# Keeyask Generation Project

## Terrestrial Effects Monitoring Plan

# Moose Population Estimate Report

TEMP-2016-09

KEEYASK

Manitoba Conservation and Water Stewardship Client File 5550.00
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2015 - 2016

# KEEYASK GENERATION PROJECT

## TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2016-09

## MOOSE POPULATION ESTIMATE REPORT

Prepared for

Manitoba Hydro

By

Knudsen Wildlife Management Systems

and

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# SUMMARY


## BACKGROUND

Construction of the Keeyask Generation Project (the Project) at Gull Rapids began in July 2014. The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the generating station on the terrestrial environment. Monitoring results will help the KHLP, government regulators, members of local First Nation communities, and the general public understand how construction and operation of the generating station will affect the environment, and whether or not more needs to be done to reduce harmful effects.

This moose survey was designed as part of the Project's Terrestrial Effects Monitoring Plan. The objective of this survey was to evaluate how the Project may be affecting patterns and trends in moose distribution, abundance, and population characteristics in Study Zone 5 (the Keeyask Region).

This report describes the results of the aerial survey conducted for moose in the winter of 2014/15. The survey was carried out in an area slightly larger than Study Zone 5, and focused mainly on areas with moderate to high moose densities.

## WHY IS THE STUDY BEING DONE?

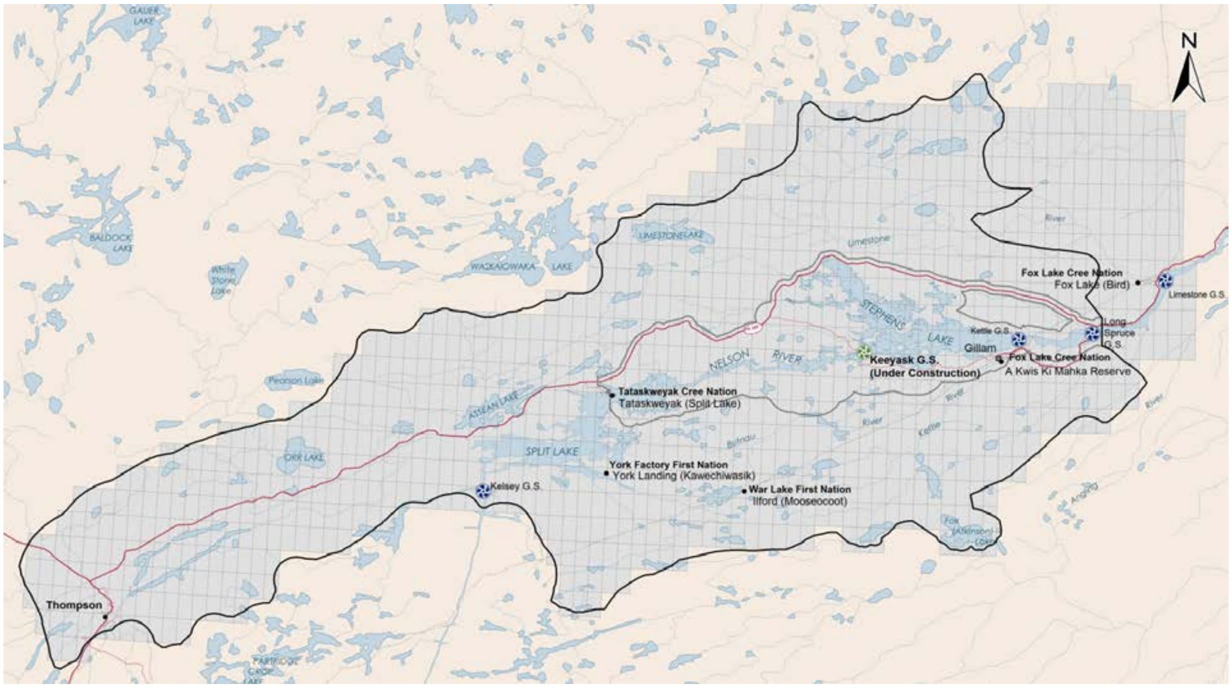
Moose are widely distributed and common in the Keeyask Region. While there was a high degree of certainty for predicted effects of the Project on moose, the partner First Nations have expressed concerns about Project effects on moose habitat and populations. In 2010, the number of moose in the Keeyask Region was counted and the population was estimated. In order to gauge the current status of the moose population now that Project construction is underway, the number of bulls, cows, and calves was estimated and the resulting proportions of bulls and calves to cows were compared with the same characteristics from the 2010 survey.

## WHAT WAS DONE?

In January 2015, aerial surveys were conducted within the Keeyask Region (see map on next page). An additional area, slightly beyond the Keeyask Region, was also surveyed to incorporate two moose management units (Wasekanoosees and Kitchisippi) in the Split Lake Resource Management Area (RMA) that overlap with the Keeyask Region.

A crew of three observers and a pilot flew regularly-spaced survey lines over the area in a fixed-wing aircraft, recording all instances of moose tracks. The area was divided into rectangular sample units. The density of moose tracks in each sample unit was recorded or estimated based on the density of tracks in the units next to it. Density was categorized as extra low, low, medium, or high. A random sample of sample units from each density category was surveyed by helicopter. The crew consisted of three observers and a pilot, and each moose was counted,

with their age and sex recorded if possible. These counts were used to estimate the size and composition of the moose population in the Keeyask Region, as well as in the two overlapping moose management units (Wasekanoosees and Kitchisippi).




**Sample units covered by the moose aerial survey in 2015**

**Pilot and crew leader in fixed-wing aircraft**

## WHAT WAS FOUND?

The moose population in the entire survey area was estimated at 1,349 individuals and was unevenly distributed. There were an estimated 1,162 moose in the Keeyask Region, a 21% increase since the previous survey in 2010. The population structure improved since 2010, with a lower bull to cow ratio and a higher calf to cow ratio.

**Moose tracks observed from fixed-wing aircraft**

**Moose observed from helicopter**

## WHAT DOES IT MEAN?

The current moose population is likely stable to increasing in the Keeyask Region. As of January 2015, no direct adverse effects from Project construction were identified on moose abundance, distribution, or population structure. The lower ratio of bulls to cows than observed in the larger Split Lake RMA, surveyed in 2010, suggests that bulls are being selectively harvested, as recommended by the Cree Nation Partners in their 2013 Moose Harvest Sustainability Plan.

## WHAT WILL BE DONE NEXT?

The moose aerial survey will be repeated in 2018 for further evaluation of Project effects on the patterns and trends in moose distribution and abundance in the Keeyask Region.

# STUDY TEAM

We would like to thank Pat Chartier of Gillam Air, Ben Hofer of Custom Helicopters, Sherrie Mason, Rachel Boone and Caroline Walmsley of Manitoba Hydro, and Ron Bretecher of North/South Consultants Inc., for logistical assistance in the field. We would also like to thank James Ehnes of ECOSTEM Ltd. for GIS support and mapping.

Biologists, technicians, and other personnel who designed, participated in, and drafted the survey results included:

- Brian Knudsen (Knudsen Wildlife Management Systems – Design, analysis, and reporting
- Robert Berger, (M.N.R.M.) – Reporting
- Nicholas LaPorte (M.N.R.M.) – Crew
- Gordon Macdonald (B.Env.Sc.) – Crew leader
- Andrea Ambrose (B.Sc.) – Survey personnel, reporting
- Mark Baschuk (M.Sc.) – Survey personnel
- Morgan Scharf (B.Env.St.) – Survey personnel
- Clayton Flett (TCN) – Survey personnel
- Jonathan Kitchekeesik (TCN) – Survey personnel
- Kenneth Ouskan (TCN)
- Eugene Spence (TCN)

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# 1.0 INTRODUCTION

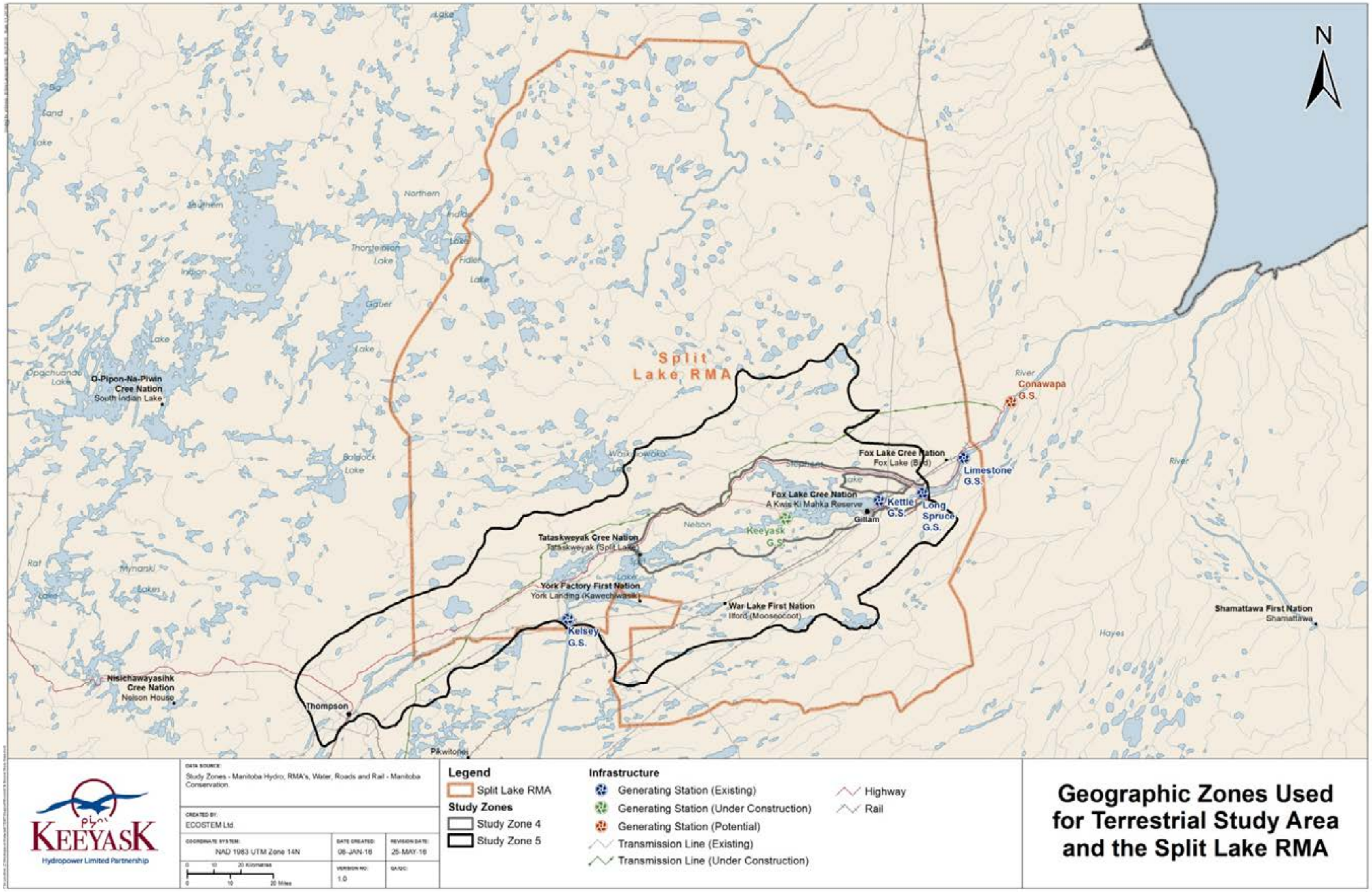
Construction of the Keeyask Generation Project (the Project), a 695 megawatt hydroelectric generating station (GS) and associated facilities, began in July 2014. The Project is located at Gull Rapids on the lower Nelson River in northern Manitoba where Gull Lake flows into Stephens Lake, 35 km upstream of the existing Kettle GS.

