SR-23-10

Moose Survey

Lower Macmillan River Moose Management Unit, 2020

July 2023

Moose survey:
Lower Macmillan River Moose Management Unit, early winter 2020

Government of Yukon
Fish and Wildlife Branch
SR-23-10

Authors

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Summary

- We conducted an early-winter moose survey using helicopters in an area upriver of Pelly Crossing along the Macmillan and Pelly rivers and upriver of the village of Mayo south of the Stewart River from November 1 to November 7, 2020.
- The main purpose of this survey was to estimate the abundance, distribution and composition of the moose population in the entire Lower Macmillan River Moose Management Unit (MMU).
- We counted all moose in survey blocks that covered about 34% of the survey area. We found a total of 1,134 moose: 304 adult bulls, 592 adult and yearling cows, 63 yearling bulls, 174 calves, and 1 unclassified moose.
- We calculated a population estimate of 1,893 moose (90% confident that the population was between 1700 and 2101) for the survey area. This number is equal to a density of 242 moose per 1,000 km² over the entire area, or 253 per 1,000 km² of suitable moose habitat. This is on the high end of the range of typical Yukon moose densities of 100-250 moose per 1,000 km² of moose habitat.
- We estimated that there were 37 calves and 21 yearlings for every 100 adult cows in the survey area. These ratios indicate that survival of calves born in 2020 and 2019 were above average and slightly above average, respectively, compared to other Yukon areas surveyed.
- We estimated that there were 56 adult bulls for every 100 adult cows in the survey area. This adult sex ratio is slightly lower than the Yukon average from surveyed populations, but well above the minimum threshold of 30 bulls per 100 cows identified in our moose management guidelines.
- This was the first population survey for moose that included the entire Lower Macmillan River MMU. These data provide a baseline for assessing the effects of any future developments or changes in harvest pressure.
- Available harvest information suggests that the total harvest of moose by all hunters in the Lower Macmillan River MMU is below the estimated sustainable harvest.

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Introduction

This report summarizes the results of an early-winter survey of moose in the Lower Macmillan River Moose Management Unit (MMU; Fig. 1), conducted on November 1-7, 2020. We conducted the survey to estimate their numbers, distribution, and composition by age and sex. We use this information along with harvest data to evaluate the current harvest rate. We also use data on moose distribution as a baseline for assessing the effects of any future developments.

Previous surveys

The Yukon Fish and Wildlife Branch previously conducted five surveys of moose that overlapped with parts of the Lower Macmillan MMU (Fig. 2), but we had never surveyed the entire area. Early-winter censuses conducted in 1982 (Johnston and McLeod 1983) and 1995 (results in Yukon Fish and Wildlife Branch file reports) included southern parts of the MMU along the Lower Macmillan and Pelly rivers. We also conducted a low-intensity early-winter census in all the MMU south of Big Kalzas Lake in 2000 (Environment Yukon 2003).

In addition, we conducted surveys aimed at mapping late-winter habitats in parts of the MMU in 2001 (O'Donoghue 2005) and early-winter habitats in 2008 (O'Donoghue and Ward 2009; Fig. 2).

Early winter is favoured for estimating abundance of moose because they concentrate in high-elevation open habitats. Also, bull moose still have their antlers and therefore, are easily identifiable. Thus, we can accurately estimate the proportion of adult bulls in the population and distinguish them from yearlings.

Community involvement

Residents of the Pelly Crossing and Mayo areas consistently place a high priority on monitoring local moose populations. They have expressed concerns at Northern Tutchone May Gatherings about high hunting pressure, particularly along the Macmillan River, and fewer moose. This hunting area is especially important for the Selkirk First Nation. Staff of the Selkirk First Nation and the First Nation of Na-Cho Nyäk Dun participated as crew leaders and observers for our survey. Additionally, the Mayo District Renewable Resources Council provided support for local observers.

