Determining Factors Affecting Moose Population Change in British Columbia: Testing the Landscape Change Hypothesis

Progress Report: February 2012–July 2015

by

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EXECUTIVE SUMMARY

This technical report is preceded by Kuzyk and Heard (2014). In response to declining Moose numbers in central British Columbia (BC), the BC Ministry of Forests, Lands and Natural Resource Operations initiated a 5-year (December 2013–March 2018) provincially-coordinated Moose research project in central BC. A Moose study on the Bonaparte Plateau north of Kamloops that began in February 2012 was integrated with this provincial project. This progress report provides an update of field studies and preliminary interpretation of results from February 2012 to 31 July 2015 for Moose in five geographically distinct study areas in central BC: Bonaparte Plateau; Big Creek; Entiako; Prince George South; and the John Prince Research Forest. During this time, 237 cow Moose were captured and fitted with GPS (Global Positioning System) radio-collars. There were 130 Moose captured using aerial darting and 107 using aerial net gunning. Two configurations of GPS radio-collars were used: those programmed for one fix/day (n = 137), and those with multi-fixes/day (n = 100). Collar performance of single fix collars for all study areas averaged 73% and ranged from 33–95%. A subsample of collars having multi-fix rates had higher fix rate success, recording 95% (Bonaparte) (range 90-98%) and 96% (Entiako) (range 87–100%) of possible locations. The majority of cow Moose were in good body condition, with pregnancy rates (78%) within the range expected for a stable population, and no indication of immediate disease or parasite concerns at the population level. As of 31 July 2015, the status of radio-collared cow Moose was: 167 active, 47 failed (i.e., either stopped collecting location data or slipped from Moose), and 23 mortalities. Probable causes of the 23 mortalities were predation (9), unregulated hunting (4), apparent starvation (4), vehicle collision (1), unknown natural (3), and two unknown. The combined annual survival rate of cow Moose from all study areas was 92 ± 8% in 2013/14 and 92 ± 5% in 2014/15, which is within the normal range for stable Moose populations. Analyses on patterns of habitat selection of radio-collared Moose are currently underway at the University of Northern British Columbia and the University of Victoria. A comprehensive analysis to determine underlying mechanisms and ecological processes affecting survival and mortality of radio-collared Moose in all five study areas will begin at the University of Northern British Columbia in year five (i.e., 2017/18) of this project. Preliminary results outlined in this progress report support the importance of investigating Moose calf survival (6–12 months).

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1. INTRODUCTION

Moose surveys conducted by regional wildlife biologists during 2011/12 through 2013/14 suggested that population declines of 50–70% had occurred in some areas of interior BC within the last decade. This decline in Moose abundance coincided with the widespread infestation of mountain pine beetle and subsequent landscape changes associated with harvesting beetle-killed timber over much of central BC (Alfaro et al. 2015), which had the potential to influence the distribution and abundance of Moose populations (Janz 2006; Ritchie 2008). In response to the Moose decline, the Ministry and its partners initiated a 5-year (December 2013–March 2018) provincially coordinated Moose research project (Kuzyk and Heard 2014). A Moose study on the Bonaparte Plateau north of Kamloops, with very similar objectives, began in February 2012 and was integrated as one of the five study areas in this project (Figure 1).

The objective of this provincial research project is to test the landscape change hypothesis that assumes Moose survival will increase when (a) forests regenerate by restricting the view of predators and hunters, (b) roads are deactivated, and (c) Moose become more uniformly dispersed on the landscape. In testing the landscape change hypothesis, we assumed cow Moose mortality has a greater effect on population growth than calf mortality, but acknowledge this assumption may be incorrect (Kuzyk and Heard 2014). Because of these assumptions, as well as financial and logistical constraints, only cow Moose survival was monitored using GPS radio-collars. Our approach was to monitor survival of at least 30 GPS radio-collared cow Moose in each of five study areas (n = 150 annually) for five years. This progress report provides an update on fieldwork and a preliminary interpretation of results for the first 41 months (February 2012–July 2015) of this study.

