Yukon

SR-25-01

Moose Survey

Dawson West Moose Management Unit, Early-winter 2017

January 2025

Moose Survey
Dawson West Moose Survey Area, Early-winter 2017

Government of Yukon
Fish and Wildlife Branch
SR-25-01

AUTHORS

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The stratification survey was flown by Scott Turner of Great River Air. The helicopters were ably piloted by Jules Leonard and Andrew Crane of TRK Helicopters Ltd.

Kirby Meister, Shawn Hughes, Jim Leary, Earl Rolf, Mel Besharah, Scott Dewindt, Vince Edmonds and Scott Turner provided their local knowledge of the study area, allowing us to stratify the study area prior to survey.

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Summary

- We conducted an early winter moose survey in the Dawson West Moose Management Unit (MMU) from November 1 to November 19, 2017. The main purpose of this survey was to estimate abundance, distribution and composition of the moose population in the MMU.
- We counted all moose in 167 of the 607 survey blocks, or around 28% of the entire survey area (9,256 km²). We observed a total of 893 moose: 287 adult bulls, 469 cows, 51 yearling bulls and 86 calves.
- We estimated a population of 1,718 moose and we are 90% confident that the population was between 1,501 and 1,967 for the survey area. This number is equal to a density of 186 moose/1,000 km² over the whole survey area, or 189 moose/1,000 km² in suitable moose habitat. This is near the middle of the range of the typical moose densities in Yukon (100 – 250 moose/1,000 km² of suitable moose habitat).
- We estimated 21 calves for every 100 adult cows in the survey area which is slightly below the observed mean for Yukon (29 calves/100 adult cows), but within the expected Yukon range (10 – 50 calves/100 adult cows). We estimated 23 yearlings for every 100 adult cows in the survey area, which is higher than the observed mean for recruitment in Yukon (18 yearlings/100 adult cows).
- We estimated 531 adult bulls in the entire survey area, or a ratio of 65 adult bulls for every 100 adult cows. This adult sex-ratio is above the minimum threshold of 30 bulls/100 cows identified in our moose management guidelines.
- We estimated a sustainable harvest of 53 bulls per year within the MMU (10% of the adult bulls). The 5-year average licensed harvest prior to the survey (2013-2017) was 17 bulls per year, or approximately 3.2% of the adult bull population. Information on First Nation harvest is required to accurately assess harvest levels in this MMU.
- This was the first survey of the entire of Dawson West MMU and additional surveys are needed to assess trends in total abundance at the MMU scale. However, we found no change in total abundance of moose in GMS 304 between 1989 and 2017.

Contents

Introduction

This report summarizes the results of the early-winter survey of moose in the Dawson West Moose Management Unit (MMU; Figure 1), conducted from November 1 to 19, 2017. The purpose of the survey was to estimate abundance, distribution and composition of the moose population in the Dawson West MMU, and to use this information to assess the sustainability of moose harvest in the MMU.

Previous surveys

This is the first moose population survey of the entire Dawson West MMU. Previous surveys that have estimated moose population size within portions of the MMU were completed in 1989 and produced a population estimate for Game Management Subzone (GMS) 304 (Figure. 2). There have been several other surveys that covered smaller areas within individual GMSs in the Dawson West MMU (see *Trend Surveys*), however, due to their small size they are not compared with results from the 2017 survey.

Census surveys

The Dawson West survey completed in 1989 was the first survey to estimate population size and covered Game Management Subzone 304 (Larsen and Ward 1991a).

Stratification surveys

The Dawson North (302 and 303) early winter stratification survey was completed in 1989 (Larsen and Ward 1991a) which covered approximately 39% of the 2017 study area. The area between the Sixty Mile River and the White River has never been surveyed.

Trend surveys

Trend surveys (not shown in Figure 2.) were flown in the area by the Alaska Department of Fish and Game (ADF&G) in 1982, and 1984-1987, and by the Government of Yukon (YG) in 1989 (Larsen and Ward 1991b).

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. The Fortymile, Sixtymile and White River drainages are traditionally important hunting areas for Tr'ondëk Hwëch'in and the area throughout the Dawson West MMU is a popular hunting area for Yukon residents.

Tr'ondëk Hwëch'in and the Dawson District Renewable Resources Council recommended that this survey occur to ensure harvest in the Dawson area is sustainable. Staff from Yukon Department of Environment, Yukon Department of Energy, Mines and Resources, Tr'ondëk Hwëch'in and the Dawson District Renewable Resources Council participated in this survey as wildlife observers, and community members with long-term knowledge of the area assisted with an expert-based stratification of the survey area that informed survey sampling (see *Methods* for details). Funding for the survey was provided, in part, by the Dawson District Renewable Resource Council.

Study Area

The survey area covered approximately 9,256 km^2 and encompassed the entire Dawson West MMU (9,210 km^2). The Dawson West MMU includes Game Management Subzones (GMS) 301, 302, 303, 304, 305 and 306 (Error! Reference source not found.), with the boundaries running from the White River to the Yukon River north of the Top of the World Highway, and running from the Alaskan border in the west, east to the Yukon River.

The Dawson West survey area is part of the Klondike Plateau ecoregion which has never been glaciated. It is uniform in character with smooth topped ridges (1200 – 1500 m a.s.l.) dissected by deep, narrow, “v”-shaped valleys. The majority of the study area (~9,095 km^2) is considered suitable moose habitat with less than 2% of the total survey (161 km^2) considered unsuitable including waterbodies 0.5 km^2 or greater in size, and areas at elevations ≥ 1500m.

Below 1000 m a.s.l., black and white spruce forests are dominant, and occasionally are present in mixed stands of poplar, birch and aspen. Poplar, birch and aspen occasionally dominate on specific land forms or on particular aspects. Subalpine areas were typically dominated by dwarf birch and interspersed with stunted white spruce. Willows and alders were often limited to drainages and regenerating areas (e.g. tailings, slides, burns).

Throughout the survey area, there are road and trail systems used to access placer claims which are typically operated on a seasonal basis (April – October). Extensive historic and current placer mining occurs in the valley bottoms of the Sixty Mile River, Fortymile River and Matson Creek drainages.

This ecoregion also receives the most lightning strikes in the territory. Consequently, much of the survey area has been burned by wildfire at some point over the last 60 years (**Error! Reference source not found.**). The 2004 and 2005 fire seasons resulted in particularly extensive burns and potentially more productive habitat for moose (e.g., ~11 to 30 years post-fire [Maier et al. 2005]).

