SR-23-17

Cassiar Mountains Moose Survey

Early-Winter 2020

September 2023

Cassiar Mountains Moose Census
Early-Winter 2020

Government of Yukon
Fish and Wildlife Branch
SR-23-17

Authors

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Summary

- We conducted an early-winter survey of moose in the Cassiar Mountains from November 10-19, 2020. This was the first survey of the entire Cassiar Mountains Moose Management Unit (MMU). The purpose was to estimate the abundance, distribution, and composition of the moose population in the MMU.

- We counted moose in 54 of 205 survey blocks, or about 26% of the MMU. We observed 195 moose including 44 mature bulls, 112 mature cows, 9 yearling bulls, 27 calves, and 3 moose of unknown sex and age class.

- We estimated 440 (331-611) moose in the Cassiar Mountains MMU. This number is equal to a density of 148 moose per 1000 km^2 of suitable moose habitat, which is on the lower end of the typical range of moose densities in surveyed areas across the Yukon (100-250 / 1000 km^2). This low density is consistent with our observations of poor moose habitat over the majority of the MMU.

- We estimated 25 calves and 16 yearlings per 100 adult cows, which is at the lower end of recruitment observed in surveyed areas across the Yukon.

- We estimated 44 adult bulls per 100 adult cows, which is above the minimum threshold of 30 adult bulls per 100 adult cows identified in our moose management guidelines.

- The 5-year average licensed harvest (2016-2020) of 12 bulls is above the recommended sustainable harvest of 10 bulls estimated for this MMU.

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Introduction

This report summarizes results of the early-winter population survey for moose in the Cassiar Mountains Moose Management Unit (MMU; Figure 1), conducted from November 10-19, 2020. The purpose of this survey was to estimate the abundance, distribution, and composition of the moose population. We use this information to assess the sustainability of the current moose harvest.

Previous Surveys

This is the first complete survey of the Cassiar Mountains MMU. We derived previous estimates of moose density in this area from census results in adjacent game management subzones, moose habitat within the Cassiar Mountains MMU, and expert opinion.

In 1983, the Liard West survey area included much of Game Management Subzone (GMS) 10-28 and 10-29, marking one of the earlier moose surveys conducted by the Game Branch. We surveyed the Liard Basin in early winter of 2016 but only included ~30% of GMS 10-28. To date, we have not surveyed GMS 10-26, or the entire western portion of the Cassiar MMU. However, GMS 10-23 and a portion of 10-24 were surveyed in 2010 as part of the Nisutlin South survey area (Figure 2).

Community Involvement

Moose have been a key part of First Nation peoples' subsistence lifestyle for generations and today are the most widely hunted game species by both Yukon First Nations and non-First Nations hunters.

There is ongoing interest from the Teslin Tlingit Council (TTC) and the Teslin Renewable Resources Council (TRRC) to collect and provide updated information on moose populations in their traditional territory, and this information will support ongoing moose management partnerships that rely on accurate population data and harvest estimates.

The TTC and TRRC identified the Cassiar Mountains MMU as a priority area for community-based moose management within the Teslin Traditional Territory, identifying high harvest rates (from both licensed and First Nation hunters) and high hunter access as key concerns. Monitoring and management objectives specific to the Cassiar MMU will be identified in the Teslin Fish & Wildlife Work Plan (2023, in prep.).

Knowledge holders and local experts from the Teslin Tlingit Council provided local knowledge about moose distribution and abundance in the Cassiar Mountains MMU that informed the sampling effort during the survey (see Methods for details). Members from the Teslin Tlingit Council and Teslin Renewable Resources Council also participated in the moose survey as aerial observers in both the stratification and census portions of the survey.

Concurrent BC Survey

The Cassiar MMU is bounded by the British Columbia/Yukon border to the south, a biologically insignificant boundary for moose in this area. The BC Government conducted a concurrent moose survey south of the Cassiar MMU, in the Teslin Population Management Unit (PMU; Figure 3). PMUs are the primary spatial scale used for moose management in BC, like Yukon's MMUs. The results of a transboundary survey will be more biologically representative of the moose population and allow us to better assess the sustainability of harvest in the Yukon. As such, we incorporated information from the Teslin PMU (BC) survey to help estimate moose abundance and composition in the Cassiar Mountains MMU (Analysis Boundary, Figure 3).

Study Area

The Yukon survey area falls entirely within the Cassiar Mountains Moose Management Unit (MMU; Environment Yukon, 2016). MMUs are used throughout the territory to monitor and manage moose at the scale of populations.

The Cassiar Mountains MMU (3523 km^2) includes GMSs 10-26, 10-28 and 10-29 (Figure 1). The MMU stretches from the Yukon-BC border north to Ram Creek and the Meister River, while it is bounded by the Morley River in the west and the Alaska Highway towards Rancheria in the east.

Suitable moose habitat makes up much of the study area (2968 km^2); this excludes land at or above 1524 m in elevation and waterbodies 0.5 km^2 or greater in size.

The survey area is almost entirely within the Pelly Mountains ecoregion, which is characterized by extensive mountains and valleys (including the northern extent of the Cassiar Mountains) separated by wide lowlands. Being the first major mountain range east of the St. Elias and Coast Mountains, precipitation can be heavy in portions of the ecoregion (Yukon Ecoregions Working Group, 2004). Rolling plateaus are present on the western, central, and eastern portions of the survey area, separating steep mountain blocks with narrow valleys dominated by dense spruce in the west-central portion of the study area (such as around Monroe Lake and Goddart Creek).

Old burns are present along the western boundary of the survey area (1950) and along the Alaska Highway near Rancheria (1958). More recent burns include a 3328 ha burn along the Meister River (1998) and a 14.62 km^2 burn in the southeast corner of the survey area, though both burns overlap only very slightly with the survey area (Figure 4).

