MOOSE DENSITY AND COMPOSITION IN THE MONTE HILLS (WILDLIFE MANAGEMENT UNIT 3-20), BRITISH COLUMBIA, JANUARY 2013.

ANDREW B. D. WALKER, British Columbia Ministry of Forest Lands and Natural Resource Operations, 102 Industrial Place, Penticton, B.C., Canada, V2A 7C8

FRANCIS IREDALE, British Columbia Ministry of Forest Lands and Natural Resource Operations, 1259 Dalhousie Drive, Kamloops, BC V2C 5Z5

CHRIS PROCTER, British Columbia Ministry of Forest Lands and Natural Resource Operations, 1259 Dalhousie Drive, Kamloops, BC V2C 5Z5

BRITISH COLUMBIA

2013

Ministry of Forest Lands and Natural Resource Operations. Project No. 7193029

ABSTRACT

In order to assess the effects of hunting, forestry practices and regulations on moose in the Monte Hills (Wildlife Management Unit 3-20), we carried out a modifed stratified random block survey (Gasaway et al. 1986; Heard et al. 2008) during January 2013 with the objectives of estimating absolute abundance and composition. The winter use of forest cover types by moose was used to delineate 2 strata. Standard sightability correction factors were applied based on estimates of vegetation cover when a group of moose was observed. Our total population estimate for the 1,288 km^2 area was 520 ± 80 moose ($\bar{x}$ ± SE). We counted 125 moose in 56 sample units (SUs) and surveyed a total of 263 km^2. We observed an overall density of 0.62 moose/km^2 in Management Unit 3-20. The number of bulls per 100 cows estimated after correcting for sightability has improved considerably since 2010 and at the time of survey was 22 ± 5.4 bulls per 100 cows, while the estimated number of calves per 100 cows was 36 ± 8.7 moose. The search effort during the census was 4.5 ± 0.29 min/km^2 ($\bar{x}$ ± SE; n = 40). We believe the bull ratio within the Management Unit will continue to improve given the changes to regulated hunting season lengths and changes in forestry practices affecting the susceptibility of moose to harvest by hunters.

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

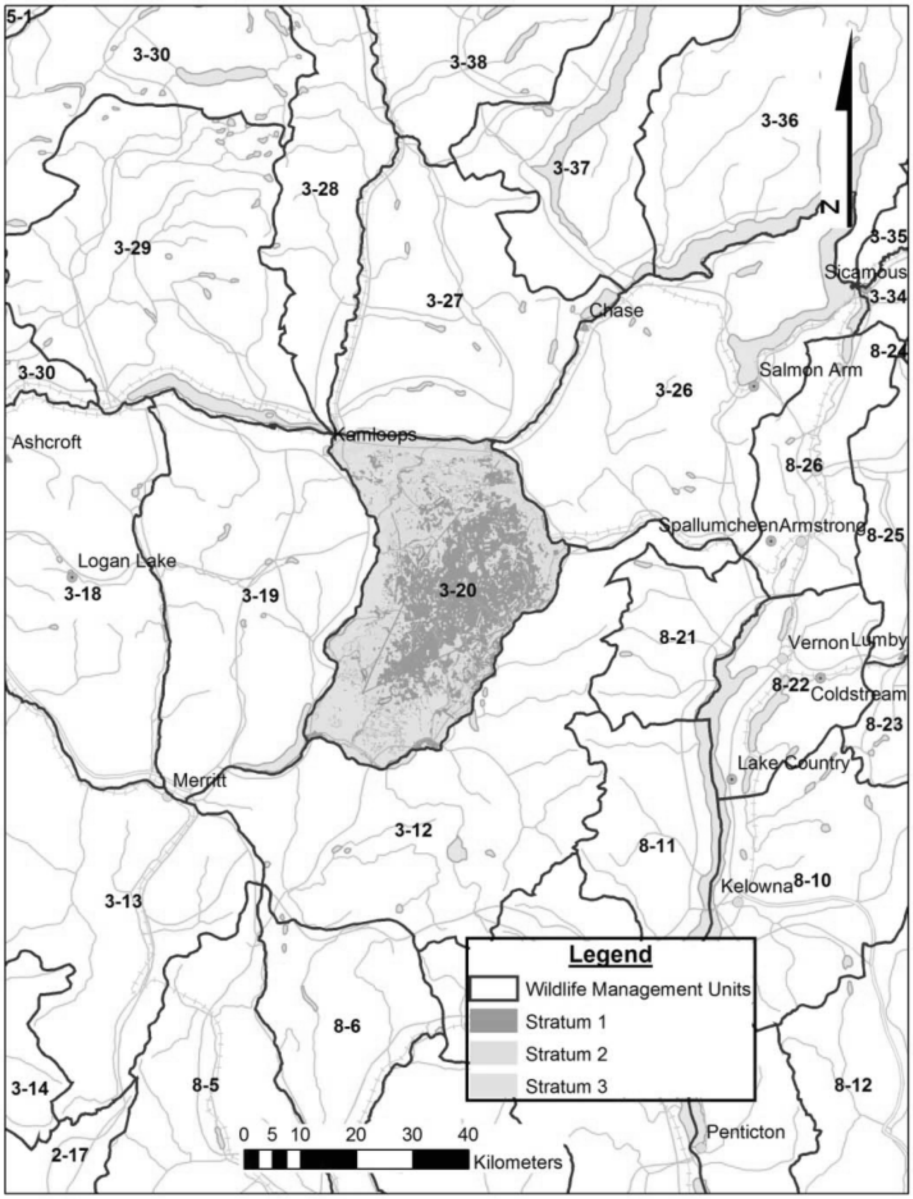
INTRODUCTION

Moose (*Alces alces*) are an important game species for resident and non-resident hunters in the Thompson-Okanagan Region and are culturally important as sustenance for First Nations. Provincially, the Thompson Region supports the second highest hunter effort in terms of resident hunter numbers and days of hunting effort for moose. Moose are harvested by resident hunters under an "Any Bull" Limited Entry Hunting (LEH) lottery and a General Open Season (GOS) Spike/Fork bull season (October 15th to November 15th) with guides allocated moose under a quota system. Previous moose composition surveys of the Monte Hills Wildlife Management Unit (WMU) 3-20 conducted in 2010, 2011 and 2012 indicated low bull numbers. These results were below regional post-hunt sex ratio objectives (i.e., 30 bulls per 100 cows), with observed bull ratios estimated at between 8 and 12 bulls per 100 cows, respectively. The decline in bull numbers appeared to coincide with an increase in the rate of forest harvesting as a result of the mountain pine beetle outbreak and an increase in the density of forestry access roads. In 2010, the Fish and Wildlife branch adjusted the moose GOS spike/fork bull season from a 41 day season through the rut to a 30 day season, largely post-rut in an effort to reduce spike/fork bull harvests and promote recruitment of yearling bulls. In January of 2013 regional wildlife biologists conducted a modified stratified random block survey (Gasaway et al. 1986; Heard et al. 2008) with the objectives of measuring moose density and composition in the Monte Hills. Information garnered from this survey will be used by regional biologists to inform harvest management and assess effectiveness of current hunting regulations.

STUDY AREA

The Monte Hills fall within the Thompson-Okanagan Region and Ministry of Forest, Lands and Natural Resource Operation's WMU 3-20 (Fig. 1). The study area covers 1,700 km^2 and spans the Nicola and the Shuswap Basin Ecosections (Demarchi 2011). The study area is bound by the South Thompson River to the north, highway 97 to the east, highway 5A to the west and Douglas Lake to the south. The area consists primarily of Interior Douglas fir dry cool (IDF dk1) with pockets of Montane Spruce very dry cool (MS xk2) and Engelmann spruce very dry cold (ESSF xc2) biogeoclimatic zones (Meidinger and Pojar 1991). At lower elevations, the dry interior forests open up onto expansive grassland dominated communities residing within the (BG xw) dry warm biogeoclimatic zone (Meidinger and Pojar 1991). As no effective geographically barriers exist to the north, there are frequent short bouts of cold dense arctic air outbreaks once air enters the interior plateaus (Demarchi 2011). Mean annual precipitation ranges from 300 - 750 mm, with 25 - 50 % as snow (Hope et al. 1991). An average annual temperature ranges from 1.6 °C to 9.5 °C (Hope et al. 1991). Forestry is the main industrial activity on the land base and harvesting has accelerated in recent years, to salvage dead and dying timber from the mountain pine beetle epidemic. This has led to an increase in road densities and loss of forest cover for moose. Loss of vegetation cover from forest harvesting around sensitive wetlands may lead to alienation of important habitat. Cattle grazing is another prominent activity and heavy summer and fall browsing by cattle within wetlands and adjacent riparian habitat may remove important forage (e.g. willow) for moose.

Fig. 1. The delineation of sample units and distribution of high (stratum 1) and low (stratum 2) density moose strata in the Monte Hills study area, January 2013.



Wolves (*Canis lupus*), black bears (*Ursus americanus*), and cougar (*Felis concolor*) are the primary predators within the study area. Other ungulate species that occur within the survey areas include: mule deer (*O.heminonus*), white-tailed deer (*Odocoileus virginainus*), and sporadic occurrences of Rocky Mountain Elk (*Cervus canadaensis*).

METHODS

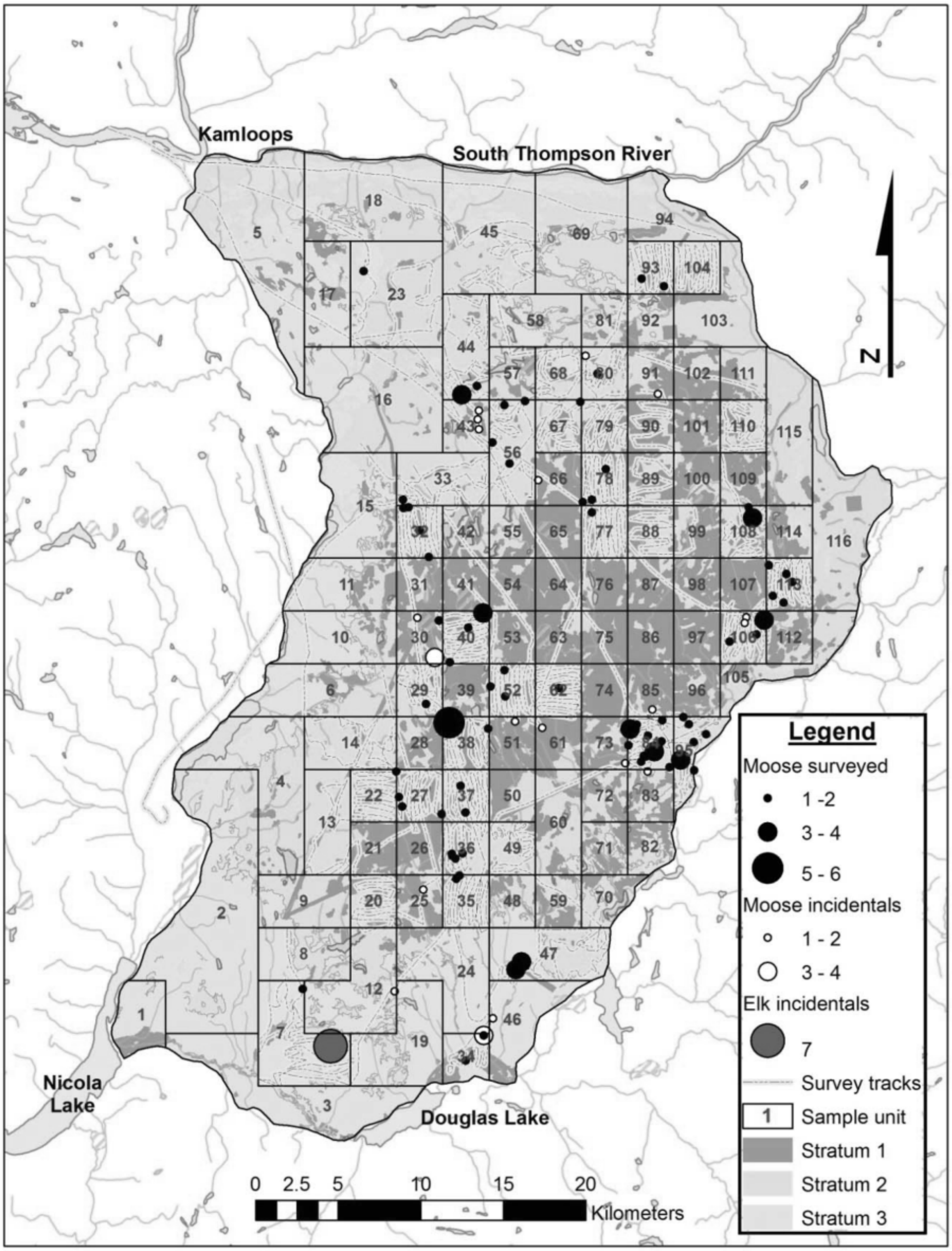
Sampling strategy

We divided the study area into 3 strata based on differences in moose densities associated with vegetation during early winter (Nielsen et al. 2005; Peek 2007; Thompson and Stewart 2007) following the approach of Heard et al. (2008). In order to remain consistent with Heard et al.'s (2008) delineation of strata, we selected young forests, deciduous-dominated forests and shrubby areas, irrespective of the nature of disturbance (human or "natural"), as stratum 1 (S1). This stratum generally contains the highest densities of moose (Heard et al. 1999; Heard et al. 2001; Walker et al. 2006; Walker et al. 2007).