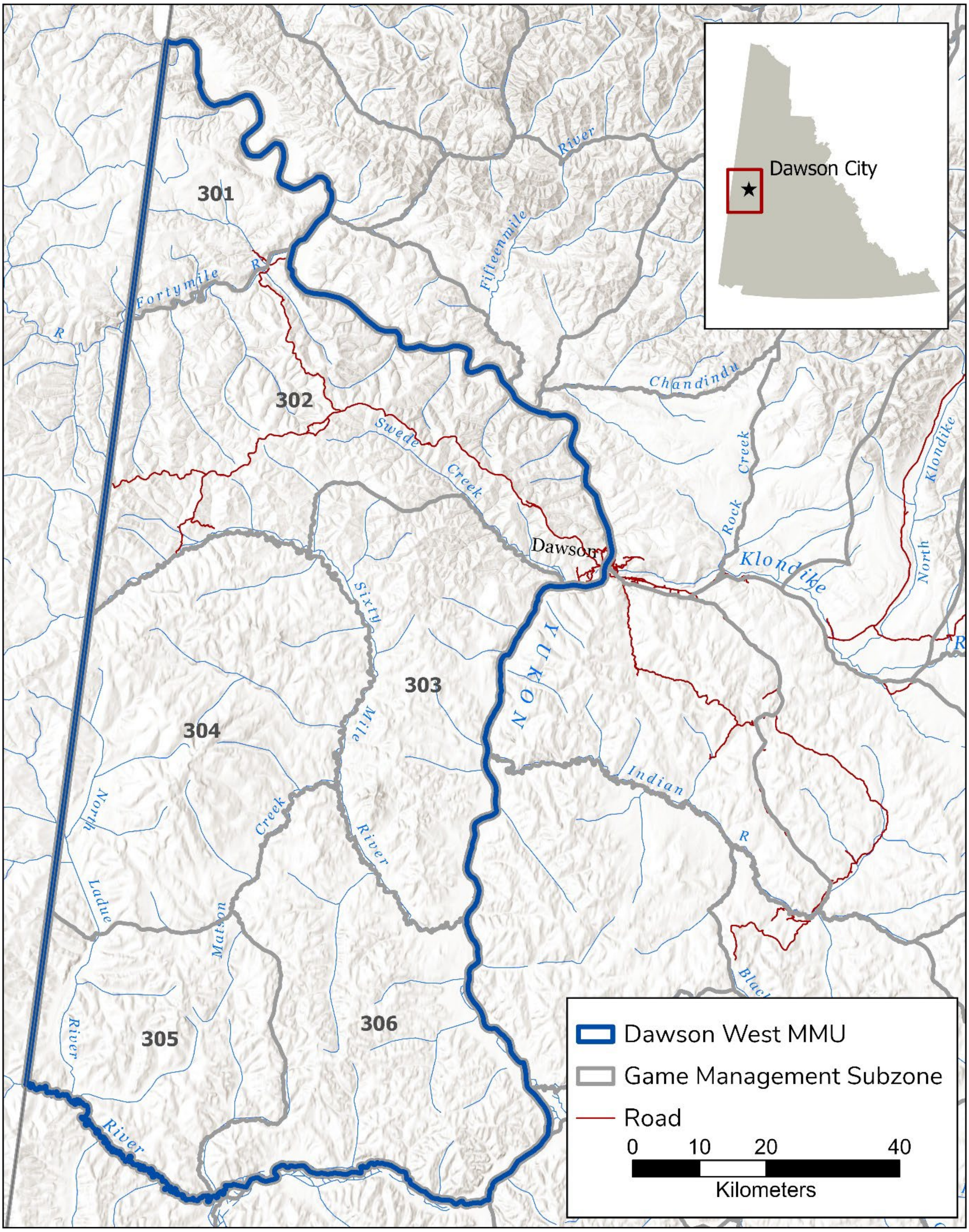

Figure 1. Dawson West Moose Management Unit.

