Northwest Territories boreal caribou population and harvest models

2020

Modèles de population et de chasse relatifs au caribou boréal des Territoires du Nord-Ouest

Government of Northwest Territories
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SOMMAIRE

Le caribou boréal est classé comme espèce menacée en vertu de la *Loi sur les espèces en péril* du Canada et de la *Loi sur les espèces en péril* (Territoires du Nord-Ouest). Aux Territoires du Nord-Ouest (TNO), la population de caribou boréal est répartie sur une superficie d'environ 441 000 km^2. Le caribou boréal est très respecté et valorisé par les chasseurs autochtones des TNO et est également apprécié et chassé pour une utilisation de subsistance par les chasseurs résidents autorisés. Dans le programme de rétablissement du caribou boréal (*Rangifer tarandus caribou*) des Territoires du Nord-Ouest, il est reconnu que l'exploitation du caribou boréal est souhaitable et que celle-ci doit être gérée de façon durable. Le ministère de l'Environnement et des Ressources naturelles des Territoires du Nord-Ouest (MERN du GTNO) surveille actuellement les taux de survie du caribou boréal, les taux de recrutement de faons et les taux de prises des chasseurs résidents. Ils n'ont pas d'estimations précises de la taille de la population actuelle, pas plus qu'il n'y a d'estimations exactes de la récolte des chausseurs autochtones.

Le présent rapport fournit les détails de la construction et de l'application d'un ensemble de modèles de population et de chasse relatifs au caribou boréal dans deux zones de gestion de la faune et six autres zones d'intérêt aux TNO. L'objectif de la modélisation est de fournir une perspective sur les relations probables entre les taux de récolte des chasseurs et les taux de croissance de la population de caribou des TNO. Les taux vitaux de base dont dépendent les modèles sont dérivés des études sur le terrain récentes menées par le MERN du GTNO) dans chacune des zones géographiques d'intérêt. Les modèles de population ont permis de déterminer des limites sur les taux de chasse qui augmenteraient la probabilité que les populations de caribou de chaque région soient en mesure de se maintenir ou de croître au fil du temps.

L'absence d'estimations précises de la population et de totaux exacts des caribous chassés actuellement signifie qu'il n'est pas possible de déterminer de façon absolue les taux de récolte durables. Le MERN du GTNO a mis en place un programme de surveillance solide pour mesurer les taux annuels de survie des femelles adultes et de recrutement de faons. Les données de surveillance indiquent que sans l'exploitation humaine, le caribou boréal des TNO serait stable (Lambda [λ] = 1,00) ou aurait la capacité d'avoir de petits niveaux de croissance annuelle de la population (λ > 1,00) dans les sites d'intérêt et les zones de gestion de la faune étudiés. Les régions méridionales de l'aire de répartition du caribou boréal (Sud du Dehcho, basses terres de Hay River, Pine Point / lac Buffalo) ne semblent pas favorables à la survie face à l'exploitation humaine, tandis que les régions boréales (Nord du Dehcho, Slave Nord [route toutes saisons des Tlicho], Mackenzie) ne peuvent soutenir qu'une exploitation limitée. La capacité de résister à l'exploitation humaine dépend de la taille, de l'emplacement et du rapport entre les sexes parmi les individus récoltés.

Les programmes de surveillance actuels (c.-à-d. les évaluations des récoltes des résidents autorisés, les études de radiotélémétrie sur la survie des femelles adultes et les enquêtes annuelles sur la composition) tireraient profit de l'ajout d'estimations des prises des chasseurs autochtone, ce qui devrait être une priorité. Le couplage des estimations de la récolte totale mises à jour avec les modèles de population clarifiera l'importance des estimations des populations. Sans connaître l'étendue totale de l'exploitation ou la taille réelle des populations, il y a incertitude dans la capacité du caribou à soutenir différents niveaux d'exploitation, et l'imposition de limites de chasse temporaires devient une option raisonnable comme mesure de précaution contre le déclin de la population.

EXECUTIVE SUMMARY

Boreal caribou are listed as a Threatened species under both Canada's Species at Risk Act and the Species at Risk (Northwest Territories) Act. In the Northwest Territories (NWT), boreal caribou occupy a range of approximately 441,000 km^2. Boreal caribou are highly respected and valued by Indigenous hunters in the NWT and are also valued and hunted for subsistence use by licensed resident hunters. In the Recovery Strategy for the Boreal Caribou (*Rangifer tarandus caribou*) in the Northwest Territories there is recognition that continued harvest of boreal caribou is desirable and that it must be managed in a sustainable manner. The Government of the Northwest Territories Department of Environment and Natural Resources (GNWT-ENR) currently monitors boreal caribou survival rates, calf recruitment rates, and resident hunter harvest rates. They do not have accurate estimates of current population sizes, nor are there accurate estimates of Indigenous harvest.

This report provides the details of the construction and application of a set of population and harvest models for boreal caribou in two Wildlife Management Zones and six other areas of interest in the NWT. The objective of the modelling is to provide perspective on likely relationships between hunter harvest levels and NWT caribou population growth rates. The basic vital rates on which the models depend are derived from recent field studies conducted by GNWT-ENR in each of the geographic areas of interest. The population models revealed limits on harvest levels that would increase the probability of caribou in each area being able to sustain themselves or grow over time.

The absence of both accurate population estimates and accurate totals of current hunter harvest means it is not possible to make absolute determinations of sustainable harvest levels. The GNWT-ENR has a strong monitoring program in place to measure annual rates of adult female survival and calf recruitment. The monitoring data indicate that without human harvest, NWT boreal caribou are stable (Lambda [λ] = 1.00) or have the capacity for small levels of annual population growth ($\lambda > 1.00$) in the areas of interest and Wildlife Management Zones being studied. Southern areas in boreal caribou range (Dehcho South, Hay River Lowlands, Pine Point / Buffalo Lake) do not appear to have any capacity to withstand human harvest and northern areas (Dehcho North, North Slave [TASR], Mackenzie) can support only a limited harvest. The ability to withstand human harvest depends on the size, location, and sex-ratio of the harvest.

The current monitoring programs (i.e., licensed resident harvest assessments, radio-telemetry studies of adult female survival, and annual composition surveys) would benefit from the addition of estimates of Indigenous harvest, which should be a priority. Coupling updated total harvest estimates with population models will clarify the importance of population estimates. Without knowing total harvest or actual population sizes there is uncertainty in the ability of caribou to sustain harvest of different levels, and imposing temporary harvest limitations becomes a reasonable option as a precaution against population decline.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

Boreal woodland caribou (*Rangifer tarandus caribou*), found in Yukon and Northwest Territories (NWT) and from British Columbia east to Labrador, are listed as Threatened under Canada's Species at Risk Act (SARA). In 2012 Environment Canada released the Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal population, in Canada (EC 2012). The responsibility for recovery planning for each range lies with the provinces and territories (ECCC 2016). In 2014, boreal caribou in the NWT were listed as Threatened under the Species at Risk (NWT) Act and a recovery strategy for boreal caribou in the NWT was prepared (Conference of Management Authorities 2017).

Boreal caribou in the NWT are considered to make up the largest portion of a single population that spans the boundary with Yukon (EC 2012, Conference of Management Authorities 2017). The Conservation and Recovery objectives are presented in the NWT boreal caribou recovery strategy:

1. *Ensure there is adequate habitat across the NWT range to maintain a healthy and sustainable population of boreal caribou.*
2. *Ensure that harvest of boreal caribou is sustainable.*
3. *Obtain information to inform sound management decisions, including boreal caribou ecology, key habitat and population indicators, and cumulative effects.*
4. *Manage boreal caribou collaboratively, using adaptive management practices and the best available information.*
5. *Exchange information with NWT people about boreal caribou in all regions.*
6. *Further to the national recovery strategy, ensure recovery obligations for protecting critical habitat and maintaining a self-sustaining population are met or exceeded in NWT.*

(Conference of Management Authorities 2017, p. 23)

Boreal caribou are highly respected and valued by Indigenous hunters in the NWT; they are also valued and hunted for subsistence use by licensed resident hunters. Objective 2 *"… focuses on a harvest of boreal caribou that allows for a self-sustaining population. Boreal caribou harvest levels are believed to be low but increasing. Accurate harvest data are lacking, with reports of anywhere from 80 to 200 caribou harvested per year. Therefore, more reliable information is needed on both harvest levels and population estimates to determine whether the harvest is sustainable. If it appears that current harvest levels do not allow for a self-sustaining caribou population, then harvest management actions (e.g., temporary harvest limitations) may need to be considered to prevent further population decline."* (Conference of Management Authorities 2017, p. 26). Actions under this objective include both harvest measurement and harvest management.

Adaptive management of wildlife harvest is enhanced with the collection of population performance measures, especially population size, composition, and vital rates, including age- and sex-specific harvest. Boreal caribou present particular challenges for accurate and precise estimation of population size, and across their range in Canada there has historically been a reliance on a combination of radio-telemetry studies (for adult female survival) and late winter classification surveys (for calf recruitment; Rettie 2017). Harvest levels of boreal caribou are poorly documented across the country. As noted in the NWT recovery strategy, information on harvest levels will enhance the ability to determine the self-sustainability of the NWT boreal caribou population as a whole, and in specific regions of NWT boreal caribou range. Within the recovery strategy, a set of specific actions were recommended to assist in meeting the sustainable harvest objectives. They are:

2.1. Measure harvest levels.

2.1.1. Educate people on the importance of reporting harvest.

2.1.2. Work with local First Nations, harvesting committees and the Dehcho Boreal Caribou Working Group to develop reporting systems for Aboriginal harvesting of boreal caribou; these systems must be respectful of treaty and Aboriginal rights and maintain harvester privacy.

2.1.3. Continue to estimate harvest levels of resident hunters through the Resident Harvest Survey.

2.1.4. Report estimated total harvest levels, including the number harvested and the sex ratio, to caribou management authorities.

2.2. Manage the harvest to ensure it is sustainable.

2.2.1. Investigate and define sustainable harvest levels.

2.2.2. Encourage harvesting practices that minimize negative impacts on the population (e.g., following traditional laws surrounding caribou hunting and use; excellence in marksmanship; ability to distinguish types of caribou; avoid harvesting cows with calves).

2.2.3. Work with officers and communities to promote compliance with hunting regulations for boreal caribou.

2.2.4. Review the NWT Wildlife Act Big Game Hunting Regulations for woodland caribou. As part of this review, consider whether regulations for boreal and mountain woodland caribou should be further differentiated, and whether changes to seasons, bag limits, quotas, open harvesting zones and/or harvest reporting mechanisms are needed.

2.2.5. Periodically review harvest levels and make management recommendations if necessary (e.g., temporary harvest limitations).

(Conference of Management Authorities 2017, p. 53)

1.2 Objectives

While there are not accurate population estimates or harvest estimates for boreal caribou in the NWT, there are vital rate data and population density estimates that can be used to:

1. determine a range of sustainable harvest levels based on varying assumptions;
2. identify important data that would improve decision making abilities;
3. associate levels of risk to NWT boreal caribou populations with various levels of harvest; and
4. provide guidance for regulation of caribou harvest.

This report provides the details of the construction and application of a set of population and harvest models for boreal caribou in six areas of interest (AOIs) and two NWT Wildlife Management Zones (WMZs). The objective of the modelling is to provide perspective on likely relationships between hunter harvest levels and NWT caribou population growth rates. The basic vital rates on which the models depend are derived from recent field studies conducted by the Government of the Northwest Territories Department of Environment and Natural Resources (GNWT-ENR) on each of the modelled caribou populations. Of particular importance for model development are the age-specific fecundity schedules and the age- and sex-specific survival schedules.

The GNWT-ENR study areas for survival and group composition monitoring are outlined in Section 2 along with the populations defined for modelling purposes. An overview of modelling procedures is presented in Section 3 and the derivation of initial population estimates for models are presented in Section 4.

The origin of initial population sizes used in models is presented in Section 5.1. The process by which survival and fecundity rates were derived from regional data and partitioned across age classes are described in Sections 5.2 and 5.3. The specific management scenarios modelled and the model results appear in Sections 6 and 7, respectively.

2. STUDY AREAS, WILDLIFE MANAGEMENT ZONES, AREAS OF INTEREST, AND NORTHWEST TERRITORIES BOREAL CARIBOU REGIONS

Boreal caribou in the NWT occupy a range of approximately 441,000 km^2 (GNWT 2108a). For recovery planning purposes the boreal caribou range in the NWT is divided into five regions. The boreal caribou study areas considered in this report are within the Southern NWT and Wek’èezhìı regions, the two southernmost regions (Figure 1). The Dehcho South, Hay River Lowlands, and Pine Point / Buffalo Lake study areas are entirely within the Southern NWT Region. The Dehcho North study area is mostly within the Southern NWT Region but its eastern portion overlaps the Wek’èezhìı Region. The Mackenzie study area spans the Southern NWT and Wek’èezhìı regions. The North Slave (TASR) study area matches the

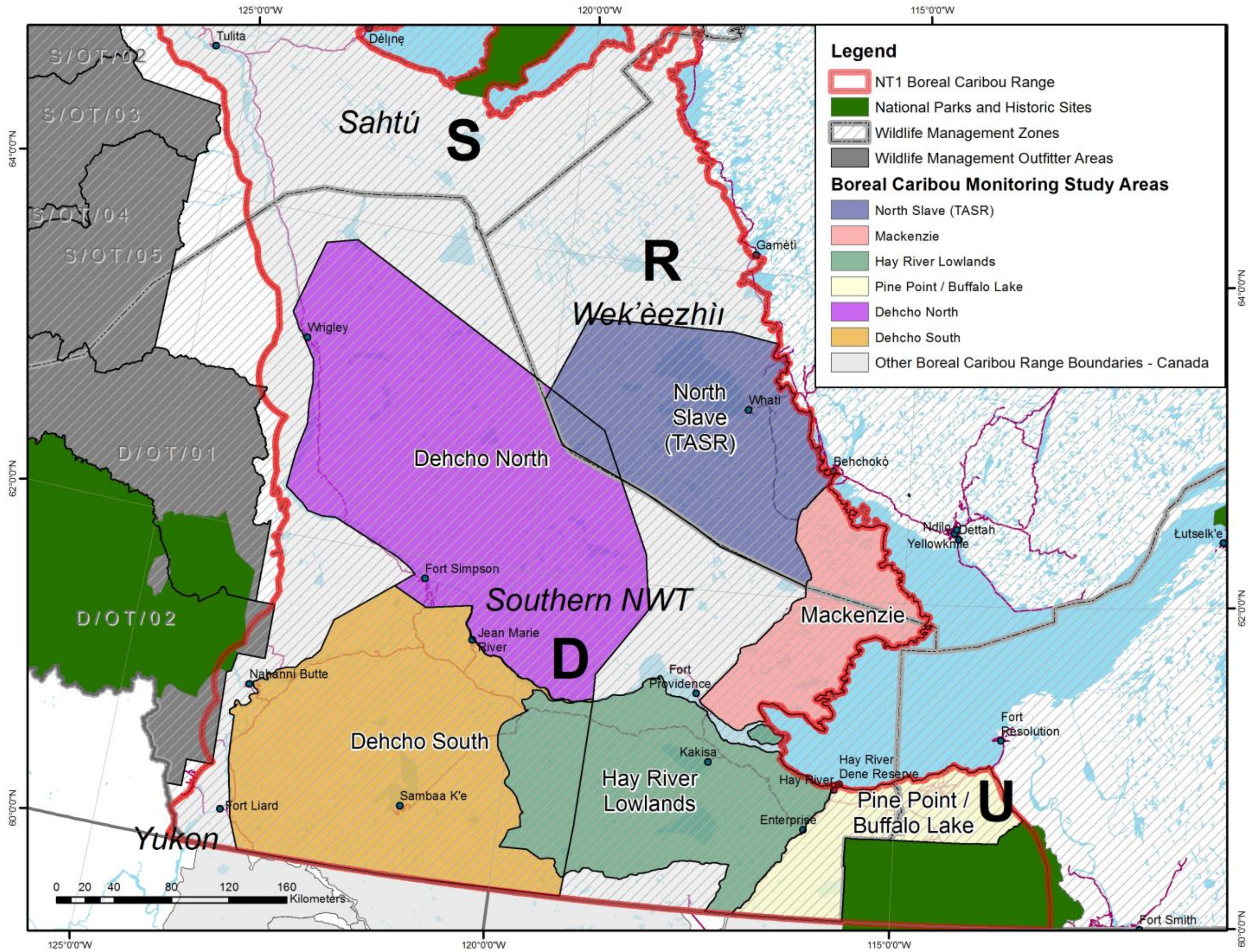

Figure 1: Northwest Territories boreal caribou range and regions. Study areas for population monitoring include Dehcho North, North Slave (TASR), Dehcho South, Mackenzie, Hay River Lowlands, and Pine Point / Buffalo Lake. Each study area was modelled as a separate population. Population models were also constructed for Wildlife Management Zones D and R, based on monitoring data from the study areas they contain.

area used for monitoring boreal caribou near the Tłįchǫ All-Season Road (TASR) and is entirely within the Wek'èezhìı Region. These six study areas constitute the AOIs referred to throughout the report.

The study areas include Indigenous communities with no restrictions on boreal caribou harvest. There is also licensed resident hunting of woodland caribou in the NWT, with a bag limit of a single boreal or mountain woodland caribou per resident hunter per year, without geographic restriction. Until 2018 there was no age or sex restriction on the animal harvested, but as of 2019, regulations changed to specify a single male boreal caribou per resident hunter per year (GNWT 2019).

3. POPULATION MODELLING

All modelling was conducted using the stochastic option in the software package RAMAS 5.0® (Akçakaya 2005). Each model was run for a period of ten years with 1000 iterations. The sections below document the values used as input data for the population models. Specific inputs for each model for each WMZ or AOI include:

1. a matrix of age and sex specific survival rates – this implicitly includes all natural sources of mortality. Six separate matrices were constructed from GNWT-ENR monitoring data;
    a. one from pooled Dehcho North and North Slave (TASR) data, used for each of those two model populations. As there was only one year of data from North Slave (TASR) caribou, their data were combined with the adjacent Dehcho North data to represent the local vital rates and variances for modelling purposes,
    b. one from Dehcho South data, used for Dehcho South models,
    c. one from Mackenzie data, used for Mackenzie models,
    d. one from pooled Hay River Lowlands, Buffalo Lake, and Pine Point data, used for separate models for Hay River Lowlands and Pine Point / Buffalo Lake. As for Dehcho North and North Slave (TASR), there were unequal data from the three areas in the South Slave Region. Seventy five percent of the data were from the Hay River Lowlands, dating back to the 2002 monitoring year. Buffalo Lake and Pine Point data began with the 2014 monitoring year. The raw data were pooled to represent the regional vital rates and variances for modelling purposes,
    e. one from pooled Dehcho North, Dehcho South, Mackenzie, Hay River Lowlands, Buffalo Lake, and Pine Point data. Used for WMZ D (Zone D) models, and
    f. one from pooled Dehcho North, North Slave (TASR), and Mackenzie data. Used for WMZ R (Zone R) models.

    Each survival matrix was held constant across all models for a given model population;
2. an age-specific fecundity matrix for the production of calves of each sex. Assuming no multiple births, fecundity is equal to the parturition (birth) rate. As for survival, six separate matrices were constructed, based on the same study area data sources and data groupings noted above

for survival calculations. Each fecundity matrix was held constant across all models for a given model population;

3. the absolute number of animals of each life stage expected to be killed through hunting in each year. These varied across models;
4. as each parameter estimate is imprecise and may vary among years, a standard deviation or standard error, as appropriate, has been estimated for each vital rate parameter (i.e., each age- or sex-specific survival and parturition rate) in each survival and fecundity matrix, and
5. finally, for the purposes of modelling, the animals in each AOI or WMZ are considered a population. The models do not include immigration or emigration from the area. In the context of discussing the model results, caribou within a WMZ or an AOI are referred to as a population, and that population's increase or decrease is based on the survival rates, parturition rates, and harvest rates dictated by the model. Ecologically, there is interchange of animals between adjacent areas (GNWT-ENR, unpublished radiotelemetry data), but the dynamics of the caribou population in each area is largely determined by its internal survival and parturition rates, and by local mortality factors including harvest. The models are for closed populations.