We used the silviculture results layer in the Land and Resource Data Warehouse to select for young forests ≤ 20 years old. In addition, leading aspen and cottonwood stands that were greater than 80% cover using Vegetation Resources Inventory (VRI) data were also added to the S1 layer. We used the following VRI descriptors to select shrubby, open areas: M 3 (meadow), OR (open range), NPBR (non productive brush), NCBR (non commercial brush). For the remainder of the study area we used shrub crown closure as a surrogate to identify shrubby, open areas. We included all areas with shrub crown closure ≥ 60 %. We overlaid the S1 stratum with 2011 orthophotos to assess the accuracy of the coverage (e.g. ≤ 20 years old forest stands) that were not captured through the initial GIS selection. As a result of this assessment we added an additional 11 polygons to the S1 stratum. We also used the silviculture and land status tracking data set to add an additional 28 polygons of early seral habitat to the high stratum S1 layer not accounted for in VRI or the 2011 orthophotos. To account for habitat transition from S1 to the S2 layer, we buffered the S1 layer by 50 meters. Powerline right-of-ways were also included because recurrent brushing provides early seral vegetation and palatable moose forage (Rea and Gillingham 2001). Stratum 2 (S2) consisted of the remaining forest cover types but was dominated by forests > 20 years old and was considered to represent low densities of moose. Low elevation grasslands were considered void of moose and not surveyed and represented the S3 layer.

We divided the census zone into a predetermined grid of 9 km^2 (3.2 × 2.8 km) blocks. Adjacent blocks were arbitrarily joined so that ≥ 3 km^2 of S1 was present in each sample unit (SU). This was an attempt to ensure moose would be observed in each SU (Heard et al. 2008). SUs were therefore made up of between 1 and 14 blocks for a total of 116 (Fig. 1). We randomly selected 40 of the 116 SUs to census (Fig. 2) and surveyed only the S1 portion of most of those SUs. Of those 40, however, 16 were randomly selected and the entire area was surveyed, excluding any nil grassland habitats and observed moose were recorded as being in S1 or S2.

Fig. 2. The observed moose and flight lines that were flown to survey the randomly selected sample units during the Monte Hills, moose inventory, January 2013.



Between the 12th and 15th of January 2013, a crew consisting of 2 observers, a navigator (who recorded the data) and a pilot (Appendix A) surveyed SUs from a Bell 206B Jet Ranger Helicopter, 30 – 50 m above the ground. SU boundaries were located using the helicopter's Global Positioning System (GPS) and a search pattern consisting of transects 200 – 400 m apart, depending on vegetation cover, were flown to cover the SU. We circled each moose and recorded its age and sex as a calf (~8 months old), cow or bull, based on the presence of a white vulva patch, the bell length and shape and facial colouration and morphology (Oswald 1998). Vegetation cover, to the nearest 5 %, was recorded within 9 m of where the moose was first seen according to the standards developed by Unsworth et al. (1998). The positions of all groups were recorded with a GPS location using a Garmin GPSMAP 76Cx (Garmin International, Inc. 2006). The recorded locations were subsequently plotted to determine the position of moose groups relative to stratum and SU boundaries.

Data analysis

Vegetation cover estimates were used to correct for sightability bias to determine stratum specific density and population estimates. Vegetation cover estimates were grouped into 5 Vegetation Cover Classes (VCC) each with a specific detection probability (DP) and sightability correction factor (SCF), as determined by Quayle et al. (2001), following the approach of Anderson and Lindzey (1996) (Table 1).

Table 1. Vegetation cover classes, range of vegetation cover (%), detection probability and sightability correction factor, that were used to extrapolate population estimates of moose in the Monte Hills, January 2013 (Quayle et al. 2001).

Vegetation Cover Class (VCC)	Vegetation Cover (%)	Detection Probability (DP)[a]	Sightability Correction Factor (SCF)[b]
1	0 - 20	0.933	1.072
2	21 - 40	0.740	1.350
3	41 - 60	0.368	2.717
4	61 - 80	0.107	9.373
5	81 - 100	0.024	41.842

[a]DP = 1/SCF

[b]SCF = 1/((exp(4.2138-1.5847×VCC))/(1+exp(4.2138-1.5847×VCC)))

For each stratum, a naïve population estimate and sampling variance for unequal sized SUs were calculated following Jolly (1969). Sightability and model variance were calculated using the program Aerial Survey (Unsworth et al. 1998) but modified with data from Heard et al. (1999*a*) and Quayle et al. (2001). Aerial Survey calculates a population estimate using a sampling fraction based on the number of surveyed SUs divided by the total number of SUs in the study area (Unsworth et al. 1998). Our analysis used a sampling fraction equal to the censused area divided by the total stratum area (Heard et al. 2008). In this approach, we are not limited to SUs of equal size. We calculated the final population estimate as the product of the naïve population estimate for both stratums and their SCF. The variance for the final population estimate was the sum of the sampling, sightability and model variances for both strata.

The population composition for the observed and estimated (corrected for sightability) number of calves and bulls per 100 cows were calculated using a jackknife estimator (Efron 1982). The number of cows, calves and bulls were summed for each SU to determine the mean and variance of calf to cow and bull to cow ratios. Ratios were calculated across both strata due to the small number of S2 SUs surveyed.

We only measured the search effort for S1 SUs because search time was not measured independently for SUs where S1 and S2 were both censused.

RESULTS

Search effort and conditions

Favourable survey conditions persisted throughout the duration of the survey with temperatures from -6° to -15°C and clear to overcast conditions. The search effort during the census was 4.5 ± 0.29 min/km^2 ($\bar{x}$ ± SE; *n* = 40). Most moose (~55%) were observed in VCC 1 and the number decreased with increasing amounts of cover (Table 1; Appendix B). Snow cover was 100 %, except for some windswept, open agricultural areas in the southern portion of the study area.

Population size and density

Our total population estimate for Management Unit 3-20 in the Monte Hills was 520 ± 80 moose (CV = 15%) during the winter of 2013 (Table 2). This is a ~25% increase in previously modelled population estimates for the Management Unit. We counted 125 moose in 40 SUs (Table 2) and observed an average group size of 1.60 ± 0.10 moose (Table 2; Appendix B). In S1, the open shrub-dominated vegetation and young regenerating forests, 123 moose from 40 SUs were counted and in S2, the older forest stands, 2 moose from 16 SUs were counted. The mean SCF for both strata (S1 = 1.30 and S2 = 1.89) was 1.34. With a total of 263 km^2 surveyed we observed an overall density of 0.62 moose/km^2. Corrected moose density in S1 (0.84 moose/km^2) was almost an order of magnitude greater than in S2 (0.08 moose/km^2). The population estimate was also much larger in S1 (470 ± 70 moose) compared to S2 (52 ± 24 moose) with the similar amounts of area S1 and S2 contribute to the study area.

Table 2. Observed and estimated number of moose by stratum in the Monte Hills, January 2013.

	Stratum 1	Stratum 2	Total
Moose Observed	123	2	125
Mean Sightability Correction Factor (SCF)	1.30	1.89	1.34
Corrected Number of Moose	160	4	164
Area of Surveyed Sample Units (km^2)	215	48	263
Corrected Density (moose/km^2)	0.74	0.08	0.62
Total Stratum Area (km^2)	626	661	1,288
No. of Sample Units Surveyed	40	16	56
No. of Sample Units in Stratum	116	116	232
Corrected Population Estimate	470	52	520
Sampling Variance	4,941	286	5,227
Sightability Variance	521	254	775
Model Variance	23	14	37
Total Variance of Population Estimate	5,485	554	6,039
Standard Error of Population Estimate	70	24	80
Coefficient of Variation of Population Estimate (%)	16	45	15

Composition

The number of calves and bulls per 100 cows was similar between observed ratios and estimated ratios corrected for sightability. No bull moose or cows with calves were observed in S2 and the number of calves and bulls per 100 cows was the same between observed and estimated ratios. The estimated number of calves per 100 cows was 36 ± 8.7 in January 2013. The number of bulls per 100 cows in 2013 was higher than previous composition estimates (Procter, unpubl. data) at 22 ± 5.4, but still below the regional objectives (i.e., 30 bulls/100 cows, post-hunt).

DISCUSSION

Abundance and distribution

The density of moose (0.62 moose/km^2) in the Monte Hills study area (Management Unit 3-20) is similar to densities estimated elsewhere in the Thompson region where wolf densities are low. During the survey no wolves were observed. Although we included all areas outside of major lakes and grasslands as winter moose habitat, we did not observe moose or moose sign above 1550 m and only one moose was observed above 1450 m during the survey. The estimated density also represents the absolute density for the Management Unit assuming no moose travel to or from the Management Unit to access seasonal ranges. Winter densities would be considerably higher if areas above 1500 m were excluded from the survey area. The distribution of moose was also consistent throughout the Management Unit except in the highest elevation sample units and those in the northern part of the survey area where high density moose strata (S1) was centered around deciduous patches or draws that drain toward the South Thompson River. The draws in the north did not appear to contain the same composition or density of deciduous shrubs as those bordering the southern grasslands. As such several sample units did not have moose. Increasing the minimum amount of high density moose stratum to > 5 km^2 and excluding areas > 1550 m as winter habitat should further improve the confidence in the population estimate for future inventories in the Management Unit, by reducing the number of sample units containing no moose.

Changes in composition

Despite consistently low bull ratios (i.e. 30 bulls per 100 cows) in the Monte Hills, sex ratios have not influenced recruitment in the Monte Hills, which is consistent with other moose populations in British Columbia (Thomson 1991). Calf to cow ratios have consistently ranged above 30 calves per 100 cows over the previous 4 years worth of composition counts (Table 3). Changes in forest harvesting practices and limiting road inventories in the area coupled with changes to the general open season spike-fork season appear to be improving the number of bulls in the population. Since 2010 there has been a 275% increase in the ratio of bulls to cows (Table 3). Although ratios during the inventory are still below regional objectives we are optimistic the positive trend will achieve 30 bulls per 100 cows in the next few years.

Table 3. Observed calf and bull ratios for moose in Wildlife Management Unit 3-20 (Monte Hills) for 2013 compared with previous years' censuses[1].