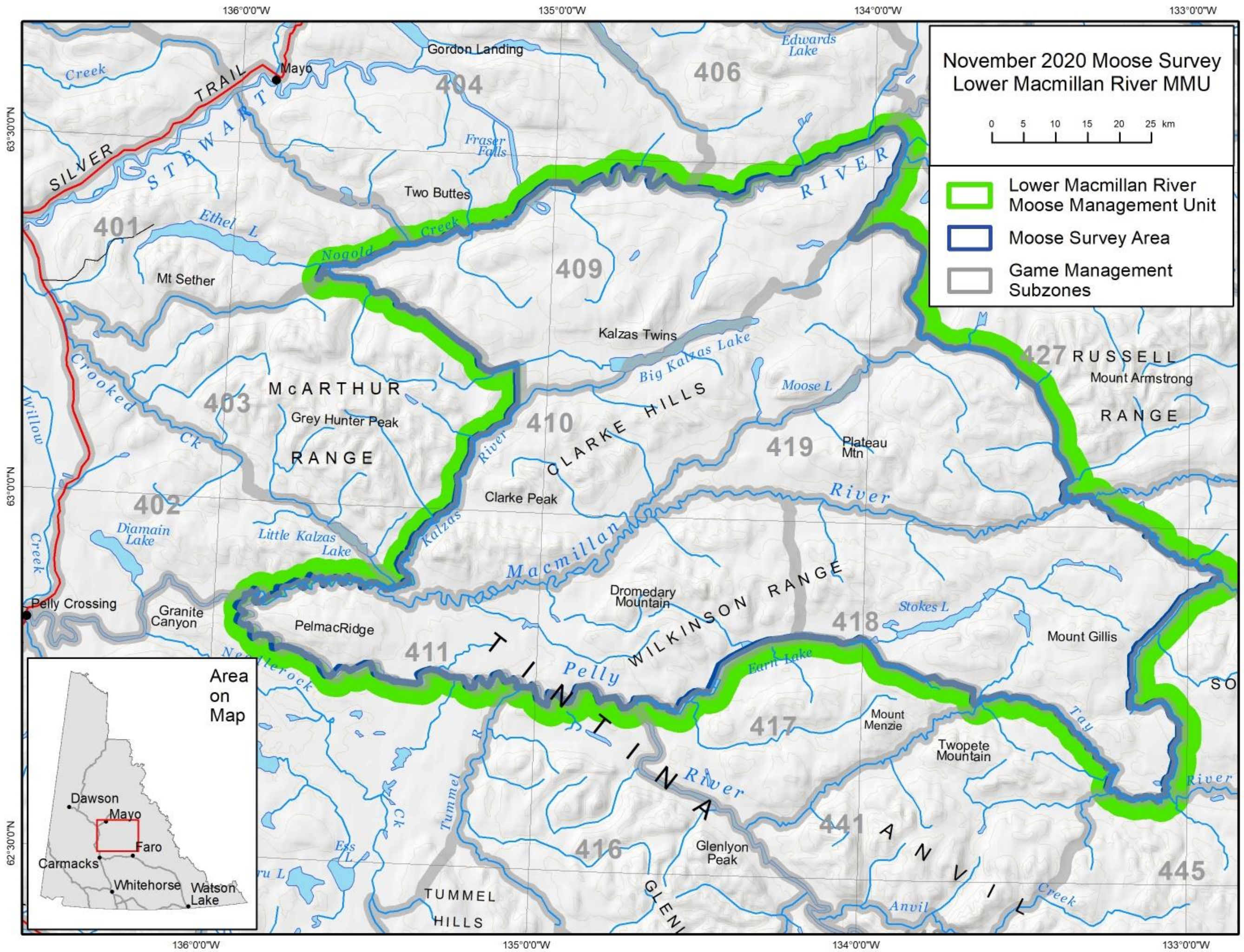

Figure 1. Lower Macmillan River Moose Management Unit (MMU) survey area, November 2020.

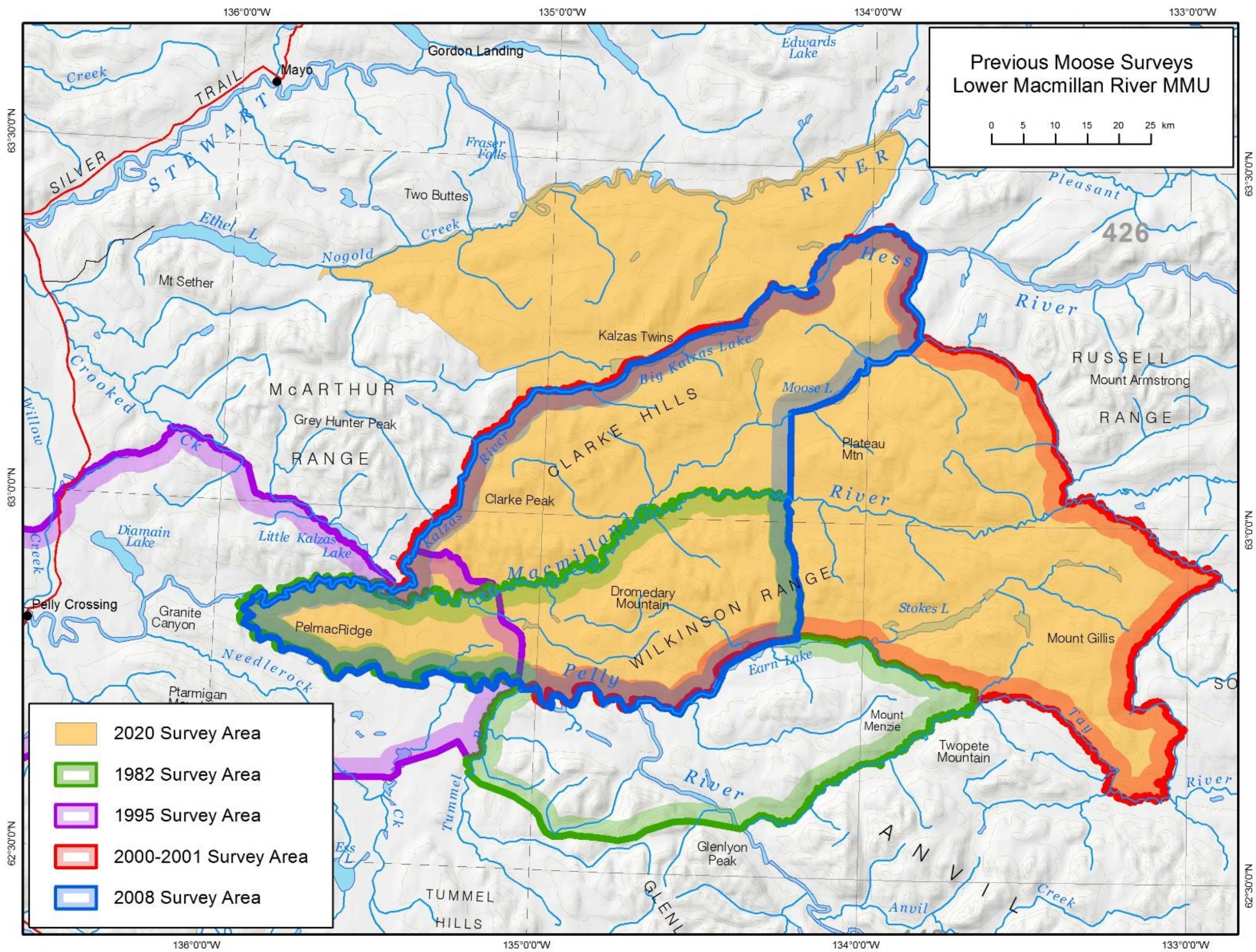

Figure 2 Previous moose surveys overlapping the Lower Macmillan River Moose Management Unit (MMU).

Study area

The Lower Macmillan River Moose Management Unit includes Game Mangement Subzones (GMSs) in the Macmillan, Pelly, and Stewart River watersheds downriver of the Russell Range (Fig. 1). Moose management units were developed to monitor and manage moose at the scale of populations throughout the territory (Environment Yukon 2016).

The Lower Macmillan MMU is about 7,825 km², and includes GMSs 409, 410, 411, 418, and 419 (Fig. 1). The northern border is the Stewart River and the southern border is defined, west to east, by the Pelly, Earn, and Tay rivers. The eastern flanks of the McArthur Range (Ddhaw Ghro Habitat Protection Area) are at the MMU's western border. On the eastern border, north to south, are the Hess River and the Russell Range.

Most of the study area (about 7,497 km²) is considered suitable moose habitat, except for approximately 4% of the area which consists of large water bodies (0.5 km² or more in size) and land areas at or above elevations of 1,524 m (5,000 feet). The area is in the Yukon Plateau North ecoregion (Smith et al. 2004). It consists mostly of rolling hills and plateaus, dissected by numerous creeks that drain into the Macmillan, Pelly, and Stewart rivers. Most of the area is forest-covered with black and white spruce, lodgepole pine, aspen, and paper birch, interspersed with wetland habitats at poorly drained sites. Willow and dwarf birch shrub habitats, alpine tundra, and unvegetated rocky areas typify the higher plateaus scattered throughout the study area.

Old and recent burns occur throughout the study area (Fig. 3), and vary in quality as moose habitat. Recent large fire years occurred in 2016 (133 km²), 2004 (346 km²), 1994 (346 km²), and 1989 (1,198 km²).