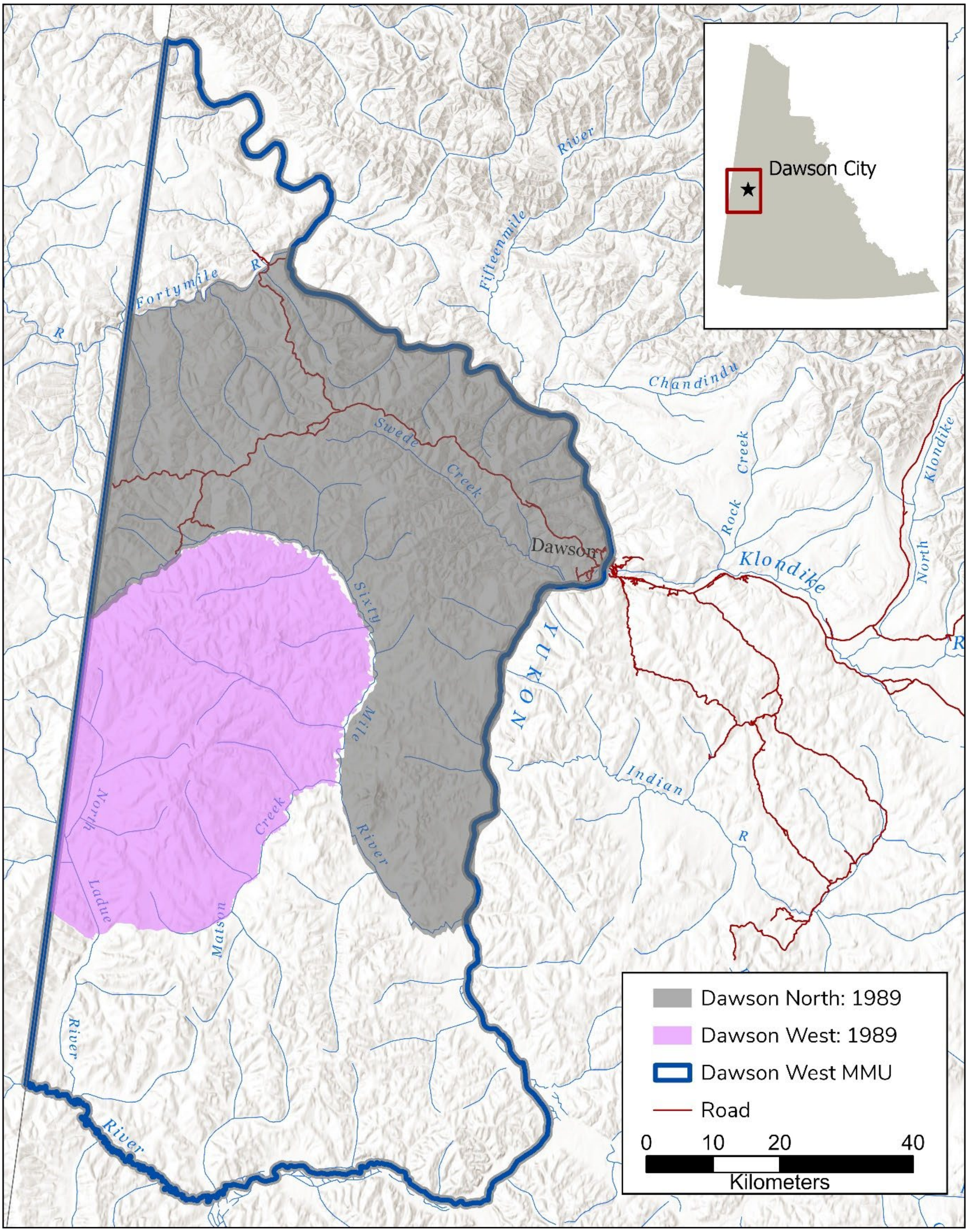

Figure 2. Previous moose stratification (Dawson North) and census (Dawson West) surveys in the Dawson West Moose Management Unit, 1989.

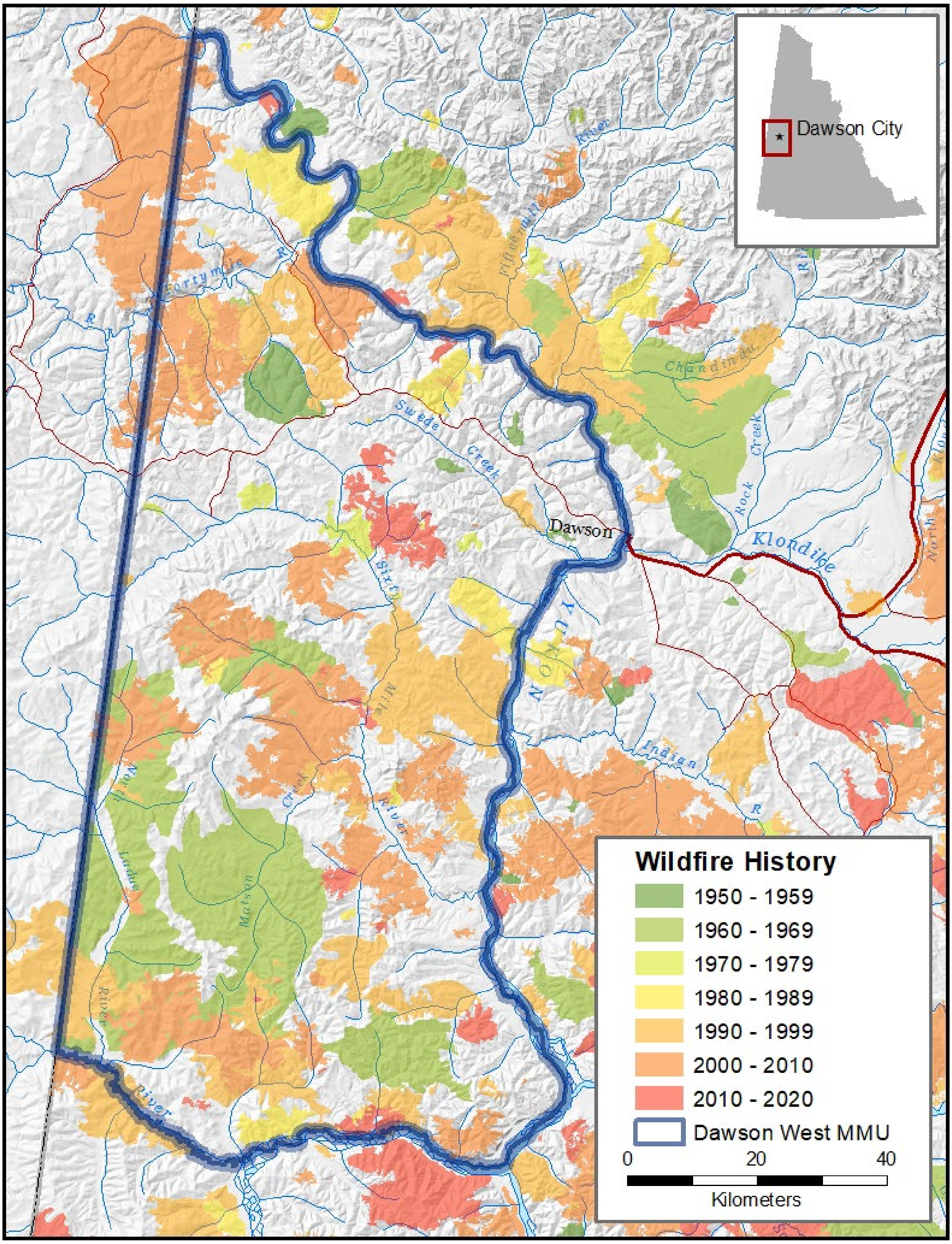

Figure 3. Dawson West Moose Management Unit fire history.

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 associated with individual survey blocks flown during a survey. This information is a combination of available local knowledge, information from previous stratification flights, 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, landscape or other factors to correct for any bias in our sample. This analysis allows us to incorporate factors that 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 utilise local knowledge, to estimate abundance in subsets of the survey area, to account for differences in composition throughout the area, and to target our sampling to survey 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. Where we lack recent information about survey blocks, we conduct a pre-census, stratification survey where observers in a fixed-wing aircraft (Cessna 206) bisect each survey block (search intensity 0.12 – 0.17 min/ km²), and classify (i.e., stratify) them as having either high, medium, low, or very low expected moose numbers, based on local knowledge, number of moose seen, tracks, and habitat. We then 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 moose abundance in as many different survey blocks as possible.

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). The adult cow estimate is then accordingly reduced.

Finally, we used a sightability correction factor (SCF) of 1.05 (5%), based on sightability flights from previous moose surveys in the Dawson area. This is the number of moose we estimate were missed during our searches of each survey block and is used to correct our final population estimates accordingly. When comparing 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 the three phases of the census survey:

1. In phase 1, we use 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. 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. For this survey, we used the stratification information from the pre-census stratification survey, and local knowledge to select survey blocks.

