Moose inventory of the Raft River area (MU 3-40)
January-February 2009

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EXECUTIVE SUMMARY

Changing large mammal communities have been implicated in the decline of endangered mountain caribou (*Rangifer tarandus caribou*) in British Columbia. In a recent analysis of mountain caribou populations in the province, predation, primarily by wolves (*Canis lupus*), was identified as the proximate cause of this decline. Moose numbers in mountain caribou range have been increasing in the last decade, and subsequent increased levels of predation have been linked to habitat changes brought about by timber harvesting, which have led to younger forests and fragmented habitats. Since there has likely been a numerical response of wolves to increased moose densities, there may be a negative effect on the long-term persistence of mountain caribou populations in the region.

Since the late 1970s, little moose population inventory work has been carried out in the North Thompson watershed. Previous efforts to conduct moose inventories in North Thompson management units (MUs) were hindered by unsettled weather and poor snow conditions. In 2005, a reconnaissance census that quantified moose composition was conducted in the upper North Thompson watershed, which included portions of MU 3-40.

We determined population size, density, and composition of moose in the Raft River area (MU 3-40) in late January–early February 2009. Before this survey, no absolute abundance estimate of moose had been made for MU 3-40. We employed the stratified random block survey technique, and applied standard sightability correction factors based on estimates of vegetation cover.

The estimate for the Raft River area (MU 3-40) was 424 (±95 [90% CI]) moose with a density of 0.63/km² within the survey area. The bull:cow ratio was 73:100 (58–88) and calf:cow ratio was 37:100 (26–48). Calf:cow ratios were variable across the census zone, with the western portion of the study area along the lower Clearwater corridor at 49:100. Comparatively few wolf tracks or moose kills were seen in areas of high calf ratios. Areas in the Raft, Mad, and North Thompson drainages had many more wolf tracks, wolves observed, and moose kills, with calf counts as low as 26:100.

We recommend that continued monitoring of moose populations in the North Thompson using formal standardized inventory methods be conducted on a regular basis (every 3–5 yrs). When attempting to manage the predator/prey system, managers should consider that planned predator reduction without similar reduction in primary prey will likely result in the rapid return of predators to their previous level, and any rapid reduction in alternative prey, either through hunting or a severe winter, will likely result in increase predation risk on caribou.
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MU 3-40 moose inventory, Jan-Feb 2009
INTRODUCTION

As recovery options for British Columbia’s (BC) endangered mountain caribou (*Rangifer tarandus caribou*) populations are implemented, managing the predator-prey system will play a key role, at least in the short term (Serrouya and Poole 2007, Wilson 2009). Recovery of the Wells Gray South mountain caribou subpopulation, which encompasses the upper North Thompson watershed, may benefit from the reduction of moose (*Alces alces*) numbers through habitat management and hunting regulations (Seip 2008). Moose are thought to negatively impact caribou because they share predators (wolves (*Canis lupus*) and cougars (*Puma concolor*)), a process that is termed “apparent competition” (Holt 1977).

Determining the abundance and distribution of primary prey, such as moose, within and adjacent to the range of mountain caribou will help direct management actions aimed at restoring a predator-prey system that does not disadvantage mountain caribou.

Previous efforts to conduct moose inventories in North Thompson management units (MUs) were hindered by unsettled weather and poor snow conditions in winter 2004 and 2005 (Lemke 2005). In 2005, a reconnaissance census that quantified moose composition was conducted in the upper North Thompson watershed (Lemke 2005). The objectives of the reconnaissance census were to determine the age/sex composition of local moose populations and refine mapping of critical moose winter range. The data would allow managers to re-evaluate moose harvest objectives and regulations in North Thompson MUs. No absolute abundance estimate of moose has been made for MU 3-40.

Our objective was to census moose populations in MU 3-40, which encompasses the Raft River area, including along the lower Clearwater corridor, the Mad River drainage, and the west side of the upper North Thompson. We employed the stratified random block (SRB) survey technique described by Gasaway et al. (1986) that provides estimates of moose abundance and population composition. Incidental observations of mule deer (*Odocoileus hemionus*) and predators, such as wolves, were also recorded.

STUDY AREA

The study area is located in the north Columbia Mountains in southeastern BC (Fig. 1). The study area lies within the Shuswap Highland ecossection, an intermediate highland area between the Cariboo plateau and mountains to the west and the Monashee Mountains to the east. The entire MU encompasses approximately 1,656 km². It is bounded to the east and south by the sweeping North Thompson River, to the west by the lower Clearwater River, and north following the height-of-land above the Raft River terminating at Blue River. The communities of Clearwater and Blue River are located at the southern and northern extents of the study area, respectively. The west boundary of the study area abuts Wells Gray Provincial Park (5,400 km²) where hunting is allowed during game hunting seasons.

The climate is transitional between drier and warmer climates farther south and moister and cooler climates to the north. It has warm, dry summers and mild winters with relatively high snowfall. Valley bottom elevations range from 430–800 m, with surrounding ridges and peaks from 1,600–2,450 m (Raft Mountain). Most ridges and summits are rounded, and despite the height of much of the terrain, the country lacks the jagged sawtooth profiles of the mountains to the east. Regenerating burns, cutblocks, and avalanche tracks were early seral habitats commonly encountered throughout the study area.