Year	Calves:100 cows	Bulls:100 cows
2010	38	8
2011	31	12
2012	37	14
2013	36	22

[1] Procter and Iredale (unpubl. data)

Sampling strategy and conditions

The 2013 SRB survey was conducted under desirable temperature and snow conditions. Heavy crusting and deep snow, which may push moose into heavier timber (where they would encounter lower snow depths or a lack of crusting), were not observed during the survey period. Moose in heavier cover are more difficult to see, and could have caused observers to possibly not see enough of them to substantially increase sightability correction. Temperatures were consistently below the upper critical temperature for moose in winter (i.e. -5°C) (Renecker and Hudson 1986) and recent snows, with 100% snow cover throughout the study area, helped with detecting recent moose activity. We used a relatively high survey effort in 2013 (4.5 min/km^2) and are confident that our coverage of surveyed areas was thorough and comparable to previous surveys in the Thompson-Okanagan.

LITERATURE CITED

Anderson, C.R., and Lindzey, F.G. 1996. Moose sightability model developed from helicopter surveys. Wildlife Society Bulletin **24:** 247-259.

Efron, B. 1982. The jackknife, the bootstrap, and other resampling plans. Society for Industrial and Applied Mathematics, Philadelphia, Pennsylvania, USA.

Goodman, L.A. 1960. On the exact variance of products. Journal of the American Statistical Association **55:** 708-713.

Heard, D.C. 1987. A simple formula for calculating the variance of products and dividends. Manuscript report for the Department of Renewable Resources, Government of the NWT.

Heard, D.C., Walker, A.B., Ayotte, J.B., and Watts, G.S. 2008. Using GIS to modify a stratified random block survey design. Alces **44:** 111-116

Heard, D.G., Watts, G.S., and Smith, R. 2001. Moose density and composition in the lower McGregor River and Herrick Creek watersheds, British Columbia, January 2001. Final Report for Common Land Information Base. Project No. 01028

Heard, D.G., Zimmerman, K.L., Yaremko, L.L., and Watts, G.S. 1999. Moose population estimate for the Parsnip River drainage, January 1998. Final report for Forest Renewal British Columbia. Project No. OP96004.

Hope, G.D., Mitchell, W.R., Lloyd, D.A., Erickson, W.R. and Harper, W.L. 1991. Interior Douglas-fir Zone. *In* Ecosystems of British Columbia. *Edited by* D.V. Meidinger and J. Pojar. Crown Publications Inc., Ministry of Forests, Victoria, B.C., Can. pp. 153-166.

Jolly, G.M. 1969. Sampling methods for aerial censuses of wildlife populations. East African Agriculture and Forestry Journal **34:** 46-49.

Quayle, J.F., MacHutchon, A.G., and Jury, D.N. 2001. Modeling moose sightability in south-central British Columbia. Alces **37:** 43-54.

Nielsen, S.E., Johnson, C.J., Heard, D.C., and Boyce, M.S. 2005. Can models of presence-absence be used to scale abundance? - Two case studies considering extremes in life history. Ecography **28:** 197-208.

Oswald, K. 1998. Moose aerial observation manual. Boreal Science Communications, Ontario Ministry of Natural Resources, Northeast Science & Technology. 95p.

Peek, J.M. 2007. Habitat relationships. *In* Ecology and management of the North American moose. *Edited by* A.W. Franzmann and C.C. Schwartz. University Press of Colorado, Boulder, Colorado, USA. pp. 351-375.

Renecker, L.A. and R.J. Hudson. 1986. Seasonal energy expenditure and thermoregulatory response of moose. Canadian Journal of Zoology. **64:** 322-327.

Thompson, I.D. and R.W. Stewart. 2007. Management of moose habitats. *In* Ecology and management of the North American moose. *Edited by* A.W. Franzmann and C.C. Schwartz. University Press of Colorado, Boulder, Colorado, USA. pp. 377-401.

Thomson, R.N. 1991. An analysis of the influence of male age and sex ratio on reproduction in British Columbia moose (*Alces alces* L.) populations. University of British Columbia.

Unsworth, J.W., Leban, F.A., Garton, E.O., D. J. Leptich, and Zager, P. 1998. Aerial Survey: User's manual. Electronic edition. Idaho Department of Fish and Game, Boise, Idaho, USA.

Walker, A.B.D., D.C. Heard, V. Michelfelder, and Watts, G.S. 2006. Moose density and composition in the Parsnip River Watershed, British Columbia, December 2005. Final Report for the Ministry of Environment. Project No. 2914568.

Walker, A.B.D., D.C. Heard, J.B. Ayotte, and Watts, G.S. 2007. Moose density and composition in the northern Williston Watershed, British Columbia, January 2007. Final Report for the Ministry of Environment. Project No. 2914568.

APPENDIX A. Itinerary and personnel involved in the in the Monte Hills, January 2013.

Date	Navigator	Observers	Pilot
12-Jan-13	Andrew Walker	Aaron Reid, Jesse Jones	Kelly Crosswell
13-Jan-13	Andrew Walker	Aaron Reid, Jesse Jones	Kelly Crosswell
14-Jan-13	Andrew Walker	Aaron Reid, Michael Burwash	Kelly Crosswell
15-Dec-13	Andrew Walker	Aaron Reid, John Surgenor	Kelly Crosswell

APPENDIX B. Moose observations, vegetation cover, snow depth and search effort in each sample unit during the in the Monte Hills, January 2013.

Sample unit	Waypoints*	Date	Stratum	Total	Cows	Calves	Bulls	Veg. cover($\bar{x}$)	Search time (min)	Area (km^2)	Search effort (min/km^2)**
7	73	14-Jan-13	1	1	1	0	0	20	NA	3.66	NA
13		14-Jan-13	1	0	0	0	0	NA	15	3.64	4.12
14		14-Jan-13	1	0	0	0	0	NA	25	3.44	7.27
20		14-Jan-13	1	0	0	0	0	NA	NA	4.25	NA
22	67	14-Jan-13	1	1	1	0	0	55	NA	3.48	NA
23	32	13-Jan-13	1	1	1	0	0	15	22	4.33	5.09
27	64-66	14-Jan-13	1	3	1	0	1	30	NA	7.84	NA
29	39	13-Jan-13	1	2	1	0	1	50	23	5.19	4.43
32	79,81-83	14-Jan-13	1	5	4	1	0	18	NA	5.54	NA
33	80	13-Jan-13	1	2	1	1	0	25	30	3.81	7.88
34	1,2	13-Jan-13	1	3	2	1	0	13	13	3.65	3.56
35	76,77	14-Jan-13	1	3	2	1	0	13	NA	4.31	NA
36	69-72	14-Jan-13	1	5	4	1	0	25	29	5.92	4.90
37	42-43	13-Jan-13	1	2	1	0	1	13	25	8.27	3.02
38	40-41	13-Jan-13	1	6	3	2	1	15	NA	7.78	NA
40	34-37	13-Jan-13	1	8	5	2	1	11	NA	7.32	NA
44	102-103	15-Jan-13	1	4	2	0	2	15	37	5.09	7.28
45		12-Jan-13	1	0	0	0	0	NA	30	4.03	7.43
47	5-7	13-Jan-13	1	10	5	3	2	15	25	4.89	5.12
49		13-Jan-13	1	0	0	0	0	NA	26	4.18	6.21
52	92-94	15-Jan-13	1	5	3	2	0	7	NA	7.07	NA
56	84	14-Jan-13	1	6	4	2	0	20	35	5.38	6.51
62	33	13-Jan-13	1	1	1	0	0	25	NA	7.62	NA
67	101	15-Jan-13	1	2	1	1	0	15	23	5.34	4.31
68		12-Jan-13	1	0	0	0	0	NA	11	3.22	3.42
77		15-Jan-13	1	1	0	0	0	45	NA	5.67	NA

*multiple GPS units were used to capture group locations of moose and resulted in some waypoint numbers being redundant.
**search time was not broken down by stratum in sample units where both stratum 1 and stratum 2 were surveyed.

Appendix B Continued

Sample unit	Waypoints	Date	Stratum	Total	Cows	Calves	Bulls	Veg. cover($\bar{x}$)	Search time (min)	Area (km^2)	Search effort (min/km^2)
78	98-100	15-Jan-13	1	4	3	1	0	18	NA	7.63	NA
79	0	15-Jan-13	1	0	0	0	0	NA	20	7.14	2.80
80	41	12-Jan-13	1	2	1	1	0	35	29	3.12	9.30
84	12-21,23,24	13-Jan-13	1	18	14	2	2	25	40	5.68	7.04
88		15-Jan-13	1	0	0	0	0	NA	NA	5.77	NA
89		15-Jan-13	1	0	0	0	0	NA	15	6.64	2.26
90		15-Jan-13	1	0	0	0	0	NA	10	7.89	1.27
93	35	12-Jan-13	1	2	2	0	0	30	NA	3.98	NA
95	25-30	13-Jan-13	1	9	4	2	3	25	22	4.64	4.74
104		12-Jan-13	1	0	0	0	0	NA	NA	4.33	NA
106	44,47,49	12-Jan-13	1	6	2	3	1	30	35	6.44	5.43
108	60-62	12-Jan-13	1	7	3	2	2	13	27	5.28	5.11
110		12-Jan-13	1	0	0	0	0	NA	23	5.64	4.08
113	50,51,53-55	12-Jan-13	1	5	5	0	0	31	NA	6.03	NA
7		14-Jan-13	2	0	0	0	0	20	NA	3.98	NA
20		14-Jan-13	2	0	0	0	0	NA	NA	4.70	NA
22		14-Jan-13	2	0	0	0	0	55	NA	5.48	NA
27		14-Jan-13	2	0	0	0	0	30	NA	1.12	NA
32		14-Jan-13	2	0	0	0	0	18	NA	3.42	NA
35		14-Jan-13	2	0	0	0	0	13	NA	3.91	NA
38		13-Jan-13	2	0	0	0	0	15	NA	1.18	NA
40		13-Jan-13	2	0	0	0	0	11	NA	1.65	NA
52		15-Jan-13	2	0	0	0	0	7	NA	1.89	NA
62		13-Jan-13	2	0	0	0	0	25	NA	1.34	NA
77	97	15-Jan-13	2	1	1	0	0	45	NA	3.29	NA
78		15-Jan-13	2	0	0	0	0	18	NA	1.33	NA
88		15-Jan-13	2	0	0	0	0	NA	NA	3.19	NA
93	39	12-Jan-13	2	1	1	0	0	15	NA	4.50	NA

*multiple GPS units were used to capture group locations of moose and resulted in some waypoint numbers being redundant.
**search time was not broken down by stratum in sample units where both stratum 1 and stratum 2 were surveyed.

RESULTS

MU 8-01 population estimate

The survey of MUs 8-01 was conducted between the 31st January and 2nd February 2014. Weather conditions during the survey were generally good with clear skies or high overcast, little light snow and mostly light winds. Temperatures ranged from –5 to –18°C during the survey. Snow cover was complete across the survey area. We used 9.98 hours of helicopter time to census MU 8-01 and an additional 2.5 hours on the pre-stratification flight. Final SUs averaged 22.3 ± 2.4 km^2 ($\bar{x}$ ± SE; n = 23) in size and search effort was 2.6 ± 1.0 minutes/km^2 (n = 10).

We counted 68 moose (47 cows, 15 calves and 6 bulls) in 39 groups during the survey. Group size ranged from 1 to 5 moose. When the sightability correction was applied, our estimate for MU 8-01 was 143 ± 48 moose ($\bar{x}$ ± 90% CI) (Table 2). The overall sightability correction factor was 1.70. Sightability corrected density was 0.28 moose/km^2 for the census area within MU 8-01 (Table 2) and corrected ratios were 15 ± 6 calves: 100 cows and 8 ± 5 bulls: 100 cows (Table 7).