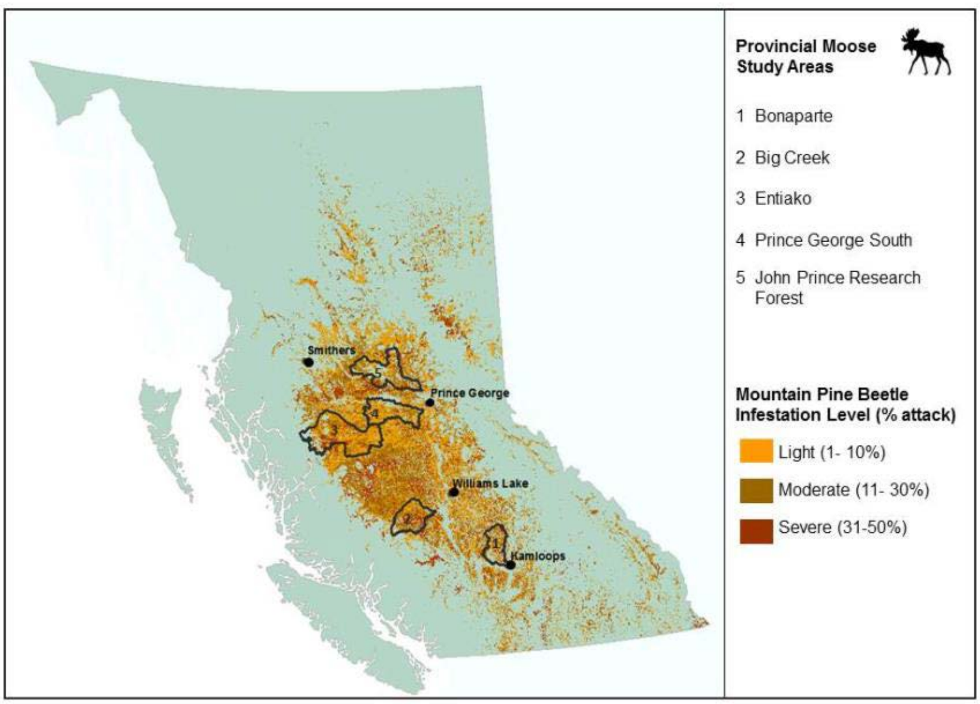

Figure 1. Provincial Moose research study areas in central BC where cow Moose survival has been monitored since February 2012 in the Bonaparte study area and December 2013 in the other four study areas. John Prince Research Forest is a parallel study contributing cow Moose survival rate information to this provincial study. The areas were strategically selected to encompass a range of habitat types and disturbance levels.

2. METHODS

Detailed rationale on the research approach and field methodologies of using GPS radio-collars to assess cow survival is described in Kuzyk and Heard (2014). Briefly, cow Moose were captured using either aerial darting or net gunning. Once sedated or restrained, the capture team assessed cow Moose for body condition, age and presence of calves. Blood samples were taken to test for pregnancy and disease and fecal samples were obtained for assessment of parasites. Captured Moose were fitted with a GPS radio-collar programmed to obtain either one positional fix daily (Vectronic radio-collars) or multiple positional fixes daily (Advanced Telemetry Systems radio-collars). Radio-collars with one fix per day were chosen for this study because collar batteries could last for five years. Some collars with multiple fixes per day were deployed to examine fine-scale habitat selection or movements in addition to monitoring survival. Fix rate success was calculated for a subsample of deployed collars. Unsuccessful fixes were occurrences where the collar was unable to obtain a GPS fix and/or where the collar was unable to transfer the location data for remote download.

Rapid-response, mortality-site investigations are a key component of this research and were conducted as soon as logistically feasible following receipt of a collar mortality signal. The probable cause of mortality was determined following a standardized protocol (Kuzyk and Heard 2014). The definition of starvation followed Murray et al. (2006) where probable cause of mortality from starvation (and disease) is called 'apparent starvation'. This included Moose that did not clearly die from other major causes of mortality such as predation but had signs of nutritional stress (e.g., minimal to no body fat). Preliminary survival rates were calculated for cow Moose from 28 February 2012 to 31 July 2015. This analysis included all cow Moose that lived more than three weeks post-capture to avoid the potential influence of capture-related stresses and physiological changes on survival (Keech et al. 2011). Survival rates were determined weekly using a Kaplan-Meir estimator (Pollock et al. 1989) with 95% confidence intervals (CIs), and monitored over a biological year (1 May–30 April). The biological year was defined as beginning May 1 to reflect a time immediately prior to Moose parturition in northern (Gillingham and Parker 2008) and southern British Columbia (Poole et al. 2007) when behavior and body condition would be relatively consistent among cows.