All models are sensitive to the parameters selected at the outset and these models are no different. The parameters applied in these models fall within the bounds of biological plausibility for the species and fit the most recently estimated vital rates, hunter kill rates, and potential population sizes of boreal caribou in the two WMZs and four AOIs described in points 1.a. through 1.f. above. The derivation of these values is discussed in Section 5 below.

4. FIELD-BASED EMPIRICAL DATA COLLECTION FOR ESTIMATING SURVIVAL, REPRODUCTION, AND HUNTING MORTALITY

4.1 Radio-telemetry studies of adult female caribou

Radio-telemetry studies of NWT boreal caribou have been on-going since 2003. Varying numbers of animals have been monitored in different study areas through time. Caribou were captured in winter, mostly in February or March, though captures have occurred as early as December and as late as April. Locations of each radio-collared animal are determined on fixed schedules and all animals are monitored for survival until death, collar failure, or programmed collar detachment. Data from 448 adult female caribou were used in the analyses presented here. Summaries of the numbers of animals monitored in each study area in each year are presented in Table A1 (Appendix A).

4.2 Late winter age and sex classification surveys

Late winter classification surveys were carried out annually in each study area. Data were available for: Dehcho North and Dehcho South from 2005 to 2018; Mackenzie from 2015 to 2018; North Slave (TASR) for 2018; Hay River Lowlands from 2004 to 2018; Pine Point and Buffalo Lake from 2015 to 2018. The surveys are telemetry-based, with a focus on locating and classifying individuals in groups containing each of the radio-collared females in the study areas. Any opportunistically sighted groups that did not contain radio-collared individuals were also classified. As such, they follow a similar protocol to surveys conducted elsewhere (e.g., Saskatchewan, Rettie and Messier 1998; Alberta, McLoughlin et al. 2003, Hervieuex et al. 2013) and are biased towards groups containing higher abundances of adult female caribou. As there may be some degree of segregation of bulls and cows in winter groups of boreal caribou, bull: cow ratios from such surveys may not be reliable for extrapolation to the population level, however calf: cow ratios to estimate recruitment are typically determined from such surveys (e.g., Rettie and Messier 1998, McLoughlin et al. 2003, Hervieux et al. 2013). Summary data from annual NWT classification surveys are presented for each modelled population in Tables B1 to B6 (Appendix B).

4.3 Hunting mortality estimates

Based on information from the NWT resident hunter surveys, resident hunters take approximately 51 woodland caribou per year, and on average about 21 per year are likely boreal woodland caribou based on location of hunt (Table 1). This estimate is the total for all boreal caribou regions and is based on the assumption that boreal and mountain woodland caribou kills are equally likely to be reported (GNWT-ENR unpublished data). Total boreal caribou harvest by Indigenous hunters is unknown; for the Dehcho Region alone it may be as low as 30 animals or more than 100 animals per year (GNWT-ENR unpublished data). The Section 11 Agreement between Canada and the GNWT summarized the available information:

> *"Accurate Indigenous harvest information for boreal caribou is not available for all areas of the NWT, but based on regional harvest studies and Traditional Knowledge reports, the average number of boreal caribou harvested by Indigenous people in the NWT could be as low as 65 (1% of the estimated population) and as high as 190, 2.9% of the estimated population …The GNWT has been working with Indigenous Governments and organizations to promote opportunities for enhanced Indigenous harvest monitoring."*
>
> (Canada and the Government of the Northwest Territories 2019, p.32)

This followed the Species at Risk Committee (2012, p. xv) who reported total annual harvest of boreal caribou in the NWT most likely represents between 1% and 3% of the estimated NWT population.

5. MODEL ELEMENTS

5.1 Initial population size

There are no empirical estimates of NWT boreal caribou population sizes, though the NWT boreal caribou status report (Species at Risk Committee 2012) adopted an estimated value of 6500 animals. In the absence of local empirical estimates, GNWT-ENR sought to examine the range of potential values of boreal caribou density reported from across Canada (between 1 and 3.5 caribou / 100 km^2 in Québec [Équipe de rétablissement du caribou forestier du Québec 2013]; to 6.3 / 100 km^2 from a more recent survey in Québec [Heppel 2015]; and including an estimate from 2019 in northern Saskatchewan of 3.69

caribou / 100 km^2 [McLoughlin et al. 2019]). For the models presented here, population size estimates in each area were based on a range of potential population densities between 1 and 6 caribou / 100 km^2 for each WMZ and AOI; with each initial model population size being a product of the size of the WMZ or AOI area and its assumed caribou density.

To provide a range of potential starting population sizes, six different initial population sizes were estimated for each of Dehcho North, North Slave (TASR), Dehcho South, Mackenzie, Hay River Lowlands, Pine Point / Buffalo Lake, Zone D, and Zone R populations (Table 2).

Table 1: Estimated annual boreal caribou harvest by licensed resident hunters in the Northwest Territories, 2001 to 2016.[1]

Year	Estimated boreal caribou harvest
2001	17
2002	22
2003	22
2004	16
2005	27
2006	21
2007	26
2008	21
2009	16
2010	44
2011	25
2012	28
2013	18
2014	8
2015	18
2016	6

[1] Source: GNWT-ENR unpublished data.

Table 2: Initial population sizes used in modelling boreal caribou in each of the Northwest Territories areas of interest and Wildlife Management Zones. Initial population sizes were based on a range of potential densities (between 1 and 6 caribou / 100 km^2)[1] in each area.

Model Population	Survival and Recruitment Data	Area (km^2)	Caribou / 100 km^2:	1	2	3	4	5	6
			Initial modelling population size (= density X area)						
Dehcho North	Combined (DN + NS)	45,841		458	917	1375	1834	2292	2750
North Slave (TASR)	Combined (DN + NS)	22,204		222	444	666	888	1110	1332
Dehcho South	Dehcho South	47,534		475	951	1426	1901	2377	2852
Mackenzie	Mackenzie	11,238		112	225	337	450	562	674
Hay River Lowlands	Combined (HRL + PP + BL)	22,794		228	456	684	912	1140	1368
Pine Point / Buffalo Lake	Combined (HRL + PP + BL)	8810		88	176	264	352	441	529
Zone D	Combined (DN + DS + Mackenzie + HRL + PP + BL)	150,137		1501	3003	4504	6005	7507	9008
Zone R	Combined (DN + NS + Mackenzie)	49,642		496	993	1489	1986	2482	2979

[1] Sources: Équipe de rétablissement du caribou forestier du Québec 2013; Heppel 2015; McLoughlin et al. 2019.

5.2 Age- and sex-specific survival

For each population, the annual adult female survival rate was calculated from radio-collar data for each individual year, and for data pooled for three-year, five-year, and ten-year periods. Pooled year data analyses were all based on periods ending on 31 August 2018. Survival analyses were based on a year that began on 01 April of the nominal year and ended on 31 March of the subsequent year (e.g., the period from 01 April 2010 to 31 March 2011 was considered the 2010 biological year); a separate record was included for each study animal for each year it was monitored until 31 August 2018 (i.e., recurrent analyses). All survival rates in the four sub-populations were calculated using the Kaplan-Meier product limit estimator generalized for staggered entry and the Greenwood error estimator (Hosmer et al. 2008, pp. 16-44) in the "survival" package in R version 3.3.3 (R Core Team 2017). When survival or mortality was uncertain in the final interval for each animal, the data were right-censored, a method tested by DeCesare et al. (2016) and determined not to bias mortality and survival estimates.

Adult female survival rates were calculated for each population in each year (Table A1, Appendix A) and with pooled data from the most recent ten -year (Table A2), five-year (Table A3), and three-year (Table A4) periods. Table A1 includes two sets of calculations for survival: one set including the 11 hunter kills recorded for radio-collared caribou and the other set excluding the 11 records that ended with an animal being killed by a hunter in the year, thus excluding the effects of hunting on survival. The multi-year summaries (Tables A2 to A4) are all based on analyses excluding records with mortality from hunting. To account for long-term variations in survival rates, the survival estimates from data pooled over the ten-year period ending in 2018 (Table A2) were used to set values for age-specific survival rates for the models.

The lifespans and patterns of age-specific survival for boreal caribou are poorly documented in the literature. Larter and Allaire (2016) documented one individual in the study area that reached 22 years old, a female that had calved during the period of the study indicating fecundity at old age. In a study of Svalbard reindeer (*Rangifer tarandus platyrhynchus*) Lee et al. (2015) documented the highest survival rates for adult females of one to eight years old; calves and individuals in 9-11 year old animals had lower survival rates and ≥ 12 year old animals had further declining survival rates. This is a similar pattern to that observed for moose where survival rates for animals greater than one year old is relatively stable with annual survival rates declining in animals beyond six to ten years old (Van Ballenberghe and Ballard 1998).

To create a survival matrix for each population, a set of age-specific survival rates were created for female boreal caribou in five age classes: yearlings; two-year-olds; 3-9 year olds; 10-14 year olds; and 15-19 year olds. All females reaching 20 years old were given a survival rate of zero. The survival rates were adjusted iteratively until the weighted survival (the sum of the number of animals in each age class times its survival rate) matched the ten-year mean survival rate for the population. While actual age-specific survival was unknown, the weighted average for each of the model populations was consistent with empirical data from radio-collared animals for the period ending in 2018 (Tables 3 to 8).

Table 3: Age- and sex-specific parturition and survival rates employed in population models for boreal caribou in the Dehcho North and North Slave (TASR) areas of interest in the Northwest Territories.

Age	Age Class	Female parturition rate (sd)[1]	Female Survival Rate[2] (sd)	Male Survival Rate (sd)[3]
0	Calves	N/A	0.425 (0.075)	0.425 (0.075)
1	Yearlings	0.000 (0.000)	0.819 (0.025)	0.739 (0.025)
2	Two-year olds	0.333 (0.075)	0.910 (0.025)	0.830 (0.025)
Adult stage 1	3-9	0.960 (0.075)	0.910 (0.025)	0.830 (0.025)
Adult stage 2	10-14	0.864 (0.075)	0.819 (0.025)	0.739 (0.025)
Adult stage 3	15-19 (female) 15 (male)	0.768 (0.075)	0.728 (0.025)	0.648 (0.025)
Adult terminal age[4]	20 (female) 16 (male)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)

[1]Parturition rates are set to: 0% of calves and yearlings and 33% of two-year-olds. Adult parturition rates are adjusted iteratively until overall population parturition rate x calf survival matches the observed calf: cow ratio at late winter. Adult stage 2 and 3 parturition rates are scaled against stage 1 parturition rates (at 90% and 80% of stage 1 rates respectively). The standard deviation for parturition rate and for calf survival matches the standard deviation of annual calf: cow ratios for the population (Table B1).

[2]The weighted average of age-specific survival rates for females age 1 and older match the empirical adult female survival from radio-collared animals. The standard deviation for survival is the Greenwood standard error estimate from multiannual Kaplan-Meier survival estimates for the population (Table A2).

[3]The yearling and adult male annual survival rates were assumed 0.08 less than female survival rates. For this population that would yield a late winter bull: cow ratio of 0.59 to 1.00

[4]The survival rate was set to 0.0 for males age 16 and for females age 20.

Base model run lambda (1.021) matches the lambda value produced through combination of adult female survival and calf: cow ratios (1.021).

Table 4: Age- and sex-specific parturition and survival rates employed in population models for boreal caribou in the Dehcho South area of interest in the Northwest Territories.

Age	Age Class	Female parturition rate (sd)[1]	Female Survival Rate[2] (sd)	Male Survival Rate (sd)[3]
0	Calves	N/A	0.400 (0.065)	0.400 (0.065)
1	Yearlings	0.000 (0.000)	0.792 (0.028)	0.702 (0.028)
2	Two-year olds	0.333 (0.065)	0.880 (0.028)	0.790 (0.028)
Adult stage 1	3-9	0.960 (0.065)	0.880 (0.028)	0.790 (0.028)
Adult stage 2	10-14	0.864 (0.065)	0.792 (0.028)	0.702 (0.028)
Adult stage 3	15-19 (female) 15 (male)	0.768 (0.065)	0.704 (0.028)	0.614 (0.028)
Adult terminal age[4]	20 (female) 16 (male)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)

[1]Parturition rates are set to: 0% of calves and yearlings and 33% of two-year-olds. Adult parturition rates are adjusted iteratively until overall population parturition rate x calf survival matches the observed calf: cow ratio at late winter. Adult stage 2 and 3 parturition rates are scaled against stage 1 parturition rates (at 90% and 80% of stage 1 rates respectively). The standard deviation for parturition rate and for calf survival matches the standard deviation of annual calf: cow ratios for the population (Table B2).

[2]The weighted average of age-specific survival rates for females age 1 and older match the empirical adult female survival from radio-collared animals. The standard deviation for survival is the Greenwood standard error estimate from multiannual Kaplan-Meier survival estimates for the population (Table A2).

[3]The yearling and adult male annual survival rates were assumed 0.09 less than female survival rates. For this population that would yield a late winter bull: cow ratio of 0.58 to 1.00

[4]The survival rate was set to 0.0 for males age 16 and for females age 20.

Base model run lambda value (0.988) is slightly lower than the lambda value produced through combination of adult female survival and calf: cow ratios (0.989).

Table 5: Age- and sex-specific parturition and survival rates employed in population models for boreal caribou in the Mackenzie area of interest in the Northwest Territories.

Age	Age Class	Female parturition rate (sd)[1]	Female Survival Rate[2] (sd)	Male Survival Rate (sd)[3]
0	Calves	N/A	0.475 (0.042)	0.475 (0.042)
1	Yearlings	0.000 (0.000)	0.910 (0.034)	0.850 (0.034)
2	Two-year olds	0.333 (0.042)	0.960 (0.034)	0.900 (0.034)
Adult stage 1	3-9	0.950 (0.042)	0.960 (0.034)	0.900 (0.034)
Adult stage 2	10-14	0.855 (0.042)	0.960 (0.034)	0.900 (0.034)
Adult stage 3	15-19 (female) 15 (male)	0.760 (0.042)	0.864 (0.034)	0.804 (0.034)
Adult terminal age[4]	20 (female) 16 (male)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)

[1]Parturition rates are set to: 0% of calves and yearlings and 33% of two-year-olds. Adult parturition rates are adjusted iteratively until overall population parturition rate x calf survival matches the observed calf: cow ratio at late winter. Adult stage 3 parturition rates are scaled against stage 1 parturition rates (90% of stage 1 rate). The standard deviation for parturition rate and for calf survival matches the standard deviation of annual calf: cow ratios for the population (Table B3).

[2]The weighted average of age-specific survival rates for females age 1 and older match the empirical adult female survival from radio-collared animals. The standard deviation for survival is the Greenwood standard error estimate from multiannual Kaplan-Meier survival estimates for the population (Table A2).

[3]The yearling and adult male annual survival rates were assumed 0.06 less than female survival rates. For this population that would yield a late winter bull: cow ratio of 0.58 to 1.00

[4]The survival rate was set to 0.0 for males age 16 and for females age 20.

Base model run lambda value (1.093) is slightly lower than the lambda value produced through combination of adult female survival and calf: cow ratios (1.094).

Table 6: Age- and sex-specific parturition and survival rates employed in population models for boreal caribou in the Hay River Lowlands and Pine Point / Buffalo Lake area of interest in the Northwest Territories.

Age	Age Class	Female parturition rate (sd)[1]	Female Survival Rate[2] (sd)	Male Survival Rate (sd)[3]
0	Calves	N/A	0.360 (0.095)	0.360 (0.095)
1	Yearlings	0.000 (0.000)	0.819 (0.019)	0.739 (0.019)
2	Two-year olds	0.333 (0.095)	0.910 (0.019)	0.830 (0.019)
Adult stage 1	3-9	0.950 (0.095)	0.910 (0.019)	0.830 (0.019)
Adult stage 2	10-14	0.855 (0.095)	0.819 (0.019)	0.739 (0.019)
Adult stage 3	15-19 (female) 15 (male)	0.760 (0.095)	0.728 (0.019)	0.648 (0.019)
Adult terminal age[4]	20 (female) 16 (male)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)

[1]Parturition rates are set to: 0% of calves and yearlings and 33% of two-year-olds. Adult parturition rates are adjusted iteratively until overall population parturition rate x calf survival matches the observed calf: cow ratio at late winter. Adult stage 2 and 3 parturition rates are scaled against stage 1 parturition rates (at 90% and 80% of stage 1 rates respectively). The standard deviation for parturition rate and for calf survival matches the standard deviation of annual calf: cow ratios for the population (Table B4).

[2]The weighted average of age-specific survival rates for females age 1 and older match the empirical adult female survival from radio-collared animals. The standard deviation for survival is the Greenwood standard error estimate from multiannual Kaplan-Meier survival estimates for the population (Table A2).

[3]The yearling and adult male annual survival rates were assumed 0.08 less than female survival rates. For this population that would yield a late winter bull: cow ratio of 0.59 to 1.00

[4]The survival rate was set to 0.0 for males age 16 and for females age 20.

Base model run lambda value (1.000) matches the lambda value produced through combination of adult female survival and calf: cow ratios (1.000).

Table 7: Age- and sex-specific parturition and survival rates employed in population models for boreal caribou in Wildlife Management Zone D in the Northwest Territories.

Age	Age Class	Female parturition rate (sd)[1]	Female Survival Rate[2] (sd)	Male Survival Rate (sd)[3]
0	Calves	N/A	0.421 (0.060)	0.421 (0.060)
1	Yearlings	0.000 (0.000)	0.812 (0.013)	0.727 (0.013)
2	Two-year olds	0.333 (0.060)	0.901 (0.013)	0.816 (0.013)
Adult stage 1	3-9	0.950 (0.060)	0.901 (0.013)	0.816 (0.013)
Adult stage 2	10-14	0.855 (0.060)	0.812 (0.013)	0.727 (0.013)
Adult stage 3	15-19 (female) 15 (male)	0.760 (0.060)	0.723 (0.013)	0.638 (0.013)
Adult terminal age[4]	20 (female) 16 (male)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)

[1]Parturition rates are set to: 0% of calves and yearlings and 33% of two-year-olds. Adult parturition rates are adjusted iteratively until overall population parturition rate x calf survival matches the observed calf: cow ratio at late winter. Adult stage 2 and 3 parturition rates are scaled against stage 1 parturition rates (at 90% and 80% of stage 1 rates respectively). The standard deviation for parturition rate and for calf survival matches the standard deviation of annual calf: cow ratios for the population (Table B5).

[2]The weighted average of age-specific survival rates for females age 1 and older match the empirical adult female survival from radio-collared animals. The standard deviation for survival is the Greenwood standard error estimate from multiannual Kaplan-Meier survival estimates for the population (Table A2).

[3]The yearling and adult male annual survival rates were assumed 0.085 less than female survival rates. For this population that would yield a late winter bull: cow ratio of 0.59 to 1.00

[4]The survival rate was set to 0.0 for males age 16 and for females age 20.

Base model run lambda value (1.011) matches the lambda value produced through combination of adult female survival and calf: cow ratios (1.011).

Table 8: Age- and sex-specific parturition and survival rates employed in population models for boreal caribou in Wildlife Management Zone R in the Northwest Territories.

Age	Age Class	Female parturition rate (sd)[1]	Female Survival Rate[2] (sd)	Male Survival Rate (sd)[3]
0	Calves	N/A	0.435 (0.073)	0.435 (0.073)
1	Yearlings	0.000 (0.000)	0.831 (0.021)	0.759 (0.021)
2	Two-year olds	0.333 (0.073)	0.926 (0.021)	0.851 (0.021)
Adult stage 1	3-9	0.950 (0.073)	0.926 (0.021)	0.851 (0.021)
Adult stage 2	10-14	0.855 (0.073)	0.834 (0.021)	0.759 (0.021)
Adult stage 3	15-19 (female) 15 (male)	0.760 (0.073)	0.741 (0.021)	0.666 (0.021)
Adult terminal age[4]	20 (female) 16 (male)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)

[1]Parturition rates are set to: 0% of calves and yearlings and 33% of two-year-olds. Adult parturition rates are adjusted iteratively until overall population parturition rate x calf survival matches the observed calf: cow ratio at late winter. Adult stage 2 and 3 parturition rates are scaled against stage 1 parturition rates (at 90% and 80% of stage 1 rates respectively). The standard deviation for parturition rate and for calf survival matches the standard deviation of annual calf: cow ratios for the population (Table B6).