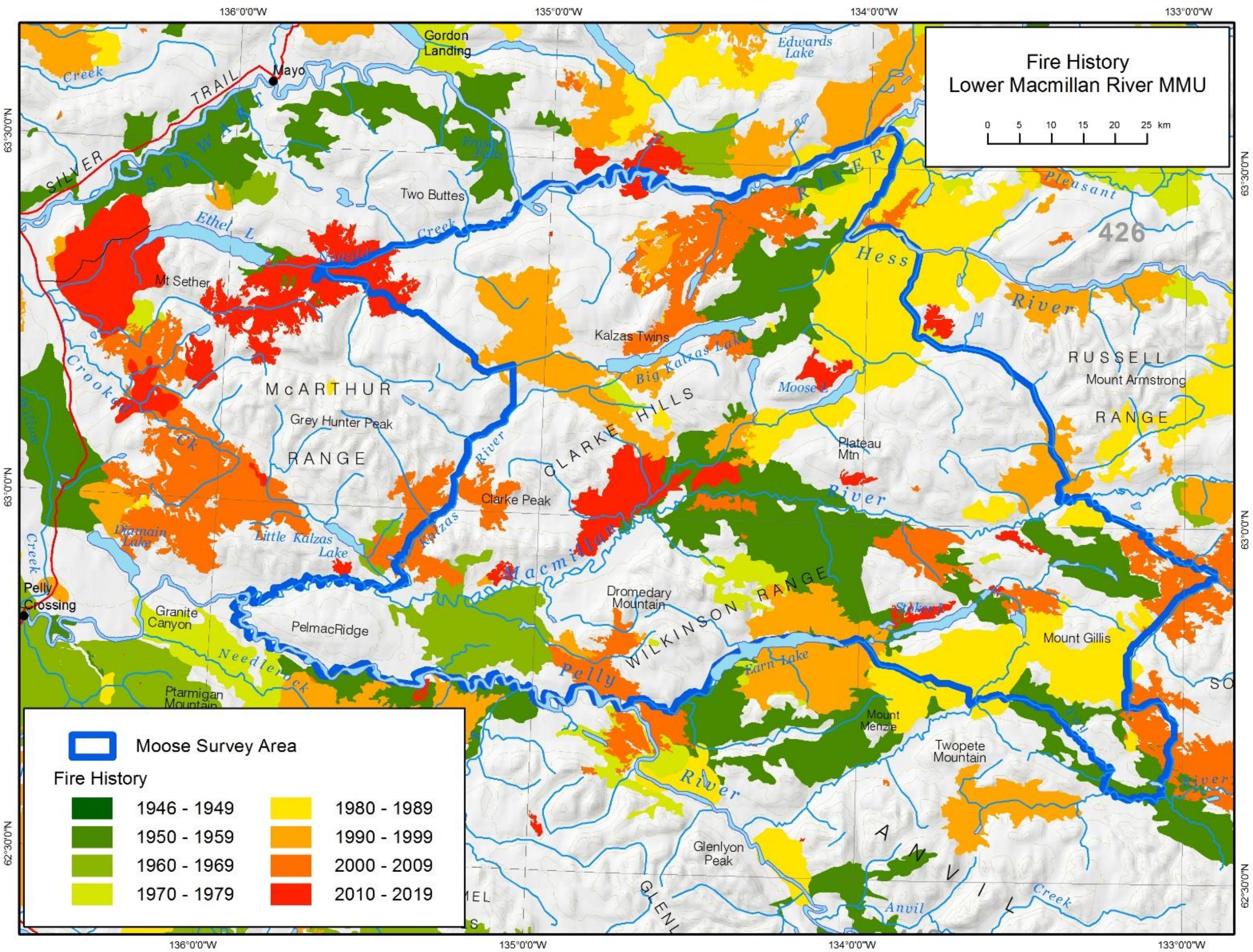

Figure 3 Lower Macmillan River Moose Management Unit (MMU) fire history.

Methods

Overview

We use a model-based technique to survey and estimate moose abundance and composition in the territory (Czetwertynski et al., *in prep,*; Appendix 1). Specifically, we develop models that relate moose abundance to information in individual survey blocks flown during the survey. This information is a combination of available local knowledge, landscape information, and habitat characteristics. These models are then used to estimate moose abundance over the areas where we did not count moose. We use any observed relationships between composition of the moose population (by age and sex) and the habitat or landscape to correct for any bias in our sample. This analysis allows us to incorporate factors found to affect the distribution of different age and sex classes across the landscape and predict the moose population composition for the entire area. Advantages of this survey method include the ability to utilise local knowledge, estimate abundance in subsets of the survey area, account for differences in composition throughout the area, and target our sampling to areas where uncertainty is greatest.

The survey area is divided into rectangular blocks 15.4-15.9 km² (2' latitude x 5' longitude) in size. We select specific blocks and use helicopters to fly transects that are about 350 to 400 m wide (search intensity of about 2 minutes per km²) and count and classify every moose observed. We survey approximately 30% of the blocks within a survey area. During ferries, all survey staff record observations about moose habitat quality and abundance in as many different blocks as possible. This information is used to evaluate the final model predictions.

Within blocks selected for sampling, we classify all moose by age (adult, yearling, calf) and sex. In early-winter surveys, we can reliably distinguish yearling bulls from adults based on antler size. However, yearling cows are often difficult to distinguish from adults. Therefore, we use the yearling bull estimate to account for yearling cows (the total number of yearlings is assumed to be twice the estimated number of yearling bulls). The adult cow estimate is then accordingly reduced.

Finally, we use an average “sightability correction factor” of 9%, based on data from previous moose surveys conducted in the Yukon, to estimate the number of moose we missed, and to correct our final population estimates accordingly. When we compare moose population data between years, we consider there to be a significant change when 90% confidence intervals or prediction intervals do not overlap.

Survey Block Selection

We select blocks to survey using different criteria in each of three phases of the census survey:

Phase 1: We use available local knowledge and information from previous surveys to classify blocks as having either high, medium-high, medium, low-medium, or low expected moose numbers. We then use this information to select blocks to be flown for the first 2-3 days of the survey (approximately 30% of the total number of blocks we expect to survey). We select blocks distributed across the survey area, covering the range of available habitat types and predicted moose abundances.

