]AL, AR, CT, DE, FL, GA, IL, IN, IA, KY, LA, ME, MD, MA, MI, MN, MS, MO, NH, NJ, NY, NC, OH, PA, RI, SC, TN, VT, VA, WV, WI

[2]AK, AZ, CA, CO, HI, ID, KS, MT, NE, NV, NM, ND, OK, OR, SD, TX, UT, WA, WY

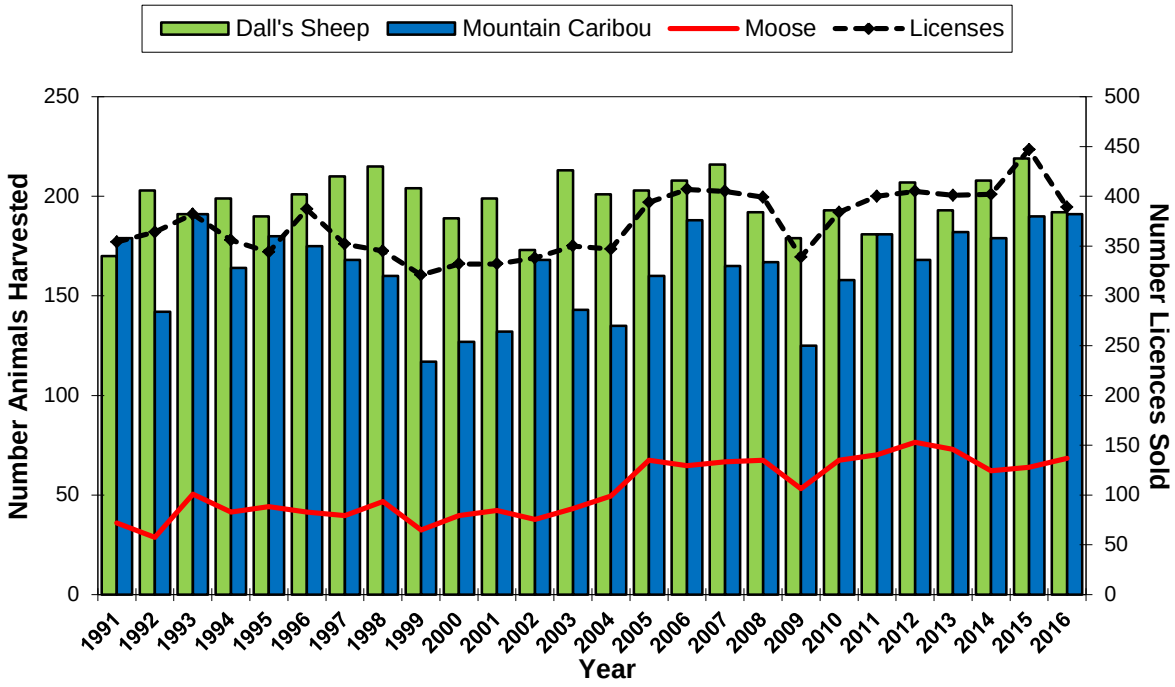

Figure 4: The number of Dall's sheep, mountain caribou, and moose harvested in the Mackenzie Mountains by non-resident hunters, and the number of non-resident licences sold during 1991-2016.

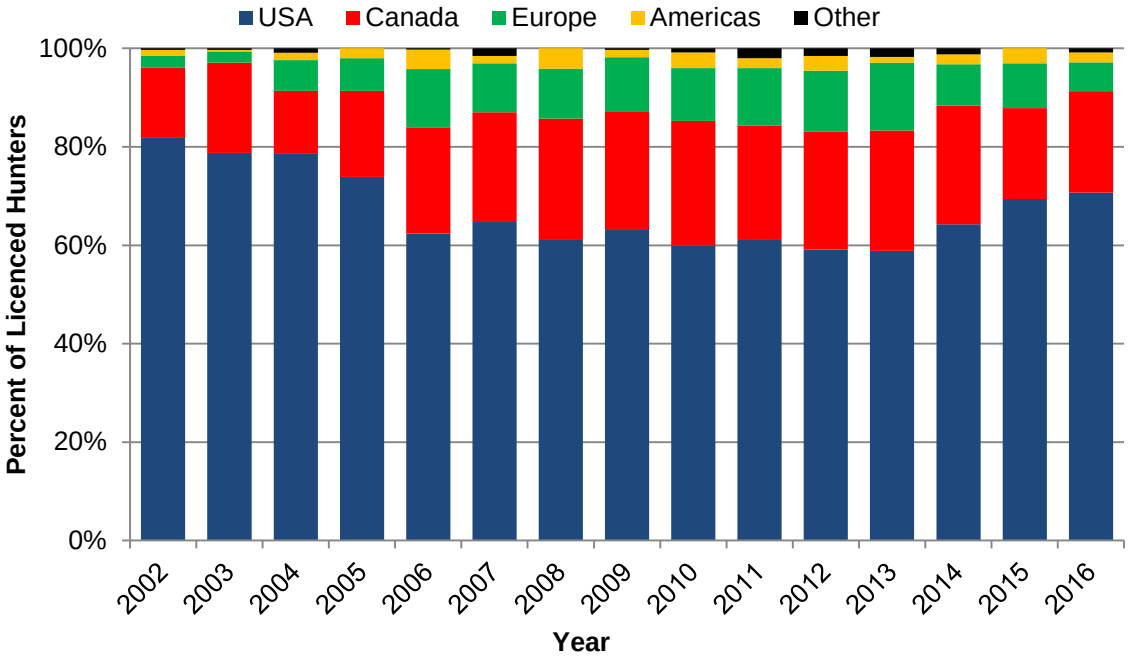

Figure 5: The geographical areas of origin of hunters purchasing licences (in %) to hunt in the Mackenzie Mountains from 2002-2016.

In general guided hunting in the Mackenzie Mountains occurs from July to October however guided hunting for wolves also occurs during winter in zone S/OT/01. This was the eighth consecutive year wolf hunting occurred in this zone; eight wolves were harvested in April 2017.

We received all but two mandatory outfitter return forms for the 389 people that purchased non-resident licences. We received 196 (55%) of the possible 354 voluntary hunter observation forms from hunters in 2016 (Table 3). This is the lowest return since 2000 and discouraging after returns in recent years were >70%. The need for returning voluntary observation forms has been emphasized at Association of Mackenzie Mountain Outfitters (AMMO) general meetings. Some of the decrease this year may have been related to a much reduced number of clients in zones affected by the park expansion, like D/OT/02, that consistently have high return in voluntary observation forms. Although most outfitters endeavour to have clients complete and submit these forms, we received only eight of 65 forms (12%) from G/OT/01, 16 of 74 (22%) from S/OT/02, and seven of 38 (18%) from S/OT/03. The limited returns from zones with large clientele, remains a

concern because it precludes the ability to generalize observations over the entire Mackenzie Mountains. Two zones with low returns cover the greatest range in latitude in the Mackenzie Mountains (Figure 1). See Figure 4 as an example of a fully completed hunter observation form.

Table 3: Percent of Mackenzie Mountain outfitter and non-resident hunter forms submitted, 1995-2016.

Form Type	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006
Outfitter Return (mandatory)	99	99	99	98	99	99	98	99	99	98	99
Hunter Observation (voluntary)	55	72	75	56[1]	60	62	60	62	71	65	64

Form Type	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995
Outfitter Return (mandatory)	100	99	98	95	92	96	96	97	98	100	98
Hunter Observation (voluntary)	65	74	60	59	57	53	51	60	50	71	80

[1]5% of forms were lost after being completed but prior to submission.

It is obvious that non-resident hunters immensely enjoyed their hunting experience in the Mackenzie Mountains (Table 4). In 2016, 98% of respondents rated their experience as either excellent (86%) or very good (12%). Not only do voluntary client comments make specific mention of the high quality of hunts (50%; n=77), and the abundance/quality of animals (29%, n=44; Appendices C, D), many comments make reference to (1) the professional and world class experience with their chosen guides, (2) the abundance of a wide variety of game species and predators, (3) the apparent health and condition of the game animals, (4) the pristine and scenic environment of the Mackenzie Mountains, and (5) compliments on the management and stewardship of the land.

Table 4: Satisfaction ratings for non-resident hunters (including non-hunting guides) in the Mackenzie Mountains, 1996-2016.

Rating	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007
Number of Hunters Reporting	195	290	262	207	212	210	193	191	239	239
Excellent (%)	86	86	88	86	93	90	88	86	85	81
Very Good (%)	12	12	10	11	5	6	10	12	10	12
Good (%)	2	2	2	2	2	4	1	2	4	5
Fair (%)	0	0	0	1	0	0	1	0	1	2
Poor (%)	0	0	0	0	0	0	0	0	0	0

Rating	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996
Number of Hunters Reporting	230	256	229	191	193	191	158	157	202	144	224
Excellent (%)	80	90	84	82	82	75	76	73	80	78	77
Very Good (%)	16	7	10	15	15	16	17	20	17	17	17
Good (%)	3	2	5	3	3	6	6	5	2	3	2
Fair (%)	1	1	0	0	0	1	0	1	1	1	3
Poor (%)	0	0	1	0	0	1	1	2	0	1	1

Comments about grizzly bears have been common since the start of the voluntary hunter observation forms in 1995; their abundance, problems created around camps and kills, and the lack of, and need for, a grizzly hunting season being consistent themes. This year was no different (Appendices C, D). In 2000 we started getting a limited number of comments about high wolf numbers. This year was no exception. We continue to get comments about the expansion of Nahanni NPR, mostly about lost hunting opportunities. This season was the first season where hunting was not permitted within the Nahanni NPR boundaries (see Figure 2.).

It was the first time hunting in the Mackenzie Mountains for 150 of 195 (77%) respondents (including non-hunting guides). The 45 repeat hunters had hunted from two to 20 times

previously. Of 195 respondents (including non-hunting guides) 92% indicated they would like to return to the Mackenzie Mountains to hunt in the future.

ENR continues to provide outfitters with summary meat record forms which can be used in conjunction with AMMO meat forms to provide better reporting of harvested meat. Both forms record the amount of meat (Dall's sheep, northern mountain caribou, moose, and mountain goat) taken from harvested animals and how the meat was used and/or distributed. This year we received summary forms from all eight outfitters, an additional 90 AMMO meat forms were also submitted. This is the sixth consecutive year we received records of meat distribution from all eight outfitters.

The distribution of wild game meat by outfitters is an important and greatly appreciated local benefit but can often be a topic of heated local debate. Meat is used in outfitter camps by guides and clients, is taken out with clients, and is provided to local communities. We believe that the information from summary meat record forms provides a better overall picture of the amount of wild game meat being distributed by the outfitters. Generally the majority of meat from harvested Dall's sheep and mountain goats is used in outfitter camps. Nevertheless, at least 1,744 kg (3,845 lbs.) from 192 harvested Dall's sheep and 84 kg (185 lbs.) from six harvested mountain goats was distributed locally. Northern mountain caribou and moose meat is also used in outfitter camps, but harvested mountain caribou and moose make up a large portion of the wild game meat that is distributed locally: at least 8,944 kg (19,718 lbs.) from 193 northern mountain caribou and at least 12,702 kg (28,003 lbs.) from 76 moose. If we use a relatively conservative $25/kg as the replacement cost for meat from local northern retailers, then some $586,850 of meat was distributed locally in 2016.

Dall's Sheep (*Ovis dalli*)

Dall's sheep is one of the most desired species sought by non-resident hunters in the Mackenzie Mountains. Tags to hunt Dall's sheep were purchased by 252 (65%) non-resident hunters in 2016. This is similar to the average number of tags purchased in the past 22 years (Table 5). At least 76% of sheep tag holders (including two resident hunters)

pursued Dall's sheep, harvesting 192 rams (Figure 4, Appendix F). The mean (±SD) length of a sheep hunt was 4.0±3.0 days, similar to hunt lengths from 1997-2016 (Table 6), but less than the 5.3 day average from 1979-1990 (Latour and MacLean 1994). Outfitted hunts in the Mackenzie Mountains are generally booked for ten days; when hunters fill their sheep tag, any remaining time is typically spent in pursuit of other big game species for which tags are held, or in hunting small game. The number of hunters taking multispecies hunts has increased in recent years (Jim Lancaster personal communication and Werner Aschbacher personal communication).

Table 5: Tags for big game species purchased by non-resident hunters with outfitters in the Mackenzie Mountains, 1995-2016.

Species	2016 389 hunters		2015 447 hunters		2014 402 hunters		2013 401 hunters		2012 396 hunters		2011 400 hunters		2010 384 hunters		2009 339 hunters		2008 391 hunters		2007 399 hunters	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Dall's Sheep	252	65	291	65	264	66	264	66	270	68	251	63	253	66	215	63	261	67	266	67
Mountain Caribou	319	82	347	78	327	81	296	74	300	76	314	79	295	77	252	74	275	70	272	68
Moose	121	31	117	26	123	31	131	33	115	29	121	30	116	30	96	28	109	28	108	27
Mountain Goat	25	6	71	16	57	14	58	14	42	11	55	14	45	12	45	13	45	12	50	13
Wolf	310	80	358	80	298	74	299	75	292	74	285	71	294	77	252	74	228	58	227	57
Wolverine	190	49	179	40	154	38	155	39	153	39	163	41	171	45	133	39	111	28	150	38
Black Bear	18	5	20	4	19	6	34	8	16	4	32	8	28	7	22	6	2	1	7	2

Species	2006 407 hunters		2005 394 hunters		2004 337 hunters		2003 347 hunters		2002 329 hunters		2001 339 hunters		2000 332 hunters		1999 321 hunters		1998 345 hunters		1997 352 hunters	
	N	**%**	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Dall's Sheep	276	68	246	62	229	68	257	74	218	66	220	65	231	70	227	71	246	71	252	72
Mountain Caribou	274	67	285	72	243	72	247	71	229	69	201	59	206	62	181	56	223	65	260	74
Moose	112	28	101	26	84	25	85	24	68	21	65	19	69	21	63	20	69	20	73	21
Mountain Goat	21	5	40	10	24	7	18	5	18	5	12	4	12	4	6	2	23	7	30	8
Wolf	201	49	214	51	166	49	207	60	159	48	137	40	155	47	89	28	165	48	209	59
Wolverine	108	27	154	39	89	26	141	40	97	29	83	25	85	26	65	20	99	29	135	38
Black Bear	3	1	40	10	8	2	9	3	3	1	0	0	6	2	2	<1	2	<1	8	2

Species	1996 387 hunters		1995 343 hunters	
	N	%	N	%
Dall's Sheep	252	65	218	64
Mountain Caribou	274	71	233	68
Moose	74	18	70	20
Mountain Goat	14	4	16	5
Wolf	193	50	72	21
Wolverine	114	30	35	10
Black Bear	0	0	0	0

Table 6: Mean length, SD and range (in days) of Dall's sheep hunts where at least one day was spent hunting from 1997-2016.

	2016	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**
Number of Reports	185	213	206	193	207	173	179	179	192	216
Mean Hunt Length	4.0	4.0	3.8	4.0	4.0	4.0	4.0	3.9	3.7	4.1
SD	3.0	3.0	2.9	3.0	3.0	3.0	3.0	2.6	2.6	2.6
Range	1-14	1-15	1-14	1-13	1-14	1-11	1-13	1-10	1-14	1-13
	2006	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**
Number of Reports	214	190	167	189	174	176	198	201	224	216
Mean Hunt Length	4.1	4.1	4.0	3.8	4.7	4.8	4.6	4.7	4.4	4.3
SD	2.7	2.6	2.9	2.9	2.7	3.0	2.7	3.1	2.8	2.6
Range	1-12	1-14	1-17	1-12	1-15	1-15	1-15	1-16	1-15	1-12

Harvest by non-residents comprises at least 90% of the total annual harvest of Dall's sheep in the Mackenzie Mountains and takes only 0.9-1.6% of the estimated 14,000-26,000 Dall's sheep in the Mackenzie Mountains (Veitch et al. 2000a). Therefore, the current non-resident harvest level appears well within sustainable limits, provided that hunting pressure is geographically distributed across each of the zones. The 2016 harvest of 192

rams is *ca.* 1.4% of 14,000. In the Yukon (YT)—where harvest is managed by a full curl rule—Dall's sheep managers have set the sustainable harvest at 4% of the non-lamb population (YT Renewable Resources 1996). In those areas of the YT where the management objective is to increase population size, harvest is limited to 2% of the total population.

There has been remarkable consistency in the mean outside contour length of the right horns from rams harvested by non-residents for the past 45 years (1972-2016), mean 89.0±1.6 cm (SD) (Appendix E, Table 7), which is surprising given the increase in average age of harvested sheep during that same period. We expected to see more broomed or broken horn tips on older animals, since horn breakage generally occurs as a result of fights between rival males (Geist 1993).

