Yukon

SR-23-12

Moose Survey

Lake Laberge Moose Management Unit, Late-winter 2019

November 2023

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Lake Laberge Moose Management Unit, Late-winter 2019

Government of Yukon
Fish and Wildlife Branch
SR-23-12

Authors

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Acknowledgements

We thank the Kwanlin Dün, Ta'an Kwäch'än, and Little Salmon/Carmacks First Nations, and the Laberge and Carmacks Renewable Resources Councils for their support. Particularly, we thank Duncan Martin, Bobby Vance, Brandy Mayes, Bruce Wilson, Deborah Fulmer, Becky Freeman, Joseph O'Brien, Allen Skookum, Ruth Blackjack, Vera Charlie, Sheila Garvice, Lorraine Graham, Rob Florkiewicz, Ross Elliott, and Meghan Larivee for their assistance as aerial observers, and to our pilots Tyson Bramwell (Trans North Helicopters) and Sean McAndrew (Summit Helicopters).

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Suggested citation:

J. Goorts, M. O'Donoghue, S. Czetwertynski, L. Jessup, and S. Westover. 2019. Moose Survey: Lake Laberge Moose Management Unit, Late-Winter 2019. Yukon Fish and Wildlife Branch Report SR-23-12, Whitehorse, Yukon, Canada.

Summary

- We conducted a late-winter survey of moose in the Lake Laberge Moose Management Unit (MMU) survey area from February 16th to 26th, 2019. This was the first survey in much of this area. The purpose of the survey was to estimate the abundance, distribution, and composition by age and sex of the moose population in the MMU.
- We counted moose in 116 of 407 survey blocks, or about 29% of the total area. We observed a total of 469 moose, including 152 mature bulls, 246 mature and yearling cows, 11 yearling bulls, 57 calves, and three unclassified adults.
- We estimated 901 (90% confident that the population is between 749 and 1135) moose in the Laberge MMU. This equates to a density of 142 moose per 1,000km^2 of suitable habitat, which is on the lower end of the typical range of moose densities in Yukon (100-250 / 1,000km^2 of suitable moose habitat).
- We estimated 31 calves and 15 yearlings per 100 adult cows, which are near the Yukon averages (29 calves and 18 yearlings per 100 adult cows).
- We estimated 64 adult bulls/100 adult cows, well above the recommended level to breed cows identified in our moose management guidelines.
- We cannot determine whether the population is increasing, decreasing, or stable as no previous survey information exists for the Laberge MMU. Results from this survey will serve as a baseline to compare future survey data.
- Using a multiplier of 1.5 times the licensed harvest to estimate First Nation harvest, we calculate the 5-year average (from 2015-2019) harvest estimate in the Laberge MMU to be 16% of the bull population. This is above the sustainable level of 10% of the bull population that is recommended in our Moose Management Guidelines. Actual First Nation harvest information is required to accurately assess the harvest pressure in this MMU.

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Introduction

This report summarizes the results of the late-winter survey of moose in the Lake Laberge Moose Management Unit (MMU; Figure 1), which was conducted February 16-17 and 19-26, 2019. The purpose of this survey was to estimate the abundance, distribution, and composition of the moose population in the Laberge MMU, and to use this information to assess the sustainability of the current moose harvest.

Previous Surveys

This is the first moose population survey of the entire Laberge MMU. In 1993 and 1998, early winter moose surveys were conducted in the Big Salmon area (Government of Yukon, unpublished data), overlapping with a portion (16%; GMSs 806 and 807) of the Laberge MMU 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 Nation and non-First Nation hunters.

There is ongoing interest from Little Salmon / Carmacks First Nation (LSCFN), Ta'an Kwäch'än Council (TKC) and Kwanlin Dün First Nation (KDFN) to collect and provide updated information on moose populations in their traditional territories, and this information will support ongoing moose management partnerships that rely on accurate population data and harvest estimates.

Knowledge holders and local experts from LSCFN, KDFN, and TKC, as well as the Laberge and Carmacks Renewable Resources Councils, provided local knowledge about moose in the Laberge MMU in late winter that contributed to the 'expert opinion' layer that was used to inform the study design (selection of survey blocks where observers count and classify moose). Members from the three First Nations and two Renewable Resource councils also participated in the moose survey as aerial observers.

Study Area

The survey area falls entirely within the Laberge Moose Management Unit (MMU; Environment Yukon 2016). Moose management units were developed to monitor and manage moose at the scale of populations throughout the territory.

The Lake Laberge MMU is about 6,716 km^2 and includes Game Management Subzones 8-01, 8-02, 8-04, 8-06, 8-07 and 8-08 (Figure 1). The western border is bounded by the North Klondike Highway from the south end of Lake Laberge north to Carmacks. The South Big Salmon, Big Salmon, and the Yukon River make up the east and northern extent, and the southern portion of the MMU area extends to the North (but not including) Teslin Mountain.

Most of the study area (6,335 km^2) is considered suitable moose habitat, with only 5% of the study area considered unsuitable, including large water bodies of 0.5 km^2 or greater in size and land above 1,524m (5,000 feet) in altitude. Most of the area within the Laberge MMU is low elevation, and is characterized by rolling hills and mountains. Only two peaks in the Laberge MMU exceed 1,500m, representing a very small portion of the study area.

The northern portion of the Laberge MMU falls within the Yukon Plateau-Central ecoregion. This area is dominated by montane boreal forest including white spruce and feathermoss with few shrubs. However, lodgepole pine and trembling aspen are prevalent at lower elevations due to the higher frequency of forest fires. The southern portion falls within the Yukon Southern Lakes ecoregion and is characterized by open coniferous and mixed woodland, with dominance by pine and including white spruce and aspen (Yukon Ecoregions Working Group, 2004).

Forest fires have occurred throughout much of the western and northern portions of the survey area in the last eight decades of recorded fire history in the Yukon (Figure 3). The more productive burns with higher quality moose habitat (usually occurring about 11 to 30 years post-fire; Maier et al. 2005) include the 1998 burn north of Fox Lake (439 km^2) and the 2004 burn north of Frank Lake (331 km^2). Other burns within the Laberge MMU vary in moose habitat quality, and some have regrowth dominated by pine, decreasing the quality for moose, such as portions of the eastern edges of the 1958 and 1998 burns north of Lake Laberge.