[2]The weighted average of age-specific survival rates for females age 1 and older match the empirical adult female survival from radio-collared animals. The standard deviation for survival is the Greenwood standard error estimate from multiannual Kaplan-Meier survival estimates for the population (Table A2).

[3]The yearling and adult male annual survival rates were assumed 0.075 less than female survival rates. For this population that would yield a late winter bull: cow ratio of 0.59 to 1.00

[4]The survival rate was set to 0.0 for males age 16 and for females age 20.

Base model run lambda value (1.038) matches the lambda value produced through combination of adult female survival and calf: cow ratios (1.038).

Available data on male caribou were inadequate to determine male survival rates. Further, the classification survey data (Section 4.2, Tables B1 to B6, Appendix B) do not permit reliable determination of the numbers of adult males relative to adult females (i.e., bull: cow ratios). Adult male caribou are known to have a shorter lifespans and lower annual survival rates than female caribou (Bergerud et al., 2008). The final step in setting survival rates for boreal caribou models was to adjust male survival rates downward from female rates for each age, uniformly across age classes until the weighted survival estimates generated a plausible late winter bull: cow ratio estimate for the populations. Studies from across boreal caribou range were examined for guidance on a likely adult sex ratio. In a study in Québec, Courtois et al. (2003) reported a bull: cow ratio of 0.61 (i.e., 61 bulls: 100 cows). More recently, Heppell (2015) reported a bull: cow ratio for northern Québec of 0.56. In a current study in northern Saskatchewan, incidental and random observations of boreal caribou groups had a late winter bull: cow ratio of 0.57 (McLoughlin et al. 2016). The models in this report assume a sex ratio 0f 0.60 bulls: cow, a ratio used to guide setting age-specific survival rate of male caribou. For these models, the age-specific male survival rates were reduced by a fixed amount below the age-specific values for the same age-class of females. The process was repeated iteratively until a ratio of 60 bulls: 100 cows was achieved. The resulting age-specific male survival rates appear in Tables 3 to 8. The amount by which age-specific male annual survival was reduced below female annual survival varied between 6% and 9%. The exact value appears below the Table for each population.

The Greenwood standard error estimator from the ten-year pooled data survival analysis was taken as the age-specific standard deviation in the model for each population. The same standard deviation was assumed for male survival as for females in the same age class, despite the absence of current male survival data.

5.3 Age-specific fecundity

RAMAS 5.0® (Akçakaya 2005) models allow for age-specific fecundity estimates and their standard deviations for each age class of females. Fecundity is expected to be the most variable vital rate for ungulate populations (Gaillard et al. 1998) and accounting for natural variation in year-to-year fecundity is important. Assuming a single calf per pregnancy, age specific fecundity is the same as the parturition rate for each age class. After accounting for the age-specific survival to late winter and the distribution of females among age classes (as determined by age-specific female survival, Tables 3 to 8), the result is the late winter calf: cow ratio.

5.3.1 Calf: cow ratios

To determine a range of fecundity values for use in modelling, annual calf: cow ratios were calculated for each population from the sets of late winter classification data. The total number of calves observed in a population during a survey was divided by the adjusted number of cow caribou observed. The adjusted cow total was the number of cows identified during the survey plus a portion of the number of unclassified (unknown) animals in the survey; the portion was determined as the ratio of observed cows: observed bulls. For each population a geometric mean calf: cow ratio was determined for the ten-year period from 2009 to 2018, except for the Mackenzie population where only four years' data were available (Tables B1 to B6). The ten-year mean calf: cow ratios were used as target values for setting age-specific parturition rates and survival rates for each population.

5.3.2 Parturition rate and parturition sex ratio

Neither the parturition rate nor the calf survival rate was known for any of the study areas. From other boreal caribou studies, a parturition rate in excess of 90% was assumed for females greater than two years old (Rettie and Messier 1998, McLoughlin et al. 2003). The late winter classification surveys provided target long-term calf: cow ratios for each population. After correcting for adult female survival, the calf: cow ratios are a weighted sum of the products of parturition rate and calf survival rate. For modelling purposes it is the products of parturition and calf survival rates that are important, not the individual parameter values.

To determine age-specific parturition rates, the yearling rate was set to zero and the two-year-old rate to 0.333. The parturition rates for females in the 10-14 year-old and 15-19 year-old age classes were reduced by constant value relative to the prime age class (3-9 year-old) females. Then the prime-age parturition rate was adjusted iteratively until the weighted age-specific survival and parturition rates yielded the ten-year (four-year for Mackenzie) geometric mean calf: cow ratios (Tables B1 to B6). The sex ratio at birth was set to 0.50 male: 0.50 female for all models.

5.4 Hunting mortality

There are no accurate estimates for total boreal caribou hunting mortality either for the NWT as a whole, or for any of the modelled populations. Resident licensed harvest is estimated at 21 boreal caribou per year with a harvest sex-ratio ranging from 0.63 to 1.00 bulls: cow (GNWT-ENR unpublished data). When combined with uncertain estimates of Indigenous hunter harvest, the estimates of total boreal caribou harvest are inadequate to reasonably predict annual harvest numbers, distribution, and sex-ratios. However, they provide a range of values to guide the development of a set of boreal caribou harvest scenarios to inform management decisions.

The NWT study animals included in the survival calculations represented a total of 1013 years of monitoring during which there were 11 hunting mortalities, or 1.1% annual mortality. However, the rate of hunting mortality determined from radio-collared animals should not be considered representative of total hunting mortality as hunter bias related to shooting radio-collared animals may exist (Jacques et al. 2011). Hunting mortality experienced by the entire population during the data collection period may be different than the 1.1% experienced by radio-collared animals.

5.5 Other mortality

The age- and sex-specific survival matrices implicitly include all non-hunting sources of mortality for each population. No additional sources of mortality are considered explicitly in these models. For boreal caribou these notably include predation by wolves (Rettie and Messier 1998, McLoughlin et al. 2003, Latham et al. 2013) and black bears (Bastille-Rousseau et al. 2011, Latham et al. 2011, Pinard et al. 2013, Rayl et al. 2018). Survival analyses from radio-collared animals (Section 5.2) explicitly removed hunting mortality prior to survival calculations and the survival rates used in the population models in this report reflect survival rates after removing the effects of hunting.

5.6 Density dependence

The effect of population density on survival and fecundity rates was excluded from all models.

5.7 Population growth rates

From data in Tables A2 and B1 to B6, excluding animals killed by hunters, each population's survival-recruitment growth rate, Lambda (λ), was calculated from the ten-year mean annual survival rate (*S*) and the ten-year late winter aerial survey calf: cow ratio (*X*), following Hatter and Bergerud (1991) and Hervieux et al. (2013);

$$\lambda = \frac{S}{1 - R}$$

Where *R* is calculated as:

$$R = \frac{(X/2)}{\big(1 + (X/2)\big)}$$

The resulting λ value for each population appears in Table 9. In each case, the baseline run of the model constructed for the population has a growth rate that matches the survival-recruitment growth rate calculated from the adult female survival rate and late winter calf: cow ratio. For reference, when the value of $\lambda = 1.00$ the population is stable (i.e., self-sustaining) during the time interval; when $\lambda < 1.00$ the population is declining; and when $\lambda > 1.00$ the population is increasing. The annual rate of increase or decline gets larger as the λ value moves away from 1.00.

The ten-year monitoring period considered for adult female survival calculations included three hunter kills in Dehcho North and one hunter kill in Dehcho South. Those hunter kills were excluded from the analyses presented in Table 9. If hunter kills were included, the ten-year λ values would be 0.963 for Dehcho North and 0.977 for Dehcho South.

6. MODEL SCENARIOS

The annual population growth rates (Lambda) for Dehcho South (0.99), Hay River Lowlands (1.00), and Pine Point / Buffalo Lake (1.00) indicate likely self-sustaining populations with no ability to support any harvest. The Lambda values for Dehcho North (1.02), North Slave (TASR; 1.02), Mackenzie (1.09), Zone D (1.01) and Zone R (1.04) indicate populations able to sustain additional mortality before population decline occurs.

Table 9: Lambda (λ) values determined for each modelled NWT boreal caribou population, exclusive of hunter kill. Calculations based on geometric mean annual adult female survival and calf recruitment rates from available data from 2008 to 2018 for each area of interest and Wildlife Management Zone.

Model Population	Ten-year geometric mean annual adult female survival rate[1]	Ten-year geometric mean recruitment rate[2]	Mean annual population growth rate (λ)
Dehcho North[3]	0.867	0.357	1.021
North Slave (TASR)[3]	0.867	0.357	1.021
Dehcho South	0.847	0.336	0.989
Mackenzie[4]	0.915	0.392	1.094
Hay River Lowlands[5]	0.870	0.298	1.000
Pine Point / Buffalo Lake[5]	0.870	0.298	1.000
Zone D	0.864	0.340	1.011
Zone R	0.880	0.359	1.038

[1]As presented in Table A2
[2]As presented in Tables B1 to B6
[3]North Slave (TASR) area had only a single year of vital rate data (2017). The raw survival and recruitment data from North Slave (TASR) and Dehcho North were combined to produce a single set of vital rates. Vital rates of both sets of models are therefore identical
[4]Mackenzie population data collection began on 1 April 2015. They are only for a three year period compared with a ten year period for each of the other populations.
[5]Owing to geographic proximity and a shortage of data from Pine Point and Buffalo Lake, the raw survival and recruitment data from Hay River Lowlands, Pine Point, and Buffalo Lake were combined to produce a single set of vital rates; Vital rates for both sets of models are therefore identical.

A set of hunting scenarios was created and applied to each of the Dehcho North, North Slave (TASR), Dehcho South, Mackenzie, Hay River Lowlands, Pine Point / Buffalo Lake, Zone D, and Zone R populations separately for each of six initial population sizes (Table 2). The scenarios were:

1. Baseline – no hunting applied. Population growth follows Lambda value for the population;
2. Non-selective harvest of 10 animals per year (modelled as 6 cows and 4 bulls);
3. Non-selective harvest of 20 animals per year (modelled as 13 cows and 7 bulls);

For the populations unlikely to support hunting mortality (Dehcho South, Hay River Lowlands, and Pine Point / Buffalo Lake) two additional hunting scenarios were modelled for each of the six initial population sizes to inform potential rate of decline. They were:

4. Cow only harvest of 20 animals per year;
5. Bull only harvest of 20 animals per year.

Additional hunting scenarios were created for Dehcho North, North Slave (TASR), Mackenzie, Zone D, and Zone R populations to determine the maximum sustainable harvest level before Lambda declined to 1.00, and to examine the effect of exceeding that harvest level by ten animals each year. The scenarios were:

6. Annual upper limit of cow only harvest where Lambda ≥ 1.00 (determined iteratively);
7. Annual upper limit of cow only harvest plus 10 additional cows;
8. Annual upper limit of bull only harvest where Lambda ≥ 1.00 (determined iteratively);
9. Annual upper limit of bull only harvest plus 10 additional bulls;
10. Annual upper limit of non-selective harvest where Lambda ≥ 1.00 (determined iteratively; with ratio of 6 bulls: 10 cows);
11. Annual upper limit of non-selective harvest plus 6 additional cows and 4 additional bulls.

6.1 Features common to all models

All models were stochastic individual-based models run 1000 times. All had the following attributes:

- The population was closed to immigration and emigration;
- Both sexes were included;
- Maximum level of polygyny was set at eight females bred by each male over 3 years old in each year;
- The inclusion of males and limits to polygyny will yield population models that account for the effects of unbalanced sex and age composition that may result from selective harvest;
- Age- and sex-specific survival as specified in Tables 3 to 8;
- Age-specific fecundity as specified in Tables 3 to 8;
- The initial population structure was generated by RAMAS from the initial population size and the survival and reproduction matrices prior to each model run;
- Between five and nine different hunting scenarios were modelled for each initial population size in each of the eight model populations as noted in Section 6 above and listed in Table C1;
- All models were density independent growth models;
- All model scenarios consider the total harvest within the model population; and
- All models were run for a ten-year period.

7. MODEL RESULTS AND IMPLICATIONS FOR MEETING MANAGEMENT OBJECTIVES

All model results are presented in Table C1 (Appendix C). A set of model scenarios; the Baseline and 10-caribou and 20-caribou non-selective harvests (scenarios 1, 2, and 3 described in Section 6 above) are also presented for each model population at each of three initial population sizes in Figures 2 to 9. The initial model population sizes presented in the Figures correspond to densities of 1.0, 3.0, and 5.0 caribou / 100 km^2; population sizes corresponding to those densities appear with each figure and in Table 2 and Table C1.

Stable baseline populations

The baseline models for Hay River Lowlands and Pine Point / Buffalo Lake each show a population in year ten that is unchanged from the initial population (Table C1, Figures 6 and 7). The λ value for these two South Slave region populations was 1.00, a value consistent with population stability. As λ is a rate, its application in models without any additional limiting factors will be the same regardless of the initial population size. Consequently, any level of harvest from a stable population results in population decline, regardless of initial population size. The declines in the models range from near or complete extirpation with an annual harvest of 10 caribou when the initial population size at Pine Point / Buffalo Lake is only 88 animals (Table C1, Figure 7) to a high of λ = 0.97 when there was non-selective harvest of 20 animals and the initial Hay River Lowlands population was set at 1140 caribou (Table C1, Figure 6). Figure 10 shows three different harvest scenario models for Hay River Lowlands, each with an annual harvest of 20 animals. The bull only harvest results in population decline of 0.8% over ten years while the cow only harvest results in a population decline by 4.0% over ten years. The non-selective harvest of 20 animals also results in a decline over ten years (2.8%). At any given density the composition of the harvest (i.e., the number of bulls compared to cows) will affect the total sustainable harvest. The patterns observed for Hay River Lowlands and Pine Point / Buffalo Lake were expected, and are consistent for other populations as well; hunting has a greater negative effect on a population when:

1. the initial population is smaller;
2. the harvest level is higher; or
3. the proportion of the harvest that is female is higher (i.e., at a given total harvest level, the effect is smallest when harvest is bulls only and highest when harvest is cows only [but see the discussion of the Mackenzie and Pine Point / Buffalo Lake populations below]).

Based on the vital rates used in the population models, neither Hay River Lowlands nor Pine Point / Buffalo Lake can sustain any level of harvest without decline.

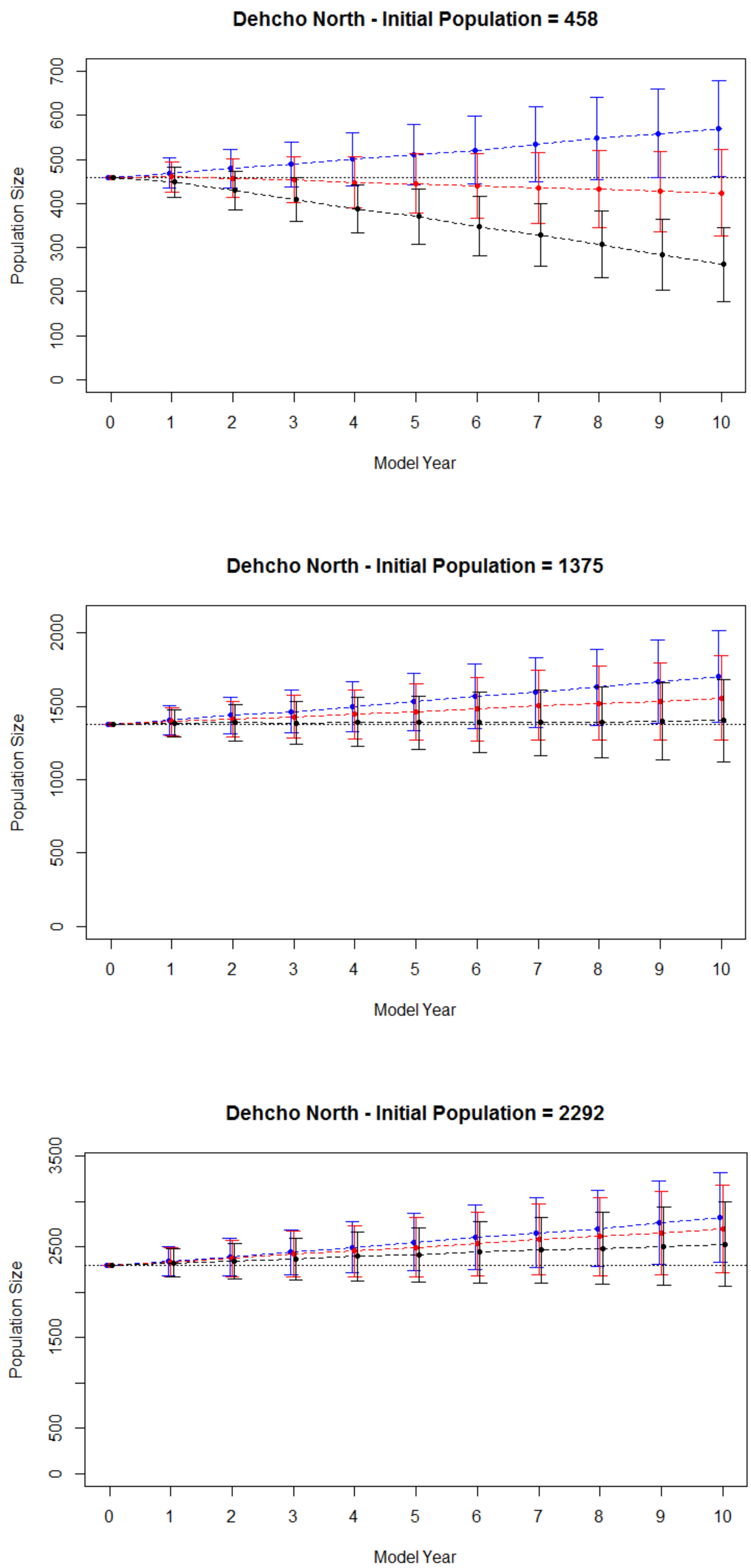

Figure 2: Dehcho North boreal caribou population model trajectories from three different initial populations. (a) 458 caribou (1 caribou / 100 km^2), (b) 1375 caribou (3 caribou / 100 km^2), and (c) 2292 caribou (5 caribou / 100 km^2). Each initial population was modelled for a 10-year period under three different hunting scenarios: no harvest (blue line); a non-selective harvest of 10 caribou per year (red line); and a non-selective harvest of 20 caribou per year (black line). All error bars are mean ± 1 SD. For reference, the horizontal black dotted line represents a stable population. Details of the models and their outcomes are listed in Table C1.