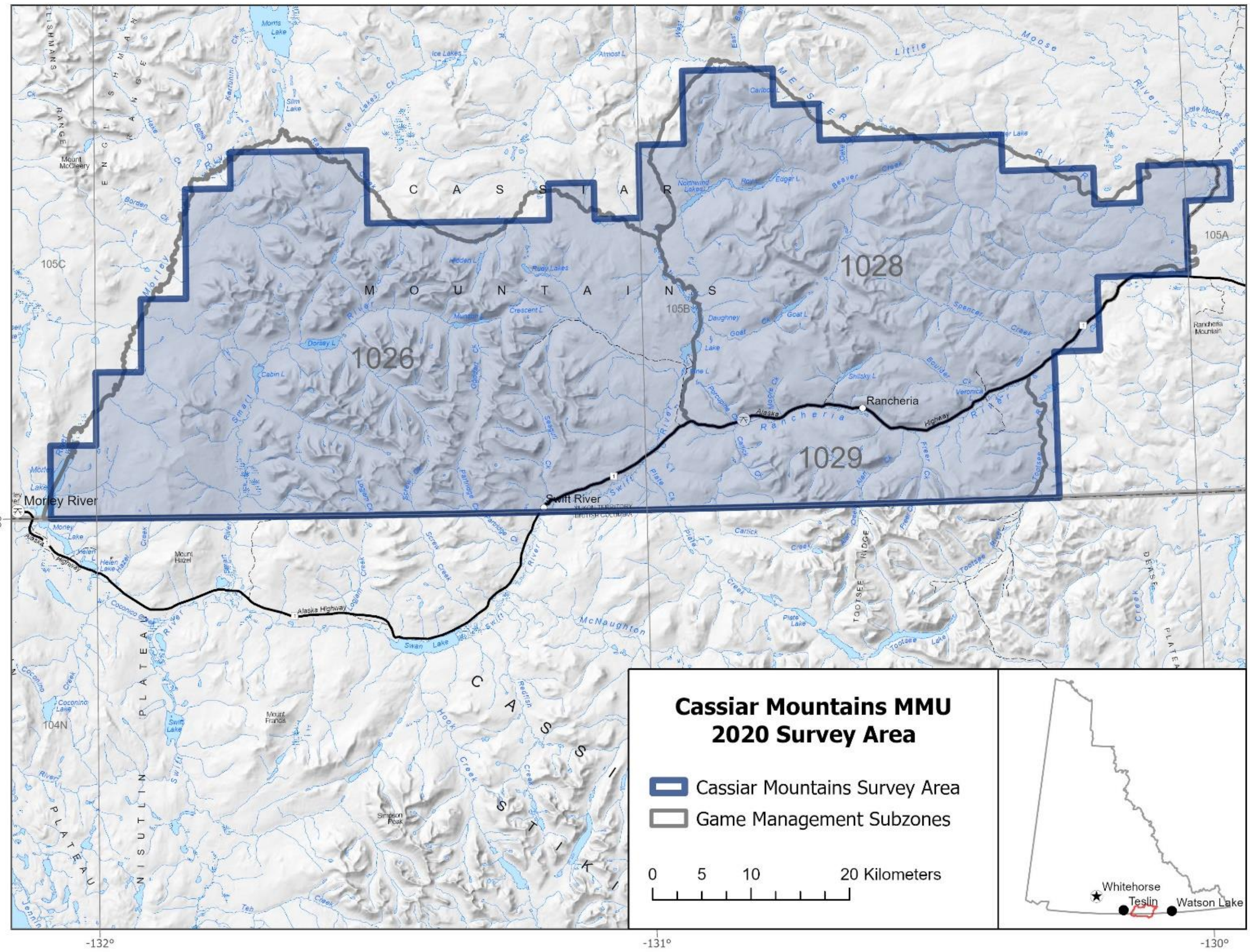

Figure 1. Cassiar Mountains survey area, November 2020. The Cassiar Mountains Moose Management Unit (MMU) includes Game Management Subzones (GMSs) 10-26, 10-28, and 10-29.

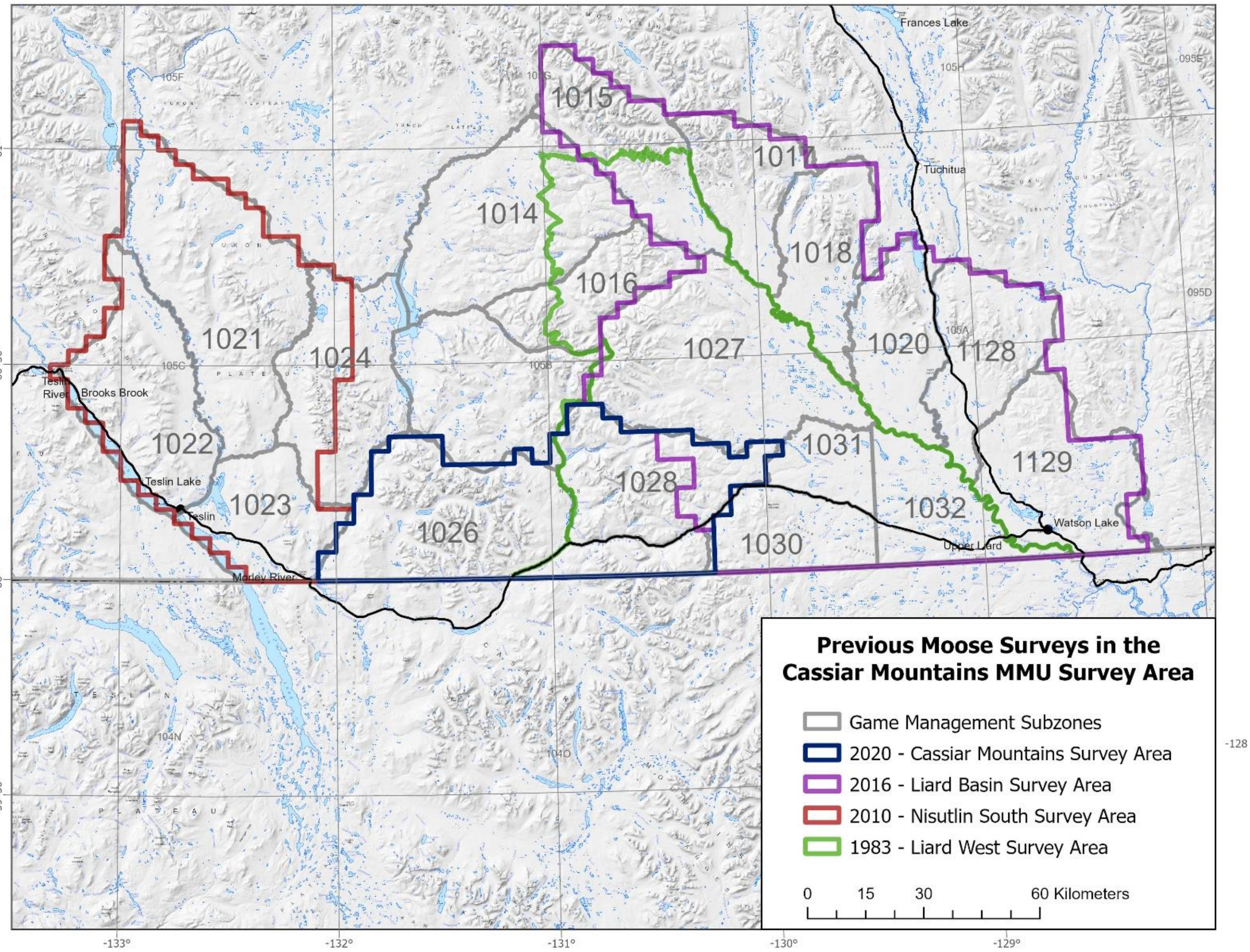

Figure 2. Previous moose surveys in, and around, the Cassiar Mountains Moose Management Unit (MMU) survey area. The MMU includes Game Management Subzones (GMSs) 10-26, 10-28, and 10-29.