Three biogeoclimatic variants encompass the majority of suitable moose winter range (<1,200 m) in MU 3-40. They include the North Thompson dry warm Interior Cedar-Hemlock (ICHdw3), Thompson moist warm Douglas-fir (IDFmw2), and the Thompson moist warm Interior Cedar-Hemlock (ICHmw3) (Lloyd et al. 1990).
Figure 1. Management unit 3-40 moose survey area covering portions of the lower Clearwater, Raft, Mad, and upper North Thompson River drainages.

The ICHdw3 variant occupies valley bottoms of the Clearwater, Raft, and Mad drainages and the North Thompson River between Clearwater and Avola (Lloyd et al. 1990). Mixed mid-seral stands dominate this variant. Stands are mixtures of broadleaf and conifer species and include lodgepole pine (*Pinus contorta var. latifolia*), Douglas-fir (*Pseudotsuga menziesii*), western white pine (*Pinus monticola*), western redcedar (*Thuja plicata*), paper birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides*). Western hemlock (*Tsuga heterophylla*) and western redcedar are the most common regeneration species and would dominate climax stands. However, a fire return interval of less than 150 yrs has restricted development of climax stands to small isolated occurrences. Most ICHdw3 stands are 60-120 years old. Douglas-fir and lodgepole pine dominate steep south slopes and hybrid white spruce (*Picea glauca x engemannii*) is commonly associated with seepage sites. Black cottonwood (*P. balsamifera ssp. trichocarpa*) is common on large floodplains along the North Thompson River.

IDFmw2 occurs along the North Thompson River from Barriere to Vavenby, and encompasses the lower reaches of the Clearwater and Raft Rivers (Lloyd et al. 1990). Fire history and human disturbance have lead to the widespread development of successional stands dominated by Douglas-fir, lodgepole pine, paper birch and aspen. At the wetter climatic range of the variant western recedar is widespread and forms co-dominant stands with Douglas-fir. On drier sites, western redcedar is absent or generally restricted to the lower canopy and shrub layers. Hybrid white spruce and subalpine fir (*Abies lasiocarpa*) commonly occurs on wet sites. Dry south slopes are typically dominated by open stands of Douglas-fir.

*MU 3-40 moose inventory, Jan-Feb 2009*
ICHmw3 occurs at mid-elevation sites above the ICHdw3 and IDFmw2 generally between 800–1,200 m where it occupies valley bottoms of the North Thompson valley (Avola to Blue River), and mid-slopes of the Clearwater, Mad and Raft river drainages. Western hemlock and western redcedar dominate late successional stands. Spruce and subalpine fir are common on wetter site series, sites subject to cold air drainage and at upper elevations. At upper elevations and the wetter geographic extremes of this variant, late succession and climax stands are more common and are typically 180–240 years old. In many areas, the ICHmw3 borders the Engelmann Spruce–Subalpine Fir (ESSF) zone between 1,250–1,600 m. Mid-winter snow accumulations vary between 1 and 2 m in depth. Upper elevation sites include the ESSF and Alpine Tundra (AT) zones where snowdepths generally exceed 2 m.

Annual precipitation ranges from 600–700 mm up to about 1,000 mm. Annual snowfall ranges vary from 280 cm near Clearwater in the south up to 420 cm near Blue River in the north. Average mean daily temperatures at Blue River, located at 680 m elevation, are −9.0°C and 16.4°C for January and July, respectively (Environment Canada climate normals, unpub. data).

Snow survey (depth) and snow pillow data (snow water equivalent) were obtained from government web sites of the Water Stewardship Division of the Ministry of Environment (MoE) (http://www.env.gov.bc.ca/rfc/river_forecast/data.htm). The data suggest that during late January and early February 2009, snow depths at mid- to upper elevations (1,249–1,900 m) were 1–16% above normal. Snow deposition in the lower elevation valleys appeared to vary among areas, with reports that low elevation (<1,000 m) snowdepths were well above average in the Clearwater and Wells Gray areas (K. Van Damme, Clearwater Conservation Officer, and M. Blackwell, Wells Gray Park Operator, personal communication).

METHODS

Sampling strategy

Background information on moose in the area of interest was compiled from past moose flights (Lemke 2005), historic moose data (MoE, unpub. data), and from interviews with MoE Clearwater conservation officers, and MoE staff familiar with the area. We delineated the pre-stratification study area of interest to include all potential moose winter range within MU 3-40, usually <1,200 m. We then further defined sample units (SUs, also known as “blocks”) approximating 20–25 km² in size, which then could be surveyed in 1–2 hrs.