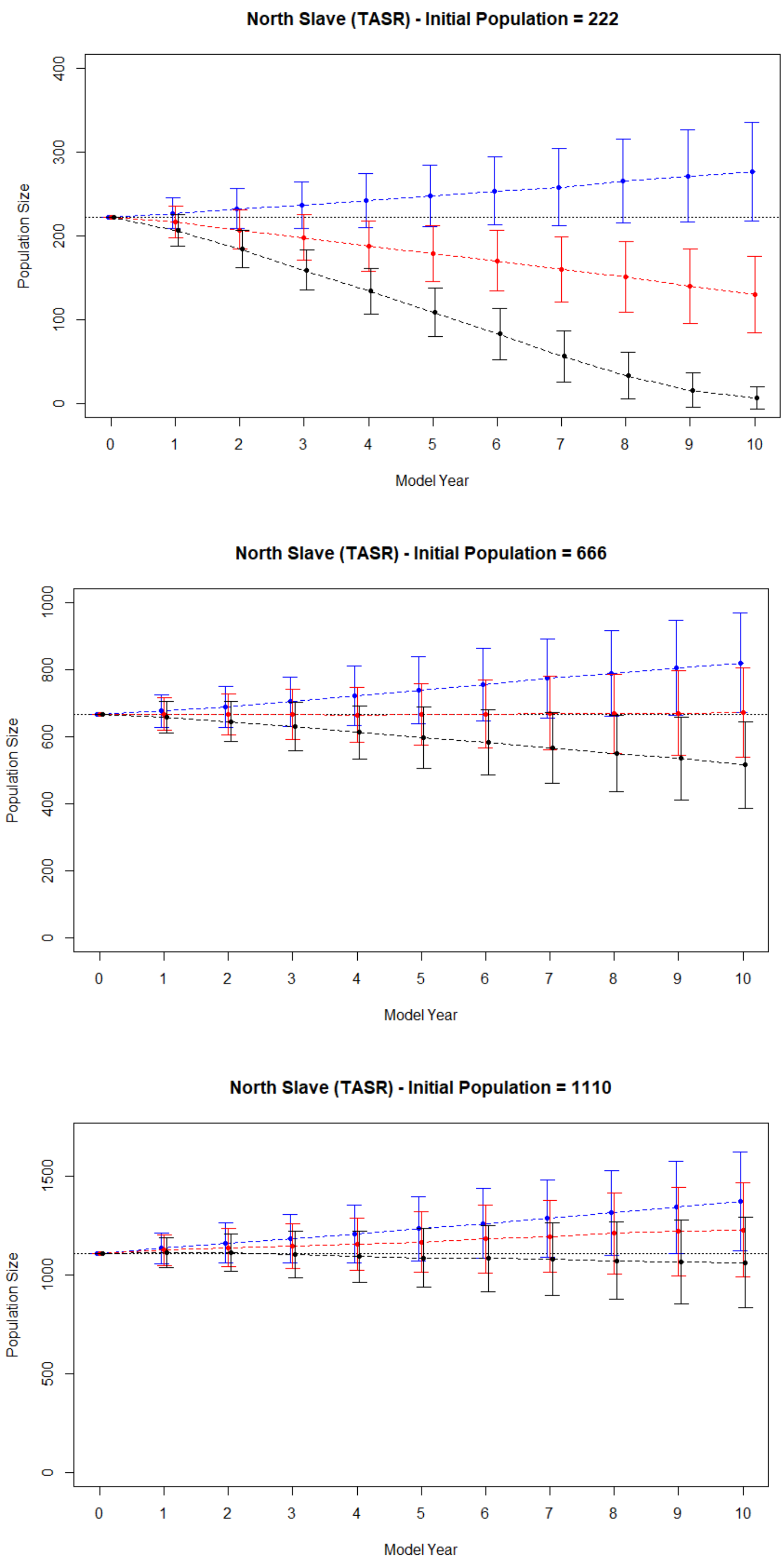

Figure 3: North Slave (TASR) boreal caribou population model trajectories from three different initial populations. (a) 222 caribou (1 caribou / 100 km^2), (b) 666 caribou (3 caribou / 100 km^2), and (c) 1110 caribou (5 caribou / 100 km^2). Each initial population was modelled for a 10-year period under three different hunting scenarios: no harvest (blue line); a non-selective harvest of 10 caribou per year (red line); and a non-selective harvest of 20 caribou per year (black line). All error bars are mean ± 1 SD. For reference, the horizontal black dotted line represents a stable population. Details of the models and their outcomes are listed in Table C1.

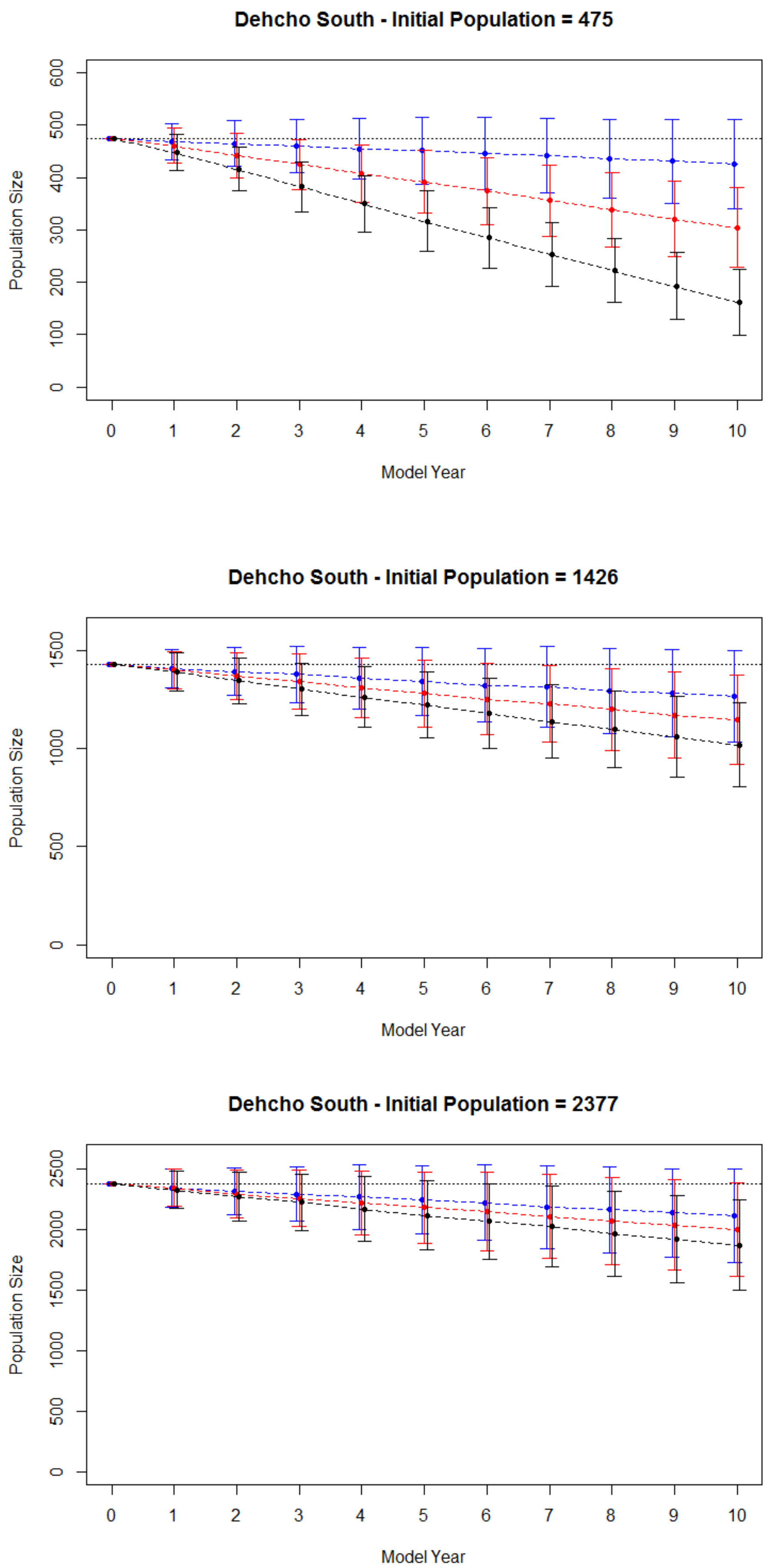

Figure 4: Dehcho South boreal caribou population model trajectories from three different initial populations. (a) 475 caribou (1 caribou / 100 km^2), (b) 1426 caribou (3 caribou / 100 km^2), and (c) 2377 caribou (5 caribou / 100 km^2),. Each initial population was modelled for a 10-year period under three different hunting scenarios: no harvest (blue line); a non-selective harvest of 10 caribou per year (red line); and a non-selective harvest of 20 caribou per year (black line). All error bars are mean ± 1 SD. For reference, the horizontal black dotted line represents a stable population. Details of the models and their outcomes are listed in Table C1.

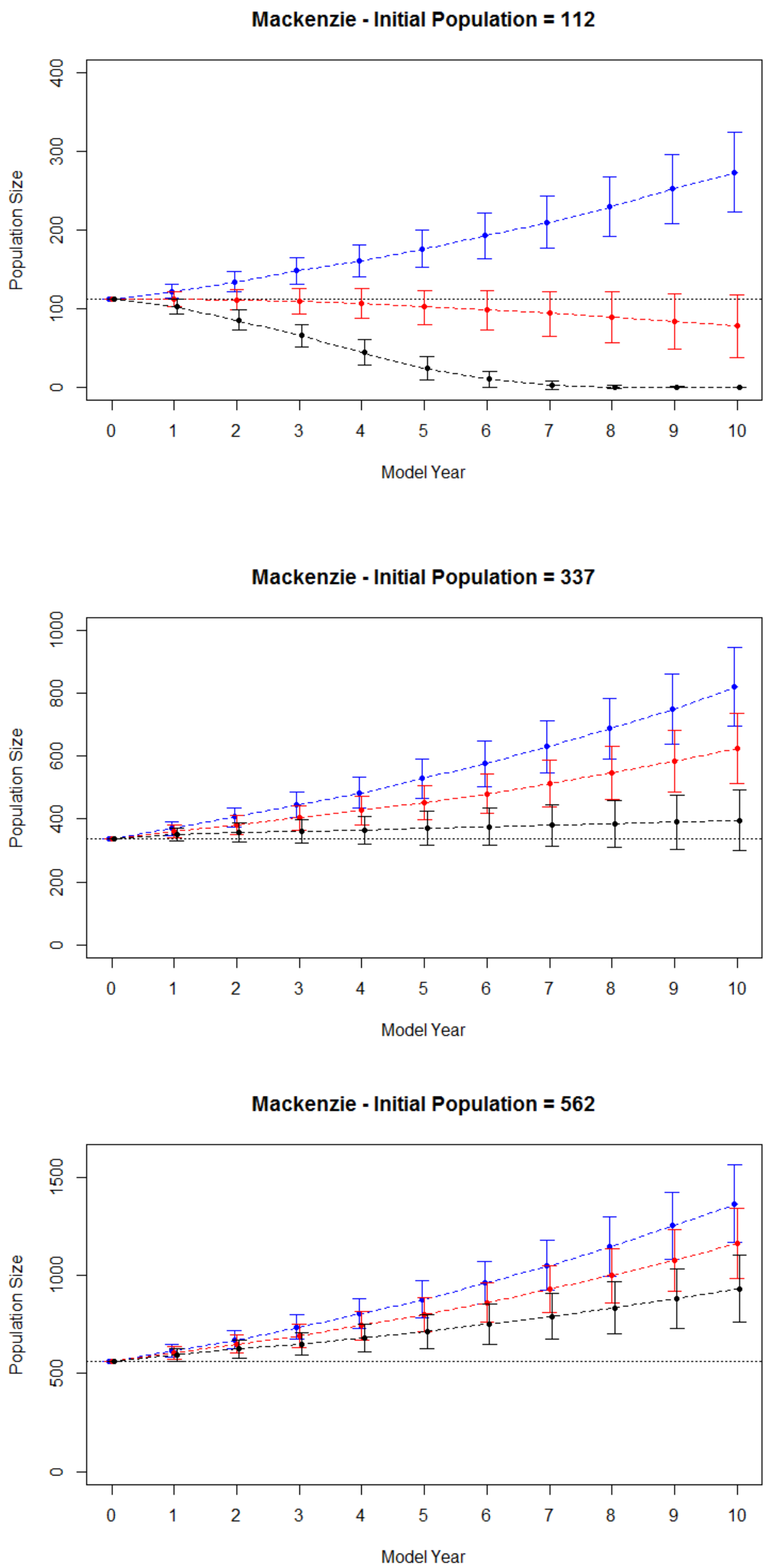

Figure 5: Mackenzie boreal caribou population model trajectories from three different initial populations. (a) 112 caribou (1 caribou / 100 km^2), (b) 337 caribou (3 caribou / 100 km^2), and (c) 562 caribou (5 caribou / 100 km^2). Each initial population was modelled for a 10-year period under three different hunting scenarios: no harvest (blue line); a non-selective harvest of 10 caribou per year (red line); and a non-selective harvest of 20 caribou per year (black line). All error bars are mean ± 1 SD. For reference, the horizontal black dotted line represents a stable population. Details of the models and their outcomes are listed in Table C1.

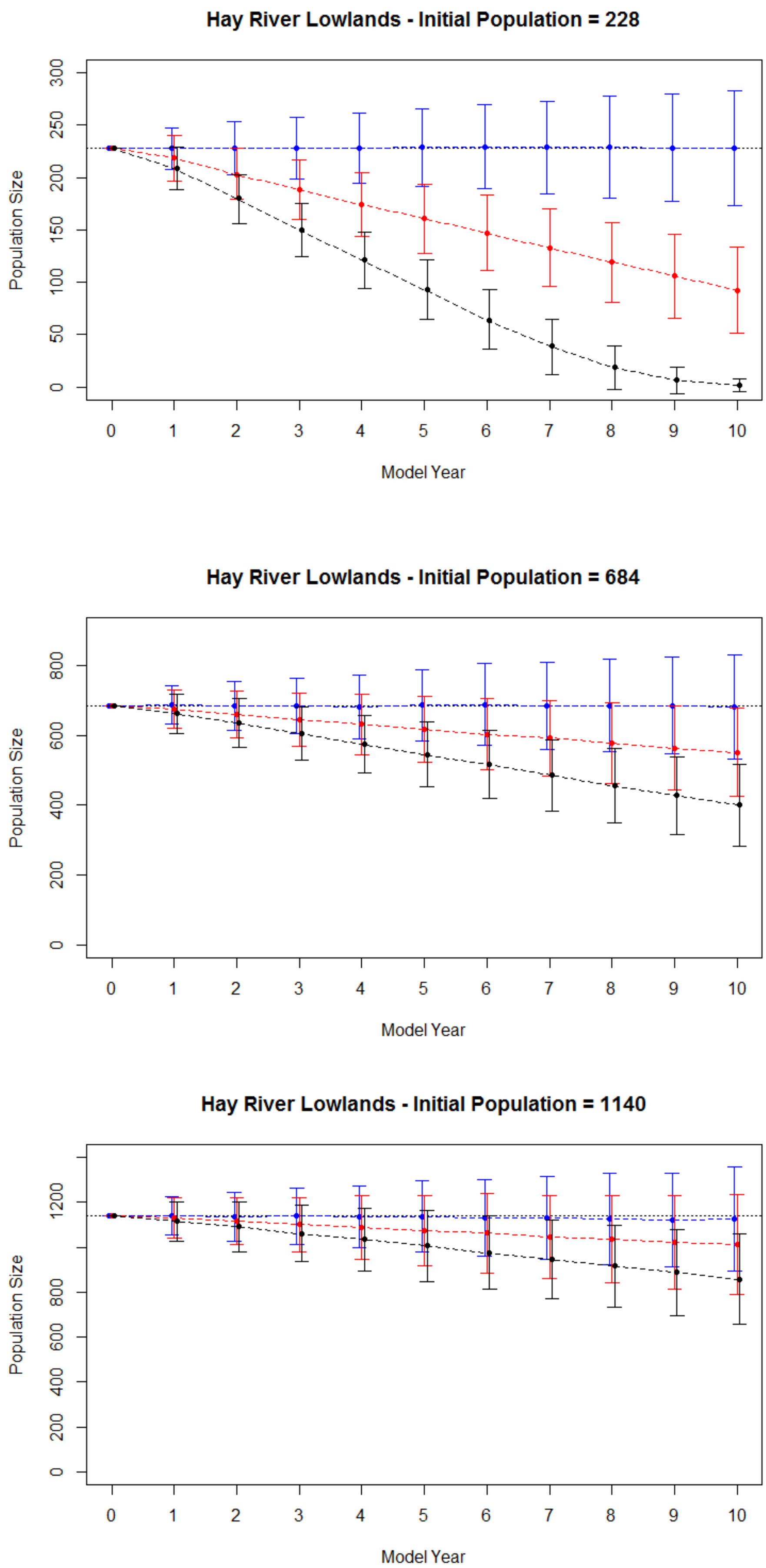

Figure 6: Hay River Lowlands boreal caribou population model trajectories from three different initial populations. (a) 228 caribou (1 caribou / 100 km^2), (b) 684 caribou (3 caribou / 100 km^2), and (c) 1140 caribou (5 caribou / 100 km^2). Each initial population was modelled for a 10-year period under three different hunting scenarios: no harvest (blue line); a non-selective harvest of 10 caribou per year (red line); and a non-selective harvest of 20 caribou per year (black line). All error bars are mean ± 1 SD. For reference, the horizontal black dotted line represents a stable population. Details of the models and their outcomes are listed in Table C1.

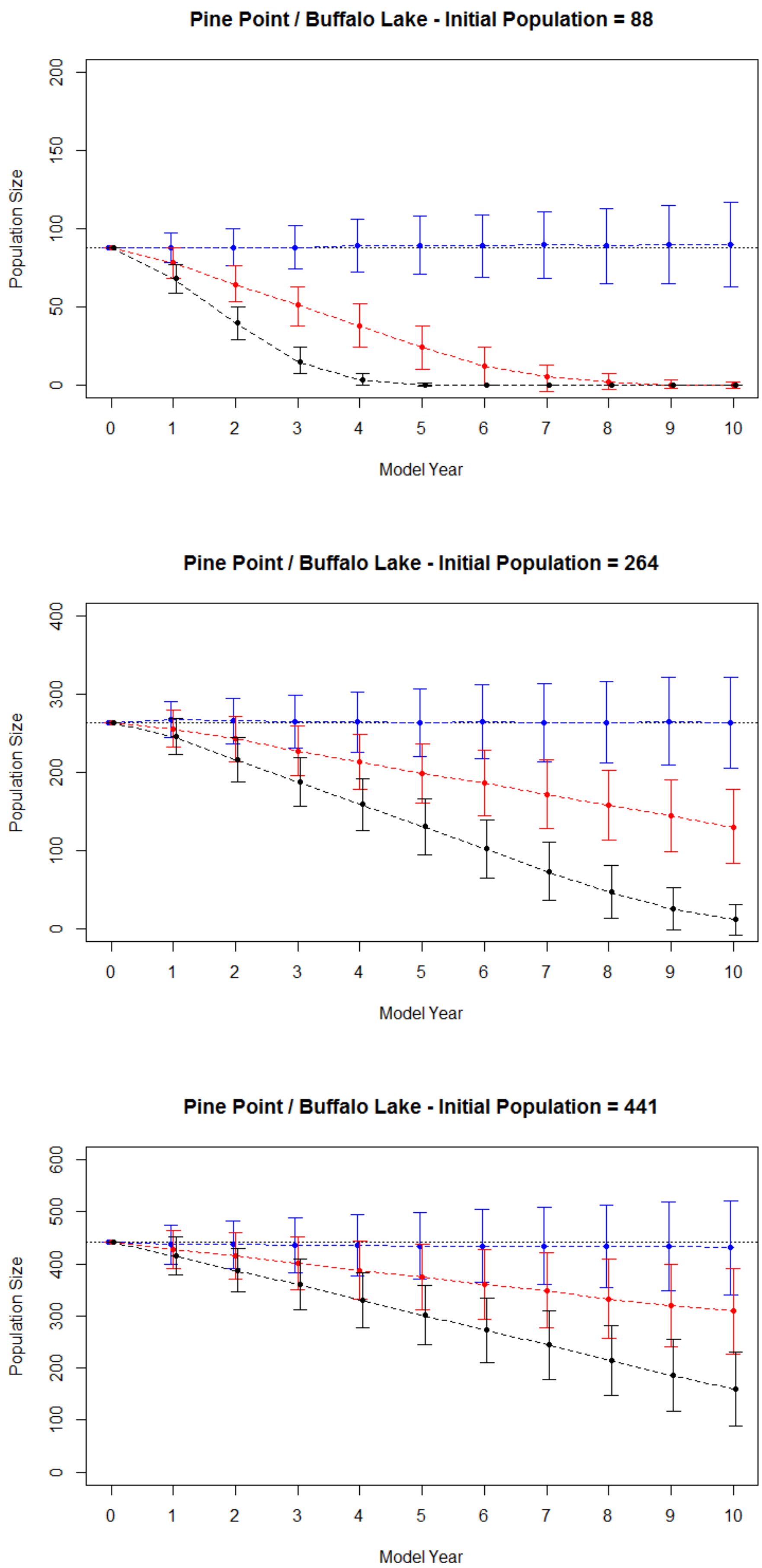

Figure 7: Pine Point / Buffalo Lake boreal caribou population model trajectories from three different initial populations. (a) 88 caribou (1 caribou / 100 km^2), (b) 264 caribou (3 caribou / 100 km^2), and (c) 441 caribou (5 caribou / 100 km^2). Each initial population was modelled for a 10-year period under three different hunting scenarios: no harvest (blue line); a non-selective harvest of 10 caribou per year (red line); and a non-selective harvest of 20 caribou per year (black line). All error bars are mean ± 1 SD. For reference, the horizontal black dotted line represents a stable population. Details of the models and their outcomes are listed in Table C1.