For this survey, prior knowledge of the area was limited. We had not conducted recent early-winter surveys, and local knowledge on moose distribution at this time of year was limited. We therefore used a model of moose-habitat relationships from the 2017 moose survey in the adjacent Upper Klondike Highway MMU (O'Donoghue and Czetwertynski 2023) to initially stratify the area (Fig. 4)

Phase 2: We use a combination of landscape characteristics (land cover, slope, elevation) and local information from phase 1 to fit the best model describing moose abundance in surveyed blocks. We then use this model to predict the number of moose in un-sampled blocks. Survey blocks to fly the following day are selected based primarily on where the level of uncertainty in the predictions is greatest and to ensure we collect appropriate data to evaluate predictor-moose abundance relationships. This process (model selection, fitting, prediction, identification of blocks to sample) is repeated nightly with additional data from each day of flying. This phase of the survey is complete when sampling: 1) provides a total population estimate with adequate precision to make management decisions for the area; 2) meets all assumptions for the final model: 3) has enough blocks counted in each sub-area for which estimates are desired, and 4) is appropriate to estimate population composition by age and sex. In this phase, we sample approximately 60% of the total number of blocks we expect to survey.

Phase 3: We generate a map showing the predicted number of moose in un-sampled blocks based on the best model and have the field crew select blocks where they believe the predictions are the least accurate. We use local knowledge plus incidental observations made during the census to select additional blocks to count. This phase represents the last 1 or 2 days of the survey depending on survey-specific conditions. Lastly, the final model is re-evaluated with all available data to determine if further sampling is required.

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Weather and snow conditions

We completed the survey in seven consecutive days, all suitable for flying, on November 1-7, 2020. It was mostly clear on four of the seven days, and cloudy with light snow on the remaining three days. Temperatures ranged from -37°C to -20°C and winds were mild to moderate.

Snow cover was complete and deeper than 15 cm throughout the survey area. We had fresh snow at the start and on several days during the survey, which aided in spotting fresh tracks. Light conditions ranged from flat to bright.

Results and discussion

Stratification

Using the model from the 2017 Upper Klondike Highway MMU moose survey (O'Donoghue and Czetwertynski 2023), we rated survey blocks in the Lower Macmillan River MMU by expected abundance of moose. We divided these into five equal-sized classes of 100 blocks each from the lowest to highest expected densities (Fig. 4). These data, along with habitat and landscape characteristics, informed selection of blocks to survey in phase 1 (see Methods).

Most of the blocks with higher expected numbers of moose were in the rolling hills and mountainous terrain north-east of the McArthur Range, north of Big Kalzas Lake, south-west of the Hess River, and in the Mount Gillis area. Large areas of these survey blocks were burned in fires during the late 1980s and 1990s.

Compared to the Mayo Moose Management Unit to the north, this area has less of the high-elevation subalpine willow habitats where moose typically congregate in the early winter.

Coverage

We counted moose in 171 of the 500 blocks, or about 34% of the total area. We concentrated our efforts in blocks where our models predicted high or uncertain numbers of moose (Fig. 5). Our total survey effort was 82.8 hours, for a search intensity of 1.86 minutes per km². We used an additional 45 hours of helicopter time to ferry between survey blocks, travel to our fuel caches at Russell Lake and the Twopete airstrip, and travel back and forth to Mayo.

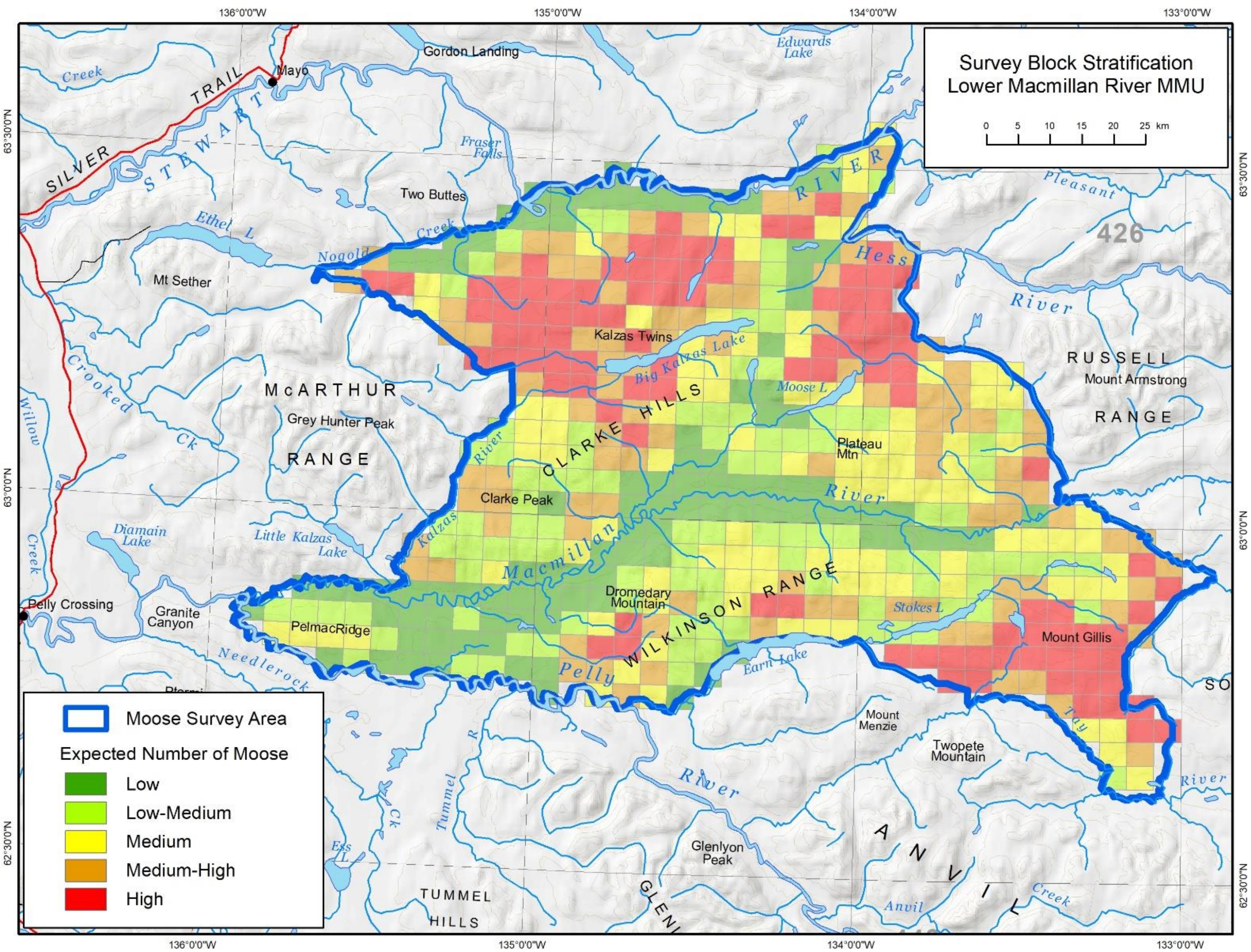

Figure 4 Survey block stratification in the 2020 Lower Macmillan River Moose Management Unit (MMU), based on habitat-moose relationships observed in the adjacent Upper Klondike Highway MMU. These data, along with habitat and landscape characteristics, informed selection of blocks to survey.