Table 1. Moose population estimate statistics for MU 8-01, Okanagan GMZ, January and February 2014.

Parameter	Stratum 1 (high)	Stratum 2 (medium)	Stratum 3 (low)	Total
No. of SU in stratum	2	3	18	23
No. of SU surveyed	2	3	5	10
Total stratum area (km^2)	62.97	67.18	383.51	514.37
Area surveyed(km^2)	62.97	67.18	115.65	245.8
Moose observed	41	21	6	68
Mean SCF[a]	1.20	1.33	3.00	1.70
Corrected population estimate	49	28	66	143
Confidence Interval (90%)	8	8	47	48
Corrected density (moose/km^2)	0.78	0.42	0.17	.28

[a]Mean Sightability Correction Factor (see Table 1)

MU 8-07 population estimate

The survey of MUs 8-07 was conducted on the 2nd and 3rd of February 2014. Weather conditions during the survey were generally good with clear skies or high overcast, little light snow and mostly light winds. Temperatures ranged from -9 to –11°C during the survey and snow cover was complete across the survey area. We used 9.48 hours of helicopter time to census MU 8-07 and an additional 3 hours on the pre-stratification flight. Final SUs averaged 23.4 ± 1.9 km^2 ($\bar{x}$ ± SE; n = 25) in size and search effort was 2.0 ± 0.8 minutes/km^2 (n = 12).

We observed 74 moose (39 cows, 14 calves, 19 bulls, and 2 unknown adults) in 41 groups during the survey. Group size ranged from 1 to 4 moose. When the sightability correction was applied, our estimate for MU 8-07 was 222 ± 78 moose ($\bar{x}$ ± 90% CI) (Table 3). The overall mean sightability correction factor was 1.76. Sightability corrected density was 0.38 moose/km^2 for the census area within MU 8-07 (Table 3) and corrected ratios were 42 ± 30 calves: 100 cows and 31 ± 10 bulls: 100 cows (Table 7).

Table 3. Moose population estimate statistics for MU 8-07, Similkameen GMZ, February 2014.

Parameter	**Stratum 1 (high)**	**Stratum 2 (medium)**	**Stratum 3 (low)**	**Total**
No. of SU in stratum	0	9	16	25
No. of SU surveyed	0	6	6	12
Total stratum area (km^2)	0	197.44	383.52	580.96
Area surveyed (km^2)	0	137.53	144.80	263.44
Moose observed	0	61	13	74
Mean SCF[a]	0	1.42	2.60	1.76
Corrected population estimate	0	131	91	222
Confidence Interval (90%)	0	25	74	78
Corrected density (moose/km^2)	0	0.66	0.24	0.38

[a]Mean Sightability Correction Factor (see Table 1)

MU 8-26 population estimate

The survey of MUs 8-26 was conducted on the 6th and 7th of January 2014. Weather conditions during the survey were good with clear skies or high overcast, light snow and variable winds. Temperatures ranged from –4 to –6°C during the survey and snow cover was complete across the survey area. We used 8.2 hours of helicopter time to census MU 8-26 and an additional 2 hours on the pre-stratification flight. Final SUs averaged 21.9 km^2 ± 1.9 km^2 ($\bar{x}$ ± SE; n = 22) in size and survey effort was 2.1 ± 0.8 minutes/km^2 (n = 10).

We counted 90 moose (50 cows, 21 calves, 12 bulls, and 7 unknown adults) in 62 groups. Group size ranged from 1 to 4 moose. When the sightability correction was applied, our estimate for MU 8-26 was 185 ± 28 moose ($\bar{x}$ ± 90% CI) (Table 5). The overall sightability correction factor was 1.26. Sightability corrected density was 0.38 moose/km^2 for the census area within MU 8-26 (Table 4) and corrected ratios were 20 ± 5 calves: 100 cows and 42 ± 11 bulls: 100 cows (Table 7).

Table 6. Moose population estimate statistics for MU 8-26, Okanagan GMZ, January 2014.

Parameter	**Stratum 1 (high)**	**Stratum 2 (medium)**	**Stratum 3 (low)**	**Total**
No. of SU in stratum	1	6	15	22
No. of SU surveyed	1	4	5	11
Total stratum area (km^2)	28.59	142.36	310.17	481.12
Area surveyed (km^2)	28.59	91.39	123.34	243.32
Moose observed	29	44	17	90
Mean SCF[a]	1.52	1.24	1.16	1.26
Corrected population estimate	44	82	59	185
Confidence Interval (90%)	13	14	20	28
Corrected density (moose/km^2)	1.54	0.58	0.19	0.38

[a]Mean Sightability Correction Factor (see Table 1)

Table 7. Comparison of habitat-based estimates[a] and SRB estimate as well as the sex and age class ratio estimates during the moose surveys conducted between 2014-2016.

Management Unit	Habitat-based Est. ± 90% CI[a]	SRB. Est. ± 90% CI	Calf: 100 cow ± 90% CI	Bull: 100 cow ± 90% CI
8-01	169 ± 24	143 ± 48	15 ± 6	8 ± 5
8-07	118 ± 18	222 ± 78	42 ± 30	31 ± 10
8-23	340 ± 61	288 ± 98	42 ± 26	24 ± 12
8-24	146 ± 22	137 ± 34	17 ± 9	30 ± 11
8-26	70 ± 12	185 ± 28	20 ± 5	42 ± 11

[a]Data originating from Gyug (2014).

Okanagan Moose Inventory 2012-2013

by

Les W. Gyug, R.P.Bio.

Okanagan Wildlife Consulting
3130 Ensign Way
West Kelowna, B.C. V4T 1T9
les_gyug@shaw.ca

Prepared for

Fish and Wildlife Branch
B.C. Ministry of Forests, Lands and Natural Resource Operations,
Penticton, B.C.

February 4, 2013

ABSTRACT

Stratified Random Block (SRB) surveys of Management Units 8-06, 8-08, 8-09 and 8-21 from December 2012 to January 2013 resulted in winter moose population estimates (± 90% CI) of 249 ± 62, 380 ± 89, 237 ± 60, and 93 ± 22, respectively. A very low bull ratio was found in 8-09 (8 bulls/100 cows); the ratio of 16 bulls/100 cows in 8-08 was the same as in 2010, but lower than it was in the past; the bull ratio in 8-06 (24 bulls/100 cows) was about half of that in 2001, and the ratio in 8-21 was relatively high (64 bulls/100 cows). Calf ratios were low in 8-08 (18 per 100 cows) but in the range of 23-33 in the other MUs.

On average, SRB estimates from the past 3 winters are now within 11% of habitat-based estimates for the same MUs so that current habitat-based estimates are now considered more reliable than when they were first developed in 2007. Moose densities in similar habitats have increased by about 50-60% over the sampled portion of the region in 2008/09-2012/13 compared to 1998/99-2007/08. A combined winter moose population estimate for the Okanagan Region (3913 moose ± 454) included 8 MUs with SRB estimates from 2010-2013, and 13 other MUs where the estimate was habitat based.

Priorities for further sampling are made. First priority should be given to classification counts where there have been no such recent counts and anecdotal information may indicate they are needed to reliably assess impacts of current hunting regulations. Second priority should be given to further SRB surveys in larger MUs where they have never been done, or not done within the past 5 years.

TABLE OF CONTENTS

List of Figures

List of Tables

Acknowledgements

This project and report was completed under contract to the British Columbia Ministry of Forests, Lands and Natural Resource Operations (FLNRO), Okanagan Region. Brian Harris, FLNRO, served as contract monitor and participated as an observer in all flights. I would like to thank FLNRO Biologist Andrew Walker, Conservation Officers Terry Myroniuk and Ed Seitz, and Greg Hoyer who participated as observers in the aerial counts. Helicopter services were provided by Valhalla Helicopters, West Kelowna, with able piloting provided by Chinook McLean, Steve McNolty and Keegan McCabe.

INTRODUCTION

Moose (*Alces alces*) is an important big game animal with the Okanagan Region (Region 8) in southern British Columbia. A winter moose population estimate for the Okanagan Region had been derived in 2007 (Gyug 2007) based on winter habitat suitability mapping of the entire region, and moose densities for each habitat stratum from Stratified Random Block (SRB) surveys of 9 of the 21 Management Units (MU) that make up the region. Gyug (2012) recommended continuing SRB, especially of any MU that had no prior population estimates. Poole and Gyug (2011) estimated the moose winter population of MU 8-11 (MUs are referred to just by their number hereafter) by SRB survey finding that moose numbers had almost doubled from 1999 to 2010. Gyug (2012) estimated the moose winter populations of 8-10, 8-12 and 8-25 finding that overall moose densities had increased, and that the 2007 population estimate was therefore biased low.

The objectives of this project were to:

1. Estimate moose winter population numbers and sex-age ratios by SRB survey in 8-06 to compare with numbers estimated in 2001,
2. Estimate moose winter population numbers and sex-age ratios by SRB surveys in 8-08, 8-09 and 8-21,
3. Revise moose winter habitat suitability mapping where required to match densities found in 2012-2013 surveys, and
4. Revise the Okanagan moose winter population estimate based on SRBs where available, and revised density information and habitat suitability mapping for other MUs.

METHODS

Management Unit Population Estimates

Each MU was pre-stratified by winter habitat suitability (areas of relatively homogeneous winter moose densities) in GIS based on previous mapping (Gyug 2007, Gyug 2012). Target block size for the SRB survey was 20.0 km^2, which would allow surveys to be completed in 20 minutes to 60 minutes at search intensities of 1 - 3 km^2 per minute. The flight routes used from December 2012-January 2013 are shown in Figure 1. The entire moose winter range in each MU was divided into uniformly-sized blocks within each stratum, and blocks randomly selected for survey within each stratum (Figs. 2-5). Any revisions to the stratification were made after the initial day of each survey once the stage of winter moose migration became apparent. Moose may be at a wide range of elevations in early winter (December) or before significant snow accumulates. As snow accumulates through late December and January they move lower in elevation so that early, mid, or late winter habitat stratification may be quite different in any given MU.

All flights were done in a Bell Jet Ranger 206B helicopter. I acted as navigator and recorder in the left front helicopter seat. Two people in the back seats acted as observers viewing through bubble windows. Block boundaries were entered into a GPS unit that also recorded the survey track, and into which all observations of moose or other ungulates were marked. Possible error on marked locations compared to actual location were up to 200 m since no attempt was made to fly right over the animal to mark the exact location. The block boundaries were also entered into the helicopter's GPS unit to assist the pilot in determining the locations of block boundaries. Searches were made along straight lines 300 m apart flown at 80-100 km/h at a height of 50-100 m. In areas where no fresh moose tracks were seen, surveys were done with more widely spaced transect lines, and at faster rates of speed to avoid coverage of large areas at high survey intensity when, in fact, no moose were currently present. The beginning and ending time for each survey block was recorded as well as the overall flight time.

When the pilot or any passenger observed moose, the helicopter was turned to circle the location to provide a more accurate count and classification. We classified all moose seen as cow, calf, antlerless bull, antlered bull (fork/spike bull, Class I, Class II or Class III bull), or as unclassified adult if we were unable to reliably determine sex of antlerless moose. Data were recorded on modified Resources Inventory Committee (1997) data forms. Recorded for each moose group was oblique canopy cover percentage where the location was made, the number of animals in the group, the general habitat type and the activity of the first animal of the group sighted (bedded, standing, or walking). All other ungulate observations were recorded but no time was spent circling them to confirm sex and age.

Moose population size, and sex or age ratios were estimated using program Aerial Survey (Leban and Garton 2000). This model assumes constant survey unit size, or at least that a constant number of moose are expected in every survey block within a stratum. The program estimates sampling, sightability and model contributions to variance, and 90% confidence intervals on final estimates. To estimate sightability error, a composite moose sightability model derived from the observations of Anderson and Lindzey (1996) from Wyoming, Quayle et al. (2001) from Kamloops, and data from Prince George sightability trials (J. Quayle, 2001, unpublished data) was applied to each data point by the software (Table 1).