The *Keeyask Generation Project Response to EIS Guidelines* (the EIS), completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project. Technical supporting information for the terrestrial environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs is provided in the *Keeyask Generation Project Environmental Impact Statement Terrestrial Supporting Volume* (TE SV). The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the generating station on the terrestrial environment. The *Terrestrial Effects Monitoring Plan* (TEMP) was developed for the Project. Monitoring activities for various components of the terrestrial environment were described, including the focus of this report, moose regional population estimates, during the construction and operation phases.

Predicted Project effects on moose in the EIS included the loss or alteration of habitat, sensory disturbance, and increased mortality due mainly to harvest and predation. Monitoring studies for moose focus in part on verifying Project effects predictions related to regional population estimates and to how moose distribution and abundance could be altered by habitat changes.

Moose are widely distributed and common in the Keeyask Region. While there was a high degree of certainty for predicted Project effects on moose, the partner First Nations expressed concerns about effects on moose habitat and populations. A Moose Harvest Sustainability Plan was developed by the Cree Nation Partners (2013) and changes in moose abundance, harvest, and habitat within the Split Lake Resource Management Area (RMA) will be documented by the Cree Nation Partners. As outlined in Section 6.3.2 of the Terrestrial Effects Monitoring Plan (TEMP), the moose survey described in this report was conducted to evaluate how the Project could be affecting patterns and trends in moose distribution, abundance, and population characteristics. To that end, the size and structure of the mid-winter moose populations of Study Zones 4 and 5 were estimated. The mid-winter moose populations in the Wasekanoosees and Kitchisippi Moose Management Units (Units 5 and 7, respectively), which largely overlapped Study Zone 5, were also described (Appendix A).

During the preparation of the Project's EIS, a moose survey was conducted in January and February 2010 in the Split Lake RMA. The Split Lake RMA includes most of the moose regional study zone (Study Zone 5) in the Project area. It also includes all of Study Zone 4 (the moose local study area). Map 1 shows the location of the Keeyask Generating Station construction site, Study Zones 4 and 5, and the Split Lake RMA. The 2010 survey generated estimates of the moose populations in all three of these study areas, for comparison with current results to quantify the trends in the number of moose in the Keeyask Region and to evaluate whether winter habitat use is affected by the Project. Projections were created for the size and structure of the moose population of the Split Lake RMA for the period 2010 to 2015, against which cumulative effects can eventually be measured.




**Map 1: Geographic Zones Used for Terrestrial Study Areas and the Split Lake Resource Management Area**

# 2.0 METHODS

Study Zones 4 and 5 have irregular boundaries (Map 2). As such, to conduct the moose survey, it was necessary to define regular boundaries that were approximately the same, but that aligned with a grid of three minute cells (three minutes of latitude by three minutes of longitude), which was the framework of sample units for the survey. Each of these cells is approximately 3 km by 5.5 km. The width varies slightly with latitude, so the area of the cells ranges from approximately 17.5 km² in the southern portions to approximately 17.0 km² in the north. Grid cells were selected to define the regular boundaries. The sampling grid extended slightly outside of Study Zone 5 (Map 3) since the grid cells are rectangular and the study zone boundaries were delineated using other criteria. The total area of the survey (16,790 km²) was the combined set of 974 grid cells in Study Zone 5, Study Zone 4 (completely contained within Study Zone 5), and additional grid cells beyond the eastern boundary of Study Zone 5 that aligned with Moose Management Units 5 and 7 (Wasekanoosees and Kitchisippi, respectively) of the Split Lake RMA.

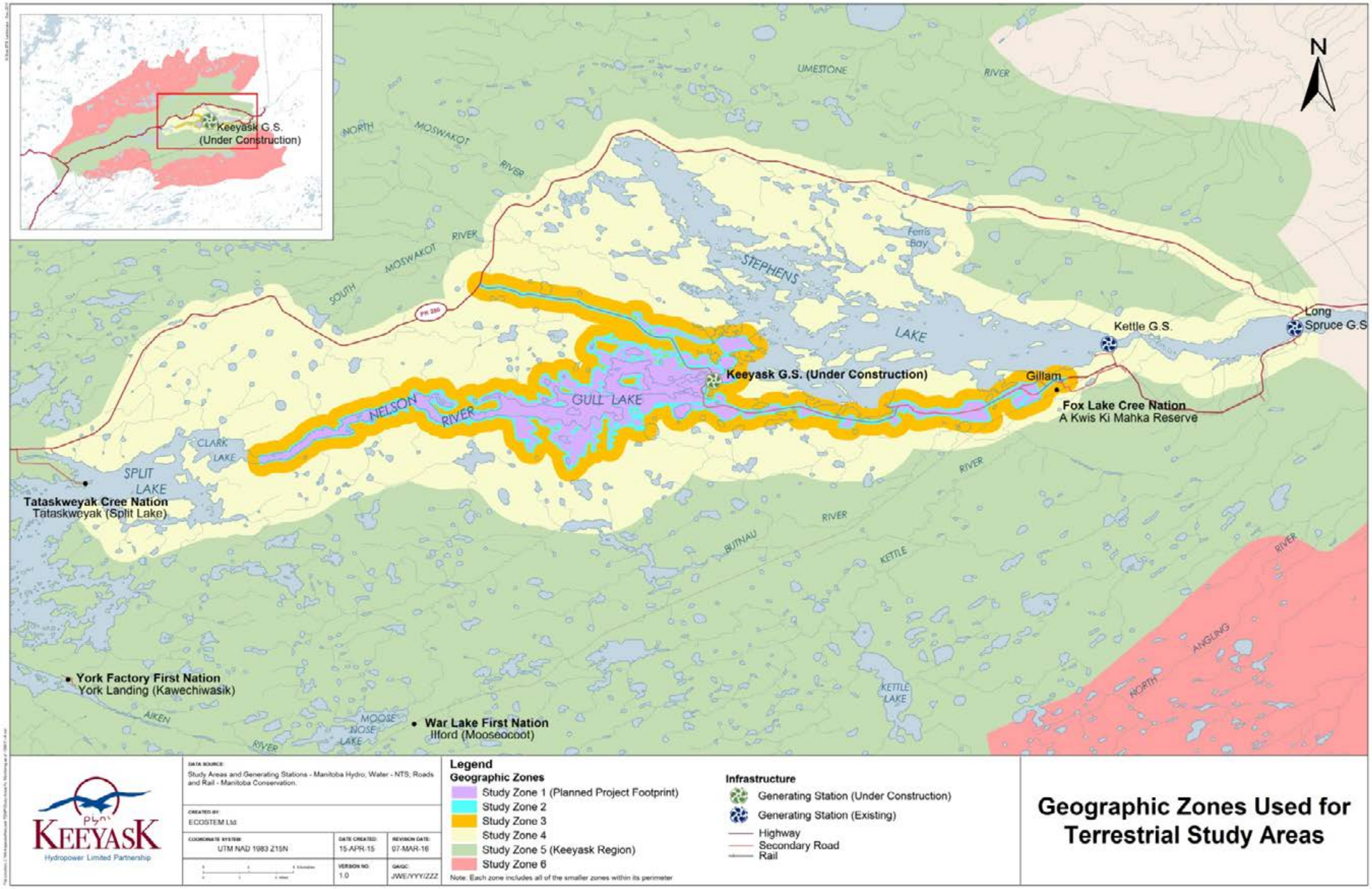
Gasaway *et al.* (1986) applied stratified random sampling specifically to the requirements of moose surveys. The methods used in this moose survey are fundamentally the same as Gasaway's, but incorporate recent technology - a geographic information system (GIS) and a Global Positioning System (GPS) unit are used to plan and carry out the survey. Gasaway's monograph is still the best description of the basic rationale and methods.

The moose aerial survey began on January 14, 2015 and ended on February 1, 2015. Stratification and sampling were scheduled to minimize the number of idle days for aircraft and crew. Twenty-one aircraft-days were spent on stratification and 13 helicopter-days were spent on sampling. Flying was limited on January 19 and 22 due to weather. The daily weather reports for Gillam and Thompson during the survey are in Appendix B.