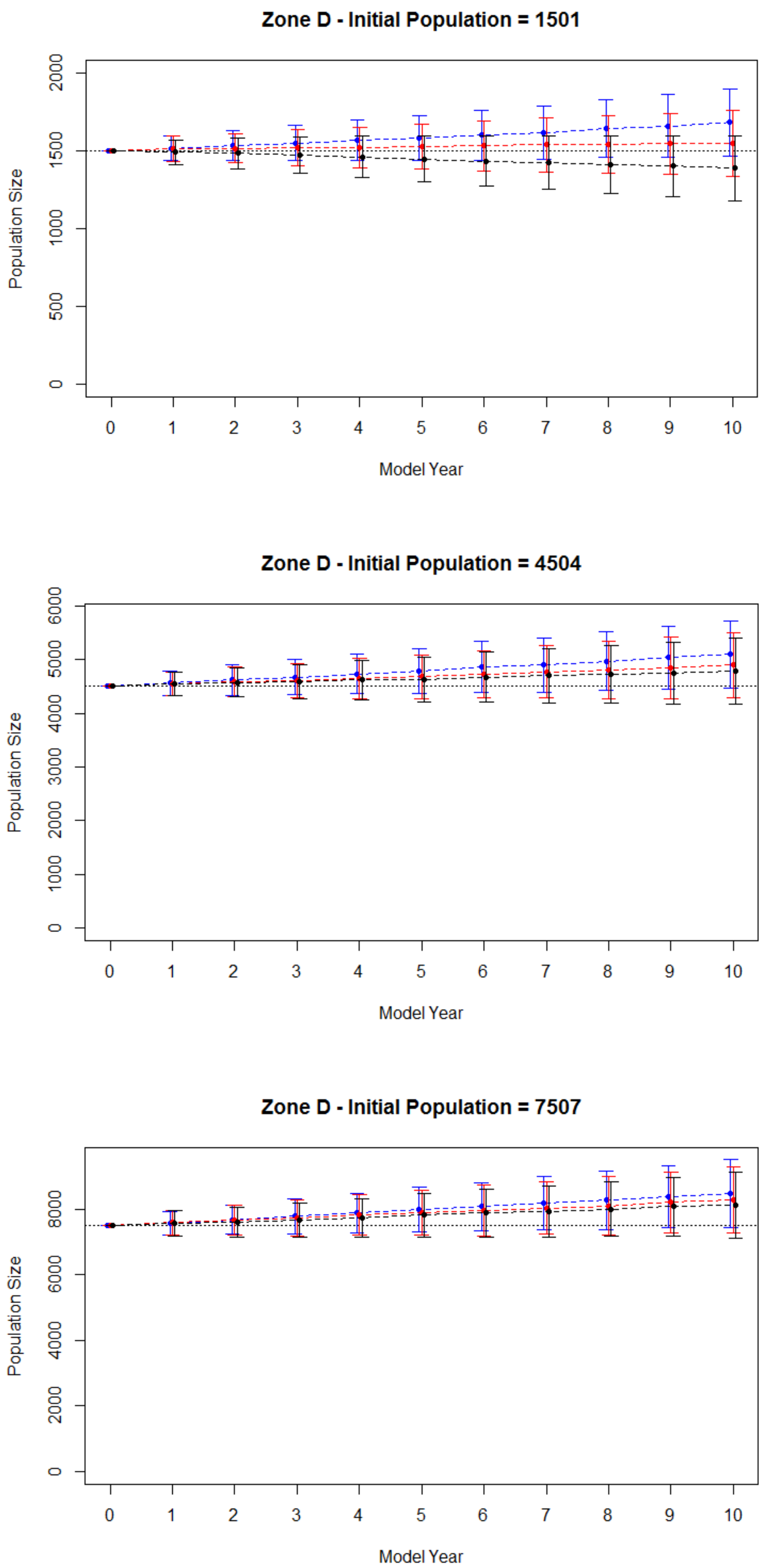

Figure 8: Wildlife Management Zone D boreal caribou population model trajectories from three different initial populations. (a) 1501 caribou (1 caribou / 100 km^2), (b) 4504 caribou (3 caribou / 100 km^2), and (c) 7507 caribou (5 caribou / 100 km^2). Each initial population was modelled for a 10-year period under three different hunting scenarios: no harvest (blue line); a non-selective harvest of 10 caribou per year (red line); and a non-selective harvest of 20 caribou per year (black line). All error bars are mean ± 1 SD. For reference, the horizontal black dotted line represents a stable population. Details of the models and their outcomes are listed in Table C1.

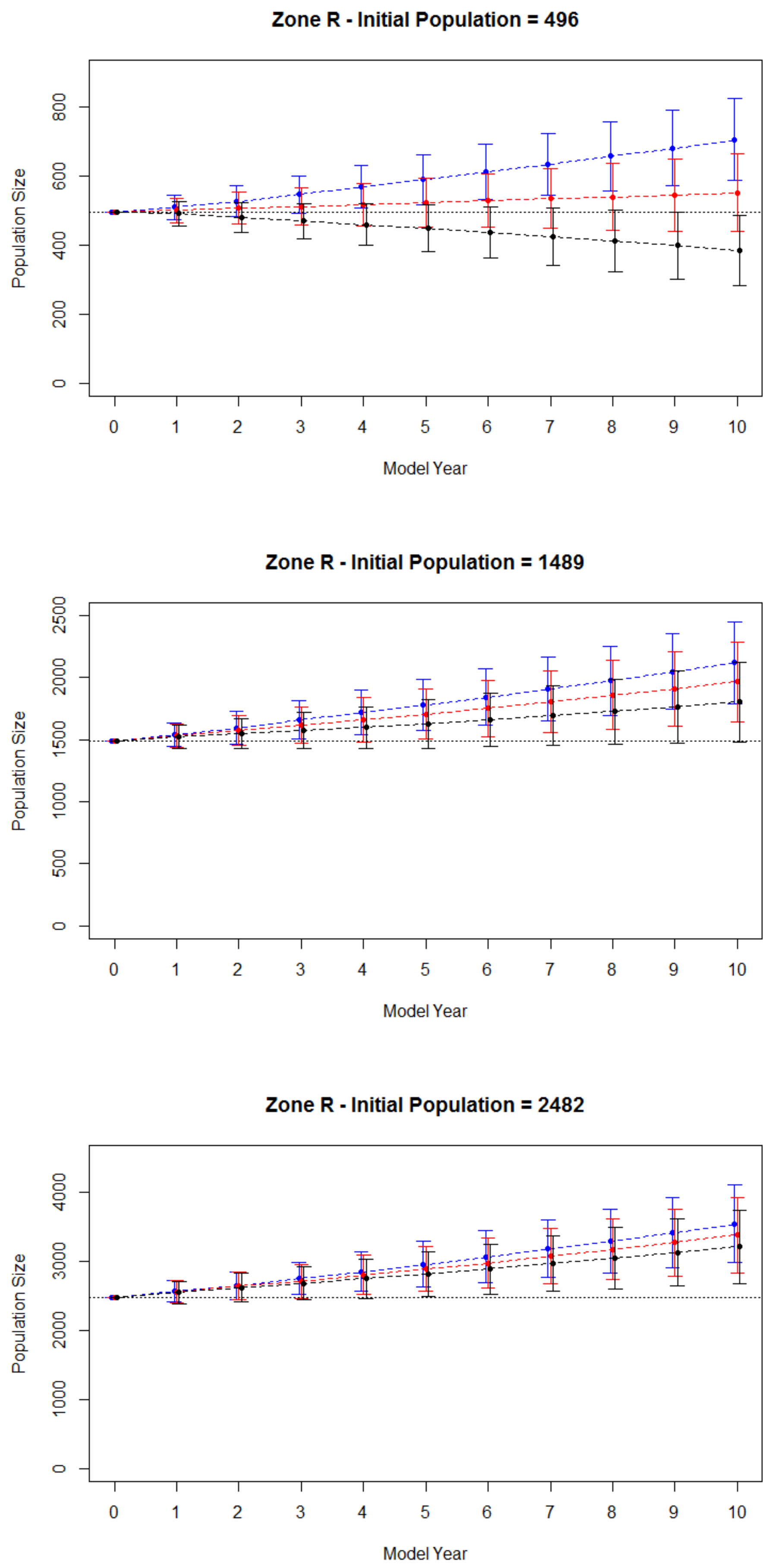

Figure 9: Wildlife Management Zone R boreal caribou population model trajectories from three different initial populations. (a) 496 caribou (1 caribou / 100 km^2), (b) 1489 caribou (3 caribou / 100 km^2), and (c) 2482 caribou (5 caribou / 100 km^2). Each initial population was modelled for a 10-year period under three different hunting scenarios: no harvest (blue line); a non-selective harvest of 10 caribou per year (red line); and a non-selective harvest of 20 caribou per year (black line). All error bars are mean ± 1 SD. For reference, the horizontal black dotted line represents a stable population. Details of the models and their outcomes are listed in Table C1.

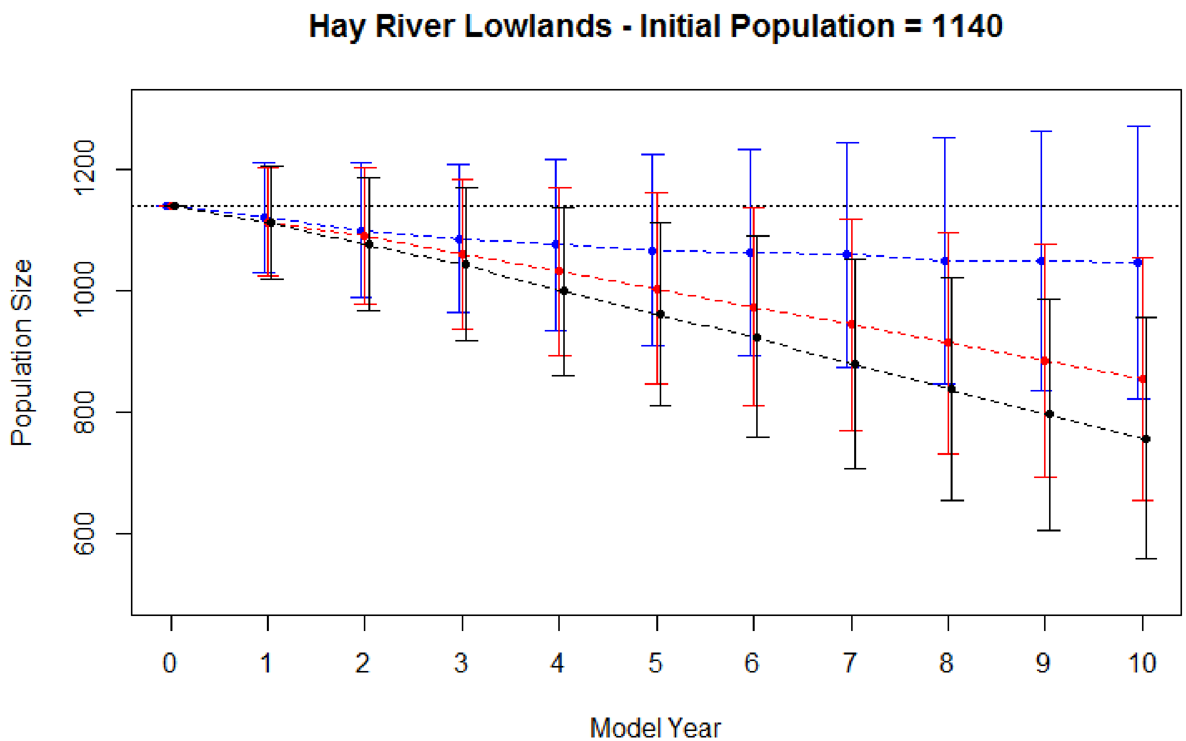

Figure 10: Hay River Lowlands boreal caribou population model trajectories from three different hunting scenarios with an initial population of 1140 caribou (3 caribou / 100 km^2). Each scenario was modelled for a 10-year period: a bull only harvest of 20 caribou per year (blue line); a non-selective harvest of 20 caribou per year (red line); a cow only harvest of 20 caribou per year (black line). All error bars are mean ± 1 SD. For reference, the horizontal black dotted line represents a stable population. Details of the models and their outcomes are listed in Table C1.

Increasing baseline populations

Three AOIs: Dehcho North; North Slave (TASR); and Mackenzie, and both WMZs: Zone D and Zone R all had baseline λ ≥ 1.00 and their baseline models show growth at every initial population size (Figures 2, 3, 5, 8, and 9; Table C1). Under scenarios 6, 8 and 10, each of these five populations was modelled by progressively increasing annual harvest until λ < 1.00. As an example, the Dehcho North population was able to sustain harvest of 5 cows and 3 bulls at the lowest initial population size (458 caribou, 1 caribou / 100 km^2) and a non-selective harvest of 27 cows and 17 bulls at the highest initial population size (2750 caribou, 6 caribou / 100 km^2; Tables 10 and C1). Those harvest sizes correspond to approximately 1.7% and 1.6% of the initial populations, respectively. A sustainable cow-only harvest would need to be lower than the sustainable non-selective harvest at each population size; conversely, a sustainable bull-only harvest may be more than double the size of the sustainable non-selective harvest for the same population at the same density (Table 10).

Like the Pine Point / Buffalo Lake population, the Mackenzie population is small (modelled initial populations between 112 and 674 caribou). Unlike the other populations, the Mackenzie population has vital rates that describe a population with higher annual growth potential (λ = 1.09). At the lowest initial population size considered, its upper limit of sustainable selective harvest is 5 cows and 3 bulls (Table 10) and at the highest initial population (6 caribou / 100 km^2) the upper limit of annual non-selective harvest is 29 cows and 17 bulls. However, at the smallest initial population size a non-selective harvest of 20 caribou per year will extirpate the population by year eight (Table C1, Figure 5). The small initial population size makes the Mackenzie population sensitive to the effects of over-harvest despite its vital rates being consistent with λ = 1.09.

The Mackenzie and Pine Point / Buffalo Lake populations are also more sensitive to bull harvests than any of the other populations. With an initial bull: cow ratio of 0.60 and a calf: cow ratio of 0.39 (Table B3), the initial model populations for Mackenzie model runs have a sex and age breakdown of 20 calves: 30 bulls: 50 cows for every 100 animals. Consequently, the smaller initial populations modelled for the Mackenzie area (112 and 225 animals; Table 2) contain 33 and 67 bulls respectively. After several years of bull-only harvest, or even non-selective harvest, the population may lack sufficient mature males to breed with remaining females. The same holds true for other small populations like Pine Point / Buffalo Lake and Hay River Lowlands at lower densities. A bias towards hunting bulls in small populations may have effects not realised in larger populations.

Dehcho North was the AOI with λ > 1.0 that had the largest population sizes modelled. At or above a starting population of 1375 caribou (3.0 caribou / 100 km^2), a non-selective harvest of 20 caribou annually is consistent with the Dehcho North remaining a self-sustaining population (Table 10, Table C1, Figure 2). Exceeding the sustainable non-selective harvest by approximately 10 caribou annually will still leave approximately 92% of the initial population by year ten; though inconsistent with NWT recovery strategy objective of self-sustaining populations (Section 1.1), a modest overharvest will not put the Dehcho North population at risk over a ten year period (Table C1). This is in contrast with the Mackenzie

Table 10: Upper limits of annual sustainable harvests for; non-selective; cow only; and bull only hunts for each modelled population at each potential population density[1]. Only managed populations with baseline population growth rates ≥ 1.00 are included. Excluded populations do not have a harvestable surplus of animals.

	Caribou / 100 km²:	1		2		3		4		5		6	
Managed Population	Licensed Hunting Model Scenario	Cow	Bull	Cow	Bull	Cow	Bull	Cow	Bull	Cow	Bull	Cow	Bull
Dehcho North	Non-Selective	5	3	9	5	13	8	18	11	23	14	27	17
	Cow Only	5		10		15		20		26		31	
	Bull Only		16		33		49		67		85		102
North Slave (TASR)	Non-Selective	2	1	4	2	6	4	9	5	11	6	13	7
	Cow Only	2		5		8		10		13		15	
	Bull Only		7		16		24		32		40		49
Mackenzie	Non-Selective	5	3	9	6	14	8	19	11	24	14	29	17
	Cow Only	6		11		16		22		27		33	
	Bull Only		8		16		25		33		41		50
Zone D	Non-Selective	8	5	16	10	24	15	32	20	40	24	50	30
	Cow Only	9		19		27		36		46		57	
	Bull Only		40		81		121		163		206		248
Zone R	Non-Selective	9	5	17	10	25	15	34	20	42	25	50	30
	Cow Only	9		18		28		37		47		57	
	Bull Only		22		45		69		92		115		137

[1]See Table 2 for population sizes associated with each density for each modelled population.

population, where the sustainable harvest at each density is similar to the sustainable harvest for Dehcho North, despite the Dehcho North range being about four times larger with about four times as many caribou at the same density. The small size of the Mackenzie population makes it susceptible to rapid decline when a few extra animals are harvested each year. The North Slave (TASR) population (Figure 3, Table 10, Table C1) is approximately half the size of the Dehcho North population. The two populations were modelled with the same vital rate matrix; hence the North Slave (TASR) sustainable harvest is approximately half the size of that determined for the Dehcho North (Table 10).

Declining baseline population

The Dehcho South population is the only AOI included in these analyses with $\lambda < 1.00$, and it is just below sustainability at $\lambda = 0.99$. At a moderate initial density of 3.0 caribou / 100 km^2 (population = 1426) it declines to 1267 caribou in ten years with no hunting (11% decline). With a non-selective harvest of 20 animals per year the year-10 population projection is 1017 animals (29% decline; Figure 4, Table C1).

Based on the best available information, the Dehcho South population cannot sustain any harvest.

Wildlife Management Zones

In the absence of hunting, the Zone D population has $\lambda = 1.011$, and shows slight growth in the baseline models (Figure 8, Table C1). It includes the Hay River Lowlands, Pine Point / Buffalo Lake, Dehcho South, and Dehcho North AOIs as well as part of the Mackenzie AOI (Figure 1). At a density of 2.0 caribou / 100 km^2, Zone D (initial population of 3003 caribou, Table 2) is estimated to have a capacity to incur non-selective hunting mortality of 26 animals before declining. Adding ten animals to the annual harvest leaves 98% of the initial population after ten years (Table C1). If the initial Zone D population is consistent with 5.0 caribou / 100 km^2 (7507 caribou, Table 2) it is estimated to decline with a non-selective harvest of anything more than 64 animals per year.

At the scale of Zone R, the baseline λ value is 1.04, growth of 4% per year. At a density of 2.0 caribou / 100 km^2 (initial population of 993 caribou, Table 2) a non-selective harvest of 27 caribou annually is sustainable. Adding ten animals to the annual harvest leaves 98% of the initial population after ten years (Table C1). If the initial Zone R population is consistent with 5.0 caribou / 100 km^2 (2482 caribou, Table 2) it is estimated to decline with a non-selective harvest of anything more than 67 animals per year. Like Dehcho North, Zone R is a larger population with λ above 1.00, and like Dehcho North it is also resistant to rapid long term population decline, even when there is modest additional harvest above sustainable levels.