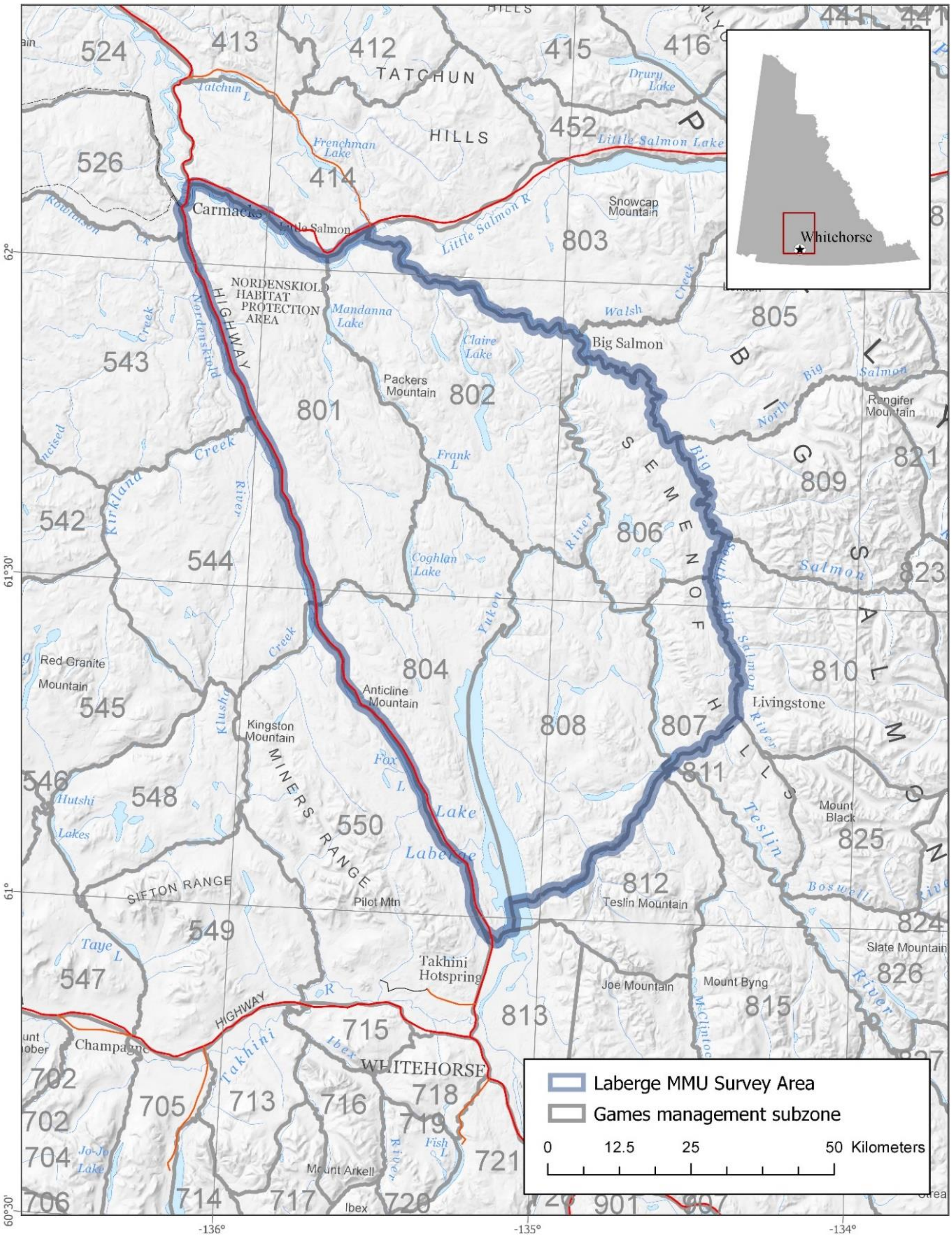

Figure 1. Laberge Moose Management Unit and February 2019 survey area.