The maximum left and right horn lengths reported in 2016 were 105.0 and 106.0 cm respectively (Table 7). The maximum horn length recorded by Boone and Crockett for Dall's sheep in North America is 116.5 cm (45.9 in.) for a sheep taken from the Mackenzie Mountains in 1973. Two of the top 50 Dall's sheep recorded in the 13th edition of the Boone and Crockett Club record book are from the Mackenzie Mountains; the highest scoring horns hold 31st place (Boone and Crockett Club on-line trophy database accessed 2017).

The Safari Club International (SCI) offers another measuring system for antlered animals. They have a unique all-inclusive record keeping system, the most used system in the world. Unlike Boone and Crockett scoring, this system has no deductions or penalizing for antler asymmetry, and provides points for all tines, which is important for caribou antlers (Jim Lancaster personal communication). Thirteen of the top 50 Dall's sheep in the SCI on-line record book are from the Mackenzie Mountains. One sheep harvested in 1983 holds 12th place in scoring (SCI on-line trophy database accessed 2017).

Table 7: Measurements of Dall's sheep ram horns from sheep harvested by non-resident hunters in the Mackenzie Mountains, 2016.

	Left Horn Contour Length		Right Horn Contour Length		Left Horn Base Circumference		Right Horn Base Circumference		Tip To Tip Spread	
	cm	in	cm	in	cm	in	cm	in	cm	in
Mean	88.4	34.8	89.1	35.1	32.3	12.7	32.3	12.7	59.5	23.4
SD	13.0	5.1	13.4	5.3	4.3	1.7	4.3	1.7	11.7	4.6
Maximum	105.0	41.3	106.0	41.7	37.0	14.6	36.5	14.4	94.6	37.2
Minimum	64.6	25.4	46.4	18.3	28.5	11.2	28.5	11.2	33.0	13.0

This year we aged 187 of 192 harvested rams; 149 (80%) were ≥10-years-old. The mean age (±SD) of harvested rams was 11.0±2.3 years (range 6.5-15.5 years, Figure 6). This is the highest average age of harvested rams recorded in the Mackenzie Mountains since records have been kept (1967), and the 29th consecutive year where the reported mean age of harvested rams was 9.5 years or older (Appendix E). This year we report a lower percent broomed horns than the 20 year average, 28% left and 23% right versus 31% left and 32% right. This is unexpected given the highest average age of rams was harvested this year.

The continued high age of harvested trophy sheep may be a result of harvest being spread out in time and space within hunting zones. Exclusivity of non-resident big game harvesting within each zone provides the opportunity for outfitters to harvest in different parts of their zone on a rotational basis and forgo hunting in some areas for two or three seasons. In recent years some outfitters have used helicopters to gain access into areas not accessible by horseback (e.g. S/OT/04). These areas have not been exposed to hunting previously, and spread out the harvest in space, likely contributing to the continued high average age of harvested rams.

Horns are not shed and provide detailed records of growth history in the form of discernable annual growth segments, or annuli. Annuli are evident in the keratin sheath of the horn, and form as the result of a stop-start pattern of growth in the winter and spring seasons, respectively. Horn growth can be limited by resource availability which is regulated by regional climatic conditions (Hik and Carey 2000). Examining horn growth patterns over time can reveal years of high and low environmental productivity. Since 2002

ENR has tried to measure the annuli from as many harvested Dall's sheep rams as possible using a flexible tape to measure the length and basal circumference of each segment; from 2002-2016, 791 Dall's sheep horns were measured.

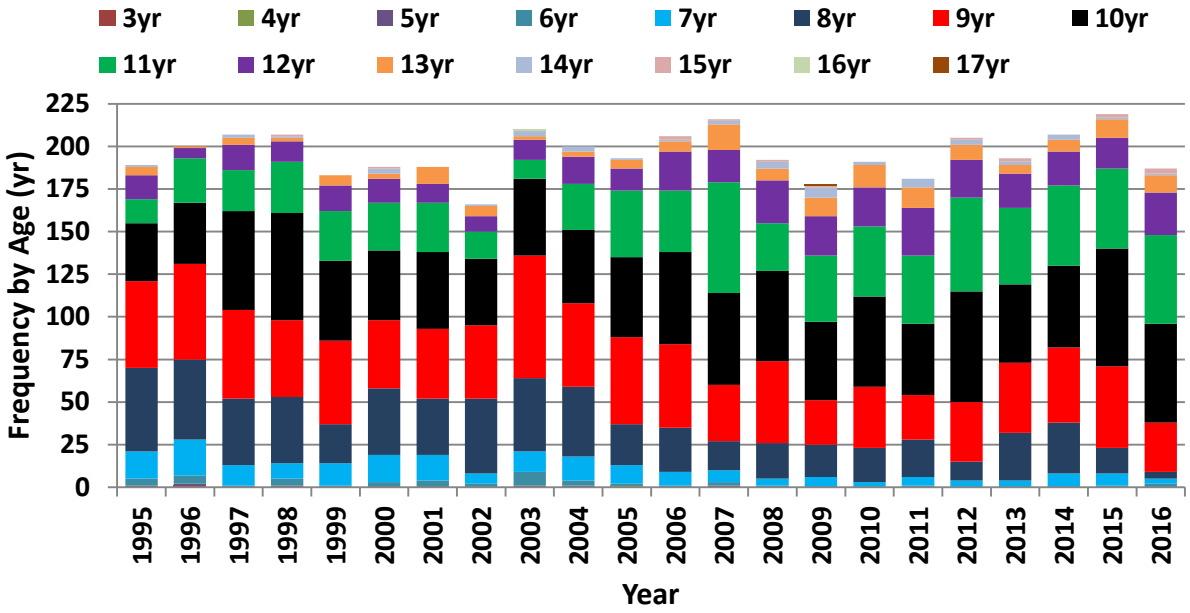

Figure 6: Age-structure of Dall's sheep ram harvest by non-resident and resident hunters in the Mackenzie Mountains, 1995-2016, based upon counting horn annuli.

Preliminary results showed that horn growth patterns were influenced by year of birth and demonstrated both statistically and biologically significant variation in volume acquisition as a function of age. This reveals the presence of a cohort effect, which suggests that birth year conditions impact the growth rates of Dall's sheep in the southern Mackenzie Mountains (K. Eykelboom unpublished data). Although the underlying cause of this variation is not clear, similar trends were seen in neighbouring populations of Dall's sheep in the Yukon. It is likely that climate plays a role in horn growth variation, and correlations in the Yukon have been found between horn growth periodicity and inter-decadal climate variability (Hik and Carey 2000). Further analysis of these patterns is underway.

Horn measurements collected by ENR (2002-2016) were used in a study at the University of Lethbridge on age structure and horn configuration. Festa-Bianchet et al. (2014) had implicated trophy hunting of bighorn sheep in Alberta as a factor in their reduced horn size

and increased age of harvest over time. The modal age class in this study was 6.5 years. In comparison, the average age of harvested Dall's sheep in the Mackenzie Mountains was 10.5 years and the age of sheep harvest had been stable over the 15 years. The age of Dall's sheep harvested was near natural mortality of Dall's sheep which suggests that genetic contributions of most harvested sheep had likely made to the population. Dall's sheep harvest in the Mackenzie Mountains is spread out both spatially and temporally which allows for a high harvested age. Any slight decreases in horn length recently may be related to climatic effects (Kennedy 2017).

We calculated an estimated 49.2 lambs per 100 ewes based upon hunter classifications of sheep observed during their hunts in 2016 (Table 8); this is lower than the average ratio of 54 lambs:100 ewes reported since 1995 (Appendix G). From 1997-2014, ground-based surveys were conducted in July in two study areas of the northern Sahtú region of the Mackenzie Mountains on an annual or semi-annual basis. Average ratios of 62.8 (range 36.7-83.0) and 55.1 (range 17.3-94.1) lambs:100 ewes were reported (A. Veitch unpublished data, Heather Sayine-Crawford personal communication). For the Richardson Mountains of the northern YT and NWT, Nagy and Carey (2013) suggest an August ratio of 43 lambs:100 ewes would have allowed for their observed 10.5% average annual rate of increase from 1986-1991. Subsequent to a decline in this unhunted population from 1997-2003, J. Nagy et al. (unpublished data) reported 28 lambs per 100 'nursery sheep' in August 2003. Surveys in the southwestern YT conducted during late June-mid-July 2015 classified 5,460 sheep, reporting a ratio 37 lambs per 100 nursery sheep; the actual recruitment in lambs:100 ewes would be higher (Troy Hegel personal communication). Jorgenson (1992) summarized 17 years of lamb:ewe classification data for a population of bighorn sheep in west-central Alberta and found a mean ratio of 43 lambs:100 ewes in September (range 25-54).

Table 8: Observations of Dall's sheep reported by non-resident hunters in the Mackenzie Mountains, 2016.

	Number of Hunters Reporting	Number Observed	Mean Number Observed/hunter	% of Sheep Classified
Rams	165	2,550	15.0	35.1
Ewes[1]	162	3,156	19.0	43.5
Lambs	156	1,553	10.0	21.4

[1] includes females >1-yr-old, yearlings, and younger rams. Also called nursery sheep.

Differences in adult sex ratios among populations may result from differences in hunting pressure, differences in survival of males and females from birth to adulthood, or both (Nichols and Bunnell 1999). However, since the ratio of rams to ewes is almost never equal in wild populations of mountain sheep, even where they are unhunted, it is clear that there is a different natural mortality rate for the two sexes. This difference was believed to be a result of injuries and stress accumulated by males during the breeding season (Geist 1971).

The 81 ram:100 ewe ratio estimated from hunter observations in 2016 falls below the 87 ram:100 ewe average reported from 1995-2016 (Appendix G). Ground-based surveys conducted in July in two areas of the northern Sahtú region of the Mackenzie Mountains on an annual or semi-annual basis from 1997-2011 reported average ratios of 63.4 and 58.1 rams:100 ewes (A. Veitch unpublished data).

In the YT, mid- to late June annual aerial surveys to count and classify sheep from 1973-1998 reported a mean of 48 rams (range 28-74) per 100 'nursery sheep' (J. Carey unpublished data). More recently, a similar survey of 5,460 sheep, in late June-mid-July 2015, reported 43 rams per 100 'nursery sheep' (Troy Hegel personal communication). For the unhunted Richardson Mountains herd (YT-NWT), J. Nagy et al. (unpublished data) reported 41 rams per 100 'nursery sheep' in 2003 following a decline from peak population size in 1997. In Alaska, ram:ewe ratio for two unhunted herds in Denali and Gates of the Arctic National Parks typically averaged 60-67:100 (Nichols and Bunnell 1999). In more heavily hunted Alaskan herds, ram:ewe ratio ranged from 33:100 (heavily hunted) to

87:100 (lightly hunted). The ram:ewe ratios reported for the Mackenzie Mountains since 1995 (Appendix G) suggest that the harvest of rams in the Mackenzie Mountains is sustainable at current levels.

Fewer rams were classified by curl in 2016 than in recent years (Table 9). This may be a reflection of the reduced number of voluntary observation forms received this year. Hunters observed fewer legal (>¾ curl) rams (n=968) than rams with <¾ curl (n=1,186). The mean number of legal rams observed per hunt was 7.0 (Table 9). In most years hunters have observed fewer legal rams than rams <¾ curl (Table 9).

As one of the collaborators in a landscape genetics study on thinhorn sheep, ENR Fort Simpson contributed horn core samples taken from over 400 Dall's sheep rams harvested in the Mackenzie Mountains. In order to insert a permanent numbered plug in ram horns, it is necessary to drill a hole in the horn. These drill shavings represent DNA samples of individual sheep. DNA samples (*ca.* 2,000) from our sheep and others throughout the North American range were genetically profiled using 153 single nucleotide polymorphisms (SNPs). Genetic profiles were used to identify population boundaries across the geographic range of thinhorn sheep, most boundaries largely delineated by river drainages and mountain range boundaries. Profiles were also used to re-examine subspecific boundaries of white Dall's sheep (*O. d. dalli*) and dark Stone's sheep (*O. d. stonei*), the latter being a distinct lineage of sheep inhabiting British Columbia (Figure 7; Sim et al. 2016a, b.).

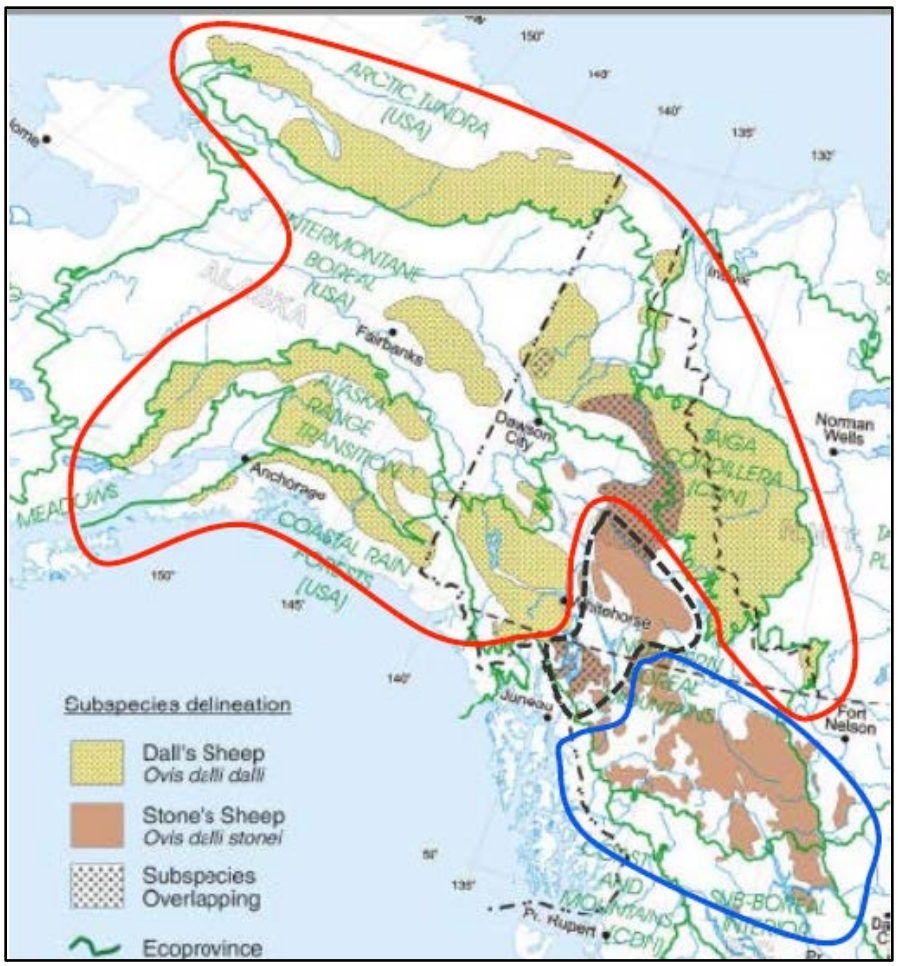

Figure 7. Map comparing genetic subspecies (Sim et al. 2016) and current subspecies boundaries (Demarchi and Hartwig 2004) for thinhorn sheep. Red lines represent the approximate genetic boundaries for Dall's sheep (*Ovis dalli dalli*), blue for Stone's sheep (*Ovis d. stonei*) and dotted line for admixed sheep. (reproduced from Sim et al. 2016b).

Table 9: Classification of Dall's sheep rams observed by non-resident hunters in the Mackenzie Mountains, 1995-2016.

Ram Class	2016		2015		2014		2013		2012		2011		2010		2009		2008	
	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl
Number of hunters reporting	142	130	215	202	208	186	156	149	140	124	149	133	158	142	139	132	184	174
Number of rams classified	968	1,186	1,406	1,693	1,372	1,484	1,006	1,230	1,117	987	1,234	1,168	1,314	1,620	1,040	1,093	1,520	1,698
% of rams classified	44.9	55.1	45.4	54.6	48.0	52.0	45.0	55.0	53.0	47.0	51.4	48.6	48.8	55.2	48.8	51.2	47.2	52.8
Mean number of rams observed/hunt	7.0	9.0	7.0	8.0	7.0	8.0	6.0	8.0	8.0	8.0	8.0	9.0	8.3	11.4	7.5	8.3	8.3	9.8

Ram Class	2007		2006		2005		2004		2003		2002		2001		2000		1999	
	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn > ¾ curl	Horn <¾ curl	Horn > ¾ curl	Horn <¾ curl	Horn > ¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl
Number of hunters reporting	150	168	108	171	186	182	188	183	127	121	148	133	186	174	151	147	144	138
Number of rams classified	1,902	2,266	1,769	2,019	1,787	1,899	2,185	2,324	1,662	1,654	1,720	1,720	1,812	1,765	1,351	1,717	1,579	1,756
% of rams classified	45.6	54.4	46.7	53.3	48.5	51.5	48.5	51.5	50.1	49.9	50.0	50.0	50.7	49.3	44.0	56.0	47.3	52.7
Mean number of rams observed/hunt	11.0	13.5	9.9	12.0	9.6	10.4	11.6	12.7	11.9	11.9	11.6	12.9	9.7	10.1	8.9	11.7	11.0	12.7

Ram Class	1998		1997		1996		1995	
	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl	Horn >¾ curl	Horn <¾ curl
Number of hunters reporting	177	177	205	205	172	174	181	180
Number of rams classified	1,848	1,924	1,538	1,586	1,713	1,699	2,070	1,645
% of rams classified	49.0	51.0	49.2	50.8	50.2	49.8	55.7	44.3
Mean number of rams observed/hunt	10.4	11.3	7.5	7.7	10.0	9.8	11.4	9.1

Northern Mountain Caribou (*Rangifer tarandus caribou*)

In their 2002 assessment, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the boreal population of woodland caribou as Threatened, and the northern mountain population of woodland caribou as Special Concern. These two populations of woodland caribou were subsequently listed under the federal *Species at Risk Act* (SARA) in 2004 and 2007 respectively. Caribou of the Mackenzie Mountains are part of the northern mountain population of woodland caribou. In order to be more specific and to avoid confusion this report will use “northern mountain caribou” when referring to caribou from the Mackenzie Mountains.