Table 1. Vegetation cover classes and detection probability for program Aerial Survey in the composite B.C. and Wyoming moose sightability model.

Vegetation Class	Percent Oblique Vegetation Cover	Detection Probability	Sightability Correction Factor
Class 1	0-20	0.971	1.030
Class 2	21-40	0.822	1.217
Class 3	41-60	0.388	2.577
Class 4	61-80	0.080	12.472
Class 5	81-100	0.012	84.471

Regional Population Estimate

The regional moose winter population estimate was the sum of the SRB estimates from any MU done within the past 5 years and habitat-based estimates for the remainder of the MUs. The habitat-based population estimate used the same methods as Gyug (2007). Moose winter densities for each stratum were estimated as the average of all SRB projects done within 5 years, i.e., after 2007. The average density times the area of each stratum gives the habitat-based population estimate. The 90% confidence interval for each MU or for the total was the stratum density standard error times the 90% z-score (1.645).

Data was submitted to FLNRO in the Wildlife Species Inventory (WSI) Species Inventory (SPI) excel file format for block and transect counts. Separate excel files were submitted in the format for which all Okanagan ungulate flight survey data from 1968 onwards have been collated.

RESULTS and DISCUSSION

Management Unit Population Estimates

SRB surveys of the winter moose populations were conducted on December 16 and 18 (8-09), January 3-15 (8-08), January 11-13 (8-06) and January 15 and 23 (8-21). Total flight time was about 53 hours, broken down by MU as follows:

8-06: 16.9 hours total, of which 12.9 hours were spent surveying within 21 blocks;
8-08: 18.4 hours total, of which 14.0 hours were within 22 blocks;
8-09: 11.7 hours total, of which 8.8 hours were within 13 blocks; and
8-21: 5.8 hours total, of which 3.7 hours were within 7 blocks.

The additional time beyond the within-block survey times included stratification and any ferry time to and from the sites from the helicopter hangar in West Kelowna. By sampling fewer blocks, and by refuelling at strategically placed fuel caches, flight time was kept to 60-85% of that previously estimated by Gyug (2010).

A total of 463 moose were counted while on survey within blocks in the 4 MUs (Table 2). Winter moose population estimates (± 90% CI) were 249 ± 62 in 8-06, 380 ± 89 in 8-08, 237 ± 60 in 8-09, and 93 ± 22 in 8-21.

Prior population estimates based on SRB surveys were only available for 8-06 which had increased from 103 ± 25 in 2001 to 249 ± 62 in 2013. The 2001 surveys had been in early February when most moose in the northern part of the MU had migrated out of the MU northwards into MU 3-12 of Region 3 (Thompson Region) (Gyug 2001). The 2000-2001 winter had been average in snow accumulation at the nearest snow pillow station at Pennask Summit (data from http://bcrfc.env.gov.bc.ca/data/asp/realtime/asp_pages/asp_2f18p.html). The moose suitability habitat mapping had been aligned to this survey time so the habitat-based estimate of 2007 was 108. In January 2013, deep snows had yet to accumulate in the northern part of the 8-06 when surveys were conducted (a below average snow year), so many moose appeared to be still present in the MU. Using revised habitat suitability mapping to reflect densities before mass winter migration out of MU 8-06, the habitat based population estimate was 244 ± 33, which was only 2% lower than the SRB population estimate of 249 ± 62. Since population numbers and sex-age ratios are used to assess and revise hunting regulations, it is important in MUs like 8-06 where there are significant winter migrations to conduct the surveys as early as possible in the winter when the estimated population and ratios better reflect those in the fall hunting season.

In 2007, estimates of winter moose populations based on habitat suitability mapping were 313, 76, and 49 for 8-08, 8-09 and 8-21 respectively (Gyug 2007). In 2012, with updated densities and habitat stratification, estimates were 399, 170, and 88 for 8-08, 8-09 and 8-21 respectively (Gyug 2012). The biggest difference among these 3 MUs was in 8-09 where the 2009 reconnaissance-level survey (Gyug 2009) upgraded the estimate of habitat suitability in the upper part of the Okanagan Mt. Park fire and the area of the 1994 Garnet Fire at Penticton/Ellis Creeks from Low to High suitability. This habitat change had not been taken into account in the 2007 estimate.

In 2013, with updated densities and habitat stratification, estimates were 430, 196, and 79 for 8-08, 8-09 and 8-21 respectively (this study). The SRB estimates were 5% lower, 39% higher and 6% higher respectively than the habitat-based estimates of 2012, and 13% higher, 21% higher and 18% higher respectively than the current habitat-based estimates. The latest revisions to the habitat-based population estimates in 2012 and 2013 appear to much more accurately reflect the estimates of the SRB surveys, being on average within 11% of each other. The 2007 estimates were low because they were based on old estimates of lower densities overall, and on habitat mapping that did not accurately reflect current suitability in some MUs.

Sex and Age Ratios

Estimated calf moose ratios were in the range of 18-33 per 100 cows in the four MUs surveyed (Table 3). Only seven yearling moose (spike or fork bulls) were counted in the 463 total moose counted (Table 3). Given the very few yearling moose counted, there is not much confidence in the yearling bull ratios presented in Table 3. Estimated bull moose ratios (including both yearling and adult moose) were in the range of 8-64 per 100 cows in the four MUs surveyed (Table 3).

Each of the MUs did have some prior calf and bull ratio estimates (Table 5) The current calf ratio in 8-06 was similar to that of 2001 (27 vs 22/100 cows) but the bull ratio was about half of that in 2001 (24 vs 52/100 cows). The current calf ratio in 8-08 was the lowest recorded since 1999 at 18 calves/100 cows compared to ratios in the 34-49 range in 1999-2004, and 26-27 in 2005-2010. Bull ratios in 8-08 had also dropped considerably: these were in the 25-43/100 cow range in 1999-2005, but were only 16 in both 2010 and 2013. The current calf ratio in 8-09 was similar to 2009 (33 vs 40/100 cows) but the bull ratio had dropped precipitously to 8 bulls/100 cows from 28 in 2009. The calf ratio in 8-21 was 23/100 cows, compared to the last survey in 2005 when no calves were seen among the 27 moose counted. The bull ratio in 8-21 continued to be among the highest recorded in the Okanagan Region at 64/100 cows, compared to 59/100 cows in 2005.

Table 2. Moose-density strata, blocks, areas, population estimates, density estimates and confidence intervals for Management Units 8-10, 8-12 and 8-25, Okanagan Region December 2011-January 2012.

MU and Density Stratum	Stratum Area (km²)	No. Blocks Total	No. Blocks Sampled	Search Intensity (min/km²)	Moose Counted	Mean SCF[1]	Est. No. Moose	90% C. I.	Est. Moose Density (/km²)
8-06									
Mod. High	87	4	3	2.3	45	1.52	91	31	1.05
Moderate	149	7	6	1.9	48	1.45	81	34	0.55
Low	267	13	9	1.6	26	1.68	64	40	0.24
Very Low	350	17	3	1.3	2	1.18	13	10	0.04
Total	**765**	**37**	**18**		**121**		**249**	**62**	
8-08									
High	25	1	1	2.3	34	1.15	39	7	1.55
Moderate	240	12	10	2.3	109	1.44	189	44	0.79
Low	768	38	11	1.4	20	2.20	152	77	0.20
Very Low	83	4	0		-		-		
Total	**1117**	**55**	**22**		**163**		**380**	**89**	
8-09									
High	60	3	3	2.5	82	1.15	94	15	1.57
Low	284	14	7	1.9	39	1.31	102	38	0.36
Very Low	205	9	3	1.5	6	2.28	41	43	0.20
Total	**548**	**26**	**13**		**127**		**237**	**60**	
8-21									
Low	182	8	5	1.6	52	1.12	93	22	0.51
Very Low	234	11	2	0.8	0		0	0	0.00
Total	**417**	**19**	**7**		**52**		**93**	**22**	

[1]Mean Sightability Correction Factor (see Table 1).

Table 3. Cow, calf and bull numbers counted and estimated, % of population estimates and sex/age ratios in Management Units 8-06, 8-08, 8-09 and 8-21, Okanagan Region December 2012-January 2013.

	Total Counted	Total Estimated	90% CI	% of Population	90% CI	Ratios (±90% C.I.)
8-06						
Cows	78	159	42	64	13	27 Calves (± 13) per 100 Cows
Calves	22	43	20	17	6	3 Yrlng Bulls (± 2) per 100 Cows
Yearling Bulls	3	5	4	2	1	21 Adult Bulls (± 5) per 100 Cows
Adult Bulls	16	34	11	13	3	24 Total Bulls (± 7) per 100 Cows
Total Bulls	19	39	12	15	4	
Unclassified	2	9	15	4	5	
8-08						
Cows	113	273	75	72	13	18 Calves (± 10) per 100 Cows
Calves	23	49	26	13	6	0 Yrlng Bulls (± 0) per 100 Cows
Yearling Bulls	0	0	0	0	0	16 Adult Bulls (± 7) per 100 Cows
Adult Bulls	23	43	18	11	5	16 Total Bulls (± 7) per 100 Cows
Total Bulls	23	43	18	11	5	
Unclassified	4	13	16	3	4	
8-09						
Cows	80	167	56	71	12	33 Calves (± 9) per 100 Cows
Calves	40	56	11	23	5	5.5 Yrlng Bulls (± 4.6) per 100 Cows
Yearling Bulls	4	9	8	4	3	2.5 Adult Bulls (± 1.5) per 100 Cows
Adult Bulls	3	4	2	2	1	8 Total Bulls (± 6) per 100 Cows
Total Bulls	7	13	10	6	4	
Unclassified	0	0	0	0	0	
8-21						
Cows	25	44	11	48	12	23 Calves (± 5) per 100 Cows
Calves	6	10	2	11	3	0 Yrlng Bulls (± 0) per 100 Cows
Yearling Bulls	0	0	0	0	0	64 Adult Bulls (± 34) per 100 Cows
Adult Bulls	16	28	13	30	9	64 Total Bulls (± 34) per 100 Cows
Total Bulls	16	28	13	30	9	
Unclassified	5	10	7	11	6	

Table 4. Prior and current moose sex and age ratios in 8-06, 8-08, 8-09 and 8-21.

MU and Date	Calves /100 Cows	Bulls /100 Cows	Total Moose Classified
8-06			
Feb 2001	22	52	47
Jan 2013	**27**	**24**	**119**
8-08			
Jan-1999	48	43	84
Dec 2003	34	25	84
Dec 2004	49	28	69
Dec 2005	27	31	71
Dec 2010	26	16	60
Jan 2013	**18**	**16**	**159**
8-09			
Jan 2009	40	28	72
Dec 2012	**33**	**8**	**163**
8-21			
Dec 2005	0	59	27
Jan 2013	**23**	**64**	**47**

Table 5. Stratified random block winter moose population estimates in the Okanagan, 1999-2012.