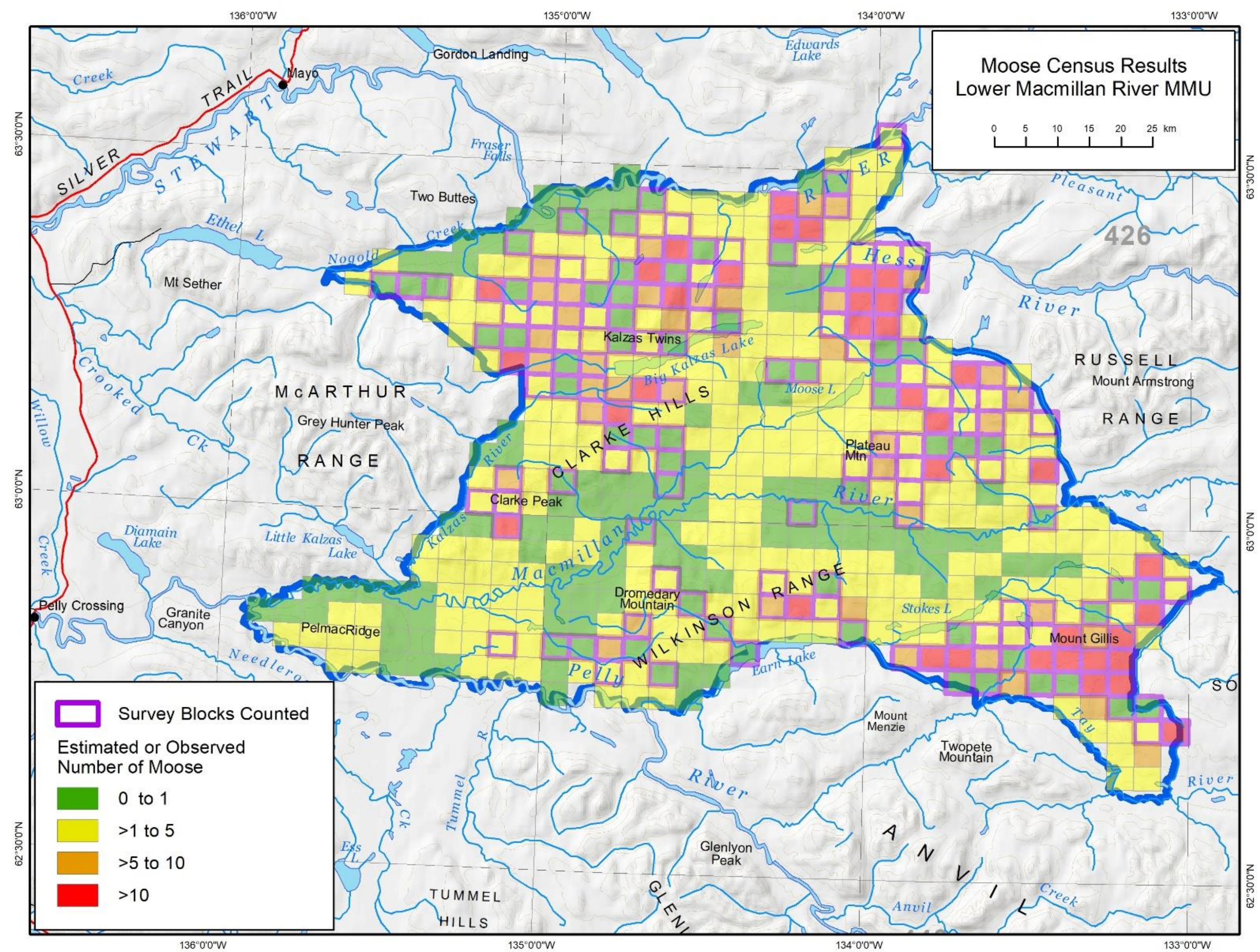

Figure 5 Moose census results in the 2020 Lower Macmillan River Moose Management Unit (MMU). Observed numbers of moose were counted by helicopter. Predicted numbers are based on models developed from the survey information collected.

Table 1. Observations of moose in survey blocks during the Lower Macmillan River Moose Management Unit (MMU) survey, November 2020.

	Total
Number of blocks counted	171
Number of adult bulls	304
Number of adult and yearling cows*	592
Number of yearling bulls	63
Number of calves	174
Number of unclassified moose	1

* Adults and yearling cows cannot be reliably distinguished from the air, so they are counted together.

Observations of moose

We counted a total of 1,134 moose, 27% of them adult bulls, 52% adult and yearling cows, 6% yearling bulls, and 15% calves (Table 1). We observed an average of 420 moose for every 1,000 km² searched. These values (total number and composition by age and sex) cannot be directly used as estimates in un-surveyed blocks because our sampling was biased towards blocks with greater numbers of moose.

Distribution of moose

Moose were widely distributed in the survey area, with the greatest numbers occurring in recent burns and high-elevation habitats. These included the 1989 and 2004 burns located in the north-east by the Hess River, the 1989 burn located around Mount Gillis, and subalpine habitats east of Plateau Mountain (Fig. 5). We also observed larger numbers in the hilly areas burned in 1994 and 2004 around Big Kalzas Lake and in some pockets on hills burned in 1994 and 2004 in the Wilkinson Range. We saw relatively few moose in the 2016 burn; in closed mature spruce, pine, and aspen forested areas; and in lowland habitats in general.

Abundance of moose

The model that best predicted moose abundance included habitat variables positively related to moose numbers: 1) old burns (5 to 35 years old; moose were mostly in the 16, 26, and 31-year old burns) and shrub habitats; 2) hilly terrain at mid-elevations (900-1250 metres), and 3) slopes less than 10°. We also found a higher likelihood of observing no moose in blocks where there was a high proportion of spruce and pine forest (model details are in Appendix 1). This model is consistent with our observations that most moose prefer higher elevation habitats with abundant willows during the early winter.

The estimated number of moose in the entire survey area, based on our counts and subsequent model predictions, was 1,893, and we are 90% confident that the population size lies between 1,700 and 2,101 (Table 2).

The estimated density of moose in the entire survey area was 242 per 1,000 km², or 253 per 1,000 km² of suitable moose habitat (Table 2). This estimate is on the high end of the range of moose densities from other areas surveyed in the Yukon, which vary from 100 to 250 moose per 1,000 km² of suitable habitat (Environment Yukon 2016).

