MACKENZIE MOUNTAIN NON-RESIDENT AND NON-RESIDENT ALIEN HUNTER HARVEST SUMMARY 2018-2021

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ABSTRACT

Data on the Mackenzie Mountains non-resident and non-resident alien harvest is collected annually by the Department of Environment and Climate Change in cooperation with each of the eight licenced outfitters. Here harvest records are compiled to assess non-resident harvest demand, harvest numbers, and success rates between 2018-2021 in comparison to previous years (1991-2017). Measurements of harvested species, hunter observations, and harvest-based sampling submissions are examined to assess indexes of abundance, population trends, demographics, and wildlife health across several big game species harvested in the Mackenzie Mountain outfitter zones.

Across all game species, harvest in 2018 and 2019 did not vary substantially from the previous five years. While the pandemic-related lack of travel prohibited an outfitting season in 2020, the 2021 season only saw a small reduction in harvest as travel restrictions relaxed after the hunting season began. Additionally, 2021 was the first year on record where the majority of outfitter clients were non-resident Canadians due to tighter restrictions on international travel.

Comparisons of numbers of Dall's sheep (*Ovis dalli*) observations per hunter day (i.e., catch per unit effort) and composition, largely reflected population trends and demographics seen in long-term study areas monitored using systematic surveys in the Sahtú and Beaufort Delta administrative regions. This indicates that voluntary hunter observation data may be a valuable tool for assessing populations of wildlife over a large geographic and difficult to monitor area.

Using hunter observations, trends and demographics of big game species in the Mackenzie Mountains were examined, however, a lack of systematic monitoring for some species and limited observations for some species precluded us from validating this data as a monitoring tool. Nevertheless, these data provide valuable insight into trends and demographics of populations that are costly to monitor and difficult to access.

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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 (Deuling, 2017; Simmons, 1968). Since then, the Mackenzie Mountains have become world-renowned for providing a high quality wilderness hunting experience (Larter & Allaire, 2017), 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 (Larter & Allaire, 2017). The outfitted hunting industry in the Mackenzie Mountains also provides employment for 150-170 outfitters, guides, pilots, camp cooks, camp helpers, and horse wranglers (Larter & Allaire, 2017). In addition, fresh meat from many harvested animals is provided to 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 sometimes to local facilities. The estimated annual replacement value of this meat has ranged from ca. $60,000-625,000 (Larter & Allaire, 2017).

Eight outfitters are currently licenced by the Government of the NWT (GNWT) to provide big game outfitting services within the Mackenzie Mountains (Figure 1, Appendix A). Under the NWT *Wildlife Act* (S.N.W.T. 2013, c.30), each of the eight licenced Mackenzie Mountai outfitters 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. Harvesting in the area including the Nahanni National Park Reserve and the Nááts'įhch'oh National Park Reserve, collectively NNPR for this report (Figure 1), is restricted to subsistence harvest by Indigenous rights holders. 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. 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 Indigenous people eligible or belonging to an Indigenous 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.

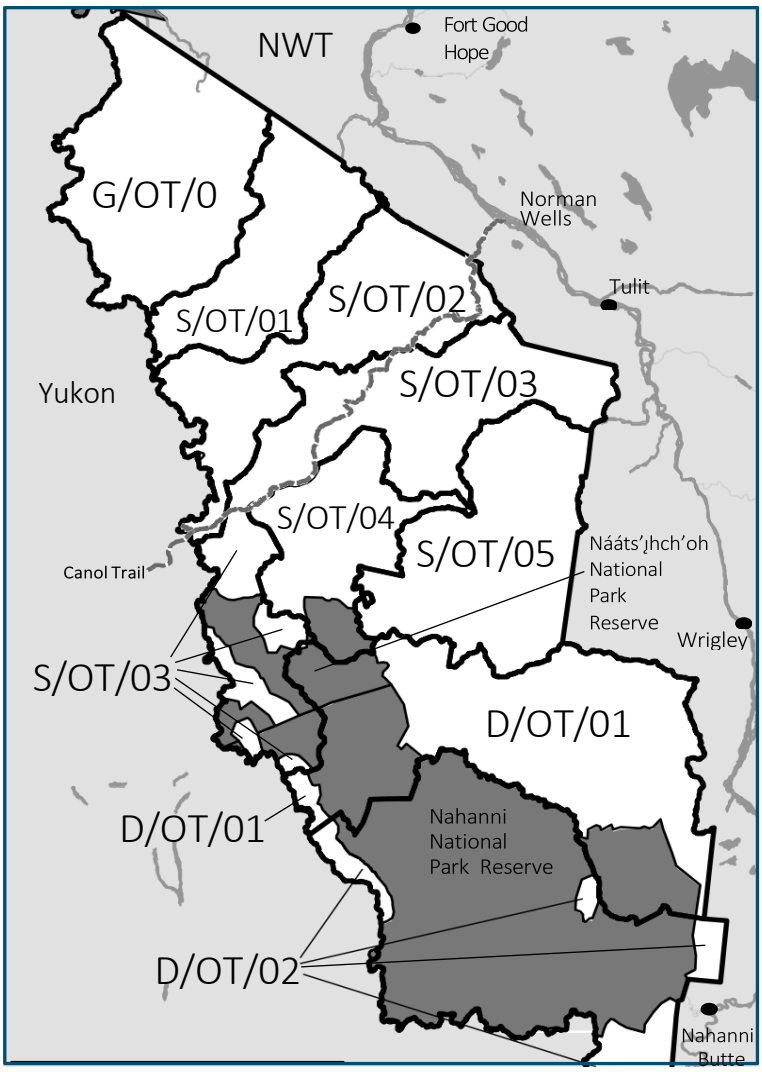


Figure 1. NWT Mackenzie Mountain Outfitting zones and names, NNPR, and land claim areas (black dotted lines). The hatched line is the Canol Trail.

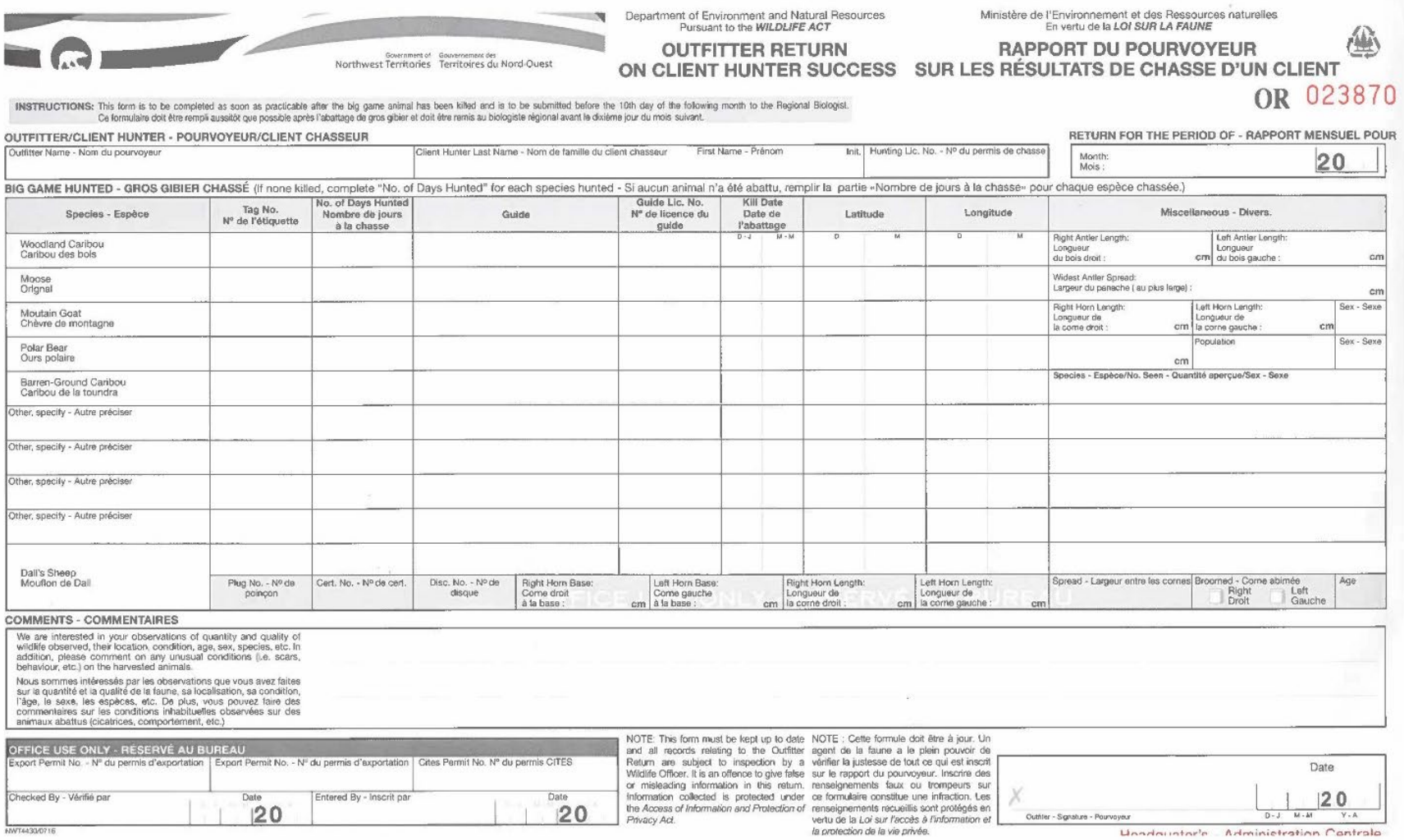
Both non-resident and non-resident alien hunters must use the services of an outfitter and must be accompanied by a licenced guide at all times while hunting big game. For simplification in this report, we refer to both non-resident and non-resident alien hunting licence holders as 'non-residents' and combine their harvest statistics unless specifically stated. Data on the age of sheep harvested and horn length include 115 resident hunters who harvested Dall's sheep in the Mackenzie Mountains without a guide between 1991 and 2021.

Individual non-resident hunters are annually restricted to one each of the following big game species: Dall's sheep (male with at least one ¾ curl horn), northern mountain woodland caribou (either sex), moose (either sex), mountain goat (either sex), wolverine (either sex), and black bear [adult not accompanied by cub(s)]. For wolves, non-resident and non-resident alien hunters may only harvest one wolf in the Dehcho and Gwich'in areas but area allowed to hunt two wolves of either sex in the Sahtú outfitter areas in the Mackenzie

Mountains (S/OT/01-05). Although non-resident hunters are allowed to hunt any moose and caribou (bull, cow, or calf) 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 overharvest (Latour & MacLean, 1994; Miller et al., 1982). There are currently no restrictions on the total number of tags for each big game species in any outfitting area or across the Mackenzie Mountains as a whole.

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 Dehcho land claims have not been settled and management of wildlife in the Dehcho currently falls under the jurisdiction of the GNWT with the exception of the NNPR. Following changes made to the Nahanni NPR boundaries in 2009 and the establishment of Nááts'įhch'oh NPR in 2014 (Parks Canada, 2017, 2021), the NNPR comprised of 34,945 km^2 in the southern Mackenzie Mountains managed at the federal level by Parks Canada. 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 Renewable Resources Board (S.C. 1994, c. 27, 13.8.1) and the Gwich'in Renewable Resources Board (S.C. 1992, c. 53, 12.8.1), 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 encompasses the extreme north end of the outfitter zones (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 Climate Change (ECC; Environment and Natural Resources prior to 2023), is responsible for licencing outfitters, guides, and hunters and for annually monitoring non-resident big game harvest in the Mackenzie Mountains.

Annually, ECC under the *Wildlife Act* related provisions in the *Wildlife Business Regulations* requires outfitters to submit an outfitter return on a client hunter success form (hereafter referred to as outfitter returns or outfitter return forms) for each person that purchased an 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 ECC to quantify harvest by non-resident hunters and report to co-management partners.



Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

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

OUTFITTER RETURN ON CLIENT HUNTER SUCCESS

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

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

OR 023870

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 de gros gibier et doit être remis au biologiste régional avant le dixième jour du mois suivant.

OUTFITTER/CLIENT HUNTER - POURVOYEUR/CLIENT CHASSEUR

Outfitter Name - Nom du pourvoyeur	Client Hunter Last Name - Nom de famille du client chasseur	First Name - Prénom	Init.	Hunting Lic. No. - N° du permis de chasse

RETURN FOR THE PERIOD OF - RAPPORT MENSUEL POUR

Month: / Mois : 20

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 (D-J M-M)	Latitude (D M)	Longitude (D M)	Miscellaneous - Divers.
Woodland Caribou Caribou des bois								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
Moutain 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								cm Population Sex - Sexe
Barren-Ground Caribou Caribou de la toundra								Species - Espèce/No. Seen - Quantité aperçue/Sex - Sexe
Other, specify - Autre préciser								
Other, specify - Autre préciser								
Other, specify - Autre préciser								
Other, specify - Autre préciser								

Dall's Sheep Mouflon de Dall	Plug No. - N° de poinçon	Cert. No. - N° de cert.	Disc. No. - N° de disque	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	Broomed - Corne abîmée Right Droit / Left Gauche	Age

COMMENTS - COMMENTAIRES

We are interested in your observations of quantity and quality 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 20	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. Information collected is protected under the *Access of Information and Protection of Privacy Act.*

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. Les renseignements récueillis sont protégés en vertu de la *Loi sur l'accès à l'information et la protection de la vie privée.*

Date 20 (D-J M-M Y-A)

X Outfitter - Signature - Pourvoyeur

Headquarter's - Administration Centrale

NWT4430/0716

Figure 2. Example of an outfitter return on client hunter success form.

Starting in 1991, the then Department of Resources, Wildlife and Economic Development requested all non-residents hunting in the Mackenzie Mountains fill out an additional voluntary questionnaire (Figure 3). The questionnaire has evolved through the years based upon suggestions from outfitters, their clients, and government staff, however, the key component of the questionnaire that has remained constant through the years is reporting the numbers and type of wildlife species seen during their hunts as well as the number of days hunted (i.e., effort). The questionnaire forms have been referred to as hunter observation forms in this report.