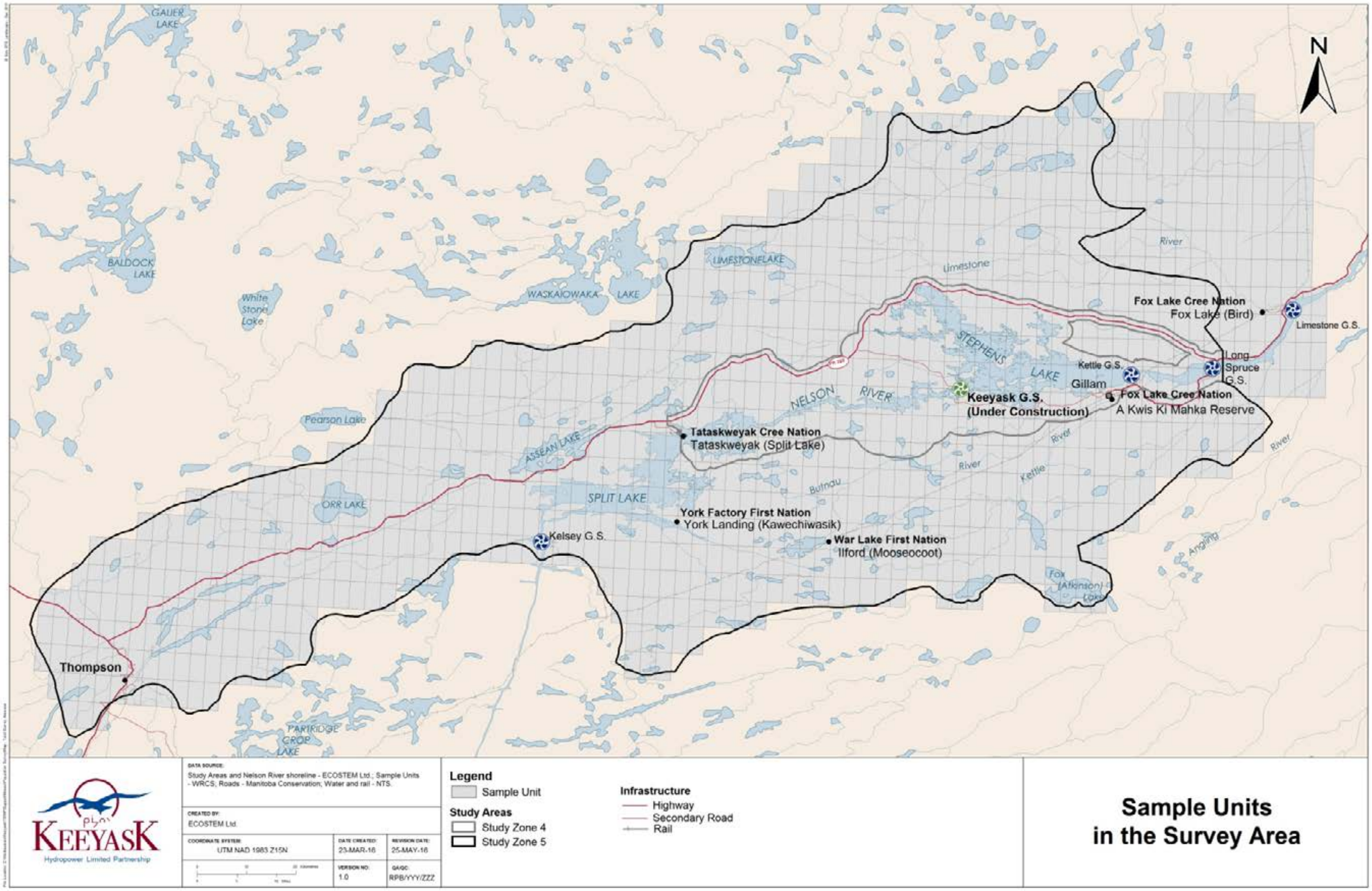
The survey followed a stratified random sampling design. The first step in this type of survey is stratification, which consists of flying a thin survey and searching for moose tracks, to allow each sample unit to be characterized as having a high, medium, or low density of moose. The second step is sampling, which consists of searching randomly selected sample units with a helicopter and counting all the moose inside the sample unit's boundary. The allocation of the sampling effort among the strata was determined by the stratum's mean density and variance. Allocation of the helicopter time was optimized using a program called Moosepop (Reed 1989; Becker and Reed 1990).

Stratification was based on moose tracks observed from a Britten-Norman Islander fixed-wing aircraft (Photo 1) with one pilot, a crew chief seated beside the pilot, and two observers in the back seats. Airspeed was approximately 160 kilometres per hour (km/h) and elevation was approximately 100 metres (m) above ground. Both airspeed and elevation varied with factors such as wind direction and terrain. Flight lines were north-south, 1.5 minutes of longitude (which is approximately 1.5 km) apart, and were arranged so that two lines were flown through each of the 974 sample units, except for 13 sample units around Thompson and the Thompson

Airport. These 13 sample units were assumed to contain no moose tracks, because they consisted mostly of urban and airport land. Whenever moose tracks were observed, the crew chief was notified. The location was marked as a waypoint in a GPS unit, and the crew chief noted the waypoint number on a data sheet, along with the associated data (Appendix C).




**Map 2: Geographic Zones Used for Terrestrial Study Areas**




**Map 3: Sample Units in the Survey Area**

**Photo 1: Britten-Norman Islander Fixed-wing Aircraft Used in the 2015 Moose Aerial Survey**

Moose were counted in sample units by using a Bell JetRanger helicopter (Photo 2), with crew arranged as described above (Photo 3). Flight lines were north-south, approximately 500 m apart, so that observers on each side were scanning a strip 250 m wide. When moose were sighted, the crew chief was notified, and the animal was classified as a bull, cow, calf, or unknown. Altitude was approximately 50 m, and airspeed varied from 100 km/h to 140 km/h.

**Photo 2: Bell JetRanger Helicopter Used in the 2015 Moose Aerial Survey**

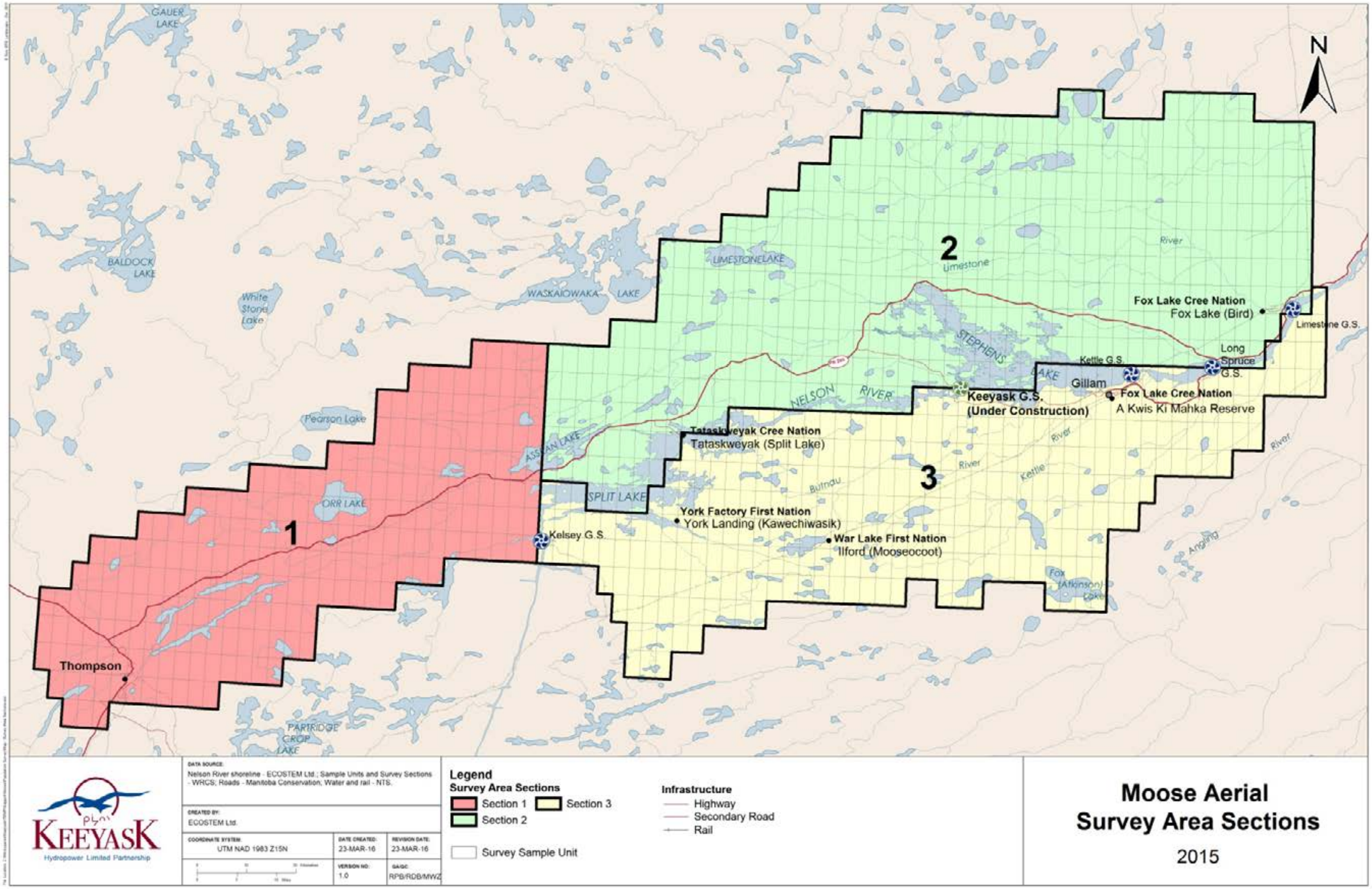

**Photo 3: Observer in Helicopter During the 2015 Moose Aerial Survey**

Stratification flights were only conducted if there had not been a significant snowfall the previous day and if visibility was good. Sampling flights were conducted on all days that had adequate visibility for detecting moose.

Each evening, data were downloaded from the GPS unit and entered from the hard copy data sheets, and transmitted as Garmin .gdb files and Excel spreadsheets to the survey's data manager. During sampling, route files for the next day's flying in the helicopter were prepared by the data manager and transmitted to the survey crew for loading into the helicopter's GPS unit for the next day's sampling.

The total survey area was divided into three sections (Map 4), each of which was surveyed as if it were a separate survey. Boundaries were chosen to reduce the length of the north-south lines that would be flown by the stratification aircraft, to give observers frequent opportunities to rest their eyes and attention. Section 1 was flown out of the Thompson Airport, while Sections 2 and 3 were flown out of the Gillam Airport.

After the three sections were completed, the data were examined to see if any strata in different sections had the same mean densities and variances. The sample units from such strata were combined for the final population estimate. The population estimates and the estimates of bull, cow and calf densities and ratios were calculated with Moosepop.




**Map 4: Moose Aerial Survey Area Sections in 2015**

# 3.0 RESULTS

## 3.1 STRATIFICATION

### 3.1.1 MOOSE TRACKS

Moose tracks were seen in 653 out of 974 sample units (Map 5). The number of tracks per sample unit ranged from 0 to 14, for a total of 2,081 track locations. This is considered to be a very low density of tracks. The absolute number of tracks per sample unit is an important characteristic of surveys in areas such as this, which are at the edges of the moose range in North America. Because moose tracks were relatively rare and there were usually no other ungulate tracks, observers had a high probability of detecting moose tracks and the moose that made them (see Section 4.0). The frequency distribution of track locations per sample unit is shown in Figure 1.

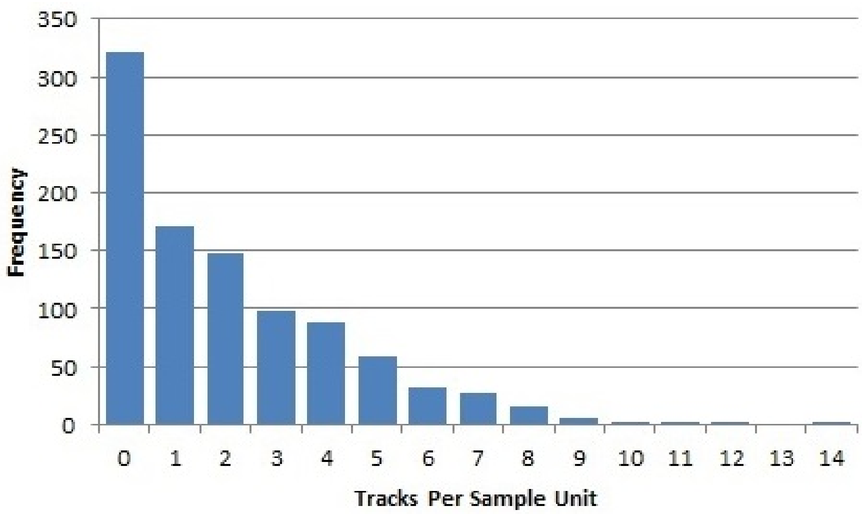



**Figure 1: Frequency Distribution of Moose Tracks Per Sample Unit in 2015**

## Map 5: Moose Track Locations Identified During Stratification Flights in 2015

*Note: This map has been removed due to the sensitive nature of the information. This map will be provided to the regulators, but will not be included in the version of the report that is publicly available.*

As observed in 2010, the distribution of moose tracks was very uneven, without any clear association of high or low density tracks with other features, with the exception that the western half of Provincial Road (PR) 280 (approximately from Thompson to Split Lake) had very few tracks near it. Large areas within the survey area were burned in 2013. The burns could have influenced moose distribution, but Map 5 suggests no obvious relationship between burned areas and moose tracks.