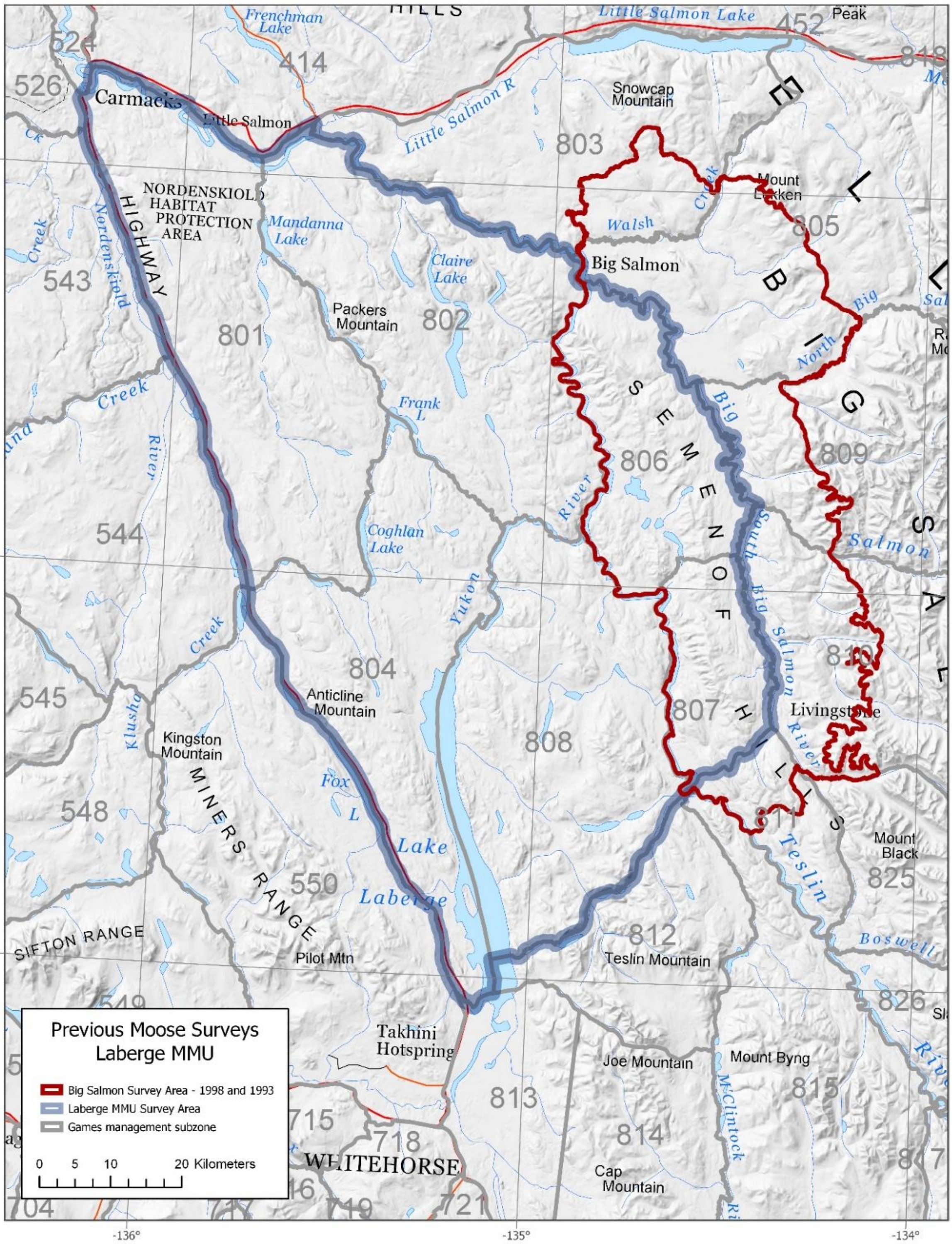

Figure 2. Previous moose surveys in the Laberge Moose Management Unit.

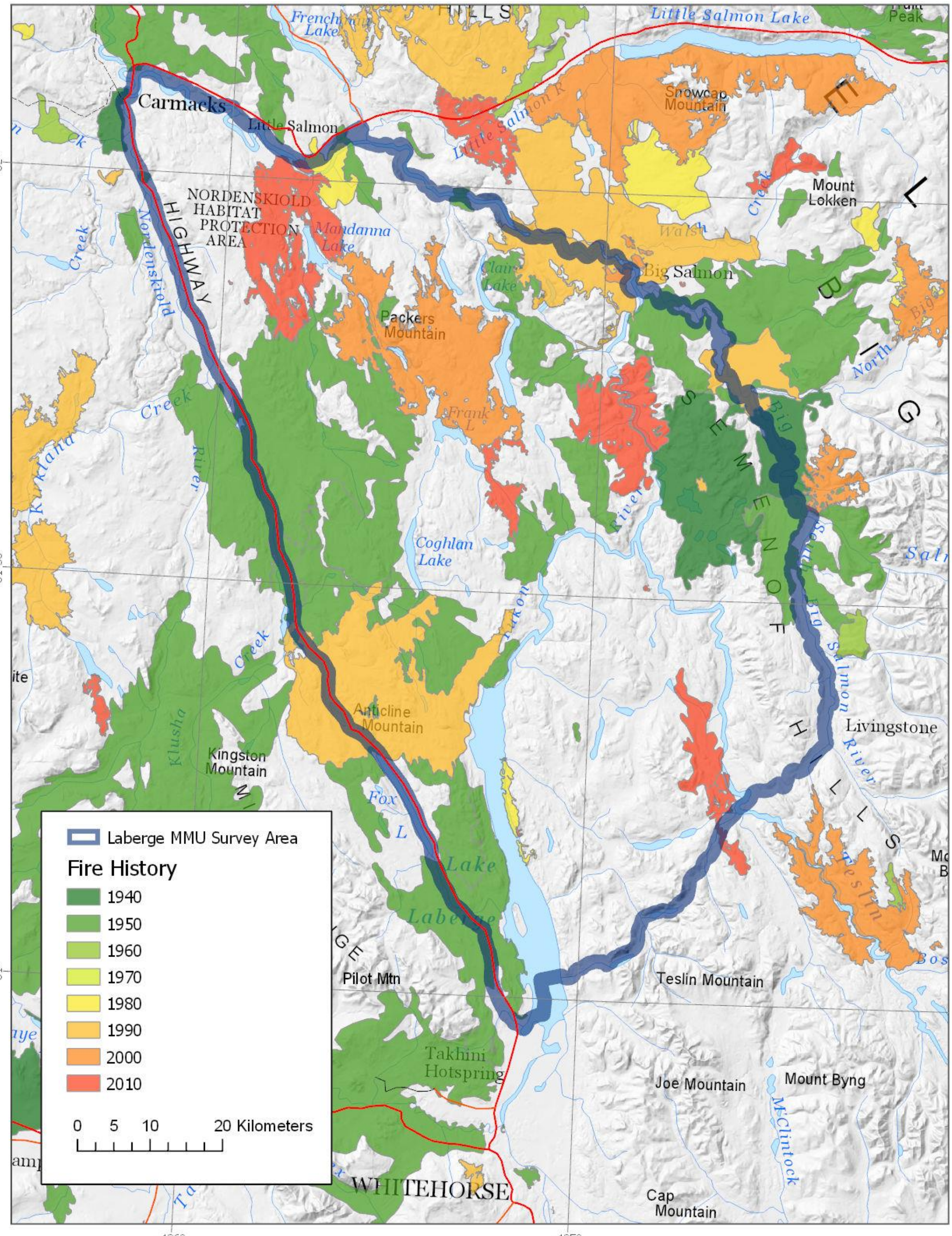

Figure 3. Laberge Moose Management Unit fire history.