MACKENZIE MOUTAINS, NORTHWEST TERRITORIES
HUNTER WILDLIFE OBSERVATION REPORT – 201__

Dear Hunter: The Department of Environment and Natural Resources (ENR), Government of the Northwest Territories is undertaking a survey and invites you to participate in completing this questionnaire about your NWT hunting experience. The survey will be used to assist us with the management of Mackenzie Mountain big game populations. Your participation is voluntary. The information is intended to be used internally by the GNWT for government programs and services. Under the *Access to Information and Protection of Privacy Act*, if a request is submitted, the GNWT may have to disclose some information included in this survey.

HUNTER INFORMATION

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

Hunting License # _____ Outfitter Zone: _____ Outfitter: _____

Start Date of Hunt _____201__ End Date of Hunt _____201__ Observations Made Over ____ Days

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

ESTIMATED NUMBER OF MOUNTAIN CARIBOU SEEN		
Bulls	Cows	Calves

ESTIMATED NUMBER OF MOOSE SEEN		
Bulls	Cows	Calves

ESTIMATED NUMBER OF MOUNTAIN GOAT SEEN			
Billys	Nannys	Kids	Unknown Age

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

How would you rate you overall hunting experience with your Outfitter? Could you please check the appropriate box.

☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor

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

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

The balance of my meat was provided to my outfitter. Yes _____ N/A _____ **Did you hunt with a bow?_____**

COMMENTS:_____

_____

_____

_____

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 2. Example of a hunter observation report form.

These data provide valuable time series of observations and have been previously explored to assess mountain caribou herd demography (Larter, 2012b, 2018). There have been no changes to the classifications of wildlife since 1995 nor the questions or format of the forms since 2013.

2021 is the 27th consecutive year (barring a lack of outfitting in 2020) that a summary of the data collected by ECC, formerly the Department of Environment and Natural Resources (ENR), on non-resident hunters in the Mackenzie Mountains has been made. Although this data has been reported annually by ECC, this report compiles all available harvest data collected from 1991-2021 to make comparisons over time.

Ownership Change

Prior to the 2017 hunting season Ramhead Outfitters (area S/OT/03) and Redstone Trophy Hunts (area S/OT/05) sold their concessions. Area S/OT/03 is now owned by Canol Outfitters and area S/OT/05 is now owned by Raven's Throat Outfitters (Figure 1).

Health and Condition of Ungulates

There is limited information on the general health and condition of Dall's sheep, northern mountain caribou, moose, and mountain goat inhabiting the area. The few studies that have been conducted have relied on the direct assistance of Association of Mackenzie Mountain Outfitters (AMMO) personnel, who provided samples from harvested animals.

Renewed interest from outfitters to screen for *Mycoplasma ovipneumoniae* in Dall's sheep initiated a new sheep health project in 2021. Kits were created and requested the following samples: nasal swabs (*Mycoplasma ovipneumoniae* screening), hair with hide (DNA and hormone analysis), fecal (hormone analysis and parasite screening), blood dried on filter paper (serology to detect presence of or exposure to diseases), and a central incisor (aging).

METHODS

Prior to the start of each 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* require outfitter return forms to be returned with all forms usually received at the end of the fall season as a complete package. 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 cooperation with ECC 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. Hunter observation forms were submitted voluntarily.

Information from both the outfitter return forms and hunter observation forms were entered into Microsoft Excel spreadsheets. Harvest data for all species is cross-referenced with data in the Licence Information System-IntraNet (LISIN) data management system maintained by ECC offices across the NWT. This includes GNWT wildlife export permit data. Additionally, because each set of legally harvested Dall's sheep horns must have a uniquely numbered identifier plug inserted prior to export, the plug numbers are cross-referenced with sheep harvest data.

In some instances, observation data were reported on outfitter return forms, but not on a hunter observation form; these observations were included in our analyses. If observation information differed between the hunter observation form and the outfitter return form for the same client, only the data from the hunter observation form was used. 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. Forms with data that had been provided were recorded, but for the wildlife observation analyses only one set of observations was used.

Observation data was included in the analysis if the number of hunter days was included on the sheet and could be linked back to an individual hunter (e.g. name, hunting licence, tag number, etc.). Hunter days were usually recorded on the observation form but occasionally lacking. If a date range for the hunt was included, the maximum number of days hunted was calculated and included. 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. Return rates for hunter observation forms were calculated using the formula below:

$$\frac{observation\ forms\ returned\ by\ licences\ hunters}{(licences\ sold - clients\ that\ did\ not\ hunt)}$$

It should be noted that some hunters marked as "did not hunt" (e.g. crew members) will occasionally still join a hunting trip and submit observation forms. Observations per hunter day were calculated per client by dividing the number of observations by the number of hunter days (i.e., catch per unit effort). These observations per hunter day were then averaged to allow for a standardized comparison across years. This was calculated for each species observed and by age/sex class (e.g. ¾ curl rams, ewes, lambs, etc.). In addition, where data was sufficient, the observations were broken down by region to provide region specific trends in data. Due to the requirement of having hunter day data for inclusion with the analysis, numbers of observations reported may differ from reports prior to 2017.

Data from the physical copies were entered using Microsoft Excel while summary statistics and analysis were performed in R (R Development Core Team, 2020).

RESULTS AND DISCUSSION

The results of the 2018 and 2019 returns and observation forms were not consolidated until 2020 and staff turnover delayed further work on the report. Also many of the outfitter returns were missing for 2018; most notably, none of the returns for Canol Outfitters (area S/OT/03) for 2018 were located. This resulted in the lowest return rate of outfitter returns since the inception of this annual report. 2019 and 2021 saw an increase in return rate (89% and 84% of returns received respectively) and ECC is working to continue to improve return rates. In general, non-resident hunting in the Mackenzie Mountains occurs from July - October however guided hunting for wolves also occurs during winter in areas S/OT/01 and S/OT/05. For the ninth consecutive year winter wolf hunting occurred in area S/OT/01. No wolves were harvested in area S/OT/05, the first year for guided winter wolf hunting in this area. Winter wolf harvests during the 2018-2021 period were not well reported for the same reasons listed above.

Return rates for voluntary observation forms averaged around 63% (1996-2021) and notably the return rates 2018-2021 were below average (57-62%, Table 1). Some of this can be attributed to forms lost in transit due to a physical change in the office where the reports are now produced, though this decrease is not as substantial as that in the outfitter returns. The utility of voluntary observation forms has been emphasized at AMMO general meetings and most outfitters endeavour to have clients complete and submit these forms with most outfitters consistently returning more than 70% of forms (see Appendix B; Table C2). However, Arctic Red River (G/OT/01) and Canol Outfitters (S/OT/03) have failed to consistently return more than 50% of their forms in recent years. Limited returns from zones with large clientele precludes the ability to generalize observations over the entire Mackenzie Mountains.

Table 1. Summary of numbers of licences sold, outfitter return and hunter observation forms collected, clients confirmed to have not hunted, and the associated percent return (%) for each form from 1991-2022.

Year	Non-resident Licences	Outfitter Returns	Hunter Observation	Confirmed "Did Not Hunt"	Outfitter Return (%)	Hunter Observation (%)
1991	346	251	-	5	73	-
1992	364	246	-	0	68	-
1993	382	306	-	0	80	-
1994	355	303	-	20	85	-
1995	333	327	-	12	98	-
1996	387	387	253	29	100	71
1997	352	346	168	18	98	50
1998	345	333	206	4	97	60
1999	321	297	163	11	93	53
2000	332	318	168	5	96	51
2001	329	292	192	10	89	60
2002	327	317	199	22	97	65
2003	344	338	203	8	98	60
2004	337	331	244	8	98	74
2005	394	394	256	26	100	70
2006	404	397	239	30	98	64
2007	399	390	244	48	98	70
2008	387	383	244	45	99	71
2009	332	330	194	28	99	64
2010	375	366	203	38	98	60
2011	396	393	218	44	99	62
2012	396	392	216	35	99	60
2013	405	396	212	32	98	57
2014	400	396	261	45	99	74
2015	447	438	298	34	98	72
2016	389	387	219	35	99	62
2017	390	390	233	39	100	66
2018	411	315	245	17*	77	62*
2019	449	400	245	19*	89	57*
2021	302	255	165	16*	84	58*

* due to low number of returns in these years, these numbers are likely a low estimate.

Licences

The number of big game hunting licences for the Mackenzie Mountains sold between 2018 and 2021 are summarized in Table 1 above. Covid-19 travel restrictions prevented any outfitting operations in 2020 but were lifted in 2021 allowing for a shorter season. Occasionally clients 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. Guides often purchase licences annually but rarely have the opportunity to hunt themselves.

In 2018 and 2019, hunters from the United States (US) purchased 77% (n=319) and 75% (n=338) of licences, surpassing 2017 (73%) and continued the increasing trend from 2013. In contrast, non-resident Canadian licences 2018 and 2019 represented 18% of sales. Foreign residents, other than

Americans, represented the remaining 4-6% of sales and continued the declining trend from 2013 (Figure 4).

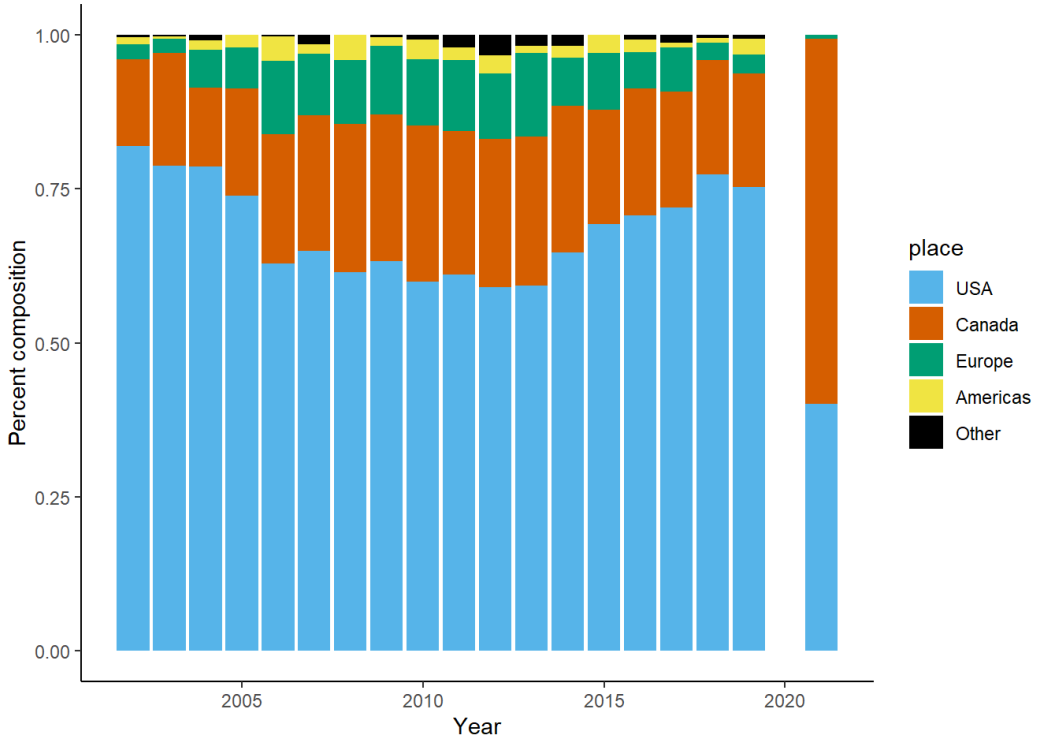


Figure 3. Geographical areas of origin of hunters purchasing licences to hunt in the Mackenzie Mountains from 2002-2021. Travel restrictions resulted in no outfitted hunts being conducted in 2020.

2021 saw the resumption of outfitter operations after Covid-19 travel restrictions in 2020. However, reductions in travel restrictions were announced close to the start of the outfitter season, resulting in a shorter season than in previous years. The remaining restrictions and late announcement made 2021 the first year where Canadian non-resident hunters outnumbered the non-resident alien hunters; making up 59% of licences.

Hunts are marketed in American dollars. In years when the Canadian and American dollars are close to par (2010-2013) *ca.* 40% of hunters were from countries other than the US. With the continued decline in the Canadian dollar to about $0.75 in 2017 the proportion of US hunters has continued to increase and was at levels similar to pre-2006 when the Canadian dollar ranged from $0.64-$0.83 (www.canadianforex.ca).

Tags

The number of tags purchased by non-resident hunters and the proportion of hunters purchasing a tag categorized by species are summarized in Table 2. Although Dall's sheep are one of the most desired species for non-resident hunters in the Mackenzie Mountains the proportion of Dall's sheep tags has declined since 2016 and was the lowest recorded in 25 years in 2019 with only 53% of non-resident hunters purchasing a Dall's sheep tag. This percentage did increase to 64% in 2021 with outfitted hunts resuming with relaxed travel restrictions. The actual number of tags had increased from a low of 222 tags purchased in 2017 to 240 in 2019. Even with the increase in the percent of hunters purchasing a tag, the shorter 2021 season resulted in only 193 tags being sold. The reduced number of sheep hunters

in recent years appears to be related to a dramatic drop in sheep clients for D/OT/02 over the past two seasons. With the expansion of NNPR in 2016, this area had its hunting area reduced by almost 80%.

Table 2. Summary of tags sold per each species (N) and percent of hunters purchasing tags (%) of each species from 1991-2021.