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

Weather and snow conditions

Weather conditions and visibility ranged from moderate to good for this survey. Light conditions were bright except on two overcast days, and snow cover was complete (100%), and ranged from approximately 15 – 90 cm in depth. Temperatures ranged from -10 °C at the beginning of the survey to -35 °C on the final day. There was occasional low cloud cover and fog present along the Yukon River and at higher elevations.

Results and Discussion

Stratification survey

We stratified a total of 607 survey blocks using a fixed-wing aircraft with 2 observers flying a single transect through each survey block. We classified 118 blocks as very high (19.4%), 195 blocks as high (32.1%), 139 blocks as medium (22.9%) and 155 blocks as low (25.5%) expected number of moose (**Error! Reference source not found.**). Most blocks stratified into classes of high expected abundance were located in previously burned areas (Figures 3 and 4).

It took 17.1 hours to stratify the entire survey area, with a search intensity of 0.11 minutes/km². We used another 2.6 hours to ferry between fuel caches, and back and forth to Dawson City.

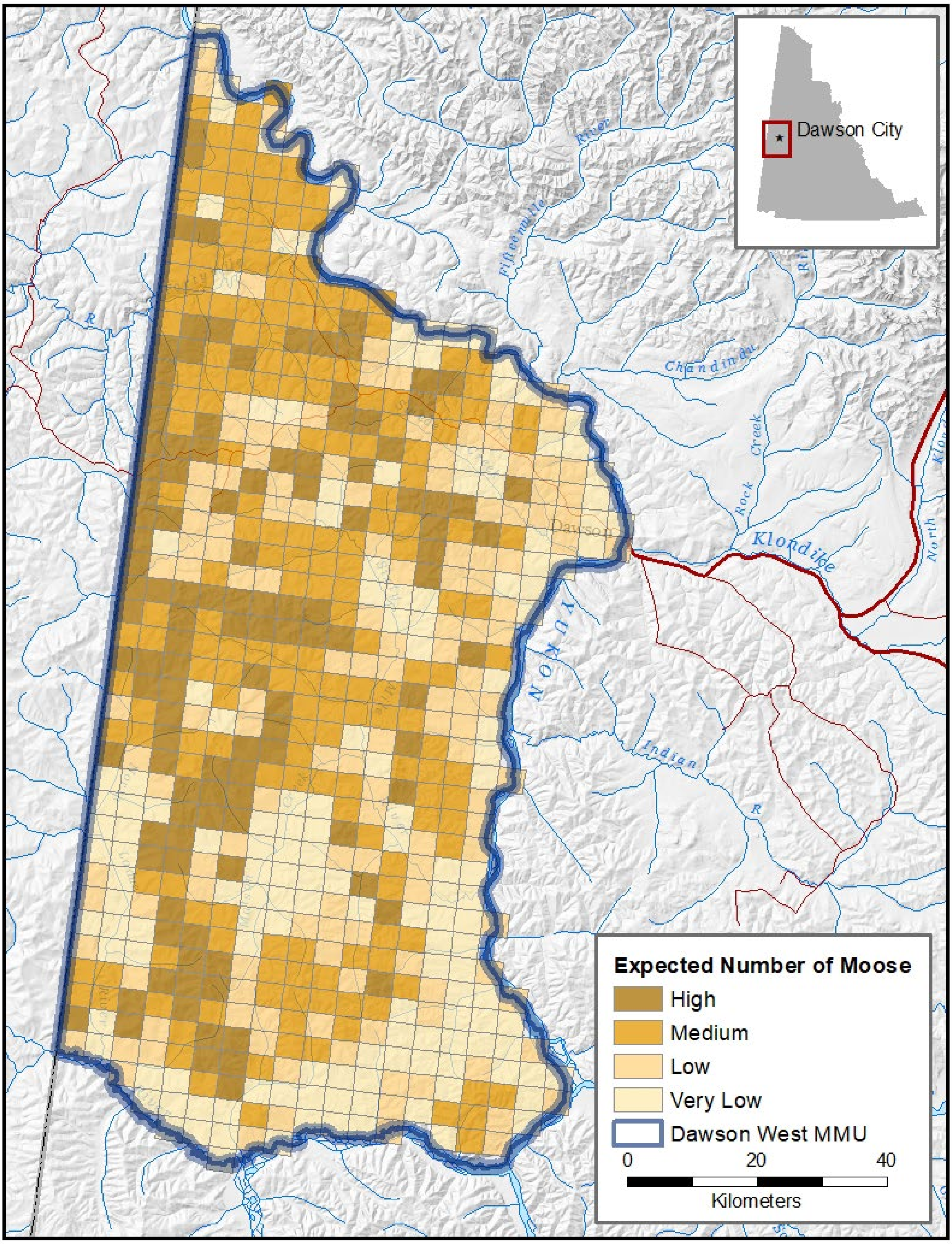

Figure 4. Survey block stratification in the Dawson West Moose Management Unit into 4 categories of expected moose abundance (high, medium, low, very low), November 2017. This stratification is based on observations from a fixed-wing aircraft flying a single transect through each survey block.

Coverage

We counted moose in 167 of the 607 blocks, or about 28% of the total survey area (Figure 5). It took 84.8 hours to count and classify moose in these blocks using two helicopter crews, for a search intensity of 2.00 minutes/km². We used another 34.5 hours of helicopter time to ferry between survey blocks and fuel caches, and back and forth to Dawson City.

Observations of moose

A total of 893 moose were observed within surveyed units including 287 (32%) mature bulls; 469 (52%) cows; 51 (6%) yearling bulls; and 86 (10%) calves (**Error! Reference source not found.**).

Table 1. Observations of moose in the Dawson West survey area during the early-winter survey, November, 2017.

	Total
Number of blocks counted	167
Number of adult bulls	287
Number of adult and yearling cows*	469
Number of yearling bulls	51
Number of calves	86
Total Number of moose observed	**893**

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

Distribution of moose

Moose were widely distributed in the survey area with the highest numbers observed in upper montane and lower sub-alpine environments, and in previously burned areas. We observed most moose in areas that burned between 1980 and 2009 (Figures 3 and 5) and saw relatively few moose in mature spruce and pine forests, or in sub-alpine areas dominated by dwarf birch. We expected to see higher numbers in some areas burned in 2004 in the southern portion of the survey area, however, these areas had relatively minimal regeneration and were potentially less ideal habitat as a result.