Methods

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 available information in individual survey blocks flown during the survey. This information is a combination of available local knowledge and landscape/habitat characteristics. These models are then used to estimate moose abundance over the areas where we did not count moose. We next use any observed relationship between composition and the habitat/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 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 uniform rectangular blocks about 16 km^2 (2' latitude x 5' longitude) in size. First, we flew a stratification survey where we classified each survey block into one of 4 categories (High, Medium, Low, Very Low; Figure 4). We used a fixed-wing aircraft and flew one transect through the middle of each survey block (100-120mph, and 300-500agl). The purpose of the stratification survey is to inform which blocks will be selected for the survey portion of the survey. For the survey part of the survey, we selected certain blocks where we use helicopters to fly transects that are about 350 to 400m wide (search intensity of about 2 minutes per km^2) and count/classify every moose observed (Figure 5). Generally, 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 selected blocks to survey using different criteria in each of three phases of the survey:

1. In phase 1, we used a combination of landscape characteristics (habitat, access) and information from the stratification flight 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 anticipate to survey). Blocks are selected 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 available information (stratification flight, habitat type, access, local knowledge) 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) was 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 anticipate to survey.

3. In phase 3, we generated a map showing the predicted number of moose in un-sampled blocks based on the best model and allow the field crew to select blocks where they believe the predictions are the least accurate. We used local knowledge plus incidental observations made during the survey to select additional blocks to count. This phase represented 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.

Within blocks selected for sampling, we classified all moose by age (adult, yearling, calf) and sex. We can reliably distinguish yearling bulls from adults based on antler size. Therefore, we used the yearling bull estimate to account for yearling cows that cannot be identified from the air (the total number of yearlings is assumed to equal twice the estimated number of yearling bulls). The adult cow estimate is then accordingly reduced.

Finally, we used 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. When comparing moose population data between years, we consider there to be a significant change when confidence intervals and/or prediction intervals do not overlap.

Weather and snow conditions

The survey was originally scheduled for early winter 2018. However, snow conditions deteriorated immediately following the first stratification (in November 2018), and the survey was postponed. Snow conditions remained poor until February 2019.

The first couple days of the survey saw sun and cloud and a day where flights were cancelled or delayed due to heavy snowfall in the southern portion of the survey area and periods of fog and light snow in the north. For the remainder of the survey the weather was clear, with temperatures ranging between -6°C and -28°C.

Snow cover was complete at low to intermediate depths. We had fresh snow within the first couple days of the survey commencing, which aided in spotting fresh tracks. Light conditions were moderate to flat in the first couple days, and improved to mostly bright following the snowfall.

Results and Discussion

Stratification survey

We conducted the first stratification survey in November 2018. However, due to deteriorating snow conditions, the survey scheduled to follow was postponed to February 2019, and a second stratification was conducted to account for the change in distribution of moose between early and late winter.

Based on our observations from the air, we classified the 407 survey blocks as 68 (17%) high, 71 (17%) medium, 98 (24%) low, and 170 (42%) very low expected numbers of moose (Figure 4). Many of the areas that we classified as high were located in the 15-20 year old burns.

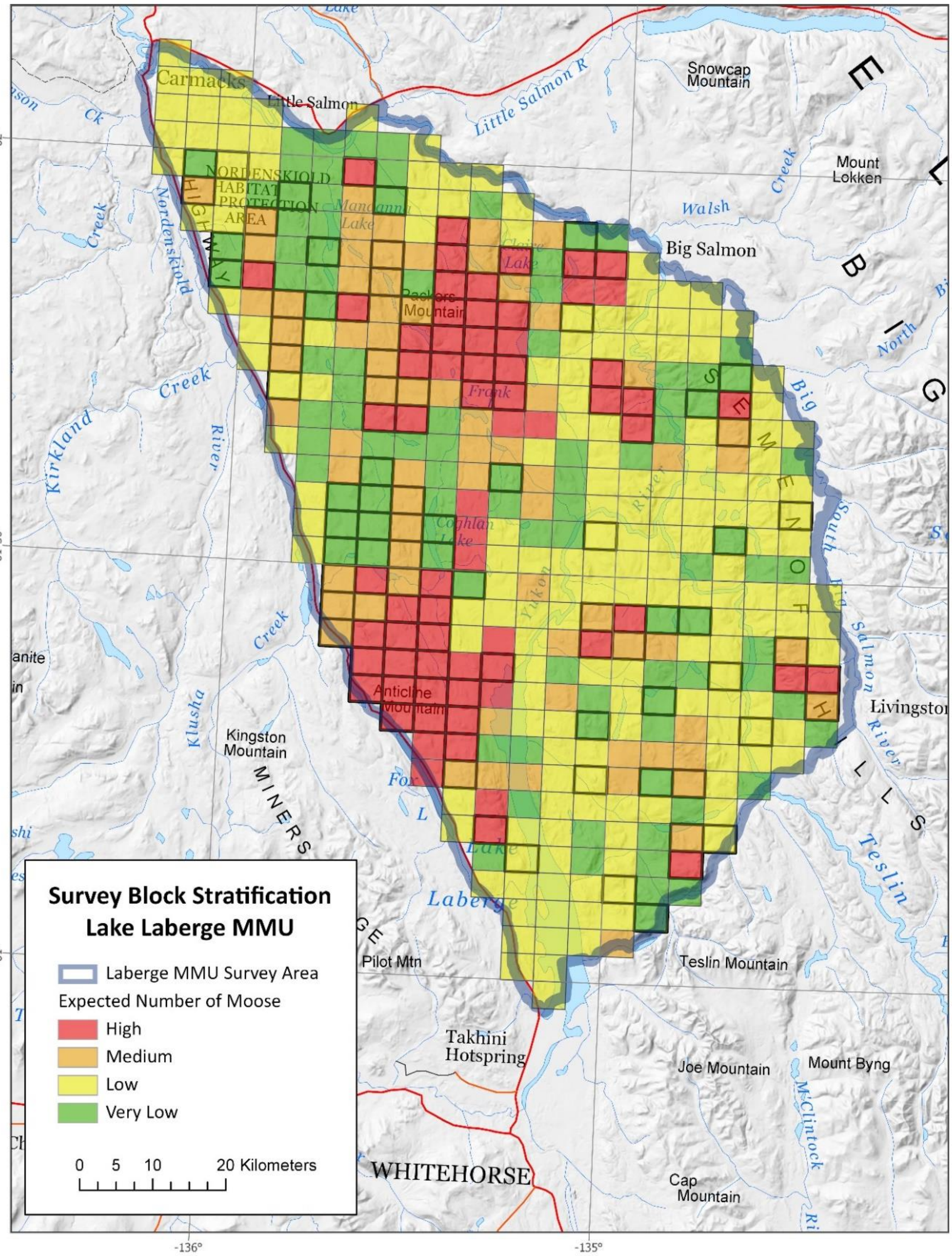

Figure 4. Survey block stratification in the Laberge Moose Management Unit into four categories of expected moose abundance (high, medium, low, very low), February 2019. This stratification is based on observations from a fixed-wing aircraft flying a single transect through each survey block.