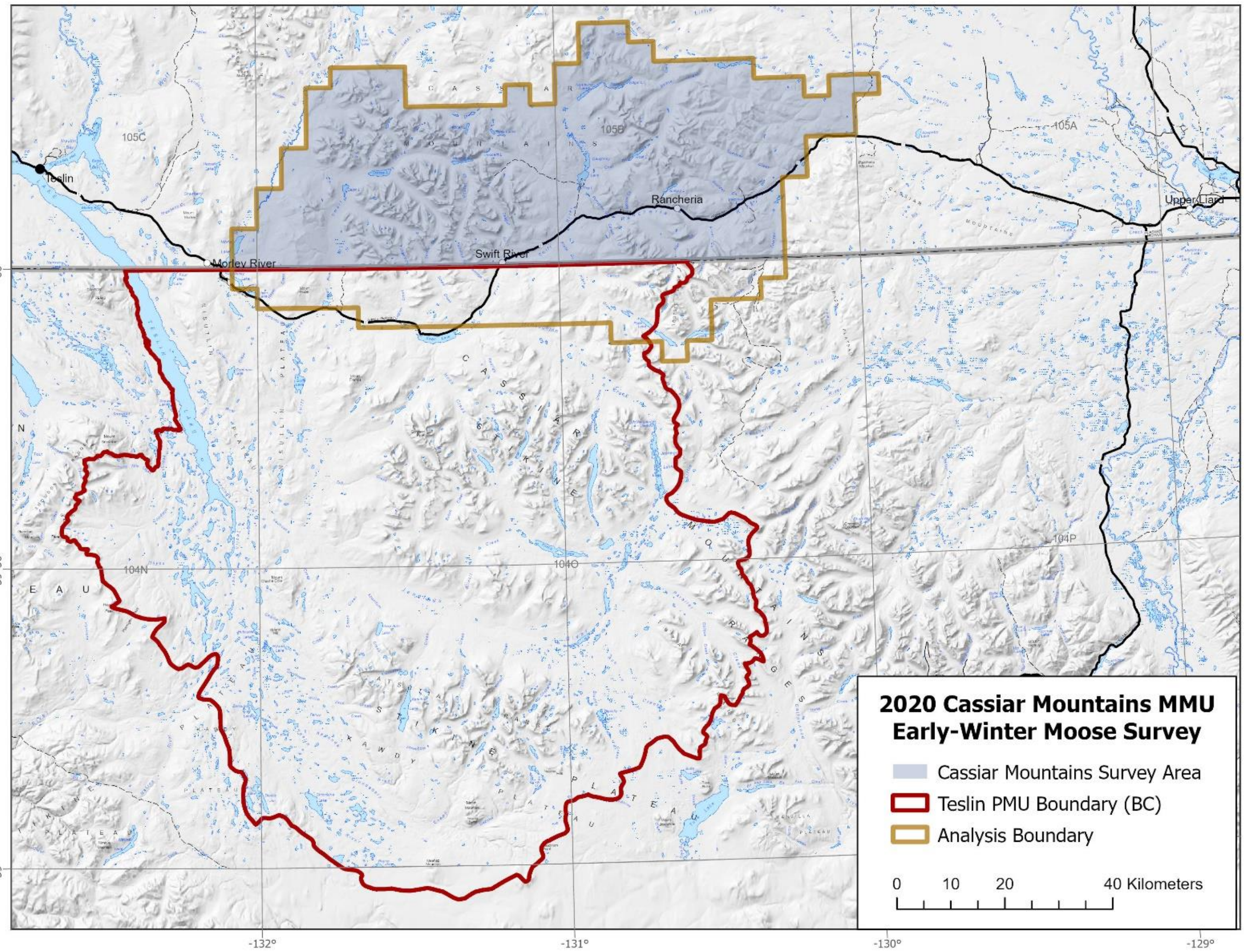

Figure 3. The Cassiar Mountains Moose Management Unit (MMU, Yukon Government) and Teslin Population Management Unit (PMU, BC Government) survey areas, November 2020. The analysis area boundary represents the area used to develop the final prediction model to estimate moose abundance in the Cassiar Mountains MMU.

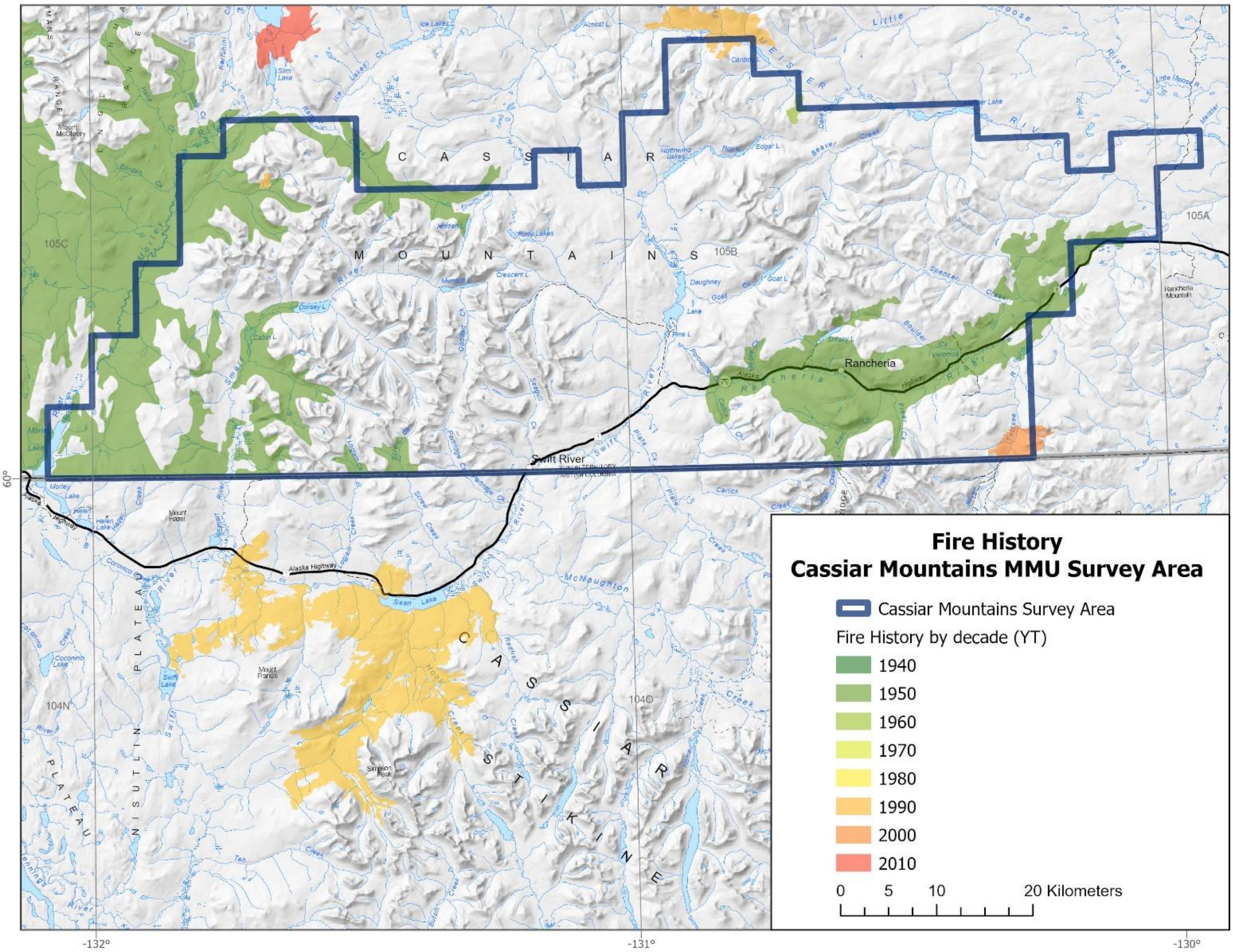

Figure 4. Fire history by decade in the Cassiar Mountains Moose Management Unit (MMU) survey area, November 2020.