Abundance of moose

The final model that best predicted moose abundance in the survey area included 4 explanatory variables (Appendix 1). Specifically, we found a positive correlation between moose abundance in a survey block and the proportion of the survey block that had burned between 1982 and 2012. We found a negative correlation between the proportion of conifer in the block and moose abundance. Lastly, our final model included a 2-category survey block stratification (high abundance and low abundance) based on our stratification survey, and the level of access (high or low) present in the survey block.

Based on our survey counts and model predictions, we estimated a population of 1,718 moose in the Dawson West survey area. Based on our analysis, we are 90% confident that the population was between 1,501 and 1,967 moose (**Error! Reference source not found.**). This includes a sightability correction factor (SCF) of 1.05 (see *Methods*), which assumes observers missed 5% of moose during the survey.

The estimated moose density across the whole survey area was 186 moose per 1,000 km^2, or, 189 per 1,000 km^2 of suitable moose habitat (**Error! Reference source not found.**; see *Study Area*). This is near the middle of the range of typical Yukon moose densities (100-250 moose per 1,000 km^2 of suitable habitat, Environment Yukon 2016). Relative to nearby survey areas this density is lower than our 2015 estimate for the Dawson Goldfields (268 moose per 1,000 km^2 of suitable moose habitat), but, comparable to densities in the Lower Stewart/White Gold survey completed in 2012 (173 moose per 1,000 km^2 of suitable moose habitat).

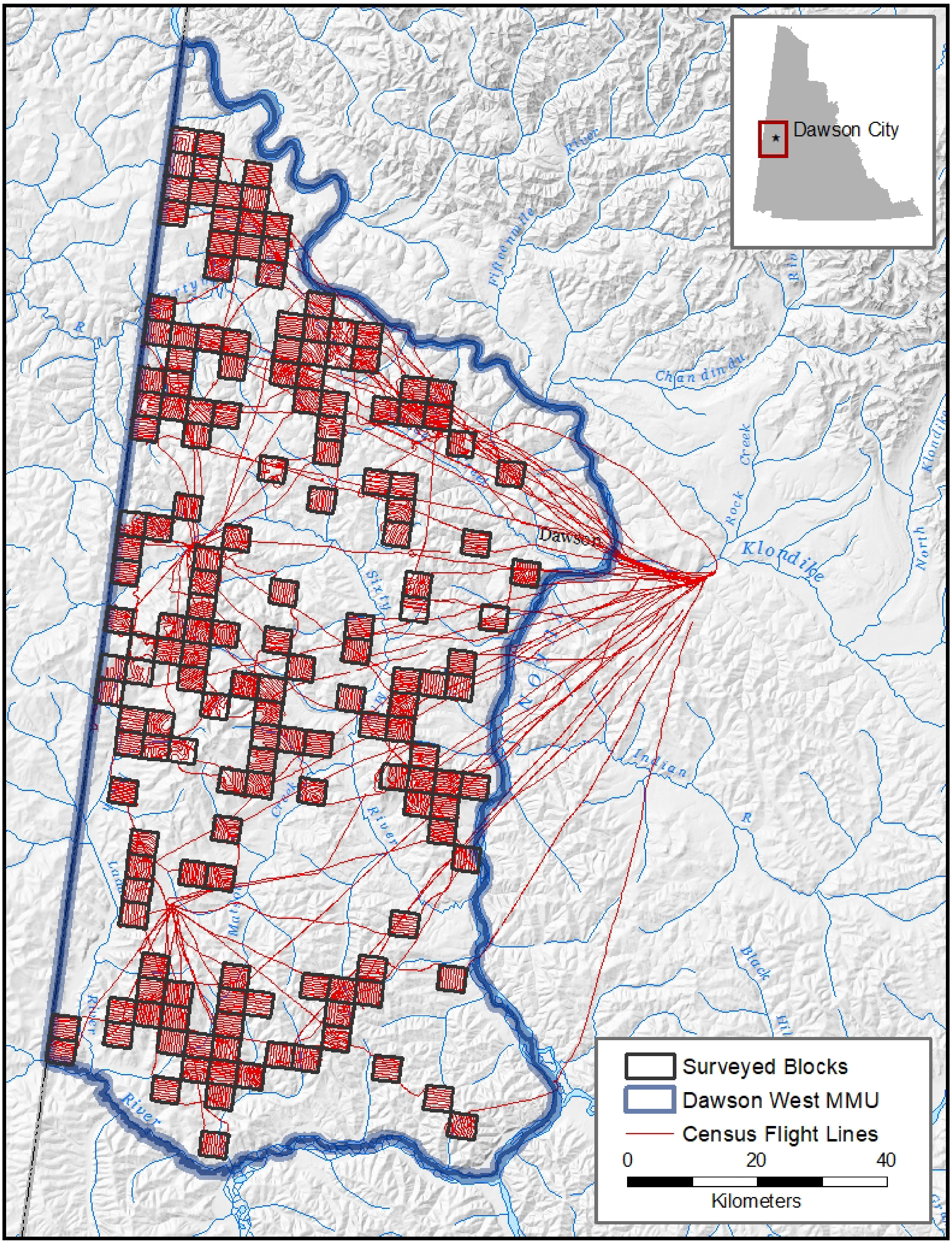

Figure 5. Helicopter flight lines and surveyed blocks from the Dawson West Moose Management Unit, early-winter 2017 November census.