Late-winter calf surveys of radio-collared cows were conducted in some study areas to assess calf survival. Prior to these surveys, the most recent GPS locations of cows were mapped to facilitate more efficient search times in locating the collared cows. Survey crews then used a helicopter to radio-track the collared individual and determine if one or more calves accompanied the cow.

3. RESULTS

3.1 GPS radio-collars and fix rate sucess

From February 2012 to 31 July 2015, 237 cow Moose were captured and fitted with GPS radio-collars (Table 1); 130 were captured by aerial darting and 107 captured by aerial net gunning. Collars were considered to have failed when they either stopped collecting location data or slipped from the Moose. In the five study areas, there were 137 radio-collars that collected one positional fix per day and 100 radio-collars that collected multiple positional fixes per day (Table 2). Location fix rate sucess varied by study area and collar type. Fix rate success for the 114 GPS collars collecting one fix per day averaged 73% (range 33–95%; Table 3). Fix rate success for 10 multi-fix radio-collars in the Entiako study area from 1 January 2014 to 31 December 2014 was 96% (range 90–98%) and 44 multi-fix radio-collars in the Bonaparte study area from February 2012 to March 2015 was 95% (range 87–100%).

Table 1. Total number and status of GPS radio-collars deployed on Moose in five study areas in central BC from February 2012 to July 2015.

Study Year	Deployed Collars	Mortalities	Failed Collars	Active Collars
2012	9	0	0	9
2012-2013	29	2	0	36
2013-2014	129	5	30	130
2014-2015	70	11	15	174
2015-2016	0	5	2	167
Totals	**237**	**23**	**47**	**167**

Table 2. Number and status of GPS radio-collars deployed on Moose in each study area in central BC from February 2012 to July 2015.

Study Area	Study Year	Deployed Collars	Mortalities	Failed Collars	Active Collars
Bonaparte*	2012	9	0	0	9
	2012-2013	29	2	0	36
	2013-2014	14	3	30	17
	2014-2015	31	2	7	39
	2015-2016	0	0	0	39
	Totals	**83**	**7**	**37**	**39**
Big Creek**	2013-2014	40	0	0	40
	2014-2015	13	3	8	42
	2015-2016	0	0	2	40
	Totals	**53**	**3**	**10**	**40**
Entiako***	2013-2014	44	0	0	44
	2014-2015	9	4	0	49
	2015-2016	0	2	0	47
	Totals	**53**	**6**	**0**	**47**
Prince George South**	2013-2014	16	0	0	16
	2014-2015	17	2	0	31
	2015-2016	0	3	0	28
	Totals	**33**	**5**	**0**	**28**
John Prince Research Forest**	2013-2014	15	2	0	13
	2014-2015	0	0	0	13
	2015-2016	0	0	0	13
	Totals	**15**	**2**	**0**	**13**

*All collars deployed collect >2 fixes per day
**All collars deployed collect 1 fix per day
***17 collars deployed collect >2 fixes per day and 36 collars deployed collect 1 fix per day

Table 3. Fix rate summary for Vectronic GPS radio-collars deployed in this study from collar deployment through 31 July 2015. Collars were programmed to record one location each day.