Year	Sheep		Caribou		Moose		Mountain Goat		Wolf		Wolverine		Black bear	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1991	220	64	260	75	78	23	29	8	225	65	147	42	1	0
1992	252	69	282	77	78	21	38	10	264	73	178	49	7	2
1993	243	64	288	75	86	23	35	9	221	58	117	31	0	0
1994	217	61	190	54	63	18	10	3	51	14	18	5	0	0
1995	218	65	233	70	70	21	16	5	72	22	35	11	0	0
1996	252	65	274	71	73	19	14	4	193	50	114	29	0	0
1997	252	72	260	74	73	21	30	9	209	59	135	38	8	2
1998	246	71	223	65	70	20	23	7	166	48	100	29	2	1
1999	227	71	181	56	63	20	6	2	89	28	65	20	1	0
2000	232	70	199	60	66	20	12	4	146	44	79	24	6	2
2001	219	67	196	60	59	18	11	3	138	42	83	25	0	0
2002	218	67	229	70	68	21	18	6	159	49	97	30	0	0
2003	257	75	247	72	85	25	18	5	208	60	141	41	9	3
2004	236	70	243	72	84	25	24	7	164	49	89	26	8	2
2005	238	60	271	69	100	25	40	10	204	52	151	38	40	10
2006	276	68	274	68	112	28	21	5	201	50	108	27	3	1
2007	284	71	272	68	108	27	50	13	227	57	150	38	7	2
2008	281	73	275	71	109	28	45	12	228	59	111	29	1	0
2009	234	70	254	77	97	29	44	13	261	79	135	41	22	7
2010	253	67	295	79	116	31	52	14	294	78	171	46	28	7
2011	251	63	314	79	121	31	55	14	285	72	163	41	32	8
2012	278	70	300	76	115	29	42	11	292	74	153	39	16	4
2013	271	67	296	73	131	32	58	14	299	74	155	38	34	8
2014	282	70	327	82	123	31	57	14	298	74	154	38	19	5
2015	300	67	347	78	117	26	71	16	358	80	179	40	20	4
2016	268	69	319	82	121	31	25	6	310	80	190	49	17	4
2017	222	57	308	79	102	26	28	7	299	77	179	46	18	5
2018	233	57	328	80	114	28	18	4	320	78	171	42	15	4
2019	240	53	343	76	134	30	23	5	408	91	184	41	17	4
2021	193	64	250	83	106	35	19	6	255	84	139	46	1	0

Northern mountain caribou, another desirable species, has seen a steady increase in the proportion of hunters purchasing tags from approximately 60% in the late 1990s to approximately 80% in recent years (Table 2). The highest years on record for tags sold were 2015 and 2019 with 347 and 343 tags sold respectively.

The sale of moose tags has steadily increased since the 1990s though the proportion of hunters purchasing moose tags has remained around 20-30% annually. Wolf tags have seen a steady increase in proportion of hunters purchasing tags since the early 2000s and spiked in 2019, the first year regulations were changed to remove both tag fees and harvest fees across the territory.

Mountain goat, wolverine, and black bear tags have not seen a noticeable change in either tags sold or proportion of hunters purchasing tags. These species are generally less common in the Mackenzie Mountains and therefore have few hunts as primary targets.

Hunt Length

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 (Larter & Allaire, 2017). For a more detailed breakdown of hunt length by year please refer to Appendix C.

The longest hunts for ungulates are generally sheep hunts with the average (±SD) from 1991-2021 of hunters hunting at least one day being 4.43 (±2.91) days. In descending order, moose hunts averaged 4.01 (±2.87) days, caribou hunts averaged 3.89 (±2.96) days, and mountain goat hunts averaged 2.84 (±2.00) days.

Carnivore hunts (wolves, wolverines, black bears) generally have fewer hunters actively pursue them and hunt durations can range widely. Wolf hunts between 1991-2021 for hunters hunting at least one day averaged 5.32 (±3.51) days, wolverine hunts averaged 6.05 (±3.59) days, and black bear hunts averaged 3.73 (±2.52) days.

Harvest and Success Rates

Numbers of animals harvested from 1995-2021 and their associate success rates are summarized in Table 3. Due to the low return rates of outfitter return forms collected between 2018-2021, these numbers represent a minimum harvest number. However, many of the missing Dall's sheep returns were captured on the return forms when horns were submitted for plugging and export. Non-resident harvest is discussed in more detail in species specific sections below.

Table 3. Summary of number of animals harvested by species (N) and percent of hunters with a successful harvest (%; i.e., success rate) from 1991-2021.

Year	Sheep		Caribou		Moose		Mountain Goat		Wolf		Wolverine		Black Bear	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1991	168	-	176	-	37	-	6	-	14	-	3	-	1	-
1992	203	-	142	-	32	-	4	-	7	-	0	-	1	-
1993	191	-	191	-	56	-	9	-	7	-	3	-	0	-
1994	198	94	164	89	46	75	5	50	15	33	2	12	0	-
1995	188	88	176	78	48	70	6	38	14	20	1	3	0	-
1996	201	84	175	69	46	71	4	31	9	5	4	4	0	-
1997	210	88	168	67	44	63	2	7	17	9	1	1	0	0
1998	215	88	160	73	52	74	5	22	9	5	0	0	0	0
1999	204	91	117	67	36	65	1	25	11	13	3	5	0	0
2000	194	85	127	65	44	68	1	8	14	10	0	0	0	0
2001	198	91	128	67	41	73	2	22	15	11	2	2	0	-
2002	167	80	166	75	42	65	5	29	11	8	1	1	0	-
2003	204	84	143	59	48	58	6	35	12	6	0	0	0	0
2004	191	81	135	56	55	65	6	25	18	11	0	0	0	0
2005	201	87	187	71	75	77	18	49	18	9	1	1	0	0
2006	198	78	188	71	72	67	12	60	22	12	1	1	0	0
2007	210	78	164	66	74	73	21	48	12	6	0	0	0	0
2008	184	74	165	65	75	76	21	50	17	9	1	1	1	100
2009	173	79	125	53	59	62	20	47	20	8	3	2	1	5
2010	185	78	158	60	75	70	13	27	19	7	3	2	0	0
2011	175	75	181	64	78	70	20	38	21	8	2	1	1	3
2012	200	77	168	60	85	77	12	30	24	9	0	0	0	0
2013	185	72	182	66	81	65	11	20	16	6	2	1	0	0
2014	204	78	178	61	69	63	14	25	22	8	1	1	0	0
2015	214	75	190	58	71	63	17	26	19	6	2	1	2	10
2016	192	76	191	65	76	70	8	32	29	10	2	1	0	0
2017	182	86	195	69	64	69	6	25	17	6	0	0	1	6
2018	173	76	162	51	64	57	1	6	28	9	9	5	0	0
2019	186	79	174	53	74	56	5	24	18	5	1	1	1	6
2021	149	79	128	54	62	60	3	16	9	4	0	0	0	0

Similarly, success rates reported represent a minimum as hunters who purchase a tag do not always pursue that species, and this is inconsistently noted on return forms.

Meat Returns

ECC 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. However, meat records since 2018 have been inconsistent and at least some are assumed to have been lost in transit. Meat records from three out of

eight outfitters were received in 2018 and only Gana River Outfitter (S/OT/01) submitted meat records for 2019 and 2021.

The distribution of wild game meat by outfitters is a local benefit but can 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. The information from ECC summary meat record forms provides an 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. 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. The limited records received from 2018-2021 reflect these observations. Using 2017 as an example, roughly 18,939 kg of meat from Dall's sheep, mountain caribou, and moose were distributed locally to the communities. Using an extremely conservative $25/kg as the replacement cost for meat from local northern retailers, then an equivalent $473,500 of meat was distributed in 2017.

Dall's Sheep (*Ovis dalli*)

Harvest

In 2018 and 2019 at least 173 and 186 rams were harvested, some of the lowest annual harvests since 1991 (Table 3). Due to the rate of outfitter return forms collected, these numbers represent a minimum harvest number, though many of the missing sheep returns were captured on the return forms when skulls were submitted for plugging and export. The abbreviated 2021 season saw a minimum of 149 sheep harvested, the lowest annual harvest recorded in the 30 years of tracking harvests 1991-2021.

Harvest by non-residents comprises at least 90% of the total annual harvest of Dall's sheep in the Mackenzie Mountains and was estimated circa 2000 to take only 0.9-1.6% of the estimated 14,000-26,000 Dall's sheep in the Mackenzie Mountains (Veitch, Simmons, et al., 2000). However, since 2000, Dall's sheep populations in the Mackenzie Mountains have likely declined (see Observations and Population Trends) while harvest numbers have remained consistent, so current harvest may be higher than the estimated 0.9-1.6%. In the Yukon (YT), where harvest is managed by a full curl rule, the sustainable harvest is set at 4% of the non-lamb population (Environment Yukon, 2019). It is unlikely the current non-resident harvest level exceeds 4% or has a large effect on population.

Observations and Population Trends

Observations per hunter day of sheep are presented in Figure 5a. We can see from the trend that the number of sheep observed per hunter day by outfitter clients was relatively stable at eight sheep per hunter day from 1991-2005. Beginning in the early 2000s the number of sheep seen per hunter day declined to about five to six sheep observed per hunter day, approximately a 30% decline. These observations mirror trends observed in two long-term sheep survey areas in the Sahtú (Figure 5b). The Katherine Creek study area (located in S/OT/02) has declined from a peak count of 204 in 1998 to approximately 30 in 2020 and 2022 representing an 85% decline from peak (Figure 5b). The Palmer Lake study area (S/OT/01) has similarly declined from a peak count of 496 in 2004 to between 150-200 in 2017-2021, representing a 60% decline.

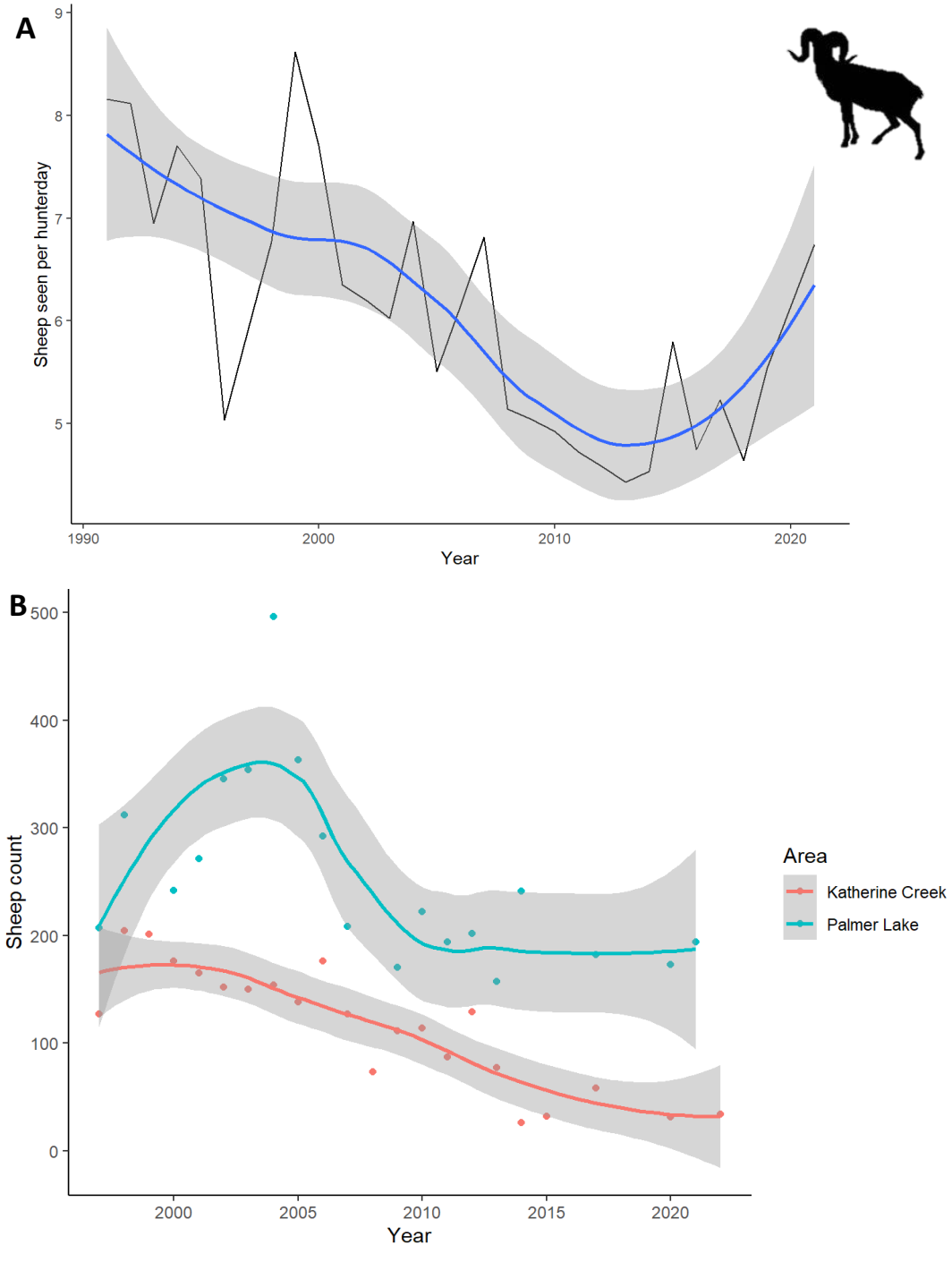


Figure 4. A) Total numbers of sheep seen per hunter day calculated from observations submitted by non-resident and non-resident alien hunters throughout the Mackenzie Mountains from 1991-2021. **B)** Total counts of sheep in the Katherine Creek (located in S/OT/02) and Palmer lake (S/OT/01) long-term study areas from 1997-2021. Ground surveys were conducted on foot from 1997-2018 and aerial surveys from 2019 to present.

The sheep population in the Richardson Mountains of the northern YT and NWT has also undergone a continued decline since reaching an estimated peak number of 1,730 in 1997 (Lambert Koizumi et al., 2011) with the 2014 estimate at 496 (Davison et al., 2018). Although the 2017 survey estimate increased to 647, this is still approximately 40% of the peak estimate (Davison et al., 2018). Sheep surveys have been done in the Dehcho along the Nahanni and Liard ranges in 2003, 2011 and 2018

(Allaire et al., 2018) and indicate that the sheep populations were higher in 2011 than 2003. However, cloud cover obscured a large portion of the range during the 2018 survey making comparisons with previous surveys difficult.