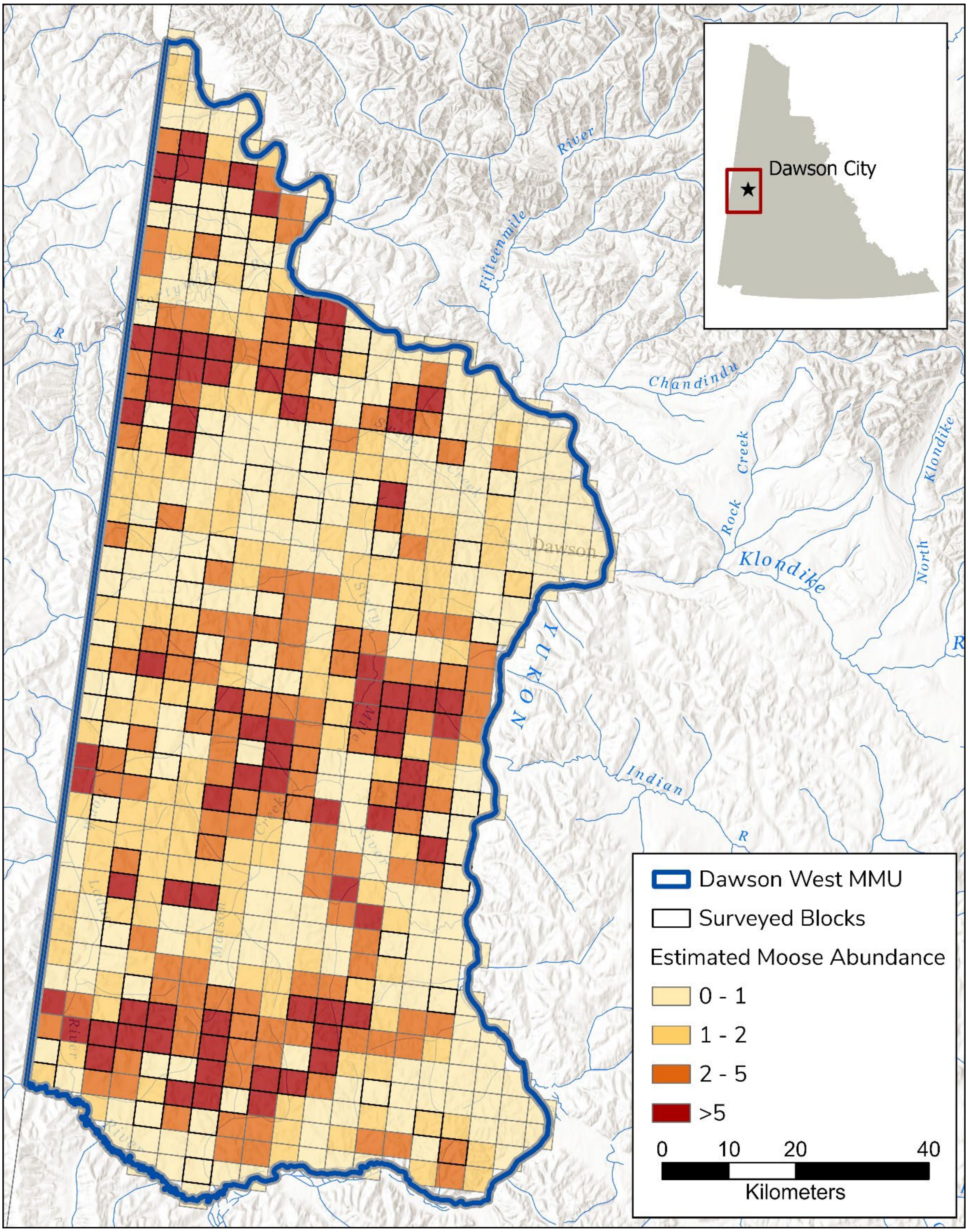

Figure 6. Observed (surveyed blocks) or predicted (model-based) moose survey results in the Dawson West Moose Management Unit from early-winter, 2017.

Table 2. Estimated abundance of moose, corrected for sightability (95%), in the Dawson West Moose Management Unit survey area in November 2017.

	Best estimate*	90% Prediction interval **
Estimated total number of moose	1718	1501 – 1967
Adult bulls	531	464 – 616
Adult cows	821	709-944
Yearlings	190	162 – 227
Calves	175	147 – 211
Density of moose (per 1,000 km^2)		
Entire area (9,256 km2)	186	
Moose habitat only (9095 km2) ***	189	

* 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% prediction 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 km^2 or greater in size.

Ages and sexes of moose

The composition of moose in a survey block was influenced by the proportion of conifer forest in the survey block. Specifically, we found that as the proportion of conifer forest in a survey block increased, the proportion of adult bulls, yearling bulls and lone cows decreased. We used these relationships to estimate moose composition in unsurveyed blocks (Appendix 1).

We estimated calf recruitment to November to be 21 calves/100 adult cows, which is below the Yukon average of 29 calves per 100 adult cows (Table 3, Environment Yukon, 2016). We calculated a yearling recruitment rate of 23 yearlings/100 adult cows, which is above the Yukon average of 18 yearlings/100 adult cows (Table 3, Environment Yukon, 2016).

We estimated an adult sex-ratio of 65 adult bulls/100 adult cows in the survey area, which is consistent with the Yukon-wide average of 64 adult bulls/100 adult cows. This value is above our minimum threshold of 30 adult bulls/100 adult 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 Dawson West survey area, November, 2017.

	Best Estimate	Estimates within 90% prediction interval*
% Adult bulls	31	29 - 32
% Adult cows	48	46 - 49
% Yearlings	11	10 - 12
% Calves	10	9 - 11
Adult bulls per 100 adult cows	65	60 - 70
Yearlings per 100 cows	23	20 - 27
Calves per 100 adult cows	21	19 - 24
% of cow-calf groups with twins	7	5 - 10

* A "90% prediction 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.

Population trend

This was the first moose census survey conducted for the entire Dawson West MMU (see *Previous Surveys*). Assessing trends in total moose abundance and, age and sex categories at the MMU scale is therefore not possible, and subsequent surveys are needed to assess future potential changes in the population across the Dawson West MMU.

However, the 1989 Dawson West survey covered GMS 304 within the Dawson West MMU (Larsen and Ward, 1989). We compared estimates from 1989 and 2017 and did not include sightability correction factors (Table 4).

The total population estimates for GMS 304 are similar between 1989 and 2017. There were an estimated 313 (CI: 254 – 362) moose in 1989 and 336 (PI: 267 – 429) in 2017 (Table 4).

We also found moose composition estimates to be similar between the two surveys, especially for the adult component of the population (Table 4). Confidence and prediction intervals overlap suggesting there have not been major changes within GMS 304 between the two surveys. We did find significantly fewer calves in 2017 than in 1989. However, estimates of recruitment (yearlings/100 adult cows) and calf survival (calves/100 adult cows) from any single survey are snapshots in time, and can vary from year to year (Environment Yukon, 2016).

Comparisons between these two surveys should be interpreted cautiously, however, as 1) survey methodologies differ slightly between these two surveys; 2) there was a substantial time interval between the two surveys; and 3) the survey area is relatively small.

Table 4. Estimated abundance and composition of moose in GMS 304 (Dawson West survey area) in 1989 and 2017*.