Methods

Overview

We use a model-based technique to survey and estimate moose populations 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. For this survey, we used data from the BC survey within our analysis boundary to fit models and make predictions in the Cassiar MMU. 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 utilize 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 ~14.9-15.2 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 (age class and sex) 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 moose abundance in as many different survey blocks as possible. We use this information to evaluate the final model predictions.

Within blocks selected for sampling, we classify all moose by age class (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 equal twice the estimated number of yearling bulls). We then reduce the adult cow estimate accordingly.

Finally, we use a Yukon average “sightability correction factor” of 9%, based on data from previous moose surveys, to estimate the number of moose we missed during our searches of each survey block, and to correct our final population estimates accordingly. We use a 90% prediction interval to describe the uncertainty in our estimates.

Survey block selection

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

1. In phase 1, we use any available local knowledge and information from previous or nearby surveys to classify blocks as having either high, medium, low, or very low expected moose numbers. For this survey, we also conducted a stratification flight to have an additional source of information (see the Stratification details in the Results and Discussion section). We use this information to select survey blocks to be flown

during the first 2-3 days of the survey (approximately 30% of the total number of blocks we expect to survey). We select blocks such that they are distributed across the survey area and cover the range of available habitat types and areas of different expected numbers of moose;

2. In phase 2, we use a combination of landscape characteristics (land cover, slope, elevation), stratification data, 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 subarea 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.

3. In 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 and 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.

Weather and Snow Conditions

Weather conditions were mostly poor during the survey, but did not limit our ability to observe moose because we were able to be selective and sample blocks with adequate visibility throughout the day. Teslin Lake remained open (ice-free) during the entire survey often creating a thick layer of ice fog between Teslin and the survey area. On most days, fog penetrated the study area, limiting access to higher elevations and the steep, narrow valleys of the Cassiar Mountains.

Temperatures ranged from -2° C to -25° C. Winds were mild to moderate but were stronger at higher elevations along ridges.

An early winter snowstorm brought more than 30 cm of snow to the survey area in early November, which was abnormal in timing and amount for southern Yukon. Snow cover was complete throughout the survey area, ranging from 30-50 cm. Frequent dustings of snow added 4-10 cm during the survey, increasing our ability to detect moose tracks.

Results and Discussion

Stratification Survey

We conducted a stratification survey with fixed-wing aircraft prior to the population survey and classified each survey block (*n* = 205) into one of four levels of expected moose abundance. We conducted the stratification survey on November 10 and 11, 2020. Based on our observations from the air, we classified 11 (5%) survey blocks as high, 67 (33%) medium, 71 (35%) low, and 56 (27%) very low expected numbers of moose (Figure 5). Many of the areas classified as high and medium were in gently sloped subalpine plateaus with abundant willows.

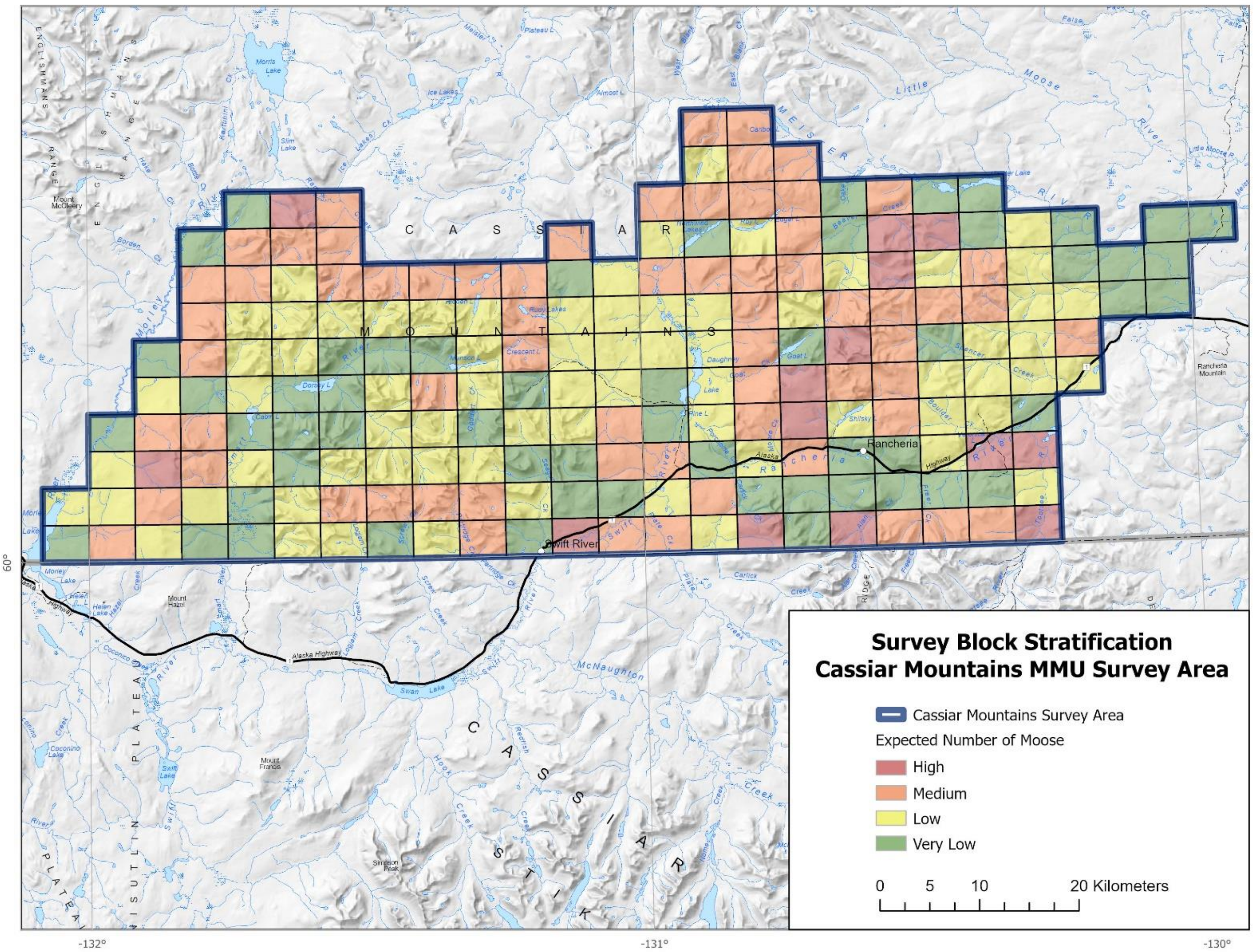

Figure 5. Results of survey block stratification in the Cassiar Mountains MMU survey area, November 10-11, 2020.