If caribou densities are similar in Zones D and R, the total number of animals in Zone D will be approximately three times that of Zone R, owing to the size differences of the WMZs (Table 2). Despite potential differences in absolute numbers of animals, Zone R appears able to sustain a similar level of harvest as Zone D. As with the North Slave (TASR) and Mackenzie AOIs that it contains, the higher λ of Zone R makes it able to sustain a higher harvest relative to its population size than Zone D. The sustainable absolute harvest levels of the two WMZs will be similar if their densities are similar.

8. DISCUSSION AND RECOMMENDATIONS

The key management objective considered in this report is the assessment of the sustainability of boreal caribou harvest in the NWT. The absence of both accurate population estimates and accurate estimates of current hunter harvest means it is not possible to make absolute determinations of sustainable harvest levels. However, GNWT-ENR has a strong monitoring program in place to measure annual rates of adult female survival and calf recruitment and these are the best data available for boreal caribou in the NWT. Relying on the data currently collected by GNWT-ENR and used in the models presented here implies that

1. The vital rates of radio-collared female caribou are representative of all female caribou in the population. This is an assumption common to ungulate population studies and should generally hold true. However, Prichard et al. (2012) showed that when caribou are radio-collared for several consecutive years they yielded survival rates that underestimated the mean survival rate in the study population and overestimated recruitment rates. The likelihood is that λ values calculated from monitoring programs like the one used by GNWT-ENR are slightly underestimated, perhaps by 1% to 2%. From a conservation perspective, this would provide a buffer against overharvest and population decline; and
2. The composition survey data accurately reflect the calf: cow ratio of all adult females in the population.

The models appear most sensitive to two things: the initial population size assumed for each population and the levels of harvest. Strand et al. (2012) cautioned that imprecise population estimates and high harvest, especially for smaller populations, contributed to reindeer decline in Norway. For boreal caribou, accurate population estimates are challenging and expensive to obtain.

If it were the only boreal caribou harvest in the NWT, the limited harvest currently estimated for licensed resident hunters (21 animals per year) would be unlikely to have significant effects on NWT boreal caribou populations, though if the harvest was focused in one or more small geographic areas, the local caribou populations may not be sustainable. The licensed harvest should continue to be monitored for numbers and locations of animals harvested. The recent move to a male-only harvest for licensed resident hunters will increase the likelihood of both population and harvest sustainability.

The most important parameter not currently available for management decision making is an accurate estimate of total boreal caribou harvest (numbers of animals and their sexes), combining both licensed resident harvest and Indigenous harvest. Accurate estimates of Indigenous boreal caribou harvest rates would allow more accurate assessments of potential population growth rates. Coupling modelling results with accurate estimates of licensed resident plus Indigenous harvest would allow the evaluation of the importance of accurate population size estimates. For example, if the harvest in the Dehcho North AOI was known to consist of zero cows and fewer than 33 bulls, the model results would indicate that the harvest was sustainable as long as the total population density was ≥ 2 caribou / 100 km^2 (Table 10). The need for a precise population estimate would then depend on knowledge of population density relative to that density threshold. The collection of location information for both Indigenous and licensed harvest would allow GNWT-ENR to evaluate risk to caribou in specific AOIs, especially those with fewer caribou.

As the two WMZs represent the southern boreal caribou range in the NWT, their joint ability to support harvest can be regarded as the boreal caribou harvest capacity for the southern NWT. Modelled values from Table 10 can be considered guidelines for each of Zones D and R. Adding the Zone D and Zone R results in Table 10 suggests that at a density of 3 caribou / 100 km^2, the sustainable harvest estimate for the two southern boreal caribou regions in the NWT would be a non-selective harvest of 49 cows and 30 bulls, a cow-only harvest of 55 caribou, or a bull-only harvest of 190 animals. The model results from the individual AOIs suggest that this harvest should be from the Mackenzie, Dehcho North, and North Slave (TASR) areas and not from Dehcho South, Hay River Lowlands, or Pine Point / Buffalo Lake areas. As seen with the modelling results for Dehcho South, seemingly modest harvests can yield significant declines to populations on the edge of sustainability.

9. MONITORING OF MANAGEMENT EFFECTIVENESS

The measure of effectiveness of harvest limits on the NWT boreal caribou population will be to monitor the harvest and, in theory would include monitoring of the caribou population with sufficient precision to detect the effects of harvest. However, the recent estimated annual licensed harvest of boreal caribou in the NWT (21 caribou per year, Section 4.3) relative to the estimated NWT boreal caribou population (Table 2) will have an inconsequential effect on the territorial population and it will not be possible to measure the effect of such a small harvest through changes in population estimates or by relying on radio-collared caribou harvest mortalities.

Confirming the location and number of licensed hunter harvests and adding assessments of Indigenous harvest to current monitoring programs (i.e., licensed resident harvest assessments, radio-telemetry studies of adult female survival, and annual composition surveys) should be a priority. These measurements of harvest are in keeping with recommendations in the NWT boreal caribou recovery strategy (see Section 1.1). Incorporating updated total harvest estimates in population models will clarify:

- the importance of acquiring population estimates; or in their absence
- the risk of the harvest to the population.

The best available information from the current monitoring of adult female survival and recruitment through radio-collaring and classification surveys, has revealed boreal caribou populations (with the possible exception of the relatively small Mackenzie population) that are near the edge of sustainability from limiting factors other than hunting. Tables A1 through A4 indicate trends towards higher adult female survival rates in more recent years. The population models here adopted longer term (ten year) demographic data which buffer any short term trends. In this case it had the effect of estimating more conservative (lower) levels of sustainable harvest than would result by using only the most recent data. Retaining a commitment to using ten year data sets and revisiting sustainable harvest modelling with updated survival, recruitment, and harvest data every three to five years is recommended.

Population surveys are unlikely to provide more accurate information for decision making than the currently available vital rate data. From available data, the sustainable harvestable surplus of boreal caribou in WMZs D and R is likely small, and depends on actual population densities and the harvest strategy adopted. Temporary harvest limitations may be justified especially in the southern AOIs in Zone D. The restriction of licensed resident harvest to males-only is a prudent decision.

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APPENDIX A

Northwest Territories Boreal Caribou adult female survival summaries

Table A1: Population specific annual adult female boreal caribou survival rates, with and without hunting mortality. To August 31, 2018

Population	Year[1]	Sample Size[2]	Hunter Kill	Overall Survival Rate[3] (SE)	Survival Rate[3] excluding hunter kill (SE)
Cameron	2003	3		1.000 (0.000)	1.000 (0.000)
Cameron	2004	21		0.667 (0.272)	0.667 (0.272)
Cameron	2005	32		0.900 (0.067)	0.900 (0.067)
Cameron	2006	43		0.764 (0.078)	0.764 (0.078)
Cameron	2007	40		0.935 (0.044)	0.935 (0.044)
Cameron	2008	33		0.788 (0.071)	0.788 (0.071)
Cameron	2009	26	1	0.718 (0.099)	0.766 (0.093)
Cameron	2010	14		0.750 (0.217)	0.750 (0.217)
Cameron	2011	3		1.000 (0.000)	1.000 (0.000)
Dehcho North	2004	5		0.800 (0.179)	0.800 (0.179)
Dehcho North	2005	12		0.750 (0.217)	0.750 (0.217)
Dehcho North	2006	19		0.727 (0.134)	0.727 (0.134)
Dehcho North	2007	20	1	0.812 (0.097)	0.867 (0.087)
Dehcho North	2008	21	2	0.765 (0.102)	0.878 (0.080)
Dehcho North	2009	23	2	0.615 (0.134)	0.755 (0.123)
Dehcho North	2010	15		0.933 (0.064)	0.933 (0.064)
Dehcho North	2011	22	1	0.726 (0.118)	0.782 (0.113)
Dehcho North	2012	21		0.846 (0.100)	0.846 (0.100)
Dehcho North	2013	21		0.692 (0.128)	0.692 (0.128)
Dehcho North	2014	21		1.000 (0.000)	1.000 (0.000)
Dehcho North	2015	24		0.792 (0.093)	0.792 (0.093)
Dehcho North	2016	40		0.724 (0.118)	0.724 (0.118)
Dehcho North (plus North Slave [TASR])	2017	44		0.970 (0.029)	0.970 (0.029)
Dehcho North (plus North Slave [TASR])	2018	43		0.974 (0.025)	0.974 (0.025)
Dehcho South	2003	6		1.000 (0.000)	1.000 (0.000)
Dehcho South	2004	18		0.800 (0.126)	0.800 (0.126)
Dehcho South	2005	21		0.625 (0.121)	0.625 (0.121)

Table A1: Population specific annual adult female boreal caribou survival rates, with and without hunting mortality. To August 31, 2018

Population	Year[1]	Sample Size[2]	Hunter Kill	Overall Survival Rate[3] (SE)	Survival Rate[3] excluding hunter kill (SE)
Dehcho South	2006	24		0.667 (0.121)	0.667 (0.121)
Dehcho South	2007	23		0.941 (0.057)	0.941 (0.057)
Dehcho South	2008	24		0.897 (0.068)	0.897 (0.068)
Dehcho South	2009	26		0.898 (0.068)	0.898 (0.068)
Dehcho South	2010	21		0.757 (0.107)	0.757 (0.107)
Dehcho South	2011	19		0.909 (0.086)	0.909 (0.086)
Dehcho South	2012	20		0.929 (0.068)	0.929 (0.068)
Dehcho South	2013	23		0.643 (0.128)	0.643 (0.128)
Dehcho South	2014	20		0.950 (0.048)	0.950 (0.048)
Dehcho South	2015	25		0.727 (0.104)	0.727 (0.104)
Dehcho South	2016	22		0.774 (0.099)	0.774 (0.099)
Dehcho South	2017	25	1	0.847 (0.103)	0.900 (0.094)
Dehcho South	2018	17		1.000 (0.000)	1.000 (0.000)
Mackenzie	2014	9		1.000 (0.000)	1.000 (0.000)
Mackenzie	2015	12		1.000 (0.000)	1.000 (0.000)
Mackenzie	2016	30		0.917 (0.079)	0.917 (0.079)
Mackenzie	2017	34		0.867 (0.062)	0.867 (0.062)
Mackenzie	2018	30		0.967 (0.032)	0.967 (0.032)
South Slave	2002	17		1.000 (0.000)	1.000 (0.000)
South Slave	2003	35		0.765 (0.102)	0.765 (0.102)
South Slave	2004	33		0.903 (0.053)	0.903 (0.053)
South Slave	2005	33	1	0.900 (0.054)	0.933 (0.045)
South Slave	2006	37	1	0.857 (0.066)	0.890 (0.059)
South Slave	2007	44	1	0.843 (0.064)	0.874 (0.059)
South Slave	2008	37		0.909 (0.050)	0.909 (0.050)
South Slave	2009	29		0.828 (0.080)	0.828 (0.080)
South Slave	2010	14		0.745 (0.131)	0.745 (0.131)
South Slave	2011	7		0.800 (0.179)	0.800 (0.179)

Table A1: Population specific annual adult female boreal caribou survival rates, with and without hunting mortality. To August 31, 2018

Population	Year[1]	Sample Size[2]	Hunter Kill	Overall Survival Rate[3] (SE)	Survival Rate[3] excluding hunter kill (SE)
South Slave	2012	27		1.000 (0.000)	1.000 (0.000)
South Slave	2013	37		0.667 (0.090)	0.667 (0.090)
South Slave	2014	45		0.854 (0.067)	0.854 (0.067)
South Slave	2015	52		0.801 (0.063)	0.801 (0.063)
South Slave	2016	65		0.935 (0.036)	0.935 (0.036)
South Slave	2017	82		0.928 (0.035)	0.928 (0.035)
South Slave	2018	68		0.970 (0.020)	0.970 (0.020)
Zone D	2002	17		1.000 (0.000)	1.000 (0.000)
Zone D	2003	41		0.765 (0.102)	0.765 (0.103)
Zone D	2004	56		0.851 (0.052)	0.861 (0.053)
Zone D	2005	66	1	0.800 (0.057)	0.820 (0.054)
Zone D	2006	80	1	0.778 (0.057)	0.794 (0.055)
Zone D	2007	87	2	0.863 (0.042)	0.891 (0.039)
Zone D	2008	82	2	0.870 (0.040)	0.898 (0.037)
Zone D	2009	78	2	0.795 (0.055)	0.832 (0.052)
Zone D	2010	50		0.814 (0.060)	0.814 (0.060)
Zone D	2011	48	1	0.798 (0.075)	0.824 (0.073)
Zone D	2012	68		0.889 (0.061)	0.889 (0.061)
Zone D	2013	81		0.668 (0.064)	0.668 (0.064)
Zone D	2014	95		0.920 (0.034)	0.920 (0.034)
Zone D	2015	113		0.803 (0.043)	0.803 (0.043)
Zone D	2016	138		0.865 (0.037)	0.865 (0.037)
Zone D	2017	162	1	0.915 (0.026)	0.923 (0.025)
Zone D	2018	136		0.969 (0.015)	0.969 (0.015)
Zone R	2004	5		0.800 (0.179)	0.800 (0.179)
Zone R	2005	12		0.750 (0.217)	0.750 (0.217)
Zone R	2006	19		0.727 (0.134)	0.727 (0.134)
Zone R	2007	20	1	0.812 (0.098)	0.867 (0.088)

Table A1: Population specific annual adult female boreal caribou survival rates, with and without hunting mortality. To August 31, 2018

Population	Year[1]	Sample Size[2]	Hunter Kill	Overall Survival Rate[3] (SE)	Survival Rate[3] excluding hunter kill (SE)
Zone R	2008	21	2	0.765 (0.103)	0.878 (0.081)
Zone R	2009	23	2	0.615 (0.135)	0.755 (0.123)
Zone R	2010	15		0.933 (0.064)	0.933 (0.064)
Zone R	2011	22	1	0.726 (0.119)	0.782 (0.114)
Zone R	2012	21		0.846 (0.100)	0.846 (0.100)
Zone R	2013	21		0.692 (0.128)	0.692 (0.128)
Zone R	2014	30		1.000 (0.000)	1.000 (0.000)
Zone R	2015	36		0.859 (0.066)	0.859 (0.066)
Zone R	2016	70		0.815 (0.075)	0.815 (0.075)
Zone R	2017	78		0.920 (0.034)	0.920 (0.034)
Zone R	2018	73		0.972 (0.020)	0.972 (0.020)

[1] Monitoring year from April 1 of the nominal year to March 31 of the following year. Data from 2018 truncated at August 31, 2018.
[2] Total number of female caribou monitored for at least a portion of the year.
[3] Kaplan-Meier survival estimate; Greenwood standard error (SE) estimate.

Table A2: Pooled ten year annual adult female boreal caribou survival rates, excluding hunting mortality. Data from 1 April 2008 to 31 August 2018.

Population	Annual Survival Rate	Standard Error	Lower 95% Confidence Interval	Upper 95% Confidence Interval
Dehcho North[1]	0.867	0.025	0.820	0.918
Dehcho South	0.847	0.028	0.794	0.903
Mackenzie[2]	0.915	0.034	0.850	0.984
South Slave	0.870	0.019	0.834	0.909
Zone D	0.864	0.013	0.839	0.890
Zone R	0.880	0.021	0.841	0.921
All Populations Pooled	0.862	0.012	0.838	0.886

[1]Includes North Slave (TASR) Data for 2017 and 2018

[2]Mackenzie population data collection began on 1 April 2015. They are only for a three year period compared with a ten year period for each of the other populations.

Table A3: Pooled five year annual adult female boreal caribou survival rates, excluding hunting mortality. Data from 1 April 2013 to 31 August 2018

Population	Annual Survival Rate	Standard Error	Lower 95% Confidence Interval	Upper 95% Confidence Interval
Dehcho North[1]	0.873	0.033	0.811	0.939
Dehcho South	0.822	0.041	0.746	0.907
Mackenzie[2]	0.915	0.034	0.850	0.984
South Slave	0.879	0.021	0.838	0.921
Zone D	0.868	0.016	0.838	0.899
Zone R	0.888	0.024	0.842	0.937
All Populations Pooled	0.874	0.015	0.845	0.903

[1]Includes North Slave (TASR) Data for 2017 and 2018

[2]Mackenzie population data collection began on 1 April 2015. They are only for a three year period compared with a five year period for each of the other populations.

Table A4: Pooled three year annual adult female boreal caribou survival rates, excluding hunting mortality. Data from 1 April 2015 to 31 August 2018.

Population	Annual Survival Rate	Standard Error	Lower 95% Confidence Interval	Upper 95% Confidence Interval
Dehcho North	0.882	0.037	0.813	0.957
Dehcho South	0.832	0.050	0.740	0.936
Mackenzie	0.915	0.034	0.850	0.984
South Slave	0.913	0.021	0.873	0.954
Zone D	0.890	0.016	0.858	0.922
Zone R	0.896	0.026	0.847	0.947
All Populations Pooled	0.895	0.016	0.865	0.926

APPENDIX B

Northwest Territories Boreal Caribou late winter composition survey summaries

Table B1: Dehcho North late winter classification survey results including recruitment rates 2006 to 2018.

Year	Groups Observed	Total Caribou	Bulls	Cows	Yearlings	Calves	Unknown	Adjusted cows[1]	Calf: cow Ratio	SE Calf: cow Ratio
2006	13	73	14	39	6	13	1	40	0.327	0.075
2007	18	110	36	58	4	12	0	58	0.207	0.054
2008	17	92	25	56	0	11	0	56	0.196	0.054
2009	14	95	23	52	1	19	0	52	0.365	0.067
2010	19	104	35	51	0	18	0	51	0.353	0.068
2011	21	101	37	42	1	19	2	43	0.441	0.077
2012	29	112	31	56	0	25	0	56	0.446	0.067
2013	21	122	34	69	1	18	0	69	0.261	0.053
2014	22	93	27	52	1	13	0	52	0.250	0.061
2015	22	170	56	78	0	36	0	78	0.462	0.057
2016	28	121	27	69	1	24	0	69	0.348	0.058
2017	32	199	85	81	0	33	0	81	0.407	0.055
2018[2]	68	368	98	206	0	64	0	206	0.311	0.032
Ten year (2009 to 2018) geometric mean									**0.357**	**0.019[3]**

[1] Within each year, all "unknown" caribou were apportioned based on year-specific bull: cow ratios to yield the adjusted number of cows for the calculation of calf: cow ratios.

[2]Classification counts for 2018 include North Slave (TASR) survey data.

[3] Standard Error (SE) of the geometric mean determined from distribution of geometric means of calf: cow values for each year, each year's calf: cow ratio determined through Monte Carlo simulations based on annual calf: cow ratio and its SE. The standard deviation for 2009 to 2018 is 0.075.

Table B2: Dehcho South late winter classification survey results including recruitment rates 2006 to 2018.

Year	Groups Observed	Total Caribou	Bulls	Cows	Yearlings	Calves	Unknown	Adjusted cows[1]	Calf: cow Ratio	SE Calf: cow Ratio
2006	17	97	21	55	7	14	0	55	0.255	0.059
2007	21	106	34	56	2	14	0	56	0.250	0.058
2008	25	149	36	89	1	23	0	89	0.258	0.047
2009	27	196	57	108	0	31	0	108	0.287	0.044
2010	28	131	26	77	1	27	0	77	0.351	0.055
2011	14	60	13	32	1	14	0	32	0.438	0.089
2012	17	85	21	48	1	15	0	48	0.313	0.068
2013	25	160	50	84	1	25	0	84	0.298	0.050
2014	20	103	32	54	0	16	1	55	0.293	0.062
2015	22	133	43	61	2	27	0	61	0.443	0.064
2016	18	92	26	50	1	13	2	51	0.253	0.061
2017	24	138	32	69	1	29	7	74	0.393	0.057
2018	30	140	32	80	0	28	0	80	0.350	0.054
					Ten year (2009 to 2018) geometric mean				**0.336**	**0.020[2]**

[1] Within each year, all "unknown" caribou were apportioned based on year-specific bull: cow ratios to yield the adjusted number of cows for the calculation of calf: cow ratios.