Year	Month	MU	Stratified Block Survey Results: Pop. Est.	Lower 90% CI	Upper 90% CI	90% CI	Estimated Densities (moose/km²): High	Mod.	Low	Very Low[1]
1999[2]	Jan	Central OK East (8-10, parts of 8-12, 8-23, 8-22)	420	298	633	51%	0.74	0.45	0.11	
1999[2]	Jan	Central OK West (8-11, 8-08 North)	473	330	616	30%	1.31	0.53	0.24	
2001[3]	Feb	8-05	128	63	193	51%			0.32	0.02
2001[3]	Feb	8-06	103	78	128	24%		0.42	0.12	0.00
2001[3]	Feb	8-14	78	29	127	63%			0.10	
2003[4]	Jan	8-23 N, 8-24	221	181	261	18%	1.08	0.45	0.19	
2005[5]	Feb	8-05	75	49	101	35%			0.13	0.03
2008[6]	Jan	8-23 S	37	30	44	23%		0.41	0.15	
2010[7]	Dec	8-11	379	297	461	22%	2.40	0.93	0.39	
2011[8]	Dec	8-10	270	186	354	31%		0.49	0.23	
2011[8]	Dec	8-25	209	175	243	16%	1.50	0.62	0.22	
2012[8]	Jan	8-12	389	324	454	17%	1.04	0.67	0.38	0.10
2012[9]	Dec	8-09	237	177	297	25%	1.57		0.36	0.20
2013[9]	Jan	8-06	249	187	311	25%		0.80[10]	0.24	0.04
2013[9]	Jan	8-08	380	291	469	23%	1.55	0.79	0.20	-
2013[9]	Jan	8-21	93	71	115	24%		0.78[11]	0.27[11]	0.00
Mean Density 1998/99-2007/08							**1.043**	**0.452**	**0.170**	**0.017**
Mean Density 2008/09 -2012/13							**1.612**	**0.726**	**0.286**	**0.056**
Std. Error 2008/09 -2012/13							**0.220**	**0.054**	**0.028**	**0.006**

[1] Very Low density estimate grouped all years because of low sample size.
Data sources: [2] Poole et al. (1999), [3] Gyug (2001), [4] Gyug (2003), [5] Gyug (2005), [6] Gyug (2008), [7] Poole and Gyug (2011), [8] Gyug (2012), [9] this study.
[10] Moderately High and Moderate were combined post-hoc.
[11] Moderate and Low were separated post-hoc.

Regional Population Estimate

For habitat extrapolation, only densities estimated in the past 5 winters were used because densities have changed significantly since 1998/99-2007/08 (Table 6). Using the revised moose winter habitat suitability mapping (Fig. 6), and the moose strata densities from only the past 5 winters (Table 6), the regional winter moose population estimate was 3806 with a 90% confidence interval of 16% (Table 7). This figure is considerably higher than the 2007 habitat-based estimate of 2174 moose (Gyug 2007) partly because of better knowledge of the habitat suitability but largely because of the higher density estimates applied to the habitat. No estimate of the confidence interval was available for the 2007 estimate. The 90% confidence interval of ±16% was improved considerably from 2012 (±32%) simply by increasing the number of MUs for which we have density estimates.

The aggregate winter moose population estimate using SRB where available (Table 7) was 3913 moose with an overall 90% CI of about 12%.

I would advise caution before assessing possible changes to hunting regulations at the MU level based on the individual MU habitat-based population estimates. While we now have much more confidence in the habitat-based population estimates than previously, sex and age ratios are still a large factor in assessing hunting pressures and we have no current data for many MUs. Sex and age ratios were found to vary considerably from MU to MU so that extrapolation from any MU to any other MU is not possible except with extra information.

The only MU outside of 8-11 to have >50 km^2 of High suitability habitat was 8-23 based on the surveys of 2001 (Gyug 2001). The High portion of 8-23 should be resurveyed (one flight) to determine if this habitat still deserves the High suitability rating or if the habitat has regenerated to the point where it is not as suitable.

Typically we have found that moose densities in the Okanagan peak in clearcuts or burns 5 to 20 years post disturbance. In 8-10 in 2011, and in 8-08 and 8-09 in 2013, densities were lower in regenerating clearcuts as the conifer layer closed in 20-30 years after cutting or burning compared to prior surveys. The Okanagan plateaus now have many clearcuts from the 1980's onwards, some of which are now moderately or highly suitable moose habitat, but many of which are regenerating to the point where they are not as suitable. Partial cuts in mid-winter Douglas-fir habitats may remain suitable for many more years post cutting than clearcuts as the canopies do not close in as quickly. Moose habitat suitability will continually change as new habitats become suitable, as noted particularly for wildfires from the period 1994-2003 in 8-09 (Gyug 2009), in 8-10, 8-12, 8-23 on the Aberdeen Plateau, and in 8-25 (Gyug 2012).

Table 6. Winter moose habitat suitability strata areas updated to 2012/13, and habitat-based moose population estimates based on habitat strata densities determined in the past 5 winters (2008/09-2012/13) compared to Stratified Random Block population estimates by Management Unit.

	Strata Area (km²)					Winter Moose Population Estimates					
						Habitat-Based			Stratified Random Block		
MU	H	M.	L	VL	Total	Est.	Low 90% CI	Upp. 90% CI	Est.[1]	Low 90% CI	Upp. 90% CI
8-01	0	89	353	57	499	169	144	193			
8-02	0	7	46	22	76	20	17	23			
8-03	6	0	65	344	414	47	39	55			
8-04	0	33	180	342	554	94	80	109			
8-05	0	0	479	355	834	157	132	182	(128)	(63)	(193)
									(75)	(49)	(101)
8-06	0	217	225	390	832	244	211	277	(103)	(78)	(128)
									249	187	311
8-07	0	40	248	332	619	118	100	136			
8-08	28	246	691	148	1113	430	365	494	380	291	469
8-09	48	28	308	172	556	196	160	232	237	177	297
8-10	12	194	436	150	791	292	250	335	(222)[2]	(136)	(308)
									270	186	354
8-11	68	119	234	30	451	264	218	310	379	297	461
8-12	25	173	602	502	1301	366	310	423	389	324	454
8-13	0	0	35	155	190	19	16	22			
8-14	0	68	733	387	1188	281	238	324	(78)	(29)	(127)
8-15	0	0	485	517	1002	168	141	195			
8-21	0	44	113	260	417	79	67	90	93	71	115
8-22	2	35	146	155	337	79	67	90			
8-23	91	89	375	374	929	340	278	401	(191)	(149)	(233)
8-24	1	73	287	148	510	146	125	168	(67)	(48)	(86)
8-25	11	214	146	218	590	228	196	259	209	175	243
8-26	0	0	203	218	422	70	59	82			
Total	292	1669	6390	5276	13627	**3806**	**3212**	**4400**			

[1] Estimates in ellipses were determined >5 years ago.
[2] Original data from Poole et al. (1999) re-interpreted to produce a SRB population estimate for 8-10.

Table 7. Okanagan Region winter moose population estimate based on SRB in MUs where available and habitat-based methods in other MUs.

	Winter Moose Population Estimates					
			90% Conf. Interval			
MU	**Est.**	**Variance**	**90% CI**	**as % of Subtotal**	**Lower limit**	**Upper limit**
Habitat-based Estimate						
8-01	169					
8-02	20					
8-03	47					
8-04	94					
8-05	157					
8-07	118					
8-13	19					
8-14	281					
8-15	168					
8-22	79					
8-23	340					
8-24	146					
8-26	70					
Subtotal	**1707**		**272**[1]	**16%**	**1435**	**1979**
SRB Estimate (2010-2013)						
8-06	249	1402				
8-08	380	2303				
8-09	237	1318				
8-10	270	2608				
8-11	379	2485				
8-12	389	1561				
8-21	93	180				
8-25	209	427				
Subtotal	**2206**	**12284**	**182**[2]	**8%**	**2024**	**2388**
Total	**3913**				**3459**	**4367**

[1] Habitat-based 90% CI estimated as in Table 7 from density by stratum from past 5 winters.

[2] SRB 90% CI estimated as square root of sum of variances x 1.645 (i.e., 90% z-score)

RECOMMENDATIONS

SRB winter moose population estimates in 2010-2013 were a much closer match to the habitat-based estimates than previous attempts in 2007. On that basis, I recommend:

1. Where survey-based population estimates and sex/age ratios are available, these should be used to assist in assessment of hunting regulations.

2. The current moose winter population estimates developed based solely on habitat suitability by MU are more reliable than in previous years, but should still be treated with caution, and only used for assessing suitability of current hunting regulations if additional information is available to confirm current sex and age ratios. Therefore, where the regional biologist may have anecdotal information indicating possible or potential problems, high priority is to complete classification counts aiming at counts of 100 moose or more per MU or group of adjacent MUs that have not been surveyed within the past 5 years. Examples of these may include:
    a. 8-23/8-24 or
    b. 8-14/8-15

3. Priority MUs for SRB surveys in the future should include (in no particular order, and should be selected randomly):
    a. Some of those never SRB surveyed but with >100 moose predicted to be present including:
        i. 8-01
        ii. 8-07
        iii. 8-15
    b. Some of those previously SRB surveyed >5 years ago with >100 moose predicted to be present including:
        i. 8-14 (last surveyed in 2001),
        ii. 8-23 (last surveyed in 2003),
        iii. 8-24 (last surveyed in 2003).

4. Other MUs with <100 predicted moose should be completed whenever funds or extra flight time is available. For example, small MUs such as 8-21 were completed with only 6 hours of flight time in January 2013. These include:
    a. 8-02
    b. 8-03
    c. 8-04
    d. 8-13
    e. 8-22
    f. 8-26

LITERATURE CITED

Anderson, C.R. Jr., and F.G. Lindzey. 1996. Moose sightability model developed from helicopter surveys. Wildlife Society Bulletin 24(2):247-259.

Gyug, L.W. 2001. Moose Stratified Block Census, Management Units 8-5, 8-6 and 8-14, Okanagan Sub-region, February 2001. B.C. Ministry of Environment, Southern Interior Region, Kamloops, B.C.

Gyug, L.W. 2003. Moose Stratified Block Census, Management Units 8-23 and 8-24, Okanagan Region, January 2003. B.C. Ministry of Water, Land and Air Protection, Okanagan Region, Penticton, B.C.

Gyug, L.W. 2005. Moose Stratified Block Census, Management Unit 8-5, Okanagan Region, February 2005. B.C. Ministry of Water, Land and Air Protection, Okanagan Region, Penticton, B.C.

Gyug, L.W. 2007. Okanagan Moose Population Estimate 2007. Okanagan Region, Ministry of Environment, Penticton, BC

Gyug, L.W. 2008. Moose Census of Aberdeen Lake area, MU 8-23, Okanagan Region, January 2008. Okanagan Region, Ministry of Environment, Penticton, BC

Gyug, L.W. 2009. Aerial Classified Moose Count, MU 8-01 and 8-09, Okanagan, January 2009. Weyerhaeuser Co. Ltd., Princeton, BC

Gyug, L.W. 2010. Okanagan moose aerial survey workplan 2010. Fish and Wildlife Section, Okanagan Region, Ministry of Environment, Penticton, BC

Gyug, L.W. 2012. Okanagan moose inventory, 2011-2012. Fish and Wildlife Section, Okanagan Region, Ministry of Environment, Penticton, BC

Leban, F., and O. Garton. 2000. Aerial Survey for Windows, Verson 1.00 Beta 6.1.4. (12 Feb 2000). Available as freeware http://www.cnrhome.uidaho.edu/fishwild/Garton/tools [Accessed 2012]

Poole, K.G., D.A. Fear, G. Mowat and C.D. Shurgot. 1999. Moose inventory in the Central Okanagan, January-February 1999. Report prepared for Ministry of Environment, Lands and Parks, Penticton, B.C.

Poole, K.G., and L.W. Gyug. 2011. Okanagan moose surveys in Management Units 8-11, 8-10 and 8-8, December 2010. Okanagan Region Wildlife Heritage Fund Society, Winfield, BC

Quayle, J.F., A.G. MacHutchon and D.N. Jury. 2001. Modeling moose sightability in south-central British Columbia. Alces 37(1): 43-54.

Resources Inventory Committee 1997. Standardized inventory methodologies for components of British Columbia's biodiversity: aerial based inventory techniques for selected ungulates bison, mountain goat, mountain sheep, moose, elk, deer and caribou. Version 1.1. Ministry of Environment, Lands and Parks, Wildlife Branch, Victoria, British Columbia.