Northern mountain caribou are another of the more desired species sought by non-resident hunters. Tags were purchased by 319 (82%) of non-resident hunters (Table 5), substantially more than the average 264 (range 181-347) since reporting started in 1995, but down from the 347 purchased in 2015. At least 60% of tag holders hunted caribou, harvesting 191 males which equalled the highest harvest in 1993 from 1991-2015 (Figure 4; Appendix F). The mean (±SD) length of a caribou hunt, determined from the 190 reports where hunters spent at least one day hunting, was 4.0±3.0 days (range 1-20 days), comparable to that of previous years (Table 10).

We calculated ratios of 33.4 calves and 41.6 bulls (males) per 100 adult females (cows) based upon hunter classifications of northern mountain caribou observed during hunts. Bulls comprised 23.8% of all caribou classified (Table 11). The calf:cow ratio estimated from hunter observations was the lowest recorded since records began in 1995 (range 33-59:100). The bull:cow ratio estimated from hunter observations was similar to the average 39:100 (range 21-61:100; Appendix G).

Table 10: Mean length, SD and range (in days) of northern mountain caribou hunts where at least one day was spent hunting from 2000-2016.

	2016	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**
Number Reports	190	206	190	196	180	187	175	155	190	172	171
Mean Hunt Length	4.0	4.0	4.0	3.0	4.0	3.0	4.0	4.0	3.0	4.0	4.3
SD	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.2	3.1
Range	1-20	1-18	1-14	1-13	1-17	1-16	1-14	1-14	1-15	1-16	1-14

	2005	2004	2003	2002	2001	2000
Number Reports	191	120	172	181	178	141
Mean Hunt Length	3.7	4.9	3.8	3.6	4.3	4.0
SD	3.8	3.9	2.8	2.7	3.2	2.7
Range	1-32	1-34	1-14	1-12	1-15	1-12

Table 11: Observations of northern mountain caribou reported by non-resident hunters in the Mackenzie Mountains, 2016.

Sex/Age Class	Number of Hunters Reporting	Number Observed	Mean Number Observed/hunter	% of Total Classified
Bulls	189	3,783	20.0	23.8
Cows	181	9,097	50.3	57.2
Calves	138	3,035	22.0	19.0

Over a period of three hunting seasons (2011-2013) ENR collected front incisor teeth from caribou harvested in the southern portion of the Mackenzie Mountains, on a voluntary basis. Tooth ages are determined by counting the cementum annuli much like the growth rings of a tree (Matson 1981; www.matsonslab.com). The ages from the 32 caribou ranged from two to 11 years (mean 6.5 years, median 6.3 years). An additional 52 archived mountain caribou teeth collected from the 1975 harvest were recently discovered and also sent out for cementum aging. The age range was strikingly similar three to 13 years (mean 6.2 years, median 6.0 years; Figure 8), with the majority of harvested males being aged from five to eight years.

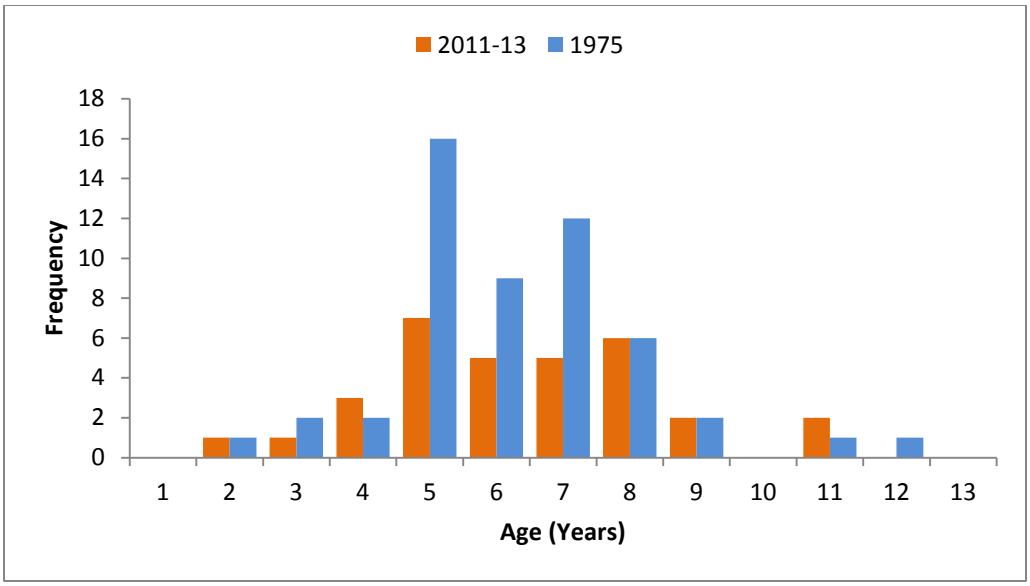

Figure 8: The age distribution of harvested male mountain caribou from 1975 (n=52, blue) and from 2011-2013 (n=32, orange).

Although antler measurement information sometimes goes unreported on outfitter forms, we received antler lengths from 127 (66%) successful hunters. This year, as in other years, there was substantial variation in antler lengths, range 77.0-145.0 cm (30.3-57.1 in.). The maximum left and right antler lengths reported were 138.0 and 145.0 cm respectively (Table 12). The maximum antler length recorded by Boone and Crockett for northern mountain woodland caribou in North America is 158.5 cm (62.4 in.) for a caribou taken from the Mackenzie Mountains in 1978. Sixteen of the top 50 mountain woodland caribou recorded are from the Mackenzie Mountains; the highest scoring antlers hold 9th place (Boone and Crockett Club on-line trophy database accessed 2017). Eighteen of the top 50 mountain woodland caribou recorded in the SCI on-line record book are from the Mackenzie Mountains, with a caribou harvested in 2006 holding second place in scoring (SCI on-line trophy database accessed 2017).

Table 12: Antler measurements of northern mountain caribou bulls harvested by non-resident hunters in the Mackenzie Mountains, 2016. All measurements are in cm (in.).

	Contour Length	
	Left Antler (cm)	**Right Antler (cm)**
Number Measured	127	127
Mean	112.7 (44.4 in.)	113.3 (44.6 in.)
SD	54.2 (21.3 in.)	54.6 (21.5 in.)
Maximum	138.0 (54.3 in.)	145.0 (57.1 in.)
Minimum	79.0 (31.1 in.)	77.0 (30.3 in.)

Since 1991 the percentage of bulls observed by clients in the Mackenzie Mountains has never been greater than 28%. This is a lower percentage than the cumulative 39% average adult bull component reported by Bergerud (1978) in his summary of eight North American caribou populations that were either non-hunted or hunted non-selectively (i.e., both males and females included in the harvest). Veitch et al. (2000c) classified 2,659 of an estimated 5,000 caribou in the central Mackenzie Mountains in August 1999 and reported only 25% of those animals as males. Surveys done on the presumed rutting grounds of the South Nahanni caribou population in 1995, 1996, and 1997 reported 24, 28, and 20% of animals classified as males ≥1-year-old (Gullickson and Manseau 2000) and in 2001 reported 27% bulls (Gunn et al. 2002). A 2007 survey during the rut estimated 33.7 bulls:100 adult cows (R. Farnell and K. Egli unpublished data). A 2008 composition count during the rut in the same general area estimated a slightly higher ratio of 35.5 bulls:100 adult cows (Troy Hegel personal communication).

Nagy (2011) determined ten activity periods for northern mountain caribou in the Sahtú using movement data from satellite collared caribou (Olsen 2000, 2001). The breeding period, or rut, was defined as October 9-25. This period was also the activity period with the greatest daily movement rate (Nagy 2011). Hunter observation data are collected and the 1999 survey was carried out prior to the breeding period (Veitch et al. 2000c). Surveys

conducted well before the rut or breeding period may underestimate the male component of the population. The surveys in 2007 and 2008 were conducted in late September and early October, just prior to the defined breeding period, and findings were more comparable to what Bergerud (1978) reported. Based upon hunter observations there is some evidence that the proportion of males differs between populations, with male:female ratio lower in Redstone than in Bonnet Plume; this difference has been consistent over the past 20-25 years (Larter 2012a; N. Larter unpublished data). Further investigation is required to explore demographic attributes of northern mountain caribou in the Mackenzie Mountains.

Northern mountain caribou in the Mackenzie Mountains are estimated to number between 15,000 and 20,000 from at least three separate populations shared between the YT and NWT (Figure 9). Currently, estimated population sizes (excluding calves) are *ca.* 4,200 for the Bonnet Plume, a minimum of 7,300 for the Redstone, and *ca.* 2,700 for the greater Nahanni (South Nahanni, Coal River and Labiche pooled) population (COSEWIC 2014). These caribou are subjected to an annual bull-selective non-resident harvest averaging 163 males per year (1991-2016). The resident harvest of northern mountain caribou in the Mackenzie Mountains also tends to be bull-selective (but not restricted to bulls). Based upon an analysis of resident hunter questionnaires *ca.* 20-25 animals were harvested annually from 2001-2010. Harvest from 2011-2015 increased to c*a.* 45 animals but remains generally light (S. Carrière unpublished data). Subsistence harvest includes both males and females, with the proportion of each dependent on the time of year that animals are harvested (J. Snortland unpublished data, ENR unpublished data). Subsistence harvesters in the Mackenzie Mountains include residents of both the NWT and YT; harvest is not generally reported.

A study on the Redstone population of northern mountain caribou was initiated by the SRRB in March 2002 when ten female caribou in the central and north-central Mackenzie Mountains were equipped with satellite radio collars (Creighton 2006, Olsen 2000, 2001,

Olsen et al. 2001). Analysis of these location data indicated that some of the collared animals in the range of the Redstone population are relatively sedentary year round, while others show the more typical seasonal migratory movements (J. Nagy personal communication).

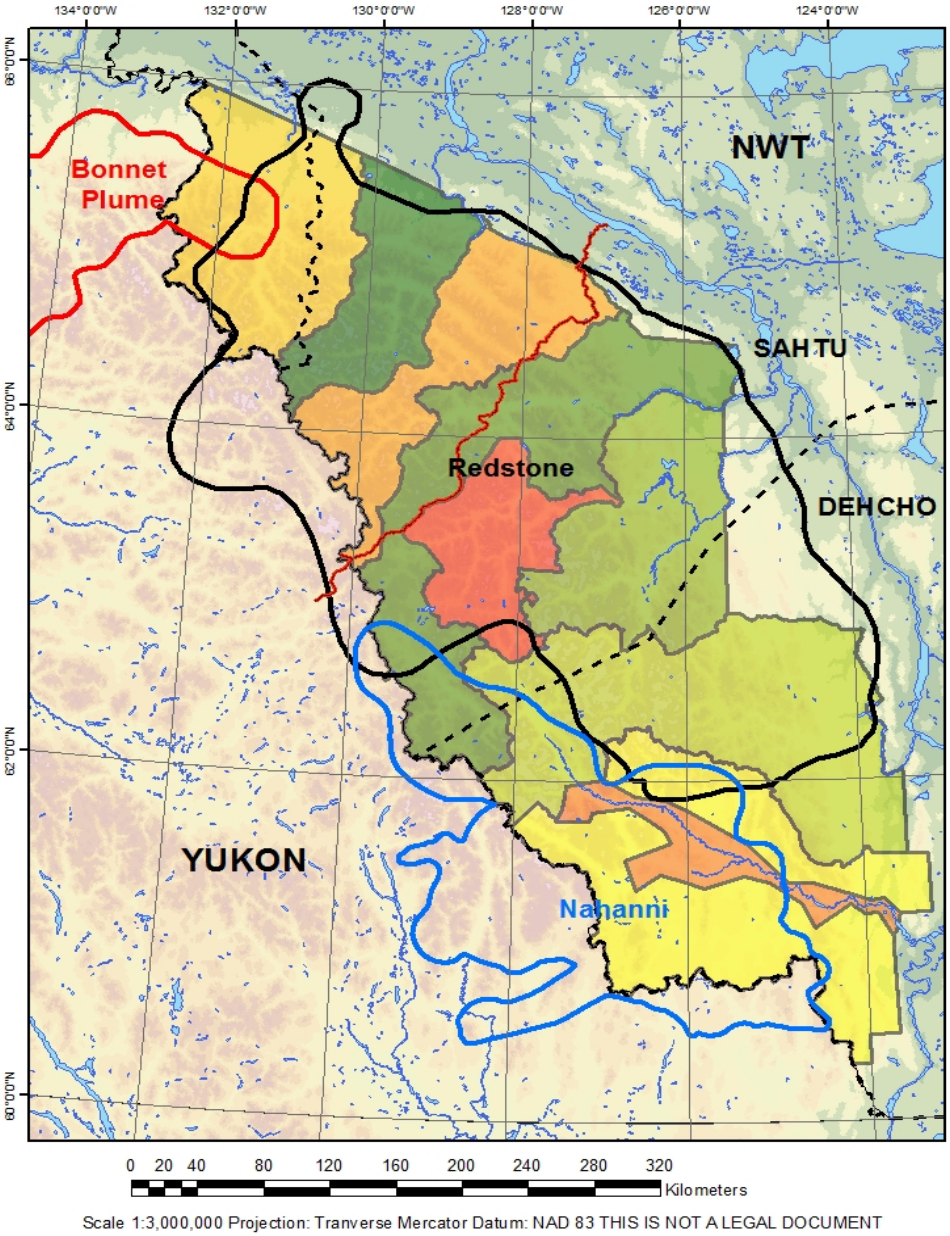

Figure 9: Distribution of Bonnet Plume (in red), Redstone (in black), and greater Nahanni (in blue) caribou populations following COSEWIC (2014) population polygons. Map: GNWT/B. Fournier, ENR (2013).

Satellite radio collars were deployed on nine adult female caribou during March 2000 and October 2001 by the YT Department of the Environment (Jan Adamczewski personal communication). These animals were believed to be part of the greater Nahanni population. In October 2004, 18 female caribou were equipped with satellite collars along the YT-NWT border. These caribou were also believed to be from the greater Nahanni population, but three animals were determined to be from the Finlayson population. This was a co-operative study between YT Territorial Government, Parks Canada (PC) and the Wildlife Conservation Society (Weaver 2006). In October 2008, 30 female caribou were equipped with satellite collars along the YT-NWT border in order to assess spatial distribution, habitat use, and population characteristics of the South Nahanni and Coal River herds of the greater Nahanni population. Collared animals permitted herd estimates based upon mark-recapture methodology and indicated stability to a slightly increasing trend for the South Nahanni herd (Hegel et al. 2016).

Tulít'a regularly conducts community hunts in the Caribou Flats. Biological samples were collected from 43 mountain woodland caribou harvested during hunts in 2013 and 2014. Blood and fecal samples were screened for pathogens, parasites and exposure to diseases. Body condition scoring was made using depth of back fat, the kidney fat index, percent bone marrow fat, and a pre-defined four score qualitative index. Preliminary results documented pathogens, diseases, and parasites that have been reported in caribou elsewhere (e.g. Johnson et al. 2010), but some were the first reported for mountain woodland caribou. No animals tested positive for *Brucella* (Carlsson et al. 2015).

Moose (*Alces americanus*)

Tags to hunt moose were purchased by 31% (n=121) of non-resident hunters in 2016, slightly above the average purchased from 2005-2016 (Table 5). At least 63% of tag holders hunted moose and harvested 76 bulls. The 2016 harvest was higher than the average 59 moose (range 32-85) harvested annually since 1991, but similar to the average from 2005-2015 (Figure 10). Since 2005, the number of moose tags purchased has

increased (Table 5, Appendix F). Success rates for moose hunts have remained relatively stable, but the increased number of tag sales in recent years has resulted in an increased overall harvest (Figure 9). The mean (±SD) length of a moose hunt, determined from the 73 reports where hunters spent at least one day hunting, was 4.0±3.0 days (range 1-16 days), similar to reports from previous years (Table 13).