[2] Standard Error (SE) of the geometric mean determined from distribution of geometric means of calf: cow values for each year, each year's calf: cow ratio determined through Monte Carlo simulations based on annual calf: cow ratio and its SE. The standard deviation for 2009 to 2018 is 0.065.

Table B3: Mackenzie late winter classification survey results including recruitment rates 2015 to 2018.

Year	Groups Observed	Total Caribou	Bulls	Cows	Yearlings	Calves	Unknown	Adjusted cows[1]	Calf: cow Ratio	SE Calf: cow Ratio
2015	11	80	17	44	0	19	0	44	0.432	0.076
2016	12	90	27	45	0	18	0	45	0.400	0.074
2017	26	99	23	54	0	22	0	54	0.407	0.067
2018	22	108	16	68	0	23	1	69	0.334	0.057
					Four year (2015 to 2018) geometric mean				**0.392**	**0.035**[2]

[1] Within each year, all "unknown" caribou were apportioned based on year-specific bull: cow ratios to yield the adjusted number of cows for the calculation of calf: cow ratios.

[2] Standard Error (SE) of the geometric mean determined from distribution of geometric means of calf: cow values for each year, each year's calf: cow ratio determined through Monte Carlo simulations based on annual calf: cow ratio and its SE. The standard deviation for 2015 to 2018 is 0.042.

Table B4: South Slave late winter classification survey results including recruitment rates 2009 to 2018.

Year	Groups Observed	Total Caribou	Bulls	Cows	Yearlings	Calves	Unknown	Adjusted cows[1]	Calf: cow Ratio	SE Calf: cow Ratio
2009	Raw data not provided. Calf: cow and SE calf: cow ratios provided.								0.190	0.035
2010	Raw data not provided. Calf: cow and SE calf: cow ratios provided								0.500	0.061
2011	Raw data not provided. Calf: cow and SE calf: cow ratios provided								0.254	0.060
2012	No survey									
2013	34	167	59	83	0	23	2	84	0.273	0.049
2014	26	126	32	77	0	16	1	78	0.206	0.046
2015	47	299	85	154	0	58	2	155	0.373	0.039
2016	44	224	60	119	0	43	2	120	0.357	0.044
2017	73	458	125	240	0	82	11	247	0.332	0.030
2018	66	422	93	250	0	78	1	251	0.311	0.029
					Ten year (2009 to 2018) geometric mean				**0.298**	**0.017[2]**

[1] Within each year, all "unknown" caribou were apportioned based on year-specific bull: cow ratios to yield the adjusted number of cows for the calculation of calf: cow ratios.

[2] Standard Error (SE) of the geometric mean determined from distribution of geometric means of calf: cow values for each year, each year's calf: cow ratio determined through Monte Carlo simulations based on annual calf: cow ratio and its SE. The standard deviation for 2009 to 2018 is 0.095.

Table B5: Zone D late winter classification survey results including recruitment rates 2006 to 2018.

Year	Groups Observed	Total Caribou	Bulls	Cows	Yearlings	Calves	Unknown	Adjusted cows[1]	Calf: cow Ratio	SE Calf: cow Ratio
2006	30	170	35	94	13	27	1	95	0.285	0.047
2007	39	216	70	114	6	26	0	114	0.228	0.039
2008	42	241	61	145	1	34	0	145	0.234	0.035
2009[2]	41	291	80	160	1	50	0	160	0.313	0.037
2010[2]	47	235	61	128	1	45	0	128	0.352	0.042
2011[2]	35	161	50	74	2	33	2	75	0.439	0.058
2012	46	197	52	104	1	40	0	104	0.385	0.048
2013	80	449	143	236	2	66	0	237	0.278	0.029
2014	68	322	91	183	1	45	0	184	0.244	0.032
2015	102	682	201	337	2	140	0	338	0.414	0.027
2016	102	527	140	283	2	98	0	286	0.343	0.028
2017	155	894	265	444	1	166	0	455	0.365	0.023
2018[3]	155	848	199	490	0	157	2	491	0.319	0.021
					Ten year (2009 to 2018) geometric mean				**0.340**	**0.011[4]**

[1] Within each year, all "unknown" caribou were apportioned based on year-specific bull: cow ratios to yield the adjusted number of cows for the calculation of calf: cow ratios.

[2] 2009 to 2011 classification survey data from Hay River Lowlands are not included as raw data were not available

[3] Classification counts for 2018 include North Slave (TASR) survey data.

[4] Standard Error (SE) of the geometric mean determined from distribution of geometric means of calf: cow values for each year, each year's calf: cow ratio determined through Monte Carlo simulations based on annual calf: cow ratio and its SE. The standard deviation for 2009 to 2018 is 0.060.

Table B6: Zone R late winter classification survey results including recruitment rates 2006 to 2018.

Year	Groups Observed	Total Caribou	Bulls	Cows	Yearlings	Calves	Unknown	Adjusted cows[1]	Calf: cow Ratio	SE Calf: cow Ratio
2006	13	73	14	39	6	13	1	40	0.327	0.075
2007	18	110	36	58	4	12	0	58	0.207	0.054
2008	17	92	25	56	0	11	0	56	0.196	0.054
2009	14	95	23	52	1	19	0	52	0.365	0.067
2010	19	104	35	51	0	18	0	51	0.353	0.068
2011	21	101	37	42	1	19	2	43	0.441	0.077
2012	29	112	31	56	0	25	0	56	0.446	0.067
2013	21	122	34	69	1	18	0	69	0.261	0.053
2014	22	93	27	52	1	13	0	52	0.250	0.061
2015	33	250	73	122	0	55	0	122	0.451	0.045
2016	40	211	54	114	1	42	0	114	0.368	0.045
2017	58	298	108	135	0	55	0	135	0.407	0.042
2018	90	476	114	274	0	87	1	275	0.317	0.028
					Ten year (2009 to 2018) geometric mean				**0.359**	**0.019[2]**

[1] Within each year, all "unknown" caribou were apportioned based on year-specific bull: cow ratios to yield the adjusted number of cows for the calculation of calf: cow ratios.

[2] Standard Error (SE) of the geometric mean determined from distribution of geometric means of calf: cow values for each year, each year's calf: cow ratio determined through Monte Carlo simulations based on annual calf: cow ratio and its SE. The standard deviation for 2009 to 2018 is 0.073.

APPENDIX C

Northwest Territories Boreal Caribou population and harvest scenario modelling summaries

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Dehcho North	Baseline - No Hunting	458	0	0	570	1.022	461	1.001
Dehcho North	Non-Selective 10	458	6	4	424	0.992	326	0.967
Dehcho North	Non-Selective 20	458	13	7	261	0.945	177	0.909
Dehcho North	Non-Selective Upper Limit	458	5	3	449	0.998	349	0.973
Dehcho North	Cow Only Upper Limit	458	5	0	458	1.000	360	0.976
Dehcho North	Bull Only Upper Limit	458	0	16	465	1.002	337	0.970
Dehcho North	Non-Selective (UL + 10)	458	11	7	302	0.959	212	0.926
Dehcho North	Cow Only (UL + 10)	458	15	0	252	0.942	173	0.907
Dehcho North	Bull Only (UL + 10)	458	0	26	157	0.898	52	0.804
Dehcho North	Baseline - No Hunting	917	0	0	1122	1.020	913	1.000
Dehcho North	Non-Selective 10	917	6	4	990	1.008	792	0.985
Dehcho North	Non-Selective 20	917	13	7	831	0.990	643	0.965
Dehcho North	Non-Selective Upper Limit	917	9	5	922	1.001	735	0.978
Dehcho North	Cow Only Upper Limit	917	10	0	913	1.000	734	0.978
Dehcho North	Bull Only Upper Limit	917	0	33	920	1.000	673	0.970
Dehcho North	Non-Selective (UL + 10)	917	15	9	774	0.983	594	0.958
Dehcho North	Cow Only (UL + 10)	917	20	0	709	0.975	543	0.949
Dehcho North	Bull Only (UL + 10)	917	0	43	580	0.955	243	0.876
Dehcho North	Baseline - No Hunting	1375	0	0	1704	1.022	1391	1.001

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Dehcho North	Non-Selective 10	1375	6	4	1555	1.012	1267	0.992
Dehcho North	Non-Selective 20	1375	13	7	1402	1.002	1121	0.980
Dehcho North	Non-Selective Upper Limit	1375	13	8	1397	1.002	1116	0.979
Dehcho North	Cow Only Upper Limit	1375	15	0	1372	1.000	1101	0.978
Dehcho North	Bull Only Upper Limit	1375	0	49	1385	1.001	1017	0.970
Dehcho North	Non-Selective (UL + 10)	1375	19	12	1263	0.992	988	0.967
Dehcho North	Cow Only (UL + 10)	1375	25	0	1188	0.985	938	0.962
Dehcho North	Bull Only (UL + 10)	1375	0	59	1152	0.982	647	0.927
Dehcho North	Baseline - No Hunting	1834	0	0	2269	1.022	1876	1.002
Dehcho North	Non-Selective 10	1834	6	4	2114	1.014	1721	0.994
Dehcho North	Non-Selective 20	1834	13	7	1949	1.006	1584	0.985
Dehcho North	Non-Selective Upper Limit	1834	18	11	1845	1.001	1496	0.980
Dehcho North	Cow Only Upper Limit	1834	20	0	1850	1.001	1488	0.979
Dehcho North	Bull Only Upper Limit	1834	0	67	1860	1.001	1335	0.969
Dehcho North	Non-Selective (UL + 10)	1834	24	15	1697	0.992	1338	0.969
Dehcho North	Cow Only (UL + 10)	1834	30	0	1640	0.989	1287	0.965
Dehcho North	Bull Only (UL + 10)	1834	0	77	1569	0.985	918	0.933
Dehcho North	Baseline - No Hunting	2292	0	0	2831	1.021	2336	1.002
Dehcho North	Non-Selective 10	2292	6	4	2703	1.017	2220	0.997

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Dehcho North	Non-Selective 20	2292	13	7	2531	1.010	2068	0.990
Dehcho North	Non-Selective Upper Limit	2292	23	14	2279	0.999	1818	0.977
Dehcho North	Cow Only Upper Limit	2292	26	0	2300	1.000	1853	0.979
Dehcho North	Bull Only Upper Limit	2292	0	85	2291	1.000	1634	0.967
Dehcho North	Non-Selective (UL + 10)	2292	29	18	2156	0.994	1712	0.971
Dehcho North	Cow Only (UL + 10)	2292	36	0	2082	0.990	1647	0.967
Dehcho North	Bull Only (UL + 10)	2292	0	95	1998	0.986	1196	0.937
Dehcho North	Baseline - No Hunting	2750	0	0	3393	1.021	2781	1.001
Dehcho North	Non-Selective 10	2750	6	4	3284	1.018	2696	0.998
Dehcho North	Non-Selective 20	2750	13	7	3091	1.012	2498	0.990
Dehcho North	Non-Selective Upper Limit	2750	27	17	2722	0.999	2200	0.978
Dehcho North	Cow Only Upper Limit	2750	31	0	2761	1.000	2238	0.980
Dehcho North	Bull Only Upper Limit	2750	0	102	2759	1.000	1968	0.967
Dehcho North	Non-Selective (UL + 10)	2750	33	21	2619	0.995	2081	0.973
Dehcho North	Cow Only (UL + 10)	2750	41	0	2522	0.991	1986	0.968
Dehcho North	Bull Only (UL + 10)	2750	0	112	2483	0.990	1585	0.946
North Slave (TASR)	Baseline - No Hunting	222	0	0	277	1.022	218	0.998
North Slave (TASR)	Non-Selective 10	222	6	4	130	0.948	84	0.907
North Slave (TASR)	Non-Selective 20	222	13	7	7	0.708	0	0.000

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
North Slave (TASR)	Non-Selective Upper Limit	222	2	1	226	1.002	172	0.975
North Slave (TASR)	Cow Only Upper Limit	222	2	0	231	1.004	177	0.978
North Slave (TASR)	Bull Only Upper Limit	222	0	7	232	1.004	169	0.973
North Slave (TASR)	Non-Selective (UL + 10)	222	7	5	106	0.929	60	0.877
North Slave (TASR)	Cow Only (UL + 10)	222	12	0	42	0.847	17	0.773
North Slave (TASR)	Bull Only (UL + 10)	222	0	17	42	0.847	27	0.810
North Slave (TASR)	Baseline - No Hunting	444	0	0	556	1.023	447	1.001
North Slave (TASR)	Non-Selective 10	444	6	4	408	0.992	314	0.966
North Slave (TASR)	Non-Selective 20	444	13	7	243	0.942	164	0.905
North Slave (TASR)	Non-Selective Upper Limit	444	4	2	458	1.003	359	0.979
North Slave (TASR)	Cow Only Upper Limit	444	5	0	442	1.000	350	0.976
North Slave (TASR)	Bull Only Upper Limit	444	0	16	435	0.998	294	0.960
North Slave (TASR)	Non-Selective (UL + 10)	444	10	6	308	0.964	219	0.932
North Slave (TASR)	Cow Only (UL + 10)	444	15	0	237	0.939	156	0.901
North Slave (TASR)	Bull Only (UL + 10)	444	0	26	143	0.893	49	0.802
North Slave (TASR)	Baseline - No Hunting	666	0	0	820	1.021	671	1.001
North Slave (TASR)	Non-Selective 10	666	6	4	671	1.001	539	0.979
North Slave (TASR)	Non-Selective 20	666	13	7	516	0.975	387	0.947
North Slave (TASR)	Non-Selective Upper Limit	666	6	4	671	1.001	539	0.979

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
North Slave (TASR)	Cow Only Upper Limit	666	8	0	656	0.998	519	0.975
North Slave (TASR)	Bull Only Upper Limit	666	0	24	656	0.998	457	0.963
North Slave (TASR)	Non-Selective (UL + 10)	666	12	8	529	0.977	404	0.951
North Slave (TASR)	Cow Only (UL + 10)	666	18	0	437	0.959	321	0.930
North Slave (TASR)	Bull Only (UL + 10)	666	0	34	334	0.933	110	0.835
North Slave (TASR)	Baseline - No Hunting	888	0	0	1096	1.021	898	1.001
North Slave (TASR)	Non-Selective 10	888	6	4	953	1.007	768	0.986
North Slave (TASR)	Non-Selective 20	888	13	7	795	0.989	619	0.965
North Slave (TASR)	Non-Selective Upper Limit	888	9	5	880	0.999	702	0.977
North Slave (TASR)	Cow Only Upper Limit	888	10	0	890	1.000	706	0.977
North Slave (TASR)	Bull Only Upper Limit	888	0	32	890	1.000	628	0.966
North Slave (TASR)	Non-Selective (UL + 10)	888	15	9	749	0.983	576	0.958
North Slave (TASR)	Cow Only (UL + 10)	888	20	0	678	0.973	514	0.947
North Slave (TASR)	Bull Only (UL + 10)	888	0	42	565	0.956	248	0.880
North Slave (TASR)	Baseline - No Hunting	1110	0	0	1373	1.021	1125	1.001
North Slave (TASR)	Non-Selective 10	1110	6	4	1229	1.010	992	0.989
North Slave (TASR)	Non-Selective 20	1110	13	7	1064	0.996	837	0.972
North Slave (TASR)	Non-Selective Upper Limit	1110	11	6	1114	1.000	888	0.978
North Slave (TASR)	Cow Only Upper Limit	1110	13	0	1103	0.999	871	0.976

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
North Slave (TASR)	Bull Only Upper Limit	1110	0	40	1120	1.001	808	0.969
North Slave (TASR)	Non-Selective (UL + 10)	1110	17	10	973	0.987	756	0.962
North Slave (TASR)	Cow Only (UL + 10)	1110	23	0	872	0.976	669	0.951
North Slave (TASR)	Bull Only (UL + 10)	1110	0	50	821	0.970	406	0.904
North Slave (TASR)	Baseline - No Hunting	1332	0	0	1651	1.022	1361	1.002
North Slave (TASR)	Non-Selective 10	1332	6	4	1495	1.012	1221	0.991
North Slave (TASR)	Non-Selective 20	1332	13	7	1332	1.000	1054	0.977
North Slave (TASR)	Non-Selective Upper Limit	1332	13	7	1332	1.000	1054	0.977
North Slave (TASR)	Cow Only Upper Limit	1332	15	0	1347	1.001	1083	0.980
North Slave (TASR)	Bull Only Upper Limit	1332	0	49	1335	1.000	955	0.967
North Slave (TASR)	Non-Selective (UL + 10)	1332	19	11	1205	0.990	942	0.966
North Slave (TASR)	Cow Only (UL + 10)	1332	25	0	1123	0.983	877	0.959
North Slave (TASR)	Bull Only (UL + 10)	1332	0	59	995	0.971	510	0.908
Dehcho South	Baseline - No Hunting	475	0	0	426	0.989	341	0.967
Dehcho South	Non-Selective 10	475	6	4	304	0.956	228	0.929
Dehcho South	Non-Selective 20	475	13	7	162	0.898	98	0.854
Dehcho South	Cow Only 20	475	20	0	78	0.835	34	0.768
Dehcho South	Bull Only 20	475	0	20	158	0.896	52	0.802
Dehcho South	Baseline - No Hunting	951	0	0	849	0.989	690	0.968

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Dehcho South	Non-Selective 10	951	6	4	728	0.974	577	0.951
Dehcho South	Non-Selective 20	951	13	7	590	0.953	449	0.928
Dehcho South	Cow Only 20	951	20	0	492	0.936	366	0.909
Dehcho South	Bull Only 20	951	0	20	767	0.979	606	0.956
Dehcho South	Baseline - No Hunting	1426	0	0	1267	0.988	1034	0.968
Dehcho South	Non-Selective 10	1426	6	4	1146	0.978	918	0.957
Dehcho South	Non-Selective 20	1426	13	7	1017	0.967	805	0.944
Dehcho South	Cow Only 20	1426	20	0	918	0.957	716	0.933
Dehcho South	Bull Only 20	1426	0	20	1198	0.983	958	0.961
Dehcho South	Baseline - No Hunting	1901	0	0	1680	0.988	1375	0.968
Dehcho South	Non-Selective 10	1901	6	4	1579	0.982	1284	0.962
Dehcho South	Non-Selective 20	1901	13	7	1433	0.972	1152	0.951
Dehcho South	Cow Only 20	1901	20	0	1326	0.965	1061	0.943
Dehcho South	Bull Only 20	1901	0	20	1611	0.984	1307	0.963
Dehcho South	Baseline - No Hunting	2377	0	0	2120	0.989	1734	0.969
Dehcho South	Non-Selective 10	2377	6	4	2004	0.983	1620	0.962
Dehcho South	Non-Selective 20	2377	13	7	1874	0.977	1499	0.955
Dehcho South	Cow Only 20	2377	20	0	1766	0.971	1420	0.950
Dehcho South	Bull Only 20	2377	0	20	2013	0.984	1646	0.964

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Dehcho South	Baseline - No Hunting	2852	0	0	2566	0.989	2105	0.970
Dehcho South	Non-Selective 10	2852	6	4	2442	0.985	1982	0.964
Dehcho South	Non-Selective 20	2852	13	7	2296	0.979	1848	0.958
Dehcho South	Cow Only 20	2852	20	0	2164	0.973	1753	0.952
Dehcho South	Bull Only 20	2852	0	20	2483	0.986	2022	0.966
Mackenzie	Baseline - No Hunting	112	0	0	273	1.093	223	1.071
Mackenzie	Non-Selective 10	112	6	4	78	0.964	38	0.898
Mackenzie	Non-Selective 20	112	13	7	0	0.000	0	0.000
Mackenzie	Non-Selective Upper Limit	112	5	3	111	0.999	70	0.954
Mackenzie	Cow Only Upper Limit	112	6	0	101	0.990	62	0.943
Mackenzie	Bull Only Upper Limit	112	0	8	126	1.012	41	0.904
Mackenzie	Non-Selective (UL + 10)	112	11	7	61	0.941	13	0.806
Mackenzie	Cow Only (UL + 10)	112	16	0	19	0.837	12	0.800
Mackenzie	Bull Only (UL + 10)	112	0	18	26	0.864	20	0.842
Mackenzie	Baseline - No Hunting	225	0	0	549	1.093	460	1.074
Mackenzie	Non-Selective 10	225	6	4	347	1.044	271	1.019
Mackenzie	Non-Selective 20	225	13	7	128	0.945	67	0.886
Mackenzie	Non-Selective Upper Limit	225	9	6	244	1.008	175	0.975
Mackenzie	Cow Only Upper Limit	225	11	0	225	1.000	157	0.965