Although the observations per hunter day increased in 2021 to six sheep per hunter day, we caution that this is a singular point and represents a season after Covid restrictions. Hunter observation data is subject to behavioural changes in both the hunters and the animals and given the lack of hunting in 2020, these values could be influenced by both eager hunters and less wary animals. In addition, this increase in sheep has not been reflected in either of the two survey areas in the Sahtú (Figure 5b). A LOESS (locally estimated scatterplot smoothing) regression was added to better visualize past and current trends by smoothing the data but should not be used to infer future populations as the tails are susceptible to variation.

Although there are many limitations to using data from observations per hunter day, the similarities in trends between established survey methods and observation data indicate that there is validity in using observation data to monitor long-term trends for sheep in the Mackenzie Mountains. These methods would have to be validated before being applied to new areas and species.

Composition

Between 1991 and 2021, we calculated an average of 54 lambs:100 ewes (range: 46-67) based upon hunter classifications of sheep observed during their hunts (Appendix D). This is very similar to the average of 61.8 (range: 23.1-88.9) lambs per 100 ewes at the Katherine Creek study area within S/OT/02 and 55.0 (range: 20.5-94.1) lambs:100 ewes Palmer Lake within S/OT/01 during 1997-2021 (ECC unpublished data) though notably the range is much smaller. This may be due to aggregate data from across the Mackenzie Mountains averaging out local variations in lamb:ewe ratios.

The estimated number of lambs per 100 ‘nursery sheep’, in the Richardson Mountains has ranged from 13-46 with 36 lambs:100 ‘nursery sheep’ in 2014 (Davison et al., 2018). Surveys in the YT report ratios of 10-40 lambs per 100 nursery sheep, though numbers can vary greatly both geographically and year to year (Environment Yukon, 2019). Due to the inclusion of young rams in these ‘nursery sheep’ recruitment in lambs:100 ewes would be higher.

Composition of sheep from hunter observations between 1991 and 2021 (Figure 6) show an average composition of 17.4% legal rams (range: 13.8-20.5%), 18.7% non-legal rams (range: 15.2-21.8%), 41.1% ewes (range: 44.9-37.9%), and 22.8% lambs (range: 19.9-26.1%). While all composition groups are relatively stable, recent years have shown an increase in the proportion of ewes and a reduction in the proportion of legal rams. It is also interesting to note that the proportion of legal rams (>¾ curl) to non-legal rams (<¾ curl) has historically been close to 1:1 indicating that recruitment equaled replacement. However, since 2013, the ratio of legal to non-legal rams has decreased suggesting that mortality in the higher age category is increasing compared to recruitment (see Appendix D).

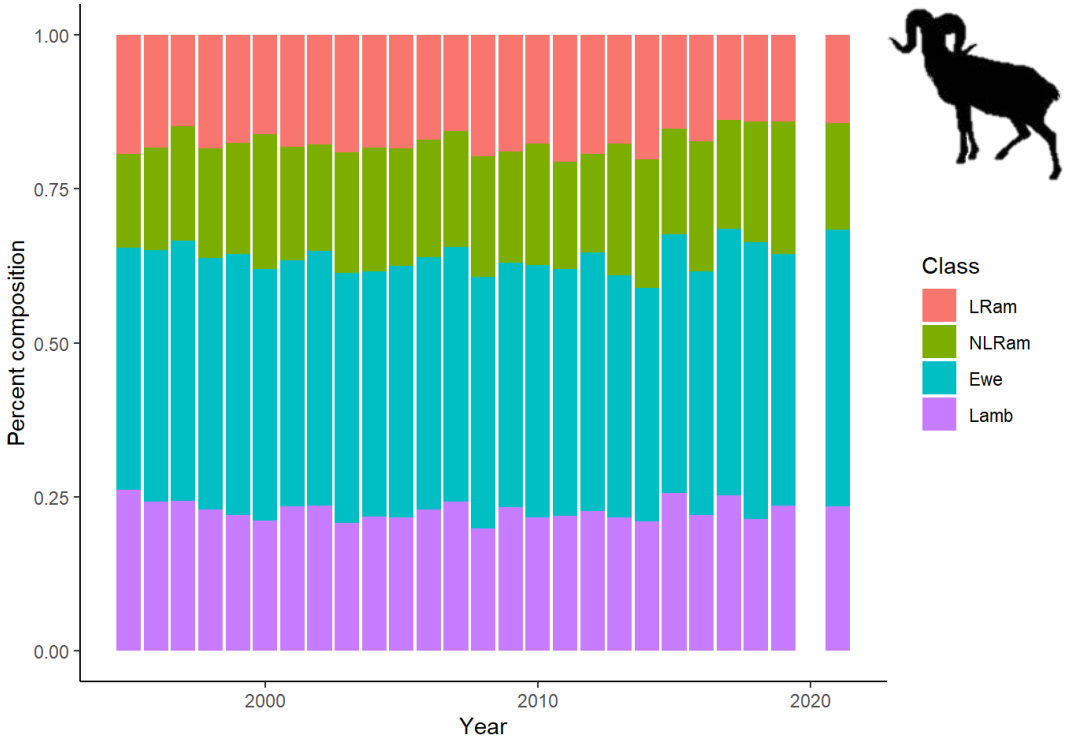


Figure 5. Percent composition of sheep calculated from observations submitted by non-resident and non-resident alien hunters throughout the Mackenzie Mountains from 1991-2021. Classifications for sheep requested on observation forms are legal rams (LRam; pink), non-legal ram (NLRam), ewe (Blue), and lamb (Purple).

Age of Harvest and Horn Measurements

The average (±SD) age of harvest for 2018, 2019, and 2021 was 9.96±1.62, 10.51±1.37, and 10.03±1.08 respectively (Figure 7a; Appendix E). The average age of harvest increased steadily from 1991-2012 before slowly declining in recent years. It is interesting to note that this decline continues even with the lack of an outfitter season in 2020. Examining the composition of harvested rams (Figure 8), the vast majority of rams harvested have been >8 years old with very few rams being <8 years of age.

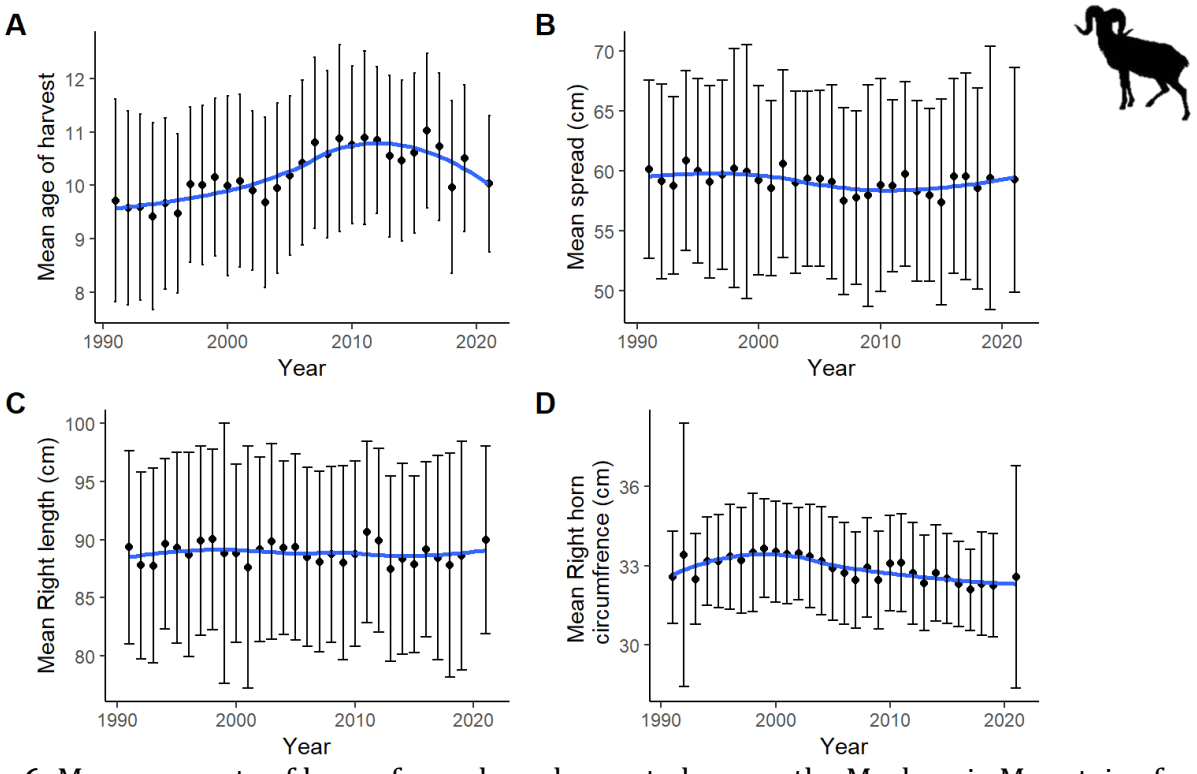


Figure 6. Measurements of horns from sheep harvested across the Mackenzie Mountains from 1991-2021.

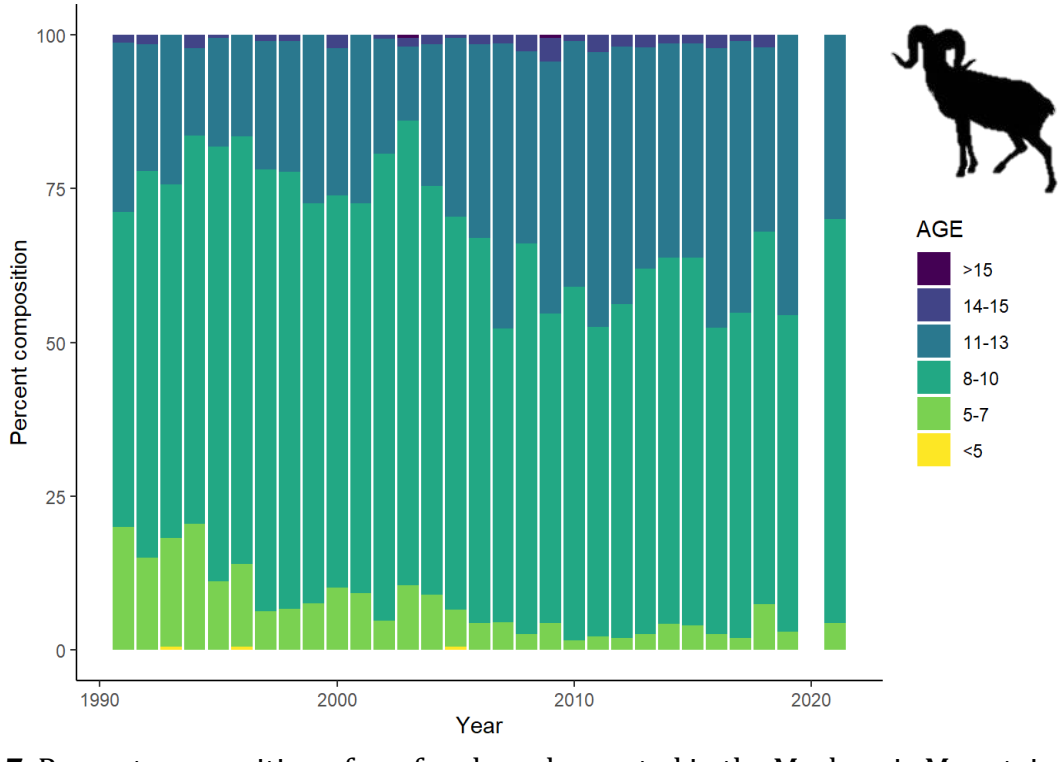


Figure 7. Percent composition of age for sheep harvested in the Mackenzie Mountains by non-resident and non-resident alien harvesters from 1991-2021.

The maximum left and right horn lengths reported between 2018 and 2021 were 108.0 and 109.5 cm respectively. The maximum horn length recorded by Boone and Crockett for Dall's sheep in North America is 115.6 cm (45.5 in.) for a sheep taken from the Mackenzie Mountains in 1973. One 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 32nd place (Boone and Crockett Club on-line trophy database accessed 2018).

The Safari Club International (SCI) offers another measuring system for trophy 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 (Larter & Allaire, 2017). Eleven 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 2018). Horns measured by ECC are considered green and are not the same as dry measurements used for official scoring measurements.

Given the increase in average age of harvested sheep, there has been remarkable consistency in the mean outside contour length of the right horns from rams harvested by non-residents (Figure 7c, see Appendix E for data from 1972-2021). More broomed or broken horn tips on older animals are expected since horn breakage generally occurs as a result of fights between rival males (Coltman et al., 2002; Martin et al., 2022). However, there is a small but noticeable decline in the average circumference at right horn base from 1999-2019 (Figure 7d). This decline only represents about 1 cm in difference but slow growing nature of horns and given the declines in observations during the same time period, this may reflect a physiological response to a stressor.

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 & Carey, 2000). Examining horn growth patterns over time can reveal years of high and low environmental productivity. Since 2002 ECC 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 2002-2017, 837 Dall's sheep horns were measured.

Preliminary results on measurements collected until 2015 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 YT. It is likely that climate plays a role in horn growth variation, and correlations in the YT have been found between horn growth periodicity and inter-decadal climate variability (Hik & Carey, 2000). An analysis of these growth patterns using the 2002-2017 dataset of measurements observed no significant trend in the average horn volume of harvested rams over this period (Karabatsos, 2020). Although Festa-Bianchet et al. (2014) implicated trophy hunting of bighorn sheep in a limited range in Alberta as a factor in their reduced horn size and increased age of harvest over time, horn measurements from the Mackenzie Mountains collected 2002-2017 do not show the decline in horn size associated with selective harvest seen in other jurisdictions (Karabatsos, 2020). Personal communication with Dr. Marco Festa-Bianchet (October 26, 2022) noted that high volumes of hunters and limited ranges in Alberta result in rams

being harvested as soon as they are legal and creates high selection pressures against faster growing rams. The relatively low level of harvest in the Mackenzie Mountains and high proportion of rams harvested at >8 years of age indicates that hunting related selection pressures are unlikely.