Study Area	Number of Collars	Fix Rate			
		Mean (%)	SE	Min (%)	Max (%)
Big Creek	40	85	1.3	59	95
Entiako	33	72	2.2	33	89
Prince George South	28	65	2.1	41	86
John Prince Research Forest	13	52	3.0	33	68
Totals	**114**	**73**	**1.4**	**33**	**95**

3.2 Capture and handling

A total of 237 cow Moose were captured from February 2012 to July 2015. Of 235 cow Moose sampled for age, 80% (n=188) were estimated to be adults, 16% (n=38) classed as old and 4% (n=9) young (Figure 2). Body condition was estimated for 194 cow Moose of which 68% (n=132) were in good body condition, 20% (n=38) were in excellent body condition, 11% (n=21) were in fair body condition, and only 2% (n=3) of cows were in poor body condition (Figure 3). Of the 196 cow Moose monitored for calf status at capture, 65% (n=128) were not accompanied by a calf, 34% (n=66) had one calf and 1% (n=2) had twins (Figure 4).

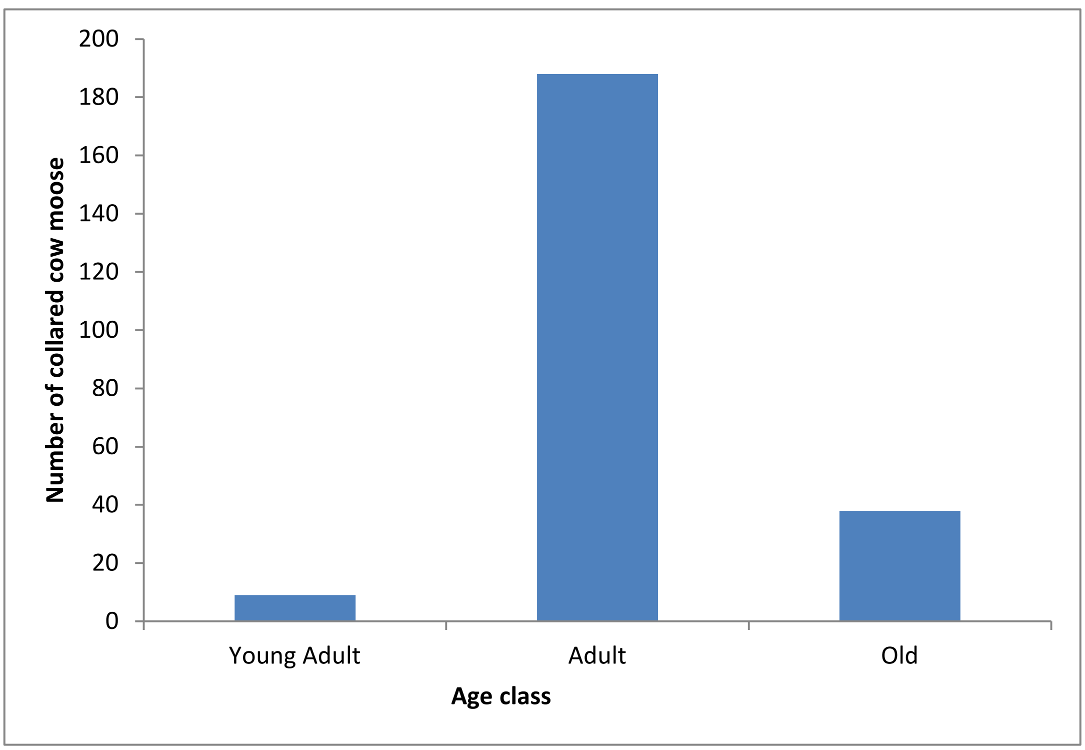

Figure 2. Estimated age of 235 cow Moose radio-collared in central BC from February 2012 to July 2015.