In 2005 there was a noticeable increase in moose harvest relative to pre-2005 levels. The consistently higher post-2004 harvest levels were likely in part related to the change in ownership of outfitting zone D/OT/01 (Figure 10). This zone is one of the largest, with an abundance of good moose habitat. From 1991-2004 the average harvest was <4 moose/year because most clients wanted to hunt Dall's sheep. The new owner has many European clients who are specifically looking for trophy moose for European mounts. He has also been utilizing previously unhunted areas of the zone. From 2005-2016 the average annual harvest has been *ca.* 20 moose from this zone. Moose in the Mackenzie Mountains are considered to be of the Alaska-YT subspecies, physically the largest subspecies of moose with large males attaining *ca.* 725 kg. (www.adfg.alaska.gov/index.cfm?adfg=moose.main). Recently, the Mackenzie Mountains have emerged as one of the top destinations to have success in taking these large moose (Jim Lancaster personal communication).

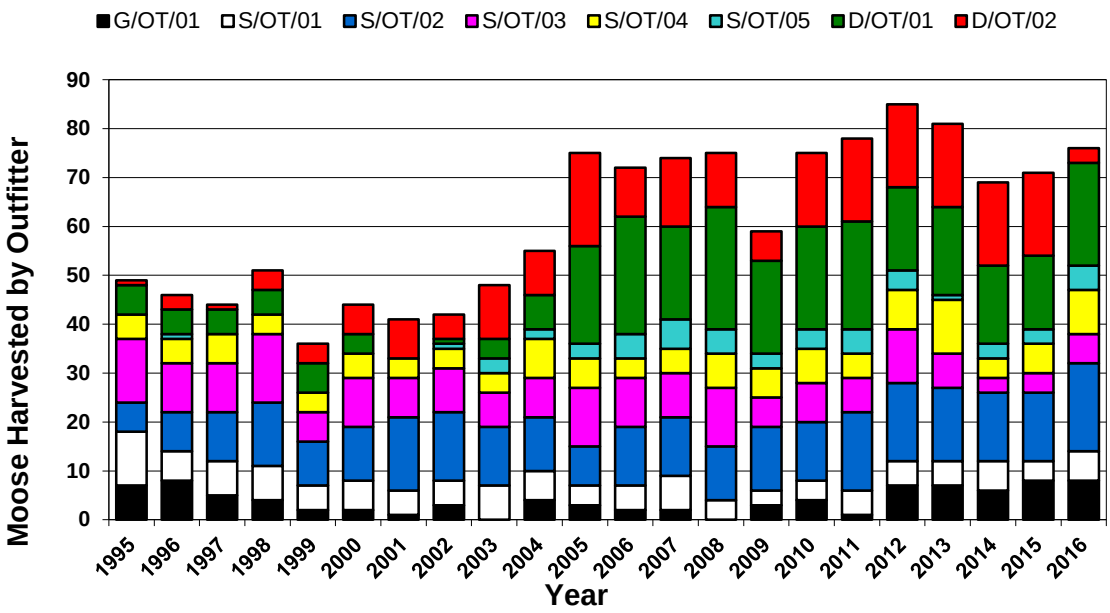

Figure 10: Moose harvested by individual Mackenzie Mountain outfitters from 1995-2016.

Table 13: Mean length, SD and range (in days) of moose hunts where at least one day was spent hunting from 2000-2016.

	2016	2015	2014	2013	2012	2011	2010	2009	2008
Number Reports	73	73	71	91	85	86	86	68	82
Mean Hunt Length	4.0	3.0	4.0	4.1	4.2	4.1	4.5	4.2	3.6
SD	3.0	3.0	3.0	3.1	3.1	2.8	4.0	3.4	2.9
Range	1-16	1-13	1-14	1-15	1-15	1-14	1-18	1-14	1-16
	2007	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	
Number Reports	80	72	85	49	60	46	42	48	
Mean Hunt Length	4.0	3.6	4.4	4.8	3.9	3.6	3.7	4.4	
SD	2.5	2.7	3.1	3.3	2.8	2.6	2.9	2.7	
Range	1-9	1-11	1-14	1-12	1-14	1-12	1-12	1-12	

Since 2003 ENR has collected front incisor teeth from moose harvested by hunters in the southern portion of the Mackenzie Mountains on a voluntary basis. Teeth are aged by analyzing cementum**.** June 1 is used as the birth date for moose (Matson 1981; www.matsonslab.com). We currently have ages from 137 harvested moose; ages range from three to 15 years (mean 7.7 years, median 7.0 years; Figure 11). The majority of the harvested males were aged from five to nine years.

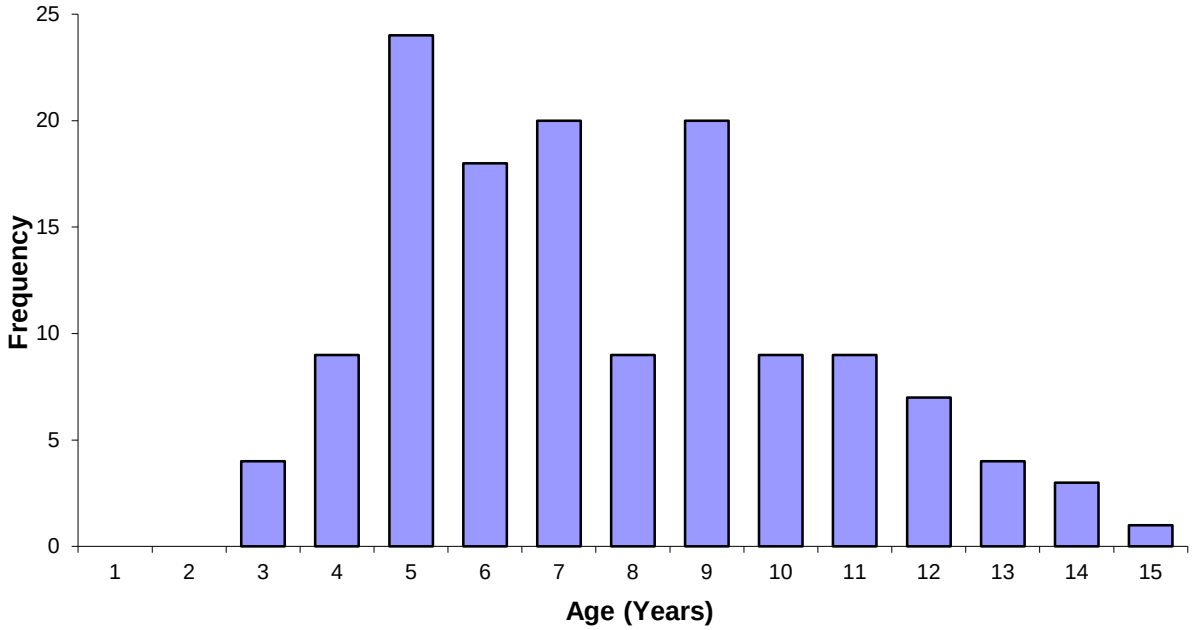

Figure 11: Ages of 137 moose teeth voluntary provided by southern Mackenzie Mountain outfitters from 2003-2016.

The mean (±SD) tip-to-tip spread of measured antlers (n=61) from bull moose harvested in 2016 was 145.9±59.8 cm (57.5±23.5 in) similar to other years (Table 14). The maximum recorded antler spread of 169.0 cm (66.5 in.) this year was less than the record spread of 196.9 cm (77.5 in.) for a moose harvested 1982. One moose taken from the Mackenzie Mountains is in the top 25 moose recorded in the record book of the 13th edition of the Boone and Crockett Club and currently holds 21st place (Boone and Crockett Club on-line trophy database accessed 2017). A moose harvested in the NWT Mackenzie Mountains in 2008 was accepted in May 2009 and holds 27th place. Three of the top 50 Alaska-Yukon moose recorded in the SCI on-line record book are from the Mackenzie Mountains, with a

moose harvested in 1996 holding 43rd place in scoring (SCI on-line trophy database accessed 2017). A moose harvested during the 2010 season ranks second as a Pope and Young World Record moose with a score of 241 5/8.

Table 14: The yearly mean and range of measured bull moose tip-to-tip antler spread in cm (in.).

	2016	2015	2014	2013	2012	2011	2010	2009	2008
Measured (n)	61	59	61	69	67	69	65	53	63
Mean Spread	145.9 (57.4)	145.0 (57.1)	144.1 (56.7)	144.9 (57.0)	142.0 (55.9)	144.0 (56.7)	143.5 (56.5)	143.5 (56.5)	145.5 (57.3)
Range	86-169 (34.0-66.5)	94-185 (37.0-72.8)	89-185 (35.0-72.6)	97-170 (38.3-67.0)	98-161 (38.6-63.4)	113-168 (44.5-66.1)	106-174 (41.7-68.5)	92-175 (36.2-68.9)	101-174 (39.8-68.5)

	2007	2006	2005	2004	2003	2002	2001	2000	1999
Measured (n)	62	56	53	38	34	32	32	34	26
Mean Spread	141.1 (55.6)	141.3 (55.6)	144.9 (57.0)	150.3 (59.2)	150.0 (59.1)	149.3 (58.8)	144.3 (56.8)	147.0 (57.9)	144.2 (56.8)
Range	102-179 (40.2-70.5)	107-170 (42.1-66.9)	122-165 (48.0-65.0)	127-174 (50.0-68.5)	107-165 (42.1-65.0)	103-178 (40.6-65.0)	113-165 (44.5-65.0)	127-179 (50.0-70.5)	109-166 (42.9-65.4)

We calculated ratios of 30.6 calves:100 adult females (cows) and 104.6 bulls:100 cows based upon hunter observations of moose during hunts (Table 15, Appendix G). The calves:100 cows in 2016 is similar to the average 30:100 calf:cow ratio (range 20-36:100) recorded since 1995. The calf:cow ratios reported for the fall in the Mackenzie Mountains remain lower than the 40-60:100 that is generally documented during early to mid-winter aerial surveys for moose along the Mackenzie River in the vicinity of the communities of Fort Good Hope (MacLean 1994a), Norman Wells (Veitch et al. 1996) and Tulít'a (MacLean 1994b) (Appendix G). However, these surveys were conducted after the major fall subsistence harvest and variable female harvest can certainly impact the interpretation of calf:cow ratios. As no research has been done on moose in the Mackenzie Mountains, we have no explanation for the apparent discrepancy in calf production, survival, or both

between the mountains and the river valley. A survey of moose in the Norman Wells study area in January 2001 estimated a calf:cow ratio of 18:100 (ENR Norman Wells unpublished data), and an aerial survey of the Mackenzie River Valley and vicinity in the Dehcho region south from the Blackwater River to Jean Marie River conducted in November 2003 estimated 32:100 (Larter 2009). These studies indicate that low calf:cow ratios may not be restricted to the Mackenzie Mountains and that further studies are required to determine the cause(s). A program was established to document calf:cow ratios annually in November in designated areas of the Mackenzie and Liard River Valleys of the Dehcho through 2010 (Larter 2009). A large-scale aerial survey of the Mackenzie River Valley and vicinity south from the Blackwater River to Jean Marie River, conducted in November 2011, estimated a calf:cow ratio of 54:100 (N. Larter and D. Allaire unpublished data).

Table 15: Observations of moose reported by non-resident hunters in the Mackenzie Mountains, 2016.

Age/Sex Class	Number of Hunters Reporting	Number Observed	Mean Number Observed/Hunter	% of Total Classified
Bulls	102	568	5.6	44.5
Cows	98	543	5.5	42.5
Calves	62	166	2.7	13.0

The calculated bull:cow ratio of 105:100 from the 2016 observations is similar to the 104:100 average from 1995-2016 (Appendix G). Bull:cow ratios from the Mackenzie Mountains continue to be generally higher than the range of 27-105:100 reported in the YT (R. Ward cited *in* Schwartz 1997) and 16:100 from heavily harvested populations in Alaska (Schwartz et al. 1992), and average of 46:100 from Norway, range (25-69:100) (Solberg et al. 2002). There has been concern that low bull:cow ratios could influence conception dates, pregnancy rates and newborn sex ratios (Bishop and Rausch 1974, Crête et al. 1981, Solberg et al. 2002) and that management strategies should maintain a high bull:cow ratio (Bubenik 1972).

Studies on tundra moose in Alaska have not found evidence that moose populations with low bull:cow ratios have reduced reproductive rates (Schwartz et al. 1992); populations with a more skewed sex ratio had a relative rate of population increase greater than populations without a skewed sex ratio (Van Ballenberghe 1983). However, a study of eight heavily harvested moose populations in Norway indicated a relationship between declining recruitment rate and skewed adult sex ratio (Solberg et al. 2002). Based upon hunter observations since 1995, there is no indication of any decreasing trend in the bull:cow ratio of moose in the Mackenzie Mountains, hence the adult sex ratios are an unlikely factor in the low calf:cow ratios reported. The reported sex ratios may have an inherent bias towards a greater number of bulls if harvesters consistently spend more time searching for moose in areas frequented more by large males than females.

Mountain Goat (*Oreamnos americanus*)

There is a wide range in the number of mountain goat tags sold annually since 1995 (six to 71), but tag sales were consistently higher from 2005 than during 1995-2004 (Table 5). The use of rotary aircraft in recent years has permitted outfitters to get into some more remote and rugged areas of their zones where they have never been before, areas where goats are resident. More hunting packages include a mountain goat, and since 2005 ten to 16% of hunters purchasing licences buy a mountain goat tag. Increased accessibility to areas of untouched goat range has likely had some effect on the increased number of goat hunters and success in goat harvest. This year, mountain goat tags were purchased by 25 (6%) of non-resident hunters, returning to 2004 levels (Table 5.). The drop is not surprising, since a large part of mountain goat range falls within the Nahanni NPR boundaries and hunting is now prohibited in these areas. We anticipate the number of goat tags purchased in future will remain low. Eight goats (six males, two females) were harvested similar to the mean annual harvest prior to 2005 (Appendix F). The mean (±SD) length of a goat hunt, determined from the eight reports where hunters spent at least one day hunting, was 3.0±2.0 days (range one to six days), similar to that reported in previous years (Table 16).

Mountain goats are known to inhabit five of the eight outfitting zones in the Mackenzie Mountains, occurring almost exclusively below 63°00'N (Veitch et al. 2002). They are most numerous in high relief terrain along the YT-NWT border between 61°00' and 62°00'N. However, since 1995 we have received hunter observations or harvest reports of goats from only four of those outfitter zones - D/OT/01, D/OT/02, S/OT/03 and S/OT/04 (Figure 1). In 2016, observations came from two zones, D/OT/01 (n=56), and D/OT/02 (n=34); harvest occurred in both zones. We estimated 67.6 goat kids and 85.3 billies per 100 nannies based upon hunter observations. Both ratios were higher than the average 63.9 kids and 68.5 billies per 100 nannies estimated from 2002-2016 (Appendix H).

Table 16: Mean length, SD and range (in days) of goat hunts where at least one day was spent hunting from 2000-2016.

	2016	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**
Number Reports	8	19	15	13	17	20	13	22	21
Mean Hunt Length	3.0	3.0	2.0	2.3	2.8	2.3	3.2	2.5	3.0
SD	2.0	2.0	2.0	1.3	1.7	1.2	1.9	2.0	1.8
Range	1-6	1-8	1-8	1-5	1-7	1-5	1-7	1-8	1-8

	2007	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**
Number Reports	27	12	18	8	6	4	2	1
Mean Hunt Length	2.7	2.8	3.8	3.9	3.0	2.8	1.5	3.0
SD	1.7	1.5	2.8	1.6	2.6	1.9	0.7	n/a
Range	1-6	2-6	1-14	2-6	1-8	1-5	1-2	3

In 2005, we began estimating the age of harvested goats by counting horn annuli; we try to age as many harvested goats as possible. The average age of 164 harvested goats (147 billies and 17 nannies) is 7.9 years (range 2.5-16.5). Ninety goats were <8 years old, 74 were >8 years old, with 40 aged >10 years old (Figure 12). Three of the eight goats

harvested in 2016 were aged >10 years; one aged at >15 years old. We got some historical age information this past year when archived mountain goat incisor teeth were discovered. The teeth from 17 harvested mountain goats, ten from 1972 and seven from 1975 were sent out for cementum aging. The age range was from one to ten years (mean 4.5 years, median 4.0 years; Figure 12), a somewhat younger distribution than that from 2005-2016, based upon counting horn annuli.