Coverage

We counted moose in 116 of 407 survey blocks, or about 29% of the total area (Figure 6). Overall, we surveyed 53 (or 78%) of the blocks classified as 'high' expected moose density based on our stratification survey, 25 (35%) of the medium-density blocks, 11 (11%) of the low-density blocks, and 27 (16%) the very-low-density blocks.

It took us about 66.9 hours to count moose in these blocks using two helicopter crews (32.8 hrs and 34.1 hrs, respectively) for a search intensity of 2.10 minutes per km^2 (Figure 5). We used another 26.1 hours of helicopter time to ferry between survey blocks, our fuel caches, and back and forth to Whitehorse and Carmacks.

Observations of moose

A total of 469 moose were observed, including 152 (32%) mature bulls, 246 (52%) mature cows, 11 (2%) yearling bulls, 57 (12%) calves, and 3 (<1%) unclassified adults (Table 1). We observed an average of 246 moose for every 1,000 km^2 searched. These values (total number and composition by age and sex) cannot be directly applied as estimates in unsurveyed blocks because our sampling was biased towards blocks with greater numbers of moose.

Table 1. Observations of moose in survey blocks of the Lake Laberge Moose Management Unit during the February 2019 Late-winter survey.

	Total
Number of blocks counted	116
Number of adult bulls	152
Number of cows	246
Number of yearling bulls	11
Number of calves	57
Number of unclassified adults	3
Total Number of moose observed	**469**

Distribution of moose

The highest numbers of moose were observed in the west and northern portions of the survey area (Figure 6), particularly in areas that burned in 1998 to 2011 with good willow shrub cover. We saw few moose in burns with regeneration dominated by pine or in mature lowland forested areas. Few moose were observed in the eastern portion of the study area, which contained a combination of these lower-quality features for moose.

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 higher-elevation areas with burns (1981-2011), shrubs, or mixed-forest (Appendix 1).

The estimated number of moose in the entire survey area, based on our counts and model predictions, was 901, and we are 90% confident that the population was between 749 and 1,135 (Table 2).

The estimated density of moose in the entire survey area was 135 moose per 1,000 km^2 or 146 per 1,000 km^2 of suitable moose habitat (Table 2). This is on the lower end of the typical Yukon moose densities of 100-250 / 1,000km^2 of suitable habitat (Environment Yukon, 2016).

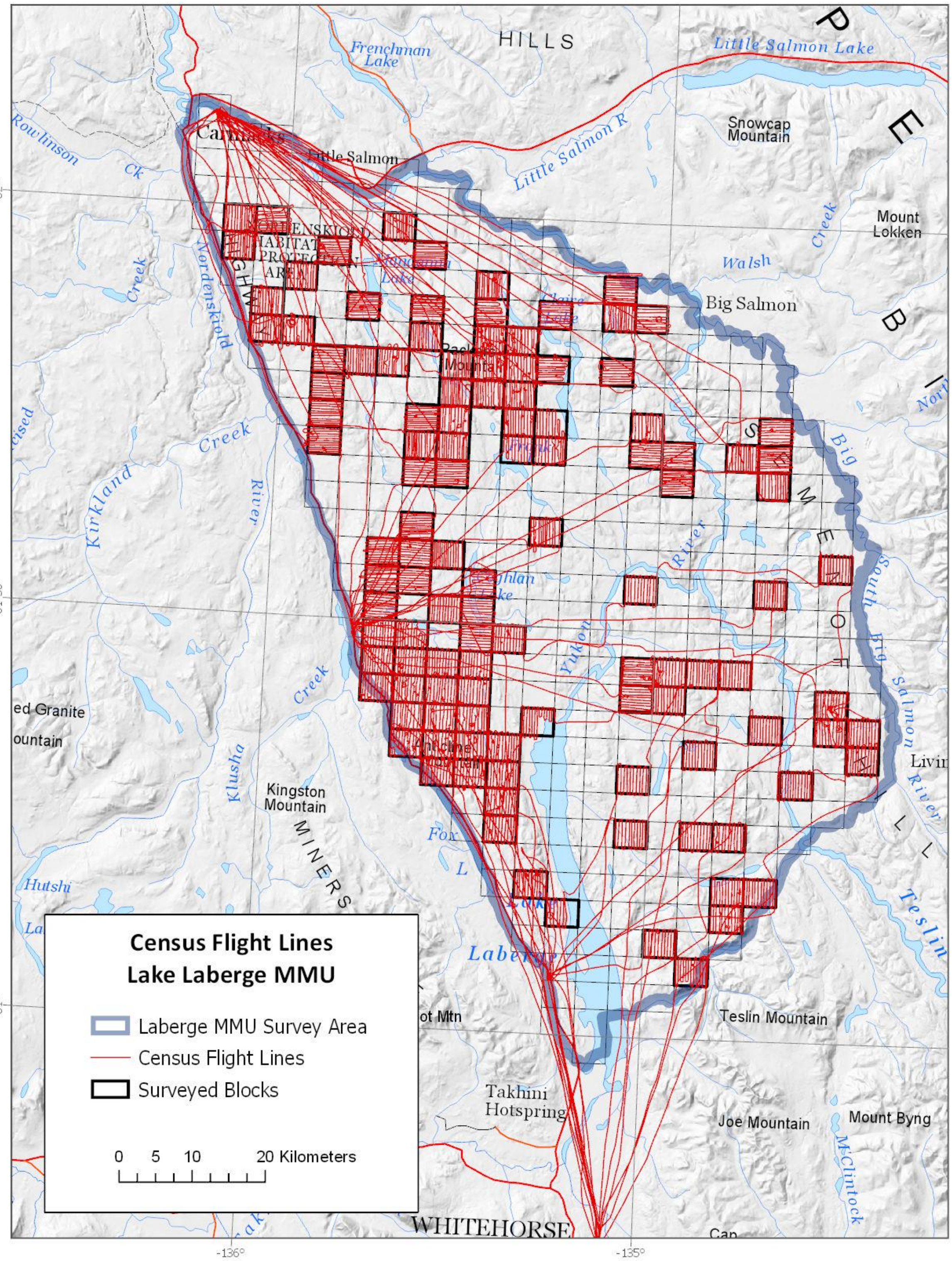

Figure 5. Helicopter flight lines and surveyed blocks from the Laberge Moose Management Unit survey, 2019.