Health

In the late 1990s, the discovery that Dall's sheep were a new host of the lungworm *Parelaphostrongylus odocoilei*, resulted in dedicated work on that infection in Dall's sheep (Jenkins, 2005; Jenkins et al., 2007; Kutz et al., 2001).

The Dall sheep health monitoring program initiated in 2021 has collected a total of 49 swabs were collected from outfitters in the Mackenzie Mountains in 2021 and 2022. PCR testing for *Mycoplasma ovipneumoniae* returned negative results for all samples (ECC unpublished data). Blood strips have been processed and are currently awaiting laboratory analysis for additional pathogen screening.

Northern Mountain Caribou (*Rangifer tarandus*)

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 2003 and 2005 respectively (Government of Canada, 2019). The status of northern mountain caribou was assessed in 2020 by NWT species at risk (SARC, 2020) and listed as Special Concern in 2021 (Department of Justice, 2021). Prior to 2019, boreal and northern mountain caribou were managed under the same tag (woodland caribou) but are now regulated as boreal caribou for populations outside the Mackenize Mountains and northern mountain caribou for populations within Mackenzie Mountain (i.e., outfitter areas). This report will use "northern mountain caribou" when referring to caribou from the Mackenzie Mountains.

A study on the Redstone population of northern mountain caribou was initiated by the Sahtú Renewable Resources Board (SRRB) in March 2002 when ten female caribou in the central and north-central Mackenzie Mountains were equipped with satellite radio collars (Creighton, 2006; Larter & Allaire, 2017). 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 (SARC, 2020). Satellite collars were deployed on nine adult female caribou during March 2000 and October 2001 by the YT Department of the Environment (J. Adamczewski personal communication). These animals were believed to be part of the greater Nahanni population. As part of a cooperative study between YT Territorial Government, Parks Canada Agency and the Wildlife Conservation Society, 18 female caribou were equipped with satellite collars in October 2004 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 (Weaver 2006). In October 2008, 30 female caribou were equipped with satellite collars along the YT-NWT border 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).

Harvest

Northern mountain caribou are another highly desired species with 328, 342, and 250 tags purchased in 2018, 2019 and 2021 respectively (Table 2) representing between 76-83% of non-resident hunters purchasing caribou tags. Hunters harvested 162, 174 and 128, caribou in 2018, 2019 and 2021 respectively. These numbers are around the average annual harvest (163, 1991-2021) except for 2021 which had a shorter season and travel restrictions, however, the success rates of hunters purchasing tags have fallen to just over 50% (Table 3).

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 *ca.* 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, ECC unpublished data). Subsistence harvesters in the Mackenzie Mountains include residents of both the NWT and YT and harvest is generally not reported.

Observations and Population Trends

Populations of northern mountain caribou in the Mackenzie Mountains are not well studied. Within the Mackenzie Mountains in the NWT there are three main herds: Bonne Plume, Redstone, and Nahanni Complex (which may be comprised of the South Nahanni, Coal River, and Labiche herds). Of these, only a portion of the Nahanni Complex (the South Nahanni herd) has been estimated both recently (within 20 years) and with any degree of rigour (COSEWIC, 2014; SARC, 2020). The South Nahanni herd was last surveyed in 2009 and 2001 prior to that. The herd wasestimated at 2,100 (95% CI 1,591-3,029) and 1,432 (95% CI 970-2,935) respectively suggesting a possible increase (T. Hegel et al., 2016). A composition survey of the Coal River herd was also conducted in 2009 but not all animals were observed making it challenging to provide a defensible estimate of the herd's size (T. Hegel et al., 2016). The best working estimate based on expert opinion remains at 450 animals (T. Hegel et al., 2016). The best guess for the Bonne Plume and Redstone herd sizes are 5,000 and 10,000 individuals respectively, though there is limited basis for these estimates (Farnell et al., 1998; Larter, 2012b).

Observations from knowledge holders indicate that there has been a significant decline in the Redstone subpopulation over the last ten to 12 years (SARC, 2020). It is unknown whether this decline in observed caribou is a result of a change in population size or in population distribution. Looking at the observations per hunter day from outfitter clients (Figure 9), there is no noticeable trend in caribou seen per hunter day. A LOESS (locally estimated scatterplot smoothing) regression was added to better visualize past and current trends by smoothing the data and we reiterate that it should not be used to infer future populations as the tails are susceptible to variation. These observations are not limited to the Redstone herd range and declines specific to herds or geographic locations may not be detected with this data. Unlike Dall's sheep, there is no other data collected to validate the observations per hunter day.

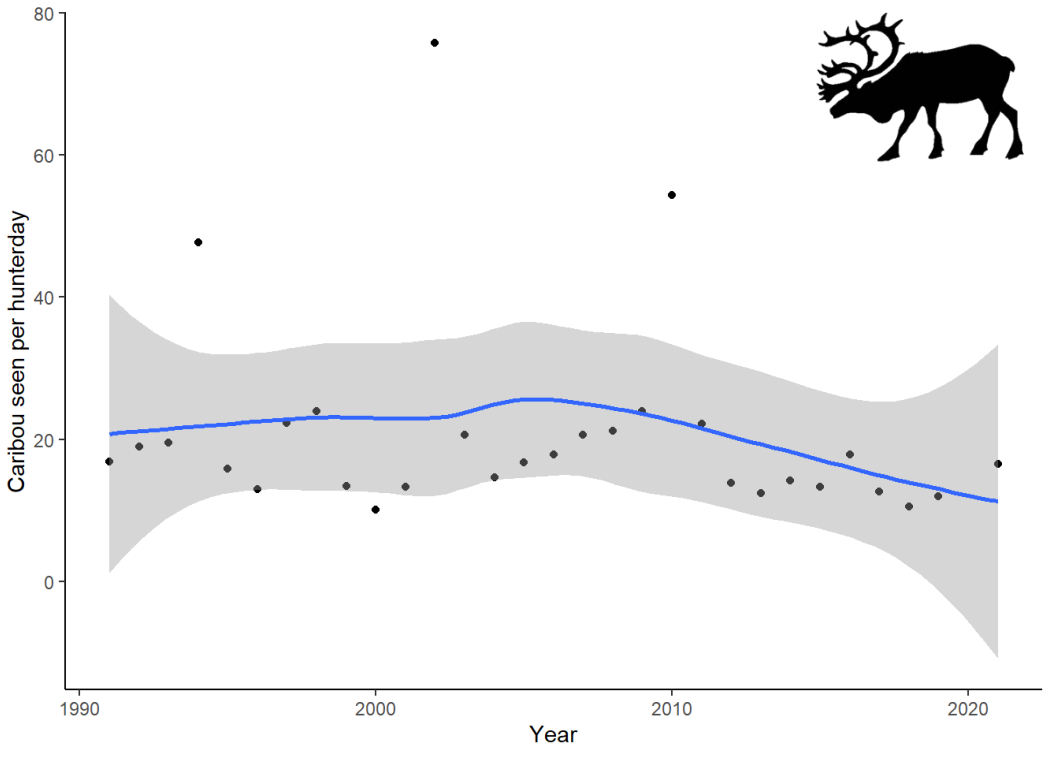


Figure 8. Total numbers of caribou seen per hunter day calculated from observations submitted by non-resident and non-resident alien hunters throughout the Mackenzie Mountains from 1991-2021.

Composition

Between 2018-2021 observed calf:cow ratios increased from 27-40 calves per 100 cows (adult females) and bull:cow ratios increased from 34-71 bulls (males) per 100 cows. These ratios were based upon hunter classifications of northern mountain caribou observed during hunts (See appendix D).

From 2018-2021 the percentage of bulls within all caribou classified rose from 19-33% (Appendix D). This is the highest recorded percentage of bulls from the outfitter observations as prior to 2021 the highest percentage of bulls was 27% in 2001. The bull:cow ratios for 2018 were below the average 37:100 (1991-2021; range 21-44:100; Appendix D) though increased to above average in 2019 and a record 71 bulls per 100 cows in 2021. This may indicate that the lack of harvest in 2020 resulted in much higher survival rates among bulls.

The average bull:cow ratio is lower than the average sex ratios of 45:100 reported in Yukon mountain caribou populations (T. M. Hegel & Russell, 2013), though this is consistent with studies in the Mackenzie Mountains that have reported percentages ranging from 20-33% (Gullickson & Manseau, 2000; T. Hegel et al., 2016; Veitch, Popko, et al., 2000). Studies conducted in the Mackenzie Mountains from 2007-2008 have reported slightly higher bull: cow ratios of 33.7-35.5 bulls per 100 adult cows(McLaren, 2016). Generally, even in populations with little to no predation, the percentage of males tends to be lower than females (Bergerud, 2000). There is little indication that low bull:cow ratios have an effect on productivity (T. M. Hegel & Russell, 2013; Yukon Department of Environment, 2016).

Although the estimated calf:cow ratio increased, it was well below the average 43:100 (1991-2021; range 25-67:100) in 2018 and 2019, though it did approach the average in 2021.

Age of Harvest and Measurements

Based upon a limited number of incisor teeth (n=84) turned in voluntarily since 1975, the range in age of harvested male caribou is two to 13 years (mean 6.3 years, median 6.0 years); with the majority from five to eight years (ECC unpublished data). Tooth ages are determined by counting the cementum annuli much like the growth rings of a tree: June 1 is used as the birthdate for caribou (Matson, 1981, www.matsonslab.com).

Although antler measurement information sometimes goes unreported on outfitter forms, we received antler lengths from 123 (76%), 102 (59%), and 99 (66%) successful hunters in 2018, 2019, and 2021 respectively. The maximum left and right antler lengths reported between 2018 and 2021 were 188 and 150 cm respectively. 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. As of 2018, thirteen 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 2018). Twenty-two 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 2018). Antlers measured by ECC are considered green and are not the same as dry measurements used for official scoring measurements.

Moose (*Alces alces*)

Harvest

Tags to hunt moose were purchased by 114 (28%), 134 (30%), and 106 (35%) non-resident hunters in 2018, 2019, and 2021 respectively and the proportion of hunters purchasing a tag is increasing (Table 2). Harvests between 2018 and 2021 ranged from 62-74 moose per year and success rates have remained relatively stable around 60% (Table 2). The average overall harvest rate appears stable in recent years (Table 3). It is noted that outfitting zone D/OT/01 is one of the largest, with an abundance of good moose habitat. From 1991-2004 the average harvest in D/OT/01 was <4 moose/year whereas after 2005 the average annual harvest has been about 20 moose/year.

Observations and Population Trends

Although moose populations along the entire Mackenzie Valley have been regularly surveyed in some areas while more opportunistically in other areas over the last 30 years, there have been no assessments of moose populations in the Mackenzie Mountains. Observations per hunter day have shown a steady increase since the early 2000s and risen from roughly 0.5 moose per hunter day to just under one moose per hunter day (Figure 10). A LOESS (locally estimated scatterplot smoothing) regression was added to better visualize past and current trends by smoothing the data and we reiterate that it should not be used to infer future populations as the tails are susceptible to variation. It is uncertain how much these trends reflect actual increases in moose numbers because, unlike Dall's sheep, there are no other data collected to validate the observations per hunter day.

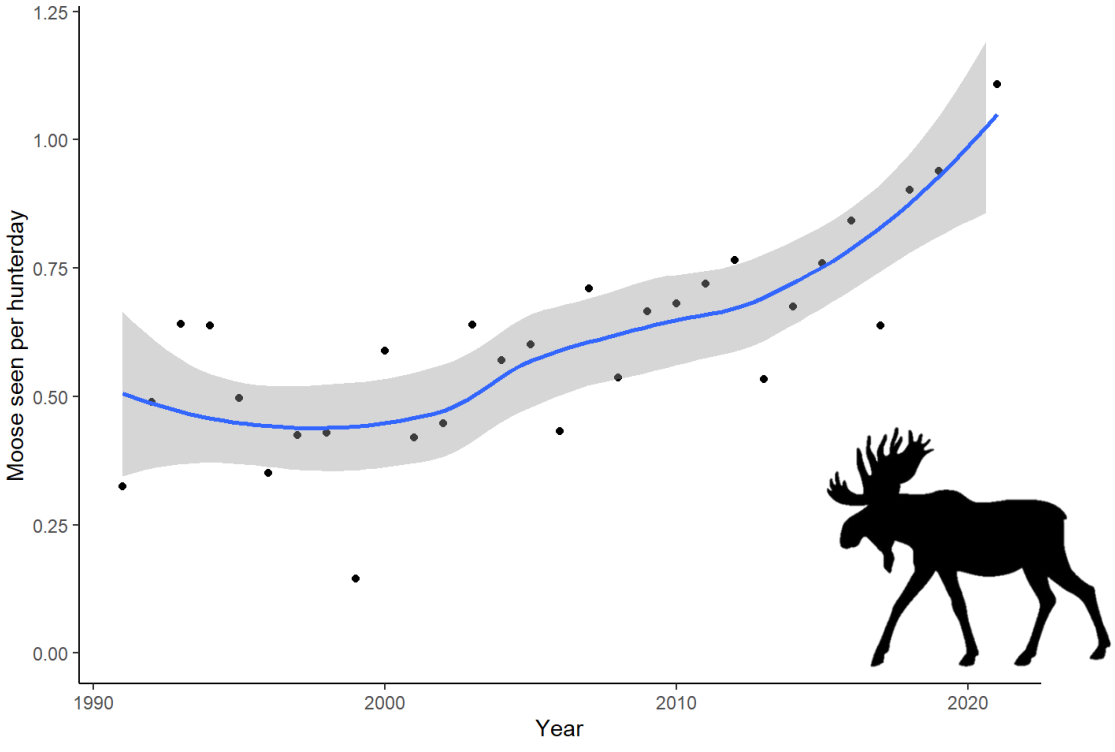


Figure 9. Total numbers of moose seen per hunter day calculated from observations submitted by non-resident and non-resident alien hunters throughout the Mackenzie Mountains from 1991-2021.