Sample units were stratified into low, medium, and high density classes, using the number of track locations seen in them. If two or fewer track locations were seen in a sample unit, it was classified as low (tagged as LO for compact labels in tables and figures). If there were three to five track locations, the sample unit was classified as medium (MED). If there were six or more track locations, the sample unit was classified as high (HI). After applying these rules, the sample units and tracks were scrutinized, and if a LO sample unit had two sets of tracks and shared a side with a HI, it was promoted to a MED to reflect the higher probability that it would contain moose.

### 3.1.2 CARIBOU TRACKS

During stratification flights, caribou tracks were recorded. Photo 4, Photo 5 and Photo 6 show track patterns that are representative of low, medium, and high caribou track densities.

**Photo 4: Representative Pattern of Low Density Caribou Tracks**

**Photo 5: Representative Pattern of Medium Density Caribou Tracks**

**Photo 6: Representative Pattern of High Density Caribou Tracks**

The distribution of caribou tracks was uneven across the moose survey area (Map 6). Only in the eastern half of Section 3 were caribou tracks sufficiently abundant to interfere with detecting moose tracks. The Nelson River was the boundary between Sections 2 and 3, and appeared also to be an approximate boundary for caribou movements. Caribou tracks were thin in Sections 1 and 2, with a slight pattern of decreasing density from east to west.

### 3.1.3 INCIDENTAL OBSERVATIONS OF PREDATORS

One wolverine and two lone gray wolves were observed incidentally during stratification. The wolverine was observed approximately 24 km northwest of the Limestone Generating Station.

**Map 6: Caribou Track Density Recorded by Transect During Stratification Flights in 2015**

*Note: This map has been removed due to the sensitive nature of the information. This map will be provided to the regulators, but will not be included in the version of the report that is publicly available.*

## 3.2 SAMPLING

Within each section, stratification increased the efficiency of sampling. Track counts created strata that had distinct differences in mean densities, with the exception of the lack of a difference between the MED and HI classes in Section 1. Between the three sections there were differences in the mean densities of moose in strata that had the same density class. For example, the mean moose density in the LO sample units in Section 3 was 2/100 km², but in the other two sections it was 5–6/100 km². These differences were taken into account when the data from the sections were merged for a population estimate of the entire survey area. The LO sample units from Section 3 were assigned to a separate stratum, and labelled Extra Low (XLO). In Section 1, the moose densities in the HI stratum were the same as in the MED strata, and also the same as the MED strata in the other two sections, so the sample units in that stratum were merged with all the other MED sample units to create a MED stratum for the entire survey.

### 3.2.1 INCIDENTAL OBSERVATIONS OF PREDATORS

Eleven gray wolves were observed during sampling flights. One group of four was observed on the Meridian River and a group of six was spotted on a snowmobile trail on a transmission line right-of-way. A lone wolf was also observed at a kill site.

## 3.3 POPULATION ESTIMATES

### 3.3.1 POPULATION ESTIMATE OF ENTIRE SURVEY AREA

The population estimate for the whole survey area is 1,349 moose (see Table 1 for more details on survey results). The complete population estimate output, as it is produced by Moosepop, is provided in Appendix D.

The bottom rows of Table 1 show the various relationships among the total area of the strata, the stratum densities, and sampling effort. The Simple Random Sampling Size shows the number of samples that would have been taken in each stratum without stratification. The expected number of samples from each stratum would have been proportional to the stratum's total area. The Stratification Sampling Ratio shows the ratio of actual samples to samples that would have been taken under simple random sampling. Without stratified sampling, the large variance in the MED and HI strata would have generated a wide confidence interval.

Note that approximately half of the population occurs in the XLO and LO strata, which constitute approximately 75% of the area. Moose at low densities such as these, over large areas, could be overlooked or disregarded in population estimates that use only information from areas of higher density. This would result in an underestimate of the population.

**Table 1: Summarized Moose Population Estimate for the Entire Survey Area in 2015**

| | Stratum | | | | |
|---|---|---|---|---|---|
| | **XLO** | **LO** | **MED** | **HI** | **TOTAL** |
| Number of sample units | 143 | 585 | 214 | 32 | 974 |
| Total area (km²) | 2,467 | 10,064 | 3,678 | 549 | 16,758 |
| Sample size | 11 | 39 | 51 | 12 | 113 |
| Area surveyed (km²) | 190 | 671 | 879 | 206 | 1,945 |
| Moose observed | 4 | 43 | 126 | 47 | 220 |
| Density (individuals/100 km²) | 2 | 6 | 14 | 23 | 8 |
| Estimated population | 52 | 645 | 528 | 125 | **1,349** |
| Sampling intensity (%) | 8 | 7 | 24 | 38 | 12 |
| Percent of samples | 10 | 35 | 45 | 11 | 100 |
| Percent of population | 4 | 48 | 39 | 9 | 100 |
| Percent of area | 15 | 60 | 22 | 3 | 100 |
| Simple random sample size | 17 | 68 | 25 | 3 | 113 |
| Stratification sampling ratio | 0.65 | 0.57 | 2.04 | 4.00 | |
| 95% confidence interval around population estimate 1,044 to 1,655 (+/- 23%) | | | | | |

The calculated confidence interval for the population estimate is +/- 23% (Table 1). However, the distributions of the counts of moose per sample unit (Figure 2) should be taken into account when interpreting and applying this figure. The consequences of the substantial non-normality of the data (i.e., more occurrences of lower densities than medium or high densities) on the accuracy of the confidence interval is not known.

Although two of the strata are labelled MED and HI, these names are intended to indicate only the relative abundance of moose within the survey area. The overall density of 8/100 km² is still considered to be very low, and relative to most other North American moose herds, all of the sample units would be considered to have a low moose density. The distribution of moose over the entire survey area is shown in Map 7.

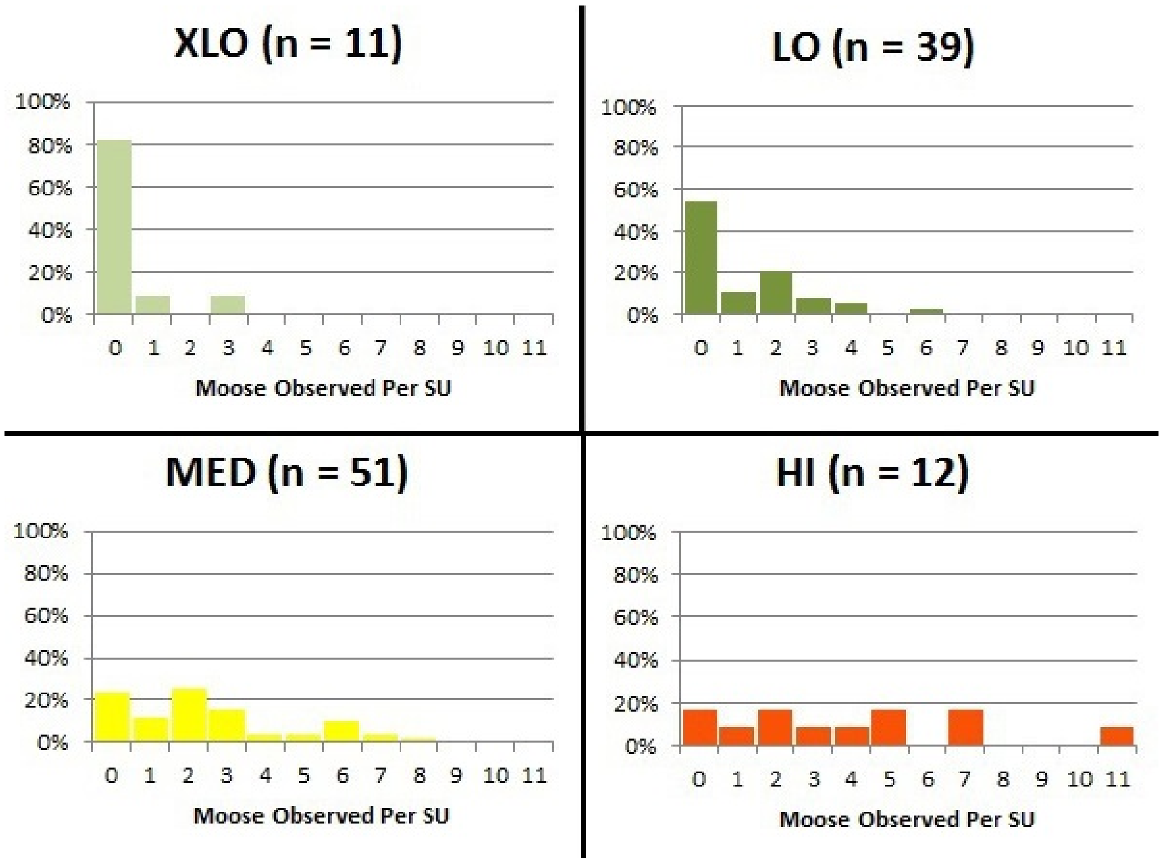



**Figure 2:** **Frequency Distribution of 2015 Counts of Moose Per Sample Unit for the Four Strata**

**Map 7: Moose Distribution in the Total Survey Area in 2015**

*Note: This map has been removed due to the sensitive nature of the information. This map will be provided to the regulators, but will not be included in the version of the report that is publicly available.*

### 3.3.2 POPULATION STRUCTURE IN THE ENTIRE SURVEY AREA

Observers were able to classify 72% of the 220 observed moose to an age/sex class: 43 bulls, 78 cows, and 38 calves. However, these numbers should not be used to generate ratios such as bull per 100 cows for the entire survey area, because the densities of the categories differ between strata, and the sampling effort was not the same in each stratum. Table 2 shows the unbiased estimates of the abundance of bulls, cows, and calves, and the ratios among them. Totals do not always match the sums of stratum values, because the individual values are rounded to the nearest integer.