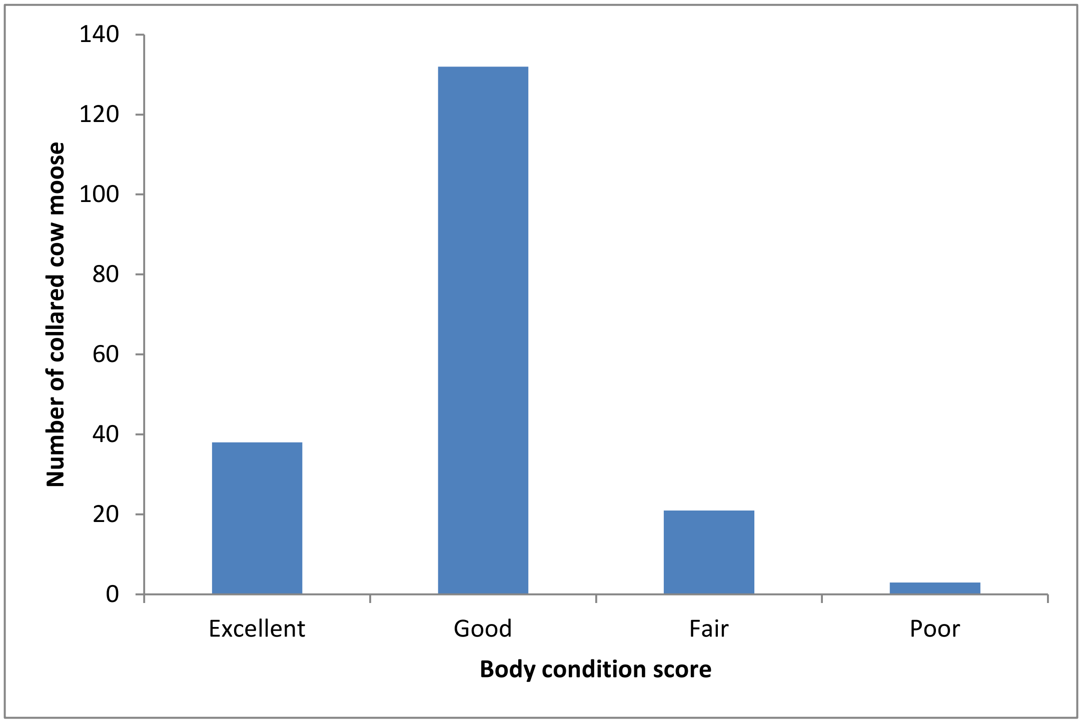

Figure 3. Body condition score of 194 cow Moose radio-collared in central BC from February 2012 to July 2015.