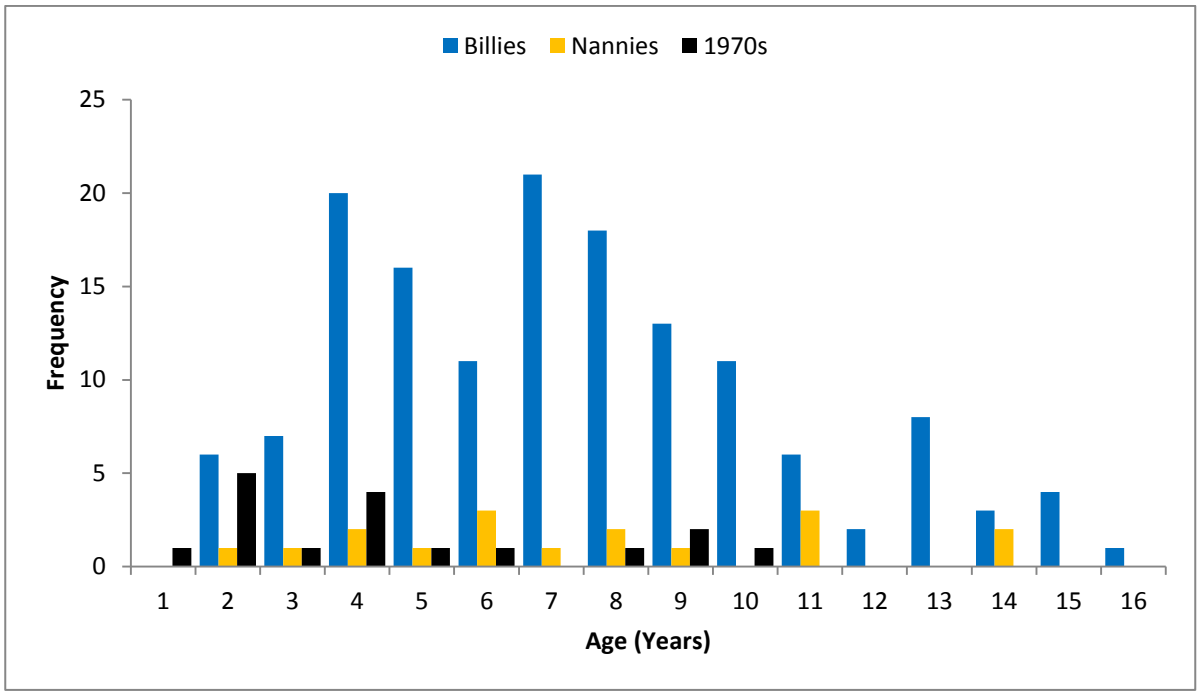

Figure 12: Ages of mountain goat billies (n=147) and nannies (n=17) harvested during 2005-2016, based upon counting horn annuli, and ages of mountain goats (n=17) harvested in 1972 and 1975, based upon cementum aging.

The longest horns from a mountain goat taken in 2016 were 23.0 cm (left) and 22.8 cm (right). No mountain goats from the NWT are listed in the top 50 in the 13th edition of the Boone and Crockett Club record book (Boone and Crockett Club on-line trophy database accessed 2017). Based upon age and horn length data over the past eleven years there may be a somewhat linear relationship between age and horn length from 4.5-13.5 years,

but for ages outside of that range there is almost no relationship. Large horned animals are found over a wide range of animal ages (Figure 13).

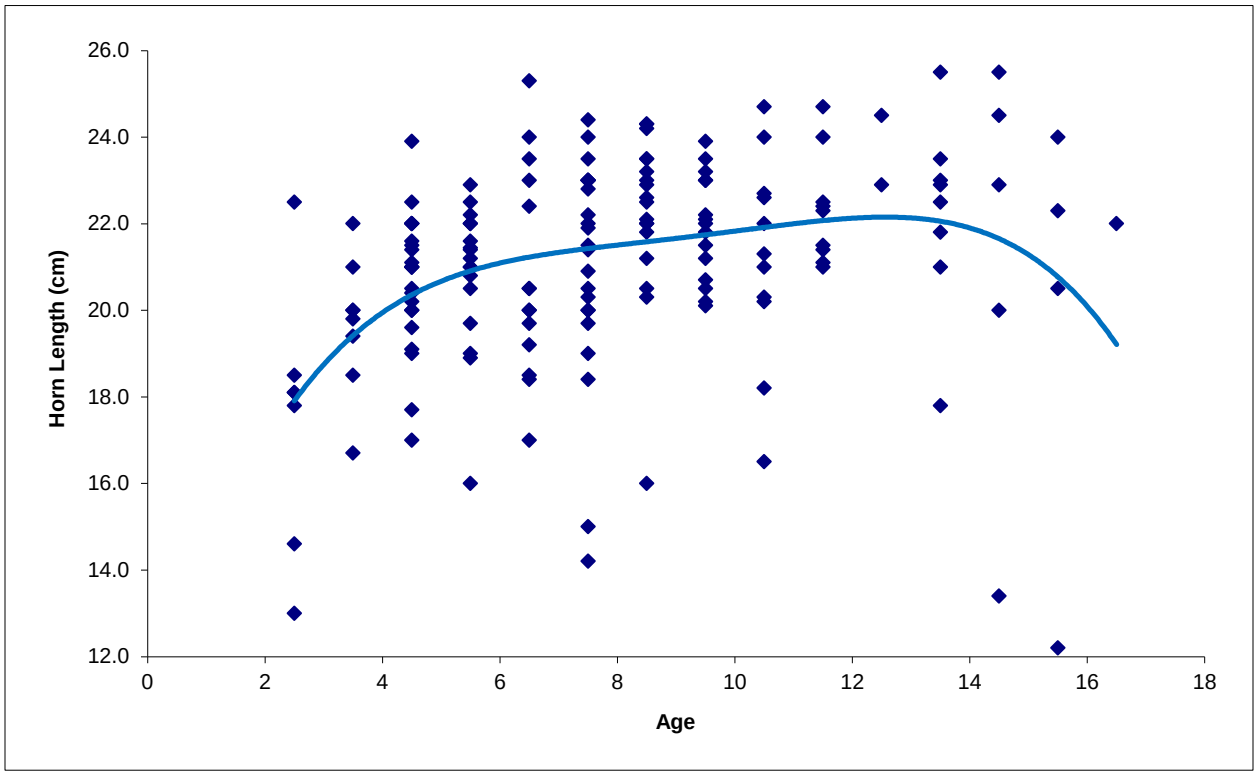

Figure 13: The relationship between the horn length (cm) and age (based upon horn annuli) from 164 mountain goats harvested in the Mackenzie Mountains 2005-2016. Line of best fit is a 4th order polynomial.

There is some evidence that goat numbers and distribution have been increasing in both zones D/OT/01 and D/OT/02 in the southern Mackenzie Mountains (Larter 2004, 2012b, Jim and Clay Lancaster and Werner Aschbacher personal communication). The total number of goats observed has been increasing in recent years and billies have been observed in places they had not been seen previously in these zones (Clay Lancaster and Werner Aschbacher personal communication, Appendix H).

In a 2.5 hr. rotary-winged survey of zone D/OT/02 on 11 September 2006, 88 goats were observed (38 billies, 27 nannies, 19 goat kids, and four yearlings), producing estimates of 140.8 billies and 70.4 goat kids per 100 nannies (N. Larter unpublished data). This survey

was conducted in an area that could not be surveyed during a 2004 aerial survey and provided similar numbers of goats and ratio estimates as the 110.7 billies and 71.4 kids per 100 nannies from that 2004 survey (Larter 2004). A rotary-wing survey was conducted 22-24 August 2011 in the Ragged Range area of zone D/OT/01; 278 goats were observed (124 billies, 80 nannies, 50 goat kids, six yearlings; 18 goats were unclassified), producing estimates of 155.0 billies and 62.5 goat kids per 100 nannies (Larter 2012b). These survey results generally support the contention of increasing goat numbers and distribution but we acknowledge there was seven years between surveys. A large portion of the areas surveyed for goats in 2004, 2006, and 2011, and indeed a substantial proportion of mountain goat range in the Mackenzie Mountains now falls within the boundaries of Nahanni NPR. This was the first year with the significantly reduced area for hunting mountain goat. We anticipate fewer hunts in future, likely at pre-2005 levels (Table 5). Concomitantly, voluntary hunter observations of mountain goat will be reduced, restricted to limited parts of mountain goat range, and are less representative of mountain goat demography of the Mackenzie Mountains as a whole.

Wolf (*Canis lupus*)

Wolf tags were purchased by 80% (n=310) of non-resident hunters in 2016 (Table 5), fewer than in 2015 but more than in any of the previous 20 years (Table 17). At least 19% (n=58) of tag holders actively hunted wolves, harvesting 29 wolves (ten males, three females and 16 with undocumented gender) (Appendix F). This is the greatest annual harvest of wolves since records have been kept. We suspect that the recent increase in tag purchases and harvest is related to the increasing number and success of winter season hunts. Hunters reported spending 1-20 days actively hunting wolves (mean ±SD 3.7±2.4 days). For the eighth year wolves were hunted during the winter season in zone S/OT/01. Eight wolves (one female and seven males) were harvested in April 2017; the greatest winter season harvest.

Hunters observed 221 wolves during 2016/2017, the lower end of the 142-317 range from previous years (1995-2015). There is no relationship between the number of wolves observed/year and annual harvest nor does the number of tags purchased/year explain annual differences in wolf observations (Table 17). The number of hunters reporting since 2001 has been consistently higher than in previous years, which is attributed to a change in how we defined hunter reporting. For data collected after 2001, we assumed that all returned observation forms where there was a blank, a zero, or a dash in the box indicating the number of wolves observed was a report of no wolves being observed. When looking at the forms this seemed like a reasonable assumption. This assumption may well be invalid for previous years' data and would bias the post 2001 values to be higher than the previous years.

Beginning in 1999, we received hunter comments on voluntary observation forms that wolf numbers were high. In subsequent years the number of hunters commenting about high wolf numbers has increased. Interestingly, for 2016, high wolf numbers was indicated by only three responding hunters.

Table 17: Observations of wolves reported by non-resident hunters in the Mackenzie Mountains, the number of wolves harvested and the number of wolf tags purchased, 1995-2016.

	2016[1]	**2015[1]**	**2014[1]**	**2013[1]**	**2012[1]**	**2011[1]**	**2010[1]**	**2009[1]**	**2008[1]**	**2007[1]**	**2006[1]**
# Hunters Reporting	251	294	216	242	215	218	203	194	244	244	239
# Wolves Observed	221	152	275	155	253	184	203	167	260	262	202
# Hunters Seeing ≥1	63	26	42	36	45	74	61	65	76	88	84
Number Harvested	29	20	23	16	24	21	19	20	17	12	23
Number Wolf Tags	310	358	298	299	292	285	294	252	228	227	201

	2005[1]	2004[1]	2003[1]	2002[1]	2001	2000	1999	1998	1997	1996	1995
# Hunters Reporting	254	244	203	197	142	116	103	148	141	76	119
# Wolves Observed	245	317	200	249	215	228	142	148	200	186	269
# Hunters Seeing ≥1	76	81	74	69	65	61	40	57	76	26	26
Number Harvested	19	18	12	11	15	14	11	9	17	11	14
Number Wolf Tags	204	166	207	159	137	145	89	165	209	194	72

[1]Change in reporting since 2002 may have resulted in the number of hunters reporting for 1995-2001 being artificially low, see text.

Wolverine (*Gulo gulo*)

This year more wolverine tags (n=190) were purchased than in any year since records started in 2005, with almost 50% of hunters purchasing tags. Prior to 2005 fewer wolverine tags were purchased (Tables 5, 18). At least 23 tag holders (12%) actively hunted wolverine; two were harvested. Hunters spent from one to 20 days actively hunting wolverine (mean ±SD of 4.2±2.6 days). Wolverines were observed in seven zones, most observations in zones G/OT/01 and S/OT/04. In only 1996 and 2014 have wolverines been observed in all zones (Figure 14). Most observations (17 of 19) were of solitary individuals; a group of two and a family group of four were also seen. Historically, wolverine observations have been mostly of solitary animals with few family groups being observed.

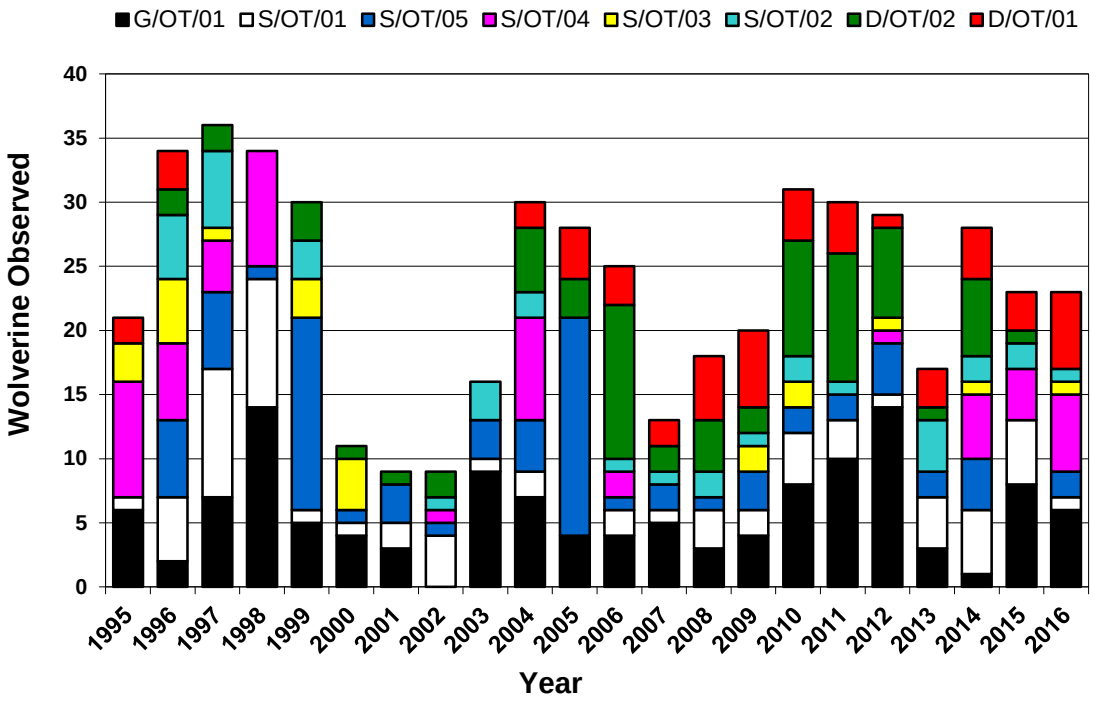

Figure 14: The number of wolverine observed by hunters from 1995-2016 and the outfitter zones where the observations occurred. Data are based upon voluntary hunter observation forms.

One could argue that the number of wolverines observed annually from 1995-2016 has somewhat of a cyclical pattern (Table 18, Figure 14), however a trend line through the data is essentially flat. Wolverine numbers are believed to be declining in some other parts of their range in the NWT (SARC 2014); our observations from the Mackenzie Mountains since 1995 do not show a declining trend.

There is no relationship between the number of wolverine observed/year and annual harvest nor do the number of tags purchased/year explain annual differences in wolverine observations (Table 18). Wolverines occur throughout the Mackenzie Mountains, but sightings are considered rare. Most wolverine observations are made in hunting zones G/OT/01, S/OT/01, S/OT/05 and D/OT/02.

Table 18: The number of reported observations of wolverine, the number of wolverine harvested, the number of hunters with wolverine tags, the percentage of total hunters with wolverine tags and the total number of hunting licences purchased for 1995-2016.

Year	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006
Reported Observations	23	23	28	17	29	30	31	20	18	13	25
Number Harvested	2	2	1	2	0	2	3	3	1	0	1
No. Wolverine Tags	190	179	154	155	153	163	171	133	111	150	108
% Wolverine Tags	49	40	38	39	39	41	45	39	28	37	27
Total Hunting Licences	389	447	402	401	396	400	384	339	399	405	407
Year	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**
Reported Observations	28	30	12	9	9	11	30	34	36	34	21
Number Harvested	1	0	0	1	2	0	3	0	1	4	1
No. Wolverine Tags	154	89	141	97	83	78	65	99	135	114	35
% Wolverine Tags	39	26	40	29	26	23	20	29	38	29	11
Total Hunting Licences	394	337	347	338	332	332	321	345	352	387	344

Black Bear (*Ursus americanus*)

This year 18 tags were purchased by non-resident hunters for black bears (Table 5); none were harvested. Only seven black bears have been harvested in the past 26 years. Black bears are relatively rare in the Mackenzie Mountains and when seen are mostly south of 63°00'N. In 2016, 21 black bears (16 adults and five cubs) were reported (Table 19). This year bears were observed in four outfitter zones D/OT/01, D/OT/02, S/OT/04 and S/OT/05. Two adults were observed in zone S/OT/04 and six adults and three cubs were observed in S/OT/05, all north of 63°00'N. As with the other post-2001 carnivore data, we assumed that all returned observation forms where blanks, zeroes, or dashes occurred in the boxes indicating the number of carnivores observed was a report of no carnivores being observed. This assumption is likely invalid for previous years' data and likely somewhat inflates the post 2001 values relative to 1996-2001 values.