**Table 2: Summarized Estimates of Moose Population Structure for the Entire Survey Area in 2015**

| | Stratum | | | | |
|---|---|---|---|---|---|
| | **XLO** | **LO** | **MED** | **HI** | **TOTAL** |
| Estimated number of bulls | 13 | 105 | 100 | 29 | 248 |
| Density (individuals/100 km²) | <1 | 1 | 3 | 5 | 1 |
| Estimated number of cows | 13 | 255 | 188 | 40 | 496 |
| Density (individuals/100 km²) | <1 | 3 | 5 | 7 | 3 |
| Estimated number of calves | 0 | 150 | 84 | 21 | 255 |
| Density (individuals/100 km²) | 0 | 1 | 2 | 4 | 2 |
| Estimated number of unknowns | 26 | 135 | 155 | 35 | 350 |
| Density (individuals/100 km²) | 1 | 1 | 4 | 6 | 2 |
| Estimated population | 52 | 645 | 528 | 125 | 1,349 |
| Density (individuals/100 km²) | 2 | 6 | 14 | 23 | 8 |
| Bulls/100 cows: 50 | | | | | |
| 95% confidence interval around p = (0.25, 0.75) is +/– 51% | | | | | |
| Calves/100 cows: 51 | | | | | |
| 95% confidence interval around p = (0.35, 0.68) is +/– 32% | | | | | |

Sixty-one observed moose (28%) were classified as unknown age/sex class, and therefore in the estimated population of 1,349 individuals, 350 moose were labelled as Unknown age/sex. This information is a useful indicator of the degree to which observers could confidently assign moose to an age/sex class, but of course in reality all these moose are bulls, cows, or calves. The proportions within this group are not known however, and in the absence of any further information, it was assumed that the Unknowns had the same composition as the rest of the population: 24.8% bulls, 49.6% cows, and 25.5% calves. After the Unknowns were partitioned and added to the other three age/sex classes, the population of 1,349 was estimated to have 335 bulls, 669 cows, and 344 calves.

Using the information in Table 2, it was possible to take the entire population of 1,349 and divide it into an expected number of bulls, cows, and calves in each of the 974 sample units. The stratum-specific density for each age/sex class was multiplied by the area of the cell, and that number was stored in the cell's row in the attribute table of the GIS. These numbers were theoretical quantities, calculated to four decimal places of precision. For example, a MED sample unit was expected to have 0.6562 bulls, 1.2291 cows, and 0.5457 calves. For individual sample units these quantities are not useful, but if one were to select a group of 100 sample units, and they were all MED, one would expect to find in that group 66 bulls, 123 cows, and 55 calves. This is the way that these cell-specific quantities were used to estimate the populations of the four areas of interest that were subsets of the entire survey area: the expected number of moose in the individual cells was added up. All the precision in the density estimates was retained and used, to avoid accumulating rounding errors.

### 3.3.3 POPULATION ESTIMATES FOR STUDY ZONES 5 AND 4

Table 3 shows the estimated populations for Study Zones 5 and 4. Population estimates were 21% and 41% higher than those measured in 2010. Map 8 shows the pattern and abundance of moose densities in the two study zones. In Study Zone 5 there were 50 calves and 51 bulls per 100 cows and in Study Zone 4 there were 49 calves and 51 bulls per 100 cows.

**Table 3: Moose Populations in Areas of Interest Within the Entire Survey Area in 2010 and 2015**

| | 2015 | | | | 2010 | |
|---|---|---|---|---|---|---|
| | **Bulls** | **Cows** | **Calves** | **Total** | **Total** | **Change (%)** |
| Study Zone 5 | 295 | 577 | 289 | 1,162 | 961 | +21 |
| Study Zone 4 | 45 | 88 | 43 | 176 | 125 | +41 |

## Map 8: Pattern of Moose Densities in Study Zones 4 and 5 in 2015

*Note: This map has been removed due to the sensitive nature of the information. This map will be provided to the regulators, but will not be included in the version of the report that is publicly available.*

# 4.0 DISCUSSION

## 4.1 SURVEY DESIGN AND INTERPRETATION

The count of moose from the helicopter during sampling in 2015 is assumed to be a total count. The Sightability Correction Factor involved in the Gasaway method, which is intended to compensate for moose that were not seen, was not applied. The reason for this approach is tied to the overall density of moose in northeastern Manitoba. Stratified random sampling was first applied to moose in the Kenai area of Alaska, where densities of moose per 100 km² ranged from 40 in the LO stratum to 300 in the HI stratum. In this survey, the comparable numbers were six to 23. Observers in Alaska would be seeing moose approximately every one to two minutes, and there would almost always be tracks underneath them. In northeastern Manitoba, observers see moose approximately every 10 to 15 minutes, and tracks are rare. In Alaska, because tracks would not provide useful cues to observers about the presence of moose in the field of view, observers had to stay alert and actually see the moose as the aircraft passed over them. In Manitoba, tracks are conspicuous (Photo 7 and Photo 8) and alert observers to the presence of moose in the immediate area. Observers reported that during sampling, they did not encounter tracks without seeing moose, which suggests that moose were not missed. Studies that have attempted to estimate the probability of sighting moose during aerial surveys have not been conducted in areas with densities as low as those reported here, so their probabilities do not apply here. Moreover, the southern studies were often conducted where other ungulates, particularly deer, were present, contributing more tracks to the snowscape and further reducing the chance to use tracks as indicators of nearby moose.

Because the survey was conducted in three sections, the randomization of sampling in the survey was not complete. By taking samples in each section approximately in proportion to the area of the section, sampling had a systematic component. Green (1979) discusses systematic and random sampling, and suggests that even completely systematic sampling rarely differs from random sampling sufficiently to justify the additional logistic difficulty of complete randomization, so long as the systematic pattern does not follow some pattern in the environment. Green (1979) was followed regarding the systematic allocation of samples to sections, but complete randomization within each section was adhered to. The only deviation from this was in Section 3, when samples were taken before stratification flying was finished, and some samples in the HI stratum were out of random order. Since there was no pattern to the deviations from randomness, the deviation was judged to be random in itself, and not consequential.

**Photo 7: Moose, Showing Conspicuous Tracks Nearby**

**Photo 8: Example of How Moose Blend in With Scattered Dark Conifers, but Nearby Tracks Draw the Eye to the Area**

To test whether caribou tracks in the eastern half of Section 3 interfered with detecting moose tracks, we identified all of the sample units in that area that had moose tracks in the LO range (two or fewer tracks) and were subsequently counted with the helicopter. Only one moose was seen in the seven sample units, suggesting that the presence of caribou tracks did not interfere with stratification.

## 4.2 POPULATION ESTIMATES

The moose population in Study Zone 5 increased 21% from 2010 to 2015, an average annual increment of approximately 4%. The ratio of calves to cows in Study Zone 5 (50:100) was greater than the 36 calves:100 cows in the Split Lake RMA in 2010 (Cree Nation Partners 2013). Because almost all cows produce one or more calves each year (Schwartz 2007; Cree Nation Partners 2013), half of the calves born in spring 2014 did not survive (Cree Nation Partners 2013). However, a ratio of approximately 30 calves:100 cows is required for a sustainable moose population (Benn 2001; Lirette 2014), which was exceeded in 2010, possibly accounting in part for the increased moose population in 2015.

The ratio of bulls to cows in Study Zone 5 (51:100) was considerably lower than the 118 bulls:100 cows in the Split Lake RMA in 2010, which was considered a surplus and indicated that too many cows were being harvested (Cree Nation Partners 2013). In 2010 there were 120 bulls:100 cows in Moose Management Unit 5 (Wasekanoosees) and 111 bulls:100 cows in Moose Management Unit 7 (Kitchisippi) (Cree Nation Partners 2013), which roughly correspond with Study Zone 5 (see Appendix A). The selective harvesting of bulls advocated in the Moose Harvest Sustainability Plan (Cree Nation Partners 2013) could have accounted, at least in part, for the improved population structure and increased moose population. A greater proportion of females in a population can result in greater recruitment rates (Courtois and Lamontagne 1999; Solberg *et al.* 1999; Solberg *et al.* 2000; Sæther *et al.* 2001; Milner *et al.* 2007) because a single bull can impregnate more than one cow in a breeding season (Schwartz 2007). The current bull:cow ratio is in line with management objectives in British Columbia, which promote a minimum of 50 bulls:100 cows in low density (<200/1,000 km²) moose populations (Ministry of Forests, Lands and Natural Resource Operations 2015), and is within the range of 30 bulls:100 cows recommended by Environment Yukon (Yukon Renewable Resources 1996; Jessup *et al.* 2014), 67 bulls:100 cows (40:60) suggested by the Ontario Ministry of Natural Resources (2009) and the approximately 90 bulls:100 cows recommended by the Saskatchewan Ministry of Environment (2015) for a sustainable moose population. As the moose population has increased since 2010, the lower bull:cow ratio does not appear to have negatively affected moose reproduction.

In addition to the improved population structure and greater recruitment of calves into the population since 2010, reduced mortality could have influenced the increased moose population. Predators such as bears and gray wolves can take 50% or more of moose calves born each spring (Ballard and Van Ballenberghe 2007; Schwartz 2007). Deep snow can hinder wolf movement, and lack of food can reduce survival. Reduced hunting efficiency or a diminished gray wolf population would reduce predation on moose; fewer individuals would be taken (*e.g.,* Bergerud *et al.* 1983) and more would survive to be added to the population and/or to reproduce. As there is no information about gray wolves specific to the survey area, the role of predation in the increased moose population is unknown.

Caribou are alternative prey for gray wolf in Study Zone 5, but are generally sparse when the large migratory herds that occasionally occupy the area are absent (Keeyask Hydropower Limited Partnership 2012). The large migration of forest-tundra woodland caribou through the region in the winter of 2012/13 (LaPorte *et al.* 2013) could have resulted in resident wolves shifting from moose to the more abundant caribou. In southeastern British Columbia, the wolf diet switched from moose to caribou in summer when moose, caribou, and wolves occupied the same areas (Seip 1992). In Alaska, wolves switched from moose to a diet that was almost entirely caribou when a migratory herd moved into their territory (Ballard *et al.* 1997 in Cree Nation Partners 2013). Such a shift could have resulted in reduced predation on moose and an increased birth rate the following year.

Changes in habitat availability could have contributed to the increased moose population in the entire survey area. A changing mosaic of recently burned and older, regenerating areas could have resulted in shifts in carrying capacity and moose distribution (*e.g.,* Lord and Kielland 2015) within and beyond Study Zone 5. Moose return to burned areas shortly after a fire, with population increases in the first two years (Peek 1974). Increased recruitment due to improved habitat did not account for the relatively large population increase observed in northern Minnesota after a fire; individuals also immigrated to the area after only six months (Peek 1974). Moose may have moved into Study Zone 5 following the forest fires in 2013 (see Map 5), accounting for some of the population increase in 2015. Moose density typically peaks 11 to 30 years post-burn (Maier *et al.* 2005), as regenerating vegetation provides good moose forage (Weixelman *et al.* 1998; Lord and Kielland 2015), particularly after 11 to 30 years (Kelsall *et al.* 1977 in Peek 2007). Immigration to older regenerating habitat in Study Zone 5 could also have contributed to the population increase.