Composition

Between 1991 and 2021, calf:cow ratios from outfitter observations averaged around 30.3 calves per 100 cows (range: 21:100-40:100). This trend has largely been stable though in recent years it has seen a decline from 35:100 in 2015 to 25:100 in 2021 (Appendix D). 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, 1994), Norman Wells (Veitch et al., 1996) and Tulít'a (Swallow et al., 2003). However, these surveys were conducted after the major fall subsistence harvest and variable female harvest can impact the interpretation of calf:cow ratios. Moose calf numbers, based upon hunter observations, are generally lower in the Mackenzie Mountains than those reported in the Mackenzie Valley. 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 (ECC Norman Wells unpublished data). Aerial surveys of the Mackenzie River Valley and vicinity in the Dehcho region south from the Blackwater River to Jean Marie River conducted in Novembers 2003, 2011, and 2017 estimated calf:cow ratios of 32.5:100, 54.4:100, and 34.4:100 (Larter 2009, N. Larter and D. Allaire unpublished data). These studies indicate that low calf:cow ratios may not be restricted to the Mackenzie Mountains.

Bull:cow ratios are on average 100.6:100 bulls per 100 cows (range: 64:100-143:100). This is consistent with bull:cow ratios from surveys in the Sahtú region around the Mackenzie Valley (Environment and Climate Change, 2024) but are generally higher than the range of 27:100-117:100

reported in the YT (Environment Yukon, 2016), 26-69:100 reported in Norway (Solberg et al., 2002), and the 5:100-38:100 from populations in Alaska (Schwartz et al., 1992; Young & Boertje, 2008).

There has been concern that low bull:cow ratios could influence conception dates, pregnancy rates and newborn sex ratios (Crête et al., 1981; Solberg et al., 2002) and some management strategies recommend maintaining a bull:cow ratio above 30:100 (Environment Yukon, 2016; Ministry of Forests Lands and Natural Resource Operations, 2015; Young & Boertje, 2008). Evidence for the influence of bull: cow ratios on the calf recruitment remains mixed (Laurian et al., 2000; Solberg et al., 2002). There does not appear to be any noticeable relationship between bull:cow ratios of moose in the Mackenzie Mountains and reported calf:cow ratios reported and thus is unlikely to be a factor in the low reported calf:cow ratios. Although there is no restriction to harvest only bulls, there is a clear selection bias due to non-resident harvesters looking for trophy animals. Given the parity between bulls and cows, it is unlikely that the non-resident harvest has a noticeable effect on male survival and by extension the population.

Age and Harvest Measurements

Based upon a limited number of incisor teeth (n=139) turned in voluntarily since 2003, the age of harvested male moose ranges from three to 15 years (mean 7.7 years, median 7.0 years) with the majority being between five to nine years (ECC unpublished data). Tooth ages are determined by counting the cementum annuli much like the growth rings of a tree; June 1 is used as the birth date for moose (Matson 1981, www.matsonslab.com).

The mean tip-to-tip spread of measured antlers from bull moose harvested between 2018-2019 was similar to other years at 148-149 cm, though this average has been steadily increasing. 2018 had the widest spreads measured yet with a maximum recorded antler spread of 225 cm (67.7 in.). This was more than the record spread of 196.9 cm (77.5 in.) for a moose harvested in 1982. As of 2018, one moose taken from the Mackenzie Mountains held the 21st place in the record book of the 13th edition of the Boone and Crockett Club; another holds 27th place (Boone and Crockett Club on-line trophy database accessed 2018). Three of the top 50 Alaska-YT moose recorded in the SCI on-line record book are from the Mackenzie Mountains, with a moose harvested in 1996 holding the highest placement (44th; SCI on-line trophy database accessed 2018). A moose harvested during the 2010 season ranks second as a Pope and Young World Record moose with a score of 241 5/8. Antlers measured by ECC are considered green and are not the same as dry measurements used for official scoring measurements.

Health

A limited number of studies have investigated the levels of a range of naturally occurring elements (most notably cadmium, lead and mercury) and radionuclides in various issues of the different wildlife species (Larter et al., 2016, 2018; Larter & Kandola, 2010). Findings from these studies have resulted in consumption notices by the GNWT Department of Health and Social Services(Government of the Northwest Territories, 2017). The moose meat associated with the consumption notice continued to be a healthy food choice. Public health concern was centered on consumption of consistent consumption of liver and kidneys.

Mountain Goat (*Oreamnos americanus*)

Harvest

Annual mountain goat tag sales have ranged from six to 71 though average about 30 tags per year (Table 2). During 2005-2015 more hunting packages included a mountain goat hunt, with 10-16% of hunters purchasing licences also purchasing a mountain goat tag. Increased accessibility from use of rotary craft has had some effect on the increased number of goat hunters and harvest numbers during this period, though the success rates did not increase (Table 3). The dramatic decrease in goat tags purchased since 2015 was anticipated because a large proportion of mountain goat range falls within the expanded boundaries of NNPR and as of 2016 hunting was prohibited in these areas. It is anticipated that the reduction in the number of goat hunters and number of goat tags purchased will continue remain at low levels for the foreseeable future. The numbers of goats harvested in 2018, 2019, and 2021 were 1,5, and 3 respectively (Table 3).

Observations and Trends

Observations of mountain goats are low in the Mackenzie Mountains with the maximum number of observations reported being 393 (Appendix F). There are also many years with zero observations reported. As a result, calculating observations per hunter day is unlikely to result in any meaningful estimation of population trend.

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 hunter observations or harvest reports of goats have been received from only four of those outfitter zones - D/OT/01, D/OT/02, S/OT/03 and S/OT/04. Since 2017, observations came from just three zones, D/OT/01, D/OT/02 and S/OT/04); harvest occurred in all three zones. The average 63.6 kids and 66.5 billies per 100 nannies estimated from 2002-2021 (Appendix D). These ratios are derived from very few observations and even fewer and more restricted range since 2016 due to the expansion of NNPR.

The number of mountain goats in the Mackenzie Mountains was estimated between 768-989 though there is evidence that this could be an underestimate (Larter, 2012a). There is limited 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; Larter & Allaire, 2017). 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 (Larter & Allaire, 2017).

In a 2.5 hr. rotary-wing 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, 2012a). Although the previous report's authors indicate this as possible evidence for increasing goat numbers and distribution (Larter

& Allaire, 2017), differences in survey area, large time gaps between surveys, and the general paucity of observation of mountain goats from much of their NWT range preclude any definitive assessment of trend using currently available data. 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 precluding future surveys conducted by ECC.

Aging and Measurements

The average age of 4.5 years (range 1-10; median 4.0; N=17) determined from archived incisor teeth (1972 n=10 and 1975 n=7). Tooth ages are determined by counting the cementum annuli much like the growth rings of a tree; June 1 is used as the birth date for mountain goat (Matson, 1981; www.matsonslab.com).

Efforts have been made to age harvested goats starting in 2005 by counting horn annuli. The average age of 173 harvested goats (153 billies and 17 nannies) is 8.0 years (range 2.5-16.5; median 7.5). This is much older than the average age and range determined from a limited number of archived incisor teeth. However, this technique is reported to only be reliable up to seven years of age (Mainguy et al., 2009; Stevens & Houston, 1989) and thus many of these estimates may not be accurate. Most harvested goats are estimated with this technique to be between four to ten years old, which is mostly within the reliable window and more consistent with cementum aging results.

The longest horns from a mountain goat taken in the Mackenzie mountains were 25.5 cm (left) and 23.3 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 2018). Horns measured by ECC are considered green and are not the same as dry measurements used for official scoring measurements.

Wolf (*Canis lupus*)

Harvest

Percent of hunters that have purchased wolf tags have generally been around 70-80% since 2009 but saw a large increase to 91% in 2019. This is likely due to the removal of tag fees for wolves across the NWT in 2019 and proportion of hunters that obtained wolf tags remained high in 2021. The increase in tag holders has not increased the number of wolves harvested and resulted in a lower success rate due to the large increase of purchased tags. For a twelfth winter season, hunting for wolves occurred in area S/OT/01. With the change in ownership winter guided hunts were offered for the first time in area S/OT/05 during spring 2018. Records of the winter wolf harvest for 2018-2021 were not well documented due to a change in office where the reports are now produced.

Observations and Trends

Hunters typically report observing between 100-300 wolves; when adjusted for hunter days this generally equates to between 0.1-0.2 wolves seen per hunter day. There doesn't appear to be any trend, positive or negative, in observations per hunter day and though the number of wolves seen per hunter day has increased steadily since 2015, this increase isn't outside of the range of interannual variability. Beginning in 1999, hunter comments on voluntary observation forms report that wolf numbers were high. In subsequent years the number of hunters commenting about high wolf numbers increased.

However, the observation data does not indicate any notable increase in wolves observed. This method for estimating wolf population trends has not been validated. There has been no rigorous assessment of wolf populations in the Mackenzie Mountains.

Wolverine (*Gulo gulo*)

Harvest

In recent years typically between 30-40% of clients purchase a wolverine tag with approximately 150-200 tags being sold (Table 2). Even with the high number of tags sold, few clients actively pursue wolverines and fewer still are successful (Table 3). 2018 had the highest annual harvest of wolverines ever with 9 wolverines being harvested.

Observations

Wolverines occur throughout the Mackenzie Mountains, but sightings are considered rare. Most observations are of solitary animals with few family groups have been observed. Typically, there are fewer than 50 observations per year from the outfitters. With so few observations, observations per hunter day are unlikely to result in any meaningful inference of population trend. Although wolverine is not at risk under the NWT *Species At Risk Act*, wolverine numbers are believed to be declining in some parts of the NWT (SARC, 2014). Even with the limited data from the outfitter observations, there is no support for a trend, positive or negative, in wolverine numbers in the Mackenzie Mountains

Black Bear (*Ursus americanus*)

Between 2018 and 2021 only one black bear was harvested (Table 3). This is only the ninth black bear to be harvested in the past 27 years. Black bears are relatively rare in the Mackenzie Mountains, generally occurring south of 63°00'N.

No more than 52 observations of black bears per year from the outfitters have ever been recorded in the Mackenzie Mountains and the majority of these observations come from the Dehcho. With so few observations, observations per hunter day are unlikely to result in any meaningful inference of population trend.

Grizzly Bear (*Ursus arctos*)

Harvest

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 (Deuling, 2017; Larter & Allaire, 2017). 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. Hunters have 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 areas with high grizzly occurrence have been avoided.

From 1993 to 2017, 81 nuisance grizzly bears have been killed, the majority in the Sahtú (n=48), with 21 and 12 for the Gwich'in and Dehcho regions, respectively (ECC unpublished data). The Sahtú covers the largest area of the Mackenzie Mountains at *ca.* 68,000 km^2. Annual human caused mortality (harvest, conflict, illegal or other) of grizzly bears between 2001 and 2016 was estimated at 6.9 bears for the Sahtú, 1.7 for the Dehcho, and 5.9 for the Gwich'in Settlement Area (SARC, 2017). These estimates are not restricted to the outfitter zones and are likely higher than the actual totals in the Mackenzie Mountains.

Observations and Trends

From 1996-2013, the number of adult grizzly bears observed by hunters annually fluctuated around a mean of 258 (range 136-365) with no discernable trend over time. Similarly, the number of cubs observed annually fluctuated around a mean of 67 (range 36-111) with no noticeable trend over time. Since 2013 the average number of adult grizzlies observed per year has risen to 465 and cubs to 119. Standardizing per hunter day, we can see that there has been a clear increase in grizzly bears observed since 2013 (Figure 11) with current observations almost doubling the numbers seen prior to 2013. A LOESS (locally estimated scatterplot smoothing) regression was added to better visualize past and current trends by smoothing the data and we reiterate that it should not be used to infer future populations as the tails are susceptible to variation. It is unknown whether this increase in the number of observed bears is a result of actual increases in the population or if this is a behavioural change influencing encounter rates between clients and bears.

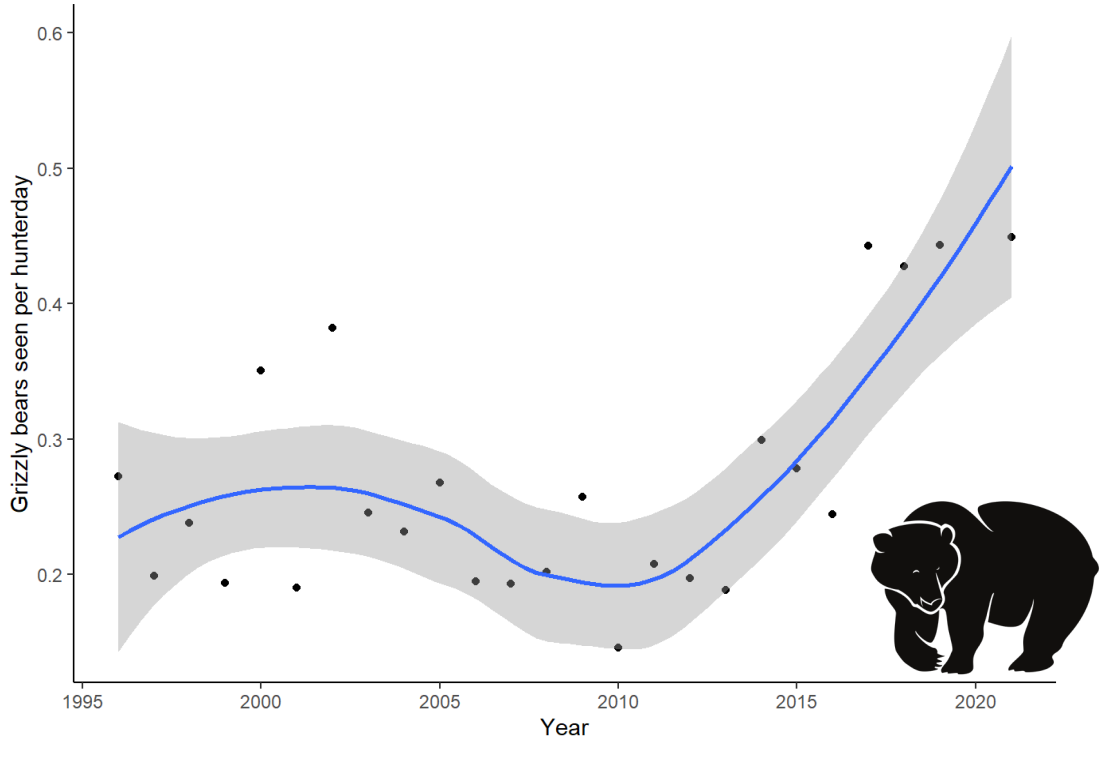


Figure 10. Total numbers of grizzly bears seen per hunter day calculated from observations submitted by non-resident and non-resident alien hunters throughout the Mackenzie Mountains from 1991-2021.