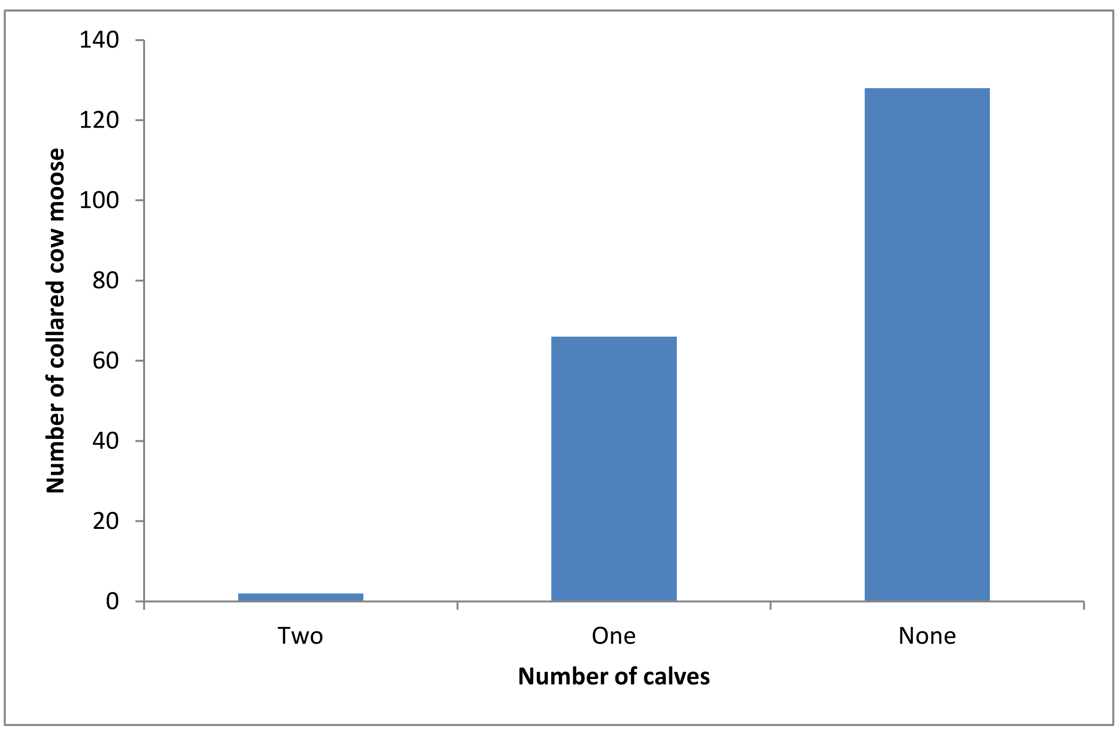

Figure 4. Calf status of 196 cow Moose when radio-collared in central BC from February 2012 to July 2015.

Table 4. Pregnancy status as detemined by serum progesterone for cow Moose radio-collared in central BC from February 2012 to July 2015. These sample sizes are insufficient to draw population level conclusions about pregnancy rates from each study area.

Study Area	Number of Samples	Percent Pregnant
Bonaparte	65	69
Big Creek	46	85
Entiako	50	82
Prince George South	31	68
John Prince Research Forest	15	100
Totals	**207**	**78%**

3.3 Biological samples

Pregnancy status was assessed for 207 of the radio-collared cow Moose using serum progesterone testing. Over the five study areas, the pregnancy rate was 78% (range 69–100%) (Table 4). Results from disease and parasite testing were interpreted to demonstrate no immediate health concerns at the population level (Dr. Helen Schwantje, pers. comm.). Collection of biological samples to assess for pregnancy, health and parasite types and levels will continue for the duration of the study.

3.4 Mortalities of radio-collared Moose

Twenty-three of the 237 radio-collared cow Moose died from February 2012 to July 2015. Probable causes of death were 39% from predation, 17% unregulated hunting, 17% apparent starvation, 4% vehicle collisions and 22% from unknown causes (Table 5). Seventy-seven percent of the mortalities were assigned a probable cause of death because the GPS radio-collar functioned to standard such that regional biologists were able to conduct mortality-site investigations in a timely manner (i.e., within 48 hours of the mortality). There were inconclusive results from 22% of mortalities: 13% classified as unknown natural and 9% classified as unknown. The unknown natural mortalities still provided valuable data as they were thought to be Moose that were not killed by predators or hunters. Those classed as unknowns were mostly due to radio-collar malfunctions that caused a long time delay between the mortality event and site investigation.

Table 5. Number of mortalities and probable cause of death of radio-collared cow Moose in central BC from February 2012 – July 2015.

Study Area	Mortalities	Probable Cause of Death
Bonaparte	7	1 predation; 1 unregulated hunting; 2 starvation; 1 vehicle collision; 2 unknown natural
Big Creek	3	2 predation; 1 unregulated hunting
Entiako	6	3 predation; 1 unknown natural; 2 unknown
Prince George South	5	2 predation; 1 unregulated hunting; 2 starvation
John Prince Research Forest	2	1 predation; 1 unregulated hunting
Totals	**23**	**9 predation; 4 unregulated hunting; 4 starvation; 1 vehicle collision; 3 unknown natural; 2 unknown**

Table 6. Survival rates of radio-collared cow Moose in central BC from February 2012 to July 2015.

Year	Survival Estimate (± 95% CI)	Number of Collars
2012	100 ± 0%	9
2012-2013	95 ± 7%	38
2013-2014	92 ± 8%	165
2014-2015	92 ± 5%	200
2015-2016	97 ± 3%	167

Table 7. Calf surveys to determine calf status of radio-collared cow Moose in central BC from February 2012 to July 2015.

Study Area	Calves/100 cows in late winter 2014 (n = # collared cows)	Calves/100 cows in late winter 2015 (n = # collared cows)
Bonaparte	not surveyed	25 calves/100 cows (n = 40, March)
Big Creek	28 calves/100 cows (n = 41, March)	37 calves/100 cows (n = 43, February)
Entiako	not surveyed	not surveyed
Prince George South	not surveyed	39 calves/100 cows (n = 18, March)
John Prince Research Forest	not surveyed	8 calves/100 cows (n = 13, February)

3.5 Annual survival rates

Annual survival rates for the 237 radio-collared Moose ranged from 92-100% (Table 6). We acknowledge that the small sample size during the 2012 study year likely limited the reliability of the survival rate estimate. Results for 2015/16 are preliminary as they do not encompass a complete biological year (1 May 2015–31 July 2015).