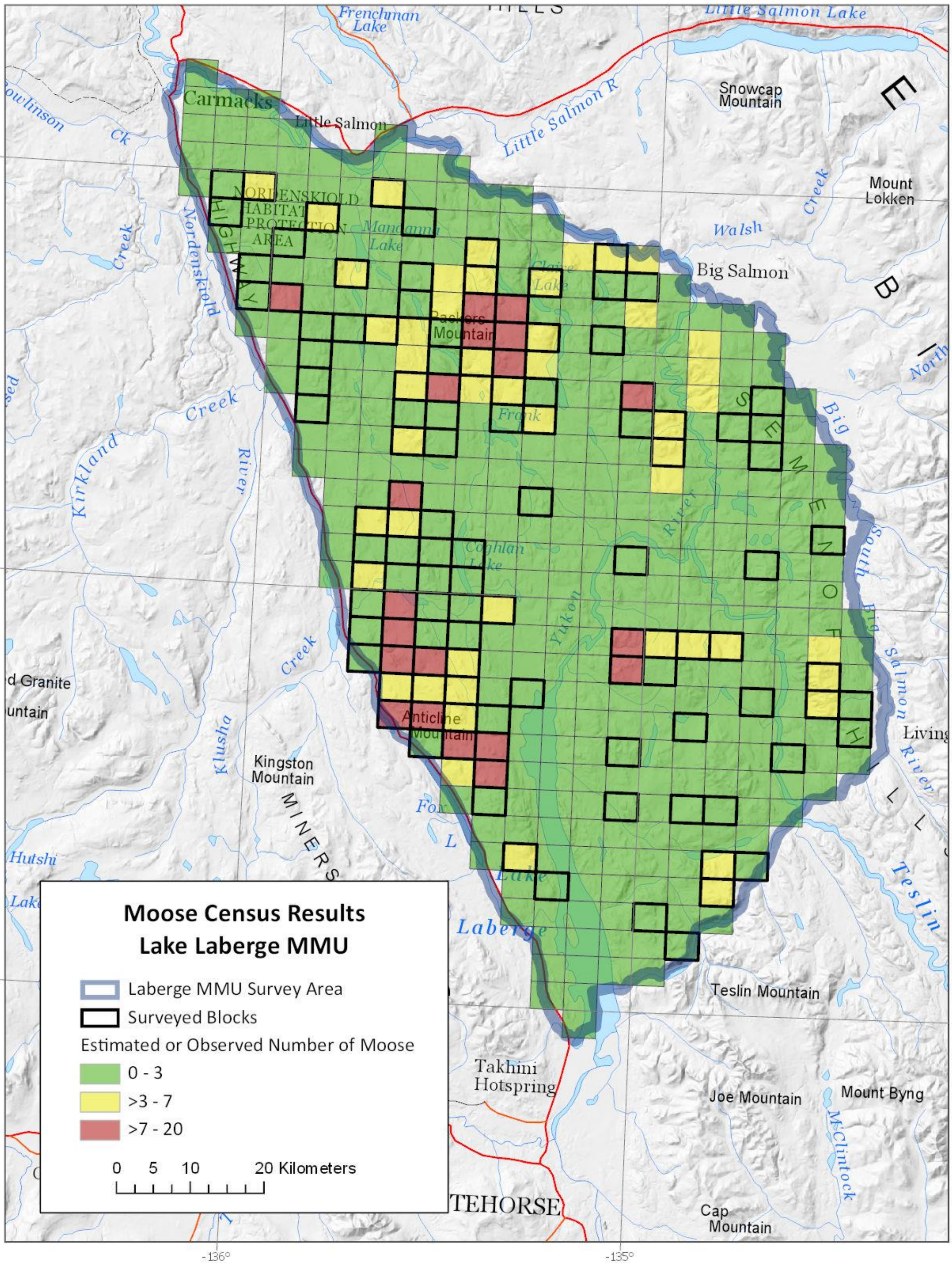

Figure 6. Observations of moose survey results in the Laberge Moose Management Unit, 2019.

Table 2. Estimated abundance of moose, corrected for sightability (91%), in the Laberge Moose Management Unit survey area in February 2019.

	Best estimate*	Estimates within 90% confidence interval **
Estimated total number of moose	901	749 - 1135
Adult bulls	269	230 - 326
Adult cows	452	376 - 564
Yearlings	61	41 - 89
Calves	130	99 - 172
Density of moose (per 1,000 km2)		
Whole area	135	112 - 170
Moose habitat only ***	142	118 - 179

* The sum of the estimated numbers of adult bulls, adult cows, yearlings, and calves is slightly different that 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% confidence interval' means that, based on our survey results, we are 90% sure 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 1,524 m (5000 ft), excluding water bodies 0.5 km2 or greater in size.

Ages and sexes of moose

The distribution of different age/sex classes of moose in surveyed blocks varied across the MMU. We found that the proportion of lone adult cows and adult bulls was greater in blocks with high-quality moose habitat. Conversely, younger bulls and cows with calves occurred in greater proportion in areas with high conifer cover and lower-quality moose habitat. We accounted for this bias when predicting the composition of the moose population in the entire MMU (Appendix 1).

Our survey results indicate that the survival of calves and yearling moose in the survey area in 2018 and 2019 was near average compared to other areas surveyed in the territory. We estimate that there were 31 calves and 15 yearlings for every 100 cows in the population (Table 3.), which is close to the Yukon averages of 29 calves and 18 yearlings per 100 adult cows (Environment Yukon, 2016). However, estimates of recruitment from one survey are snapshots in time and survival carries from year to year.