# 5.0 SUMMARY AND CONCLUSIONS

The moose population in Study Zone 5 has increased since 2010. The lower ratio of bulls to cows than observed in the Split Lake RMA in 2010 suggests that bulls are being selectively harvested, as recommended by the Moose Harvest Sustainability Plan. This lower bull:cow ratio appears to be benefiting the moose population by increasing recruitment rates, as indicated by the increased calf:cow ratio since 2010. Other factors, particularly reduced predation and increased habitat availability, could also have contributed to the increase. The current harvest appears sustainable and the moose population is likely stable. No adverse Project effects on moose abundance, distribution, or population structure were identified.

As indicated in the TEMP, an aerial survey for moose will be conducted in winter 2018 for further evaluation of Project effects on patterns and trends in moose distribution and abundance in Study Zone 5. This survey will be coordinated with any aerial surveys for moose being done within the Split Lake RMA to support the Moose Harvest Sustainability Plan (Cree Nation Partners 2013).

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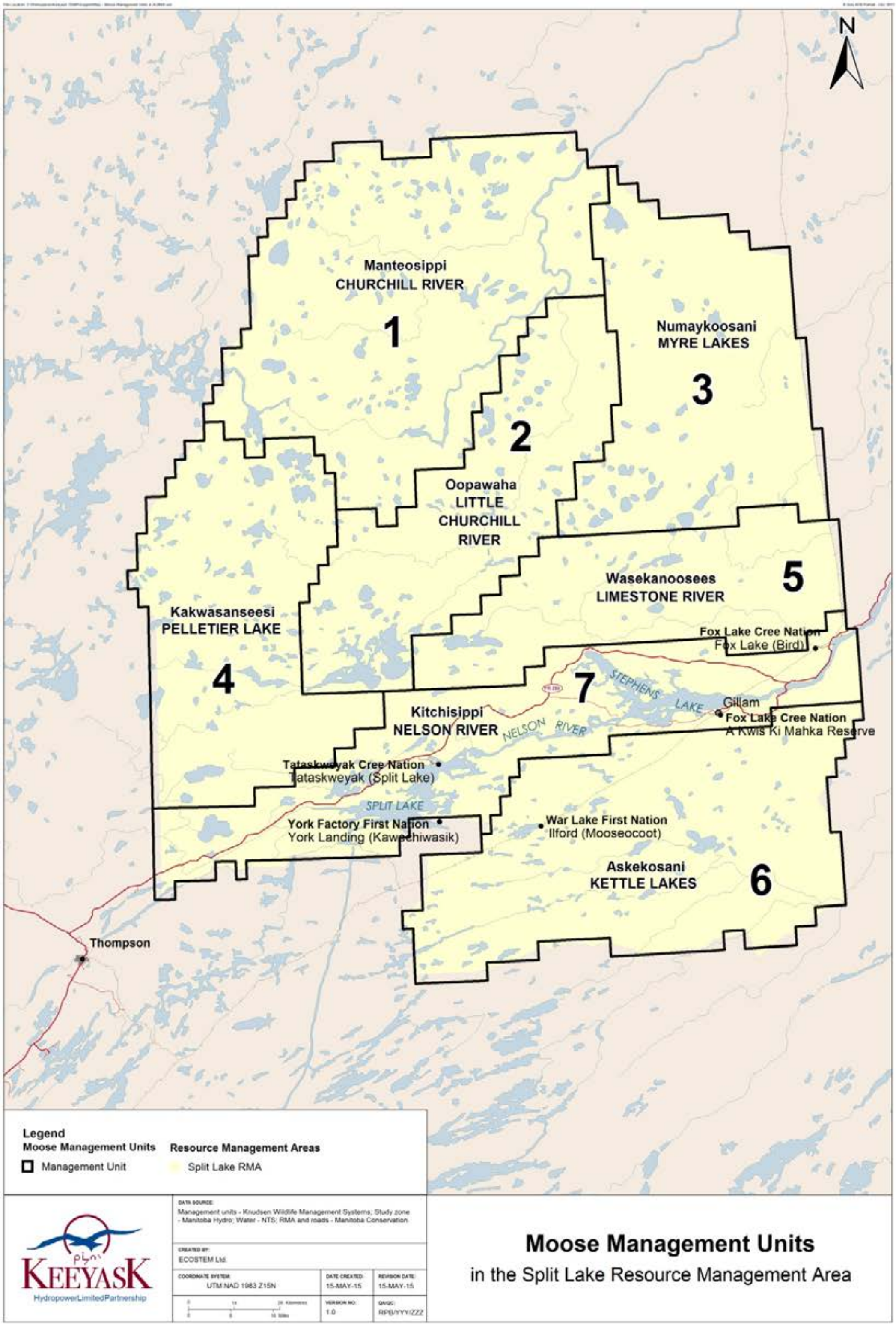
# APPENDIX A: Population Estimates for Moose Management Units 5 and 7

# INTRODUCTION

During the preparation of the Keeyask Generation Project's environmental impact assessment, a moose survey was conducted in January and February 2010 in the Split Lake Resource Management Area (RMA). The 2010 survey generated estimates of the moose population and projections were created for the size and structure of the moose population of the Split Lake RMA for the period 2010 to 2015.

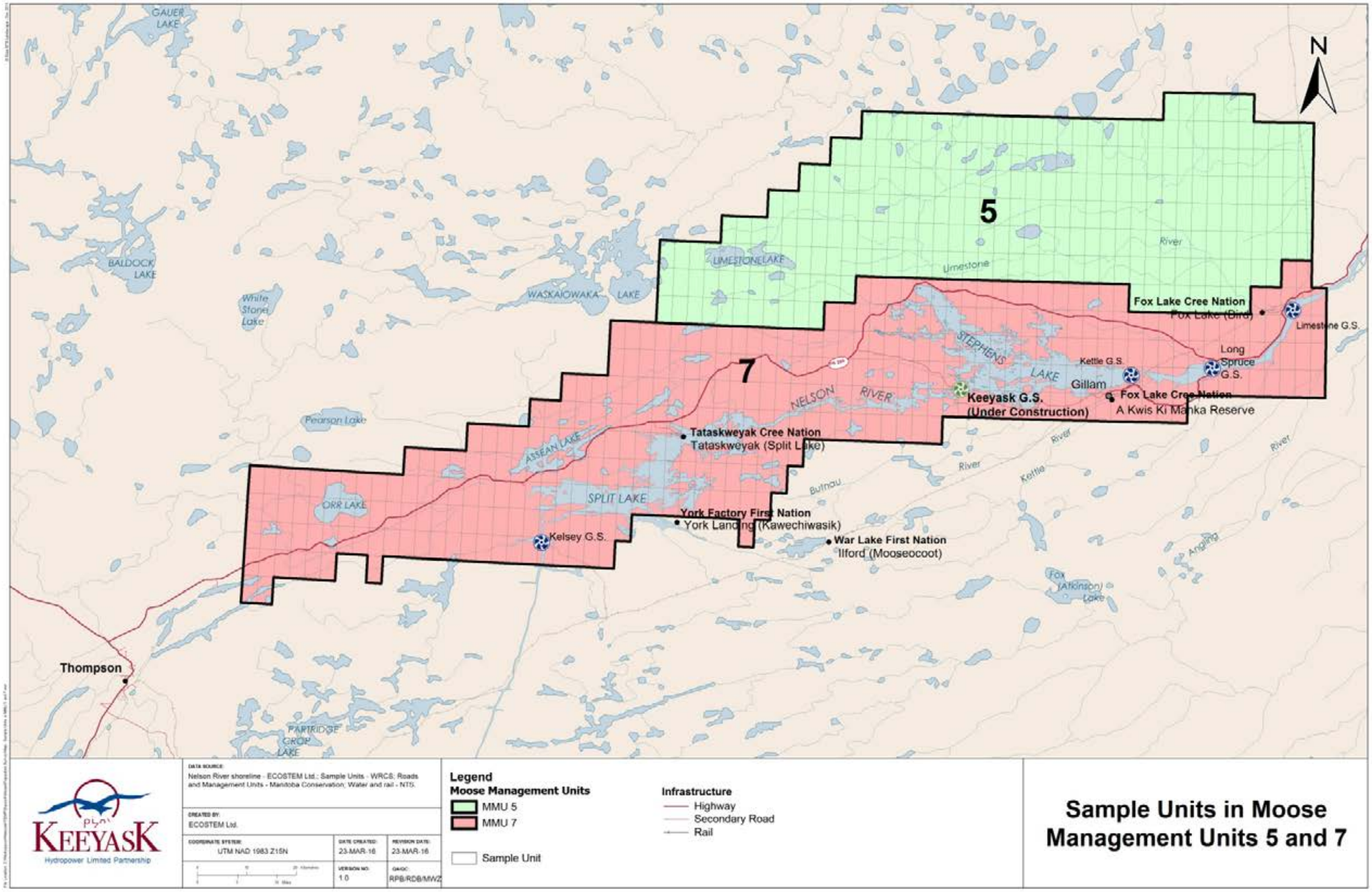
The results of the 2010 survey were used to prepare a Moose Harvest Sustainability Plan (Cree Nation Partners 2013) that divided the Split Lake RMA into seven Moose Management Units, providing a framework for future moose management in the RMA (Map 9). Population estimates were generated for all seven Moose Management Units, and projections were created for various harvest strategies for the period 2010 to 2015. Data from the 2015 moose survey were used to estimate the populations of Moose Management Units 5 (Wasekanoosees) and 7 (Kitchisippi) for comparison with the previous estimates.




**Map 9: Moose Management Units in the Split Lake Resource Management Area**

# METHODS

Survey methods were described in Section 2.0. The boundaries of Moose Management Units 5 and 7 were aligned with the three minute grid (Map 10).




**Map 10: Sample Units in Moose Management Units 5 and 7**

# RESULTS

Table 4 shows the estimated populations for Moose Management Units 5 and 7 in 2015. Population estimates were 22% and 32% higher than in 2010. Map 11 shows the pattern and abundance of moose densities in Moose Management Units 5 and 7.

**Table 4: Moose Populations in Moose Management Units 5 and 7**

| | 2015 | | | | 2010 | |
|---|---|---|---|---|---|---|
| | Bulls | Cows | Calves | Total | Total | Change (%) |
| Moose Management Unit 5 | 116 | 222 | 113 | 451 | 369 | +22 |
| Moose Management Unit 7 | 113 | 222 | 112 | 446 | 337 | +32 |

The best context for the survey results is the Moose Management Units. For both of the surveyed units, there are 2010 baseline population estimates, models that are explicit in their construction and assumptions, and predictions of January 2015 populations to which the survey results can be compared. Table 5 and Table 6 summarize all these quantities, and show the positive changes that have occurred in both the total population and the age/sex structure. There were 51 calves and 52 bulls per 100 cows in Moose Management Unit 5 during the 2015 survey. In Moose Management Unit 7, there were 50 calves and 51 bulls per 100 cows in 2015.