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Mackenzie	Bull Only Upper Limit	225	0	16	283	1.023	125	0.943
Mackenzie	Non-Selective (UL + 10)	225	15	10	53	0.865	4	0.668
Mackenzie	Cow Only (UL + 10)	225	21	0	54	0.867	39	0.839
Mackenzie	Bull Only (UL + 10)	225	0	26	64	0.882	50	0.860
Mackenzie	Baseline - No Hunting	337	0	0	822	1.093	696	1.075
Mackenzie	Non-Selective 10	337	6	4	624	1.064	513	1.043
Mackenzie	Non-Selective 20	337	13	7	396	1.016	300	0.988
Mackenzie	Non-Selective Upper Limit	337	14	8	363	1.007	268	0.977
Mackenzie	Cow Only Upper Limit	337	16	0	352	1.004	258	0.974
Mackenzie	Bull Only Upper Limit	337	0	25	375	1.011	144	0.918
Mackenzie	Non-Selective (UL + 10)	337	20	12	168	0.933	86	0.872
Mackenzie	Cow Only (UL + 10)	337	26	0	112	0.896	68	0.852
Mackenzie	Bull Only (UL + 10)	337	0	35	110	0.894	83	0.869
Mackenzie	Baseline - No Hunting	450	0	0	1100	1.093	937	1.076
Mackenzie	Non-Selective 10	450	6	4	892	1.071	744	1.052
Mackenzie	Non-Selective 20	450	13	7	661	1.039	530	1.016
Mackenzie	Non-Selective Upper Limit	450	19	11	466	1.003	344	0.973
Mackenzie	Cow Only Upper Limit	450	22	0	448	1.000	326	0.968
Mackenzie	Bull Only Upper Limit	450	0	33	482	1.007	187	0.916

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Mackenzie	Non-Selective (UL + 10)	450	25	15	265	0.948	156	0.899
Mackenzie	Cow Only (UL + 10)	450	32	0	184	0.914	109	0.868
Mackenzie	Bull Only (UL + 10)	450	0	43	167	0.906	110	0.869
Mackenzie	Baseline - No Hunting	562	0	0	1364	1.093	1168	1.076
Mackenzie	Non-Selective 10	562	6	4	1161	1.075	982	1.057
Mackenzie	Non-Selective 20	562	13	7	932	1.052	763	1.031
Mackenzie	Non-Selective Upper Limit	562	24	14	577	1.003	432	0.974
Mackenzie	Cow Only Upper Limit	562	27	0	578	1.003	430	0.974
Mackenzie	Bull Only Upper Limit	562	0	41	632	1.012	249	0.922
Mackenzie	Non-Selective (UL + 10)	562	30	18	377	0.961	240	0.918
Mackenzie	Cow Only (UL + 10)	562	37	0	293	0.937	176	0.890
Mackenzie	Bull Only (UL + 10)	562	0	51	233	0.916	128	0.862
Mackenzie	Baseline - No Hunting	674	0	0	1619	1.092	1392	1.075
Mackenzie	Non-Selective 10	674	6	4	1422	1.078	1205	1.060
Mackenzie	Non-Selective 20	674	13	7	1208	1.060	1000	1.040
Mackenzie	Non-Selective Upper Limit	674	29	17	670	0.999	494	0.969
Mackenzie	Cow Only Upper Limit	674	33	0	664	0.999	497	0.970
Mackenzie	Bull Only Upper Limit	674	0	50	678	1.001	254	0.907
Mackenzie	Non-Selective (UL + 10)	674	35	21	486	0.968	326	0.930

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Mackenzie	Cow Only (UL + 10)	674	43	0	376	0.943	232	0.899
Mackenzie	Bull Only (UL + 10)	674	0	60	290	0.919	141	0.855
Hay River Lowlands	Baseline - No Hunting	228	0	0	228	1.000	173	0.973
Hay River Lowlands	Non-Selective 10	228	6	4	92	0.913	51	0.861
Hay River Lowlands	Non-Selective 20	228	13	7	2	0.623	0	0.000
Hay River Lowlands	Cow Only 20	228	20	0	16	0.767	10	0.731
Hay River Lowlands	Bull Only 20	228	0	20	30	0.816	21	0.788
Hay River Lowlands	Baseline - No Hunting	456	0	0	458	1.000	355	0.975
Hay River Lowlands	Non-Selective 10	456	6	4	325	0.967	242	0.939
Hay River Lowlands	Non-Selective 20	456	13	7	181	0.912	108	0.866
Hay River Lowlands	Cow Only 20	456	20	0	93	0.853	43	0.790
Hay River Lowlands	Bull Only 20	456	0	20	187	0.915	59	0.815
Hay River Lowlands	Baseline - No Hunting	684	0	0	682	1.000	533	0.975
Hay River Lowlands	Non-Selective 10	684	6	4	551	0.979	426	0.954
Hay River Lowlands	Non-Selective 20	684	13	7	400	0.948	283	0.916
Hay River Lowlands	Cow Only 20	684	20	0	307	0.923	201	0.885
Hay River Lowlands	Bull Only 20	684	0	20	545	0.978	364	0.939
Hay River Lowlands	Baseline - No Hunting	912	0	0	916	1.000	731	0.978
Hay River Lowlands	Non-Selective 10	912	6	4	775	0.984	607	0.960

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Hay River Lowlands	Non-Selective 20	912	13	7	636	0.965	476	0.937
Hay River Lowlands	Cow Only 20	912	20	0	532	0.948	382	0.917
Hay River Lowlands	Bull Only 20	912	0	20	811	0.988	619	0.962
Hay River Lowlands	Baseline - No Hunting	1140	0	0	1125	0.999	894	0.976
Hay River Lowlands	Non-Selective 10	1140	6	4	1010	0.988	788	0.964
Hay River Lowlands	Non-Selective 20	1140	13	7	856	0.972	656	0.946
Hay River Lowlands	Cow Only 20	1140	20	0	758	0.960	559	0.931
Hay River Lowlands	Bull Only 20	1140	0	20	1047	0.992	822	0.968
Hay River Lowlands	Baseline - No Hunting	1368	0	0	1378	1.001	1102	0.979
Hay River Lowlands	Non-Selective 10	1368	6	4	1229	0.989	982	0.967
Hay River Lowlands	Non-Selective 20	1368	13	7	1086	0.977	831	0.951
Hay River Lowlands	Cow Only 20	1368	20	0	993	0.968	755	0.942
Hay River Lowlands	Bull Only 20	1368	0	20	1273	0.993	1006	0.970
Pine Point/Buffalo Lake	Baseline - No Hunting	88	0	0	90	1.002	63	0.967
Pine Point/Buffalo Lake	Non-Selective 10	88	6	4	0	0.000	0	0.000
Pine Point/Buffalo Lake	Non-Selective 20	88	13	7	0	0.000	0	0.000
Pine Point/Buffalo Lake	Cow Only 20	88	20	0	4	0.734	1	0.639
Pine Point/Buffalo Lake	Bull Only 20	88	0	20	7	0.776	4	0.734
Pine Point/Buffalo Lake	Baseline - No Hunting	176	0	0	175	0.999	132	0.972

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Pine Point/Buffalo Lake	Non-Selective 10	176	6	4	44	0.871	12	0.764
Pine Point/Buffalo Lake	Non-Selective 20	176	13	7	0	0.000	0	0.000
Pine Point/Buffalo Lake	Cow Only 20	176	20	0	11	0.758	6	0.713
Pine Point/Buffalo Lake	Bull Only 20	176	0	20	19	0.800	14	0.776
Pine Point/Buffalo Lake	Baseline - No Hunting	264	0	0	263	1.000	205	0.975
Pine Point/Buffalo Lake	Non-Selective 10	264	6	4	130	0.932	82	0.890
Pine Point/Buffalo Lake	Non-Selective 20	264	13	7	12	0.734	0	0.000
Pine Point/Buffalo Lake	Cow Only 20	264	20	0	21	0.776	14	0.746
Pine Point/Buffalo Lake	Bull Only 20	264	0	20	39	0.826	27	0.796
Pine Point/Buffalo Lake	Baseline - No Hunting	352	0	0	351	1.000	275	0.976
Pine Point/Buffalo Lake	Non-Selective 10	352	6	4	214	0.951	151	0.919
Pine Point/Buffalo Lake	Non-Selective 20	352	13	7	71	0.852	20	0.751
Pine Point/Buffalo Lake	Cow Only 20	352	20	0	39	0.803	20	0.751
Pine Point/Buffalo Lake	Bull Only 20	352	0	20	74	0.856	32	0.787
Pine Point/Buffalo Lake	Baseline - No Hunting	441	0	0	431	0.998	341	0.975
Pine Point/Buffalo Lake	Non-Selective 10	441	6	4	309	0.965	226	0.935
Pine Point/Buffalo Lake	Non-Selective 20	441	13	7	159	0.903	88	0.851
Pine Point/Buffalo Lake	Cow Only 20	441	20	0	83	0.846	36	0.778
Pine Point/Buffalo Lake	Bull Only 20	441	0	20	160	0.904	43	0.792

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Pine Point/Buffalo Lake	Baseline - No Hunting	529	0	0	528	1.000	414	0.976
Pine Point/Buffalo Lake	Non-Selective 10	529	6	4	392	0.970	289	0.941
Pine Point/Buffalo Lake	Non-Selective 20	529	13	7	250	0.928	161	0.888
Pine Point/Buffalo Lake	Cow Only 20	529	20	0	155	0.884	82	0.830
Pine Point/Buffalo Lake	Bull Only 20	529	0	20	308	0.947	137	0.874
Zone D	Baseline - No Hunting	1501	0	0	1683	1.012	1467	0.998
Zone D	Non-Selective 10	1501	6	4	1546	1.003	1334	0.988
Zone D	Non-Selective 20	1501	13	7	1387	0.992	1180	0.976
Zone D	Non-Selective Upper Limit	1501	8	5	1510	1.001	1295	0.985
Zone D	Cow Only Upper Limit	1501	9	0	1506	1.000	1308	0.986
Zone D	Bull Only Upper Limit	1501	0	40	1502	1.000	1283	0.984
Zone D	Non-Selective (UL + 10)	1501	15	8	1346	0.989	1154	0.974
Zone D	Cow Only (UL + 10)	1501	19	0	1310	0.986	1117	0.971
Zone D	Bull Only (UL + 10)	1501	0	50	1411	0.994	1144	0.973
Zone D	Baseline - No Hunting	3003	0	0	3394	1.012	2961	0.999
Zone D	Non-Selective 10	3003	6	4	3253	1.008	2834	0.994
Zone D	Non-Selective 20	3003	13	7	3074	1.002	2683	0.989
Zone D	Non-Selective Upper Limit	3003	16	10	3008	1.000	2606	0.986
Zone D	Cow Only Upper Limit	3003	19	0	3023	1.001	2610	0.986

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Zone D	Bull Only Upper Limit	3003	0	81	3037	1.001	2628	0.987
Zone D	Non-Selective (UL + 10)	3003	22	14	2876	0.996	2491	0.981
Zone D	Cow Only (UL + 10)	3003	29	0	2813	0.993	2436	0.979
Zone D	Bull Only (UL + 10)	3003	0	91	2961	0.999	2540	0.983
Zone D	Baseline - No Hunting	4504	0	0	5097	1.012	4473	0.999
Zone D	Non-Selective 10	4504	6	4	4899	1.008	4296	0.995
Zone D	Non-Selective 20	4504	13	7	4784	1.006	4176	0.992
Zone D	Non-Selective Upper Limit	4504	24	15	4512	1.000	3926	0.986
Zone D	Cow Only Upper Limit	4504	27	0	4495	1.000	3906	0.986
Zone D	Bull Only Upper Limit	4504	0	121	4499	1.000	3890	0.985
Zone D	Non-Selective (UL + 10)	4504	30	19	4386	0.997	3794	0.983
Zone D	Cow Only (UL + 10)	4504	37	0	4344	0.996	3775	0.982
Zone D	Bull Only (UL + 10)	4504	0	131	4477	0.999	3840	0.984
Zone D	Baseline - No Hunting	6005	0	0	6792	1.012	5970	0.999
Zone D	Non-Selective 10	6005	6	4	6633	1.010	5833	0.997
Zone D	Non-Selective 20	6005	13	7	6469	1.007	5634	0.994
Zone D	Non-Selective Upper Limit	6005	32	20	5989	1.000	5208	0.986
Zone D	Cow Only Upper Limit	6005	36	0	6054	1.001	5257	0.987
Zone D	Bull Only Upper Limit	6005	0	163	6013	1.000	5204	0.986

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Zone D	Non-Selective (UL + 10)	6005	38	24	5840	0.997	5065	0.983
Zone D	Cow Only (UL + 10)	6005	46	0	5827	0.997	5067	0.983
Zone D	Bull Only (UL + 10)	6005	0	173	5986	1.000	5187	0.985
Zone D	Baseline - No Hunting	7507	0	0	8483	1.012	7448	0.999
Zone D	Non-Selective 10	7507	6	4	8291	1.010	7287	0.997
Zone D	Non-Selective 20	7507	13	7	8137	1.008	7136	0.995
Zone D	Non-Selective Upper Limit	7507	40	24	7533	1.000	6571	0.987
Zone D	Cow Only Upper Limit	7507	46	0	7513	1.000	6536	0.986
Zone D	Bull Only Upper Limit	7507	0	206	7508	1.000	6471	0.985
Zone D	Non-Selective (UL + 10)	7507	46	28	7435	0.999	6441	0.985
Zone D	Cow Only (UL + 10)	7507	56	0	7283	0.997	6375	0.984
Zone D	Bull Only (UL + 10)	7507	0	216	7510	1.000	6476	0.985
Zone D	Baseline - No Hunting	9008	0	0	10,158	1.012	8917	0.999
Zone D	Non-Selective 10	9008	6	4	10,037	1.011	8815	0.998
Zone D	Non-Selective 20	9008	13	7	9823	1.009	8624	0.996
Zone D	Non-Selective Upper Limit	9008	50	30	9038	1.000	7871	0.987
Zone D	Cow Only Upper Limit	9008	57	0	9031	1.000	7853	0.986
Zone D	Bull Only Upper Limit	9008	0	248	9019	1.000	7763	0.985
Zone D	Non-Selective (UL + 10)	9008	56	34	8912	0.999	7706	0.985

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Zone D	Cow Only (UL + 10)	9008	67	0	8834	0.998	7726	0.985
Zone D	Bull Only (UL + 10)	9008	0	258	8939	0.999	7635	0.984
Zone R	Baseline - No Hunting	496	0	0	707	1.036	588	1.017
Zone R	Non-Selective 10	496	6	4	552	1.011	440	0.988
Zone R	Non-Selective 20	496	13	7	385	0.975	282	0.945
Zone R	Non-Selective Upper Limit	496	9	5	485	0.998	378	0.973
Zone R	Cow Only Upper Limit	496	9	0	503	1.001	398	0.978
Zone R	Bull Only Upper Limit	496	0	22	507	1.002	323	0.958
Zone R	Non-Selective (UL + 10)	496	15	9	326	0.959	233	0.927
Zone R	Cow Only (UL + 10)	496	19	0	286	0.946	192	0.909
Zone R	Bull Only (UL + 10)	496	0	32	162	0.894	69	0.821
Zone R	Baseline - No Hunting	993	0	0	1416	1.036	1183	1.018
Zone R	Non-Selective 10	993	6	4	1257	1.024	1034	1.004
Zone R	Non-Selective 20	993	13	7	1097	1.010	885	0.989
Zone R	Non-Selective Upper Limit	993	17	10	987	0.999	791	0.978
Zone R	Cow Only Upper Limit	993	18	0	1007	1.001	811	0.980
Zone R	Bull Only Upper Limit	993	0	45	1022	1.003	657	0.960
Zone R	Non-Selective (UL + 10)	993	23	14	842	0.984	643	0.957
Zone R	Cow Only (UL + 10)	993	28	0	790	0.977	605	0.952

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Zone R	Bull Only (UL + 10)	993	0	55	591	0.949	216	0.859
Zone R	Baseline - No Hunting	1489	0	0	2119	1.036	2448	1.051
Zone R	Non-Selective 10	1489	6	4	1967	1.028	1645	1.010
Zone R	Non-Selective 20	1489	13	7	1802	1.019	1484	1.000
Zone R	Non-Selective Upper Limit	1489	25	15	1495	1.000	1197	0.978
Zone R	Cow Only Upper Limit	1489	28	0	1502	1.001	1218	0.980
Zone R	Bull Only Upper Limit	1489	0	69	1493	1.000	934	0.954
Zone R	Non-Selective (UL + 10)	1489	31	19	1333	0.989	1052	0.966
Zone R	Cow Only (UL + 10)	1489	38	0	1281	0.985	1013	0.962
Zone R	Bull Only (UL + 10)	1489	0	79	1022	0.963	434	0.884
Zone R	Baseline - No Hunting	1986	0	0	2860	1.037	2404	1.019
Zone R	Non-Selective 10	1986	6	4	2700	1.031	2250	1.013
Zone R	Non-Selective 20	1986	13	7	2538	1.025	2094	1.005
Zone R	Non-Selective Upper Limit	1986	34	20	1986	1.000	1605	0.979
Zone R	Cow Only Upper Limit	1986	37	0	2004	1.001	1614	0.979
Zone R	Bull Only Upper Limit	1986	0	92	2017	1.002	1269	0.956
Zone R	Non-Selective (UL + 10)	1986	40	24	1824	0.992	1429	0.968
Zone R	Cow Only (UL + 10)	1986	47	0	1774	0.989	1405	0.966
Zone R	Bull Only (UL + 10)	1986	0	102	1562	0.976	736	0.906

Table C1: Population model and hunting scenario results for boreal caribou populations in the Northwest Territories.

Modelled Population	Hunting Model Scenario	Initial population	Annual Cow harvest	Annual Bull Harvest	Year 10 projected population	Mean annual rate of change (λ)	Year 10 pop - 1 sd	Mean annual λ (Year 10 pop - 1 sd)
Zone R	Baseline - No Hunting	2482	0	0	3547	1.036	2981	1.018
Zone R	Non-Selective 10	2482	6	4	3385	1.032	2839	1.014
Zone R	Non-Selective 20	2482	13	7	3212	1.026	2673	1.007
Zone R	Non-Selective Upper Limit	2482	42	25	2486	1.000	1990	0.978
Zone R	Cow Only Upper Limit	2482	47	0	2494	1.000	2026	0.980
Zone R	Bull Only Upper Limit	2482	0	115	2488	1.000	1522	0.952
Zone R	Non-Selective (UL + 10)	2482	48	29	2543	1.002	1867	0.972
Zone R	Cow Only (UL + 10)	2482	57	0	2289	0.992	1820	0.969
Zone R	Bull Only (UL + 10)	2482	0	125	2027	0.980	1012	0.914
Zone R	Baseline - No Hunting	2979	0	0	4235	1.036	3579	1.019
Zone R	Non-Selective 10	2979	6	4	4107	1.033	3450	1.015
Zone R	Non-Selective 20	2979	13	7	3938	1.028	3312	1.011
Zone R	Non-Selective Upper Limit	2979	50	30	3021	1.001	2415	0.979
Zone R	Cow Only Upper Limit	2979	57	0	2999	1.001	2427	0.980
Zone R	Bull Only Upper Limit	2979	0	137	2997	1.001	1879	0.955
Zone R	Non-Selective (UL + 10)	2979	56	34	2873	0.996	3445	1.015
Zone R	Cow Only (UL + 10)	2979	67	0	2779	0.993	2223	0.971
Zone R	Bull Only (UL + 10)	2979	0	147	2604	0.987	1356	0.924