We estimated that there were 64 adult bulls for every 100 adult cows in the survey area (Table 3). This is 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).

Table 3. Estimated composition of the moose population in the Laberge Moose Management Unit survey area in February 2019.

	Best Estimate	Estimates within 90% confidence interval
% Adult bulls	31	29-32
% Adult cows	48	45-50
% Yearlings	7	5-9
% Calves	15	13-17
Adult bulls per 100 adult cows	64	59-70
Yearlings per 100 cows	15	11-20
Yearlings per 100 adults (recruitment rate)	8	6-11
Calves per 100 adult cows	31	27-35
% of cow-calf groups with twins	8	5-11

* A "90% confidence interval" means that, based on our survey results, we are 90% sure 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 (Environment Yukon, 2016). Specifically, in areas where survey information is available, we estimate that 10% of the adult bull population can be sustainably harvested annually (Environment Yukon, 2016). Based on the results of the 2019 late-winter moose survey in the Laberge MMU, we estimate that 27 bulls (10% of the estimated 269 adult bulls) can be sustainably harvested annually from this population.

The 5-year average total licensed harvest (from 2015-2019) is 17.6 bulls or 65% of the estimated sustainable harvest. Although this is below the sustainable rate of 23 bulls, this does not include moose harvested by First Nation hunters. In order to account for First Nation Harvest, we make assumptions based on previous information or local knowledge. In this case, we use a multiplier of 1.5 times the resident licensed harvest to estimate First Nation harvest. However, complete First Nation harvest data are needed to establish the actual harvest rate. Considering potential First Nation harvest, the total average annual harvest is likely more than the estimated sustainable limit. Harvest by licenced hunters has been slowly increasing in the Laberge MMU (Figure 6).

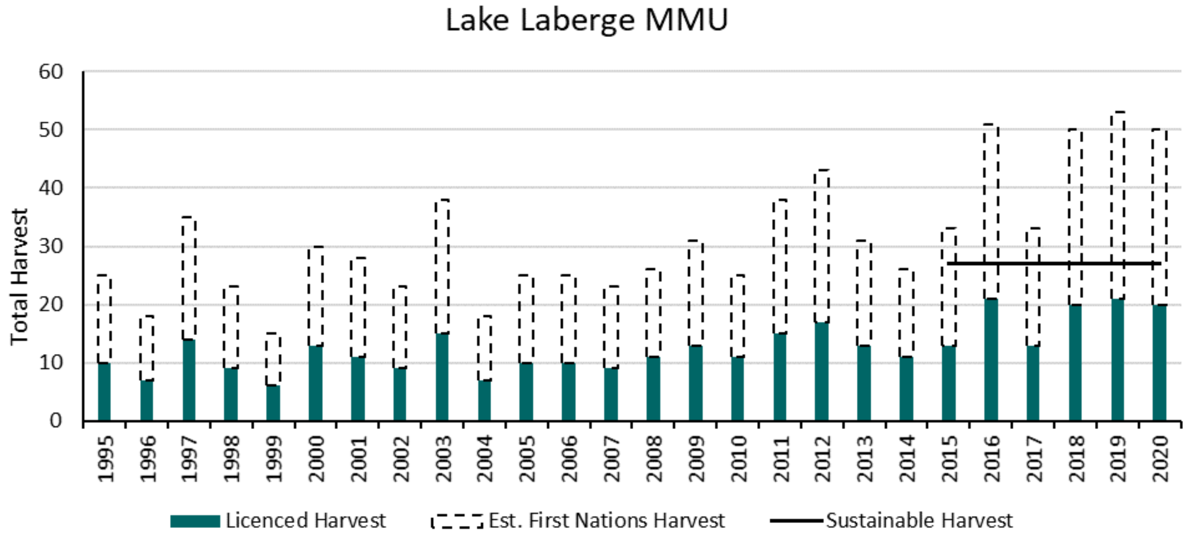

Figure 6. Total annual licensed and estimated First Nation harvest of moose in the Laberge moose management unit. The sustainable limit of 27 bulls based on the new survey data was backdated 5 years in order to compare it to the 5-year average annual harvest.

Other wildlife sightings

In addition to the 469 moose we saw during the survey, we counted 80 moose in 55 groups outside of the surveyed blocks or while travelling between blocks. We also saw 56 caribou in 14 groups. These caribou were located east of Lake Laberge and south of Hootalinqua and were from the Laberge caribou herd. One bison was observed on the east side of the North Klondike highway 30km south of Carmacks. Forty-one elk were observed near the North Klondike highway, most near or south of Braeburn. Sixteen thinhorn sheep were located in three groups; two northwest of Livingston, and one southeast of Braeburn. Finally we observed 13 wolves in 3 groups, 7 lynx, 11 mule deer, 1 red fox, and 1 porcupine.

Conclusions and Recommendations

- We estimate that there is a low-medium density moose population in the Laberge Moose Management Unit compared to other areas surveyed in the territory.
- Survival of calves and yearlings was average for 2018 and 2019 in the Laberge Moose Management Unit.
- The ratio of adult bulls to adult cows is well above the recommended minimum of 30 adult bulls/ 100 adult cows.
- The current harvest of moose (both licensed and First Nation) in the MMU is likely above the sustainable level. First Nation harvest information could help assess the sustainability of total harvest.
- Harvest management and the collection of harvest data should be discussed with the affected First Nations and Renewable Resource Councils to ensure harvest does not exceed sustainable levels.
- We should continue to monitor moose populations in this area.

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Appendices

Appendix 1. Analyses and models used to estimate the abundance and composition of moose in the Lake Laberge Moose Management Unit from 2019 late-winter survey data.

We estimated abundance and composition of moose in the Lake Laberge 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).

1) 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 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 469 moose locations and we generated 5000 random locations (approximately 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 400m 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 412 moose locations and 5000 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 400m scale included 3 covariates (Table 2). Specifically, moose selected for sub-blocks where the majority landcover (250m scale) was burns (1981-2011), shrubland, or mixed-forest. Moose further selected for higher elevations and sub-blocks with greater percentage of shrub cover (30m scale, 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 quality” covariate used in further analyses.