3.6 Late winter calf surveys

Five late winter calf surveys were conducted in 2014 and 2015 to monitor the presence of calves with radio-collared cows. Calf:cow ratios varied among study areas from 8–37 calves:100 cows (Table 7).

4. DISCUSSION

The primary objective of this study is to examine cow Moose survival in relation to landscape change (Kuzyk and Heard 2014). Cow survival was monitored by deploying radio-collars on cow Moose in five study areas. In general, cow Moose monitored in the first 41 months of this study were in good body condition and had pregnancy and survival rates within ranges expected for stable populations. Most of the cow Moose captured were adults with only 16% classed as old and 4% young. The majority of cow Moose were estimated to be in fair to excellent body condition (only 2% in poor condition).

Sixty-five percent of cow Moose did not have a calf at capture. Because capture crews did not intentionally select cows based on presence of calf, the number of cows with calves at capture is generally consistent with the measure of 25 calves: 100 cows, which is a general indicator for a stable population (Bergerud and Elliot 1986). These results were similar to three of five late winter calf surveys that determined calf: cow ratios were at or above levels for a stable population; caution should be used when interpreting calf survey results due to small sample sizes. Some late winter calf surveys excluded cows that were radio-collared earlier in the same winter because they were not accompanied by a calf and therefore assumed to still not have a calf. Future surveys could consider a standardized approach and monitor all radio-collared cow Moose in the event calf status at capture was incorrect.

Biological sampling of radio-collared cows determined pregnancy rates of 78%, which is within levels found for stable populations (Heard et al. 1997). Study area-specific pregnancy rates were presented but sample sizes were too small to draw area-specific interpretations at this stage of the study. Preliminary analysis for parasites and diseases indicate no obvious concerns at the population level but monitoring will continue for the duration of the study.

Overall annual survival rates of cow Moose in this study (92 ± 8%) were within the normal range for stable populations (Bangs et al. 1989; Ballard et al. 1991; Bertram and Vivion 2002). Cow survival rates in our study were above those determined for Moose in areas of Northwest Territories (85%; Stenhouse et al. 1995) and in northern Alberta (75–77%; Hauge and Keith 1981). Our sample of 23 mortalities is not considered sufficient to draw any conclusions on impact of different probable causes of death on survival rates and population growth.

Since GPS radio-collars are currently the primary tool used to monitor cow survival, assessing radio-collar performance was an important component of this report because it informs the selection of future collar types to deploy. Although the success rate of multi-fix collars was superior, their battery life is shorter, which reduces the overall length of time available to assess survival. Because the study is in Year three of five and therefore have reduced battery longevity requirements, collars programmed to obtain two fixes per day will be deployed in winter 2015/16 and their fix rate success subsequently assessed.

The role of calf survival affecting population growth in all our study areas remains unknown. In some study areas calf:cow ratios were at or below those required to maintain a stable population while in others, ratios reported were within ranges for Moose populations experiencing both wolf and bear predation (Gasaway et al. 1992). Standardized late-winter calf surveys will be conducted in all study areas in order to improve our understanding of calf survival. Some stakeholders and First Nations continue to express concerns over declining Moose populations. Consequently, determining Moose calf survival (6–12 months) and its relative importance in population growth remains an important research gap to be addressed (Kuzyk and Heard 2014), and perhaps most useful with a focus on study areas with continued low calf:cow ratios. Future modeling efforts may also help understand the role of calf survival in our study areas.

Analysis of habitat selection of radio-collared Moose is currently underway at the University of Northern British Columbia (Big Creek, Prince George South, Entiako study areas) and the University of Victoria (Bonaparte study area). The comprehensive survival analysis, which includes analysis of all data from radio-collared Moose from all five study areas (i.e., above areas and John Prince Research forest), is expected to begin at University of Northern British Columbia in year five (i.e., 2017/18) of this project.

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