There have been attempts to estimate bear populations in the Mackenzie Mountains (Miller et al., 1982; SARC, 2017; Weaver, 2006), usually in small select study areas and with many intervening years between estimates; precluding any assessment of trend. In 2017 ENR conducted a pilot hair snagging

project in an area along the Canol Trail, in the southwestern Sahtú, which operated out of the ECC check station at Mile 222. From late June to late August 2017, 86 hair snagging stations were set up and monitored every two weeks over a 7,000 km^2 grid (Figure 12).

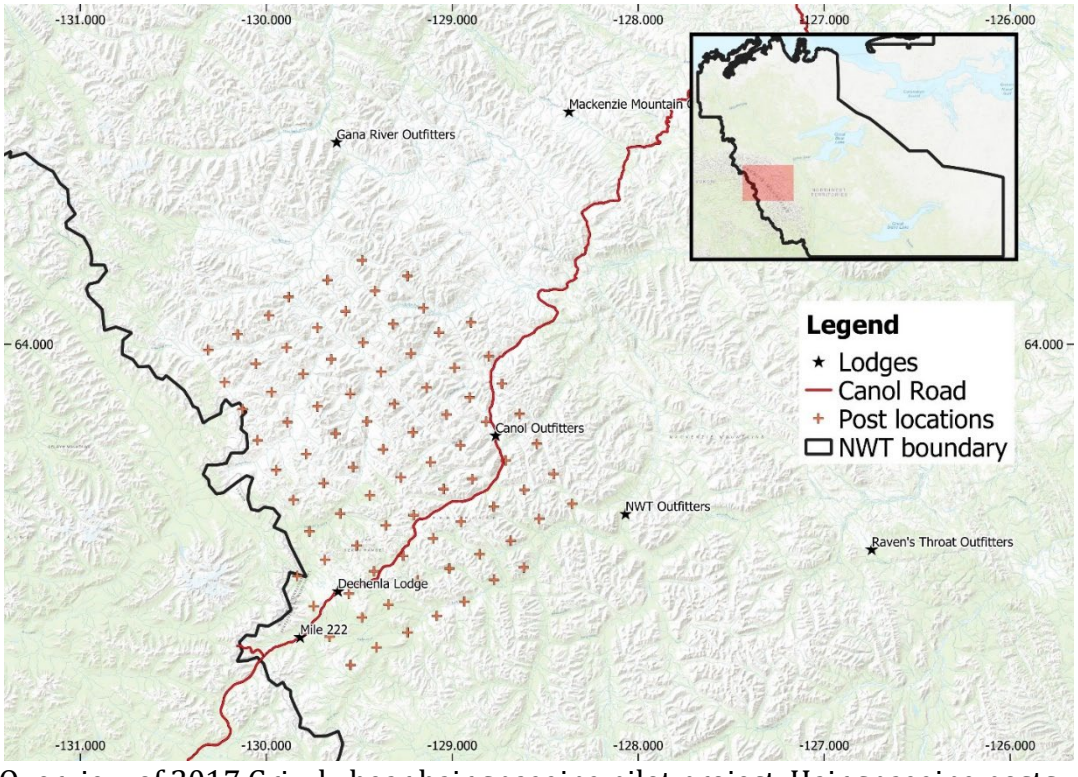


Figure 11. Overview of 2017 Grizzly bear hair snagging pilot project. Hair snagging posts were spaced 9 km apart over a 7,000 km^2 grid at the southwestern portion of the Canol Trail and monitored between mid-June to mid-August 2017.

The number of posts visited by grizzly bears ranged from 16-27 per session, an average 24% visitation rate. Bear hair samples (n=1,533) were submitted to Wildlife Genetics International for genetic analyses. Genotyping was carried out on up to eight samples per active post. There was a high (77%) success rate of DNA extraction, likely due to a short sampling interval and little rain. The DNA analysis identified 91 different individual grizzly bears (35 males and 56 females) at the posts and preliminary analysis of these data estimate between 92 and 154 bears in the study area (mean = 119) or a density of between 13-22 bears per 1,000 km^2 (K. Chan unpublished data) which is in the same range as densities found in Miller et al. (1982) and Weaver (2006).

There are currently no plans to extend the study to other areas or to revisit determine a population trend since 2017.

Composition

Because grizzly cubs 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 cub observations (Appendix D). The percent 'cubs' reported from 1996-2017 ranges from 12.4-29.0 (mean = 19.5) but in recent years have remained near average (See Appendix D). Miller et al. (1982) estimated that cubs and yearlings made up 14.3 and 10.4%, of the grizzly population respectively between 1973-1977.

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 1996-2021 voluntary hunter observation forms were used to estimate litter size from only those observations where cubs were present with a single adult bear, resulting in a mean litter size of 1.67 based on annual estimates (range 1.25-2.13). Comparisons of our results with Miller et al. (1982) should consider that we do not have a large sample size of observations annually (range = 5-37) and observations are from zones across the Mackenzie Mountains and not a focused study area. Non-resident hunting ceased in the Mackenzie Mountains in 1982, and although resident hunting still occurs, it is extremely limited.

The average age of bears in the Mackenzie Mountains is not known, though the oldest bear from a small number of defence kills in the southern Mackenzie Mountains has been documented at 22 years (SARC, 2017).

Conflict

Larter & Allaire (2017) reported that 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 (Larter & Allaire, 2017). 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 in the Mackenzie Mountains (Larter & Allaire, 2017). Unfortunately, in 2014 a hunter was fatally injured in a grizzly bear attack while butchering a moose with a guide (the first documented hunter fatality in the Mackenzie Mountains), and in 2016 there was a second mauling under similar circumstances in the same area (S/OT/02). The hunter was seriously injured but survived. No bears during the hair snagging pilot or ones that have been dispatched as a result of defence of life or property have been forensically matched to the bears involved in the two human incidents.

SUMMARY

Across game species, harvest in 2018 and 2019 did not vary substantially from the previous five years. However, the lack of travel prohibited an outfitting season in 2020 and 2021 saw a small reduction in harvest as travel restrictions relaxed after the hunting season began. 2021 was also the first year on record where the majority of outfitter clients were non-resident Canadians due to tighter restrictions on international travel.

Although we explored the use of hunter observations to understand trends and demographics with harvested big game species in the Mackenzie Mountains, lack of systematic monitoring for northern mountain caribou (*Rangifer tarandus*), moose (*Alces alces*), wolf (*Canis lupus*) and grizzly bear (*Ursus arctos*) precluded us from validating this data as a monitoring tool. Mountain goat (*Oreamnos americanus*), wolverine (*Gulo gulo*), and black bear (*Ursus americanus*) generally do not have enough observations per year to assess populations using these methods. However, even though these data remain unvalidated for many species, it has been demonstrated that these data can provide valuable insight, especially collected over time long periods of time, into trends and demographics of populations that are costly to monitor and difficult to access.

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 can be completed in a timely fashion. Your continued commitment to collecting and providing a variety of biological samples and wildlife behaviour observations is greatly appreciated.

We thank Renewable Resources Officers and clerks with the Department of Environment and Climate Change in Norman Wells, Fort Simpson, and Fort Liard for collecting and organizing data from non-resident hunters in their respective offices. Special thanks go to Mia Smith and Michael Gast for gathering and entering the data. 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.

Suzanne Carrière provided unpublished data and analyses of northern mountain caribou NWT resident harvest. Matson's Laboratory aged all moose, mountain caribou and mountain goat teeth. Dr. Naima Jutha arranged for all wildlife health kits to be sent out for analysis.

PERSONAL COMMUNICATIONS

Jan Adamczewski. Wildlife Biologist (Ungulates), Environment and Climate Change. Yellowknife, NT.

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APPENDIX A. OUTFITTERS LICENCED TO PROVIDE SERVICES TO NON-RESIDENT HUNTERS IN THE MACKENZIE MOUNTAINS, NWT–2021

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

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 V1G4G3
P: (250)786-5118
F: (250)786-5404
E: mmostanstevens@gmail.com
Website: www.mmo-stanstevens.com

S/0T/03 –CANOL OUTFITTERS
Glenda Groat
PO Box 59
Norman Wells, NT, X0E 0V0
P: (867)444-4868
E: canoloutfitters@gmail.com
Website: www.canoloutfitters.ca

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 –RAVEN'S THROAT OUTFITTERS
Griz and Ginger Turner
P.O. Box 58
Whitehorse, YT Y1A 5X9
P: (867)332-7286
E: hunts@ravensthroat.com
Website: www.ravensthroat.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

APPENDIX B: SUMMARY OF OUTFITTER RETURN AND OBSERVATION FORM RETURNS BY OUTFITTER FROM 2015-2021

Table C1. Number of outfitter return on client hunter success forms returned for each outfitter from 2015 to present.

Year	Arctic Red	Canol	Gana River	Mackenzie Mountains	Nahanni Butte	NWT	Ramhead	Ravens Throat	Redstone	South Nahanni
2015	70	0	53	61	80	26	35	0	52	61
2016	65	0	58	73	18	41	38	0	44	50
2017	71	29	62	75	17	51	0	46	0	39
2018	46	0	50	65	20	54	0	38	0	42
2019	56	37	61	71	18	66	0	43	0	48
2021	45	30	27	55	10	36	0	28	0	24

Table C2. Number of voluntary hunter observation forms returned for each outfitter from 2015 to present.

Year	Arctic Red	Canol	Gana River	Mackenzie Mountains	Nahanni Butte	NWT	Ramhead	Ravens Throat	Redstone	South Nahanni
2015	22	0	34	33	73	25	3	0	51	57
2016	9	0	35	38	13	38	7	0	33	46
2017	20	0	41	50	16	46	0	24	0	36
2018	42	0	33	25	18	49	0	40	0	38
2019	10	2	44	37	17	57	0	38	0	40
2021	18	0	20	34	10	33	0	28	0	22

APPENDIX C: MEAN HUNT LENGTH AND STANDARD DEVIATION FOR EACH SPECIES WHERE AT LEAST ONE DAY WAS SPENT HUNTING

Year	Sheep		Caribou		Moose		Mountain Goat		Wolf		Wolverine		Black bear	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1991	4.86	2.91	3.46	2.50	3.87	2.17	-	-	-	-	-	-	-	-
1992	5.26	2.86	3.72	2.64	-	-	-	-	-	-	-	-	-	-
1993	5.61	3.41	3.83	2.54	3.91	2.35	-	-	-	-	-	-	-	-
1994	4.47	2.76	3.48	2.63	4.24	2.75	-	-	-	-	-	-	-	-
1995	5.06	2.93	4.51	3.38	4.39	2.63	4.50	2.35	7.70	4.68	8.44	4.81	-	-
1996	4.97	2.99	4.33	3.06	4.28	2.73	2.20	0.84	6.14	3.69	6.58	3.89	-	-
1997	4.32	2.59	4.13	3.04	4.29	2.92	3.20	2.59	5.91	3.20	7.00	3.17	6.60	0.89
1998	4.40	2.77	4.03	2.92	4.03	2.79	2.56	2.07	6.20	3.37	7.26	3.20	-	-
1999	4.70	3.07	4.46	3.32	4.11	3.02	3.00	-	6.54	4.61	7.53	4.02	-	-
2000	4.64	2.74	3.98	2.67	4.38	2.70	3.00	-	5.91	3.49	7.06	3.38	-	-
2001	4.82	3.03	4.28	3.16	3.74	2.89	1.50	0.71	6.77	3.11	7.21	3.16	-	-
2002	4.66	2.72	3.59	2.63	3.61	2.50	2.75	1.71	4.72	3.43	5.86	3.51	-	-
2003	4.15	2.80	3.81	2.72	3.85	2.75	3.00	2.61	5.87	3.38	5.69	2.96	-	-
2004	4.32	3.44	4.86	3.78	4.76	3.05	3.88	1.55	6.09	4.47	6.41	5.21	5.00	-
2005	4.49	2.84	4.73	3.64	4.36	3.09	4.06	3.35	6.00	3.52	6.05	3.01	-	-
2006	4.07	2.64	4.29	3.00	3.58	2.54	2.83	1.34	5.06	3.33	5.23	3.21	-	-
2007	4.25	2.67	4.04	3.12	3.98	2.37	2.74	1.68	5.03	3.33	5.91	3.27	-	-
2008	4.13	2.91	3.34	2.48	3.63	2.92	3.05	1.83	4.30	3.19	3.83	1.75	2.00	-
2009	4.08	2.57	3.96	2.83	4.15	3.41	2.50	2.04	5.49	3.00	6.03	2.88	2.00	1.41
2010	4.45	2.78	3.92	3.12	4.45	3.99	3.15	1.77	5.47	3.13	6.66	3.28	1.00	-
2011	4.03	2.78	3.50	2.48	4.10	2.80	2.25	1.21	3.85	3.16	5.12	3.76	1.00	-
2012	3.89	2.60	3.64	2.63	4.15	3.02	2.76	1.68	4.73	2.78	5.12	2.59	-	-
2013	4.03	2.97	3.49	2.71	4.09	3.08	2.31	1.32	3.96	2.58	4.23	2.84	-	-
2014	3.89	2.99	3.65	2.64	4.24	2.94	1.93	1.83	4.03	2.88	5.04	3.75	-	-