Table 1. Estimated abundance of moose, corrected for sightability (9%,) in the Lower Macmillan River Moose Management Unit (MMU), November 2020.

	Best estimate*	**Estimates within 90% prediction interval****
Estimated total number of moose	1893	1700-2101
Adult bulls	488	434-547
Adult cows	876	786-982
Yearlings	183	163-207
Calves	322	281-375
Density of moose (per 1,000 km^2)		
Entire area	242	217-268
Moose habitat only***	253	226-279

* The sum of the estimated numbers of adult bulls, adult cows, yearlings, and calves is slightly different than the estimated total number of moose in the study area because we rounded off estimates from individual survey blocks in the compositional analysis to estimate numbers in each age and sex category of moose.

** A "90% prediction interval" means that, based on our survey results, we are 90% sure that the true number lies within this range.

*** Suitable moose habitat is considered to be all areas at elevations lower than 1,524 m (5,000 ft.), excluding water bodies 0.5 km^2 or greater in size.

Table 2. Estimated composition of the moose population in the Lower Macmillan River Moose Management Unit (MMU), November 2020.

	Best Estimate	Estimates within 90% prediction interval*
% Adult bulls	26%	25-27%
% Adult cows	47%	45-48%
% Yearlings	10%	9-11%
% Calves	17%	16-18%
Adult bulls per 100 adult cows	56	52-59
Yearlings per 100 adult cows	21	19-24
Yearlings per 100 adults (recruitment rate)	12	11-13
Calves per 100 adult cows	37	34-40
% of cow-calf groups with twins	13%	10-15%

* A "90% prediction interval" means that, based on our survey results, we are 90% sure that the true number lies within this range.

Ages and sexes of moose

We found that habitat type affected the distribution of different age and sex groups of moose. Specifically, we saw significantly greater proportions of adult bulls and lone adult cows in survey blocks with more of the most favoured land cover types (burns, shrub habitats, and mixed coniferous-deciduous forests) and topography (mid-elevation and slopes smaller than 10 degrees). However, cows with calves were found in greater proportions in blocks with less favourable habitats (details in Appendix 1). We used these relationships to estimate the composition of the moose population by age and sex in the entire survey area, accounting for this observed bias (Table 3).

Our survey results indicate that, compared to other Yukon areas, survival of calves born in 2020 and 2019 were above average and slightly above average, respectively, We estimated there were 37 calves and 21 yearlings for every 100 adult cows in the population (Table 3), whereas Yukon averages are 29 calves and 18 yearlings per 100 adult cows (Environment Yukon 2016). Estimates of recruitment from one survey are snapshots in time and survival varies from year to year.

We estimated that there were 56 adult bulls for every 100 adult cows in the survey area (Table 3). This is slightly lower than the Yukon average of 64 bulls per 100 adult cows, but well above the minimum level of 30 bulls per 100 cows recommended in the *Science-based Guidelines for Management of Moose in Yukon* (Environment Yukon 2016).

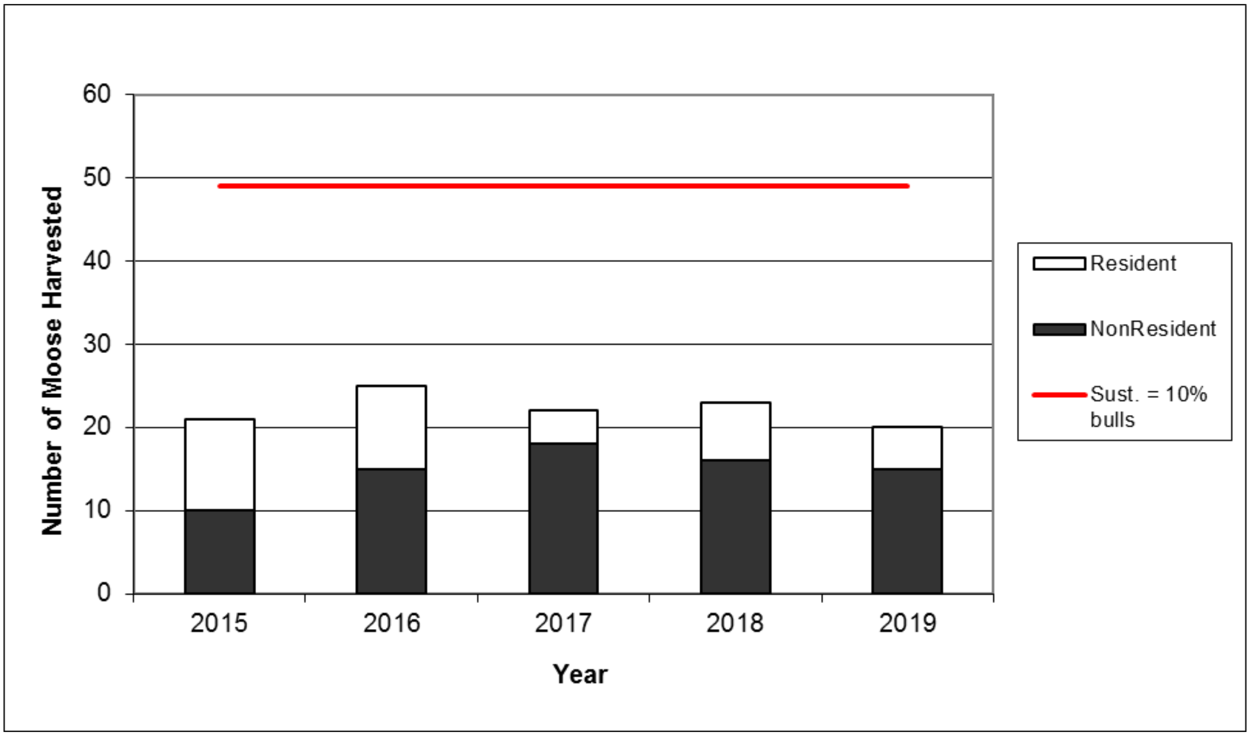

Figure 6 Harvest of moose by licenced hunters in the Lower Macmillan River Moose Management Unit (MMU) from 2015 through 2019. Here, resident harvest includes moose harvested with special-guided permits. The estimated total sustainable harvest is 49 bulls per year. First Nation harvest in the central Yukon is generally similar to licenced resident harvest.

Harvest

Based on the results of this survey, we estimate that there were 488 (434-547) adult bulls in the Lower Macmillan River MMU. The sustainable harvest is estimated at 10% of adult bulls (Environment Yukon 2016), or 49 bulls per year.