Table 19: Observations of black bears reported by non-resident hunters (including non-hunting guides) in the Mackenzie Mountains, 1995-2016.

	2016[1]		2015[1]		2014[1]		2013[1]		2012[1]		2011[1]		2010[1]		2009[1]		2008[1]	
	Cub	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**
Total # Observed	5	16	2	14	5	27	12	18	3	34	2	27	0	29	3	14	8	48
% of Total Observed	29	71	13	87	16	84	40	60	8	92	7	93	0	100	18	82	14	86
No. Hunters Reporting	196	196	298	298	262	262	212	212	216	216	218	218	203	203	194	194	244	244
No. Hunters Saw at Least 1	2	12	1	11	4	22	4	13	1	7	2	19	0	8	3	10	3	10
Maximum # Observed	3	3	2	3	2	2	4	3	2	3	1	8	0	2	1	3	3	4

	2007[1]		2006[1]		2005[1]		2004[1]		2003[1]		2002[1]		2001		2000		1999	
	Cub	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**
Total # Observed	4	34	2	27	4	21	1	23	3	34	3	17	0	7	2	15	4	7
% of Total Observed	11	89	7	93	16	84	4	96	8	92	15	85	0	100	12	88	36	64
No. Hunters Reporting	244	244	239	239	256	256	229	229	191	191	199	199	127	130	88	93	87	89
No. Hunters Saw at Least 1	2	17	1	14	3	18	1	19	2	21	2	14	1	7	1	10	2	6
Maximum # Observed	2	8	2	11	2	2	1	3	2	7	2	3	0	1	2	3	2	2

	1998		1997		1996		1995 [2]
	Cub	Ad	Cub	Ad	Cub	Ad	All Bears
Total # Observed	0	15	2	3	1	10	11
% of Total Observed	0	100	40	60	9	99	nil
No. Hunters Reporting	121	124	96	96	6	14	44
No. Hunters Saw at Least 1	0	8	2	3	1	9	9
Maximum # Observed	0	3	1	1	1	2	2

[1] Change in reporting for 2002 may have resulted in artificially lower numbers of hunters reporting for 1995-2001.
[2] All bears not separated out by cubs and adults.

Grizzly Bear (*Ursus arctos*)

The Mackenzie Mountains have been closed to non-residents for hunting grizzly bears since 1982 and resident hunters have been restricted to one bear per lifetime since the same year (Veitch 1999). It is clear from hunter comments on voluntary observation forms that, despite the lack of hunting opportunities, grizzly bears in the Mackenzie Mountains remain a subject of considerable interest for non-resident hunters and their guides (Appendices C, D). For the past 18 years there have been a variety of comments about grizzly bears and 2016 was no exception. This year hunters reported the loss of meat, capes and food to grizzly bears, and commented that there were too many grizzly bears and a hunt should be considered. Outfitters also continue to mention camp and equipment damage by grizzly bears both during and after the season. To minimize human-grizzly bear interactions electric fences have been used at main camps, temporary camp use has been reduced, clean camp policy has become standard for most camps, and some known high-use grizzly bear areas have been avoided.

Even though moose calf numbers, based upon hunter observations, are generally lower in the Mackenzie Mountains than those reported in the Mackenzie Valley, and predation by grizzly bears could be a potential cause (Ballard 1992), there were few hunter comments indicating low moose or caribou calf numbers.

From 1996-2013, the number of adult grizzly bears observed annually has fluctuated around a mean of 305 (range 218-402) with no discernable trend over time. Similarly the number of cubs observed annually fluctuated around a mean of 76 (range 40-115) with no trend over time, but there was a noticeable increase in the observed number of bears from 2013-2015 to >600 adults (Figure 15, Table 20). This year observations of adult (n=337), and cubs (n=69), were similar to those reported from 1996-2013 (Figure 15, Table 20). From 1996-2016 a positive trend in grizzly bear observations remains.

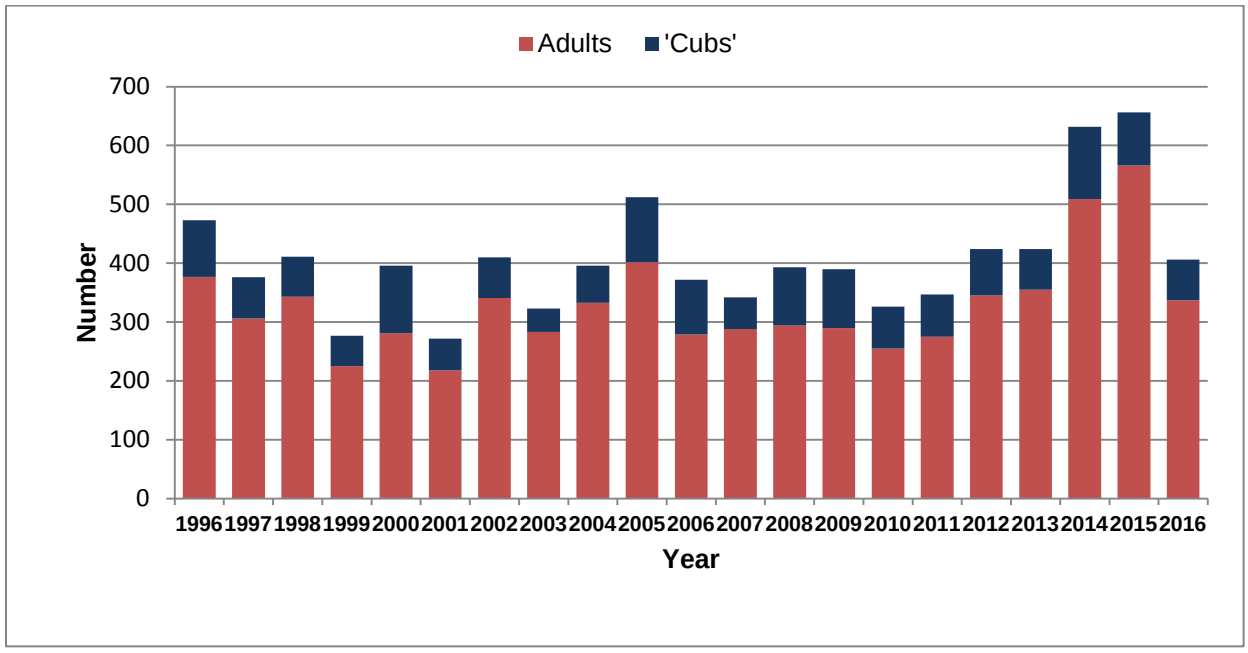

Figure 15: The number of adult and 'cub' grizzly bears observed by hunters from 1996-2016. Data are based upon returned voluntary hunter observation forms. 'Cubs' likely refer to cubs-of-the-year, yearlings, and possibly two-year olds.

Because cub grizzlies in the Mackenzie Mountains tend to stay with their mothers for three years (Miller et al. 1982), reported observations of 'cubs' likely refers to cubs-of-the-year,

yearlings, and possibly two-year-old bears. This may account for some of the variability in our cub observations (Figure 14). The percent 'cubs' reported from 1996-2016 ranges from 12.4-29.0 (mean 19.5). Miller et al. (1982) estimated that cubs and yearlings made up 14.3 and 10.4%, respectively of the grizzly population during 1973-1977. If yearlings were reported as cubs this could explain the high range we report for observed 'cubs'.

Since 1993, 79 nuisance grizzly bears have been killed, the majority in the Sahtú (n=48), with 19 and 12 for the Gwich'in and Dehcho regions, respectively (ENR unpublished data). The Sahtú covers the largest area of the Mackenzie Mountains at *ca.* 68,000 km^2. In 2016 only one nuisance grizzly bear was killed, fewer than the seven and two killed during the previous two years.

Most instances of grizzly-human conflict used to come at night when grizzlies took the meat, and left without incident. However, more recently there have been increasing reports of grizzlies claiming either meat or hides from kills while guides were in the vicinity or while they were at camp (Carl Lafferty personal communication). A frequent comment of guided hunters is that bears have lost their fear of humans because of a lack of hunting and they are concerned that this has become a human safety issue. Prior to 2014 there were no documented incidences of injuries to humans caused by grizzly bear attacks (Veitch 1999). Unfortunately, in 2014 a hunter was fatally injured in a grizzly bear attack while butchering a moose with his guide (the first documented hunter fatality in the Mackenzie Mountains), and last year there was a second mauling under similar circumstances in the same zone (S/OT/02). The hunter was seriously injured but survived. This year grizzly observations were down from 2014 and 2015, there were no maulings and only one nuisance bear was destroyed.

There have been no demographic studies on grizzly bears in the Mackenzie Mountains since field research conducted in 1973-1977 in a remote area of just 3,000 km^2 near the YT border (Miller et al. 1982). Miller et al. (1982) documented a low reproductive rate for

female grizzly bears. No sows less than eight-years-old produced cubs, the average inter-litter interval was 3.8 years, and there was a mean litter size of 1.8. From 1996-2016 we used voluntary hunter observation forms and estimated litter size from only those observations where cubs were present with a single adult bear. We report a mean litter size of 1.7 based on annual estimates (range 1.3-2.1). Comparisons of our results with Miller et al. (1982) must take into account that we do not have a large sample size of observations annually and that these observations are potentially from all zones of the Mackenzie Mountains, not a small area. Also, in the 1970s grizzly bears were hunted by non-residents; non-resident hunting ceased in the Mackenzie Mountains in 1982. Although resident hunting still occurs, it is extremely limited. Therefore grizzly bears observed during 1996-2016 and the current grizzly bear population have really not been exposed to human harvest for at least one generation.

In a recent summary of grizzly bear harvest in the Gwich'in Settlement Area, the population for the Mackenzie Mountains zone was 110 bears (≥2 years old) (ENR 2014). This zone overlaps about 75% of zone G/OT/01 and a small portion of zone S/OT/01 (see Figure 1). Does the recent increase in bear observations and bear-human interactions translate into increasing bear numbers in the Mackenzie Mountains, or were conditions different in 2014 and 2015? Grizzly bear numbers have increased in parts of the Rocky Mountain range in Alberta (from 2004-2014) in response to recovery planning (https://friresearch.ca/research/estimates-grizzly-bear-population-size-and-density-report). At the 2015 AMMO annual general meeting, ENR and AMMO members agreed that there was a need to get a better idea of grizzly bear numbers throughout the Mackenzie Mountains. Studies employing the use of hair snagging and DNA analyses, similar to those used by Paetkau et al. (1998) and Weaver (2006) were discussed at length.

Six grizzly bear hair samples collected in summer 2015 by AMMO members were forwarded to Wildlife Genetics International for analyses. Unfortunately, three of the samples could not be analyzed because of substandard quality. The remaining samples

identified three individual bears, one female and two males. None of these bears were matched to the bears involved in the two human incidents. ENR agreed to plan a pilot hair snagging study during summer 2017.

Table 20: Observations of grizzly bear reported by non-resident hunters in the Mackenzie Mountains, 1995-2016; total number of bears observed, percentage of cubs/adults, number of hunters reporting grizzly observations, number of hunters seeing at least one cub/adult, the mean and maximum number of cub/adults observed.

	2016		2015		2014		2013		2012		2011		2010		2009		2008	
	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad
Total # Observed	69	337	90	566	123	509	69	355	79	345	72	275	71	255	100	290	99	294
% of Total #	17	83	14	86	19	81	16	84	19	81	21	79	22	78	26	74	25	75
# Hunters Reporting	36	126	37	177	56	155	29	123	46	138	38	123	33	104	47	109	48	139
# Hunters Saw ≥1	24	83	24	111	39	103	20	74	24	71	28	65	25	53	36	64	31	64
Mean # Observed	1.9	2.7	2.4	3.2	2.2	3.3	2.4	2.9	1.7	2.5	1.9	2.2	2.2	2.5	2.1	2.7	2.1	2.1
Maximum # Observed	6	11	10	19	9	14	6	15	5	14	4	10	5	11	6	20	6	12

	2007		2006		2005		2004		2003		2002		2001		2000		1999	
	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad	Cub	Ad
Total # Observed	54	288	93	279	110	402	63	333	40	283	69	341	59	222	113	281	52	225
% of Total #	16	84	25	75	21	79	16	84	12	88	17	83	21	79	29	71	19	81
# Hunters Reporting	28	127	50	122	49	150	34	131	19	120	34	128	136	171	108	131	98	117
# Hunters Saw ≥1	17	56	32	70	10	65	15	57	9	53	11	48	28	104	51	97	28	81
Mean # Observed	1.9	2.3	1.9	2.3	2.0	2.3	1.9	2.5	2.1	2.4	2.0	2.7	0.4	1.3	1.1	2.1	0.5	1.9
Maximum # Observed	5	15	5	12	10	16	4	15	12	7	8	20	5	10	8	12	4	12

	1998		1997		1996		1995
	Cub	**Ad**	**Cub**	**Ad**	**Cub**	**Ad**	**All Bears[1]**
Total # Observed	68	343	70	306	96	377	389
% of Total #	17	83	19	81	20	80	nil
# Hunters Reporting	139	177	110	170	49	132	138
# Hunters Saw ≥1	31	105	32	129	46	129	123
Mean # Observed	0.5	1.9	0.6	1.8	2.0	2.9	2.8
Maximum # Observed	6	16	12	17	5	15	16

[1] All bears not separated out by cubs and adults.

ACKNOWLEDGEMENTS

We appreciate the continued co-operation from the Association of Mackenzie Mountain Outfitters and each individual outfitter operation in the Mackenzie Mountains. We thank them for the extra efforts they make in completing, signing, and submitting their harvest reports and meat distribution forms. We especially want to thank those outfitters who spent additional time compiling and sending additional information so that this report could be completed in a timely fashion.

We thank Renewable Resources Officers and clerks with ENR in Norman Wells, Fort Simpson, and Fort Liard for collecting and organizing data from non-resident hunters in their respective offices. We also greatly appreciate the efforts, interest, and co-operation shown by our visiting hunters and the more than 80 guides that completed the forms, reported observations of animals seen, and did the various antler and horn measurements. We would particularly like to thank those hunters that took the time to write comments about their hunting experience.

John Nagy provided unpublished data from Richardson Mountain Dall's sheep work and a reanalysis of satellite collared mountain caribou data. Troy Hegel provided unpublished northern mountain caribou data from the Yukon. Suzanne Carrière provided unpublished data and analyses of northern mountain caribou NWT resident harvest. We gratefully acknowledge the Boone and Crocket Club for providing us with access to their on-line trophy database and Safari Club International for providing us with access to their on-line trophy database. Matson's Laboratory aged all moose, mountain caribou and mountain goat teeth.

PERSONAL COMMUNICATIONS

Jan Adamczewski, Ph.D., Wildlife Biologist, Ungulates. Environment and Natural Resources. Yellowknife, NWT

Werner Aschbacher. South Nahanni Outfitters. Whitehorse, YT

Harold Grinde, President. Association of Mackenzie Mountain Outfitters. Rimbey, AB

Troy Hegel, Ungulate Biologist (Caribou/Sheep/Goat). Fish and Wildlife Branch YT Environment. Whitehorse, YT

Carl Lafferty, Regional Superintendent. Environment and Natural Resources. Fort Simpson, NWT

Clay Lancaster, Nahanni Butte Outfitters. Charlie Lake, BC

Jim Lancaster, Nahanni Butte Outfitters. Smithers, BC

John Nagy, Ph.D., University of Alberta. Edmonton, AB

Heather Sayine-Crawford, Manager, Wildlife Research and Management, Environment and Natural Resources, Yellowknife, NWT

LITERATURE CITED

Ballard, W.B. 1992. Bear Predation on Moose: A Review of Recent North American Studies and Their Management Implications. Alces (Supplement) 1:1-15.

Bergerud. A.T. 1978. Caribou. pp.83-102 *in* Schmidt, J.L. and D. L. Gilbert (eds.) Big Game of North America: Ecology and Management. Stackpole Books, Harrisburg, PA. 494pp.

Bishop, R.H. and R. A. Raush. 1974. Moose Population Fluctuations in Alaska. 1950-1972. *Le Naturaliste Canadien* 101:559-593.

Boone and Crockett Club on-line trophy database accessed 2017.

Bubenik, A.B. 1972. North American Moose Management in Light of European Experiences. Proceedings of the North American Moose Conference Workshop 8:276-295.

Carlsson, A., S. Kutz, R. Popko, A. Veitch and S. Berens. 2015. Overview of mountain woodland caribou sample collection and pathogen screening as part of the Wildlife Health Monitoring Program in the Sahtú Settlement Area. Unpublished report for Sahtú Renewable Resources Board. 10pp.