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 1 count model coefficient and 2 coefficients in the zero-inflation component (Table 4). The number of moose observed in a survey block was positively correlated to *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 *RSPF* values and in blocks with greater than 80% conifer cover (*Conifer*). 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 confidence 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*). This approach enables us to generate realistic estimates of subsets of the survey area when required and allows for meaningful stakeholder participation.

2) Composition estimation

We used a compositional analysis to describe the composition 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 *RSPF* covariate that accounted for the lesser proportion of lone adult cows and adult bulls in survey blocks with lower quality moose habitat (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 confidence 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 Lake Laberge Moose Management Unit (MMU), February 2019.

Covariate Name	Description	Source
Landcover6	Categorical covariate of the majority Landcover class within sub-blocks reduced to 6 classes (Conifer, deciduous, mixed forest, shrubland, other, burns between 1981-2012).	North American Land Cover 2010 250m x 250m resolution, Canada Center for Remote Sensing (CCRS), Natural Resources Canada. Canadian National Fire Database.
Elev	Mean elevation in km of the sub-block.	Canadian Digital Elevation Model 30m x 30m resolution, Natural Resources Canada.
Shrub	Percent of the survey sub-block with either low or tall shrub cover type.	EOSD Land Cover Classification 25m x 25m resolution, Canadian Forest Service.
NALC_Conifer or NALC_Shrub	Percent of the survey block with needle leaf forest or shrub cover type.	North American Land Cover (NALC) 2010 250m x 250m resolution, Canada Center for Remote Sensing (CCRS), Natural Resources Canada. Canadian National Fire Database.
Burn1981-2012	Percent of the survey block burned between 1981 and 2012.	Natural Resources Canada. Canadian National Fire Database.
STRAT	Categorical covariate describing survey blocks as High, Medium, or Low probability of observing moose.	Fixed-wing flight prior to the survey with crew of a navigator and 2 rear-seat observers.

Table 2: List of best models describing the Resource Selection of moose observed in survey sub-blocks (approximately 400m x 400m) in the Lake Laberge Moose Management Unit (MMU) (February 2019) with associated AIC scores and model weights.

Model	*df*	AIC	ΔAIC	*w*
Landcover6 + Elev + Shrub	8	2669.5	0.0	0.79
Landcover6 + Elev	7	2672.1	2.6	0.21
Landcover6 + Shrub	7	2745.3	75.8	0.00

Table 3. Logistic regression estimates for the Resource Selection Probability Function (RSPF) used to describe locations of moose observed in surveyed sub-blocks (approximately 400m x 400m) in the Lake Laberge survey area, February 2019 (n=412, Log-likelihood=-1327). We used this model to generate RSPF values for unsurveyed sub-blocks.

		Estimate	Standard Error	*Z*	*P*
(Intercept)		-6.423	0.374	-17.16	<0.001
Landcover6					
	Deciduous	0.743	0.292	2.54	0.011
	Mixed	0.275	0.207	1.33	0.185
	Shrubland	0.416	0.261	1.60	0.111
	Other	-0.544	0.729	-0.75	0.455
	Burns(1981-2012)	1.660	0.152	10.93	<0.001
Elevation		2.897	0.329	8.81	<0.001
Shrub		0.556	0.256	2.17	0.030

Table 4. List of best models describing the number of moose observed in survey blocks in the Lake Laberge survey area (February 2019) with associated AIC scores and model weights.

Model		*df*	AIC	ΔAIC	*w*
Count Covariates	Zero Inflation Covariates				
RSPF	RSPF + Conifer	6	353.0	0	1.00
RSPF	STRAT	6	394.7	41.7	0
RSPF	RSPF	5	440.9	87.9	0
RSPF	Conifer	5	468.7	115.7	0

Table 5. Zero-Inflated Negative Binomial (ZINB) regression estimates for counts of moose observed in surveyed sample blocks (approximately 16 km^2) in the Lake Laberge survey area, February 2019 (n=116, Log-likelihood=-171). We used this model to generate the population estimate and prediction intervals for the Lake Laberge Moose Management Unit (MMU).

	Estimate	Standard Error	*Z*	*P*
Count model coefficients (negbin with log link):				
(Intercept)	0.726	0.198	3.670	0.00024
SUM_RSPF	0.087	0.019	4.549	5.4E-06
Log(theta)	1.403	0.329	4.263	2E-05
Zero-inflation model coefficients (binomial with logit link):				
(Intercept)	-0.253	1.248	-0.203	0.83919
SUM_RSPF	-0.879	0.290	-3.035	0.00241
NALC_Need	4.955	1.785	2.775	0.00552

Table 6. List of best models describing the composition of moose observed in the Lake Laberge survey area (February 2019) with associated AIC scores.

Model	AIC	ΔAIC
RSPF	647.8	0.0
Null	671.4	23.6
Burn1981-2012	671.6	23.7
NALC_Shrub	672.3	24.5
NALC_Conifer	675.4	27.6
Shrub	678.6	30.8

Table 7. Compositional model regression estimates for moose in the Lake Laberge survey area, February 2019 (n=116, Log-likelihood=-327). This model was used to generate the composition and related prediction intervals for the Lake Laberge Moose Management Unit (MMU).

	Estimate	Standard Error	*Z*	*P*
(Intercept):BULL_LARGE	0.031	0.301	0.102	0.919
(Intercept):BULL_SMALL	-0.865	0.590	-1.465	0.143
(Intercept):COW_1C	-0.207	0.359	-0.576	0.565
(Intercept):COW_2C	-2.622	0.949	NA	NA
(Intercept):LONE_COW	0.293	0.291	1.006	0.314
RSPF:BULL_LARGE	0.106	0.031	3.442	0.001
RSPF:BULL_SMALL	-0.126	0.088	-1.428	0.153
RSPF:COW_1C	0.005	0.039	0.126	0.900
RSPF:COW_2C	-0.007	0.107	-0.064	0.949
RSPF:LONE_COW	0.100	0.030	3.294	0.001

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