During the 5 hunting seasons preceding this survey (2015 to 2019), the reported harvest of moose by licenced resident and non-resident hunters averaged about 22 moose per year in the MMU (Fig. 6). This figure does not include harvest data from First Nation hunters, which are reported annually at Northern Tutchone May Gatherings. First Nation harvest rates are generally similar to those of licenced resident hunters in much of the central Yukon. Harvest by licenced resident hunters averaged 7 moose per year from 2015 through 2019. Total harvest is therefore likely below the sustainable rate for this MMU.

This is an important traditional and current hunting area for the Selkirk First Nation. Local hunters have reported increasing numbers of boats and hunters on the Macmillan River, and have noted it has become hard to harvest a moose and find unoccupied room at traditional hunting camps. Taking boats up the Macmillan and Pelly rivers are the main ways that ground-based hunters gain access to this area. Therefore, despite a relatively high-density moose population over the entire MMU, observations suggest there may be local depletion of moose numbers along the rivers.

Other wildlife sightings

In addition to the 1,134 moose counted during the census, we also observed 403 moose in 158 groups outside our surveyed blocks or while travelling between blocks.

Additionally, we counted 486 caribou in 68 groups. These groups were concentrated in three areas. Most (365) were caribou from the Ethel Lake herd, seen on the high plateaus north-west of Big Kalzas Lake. We also saw 85 Moose Lake herd caribou in the area north of the Macmillan River and between Plateau Mountain in the west and the Russell Range in the east. We observed another 36 caribou, likely from the Tay River herd, in the Wilkinson Range, north-east of Earn Lake.

We saw a single ram thinhorn sheep on hills north of the Pelly River. We spotted 19 wolves in five groups, including one observation of a pack of six animals at a site where they had killed a large bull moose east of Big Kalzas Lake. Lastly, we saw 2 lynx along the Moose and Stewart rivers, and a snowy owl north of Kalzas Twins.

Conclusions and recommendations

- We estimated that there was a high-density moose population in the Lower Macmillan River MMU compared to other areas surveyed in the territory.
- This is the first complete census of moose in this area so we cannot estimate the population trend.
- Survival of calves and yearlings was relatively high in 2020 and 2019 in the MMU.
- The ratio of adult bulls to adult cows in the survey area was well above the recommended minimum of 30 adult bulls per 100 adult cows.
- The present harvest of moose is likely within sustainable levels for this area.
- We should continue to monitor moose populations in this area using aerial and ground-based monitoring.

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Appendix 1 – Analyses and models used to estimate the abundance and composition of moose in the Lower Macmillan River Moose Management Unit from 2020 early-winter survey data.

We estimated abundance and composition of moose in the Lower Macmillan River survey area and Moose Management Unit (MMU) using a three-staged approach. We first used moose locations in surveyed blocks to generate Resource Selection Probability Functions (RSPFs). This information was then scaled up to the survey block and used with abundance information to generate count models and provide estimates of moose with prediction intervals for unsampled survey blocks. Lastly, we used predicted and observed moose abundance together with moose composition information from surveyed blocks to estimate the composition of moose over the entire survey area.

For all analyses, potential covariates were screened/sampled to ensure that they met model assumptions, were spatially representative, and biologically relevant. We used screened covariates to generate potential models and selected the best model based on Akaike's Information Criterion (AIC; Burnham and Anderson 2002) and AIC weights (Wagenmakers and Farrell 2004).

<u>1) Abundance estimation</u>

We generated a small-scale grid such that within each survey block (approximately 4 km x 4 km) there were 100 sub-blocks (approximately 400 m x 400 m). We selected this sub-block size because we believe it captures the approximate error in moose locations taken from the helicopter and represents the scale at which moose site selection occurs (Third Order Selection, Johnson 1980). We queried each sub-block for landscape and vegetation characteristics that could potentially influence moose occurrence or abundance. All covariates were screened for their relationship to occurrence/abundance and those that had biologically and statistically significant relationships were considered in candidate models (Table 1).

Our initial dataset included 1134 moose locations and we generated 113,400 random locations (100 random points for each moose location). We restricted random locations to sub-blocks that were within sampled survey blocks and within sub-blocks where we observed no moose (unused sub-blocks). We intersected the moose and random locations within sub-blocks to describe the landscape and vegetation characteristics for each point location at the 400-m scale.

To estimate the RSPF, we assumed that habitat selection is similar for all age/sex animals excluding calves so calf-cow groups were considered as 1 location. Therefore, the final dataset included 959 moose locations and 95,900 random locations. For simplicity, we used logistic regression to estimate coefficients for the RSPF model because of our used and unused sub-block design. The model that best described moose habitat selection at the 400-m scale included 3 covariates, including 2 polynomial terms (Table 2). Specifically, moose selected for sub-blocks where the majority land cover (30-m scale) was past burns (5 to 35 years old, Maier et al. 2005), or a combination of shrubland and mixed forest. Moose further selected for mid-elevations of approximately 900 to 1250 meters and slopes of less than 10 degrees (Table 3). We used this model to predict RSPF values for sub-blocks in unsampled survey blocks and then summed all RSPF values within each survey block. These block-level RSPF values then represented a general "habitat selection" covariate used in further analyses and are denoted "*SumRSPF*".

We used Zero-Inflated Negative Binomial regression Models (ZINB) to describe the distribution of the number of moose counted in sampled survey blocks. These models best describe low density and spatially aggregated moose distribution across survey blocks in Yukon because they account for overdispersion and excess zeros. We estimated models with the zeroinfl() function in the pscl package for R (Zeileis et al. 2008). The model that best described the data included 2 count model coefficients and 2 coefficients in the zero-inflation component (Table 4). The number of moose observed in a survey block was positively correlated with SumRSPF and Fire25, the "habitat selection" descriptor and ≥ 25% fire threshold, respectively, for each survey block. In addition, there was a greater likelihood of observing 0 moose in blocks with smaller values of SumRSPF and greater than approximately 80% conifer cover (NALC250Shrub). This model was used to predict the number of moose in unsurveyed units of the survey area (Table 5). The final population estimate and bootstrapped prediction intervals were obtained by combining the actual number of observed moose in sampled survey blocks with predictions from unsampled survey blocks (Czetwertynski et al., *in prep*).

2) Composition estimation

We used a compositional analysis to describe the composition by age and sex of the moose population in the sampled dataset using the vglm() function in the VGAM package for R (Yee 2010). We found that the best model included the *SumRSPF2* covariate that accounted for the lesser proportion of lone adult cows and adult bulls in survey blocks with lower values of the *SumRSPF2* predictor (Table 6). This model (Table 7) was then applied to unsurveyed sample units where the total number of moose was predicted by the ZINB model to obtain the composition estimates and associated bootstrapped prediction intervals of the moose population in the survey area (Czetwertynski et al., *in prep*).