**Table 5: Moose Population in Moose Management Unit 5: Wasekanoosees (Total Area 4,260 km²)**

| | 2010 | 2015 | |
|---|---|---|---|
| | Actual | Projected Sustainable | Actual |
| Bulls | 176 (48%) | 96 (23%) | 116 (26%) |
| Cows | 147 (40%) | 217 (52%) | 222 (49%) |
| Calves | 46 (12%) | 102 (25%) | 113 (25%) |
| Total | 369 | 414 | 451 |
| Density: 11/100 km² | | | |

**Table 6: Moose Population in Moose Management Unit 7: Kitchissipi (Total Area 6,207 km²)**

| | 2010 | 2015 | |
|---|---|---|---|
| | Actual | Projected Sustainable | Actual |
| Bulls | 154 (46%) | 76 (22%) | 113 (25%) |
| Cows | 133 (39%) | 178 (53%) | 222 (50%) |
| Calves | 50 (15%) | 84 (25%) | 112 (25%) |
| Total | 337 | 338 | 446 |
| Density: 7/100 km² | | | |

## Map 11: Pattern of Moose Densities in Moose Management Units 5 and 7 in 2015

*Note: This map has been removed due to the sensitive nature of the information. This map will be provided to the regulators, but will not be included in the version of the report that is publicly available.*

# DISCUSSION

The structure of the moose population in Moose Management Units 5 and 7 changed from 2010 to 2015 (Figure 3). The number of bulls decreased, while the number of cows and calves increased in both units over the five-year period. The selective harvesting of bulls suggested in the Moose Harvest Sustainability Plan (Cree Nation Partners 2013) likely accounted, at least in part, for the improved population structure (see Section 4.2).

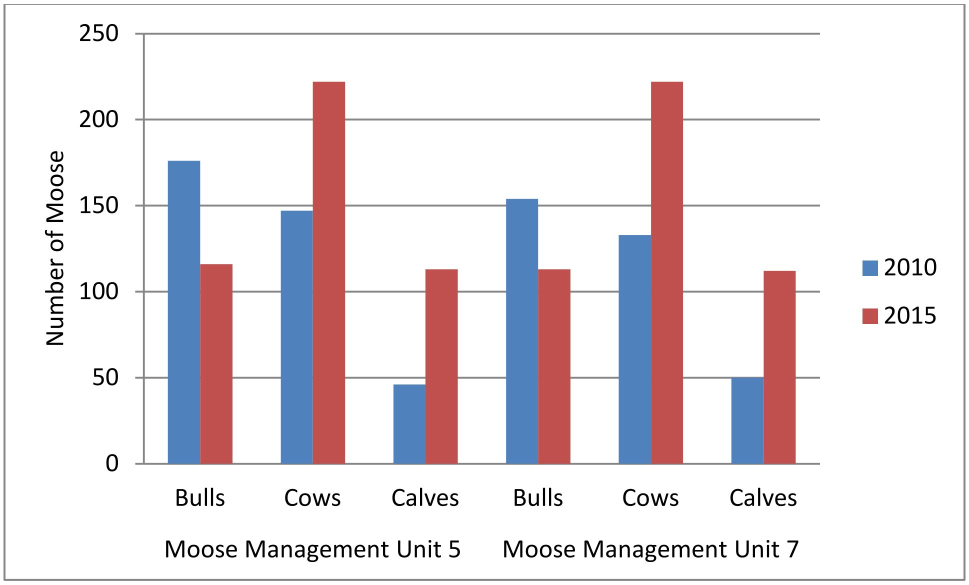



**Figure 3: Moose Population Structure in Moose Management Units 5 (Wasekanoosees) and 7 (Kitchissipi) in 2010 and 2015**

Moose populations in Moose Management Units 5 and 7 in 2015 were somewhat different than projections from the Moose Harvest Sustainability Plan for the same year (Cree Nation Partners 2013). The number of moose in Moose Management Unit 5 was expected to increase from 360 in 2010 to 579 in 2015. In Moose Management Unit 7, the moose population was expected to be the same in 2010 (n = 337) and 2015 (n = 338). There were 25% fewer moose in Moose Management Unit 5 and 28% more moose in Moose Management Unit 7 than predicted (Table 7). In all, there were 2% more moose than projected in the combined units, which overlap Study Zone 5. Calf:cow and bull:cow ratios were greater than those predicted to be sustainable in both Moose Management Units. Based on the increased moose population in both moose management units from 2010 to 2015, the current harvest level appears to be sustainable.

**Table 7: Projected and Current Moose Population in Moose Management Units 5 (Wasekanoosses) and 7 (Kitchissipi)**

| | 2015 Projection | 2015 Population | Difference | % Difference |
|---|---|---|---|---|
| Moose Management Unit 5 | 579 | 451 | -128 | 25% |
| Moose Management Unit 7 | 338 | 446 | +108 | 28% |
| Total | 917 | 897 | 20 | 2% |

This survey is a useful proof of concept that the Moose Management Units are a good long-term framework for managing moose in the Split Lake RMA in a focused manner.

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# APPENDIX B:
# Daily Weather Report at Gillam and Thompson Airports
# January 11 to February 1, 2015

| Location | Month | Day | Max Temp °C[1] | Min Temp °C[1] | Total Snow cm[1] | Snow on Ground cm[1] | Speed of Max Wind Gust km/h[1] | Fixed-wing Flying | Helicopter Flying |
|---|---|---|---|---|---|---|---|---|---|
| Gillam | Jan. | 13 | -15.6 | -25.3 | 3.6 | 23 | <31 | | |
| | | 14 | -21.7 | -29.6 | 0.8 | 26 | <31 | ✓ | |
| | | 15 | -22.8 | -33.1 | 1.4 | 26 | <31 | ✓ | |
| | | 16 | -19.4 | -36.6 | 2 | 25 | 32 | ✓ | ✓ |
| | | 17 | -17.8 | -28.4 | 0 | 27 | 44 | | ✓ |
| | | 18 | -23.4 | -34.4 | trace | 29 | 32 | ✓ | |
| | | 19 | -15.9 | -23.4 | 0.4 | 29 | <31 | | ✓ |
| | | 20 | -19.3 | -30.6 | trace | 29 | <31 | ✓ | ✓ |
| | | 21 | -17.1 | -29.2 | 0.6 | 28 | <31 | ✓ | |
| | | 22 | -3.4 | -23 | 1.8 | 29 | 39 | | |
| | | 23 | -3.9 | -25.7 | trace | 29 | 54 | ✓ | |
| | | 24 | -24 | -31.6 | trace | 29 | <31 | ✓ | |
| | | 25 | -16.2 | -32.7 | 2 | 29 | <31 | ✓ | ✓ |
| | | 26 | -11.5 | -21.1 | 0 | 31 | <31 | ✓ | ✓ |
| | | 27 | -5 | -24.8 | trace | 31 | 50 | | ✓ |
| | | 28 | -23.4 | -29.9 | 0.4 | 31 | <31 | | ✓ |
| | | 29 | -20.5 | -30.3 | 0.2 | 31 | 39 | | ✓ |
| Thompson | | 27 | -4.7 | -25.4 | trace | 28 | 44 | ✓ | |
| | | 28 | -21.7 | -28.7 | 1.8 | 28 | <31 | ✓ | |
| | | 29 | -20.2 | -29.3 | trace | 29 | 39 | ✓ | |
| | | 30 | -18.1 | -30.5 | trace | 29 | 43 | ✓ | |
| | | 31 | -25.5 | -33.8 | trace | 28 | <31 | | ✓ |
| | Feb. | 1 | -22.5 | -34.3 | trace | 27 | <31 | | ✓ |

1. Source: Environment Canada 2015. Available from climate.weather.gc.ca. Accessed January 13, 2016.

# APPENDIX C:
# Data Sheets

## Stratification Data Sheet

KGS TEMP Moose Aerial Survey - Fixed-Wing 2014

Date: Jan 18, 2014 Observers: GM ES

Area: 3 Lift-off time: 9:32 Page #: 1 Temp: -30°C

Visibility: 10 km Wind spd/dir.: Weather notes: sunny, clear

| TR | Wpt | Tracks (n) | Moose (n) | Side (R,M,L) | Card Tracks (Z,L,M,H) | Comments |
|---|---|---|---|---|---|---|
| 77 | 1 | ✓ | | R | Z | |
| \| | 2 | ✓ | | R | Z | |
| | 3 | ✓ | | L | Z | |
| | 4 | ✓ | | L | Z | |
| | 5 | ✓ | | R | Z | |
| | 6 | ✓ | | R | Z | |
| | 7 | ✓ | | R | Z | |
| | 8 | ✓ | | R | Z | |
| | 9 | ✓ | | R | Z | |
| | 10 | ✓ | | R | Z | |
| | 11 | ✓ | | R | Z | |
| 71 | 12 | ✓ | | R | Z | |
| 78 | 13 | ✓ | 1 | L R | Z | cow on L |
| | 14 | ✓ | | L | Z | |
| | 15 | ✓ | | R | Z | |

## Sampling Data Sheet

KGS TEMP 2015 Moose Aerial Survey - Helicopter

Date: Jan 22, 2015 Observers: GM MS EJ
Area: 2 Lift-off time: 9:07 Page #: 1 Temp: -15°C
Visibility: 10 km Wind spd/dir: 20 km W Weather notes: overcast

| Block | Wpt | Moose (n) | Antlers Y | Antlers N | Vulva patch Y | Vulva patch N | Adult | Bull | Cow | Calf | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 61 | 1 | 1 | | | | | 1 | | | | 9:20 |
| 01 61 | 2 | 3 | 1 | | | | 2 | 1 | | | [illegible] in burn |
| 01 61 | 3 | 2 | | | | | | | 1 | 1 | |
| 01 61 | 4 | 2 | | | | | | | 1 | 1 | in burn 9:[illegible] |
| 02 15 | 5 | 3 | 1 | | 2 | | | 1 | 2 | | antlers on bull 5yrs 10:26 10:23 |
| 04 73 | — | | | | | | | | | | no moose observed 10:29 10:54 |
| 04 29 | — | | | | | | | | | | no moose observed 10:55 11:15 |
| 05 41 | | | | | | | | | | | no moose observed 11:21 11:41 |
| 03 21 | 6 | 1 | | | ✓ | | | | 1 | | 12:54 |
| 03 21 | 7 | 1 | | | ✓ | | | | 1 | | |
| 03 21 | 8 | 1 | | | | | 1 | | | | fir 13:16 |
| 03 75 | 9 | 2 | | | | | 2 | | | | 13:19 |
| 03 75 | 10 | 1 | | ✓ | | ✓ | | 1 | | | Dark face big [illegible] |
| 37 8 | 11 | 2 | | | | | | | 1 | 1 | close |
| 03 75 | 12 | 2 | | | | | 2 | | | | further out 13:43 |