Committee on the Status of Endangered Wildlife in Canada. 2014. COSEWIC Assessment and Status Report on the Caribou *Rangifer tarandus,* Northern Mountain population, Central Mountain Population and Southern Mountain Population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xxii + 113pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Creighton, T.B. 2006. Predicting Mountain Woodland Caribou Habitat in the Mackenzie and Selwyn Mountains through Correlation of ARGOS Collar Locations and MODIS Spectral Reflectance. MSc Thesis, School of Geography, Birkbeck College, University of London. 112pp.

Crête, M., R.J. Taylor and P.J. Jordan. 1981. Optimization of Moose Harvest in Southwestern Quebec. Journal of Wildlife Management 45(3): 598-611.

Dehcho Drum, January 21, 2016. Parks Canada settles with Nahanni guides – Hunting outfitters paid $3.15 million after yearlong battle. p. 10.

Demarchi, R. and C. Hartwig. 2004. Status of thinhorn sheep in British Columbia. BC Ministry of Water, Land and Air Protection, Biodiversity Branch. Bulletin No. B-119. 96pp.

Environment and Natural Resources. 2014. Summary of Grizzly Bear Harvest Data in the Gwich'in Settlement Area July 2005 to June 2014. Environment and Natural Resources, Government of the Northwest Territories. Inuvik, NT. 7pp.

Environment and Natural Resources. 2016. Northwest Territories Summary of Hunting Regulations July 1, 2016 to June 30, 2017. Environment and Natural Resources, Government of the Northwest Territories. 44pp.

Festa-Bianchet, M., F. Pelletier, J.T. Jorgenson, C Feder and A. Hubbs. 2014. Decrease in horn size and increase in age of trophy sheep in Alberta over 37 years. Journal of Wildlife Management 78: 133-141.

Geist, V. 1971. Mountain Sheep: a Study in Behaviour and Evolution. University of Chicago Press, Chicago, IL. 399pp.

Geist, V. 1993. Wild Sheep Country. NorthWord Press, Minocqua, WI. 173pp.

Gullickson, D. and M. Manseau. 2000. South Nahanni Woodland Caribou Herd Seasonal Range Use and Demography. Parks Canada Agency. 87pp.

Gunn, A., R. Farnell, J. Adamczewski, J. Dragon and L. Labarge. 2002. Census for the South Nahanni Mountain Caribou Herd, September 2001. Resources, Wildlife and Economic Development. Manuscript Report No. 147. 36pp.

Hegel, T., K. Russell, W.J. Rettie and D.P. Tate. 2016. South Nahanni and Coal River Northern Mountain caribou herds: population status and demographic characteristics. Yukon Fish and Wildlife Branch Report TR-14-06. Whitehorse, YT. 29pp.

Hik, D.S. and J. Carey. 2000. Cohort variation in horn growth of Dall's sheep rams in the southwest Yukon, 1969-1999. Biennial Symposium of the Northern Wild Sheep and Goat Council 12: 88-100.

http://matsonslab.com/

https://friresearch.ca/resource/estimates-grizzly-bear-populayion-size-and-density-report

Johnson D, N.J. Harms, N.C. Larter, B.T. Elkin, H. Tabel and G. Wei. 2010. Serum biochemistry, serology and parasitology of boreal caribou (*Rangifer tarandus caribou*) in the Northwest Territories, Canada. Journal of Wildlife Diseases 46: 1,096-1,107.

Jorgenson, J.T. 1992. Seasonal Changes in Lamb:Ewe Ratios. Biennial Symposium of the Northern Wild Sheep and Goat Council 8:219-226.

Kennedy, S. 2017. Age structure and horn configuration of Dall's sheep harvested in the Mackenzie Mountains, NWT. Department of Biological Sciences, Independent Study, University of Lethbridge. Lethbridge, AB.

Larter, N.C. 2004. Mountain Goat Survey Flat River Area, Western Mackenzie Mountains, September 2004. Resources, Wildlife and Economic Development. Manuscript Report No. 157. 24pp.

Larter, N.C. 2009. A Program for Monitoring Moose Populations in the Dehcho Region of the Northwest Territories, Canada. Alces 49: 89-99.

Larter, N.C. 2012a. Preliminary Analysis of Hunter Observations of Northern Mountain Caribou in the Mackenzie Mountains, 1991-2010. Environment and Natural Resources. Manuscript Report No. 217. 16pp.

Larter, N.C. 2012b. Mountain Goat Survey Ragged Range Area, Southern Mackenzie Mountains, August 2011. Environment and Natural Resources. Manuscript Report No. 212. 25pp.

Larter, N.C. and D.G. Allaire. 2003. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2002. Resources, Wildlife and Economic Development. Manuscript Report No. 152. 50pp.

Larter, N.C. and D.G. Allaire. 2004. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2003. Resources, Wildlife and Economic Development. Manuscript Report No. 154. 51pp.

Larter, N.C. and D.G. Allaire. 2005. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2004. Environment and Natural Resources. Manuscript Report No. 165. 51pp.

Larter, N.C. and D.G. Allaire. 2006. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2005. Environment and Natural Resources. Manuscript Report No. 168. 72pp.

Larter, N.C. and D.G. Allaire. 2007. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2006. Environment and Natural Resources. Manuscript Report No. 174. 65pp.

Larter, N.C. and D.G. Allaire. 2008. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2007. Environment and Natural Resources. Manuscript Report No. 180. 77pp.

Larter, N.C. and D.G. Allaire. 2009. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2008. Environment and Natural Resources. Manuscript Report No. 195. 80pp.

Larter, N.C. and D.G. Allaire. 2010. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2009. Environment and Natural Resources. Manuscript Report No. 208. 79pp.

Larter, N.C. and D.G. Allaire. 2011. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2010. Environment and Natural Resources. Manuscript Report No. 211. 83pp.

Larter, N.C. and D.G. Allaire. 2012. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2011. Environment and Natural Resources. Manuscript Report No. 220. 83pp.

Larter, N.C. and D.G. Allaire. 2013. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2012. Environment and Natural Resources. Manuscript Report No. 234. 93pp.

Larter, N.C. and D.G. Allaire. 2014. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2013. Environment and Natural Resources. Manuscript Report No. 245. 85pp.

Larter, N.C. and D.G. Allaire. 2015. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2014. Environment and Natural Resources. Manuscript Report No. 250. 89pp.

Larter, N.C. and D.G. Allaire. 2016. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary 2015. Environment and Natural Resources. Manuscript Report No. 256. 95pp.

Latour, P. and N. MacLean. 1994. An Analysis of Data Returned by Outfitted Hunters from the Mackenzie Mountains, NWT, 1979-1990. Renewable Resources. File Report No. 110. 52pp.

MacLean, N. 1994a. Population Size and Composition of Moose in the Tulít'a Area, NWT, November 1993. Renewable Resources. Manuscript Report No. 78. 28pp.

MacLean, N. 1994b. Population Size and Composition of Moose in the Fort Norman Area, NWT, November 1993. Renewable Resources. Manuscript Report No. 80. 28pp.

Matson, G.M. 1981. Workbook for Cementum Analysis. Matson's, Milltown, Montana USA. 31pp.

Microsoft Corporation. 2010. Excel version 14 (computer program). Redmond, WA.

Miller, S.J., N. Barichello and D. Tait. 1982. The Grizzly Bears of the Mackenzie Mountains, Northwest Territories. N.W.T. Wildlife Service. Completion Report No. 3. 128pp.

Minitab Inc. 1989. Minitab version 7.2 (computer program). State College, PA: Minitab Inc.

Nagy, J.A. 2011. Use of Space by Caribou in Northern Canada. PhD thesis, Department of Biological Sciences, University of Alberta. 164pp.

Nagy, J. and J. Carey. 2013. Dall's Sheep Survey in the Richardson Mountains, 1991. Environment and Natural Resources. 30pp.

Nichols, L. and F. Bunnell. 1999. Natural History of Thinhorn Sheep. pp. 23-77 *in* Valdez, R. and Krausman, P.R. (eds.). Mountain Sheep of North America. University of Arizona Press, Tucson, AZ. 353pp.

Olsen, B. 2000. Fall Distribution and Population Composition of Woodland Caribou in the Central Mackenzie Mountains, October 2000. Sahtú Renewable Resources Board, Tulít'a, NWT. Environment and Natural Resources. Manuscript Report No. 1 (draft). 34pp.

Olsen, B. 2001. Caribou Studies in the Redstone River Watershed: Research Proposal 2001. Unpublished research proposal submitted to Sahtú Renewable Resources Board, Tulít'a, NWT. 10pp.

Olsen, B., M. MacDonald and A. Zimmer. 2001. Co-management of Woodland Caribou in the Sahtú Settlement Area: Workshop on Research, Traditional Knowledge, Conservation and Cumulative Impacts. Sahtú Renewable Resources Board, Tulít'a, NWT. Special Publication No. 1. 22pp.

Paetkau, D., L. Waits, P. Clarkson, L. Craighead, E. Vyse, R. Ward and C. Strobeck. 1998. Variation in genetic diversity across the range of North American brown bears. Conservation Biology 12: 418-429.

Safari Club International on-line trophy database accessed 2017.

Schwartz, C.C. 1997. Reproduction, Natality, and Growth. pp. 141-171 *in* Franzmann, A.W. and Schwartz, C.C. (eds.) Ecology and Management of the North American Moose. Smithsonian Institution Press, Washington, DC. 733pp.

Schwartz, C.C., W.L. Regelin and A.W. Franzmann. 1992. Male Moose Successfully Breed as Yearlings. Journal of Mammalogy 63: 334-335.

Sim, Z., J.C. Hall, B. Jex, T.M. Hegel and D.W. Coltman. 2016a. Genome-wide set of SNPs reveals evidence for two glacial refugia and admixture from postglacial recolonization in an alpine ungulate. Molecular Ecology 25: 3,696-3,705.

Sim, Z., B. Jex, T. Hegel, C. Davis and D.W. Colman. 2016b. Population genetics of the world's thinhorn sheep (*Ovis dalli*). Paper presented at 20th North American Wild Sheep and Goat Council, 9-12 May 2016 Moscow ID and Pullman WA.

Simmons, N.M. 1968. Big Game in the Mackenzie Mountains, Northwest Territories. Proceedings of the Federal-Provincial Wildlife Conference. 32: 35-42.

Solberg, E.J., A. Loison, T.H. Ringsby, B.E. Sæther and M. Heim. 2002. Biased Adult Sex Ratio can Affect Fecundity in Primiparous Moose *Alces alces*. Wildlife Biology 8: 117-128.

Species at Risk Committee. 2014. Species Status Report for Wolverine (*Gulo gulo*) in the Northwest Territories. Species at Risk Committee, Yellowknife, NT. 141pp.

Van Ballenberghe, V. 1983. The Rate of Increase in Moose Populations. Alces 25: 25-30.

Veitch, A.M. 1999. Status of Grizzly Bears in the Mackenzie Mountains, NWT. Resources, Wildlife and Economic Development. Unpublished report. 28pp.

Veitch, A.M. and R.A. Popko. 1996. 1995 Mackenzie Mountain Non-resident Hunter Harvest Summary. Renewable Resources. Manuscript Report No. 90. 32pp.

Veitch, A.M. and R.A. Popko. 1997. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary, 1996. Resources, Wildlife and Economic Development. Manuscript Report No. 97. 48pp.

Veitch, A.M., R.A. Popko and N. McDonald. 1996. Size, Composition, and Harvest of the Norman Wells Area Moose Population, November 1995. Renewable Resources. Manuscript Report No. 93. 42pp.

Veitch, A.M. and E.N. Simmons. 1998. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary, 1997. Resources, Wildlife and Economic Development. Manuscript Report No. 106. 38pp.

Veitch, A.M. and N. Simmons. 1999. Dall's Sheep – Northwest Territories. pp.54-58 *in* Toweill, D.E. and V. Geist (eds.) Return of Royalty: Wild Sheep of North America. Boone and Crockett Club and Foundation for North American Wild Sheep, Missoula, MT. 224pp.

Veitch, A. and E. Simmons. 2000. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary, 1999. Resources, Wildlife and Economic Development. Manuscript Report No. 121. 38pp.

Veitch, A.M., E. Simmons, J. Adamczewski and R.A. Popko. 2000a. Status, Harvest, and Co-management of Dall's Sheep in the Mackenzie Mountains, NWT. Northern Wild Sheep and Goat Council 11: 134-153

Veitch, A., E. Simmons and N. Whiteman. 2000b. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary, 1998. Resources, Wildlife and Economic Development. Manuscript Report No. 120. 40pp.

Veitch, A., R.A. Popko and N. Whiteman. 2000c. Classification of Woodland Caribou in the Central Mackenzie Mountains, Northwest Territories, August 1999. Resources, Wildlife and Economic Development. Manuscript Report No. 122. 24pp.

Veitch, A. and E. Simmons. 2002. Mackenzie Mountain Non-resident and Non-resident Alien Hunter Harvest Summary, 2000. Resources, Wildlife and Economic Development. Manuscript Report No. 137. 40pp.

Veitch, A, E. Simmons, M. Promislow, D. Tate, M. Swallow and R.A. Popko. 2002. The Status of Mountain Goats in Canada's Northwest Territories. Northern Wild Sheep and Goat Council 13: 49-62.

Weaver, J.L. 2006. Big Animals and Small Parks: Implications of Wildlife Distribution and Movements for Expansion of Nahanni National Park Reserve. Wildlife Conservation Society Canada, Toronto, ON. Conservation Report No. 1. 108pp.

www.adfg.alaska.gov/index.cfm?adfg=moose.main.

www.canadianforex.ca

www.canadianzinc.com/docs/NR060909.001.pdf.

www.cbc.ca/news/canada/north/parks-canada-settlements-nwt-1.3391646

www.huntingreport.com.

www.pc.gc.ca/pn-np/nahanni/ne/ne2_e.asp.

www.spectacularnwt.com/whattodo/hunting/themackenziemountains.

Yukon Renewable Resources. 1996. Sheep Management Guidelines. Renewable Resources. Whitehorse, YT. 10pp.

APPENDIX A. Outfitters licenced to provide services to non-resident hunters in the Mackenzie Mountains, NWT – 2016.

D/0T/01 – SOUTH NAHANNI OUTFITTERS LTD.
Werner Aschbacher and Sunny Petersen
P.O. Box 31119
Whitehorse, YT Y1A 5P7
P: (867)399-3194
F: (867)399-3194
E: info@huntnahanni.com
Website: www.huntnahanni.com

D/0T/02 – NAHANNI BUTTE OUTFITTERS
Jim Lancaster
PO Box 3854
Smithers, BC VOJ 2N0
P: (250)846-5309
P: (250)263-9197
E: jladventures@xplornet.com
Website: www.lancasterfamilyhunting.com

G/0T/01 – ARCTIC RED RIVER OUTFITTERS
Tavis Molnar
PO Box 1
Whitehorse, YT Y1A 5X9
P: (867)633-4934
F: (867)633-4934
E: info@arcticred-nwt.com
Website: www.arcticred-nwt.com

S/0T/01 – GANA RIVER OUTFITTERS
Harold Grinde
P.O. Box 528
Rimbey, AB T0C 2J0
P: (403)357-8414
E: ganariver@pentnet.net
Website: www.ganariver.com

S/0T/02-MACKENZIE MOUNTAIN OUTFITTERS
Stan and Helen Stevens
P.O. Box 175
Dawson Creek, BC V1G 4G3
P: (250)786-5118
F: (250)786-5404
E: mmostanstevens@gmail.com
Website: www.mmo-stanstevens.com

S/0T/03 – RAMHEAD OUTFITTERS
Stan and Debra Simpson
PO Box 5551
High River, AB, T1V 1M6
P: (780)446-8774
F: (780)848-7550
E: ramheadoutfitters@hotmail.com
Website: www.ramheadoutfitters.com

S/0T/04 - NWT OUTFITTERS
Clay Lancaster
13397 Parkside Crescent
Lake Country, BC V4V 2S7
P: (250)263-7778
E: jladventuresxplornet.com
Website: www.lancasterfamilyhunting.com

S/0T/05 - REDSTONE TROPHY HUNTS
Dave Dutchik
P.O. Box 1172
Cochrane, AB T4C 1B2
Cell: (250)261-9962
P/F: (403)975-8862
E: redstonehunts@yahoo.ca
Website: www.redstonehunts.com

APPENDIX B. Summary of fees, bag limits and seasons for big game species available to non-resident hunters in the Mackenzie Mountains, NWT - 2016. (Note: all prices are in Canadian funds.)