Coverage

We counted moose in 54 of 205 survey blocks, or about 26% of the MMU. We surveyed 10 (or 77%) of the blocks classified as 'high' expected moose density based on our stratification survey, 17 (26%) of the medium-density blocks, 14 (20%) of the low-density blocks, and 13 (24%) the very-low density blocks.

We flew ~30.5 hrs to count moose in these blocks using a single helicopter and crew, for a search intensity of 1.94 minutes per km^2 (Figure 6). We used another 16.8 hrs of helicopter time to ferry between survey blocks, our fuel caches, and back and forth to Teslin.

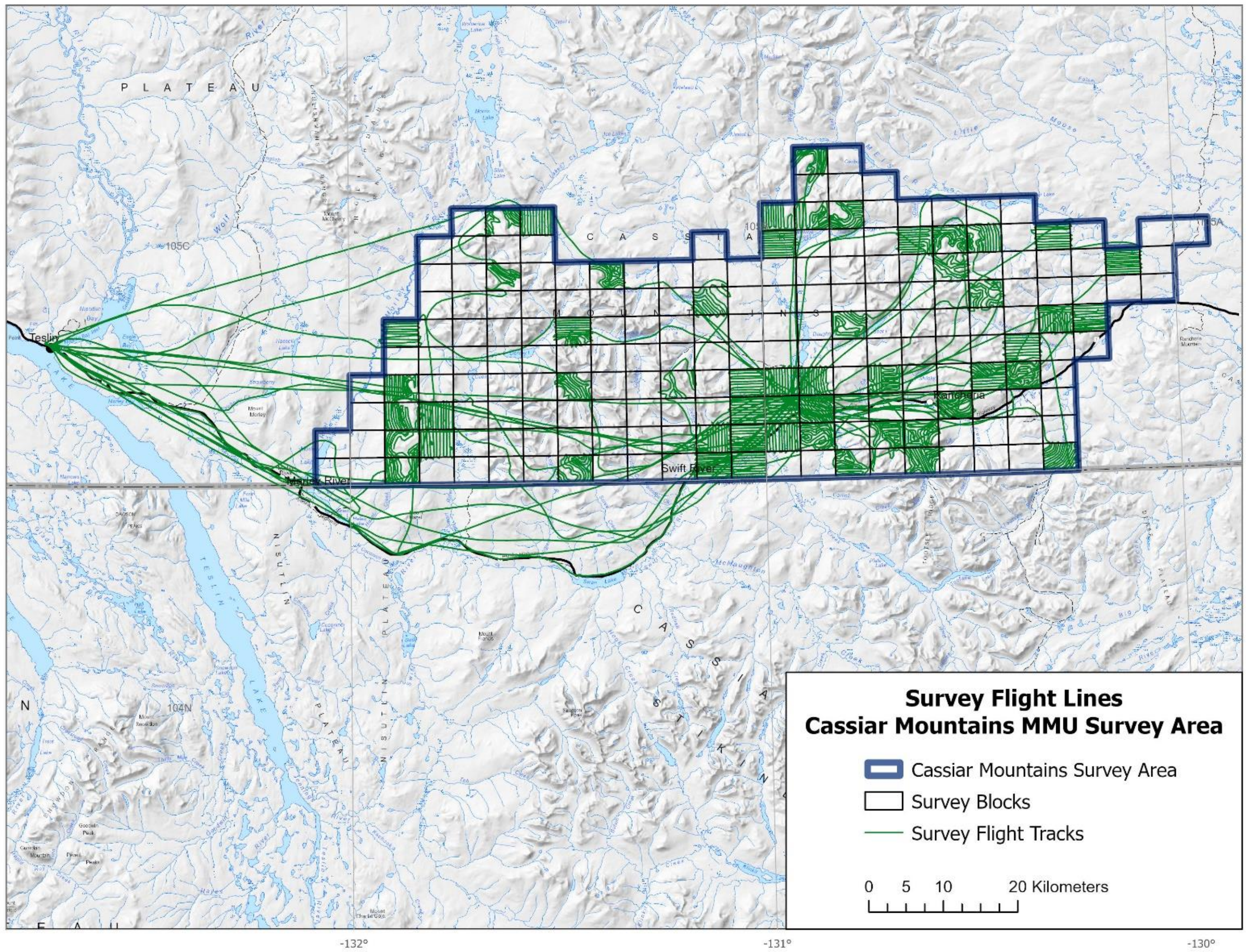

Figure 6. Helicopter flight tracks during Cassiar Mountains moose survey, November 10-11, 2020

Observations of Moose

We observed a total of 195 moose, including 44 (23%) mature bulls, 112 (57%) cows, 9 (5%) yearling bulls, 27 (14%) calves, and 3 (1%) moose of unknown sex and age class in the MMU (Table 1).

Table 1. Observations of moose in survey blocks in the Cassiar Mountains Moose Management Unit (MMU), November 2020.

	Total
Number of blocks counted	54
Number of adult bulls	44
Number of adult and yearling cows*	112
Number of yearling bulls	9
Number of calves	27
Number of unknown sex/age	3
Total number of moose observed	195

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

Distribution of Moose

We observed the highest numbers of moose in the southern half of the survey area (Figure 7). As expected in early-winter, moose were concentrated in the subalpine and higher elevation open spruce forest with good willow cover. We observed the highest numbers of moose in the subalpine areas of Hazel Ridge, and along the high elevation, open willow slopes along the Alaska highway near the Swift and Rancheria rivers (Figure 7). Some areas that were burned during fires in 1950, 1958, and 2009 were also productive. We counted few moose in lowland and forested areas, in the steep and rocky Dorsey Range mountains, and in the subalpine areas near Goat Lake.

Abundance of Moose

The number of moose observed in a survey block was positively correlated to the "habitat quality" of the survey block. Specifically, moose selected for blocks with a high proportion of burns (1990-2015) or shrub cover at elevations between 1000 m and 1400 m (Appendix 1). This model is consistent with our observations that most moose move to subalpine habitats with abundant willows during the early winter.

Based on our counts and model predictions, we estimated 440 moose in the Cassiar Mountains MMU and we are 90% confident that the population ranged between 331 and 611 (Table 2). We estimated a density of 125 moose per 1000 km^2 in the MMU or 148 moose per 1000 km^2 of suitable moose habitat (Table 2). This is on the lower end of the typical Yukon moose densities observed in surveyed areas of 100-250 per 1000 km^2 of suitable moose habitat (Government of Yukon, 2016). However, observed moose abundance was consistent with habitat quality throughout the survey area.