# APPENDIX D:
# Raw Output Tables From Moosepop Population Estimates

**KTM Moose Survey, Jan 2015**

*** * * * ESTIMATED POPULATION SIZE * * * ***

| PAR/STRAT | XLO | LO | MED | HI | TOTAL |
|---|---|---|---|---|---|
| N | 143 | 585 | 214 | 32 | 974 |
| Tot area | 2471.40 | 10089.00 | 3681.30 | 547.90 | 16789.60 |
| n | 11 | 39 | 51 | 12 | 113 |
| Area sur | 190.00 | 673.10 | 880.40 | 205.30 | 1948.80 |
| # seen | 4 | 43 | 126 | 47 | 220 |
| Density | 0.0211 | 0.0639 | 0.1431 | 0.2289 | 0.0803 |
| To | 52.0 | 644.5 | 526.9 | 125.4 | |
| V(To) | 1468.00 | 18004.29 | 3311.10 | 575.47 | |
| SCFo | 1.000000 | 1.000000 | 1.000000 | 1.000000 | |
| V(SCFo) | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| SCF df | 9999 | 9999 | 9999 | 9999 | |
| To df | 10 | 38 | 50 | 11 | |

Te= 1348.8 V(Te)= 23358.88 df(Te)= 61

80% CI around Te = (1150.8,1546.9) is +/- 14.68%

90% CI around Te = (1093.5,1604.2) is +/- 18.93%

95% CI around Te = (1043.2,1654.4) is +/- 22.66%

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

Numerator = Tot.Cows

| PAR/STRAT | XLO | LO | MED | HI | TOTAL |
|---|---|---|---|---|---|
| N | 143 | 585 | 214 | 32 | 974 |
| Tot area | 2471.40 | 10089.00 | 3681.30 | 547.90 | 16789.60 |
| n | 11 | 39 | 51 | 12 | 113 |
| Area sur | 190.00 | 673.10 | 880.40 | 205.30 | 1948.80 |
| # seen | 1 | 17 | 45 | 15 | 78 |
| Density | 0.0053 | 0.0253 | 0.0511 | 0.0731 | 0.0295 |
| Wen | 13.0 | 254.8 | 188.2 | 40.0 | |
| V(Wen) | 156.13 | 3356.21 | 888.66 | 69.01 | |
| SCFo | 1.000000 | 1.000000 | 1.000000 | 1.000000 | |
| V(SCFo) | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| SCF df | 9999 | 9999 | 9999 | 9999 | |
| df | 10 | 38 | 50 | 11 | |

Wen= 496.0 V(Wen)= 4470.00 df(Wen)= 63

80% CI around Wen = (409.4, 582.6) is +/- 17.46%

90% CI around Wen = (384.4, 607.7) is +/- 22.51%

95% CI around Wen = (362.4, 629.6) is +/- 26.94%

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

Denominator = TotMoose

| PAR/STRAT | XLO | LO | MED | HI | TOTAL |
|---|---|---|---|---|---|
| N | 143 | 585 | 214 | 32 | 974 |
| Tot area | 2471.40 | 10089.00 | 3681.30 | 547.90 | 16789.60 |
| n | 11 | 39 | 51 | 12 | 113 |
| Area sur | 190.00 | 673.10 | 880.40 | 205.30 | 1948.80 |
| # seen | 4 | 43 | 126 | 47 | 220 |
| Density | 0.0211 | 0.0639 | 0.1431 | 0.2289 | 0.0803 |
| Wed | 52.0 | 644.5 | 526.9 | 125.4 | |
| V(Wed) | 1468.00 | 18004.29 | 3311.10 | 575.47 | |
| SCFo | 1.000000 | 1.000000 | 1.000000 | 1.000000 | |
| V(SCFo) | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| SCF df | 9999 | 9999 | 9999 | 9999 | |
| df | 10 | 38 | 50 | 11 | |

Wed= 1348.8 V(Wed)= 23358.88 df(Wed)= 61

80% CI around Wed = (1150.8, 1546.9) is +/- 14.68%

90% CI around Wed = (1093.5, 1604.2) is +/- 18.93%

95% CI around Wed = (1043.2, 1654.4) is +/- 22.66%

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

```
Numerator = Tot.Cows

Denominator = TotMoose

Ratio:  p = Numerator / Denominator


p=  0.3677     V(p)=     0.00118377     df(p)= 61


80% CI around p = (0.3231, 0.4123) is +/- 12.12%

90% CI around p = (0.3103, 0.4252) is +/- 15.63%

95% CI around p = (0.2989, 0.4365) is +/- 18.71%
```

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

Numerator = Tot.Bull

| PAR/STRAT | XLO | LO | MED | HI | TOTAL |
|---|---|---|---|---|---|
| N | 143 | 585 | 214 | 32 | 974 |
| Tot area | 2471.40 | 10089.00 | 3681.30 | 547.90 | 16789.60 |
| n | 11 | 39 | 51 | 12 | 113 |
| Area sur | 190.00 | 673.10 | 880.40 | 205.30 | 1948.80 |
| # seen | 1 | 7 | 24 | 11 | 43 |
| Density | 0.0053 | 0.0104 | 0.0273 | 0.0536 | 0.0147 |
| Wen | 13.0 | 104.9 | 100.4 | 29.4 | |
| V(Wen) | 156.13 | 2527.81 | 498.54 | 43.25 | |
| SCFo | 1.000000 | 1.000000 | 1.000000 | 1.000000 | |
| V(SCFo) | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| SCF df | 9999 | 9999 | 9999 | 9999 | |
| df | 10 | 38 | 50 | 11 | |

Wen= 247.6 V(Wen)= 3225.73 df(Wen)= 59

80% CI around Wen = (174.0, 321.3) is +/- 29.73%

90% CI around Wen = (152.7, 342.6) is +/- 38.34%

95% CI around Wen = (134.0, 361.3) is +/- 45.89%

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

```
Numerator = Tot.Bull

Denominator = TotMoose

Ratio:  p = Numerator / Denominator


p=  0.1836     V(p)=     0.00111569     df(p)= 59


80% CI around p = (0.1403, 0.2269) is +/- 23.58%

90% CI around p = (0.1278, 0.2394) is +/- 30.41%

95% CI around p = (0.1168, 0.2504) is +/- 36.40%
```

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

Numerator = Tot.Calf

| PAR/STRAT | XLO | LO | MED | HI | TOTAL |
|---|---|---|---|---|---|
| N | 143 | 585 | 214 | 32 | 974 |
| Tot area | 2471.40 | 10089.00 | 3681.30 | 547.90 | 16789.60 |
| n | 11 | 39 | 51 | 12 | 113 |
| Area sur | 190.00 | 673.10 | 880.40 | 205.30 | 1948.80 |
| # seen | 0 | 10 | 20 | 8 | 38 |
| Density | 0.0000 | 0.0149 | 0.0227 | 0.0390 | 0.0152 |
| Wen | 0.0 | 149.9 | 83.6 | 21.4 | |
| V(Wen) | 0.00 | 2029.99 | 382.45 | 42.07 | |
| SCFo | 1.000000 | 1.000000 | 1.000000 | 1.000000 | |
| V(SCFo) | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| SCF df | 9999 | 9999 | 9999 | 9999 | |
| df | 10 | 38 | 50 | 11 | |

Wen= 254.9 V(Wen)= 2454.51 df(Wen)= 54

80% CI around Wen = (190.6, 319.2) is +/- 25.23%

90% CI around Wen = (171.9, 337.8) is +/- 32.54%

95% CI around Wen = (155.5, 354.2) is +/- 38.98%

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

```
Numerator = Tot.Calf

Denominator = TotMoose

Ratio:  p = Numerator / Denominator


p=  0.1890     V(p)=     0.00074454     df(p)= 54


80% CI around p = (0.1535, 0.2244) is +/- 18.74%

90% CI around p = (0.1433, 0.2346) is +/- 24.17%

95% CI around p = (0.1342, 0.2437) is +/- 28.96%
```

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

Numerator = Unknown

| PAR/STRAT | XLO | LO | MED | HI | TOTAL |
|---|---|---|---|---|---|
| N | 143 | 585 | 214 | 32 | 974 |
| Tot area | 2471.40 | 10089.00 | 3681.30 | 547.90 | 16789.60 |
| n | 11 | 39 | 51 | 12 | 113 |
| Area sur | 190.00 | 673.10 | 880.40 | 205.30 | 1948.80 |
| # seen | 2 | 9 | 37 | 13 | 61 |
| Density | 0.0105 | 0.0134 | 0.0420 | 0.0633 | 0.0209 |
| Wen | 26.0 | 134.9 | 154.7 | 34.7 | |
| V(Wen) | 281.28 | 2353.22 | 928.72 | 101.27 | |
| SCFo | 1.000000 | 1.000000 | 1.000000 | 1.000000 | |
| V(SCFo) | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | |
| SCF df | 9999 | 9999 | 9999 | 9999 | |
| df | 10 | 38 | 50 | 11 | |

Wen= 350.3 V(Wen)= 3664.49 df(Wen)= 78

80% CI around Wen = (272.1, 428.6) is +/- 22.34%

90% CI around Wen = (249.5, 451.1) is +/- 28.77%

95% CI around Wen = (229.8, 470.8) is +/- 34.40%

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

```
Numerator = Unknown

Denominator = TotMoose

Ratio:  p = Numerator / Denominator


p=  0.2597     V(p)=     0.00133964     df(p)= 61


80% CI around p = (0.2123, 0.3071) is +/- 18.26%

90% CI around p = (0.1986, 0.3209) is +/- 23.54%

95% CI around p = (0.1865, 0.3329) is +/- 28.18%
```

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

```
Numerator = Tot.Calf

Denominator = Tot.Cows

Ratio:  p = Numerator / Denominator


p=  0.5138     V(p)=     0.00656715     df(p)= 54


80% CI around p  = (0.4087, 0.6190) is +/- 20.47%

90% CI around p  = (0.3782, 0.6495) is +/- 26.40%

95% CI around p  = (0.3513, 0.6763) is +/- 31.63%
```

**CALCULATE SEX AGE RATIOS AND COMPOSITION PARAMETERS**

```
Numerator = Tot.Bull

Denominator = Tot.Cows

Ratio:  p = Numerator / Denominator


p=  0.4993     V(p)=     0.01609086     df(p)= 59


80% CI around p  = (0.3348, 0.6637) is +/- 32.94%

90% CI around p  = (0.2872, 0.7113) is +/- 42.47%

95% CI around p  = (0.2454, 0.7531) is +/- 50.84%
```

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