Game Management Subzone 304	Survey year	
	1989 (90% CI)**	**2017 (90% PI)****
Estimated total number of moose	313 (254 - 362)	336 (267 – 429)
Adult bulls	120 (91 – 149)	130 (105 – 164)
Adult cows***	114 (81 – 147)	140(108-184
Yearlings***	28 (17 – 39)	42 (30 – 58)
Calves	51 (33 – 69)	23 (15 – 33)
Adult bull : 100 adult cows	105 (83 – 127)	93 (79 – 109)
Yearlings : 100 adult cows	25 (14 – 36)	30 (22 – 42)
Calves : 100 adult cows	45 (36 – 54)	16 (12 – 22)
Density (moose/1000km^2 moose habitat)****	168	164

* No sightability correction was applied to any of the results to allow for comparison between years.
** A "90% confidence interval" or a "90% prediction 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 of this range. For a confidence interval, this is at the mean; for a prediction interval, this is at the median.
*** 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 in the population. We use this assumption to estimate the total number of adult cows in the survey area by subtracting the number of yearling bulls observed from the total number of cows counted.
**** Suitable moose habitat is considered to be all areas at elevations lower than 1,524 m (5000 ft), excluding water bodies 0.5 km^2 or greater in size.

Harvest and mortality

In the Yukon, moose are managed by Moose Management Units (MMUs), which are generally groupings of game management subzones that encompass biologically appropriate moose populations to the best extent possible (Environment Yukon, 2016). We estimate sustainable harvests for moose populations at the MMU scale. Specifically, in areas where survey information is available, we estimate that 10% of the adult bull population can be sustainably harvested annually with minimal risk of a population decline (Environment Yukon, 2016). Our survey results indicate 531 (C.I: 464 - 616) adult bulls in the MMU (Table 2) and therefore a total sustainable harvest of 53 bulls annually.

Licensed harvest is predominantly composed of resident harvest in the Dawson West MMU MMU (62.5 – 100%; 1995-2017). During the 5 hunting seasons preceding the 2017 survey (2013 to 2017), harvest of moose by licensed hunters in the Dawson West MMU averaged around 17 moose per year (range: 13 – 25, Figure 6), or 32% of the total sustainable harvest. This is slightly higher than the long-term (1995-2017) average for the MMU, of 16 moose per year (range 6-30). Licensed harvest in the years since the survey (2018 – 2023) has remained relatively consistent, with an average of around 18 bulls per year harvested (range: 13 – 24).

In areas where we have population information from multiple surveys, we consider population trends over time to be the strongest indicator of harvest sustainability, particularly when First Nation harvest information is not available. While total licensed harvest is within sustainable harvest guidelines, additional surveys are required to assess population trends. First Nation harvest information is also required to accurately quantify the level of harvest in this population and ensure that total harvest does not exceed sustainable levels.

In addition to harvest mortality, there are believed to be few incidental sources of mortality (e.g., road kill).

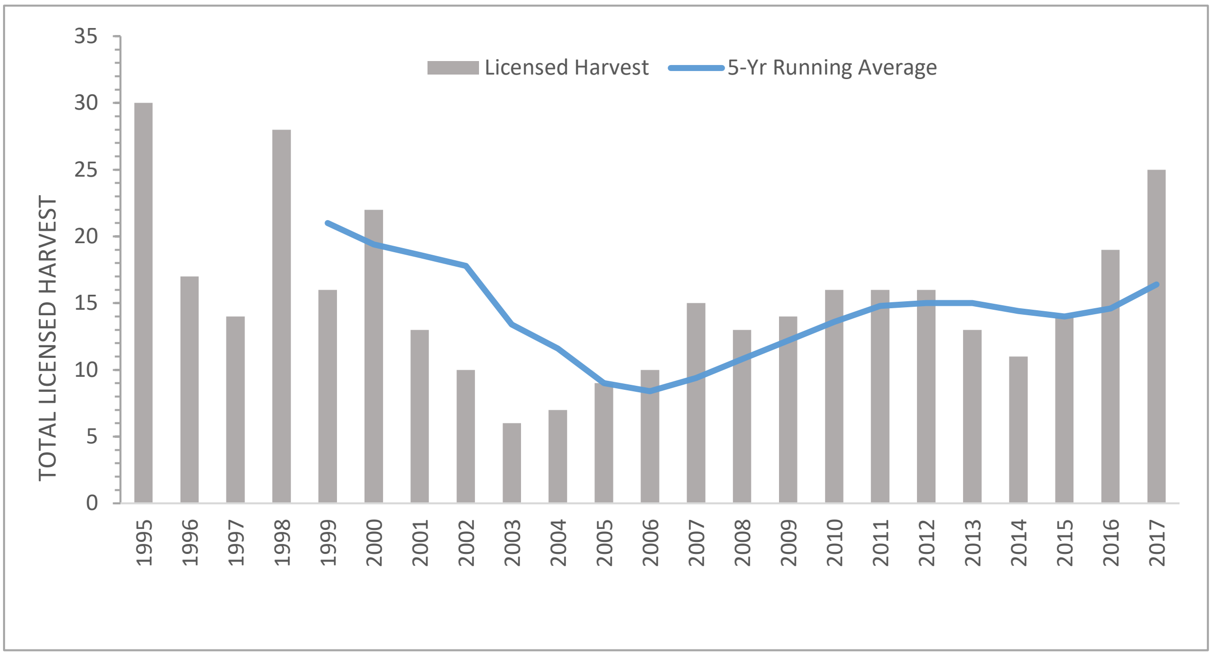

Figure 6. Total reported licensed harvest of moose in the Dawson West Moose Management Unit with 5-year running average.

Other wildlife sightings

In addition to the 893 moose we counted during the 2017 survey, we saw 298 moose outside of the surveyed blocks or while travelling between blocks.

A variety of other species were observed during the survey including 12,243 caribou from the Fortymile herd, with some individuals from the Nelchina herd potentially in the area. We also recorded 8 wolves, 6 gyrfalcons, 1 kestrel, 1 American marten, 6 unidentified raptors, 3 red fox, 20 ptarmigan, 263 sharp-tailed grouse, 2 owls and 2 wolverines.