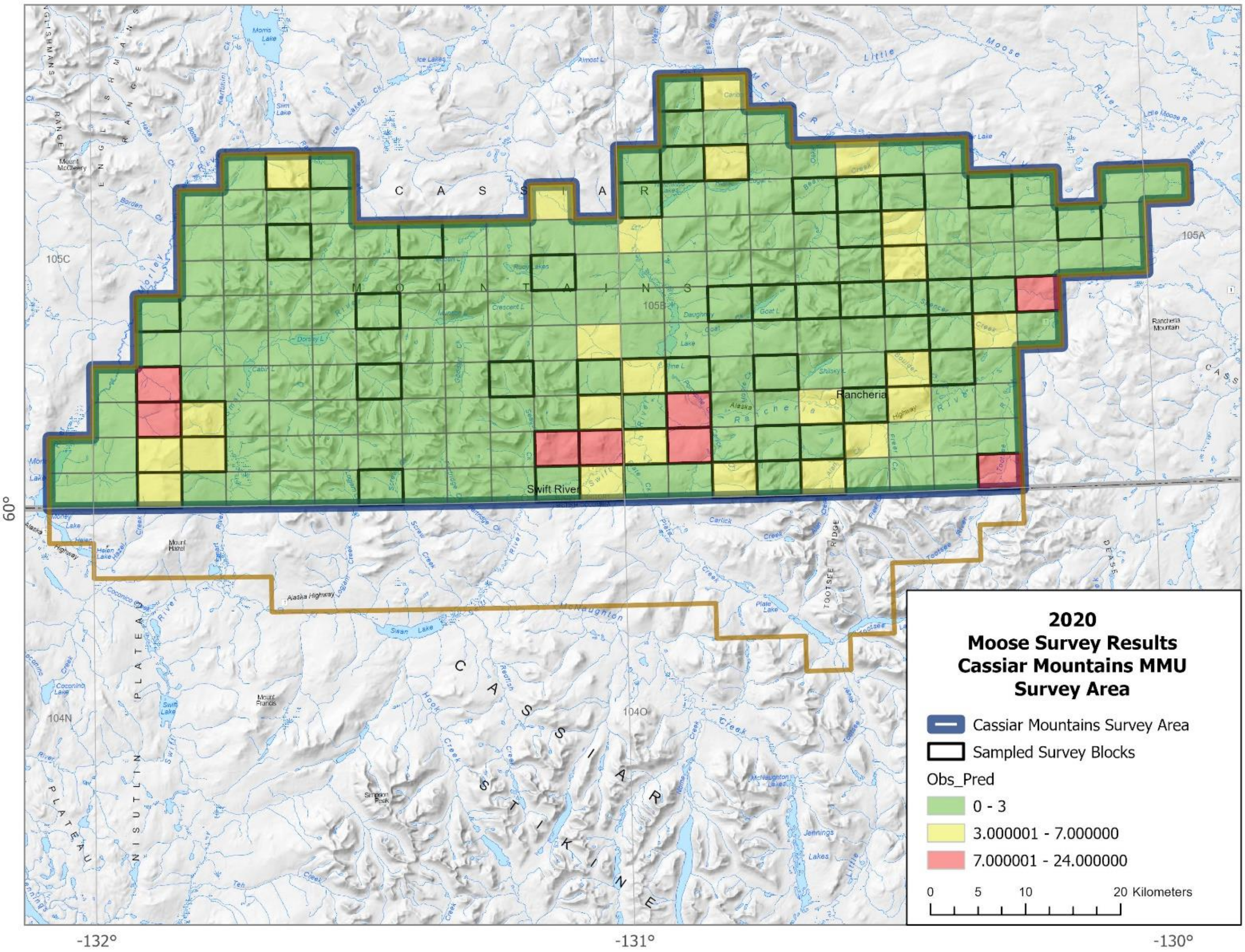

Figure 7. Estimated or observed numbers of moose in the Cassiar Mountains survey area, November 2020. Note, estimated numbers of moose reported herein are for the Cassiar MMU survey area only, and not the analysis boundary that includes portions of British Columbia.

Table 2. Estimated abundance of moose, corrected for sightability (9%), Cassiar Mountains Moose Management Unit (MMU), November 2020.

	Best estimate	90% prediction intervals *
Estimated total number of moose	440	331-611
Adult bulls	104	76-147
Adult cows	238	178-328
Yearlings	38	26-58
Calves	59	44-84
Density of moose (per 1,000 km^2)		
Entire area	125	94-173
Moose habitat only **	148	112-206

* A '90% prediction interval' means that, based on our survey results, we are 90% confident that the true number lies within this range. Our best estimate is near the middle (at the median) of this range.

** Suitable moose habitat is considered to be all areas at elevations lower than 1524 m (5000 ft), excluding water bodies 0.5 km^2 or greater in size.

Ages and Sexes of Moose

We found a non-significant influence of landscape or habitat within survey blocks on moose composition and used this information to estimate moose composition in unsurveyed blocks (Appendix 1).

We estimated 25 (21-29) calves and 16 (12-21) yearlings for every 100 adult cows in the population (Table 3.), which is slightly below the averages in surveyed areas across the Yukon of 29 calves and 18 yearlings per 100 adult cows (Government of Yukon, 2016). However, estimates of recruitment from one survey are snapshots in time and survival varies from year to year.

We estimated 44 (38-51) adult bulls for every 100 adult cows in the survey area (Table 3). This is above the minimum level of 30 bulls per 100 cows recommended in the Science-based Guidelines for Management of Moose in Yukon (Government of Yukon, 2016).

Table 3. Estimated composition of the moose population in the Cassiar Mountains Moose Management Unit (MMU), November 2020.

	Best Estimate	90% prediction intervals *
% Adult bulls	24	21-26
% Adult cows	54	51-57
% Yearlings	9	7-11
% Calves	13	12-15
Adult bulls per 100 adult cows	44	38-51
Yearlings per 100 adult cows	16	12-21
Yearlings per 100 adults (recruitment rate)	10	8-13
Calves per 100 adult cows	25	21-29
% of cow-calf groups with twins	4	2-8

* A "90% prediction interval" means that, based on our survey results, we are 90% confident that the true number lies within this range, and that our best estimate is near the middle (at the median) of this range.

Harvest

In the Yukon, we estimate sustainable harvests for moose populations at the MMU scale (Government of Yukon, 2016). Specifically, in areas where recent (within 10 years) survey information is available, we estimate that 10% of the adult bull population can be sustainably harvested annually (Government of Yukon, 2016). Therefore, the estimated sustainable annual harvest from this population is 10 bulls (10% of the estimated 104 total adult bulls) (Figure 8).

The 5-year average reported licensed harvest (from 2016-2020) in the Cassiar MMU is 12.2 bulls (Figure 9). This is above the estimated sustainable harvest of 10 bulls and does not include moose harvested by

First Nation hunters. To estimate First Nation harvest, we use a multiplier of 1.5 times the licensed resident harvest (average of 18 bulls per year, 2016-2020). Therefore, our best estimate of total harvest (2016-2020, licensed and First Nation) for this MMU is 30 bulls per year. Actual First Nation harvest information is required to accurately assess harvest pressure for this MMU.