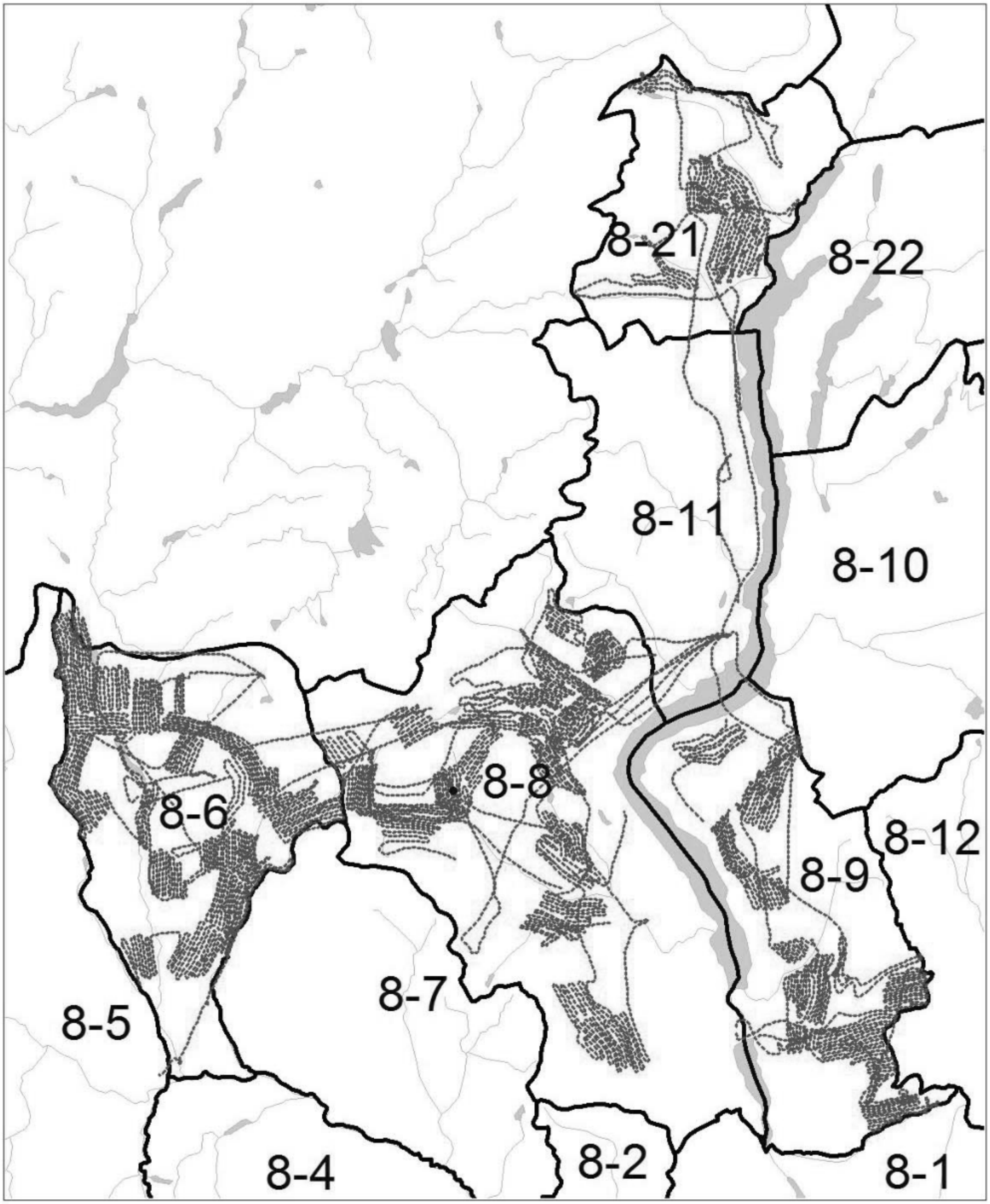


Figure 1. Helicopter flight routes in the Okanagan Region moose winter inventories, December 2012 – January 2013.

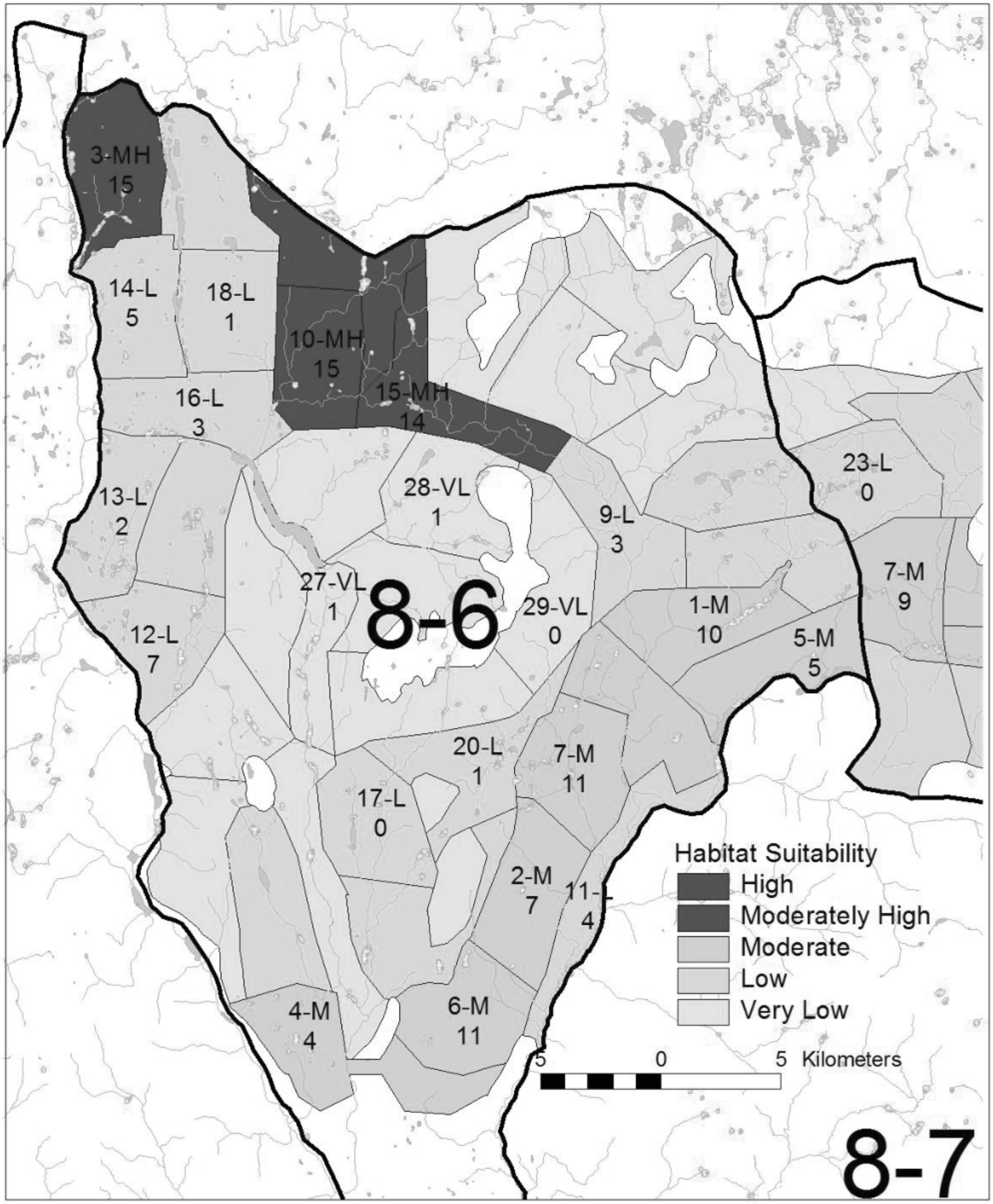


Figure 2. Stratified randomly-selected blocks in Management Unit 8-06, January 11-13, 2013. The number of moose counted in each block is below the block identifier.

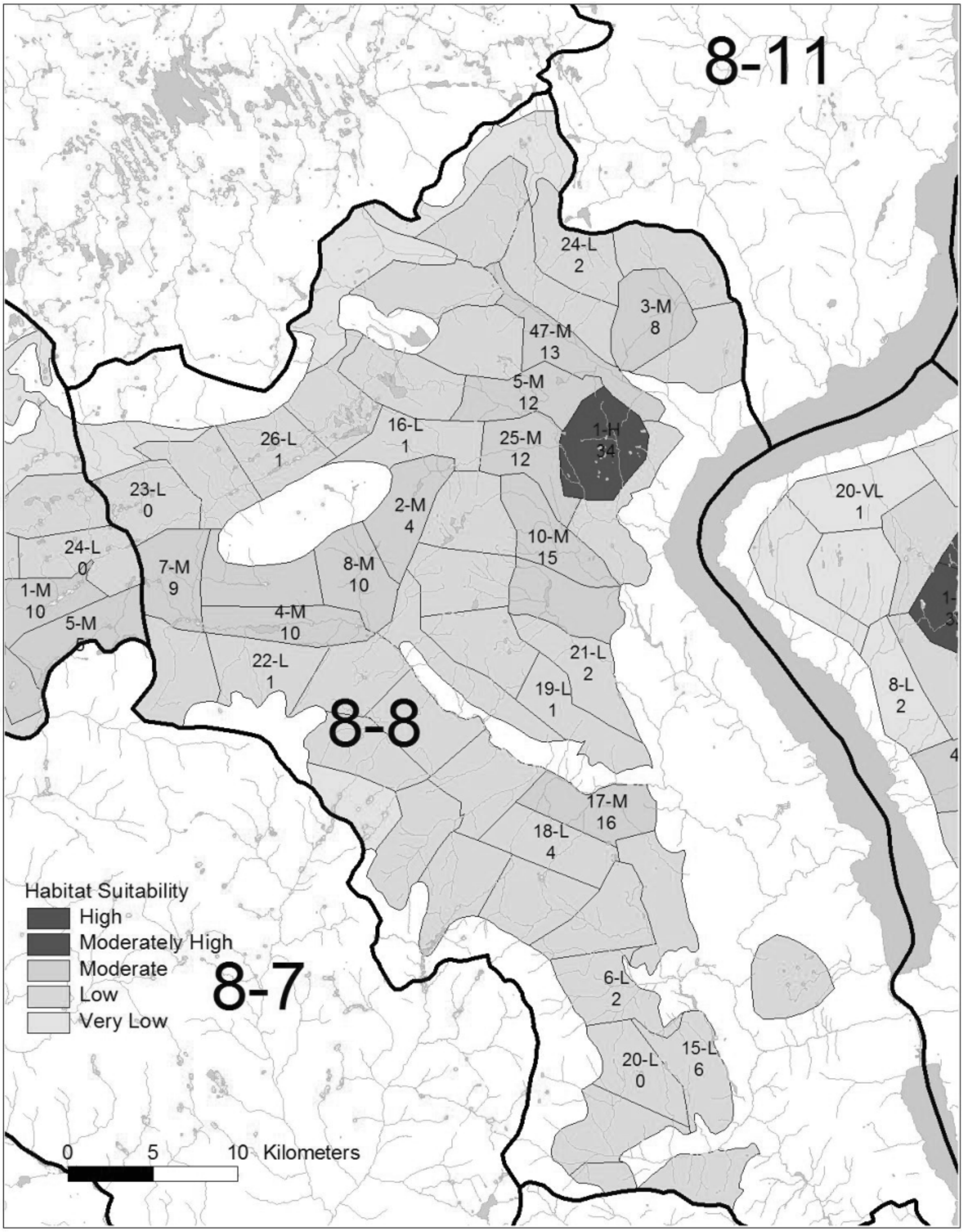


Figure 3. Sampled stratified randomly-selected blocks in Management Unit 8-08, January 3-15, 2013. The number of moose counted in each block is below the block identifier.