Conclusions and recommendations

- We estimated 1,718 moose in the Dawson West survey area in November 2017. Moose density in available moose habitat was 189 moose/1,000 km^2, which is within the typical Yukon-wide range of moose densities of 100 – 250 moose/1,000 km^2 in moose habitat. Based on 2017 estimates from within GMS 304, and a previous GMS 304 survey in 1989, the number of moose appears to have remained relatively stable.
- We estimated the adult sex-ratio at 65 bulls per 100 adult cows. This ratio is above the minimum of 30 bulls per 100 cows recommended by Yukon's Science Based Guidelines for the Management of Moose (2016) to reduce the risk to reproductive success (timing of breeding and birth, offspring sex-ratio and survival).
- Early-winter calf recruitment (21 calves per 100 adult cows) was near the average for areas surveyed in the Yukon (29) and within the Yukon wide range (10 – 50). We estimated 23 yearlings per 100 adult cows, which is higher than the Yukon average of 18 (range: 5 – 40), suggesting high calf survival in 2016.
- The 5-year average reported licensed harvest (2013-2017) for the Dawson West MMU is 17 bulls or 32% of the estimated sustainable harvest.
- First Nation harvest information is required to monitor the level of harvest in this population and ensure that total harvest does not exceed sustainable levels.
- This was the first census survey of the entire Dawson West MMU and additional surveys are needed to assess trends in the population to ensure the sustainability of harvest in the Dawson West MMU.

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Appendices

Appendix 1. Analyses and models used to estimate the abundance and composition of moose in the Dawson West Moose Management Unit from 2017 early-winter survey data.

We considered a combination of expert opinion and landscape/habitat covariates to estimate the number and composition of moose in the Dawson West MMU (Table S1). For all analyses, individual 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).

We first used weighted Zero-Inflated Negative Binomial regression Models (ZINB) to describe the distribution of the number of moose counted in sampled survey units in early winter. These models best describe low density and spatially aggregated moose distribution across survey units in Yukon because they account for overdispersion and excess zeros in the data. 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 4 coefficients (Table S2). The number of moose observed in a survey unit was positively correlated to 1) *PFire_1982_2012*, the percent of the survey unit burned between 1982 and 2012, and 2) *Strat*, a layer predicting high or low abundance of moose based on a fixed-wing stratification flight prior to the survey. The number of moose observed in a survey unit was negatively correlated to 3) *PNeedle*, the percent of area within a survey unit containing needle leaf forest, and 4) *LKAccess*, a layer generated by Regional Biologists and local experts that describes whether a survey unit is accessible (by ATV/truck or boat). This model was used to predict the number of moose in unsurveyed units of the survey area (Table 3). The final population estimate and bootstrapped confidence intervals were obtained by combining the actual number of observed moose in sampled survey units with predictions from unsampled survey units. This approach enables us to generate realistic estimates of subsets of the survey area when required (in this case for each of the 1 subset within the survey area) and allows for meaningful stakeholder participation.

We next 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 *PNeedle* covariate that accounted for the proportion of adult bulls, yearling bulls and adult cows decreasing as the proportion of needle leaf forest in the survey unit increased (Table S4). This model (Table S5) 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 S1: Description of selected list of coefficients considered for predicting the number of moose in survey units (approximately 16 km^2) and the population composition in the Dawson West Moose Management Unit (MMU) survey area, November 2017.

Covariate Name	Description	Source
Strat	Binary covariate describing predicted high (1) or low (0) numbers of moose in the survey unit.	Fixed-wing stratification flight prior to survey.
LKAccess	Binary covariate describing whether the survey unit is accessible (1) or not (0) to hunters via trails or waterways.	Dawson Regional staff and local experts.
PFire1982_2012	Percent of survey unit burned between 1982 and 2012.	Canadian National Fire Database.
PDes_Shr	Percent of area within each survey unit with Broadleaf, Deciduous, or Shrubland habitat types.	North American Land Cover 2010, Canada Center for Remote Sensing (CCRS), Natural Resources Canada.
PNeedle	Percent of the survey unit with Needleleaf forest cover type.	North American Land Cover 2010, Canada Center for Remote Sensing (CCRS), Natural Resources Canada.

Table S2: List of best models describing the number of moose observed in survey units in the Dawson West Moose Management Unit (MMU) survey area (November 2017) with associated AIC scores and model weights.

Model	df	AIC	ΔAIC	w
Strat + PNeedle + PFire1982_2012 + LKAccess	7	634.3	0.00	0.977
Strat + PNeedle + PFire1982_2012 + PDes_Shr	7	642.0	7.67	0.021
Strat + PFire1982_2012 + LKAccess + PDes_Shr	7	647.2	12.84	0.002
Strat + PNeedle + PFire1982_2012	6	653.7	19.36	0.000

Table S3: Weighted Zero-Inflated Negative Binomial (ZINB) regression estimates for counts of moose observed in surveyed sample units (approximately 16 km^2) in the Dawson West Moose Management Unit (MMU) survey area, November 2017 (n=167, Log-likelihood=-310.2)

	Estimate	Standard Error	Z	P
Count model coefficients (negbin with log link):				
(Intercept)	0.546	0.332	1.643	0.100
Strat	0.716	0.252	2.840	0.005
PNeedle	-0.668	0.204	-3.272	0.001
LKAccess	-1.223	0.528	-2.316	0.021
PFire1982_2012	1.385	0.278	4.988	<0.001
Log(theta)	0.525	0.210	2.504	0.012
Zero-inflation model coefficients (binomial with logit link):				
(Intercept)	-1.316	0.387	-3.397	<0.001

Table S4: List of top models describing the composition of moose observed in the Dawson West Moose Management Unit (MMU) survey area (November 2017) with associated AIC scores and model weights.

Model	AIC	ΔAIC	w
PNeedle	1052.6	0.000	0.981
LKAccess	1060.8	8.141	0.017
PDes_Shr	1065.2	12.564	0.002
Null	1067.8	15.116	0.001
PFire1982_2012	1076.6	23.985	0.000

Table S5: Compositional model regression estimates for moose in the Dawson West Moose Management Unit (MMU) survey area, November 2017 (n=167, Log-likelihood=-516.3)

	Estimate	Standard Error	Z	P
(Intercept):BULL_LARGE	1.607	0.168	9.594	<0.001
(Intercept):BULL_SMALL	-0.174	0.234	-0.743	0.457
(Intercept):COW_1C	-0.170	0.219	-0.778	0.436
(Intercept):COW_2C	-2.537	0.568	-4.470	<0.001
(Intercept):LONE_COW	1.717	0.163	10.512	<0.001
PNeedle:BULL_LARGE	-2.962	0.744	-3.983	<0.001
PNeedle:BULL_SMALL	-2.465	1.163	-2.119	0.034
PNeedle:COW_1C	0.112	0.840	0.133	0.894
PNeedle:COW_2C	-0.764	2.457	-0.311	0.756
PNeedle:LONE_COW	-1.326	0.662	-2.004	0.045

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