Species	Status	Tag Fee	Trophy Fee	Bag Limit	Season
Black Bear	Non-resident	$40.00	$200.00	1 adult bear not accompanied by a cub	15 Aug - 31 Oct 15 Aug – 30 June
	Non-resident alien	$100.00	$200.00		
Woodland Caribou	Non-resident	$40.00	$400.00	1	25 Jul - 31 Oct
	Non-resident alien	$100.00	$400.00		
Mountain Goat	Non-resident	$40.00	$400.00	1	15 Jul - 31 Oct
	Non-resident alien	$100.00	$400.00		
Moose	Non-resident	$40.00	$400.00	1	1 Sep - 31 Oct
	Non-resident alien	$100.00	$400.00		
Dall's Sheep	Non-resident	$40.00	$400.00	1 adult male with min. ¾ curl	15 Jul - 31 Oct
	Non-resident alien	$100.00	$400.00		
Wolf	Non-resident	$40.00	$200.00	1 or 2[2]	25 Jul - 10 Oct
	Non-resident alien	$100.00	$200.00	2	1 Aug - 15 Apr
Wolverine	Non-resident	$40.00	$200.00	1	25 July - 10 Oct
	Non-resident alien	$100.00	$200.00	1[3]	1 Aug – 15 Apr

Source: Environment and Natural Resources. 2016. Northwest Territories Summary of Hunting Regulations. Yellowknife, NT. 42pp.

[2] Limit of one wolf from D/OT/01-02 and G/OT/01; limit of two wolves from S/OT/01-05.

[3] Limit of one wolverine from S/OT/01-05, D/OT/01-02 and G/OT/01, could hunt wolverine in S/OT/01-05 1 August - 15 April.

APPENDIX C. Comments provided from non-resident hunters in the Mackenzie Mountains, NWT on voluntary Hunter Wildlife Observation Report forms, 2016. We have not printed actual names of outfitters or their guides (XXX).

XXX is an excellent guide. He is mentally & physically skilled and uncanny in his hunting skill and acumen.
Great time, stinking weather
My experience was exceptional. The area/landscape was magnificent. The XXX owners and family are awesome and the guide was perfect.
Saw a grizzly bear 50 yards from where we were camped. Excellent hunt, food, great guide. Thank you!!
All things are excellent I would recommend the hunt for all hunters in XXX.
Hunted together with XXX and XXX.
It was a great time, the best outfitters ever have seen.
Home away from home, thanks. Always welcome in XXX, XXX.
Excellent hunt, excellent outfitter.
Ticks found on ram taken.
Great experience!
Found dead moose cow (bear kill)
Lots of griz and wolf sign
The wolves seemed like they were not scared of us. Shot one from our tent at 9:00AM at less than 100 yards.
XXXX operates in a professional manner, treats their clients with respect and makes safety a priority. Impressive Outfit.
Saw a lot of grizzly bear sign.
Many animals of all species, ecosystem appears well balanced.
Good time - hunt
Hardly any calves with the caribou.
Hunted together with XXX
Hunted together
Rugged beautiful country
Outstanding hunt
Outfitter is top notch. 100% professional and has the client foremost on his mind. Will do all in his power to have a successful hunt for the client. Outfitter guides felt like family all through the hunt and did everything they could to provide a successful hunt. A pleasure.
Hunt of a life time.
XXX is a waste of your revenue. The river was already a "state" park. You are keeping people that may otherwise be able to see your country from doing so. What a shame!
Guide + outfitter were outstanding great beyond words.
Great!!!
Excellent - outfitter was efficient + very accommodating.
The XXX needs to be opened back up for everyone to visit and hunt. Now if you are handicapped you can only enjoy the river.
No harvest business meeting
No harvest injured shoulder

Can't wait to do it again!
Great hunt good weather, sheep in great shape.
Healthy, strong, smart rams.
Bottom right jaw was broken and rehealed, numerous scars along right side of body. Sheep was healthy and in good shape.
I had an excellent hunt with a great outfitter. The whole experience was wonderful. The scenery and the animals were amazing. A truly wild and beautiful, special place.
Good hunt healthy animals.
Great hunt, good weather, lots of sheep + bou.
Good weather, tonnes of animals, sheep in great shape, good berry crop. Lots of grizzly along river bottom.
All animals seen appeared healthy.
All animals strong and healthy.
All animals looked in great shape.
Great experience, terrific outfitter + all his crew. I am happy with the entire trip.
XXX exceeded our expectations. I would highly recommend XXX and XXX.
Good hunt not as many caribou, a few more wolves than usual.
Great hunt weather warmed up caribou slowed down healthy animals.
Great hunt, weather warmed up, bou slowed down.
Lots of moose
All animals looked in great shape
Wow!! Awesome coming back for moose! Great hunt!!
XXX is a class operation!
Excellent hunt
Well worth the trip. Had a great time.
We saw grizzly bears numerous times. The sow with 2 cubs was seen multiple times. One grizzly invaded our camp + ate sheep meat. Need to shoot some!
No communication, lack or absence of any safety briefings, no personalization or effort made towards filling our caribou tag? Worst sheep hunting experience!!!
XXX provided a top notch professional service + experience that exceeded my expectations.
Wonderful experience/place/people. God bless!!
Lots of bear (grizzly) sign present in all areas we hunted.
Had a wonderful time - Experience was excellent - a lot of grizzlies - NWT should have a grizzly season! XXX was a very professional and family oriented business!
Excellent organization, ethical approach to hunting staff very helpful and knowledgeable. Great family "ambiance".
Lots of Grizzly bears around. Several came into camp at night. On one occasion bear took 1 rear quarter of moose meat.
More than just hunting, it was an amazing experience in nature with a great crew!
Best hunt of my life time. Fantastic guiding outfit - could not be any better. Lots of game in great area with very good scenery.
Beautiful country! Can't wait to return!!
Outstanding outfit and area. Unreal scenery.
Excellent guide, excellent facilities, overall really enjoyable experience!
XXX is the best! Very hospitable people and are always there to help, I always tell people to come to the XXX and if they are hunters to talk to XXX!

Beautiful country and game.
XXX is my favorite place to hunt
Crew member, did not hunt
The grizzly population does not have a level of fear for humans due to no hunting season. They act very differently than bears that are hunted. These bears are hyper-aggressive towards humans. A small hunting season would go a long way towards reducing human-bear conflicts.
Best outfitter that I have hunted with to date. Grizzlies need to be thinned out.
Incredible area and wonderful experience. What a great place with hundreds of caribou.
Shoot bears to many.
Hotel guy is very rude.
Excellent hunt, amazing country.
Wonderful hunt. Big moose (all hunts - 7 took moose ~ 60+)
Was a great experience. One of the most beautiful places I have been. Would definitely recommend hunting in the XXX.
Great week.
Excellent hunt, a lot of game and beautiful area.
Another great XXX trip, thanks so much for everything.
78 year old gentleman.
Beautiful.
Got sick went home.
Great experience, super outfitter all hunting was great and fair chase.
Great outfitters, excellent guide, good sheep density, very professional.
Bow hunter wounded caribou, could not recover.
Was a totally awesome experience. The XXX run a top notch operation from their main camp to their guides + knowledge, again awesome. Ram had bullet hole in left horn.
Terrific hunt with fantastic people.
Great hunt!
Awesome hunt/ great outfitter.
Need to open a non-resident grizzly season. Lots of bears that do not fear humans.
Outstanding talented guides, talented skinners, keen eyes, exercise safety day and night, very good copter safety, XXX and XXX are nice to be around, I would certainly be guided by either of them again.
Excellent hunt, first class outfitter, guide, pilot and accommodations. Plenty of game.
Great place.
Excellent hunt. Great outfitter. Lots of game. Too many grizzlies/predators. A grizzly season maybe in order.
I had two bears charge!
Missed rams.
Excellent outfitter.
Wonderful, challenging experience. XXX do an excellent job with conservation + an overall hunting experience.
Excellent area & outfitter.
Taking 40lbs of meat.
Awesome time!
Animals that were observed were all very healthy.

Excellent experience and service from all parties encountered. Except XXX Airline, they are terrible service providers. Saw good numbers of sheep as noted above in limited area hunted. No unusual conditions or behaviours, good bull caribou.
We found a dead lamb that appeared to have died from a disease.
1 cross fox.
Game was plentiful. My sheep had a broken left shoulder or leg - was not bearing any weight on it and the sheep appeared to be under weight.
Good number of animals everything looked good.
These guys are great! Very professional.
Great country, good numbers.
Great quality and quantity of animals. Nothing unusual observed.
Quantity and conditions of the animals seemed normal.
Wow! Amazing! Great numbers + quality.
I observed a lot of game and they appear to be in excellent condition.
NWT needs to control the grizzly bear population in this area.
Nothing unusual. Beautiful country.
Nothing unusual, good quality and quantity.
Beautiful country, game rich area. All animals observed appeared to be very healthy and plentiful.
Plenty of sheep and caribou. They looked healthy and we observed lots of caribou groups in the bowls and bogs.
The quality and quantity of al wildlife was excellent. Sheep + caribou all seemed to be in great condition.
I strongly feel that grizzly bear hunting should be considered.
Nothing unusual on animals observed, everything looked healthy + in good condition.
Quantity of animals about what was expected.
All animals I saw were in good health, however, there are too many bears that have a negative impact on the sheep and caribou. We found where several sheep had been killed.
Abundant animals and all healthy and unaware of humans.
I saw lots of caribou. Plenty younger bulls and about two dozen mature bull caribou
I am a guide and hunt for myself if I get a day off. Enjoyed all as usual.
Great country and outfitter! Wonderful time!
Caribou everywhere - immense area - caribou herds healthy.
Everything looks great!
Very plentiful land. Numerous mature healthy moose and caribou.
Great country + lots of game! Excellent quality and quantity of caribou! I saw many sheep from a distance. Moose were spotted in several valleys. I saw 20+ moose.
Outfitter and facilities are excellent - staff is very knowledgeable + competent. Game quantity and quality of trophies excellent - seems to be a high wolf population. Hunted moose - seem to be lots of bulls - cows were harder to find and calves were very few. Wolf population seemed to be a little excessive - saw lots of caribou both bulls and cows and some calves. Saw a good amount of sheep from a distance.
I'll be back.

APPENDIX D. Summary of 2016 voluntary hunter comments broken down into specific topics.

No. of Hunters Reporting	No. of Hunters Mentioning Good Quality Hunts	No. of Hunters Mentioning Abundance /Quality of Animals	No. of Hunters Mentioning Grizzlies	No. of Hunters Mentioning Wolves	No. of Hunters Mentioning Park Expansion	No. of Hunters Mentioning Bad Weather
154	77	44	18	3	2	1

APPENDIX E. Number, age and horn length measurements of Dall's sheep rams harvested by non-resident hunters in the Mackenzie Mountains, 1967-2016. Number harvested includes 10[1], 2[2], 6[3], 8[4], 7[5], 9[6], 4[7], 11[8], and 5[9] harvested by resident hunters.

Year	Number of Sheep Harvested	Age (Years)		Length of Right Horn	
		Mean	Sample Size	Mean (cm)	Sample Size
1967-1968	223	8.4	Unknown	86.4	168
1969	110	-	-	-	-
1970	94	-	-	-	-
1971	88	-	-	-	-
1972	110	8.5	96	86.2	90
1973	89	8.9	86	84.4	88
1974	93	9.2	85	88.6	91
1975	129	7.6	67	84.6	127
1976	144	7.8	46	88.0	144
1977	132	5.7	69	86.8	132
1978	187	8.5	115	88.9	165
1979	200	8.7	108	90.8	154
1980	188	-	-	90.1	127
1981	183	8.1	101	92.7	157
1982	126	8.7	98	89.7	124
1983	100	9.0	80	90.9	94
1984	102	8.4	98	91.2	99
1985	123	8.1	115	89.7	112
1986	154	8.8	132	88.4	153
1987	148	8.9	148	89.4	148
1988	177	9.8	166	91.7	161
1989	207	9.9	199	90.4	203
1990	219	9.8	200	90.2	218
1991	170	9.7	161	89.1	170
1992	203	9.7	199	88.0	202
1993	191	9.7	181	87.6	190
1994	199	9.5	191	89.8	196
1995	189	9.6	189	88.9	189

Year	Number of Sheep Harvested	Age (Years)		Length of Right Horn	
		Mean	Sample Size	Mean	Sample Size
1996	201	9.5	200	88.7	201
1997	210	10.0	206	89.9	203
1998	215	10.0	207	90.0	209
1999	204	10.2	183	88.8	184
2000	194	10.0	188	88.9	188
2001	199	10.1	183	87.7	184
2002	173 [6]	9.9	166	89.2	166
2003	213 [3]	9.7	210	89.8	212
2004	201 [1]	10.0	199	89.3	200
2005	203 [7]	10.2	196	89.4	199
2006	208 [8]	10.4	206	88.4	207
2007	216 [3]	10.8	216	88.3	216
2008	192 [4]	10.6	192	88.8	192
2009	179 [5]	10.9	178	88.2	178
2010	193 [6]	10.8	191	88.7	192
2011	181 [7]	10.8	181	90.5	181
2012	207 [6]	10.9	205	89.9	206
2013	193 [4]	10.5	193	87.5	193
2014	208 [7]	10.5	207	88.4	208
2015	219 [9]	10.6	219	88.0	218
2016	192 [2]	11.0	187	89.1	189
Mean 1972-2016	**177**	**10**	**160**	**89.0**	**170**

APPENDIX F. Outfitted non-resident hunter harvests in the Mackenzie Mountains, 1991-2016. Number harvested includes 10[1], 2[2], 6[3], 8[4], 7[5], 9[6], 4[7], 11[8] and 5[9] harvested by resident hunters.

Year	Number of Licences Sold	Number of Animals Harvested						
		Dall's Sheep	Mountain Caribou	Moose	Mountain Goat	Wolf	Wolverine	Black Bear
1991	354	170	179	40	6	14	3	1
1992	364	203	142	32	4	7	0	0
1993	382	191	191	56	9	7	3	0
1994	356	199	164	46	5	15	2	0
1995	344	189	180	49	6	14	1	0
1996	387	201	175	46	4	9	4	0
1997	352	210	168	44	2	17	1	0
1998	345	215	160	52	5	9	0	0
1999	321	204	117	36	1	11	3	0
2000	332	194	127	44	1	14	0	0
2001	332	199	128	41	2	15	2	0
2002	338	173 [6]	168	42	5	11	1	0
2003	350	213 [3]	143	48	6	12	0	0
2004	347	201 [1]	135	55	6	18	0	0
2005	398	203 [7]	160	75	18	19	1	0
2006	418	208 [8]	188	72	12	23	1	0
2007	405	216 [3]	165	74	21	12	0	0
2008	399	192 [4]	167	75	21	17	1	2
2009	339	179 [5]	125	59	20	20	3	1
2010	384	193 [6]	158	75	13	19	3	0
2011	400	181 [7]	181	78	20	21	2	1
2012	405	207 [6]	168	85	12	24	0	0
2013	409	193 [4]	182	81	11	16	2	0
2014	407	208 [7]	179	69	14	23	1	0
2015	447	219 [9]	190	71	17	20	2	2
2016	389	192[2]	191	76	8	29	2	0
Mean 1991-2016	**373**	**198**	**163**	**59**	**10**	**16**	**1**	**0**

APPENDIX G. Summary of age and sex ratios calculated from non-resident hunter observation reports in the Mackenzie Mountains, 1995-2016.

Year	Dall's Sheep		Mountain Caribou		Moose	
	Lambs: 100 Ewes	Rams: 100 Ewes	Calves: 100 Cows	Bulls: 100 Cows	Calves: 100 Cows	Bulls: 100 Cows
1995	67	82	36	34	30	95
1996	44	82	45	40	26	76
1997	57	55	36	21	30	107
1998	60	84	35	34	30	95
1999	58	90	43	25	20	100
2000	47	90	41	39	26	89
2001	59	89	56	61	28	120
2002	58	89	59	31	29	96
2003	50	83	39	36	25	129
2004	53	93	42	38	30	101
2005	51	98	42	42	33	110
2006	53	96	43	37	33	137
2007	64	83	52	37	36	101
2008	49	98	41	40	31	115
2009	55	94	45	39	31	90
2010	49	93	45	46	35	101
2011	56	91	44	35	33	123
2012	53	86	40	46	33	88
2013	52	92	36	43	29	106
2014	55	93	36	41	29	103
2015	58	72	43	50	34	98
2016	49	81	33	42	31	105
Mean 1995-2016	**54**	**87**	**42**	**39**	**30**	**104**

APPENDIX H. Summary of age and sex ratios calculated from non-resident hunter observation reports of mountain goats, 2002-2016.

Year	Kids:100 Nannies	Billies:100 Nannies	Total Animals
2002	55.2	75.9	69
2003	61.5	70.5	182
2004	57.1	77.1	84
2005	66.0	50.4	306
2006	61.5	51.4	245
2007	71.2	57.7	393
2008	54.3	97.1	264
2009	64.6	59.0	327
2010	78.3	46.2	239
2011	64.0	59.0	243
2012	51.8	71.9	257
2013	69.6	75.0	144
2014	67.8	58.5	277
2015	67.5	92.5	212
2016	67.6	85.3	90
Mean 2002-2016	**63.9**	**68.5**	**222.1**