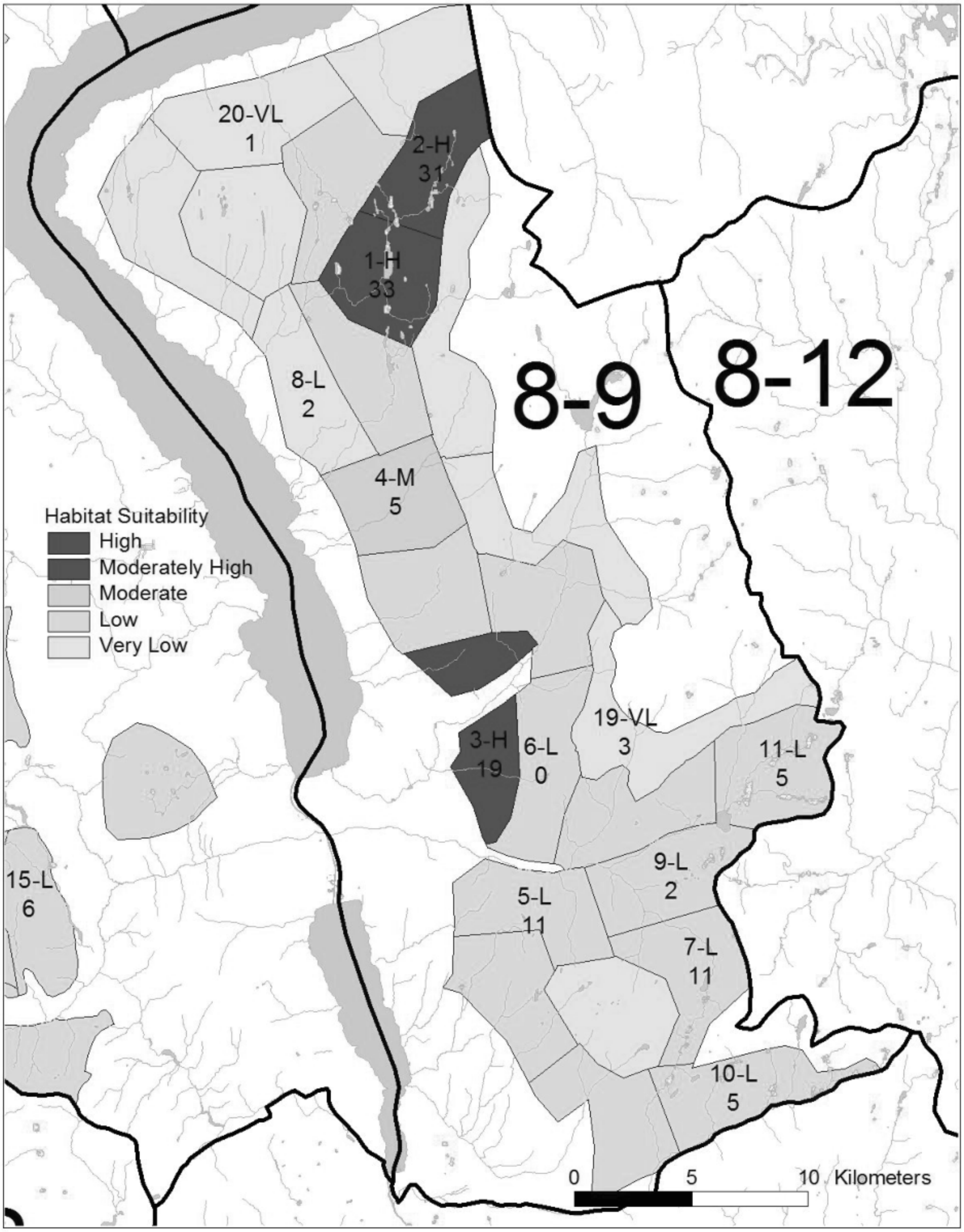


Figure 4. Sampled stratified randomly-selected blocks in Management Unit 8-09, December 16-18, 2012. The number of moose counted in each block is below the block identifier.

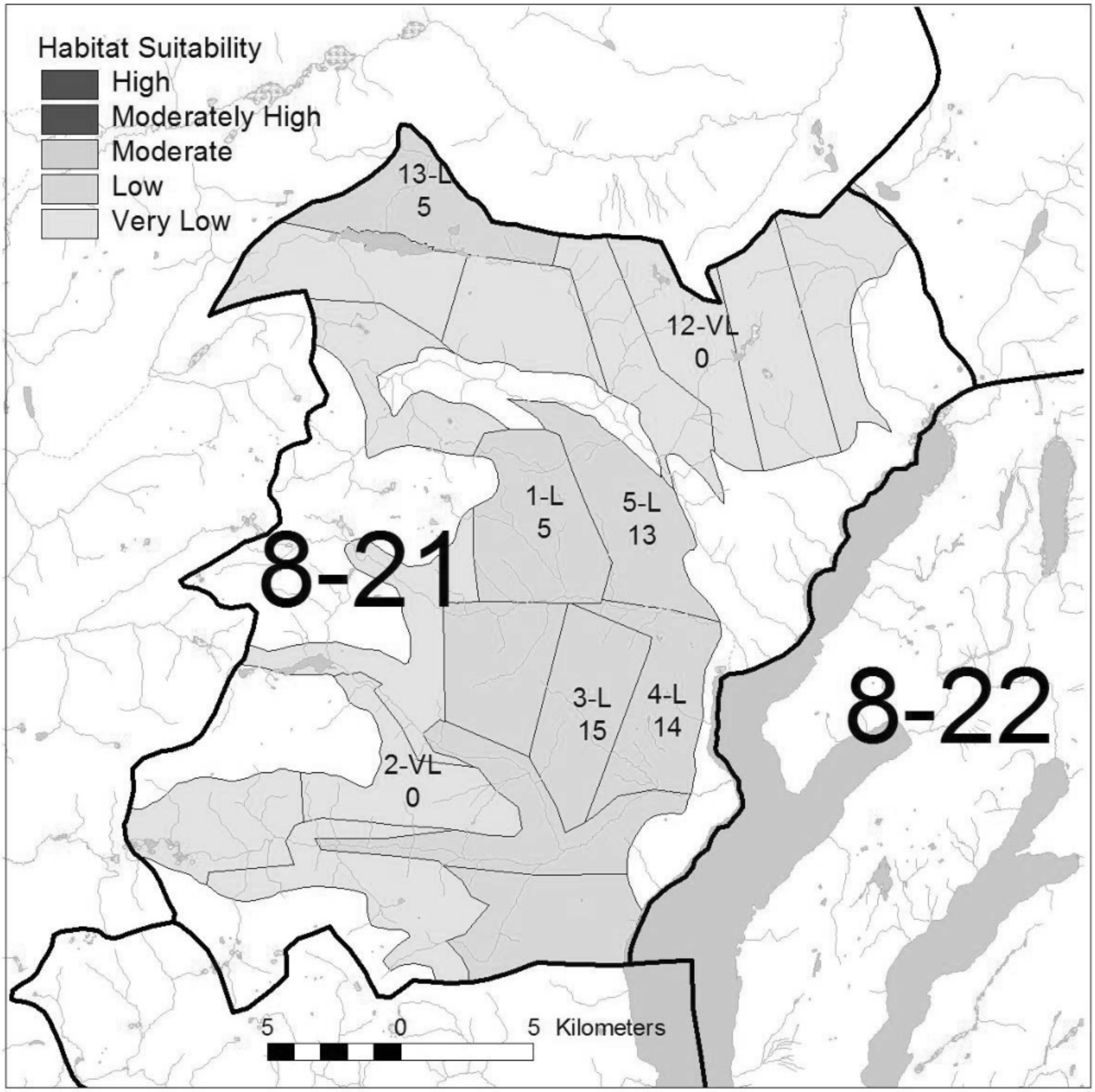


Figure 5. Sampled stratified randomly-selected blocks in Management Unit 8-21, January 15-23, 2013. The number of moose counted in each block is below the block identifier.

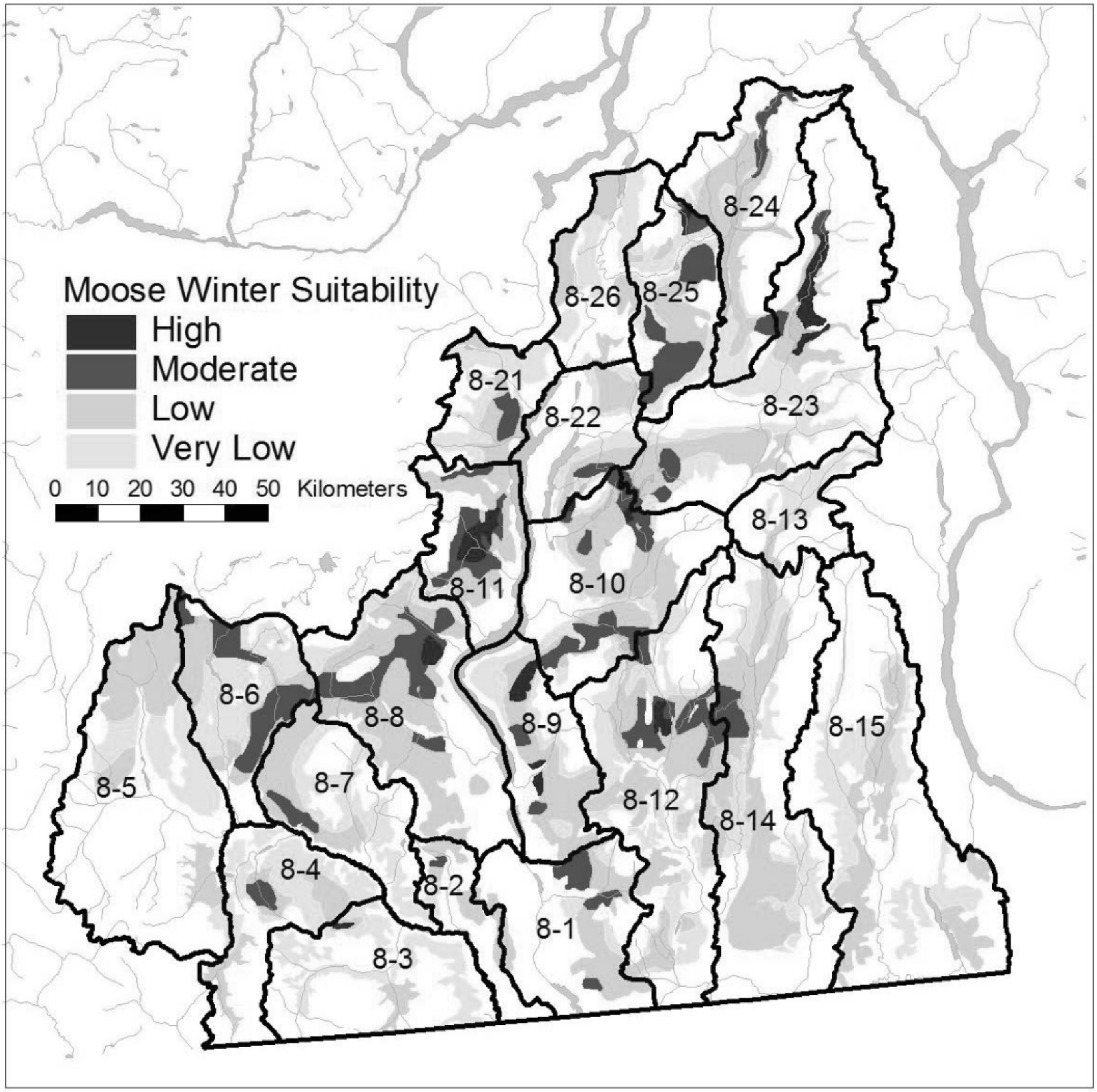


Figure 6. Moose winter habitat suitability in the Okanagan Region revised in 8-06, 8-08, 8-09 and 8-21 after the flights of December 2012 – January 2013.