Year	Sheep		Caribou		Moose		Mountain Goat		Wolf		Wolverine		Black bear	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2015	4.16	3.04	3.67	3.09	3.49	2.57	2.68	2.24	3.79	2.34	4.21	2.56	3.00	2.83
2016	4.12	2.77	3.69	3.24	4.14	3.04	2.50	2.27	5.17	3.77	4.74	4.54	-	-
2017	4.67	3.31	3.88	2.95	3.82	3.43	2.57	1.72	4.82	3.40	6.67	6.03	3.00	-
2018	4.29	2.88	3.41	2.77	3.65	2.29	2.00	-	4.32	2.72	4.25	2.65	-	-
2019	4.06	2.91	3.51	2.90	3.36	2.26	2.40	1.95	2.47	2.09	8.00	-	1.00	-
2021	4.17	2.78	3.26	2.81	3.63	2.51	3.00	2.83	5.50	3.99	11.00	1.41	-	-

APPENDIX D. SUMMARY OF AGE AND SEX RATIOS CALCULATED FROM NON-RESIDENT HUNTER OBSERVATION REPORTS IN THE MACKENZIE MOUNTAINS, 1991-2021

Year	Sheep			Caribou			Moose		Mountain Goat		Grizzly Bear
	Lambs: 100 Ewes	Rams: 100 Ewes	Non-legal: 100 Legal Rams	Calves: 100 cows	Bulls: 100 Cows	% Bull	Calves: 100 cows	Bulls: 100 Cows	Kids: 100 Nannies	Billies: 100 Nannies	% Cub
1991	50	87	-	39	51	27	23	80	-	-	0
1992	49	65	-	41	36	20	28	64	-	-	-
1993	50	77	-	46	52	26	40	73	-	-	-
1994	56	86	-	58	23	13	35	85	-	-	-
1995	67	82	126	42	43	23	39	102	-	-	-
1996	57	84	101	43	39	21	25	76	-	-	21
1997	59	64	57	36	25	15	29	104	-	-	22
1998	57	80	95	36	34	20	28	96	-	-	16
1999	59	82	86	45	22	13	25	143	-	-	21
2000	46	85	77	41	38	21	29	94	-	-	29
2001	59	84	98	57	59	27	29	111	-	-	21
2002	58	84	97	61	30	9	28	98	-	-	16
2003	50	83	101	39	34	16	26	138	62	69	13
2004	53	90	92	42	38	15	31	103	51	46	16
2005	52	97	95	42	40	15	33	110	66	50	23
2006	54	97	86	43	34	13	34	139	65	59	25
2007	64	80	83	53	36	13	36	101	71	58	16
2008	49	95	90	41	38	15	30	113	-	-	24
2009	54	94	97	46	38	16	31	88	65	59	25
2010	47	79	90	45	41	14	36	96	78	46	23
2011	54	89	110	44	32	13	33	122	64	59	22
2012	57	85	112	42	43	19	31	86	52	72	21
2013	55	91	81	37	43	19	30	102	70	75	19
2014	55	92	93	36	38	16	31	99	68	58	20

Year	Sheep			Caribou			Moose		Mountain Goat		Grizzly Bear
	Lambs: 100 Ewes	Rams: 100 Ewes	Non-legal: 100 Legal Rams	Calves: 100 cows	Bulls: 100 Cows	% Bull	Calves: 100 cows	Bulls: 100 Cows	Kids: 100 Nannies	Billies: 100 Nannies	% Cub
2015	61	70	82	44	45	18	34	91	64	96	16
2016	53	84	79	35	38	18	32	103	68	85	21
2017	58	67	67	36	41	23	30	95	58	36	19
2018	50	87	65	27	34	19	21	115	55	20	21
2019	56	76	67	38	46	25	27	89	56	77	22
2021	45	74	71	40	71	33	25	103	67	133	19

APPENDIX E: SHEEP HORN MEASUREMENTS 1991-2021

Year	Age of harvest		Left horn Length		Right Horn Length		Left Horn Circumference at base		Right Horn Circumference at base	
	Mean (cm)	SD (cm)	Mean (cm)	SD (cm)	Mean (cm)	SD (cm)	Mean (cm)	SD (cm)	Mean (cm)	SD (cm)
1991	9.72	1.90	88.77	8.78	89.33	8.29	32.52	1.69	32.57	1.75
1992	9.58	1.82	88.17	7.69	87.78	8.05	33.39	5.06	33.42	4.98
1993	9.59	1.74	88.29	8.05	87.75	8.39	32.58	1.72	32.50	1.71
1994	9.42	1.75	90.80	7.70	89.64	7.33	33.28	1.72	33.19	1.67
1995	9.66	1.61	89.56	8.07	89.27	8.22	33.15	1.76	33.17	1.77
1996	9.47	1.49	89.46	8.96	88.70	8.78	33.45	2.03	33.34	1.98
1997	10.01	1.45	90.29	8.65	89.88	8.16	33.27	1.93	33.20	2.00
1998	10.01	1.49	90.40	7.72	90.01	7.77	33.43	2.14	33.51	2.24
1999	10.15	1.47	89.62	8.82	88.79	11.21	33.47	1.88	33.66	1.87
2000	9.99	1.68	89.45	7.16	88.81	7.70	33.47	1.86	33.54	1.91
2001	10.08	1.62	88.88	8.37	87.59	10.42	33.47	1.91	33.46	1.90
2002	9.90	1.49	89.39	7.70	89.14	7.96	33.58	1.77	33.47	1.75
2003	9.68	1.59	89.91	8.73	89.82	8.43	33.37	1.94	33.37	1.95
2004	9.95	1.60	89.54	7.69	89.30	7.46	33.17	2.10	33.18	2.04
2005	10.19	1.49	89.59	7.64	89.38	8.01	32.90	1.92	32.90	1.95
2006	10.43	1.55	89.19	7.62	88.50	7.69	32.68	1.84	32.73	1.93
2007	10.80	1.60	87.47	8.49	88.09	7.80	32.46	1.69	32.46	1.82
2008	10.58	1.56	88.64	8.23	88.71	7.59	33.02	1.93	32.93	1.88
2009	10.88	1.75	88.24	8.16	88.00	8.32	32.38	1.91	32.46	1.85
2010	10.76	1.48	89.26	7.32	88.77	8.00	33.12	1.76	33.10	1.81
2011	10.89	1.62	91.08	7.86	90.65	7.80	33.09	1.87	33.12	1.85
2012	10.85	1.37	90.57	7.81	89.92	7.89	32.61	1.92	32.72	1.93
2013	10.55	1.51	87.23	8.40	87.47	7.97	32.36	1.81	32.35	1.80
2014	10.47	1.51	88.38	8.17	88.34	8.20	32.66	1.89	32.73	1.83
2015	10.61	1.50	87.69	8.08	87.85	7.59	32.63	1.63	32.52	1.69
2016	11.02	1.45	88.43	6.92	89.17	7.55	32.31	1.66	32.31	1.60
2017	10.72	1.37	89.88	7.62	88.42	8.78	32.18	1.63	32.10	1.53
2018	9.97	1.62	87.57	11.19	87.80	9.62	32.30	2.21	32.32	1.96
2019	10.51	1.37	87.89	11.11	88.62	9.84	32.21	2.21	32.26	1.96
2021	10.03	1.28	89.46	7.45	89.95	8.09	32.52	4.16	32.58	4.22

APPENDIX F: RAW OBSERVATION NUMBERS

Table F1. Raw observations of Dall's Sheep, caribou and moose by year.

Year	Legal ram	Non-legal ram	Rams	Ewe	Lamb	Sheep Total	Caribou Bull	Caribou Cow	Caribou Calf	Caribou Total	Moose Bull	Moose Cow	Moose Calf	Moose Total
1991	0	0	2,665	3,060	1,531	7,256	3,893	7,593	2,985	14,471	164	205	47	384
1992	0	0	3,008	4,655	2,293	9,956	2,753	7,744	3,207	13,704	88	138	39	258
1993	0	0	2,943	3,809	1,909	8,661	5,516	10,685	4,919	21,120	276	380	153	794
1994	0	0	3,180	3,699	2,066	8,945	4,767	21,014	12,233	38,014	277	326	113	695
1995	2,063	1,637	3,700	4,497	3,018	11,215	5,141	12,067	5,084	22,292	377	369	144	792
1996	1,468	1,451	2,919	3,489	1,990	8,558	4,874	12,608	5,364	22,846	277	366	93	548
1997	892	1,554	2,446	3,822	2,257	8,772	3,947	16,005	5,819	26,471	291	280	82	651
1998	1,485	1,563	3,048	3,795	2,180	9,023	4,794	14,110	5,084	23,988	318	332	92	653
1999	1,212	1,403	2,615	3,202	1,902	7,724	2,004	9,149	4,082	15,235	93	65	16	131
2000	1,140	1,487	2,627	3,084	1,426	7,137	2,354	6,230	2,556	11,140	317	337	97	664
2001	1,609	1,649	3,258	3,884	2,289	9,431	4,024	6,821	3,870	14,945	254	228	66	521
2002	1,600	1,654	3,265	3,875	2,256	9,473	4,182	13,873	8,394	47,230	262	267	76	605
2003	1,495	1,475	2,970	3,594	1,786	8,350	3,434	10,150	3,940	21,875	376	273	70	719
2004	2,062	2,234	4,296	4,752	2,538	11,586	3,476	9,062	3,820	22,960	453	438	137	1,028
2005	1,722	1,810	3,532	3,628	1,877	9,037	3,976	9,937	4,218	26,544	492	446	148	1,086
2006	1,647	1,926	3,573	3,693	1,991	9,257	3,446	10,069	4,339	26,352	333	240	82	655
2007	1,871	2,251	4,177	5,190	3,333	12,700	4,380	12,057	6,347	34,768	432	426	152	1,010
2008	1,506	1,681	3,266	3,422	1,683	8,371	3,256	8,638	3,499	21,896	413	367	110	890
2009	1,023	1,056	2,079	2,203	1,196	5,478	3,938	10,488	4,799	25,125	364	414	127	905
2010	1,024	1,144	2,168	2,731	1,280	6,179	4,700	11,549	5,179	32,575	398	415	149	962
2011	1,189	1,084	2,273	2,546	1,384	6,203	3,787	11,892	5,275	28,691	447	367	120	934
2012	1,098	977	2,075	2,451	1,404	5,930	3,931	9,073	3,810	20,457	406	474	149	1,029
2013	987	1,212	2,199	2,407	1,317	5,923	3,306	7,606	2,804	17,055	329	321	96	746
2014	1,330	1,430	2,760	2,994	1,649	7,403	4,001	10,429	3,792	24,755	459	464	145	1,068
2015	1,291	1,570	2,861	4,064	2,472	9,397	3,585	7,883	3,457	19,642	457	501	169	1,127
2016	1,119	1,421	2,515	2,990	1,598	7,105	3,882	10,115	3,540	21,738	513	498	157	1,157
2017	1,152	1,719	2,871	4,263	2,468	9,602	4,632	11,338	4,089	20,059	393	415	126	934
2018	874	1,355	2,737	3,148	1,570	7,468	3,093	9,057	2,457	15,989	619	540	115	1,201

Year	Legal ram	Non-legal ram	Rams	Ewe	Lamb	Sheep Total	Caribou Bull	Caribou Cow	Caribou Calf	Caribou Total	Moose Bull	Moose Cow	Moose Calf	Moose Total
2019	1,037	1,546	2,583	3,391	1,915	7,889	4,349	9,521	3,600	17,470	621	695	191	1,507
2021	974	1,371	2,672	3,599	1,621	7,892	6,421	9,050	3,585	19,741	563	548	138	1,230

F2. Raw observations of mountain goat, wolves, wolverine, black bear and grizzly bear. Cumulative hunter days for each year are included.

Year	Mountain Goat Billy	Mountain Goat Nanny	Mountain Goat Kid	Mountain Goat	Wolves	Wolverine	Black bear	Grizzly Bear Adult	Grizzly Bear Cub	Grizzly bear Total	Hunter days
1991	0	0	0	0	9	2	0	0	0	154	1,187.5
1992	0	0	0	0	2	0	0	0	0	0	1,240
1993	0	0	0	0	0	0	0	0	0	0	1,509
1994	0	0	0	0	0	0	0	0	0	0	1,292
1995	0	0	0	31	269	21	0	0	0	0	1,683
1996	0	0	0	17	161	26	10	319	85	404	1,804
1997	0	0	0	0	154	33	2	237	66	303	1,552
1998	0	0	0	0	114	32	9	296	58	354	1,374
1999	0	0	0	9	76	17	6	136	36	172	1,037
2000	0	0	0	9	213	11	17	266	111	377	1,164
2001	0	0	0	28	181	10	6	201	53	254	1,431
2002	0	0	0	0	253	10	21	365	68	433	1,474
2003	54	78	48	181	194	9	35	253	38	291	1,403
2004	18	39	20	79	304	28	23	305	59	364	1,797
2005	71	141	93	306	229	25	25	356	106	462	2,059
2006	57	97	63	238	186	25	27	237	78	315	1,845
2007	94	163	116	393	255	10	38	277	53	330	1,929
2008	0	0	0	0	263	17	52	280	90	370	1,821
2009	85	144	93	322	175	16	14	264	88	352	1,405
2010	49	106	83	239	139	24	29	173	51	224	1,430
2011	63	106	68	243	159	20	28	211	58	269	1,516
2012	82	114	59	257	224	18	33	223	60	283	1,502
2013	42	56	39	144	140	13	30	237	54	286	1,615
2014	69	118	80	277	242	28	32	457	114	571	1,879
2015	67	70	45	186	136	20	15	446	85	531	1,960

Year	Mountain Goat Billy	Mountain Goat Nanny	Mountain Goat Kid	Mountain Goat	Wolves	Wolverine	Black bear	Grizzly Bear Adult	Grizzly Bear Cub	Grizzly bear Total	Hunter days
2016	29	34	23	90	196	21	21	280	74	354	1,621
2017	27	74	43	149	243	33	22	572	132	704	1,810
2018	4	20	11	35	341	53	38	504	161	783	1,607
2019	33	43	24	100	283	18	30	598	168	763	1,658.5
2021	16	12	8	0	211	23	41	401	99	523	1,233