Table 1: Description of selected list of coefficients considered for Resource Selection Probability Functions (RSPFs) and models of abundance/composition of moose in the Lower Macmillan River survey area, November 2020.

Covariate Name	Description	Source
FireShrub	Binary covariate of the majority land cover class within sub-blocks: 1 = majority land cover was either a burn (5-35 years old) or shrub (Temperate or sub-polar shrubland, Sub-polar or polar shrubland lichen moss, or mixed forest); 0 = other majority land cover category.	North American Land Cover 2015 30 m x 30 m resolution, Canada Center for Remote Sensing (CCRS), Natural Resources Canada. Canadian National Fire Database.
Elevation	Mean elevation in km of the sub-block.	Canadian Digital Elevation Model 30 m x 30 m resolution, Natural Resources Canada.
Slope	Mean slope in degrees of the sub-block	Canadian Digital Elevation Model 30 m x 30 m resolution, Natural Resources Canada
NALCShrub	Binary covariate of the majority land cover class within sub-blocks: 1 = majority land cover was shrub (Temperate or sub-polar shrubland); 0 = other majority land cover category.	North American Land Cover 2015 30 m x 30 m resolution, Canada Center for Remote Sensing (CCRS).
Fire	Percent of the survey block comprised of a past burn (5-35 years old).	Natural Resources Canada. Canadian National Fire Database.

Fire25 / 50	Binary covariate of the land cover class within sub-blocks: 1 = ≥ 25% / 50% of the land cover was a burn (5-35 years old); 0 = < 25% / 50% of the block was comprised of a burn.	Natural Resources Canada. Canadian National Fire Database.
NALC250Needle	Percent of the survey block comprised of conifer (Temperate or sub-polar needleleaf forest and sub-polar taiga needleleaf forest).	North American Land Cover 2010 250 m x 250 m resolution, Canada Center for Remote Sensing (CCRS).
ABoVENeedle	Percent of the survey block comprised of conifer (Evergreen forest and woodland).	ABoVE Dominant Land Cover 2014 30 m x 30 m resolution, Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Table 2: List of best models describing the Resource Selection of moose observed in survey sub-blocks (approximately 400 m x 400 m) in the Lower Macmillan River survey area (November 2020) with associated AIC scores and model weights.

Model	*df*	AIC	ΔAIC	*w*
FireShrub + $Elevation^2$ + $Slope^2$	6	11782.45	00.00	1
Fire + NALCShrub + $Elevation^2$ + $Slope^2$	7	11804.77	22.32	0
Fire + $Elevation^2$ + $Slope^2$	6	11820.61	38.16	0

Table 3: Logistic regression estimates for the Resource Selection Probability Function (RSPF) used to describe locations of moose observed in surveyed sub-blocks (approximately 400 m x 400 m) in the Lower Macmillan River survey area, November 2020 (Log-likelihood = -5885.22). We used this model to generate RSPF values for unsurveyed sub-blocks.

	Estimate	Standard Error	*Z*	*P*
(Intercept)	-17.7484	0.8218	-21.5980	<0.001
FireShrub	1.6441	0.1063	15.4630	<0.001
Elevation	20.1500	1.4336	14.0560	<0.001
$Elevation^2$	-8.1378	0.6226	-13.0710	<0.001
Slope	0.0429	0.0229	01.8700	0.062
$Slope^2$	-0.0048	0.0011	-04.3530	<0.001

Table 4: List of best models describing the number of moose observed in survey blocks in the Lower Macmillan River survey area (November 2020) with associated AIC scores and model weights.

Model		Distrib.	*df*	AIC	ΔAIC	*w*
Count Covariates	Zero Inflation Cov.					
SumRSPF + Fire25	SumRSPF2 + NALC250Needle	ZINB	6	934.37	00.00	0.56
SumRSPF	ABoVENeedle	ZINB	4	935.56	01.91	0.31
SumRSPF + Fire50	ABoVENeedle	ZINB	5	937.40	03.03	0.12
SumRSPF + Fire25		NB	4	946.33	11.96	0.00
SumRSPF + Fire25 + ABoVENeedle		NB	5	947.76	13.39	0.00

Table 5: Zero-Inflated Negative Binomial (ZINB) regression estimates for counts of moose observed in surveyed sample blocks (approximately 16 km^2) in the Lower Macmillan River survey area, November 2020 (Log-likelihood = -458.90). We used this model to generate the population estimate and prediction intervals for the Lower Macmillan River survey area and Moose Management Unit (MMU).

	Estimate	Standard Error	*Z*	*P*
Count model coefficients (negbin with log link):				
(Intercept)	0.6739	0.2342	2.8780	0.004
SumRSPF	0.4629	0.9464	4.8910	<0.001
Fire25	0.5429	0.1971	2.7540	0.006
Log(theta)	0.2989	0.2047	1.4600	0.144
Zero-inflation model coefficients (binomial with logit link):				
(Intercept)	-1.3432	1.0117	-1.3280	0.1843
SumRSPF	-0.9085	0.5288	-1.7180	0.0858
NALC250Needle	2.5274	1.1494	2.1990	0.0279

Table 6: List of best models describing the composition of moose observed in the Lower Macmillan River survey area (November 2020) with associated AIC scores and model weights.

Model	AIC	ΔAIC	*w*
SumRSPF	1301.38	0.00	0.64
NALC250Needle	1303.06	1.68	0.28
Fire (5 to 35 years old)	1306.75	5.38	0.04
ABoVENeedle	1307.56	6.19	0.03
NALCShrub	1310.0.08	8.63	0.01

Table 7: Compositional model regression estimates for moose in the Lower Macmillan River survey area, November 2020 (Log-likelihood = -640.689). We used this model to generate the composition and related prediction intervals for the Lower Macmillan survey area and Moose Management Unit (MMU).

	Estimate	Standard Error	*Z*	*P*
(Intercept):BULL_LARGE	0.069	0.220	0.312	0.755
(Intercept):BULL_SMALL	-2.020	0.377	-5.362	<0.001
(Intercept):COW_1C	-0.321	0.257	-1.248	0.212
(Intercept):COW_2C	-1.937	0.530	-3.651	<0.001
(Intercept):LONE_COW	0.345	0.208	1.646	0.099
SumRSPF:BULL_LARGE	0.326	0.142	2.302	0.021
SumRSPF:BULL_SMALL	0.661	0.220	3.000	0.003
SumRSPF:COW_1C	0.065	0.169	0.386	0.699
SumRSPF:COW_2C	-0.258	0.378	-0.683	0.495
SumRSPF:LONE_COW	0.384	0.134	2.865	0.004

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