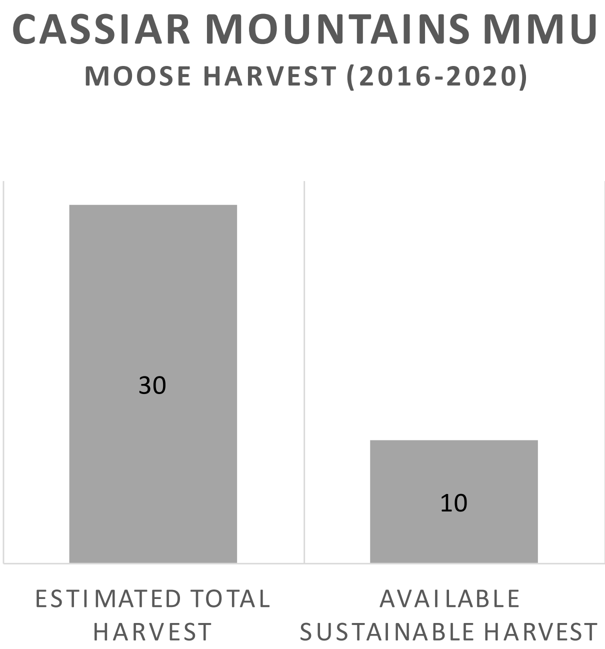

Figure 8. The 5-year average total estimated harvest includes reported licensed harvest and estimated First Nation harvest. The sustainable limit of 10 bulls is based on the 2020 survey data.

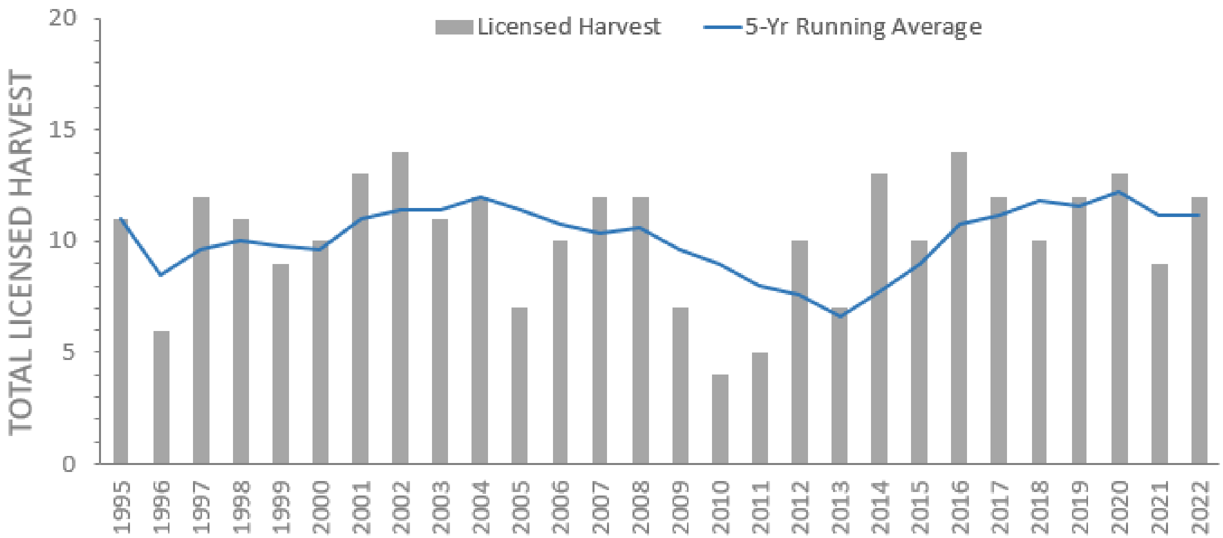

Figure 9. Total reported licensed harvest of moose in the Cassiar Mountains Moose Management Unit (MMU) with 5-year running average.

Other Wildlife Sightings

We counted 39 moose in 23 groups outside of the surveyed blocks or while travelling between blocks. We also observed 24 Wolf Lake caribou in 3 groups located north of Goat Lake, west of Northwind Lakes, and north of Spencer Creek. We observed 5 thinhorn sheep in two groups, both in the mountains northeast of Goat Lake. Finally, we observed 7 wolves (3 singles and a group of 4), 1 deer, and 1 red fox.

Conclusions and Recommendations

- We found the moose density in the Cassiar Mountains survey area to be on the lower end of the typical range of moose densities in the Yukon. However, observed moose abundance was consistent with habitat quality throughout the survey area.

- Survival of calves and yearlings was slightly below the average observed in surveyed areas across the Yukon.

- The ratio of adult bulls to adult cows is above the recommended minimum of 30 adult bulls/ 100 adult cows identified in our Moose Management Guidelines.

- The 5-year average total (reported licensed and estimated First Nation) harvest is currently above the sustainable level estimated for the MMU.

- First Nation harvest information is required for an accurate assessment of the harvest pressure in the MMU.

- This survey serves as a baseline to compare future survey data.

- We recommend continuing to monitor this population and working with First Nations to accurately quantify harvest pressure in the MMU.

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Appendices

Appendix 1. Analyses and models used to estimate the abundance and composition of moose in the Cassiar Mountains Moose Management Unit from November 2020 survey data.

1) Overview

We estimated abundance and composition of moose in the Cassiar Mountains Moose Management Unit (MMU) with a three-staged approach using data from the greater Cassiar Mountains survey area (see Study Area section for details). We first used moose locations in surveyed blocks within the survey area to generate Resource Selection Probability Functions (RSPFs) at the scale of moose locations. This information was then scaled up to the survey block scale to generate count models and provide estimates of moose abundance for unsampled survey blocks. Lastly, we used predicted and observed moose abundance with moose composition information from surveyed blocks to estimate the composition of moose over the entire survey area.

For all analyses, we included biologically relevant and spatially representative covariates expected to influence moose occurrence and composition. We used these covariates to generate candidate models and based further inference on the highest-ranking model determined using Akaike's Information Criterion (AIC; Burnham and Anderson 2002) and AIC weights (Wagenmakers and Farrell 2004).

2) Abundance estimation

We generated a small-scale grid such that within each survey block (approximately 4km x 4km) there were 100 sub-blocks (approximately 400m x 400m). 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/abundance. All covariates deemed biologically relevant were considered in candidate models (Table 1). We identified sub-blocks as Used or Unused based on whether they contained a moose location.

To estimate the RSPF, we considered only the sub-blocks located within surveyed blocks (16 km2). When intersecting sub-blocks with moose locations, we assumed habitat selection was similar for all age/sex classes excluding calves. Thus, cow-calf groups were considered as a single location and lone calves (n = 2) were excluded. Therefore, the final dataset included 192 Used sub-blocks and 19,200 Unused random sub-blocks (100 random sub-blocks for each used sub-block).

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 400m scale included 3 covariates (Table 2). Specifically, moose selected for sub-blocks where the majority landcover (30m scale) was burns (1990-2015) or shrubland. Moose further selected for elevations between 1,000m and 1,400m and sub-blocks with the presence of tall shrub (30m scale, Table 3). We used this model to predict RSPF values for sub-blocks within unsampled survey blocks and then summed all RSPF values within each survey block (4km x 4km scale). These block-level summed RSPF (Summed RSPF) values then represented a general "habitat quality" covariate used in subsequent count and composition analyses.

We fit Negative Binomial (NB) and Zero-Inflated Negative Binomial regression Models (ZINB) to relate the number of moose counted in surveyed blocks with selected coefficients. These models best describe low density and spatially aggregated moose distribution across survey blocks in Yukon because they account for overdispersion (NB models) and excess zeros (ZINB models). We estimated models with the zeroinfl() function in the pscl package for R (Zeileis et al. 2008; R Core Team, 2023). The 2 most parsimonious models included the Summed RSPF variable in both the count and zero-inflation components (Table 4). Therefore, the number of moose observed in a survey block was positively correlated to Summed RSPF (the "habitat quality") of the survey block. In addition, there was a greater likelihood of observing 0 moose in a survey block at lower Summed RSPF values.

We used the weighted average of these abundance models to predict the number of moose in the remaining unsurveyed blocks (Table 5). We obtained the final population estimate and bootstrapped prediction intervals by combining the actual number of observed moose in sampled survey blocks with the distributions of predictions from unsurveyed blocks generated from 1,000 bootstraps (Czetwertynski et al., in prep). This approach enables us to generate realistic estimates of subsets of the survey area when required (in this case for the Cassiar Mountains MMU).

3) Composition estimation

We used a compositional analysis to describe the age/sex composition of the moose population in the surveyed blocks using the vglm() function in the VGAM package for R (Yee 2010). We did not find any covariate that significantly affected the distribution of moose composition in the survey area (Table 6). We applied this null model (Table 7) to unsurveyed blocks where the median number of moose was predicted by the ZINB count model. We obtained the final composition estimates and associated prediction intervals of the surveyed area by iteratively bootstrapping (1,000 runs) the count and composition models (Czetwertynski et al., in prep). Lastly, the results were subset for the Cassiar Mountains MMU to provide estimates for management purposes.

Table 1: Description of selected covariates considered for Resource Selection Probability Functions (RSPFs) and models of abundance/composition of moose in the Cassiar Mountains survey area, November 2020.

Covariate Name	Description	Source
Landcover_4	Categorical covariate of the majority Landcover class within sub-blocks reduced to 4 classes (Conifer, deciduous or mixed forest, shrubland or burns 5-35 years old, other).	North American Land Cover 2015, 30m x 30m resolution, Canada Center for Remote Sensing (CCRS), Canadian National Fire Database. Natural Resources Canada.
Elev	Mean elevation in km of the sub-block.	Canadian Digital Elevation Model, 30m x 30m resolution. Natural Resources Canada.
TallShrub_01	Binary covariate describing the presence (1) or absence (0) of tall shrub cover type.	ABoVE Landsat-derived Dominant landcover 2014, 30m x 30m resolution, NASA.
Perc. Needle Forest	Percent of the survey block with needle leaf forest cover type.	North American Land Cover (NALC) 2015, 30m x 30m resolution, Canada Center for Remote Sensing (CCRS), Natural Resources Canada.
Perc. Shrub or Burn	Percent of the survey block with shrub cover or burns 3-35 years old.	North American Land Cover 2015, 30m x 30m resolution, Canada Center for Remote Sensing (CCRS), Canadian National Fire Database. Natural Resources Canada.

Table 2: List of top-ranking models describing the Resource Selection of moose at the 400m scale in the Cassiar Mountains survey area (November 2020) with associated AIC scores and model weights.

Model	df	AIC	ΔAIC	w
Landcover_4_Fire + Elev + Elev2 + Tall Shrub_01	7	1461.0	0.0	0.98
Landcover_4_Fire + TallShrub_01	5	1468.5	7.5	0.02
Landcover_4_Fire + Elev + Elev2	6	1483.7	22.7	0.00
Landcover_4_Fire	4	1490.5	29.5	0.00
Landcover_4	4	1497.5	36.5	0.00

Table 3: Logistic regression estimates for the Resource Selection Probability Function (RSPF) used to describe selection in sub-blocks (approximately 1.6 km2) within surveyed blocks (approximately 16 km2) in the Cassiar Mountains survey area, November 2020 (n = 192, Log-likelihood =-965.51). We used this model to generate RSPF values for unsurveyed sub-blocks.

	Estimate	Standard Error	Z	P
(Intercept)	-19.616	4.243	-4.62	<0.001
Landcover_4				
Deciduous or Mixed Forest	0.977	0.236	4.14	<0.001
Shrub or Burns 5-35 years old	1.328	0.177	7.49	<0.001
Other	-2.157	1.023	-2.11	0.035
Elevation	23.816	6.989	3.41	0.001
Elevation2	-10.097	2.860	-3.53	<0.001
Tall Shrub_01	1.154	0.237	4.88	<0.001

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

Model		Distribution	df	AIC	ΔAIC	w
Count Covariates	ZI Covariates					
Summed RSPF*	Summed RSPF	ZINB	3	280.6	0.0	0.53
Summed RSPF	Summed RSPF	ZINB	4	281.1	0.5	0.42
Perc. Shrub or burn	Perc. Shrub or burn	ZINB	4	287.3	6.6	0.02
Summed RSPF	.	NB	3	287.5	6.8	0.02
Perc. Shrub or burn	.	NB	3	288.7	8.1	0.01

* The intercept for the count portion of the model is fixed at 0

Table 5: Zero-Inflated Negative Binomial (ZINB) regression estimates for the 2 top models moose observed in surveyed blocks (approximately 16 km2) in the Cassiar Mountains survey area, November 2020 (n = 68; Log-likelihood =-135.6, -136.3). We used weighted averages of these models to generate the population estimate and prediction intervals for the Cassiar Mountains Moose Management Unit (MMU).

Model 1	Estimate	Standard Error	Z	P
Count model coefficients (negbin with log link)				
Summed RSPF	1.471	0.205	7.17	0.000
Log(theta)	-0.397	0.270	-1.47	0.142
Zero-inflation model coefficients (binomial with logit link)				
(Intercept)	13.650	15.240	0.90	0.371
Summed RSPF	-44.370	54.200	-0.82	0.413

Model 2	Estimate	Standard Error	Z	P
Count model coefficients (negbin with log link)				
(Intercept)	0.891	0.388	2.30	0.022
Summed RSPF	0.758	0.371	2.05	0.041
Log(theta)	0.283	0.483	0.59	0.558
Zero-inflation model coefficients (binomial with logit link)				
(Intercept)	2.171	1.281	1.70	0.090
Summed RSPF	-5.125	2.856	-1.79	0.073

Table 6: List of top-ranking models describing the composition of moose observed in the Cassiar Mountains survey area (November 2020) with associated AIC scores.

Model	AIC	ΔAIC	w
Null	266.1	0.0	0.94
Perc. Shrub or burn	273.7	7.6	0.02
Perc. Needle Forest	273.7	7.6	0.02
Summed RSPF	273.8	7.7	0.02

Table 7: Compositional model regression estimates for moose in the Cassiar Mountains survey area, November 2020 (n = 68, Log-likelihood =-128.1). This model was used to generate the composition and related prediction intervals for the Cassiar Mountains Moose Management Unit (MMU).

	Estimate	Standard Error	Z	P
(Intercept):BULL_LARGE	0.654	0.242	2.71	0.007
(Intercept):BULL_SMALL	-1.061	0.387	-2.74	0.006
(Intercept):COW_1C	-0.167	0.290	-0.58	0.564
(Intercept):COW_2C	-3.258	1.019	NA	NA
(Intercept):LONE_COW	1.296	0.221	5.85	<0.001

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