The Raft survey followed a stratified random block design, using procedures modified from Gasaway et al. (1986), Timmermann (1993), Timmermann and Buss (1997), and Resource Information Standards Committee (RISC 2002). Sample units were designated into strata based on expected high, medium, and low moose densities. To verify SU boundaries and initial stratification, we conducted a stratification flight using a Cessna 337 fixed-wing aircraft, with a pilot, a navigator (next to the pilot) and 2 backseat observers. All persons participated in locating animals and tracks. Flight speed was 140–200 km/h at an altitude of 100–200 m above ground level. We recorded moose (not classified) and moose tracks (recorded as Few, Some, or Many for relative numbers). Flight path and sightings were recorded on a global positioning system (GPS; Garmin 76, Garmin Industries, Olathe, Kansas, USA). Our stratification flight pattern generally meandered among our areas of interest (Gasaway et al. 1986), with a focus on determining relative distribution of moose sign, and determining how high in elevation moose were present.

Sample unit boundaries and designations were adjusted subsequent to the stratification flight, based primarily on the number of moose and tracks observed, along with historical information, local knowledge, and a subjective habitat assessment. The resulting study area (census zone) was 677.5 km². We designated 3 strata for the Raft survey and initially selected all high SUs, 8 randomly selected medium SUs, and 3 randomly selected low SUs.
We used a Bell 206B Jet Ranger helicopter equipped with rear bubble windows during the census, with a pilot and 3 observers. The same navigator/observer was present for all flights. All occupants participated in locating animals. Each selected SU was surveyed at 80–120 km/h airspeed at 75–125 m above ground. We searched each SU along 150–250-m wide transects (expanded to 400-m wide transects in very open areas), usually flown along parallel lines back and forth across the SU or contouring steeper terrain. We occasionally flew above the upper elevation boundary of the study area to check if moose resided outside the planned SUs. We used real-time GPS to track our flight path within each SU to ensure complete and accurate coverage.

We circled all moose groups to determine sex and age of each animal (Timmermann and Buss 1997) and determine if the group was within the SU boundary. Smaller body size and a shorter face identified calves. Cows were identified primarily by the presence of a white vulva patch, and to a lesser extent by even, light colour of the snout, and the absence of pedicel scars. Bulls were identified by larger body size, darker facial coloration, absence of a white vulva patch, and presence of pedicel scars (RISC 2002). Some adult animals could not be approached closely to be classified or were obscured by vegetation, and were designated as unknown adults. The estimated elevation of the moose group was recorded based on the helicopter’s altimeter (in feet).

For each moose group (1 or more animals) observed we estimated oblique cover as percent vegetative cover (perhaps best described as screening cover) around the first animal seen in the group (Anderson and Lindzey 1996, Unsworth et al. 1998, Quayle et al. 2001). This was estimated by flying a complete circle at an oblique angle around the point where moose were first seen. Vegetative cover was estimated to the nearest 10% starting at 5% (e.g., to 5%, 15%, 25%, etc.) measured obliquely within a 9–10 m radius around each group of moose. We regularly discussed and standardized our estimates of vegetative cover.

Locations of other wildlife observed were recorded during the survey. Group locations were recorded but no classification or precise counts were conducted on non-moose ungulates. Given the large numbers of mule deer observed, we felt it would have taken too much effort and detracted from the moose survey to count and classify them.

Data analysis

We estimated moose population size using program MOOSEPOP (Version 2.0; R.A. DeLong and D.J. Reed, Alaska Department of Fish and Game, Fairbanks, Alaska, USA) with sightability correction applied to each stratum calculated using program AERIAL SURVEY (Unsworth et al. 1998). Detection probabilities were determined using sightability data from a BC model (Quayle et al. 2001), updated with data compiled from an additional 20 sightability trials conducted in Prince George in 2001 (J. Quayle, MoE, unpub. data; Table 1). In the BC model, 5 cover classes were used, separated at the 20%, 40%, etc. boundaries of percent vegetation cover. We calculated the population estimate using a spreadsheet program developed by MoE (HEARDPOP; J. Quayle, MoE, unpub. data), where the estimate variance was calculated as a sum of the sampling, sightability and model variances between the 2 programs. The high-stratum degrees of freedom (df) were adjusted to \( n - 1 \) moose counted, since it was a count, not a sample of moose in that stratum, and the total df were adjusted to the sum of the strata (Serrouya and Poole 2007).
Table 1. Vegetation cover classes and their associated detection probability and sightability correction factors (program AERIAL SURVEY, Unsworth et al. 1998, as modified using Quayle et al. 2001 and updated with data from Prince George sightability trials, 2001 [J. Quayle, MoE, unpub. data]).

<table>
<thead>
<tr>
<th>Vegetation class</th>
<th>Percent vegetation cover</th>
<th>Detection probability</th>
<th>Sightability correction factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>0–20</td>
<td>0.9576</td>
<td>1.044</td>
</tr>
<tr>
<td>Class 2</td>
<td>21–40</td>
<td>0.7813</td>
<td>1.280</td>
</tr>
<tr>
<td>Class 3</td>
<td>41–60</td>
<td>0.3611</td>
<td>2.770</td>
</tr>
<tr>
<td>Class 4</td>
<td>61–80</td>
<td>0.0821</td>
<td>12.183</td>
</tr>
<tr>
<td>Class 5</td>
<td>81–100</td>
<td>0.0140</td>
<td>71.676</td>
</tr>
</tbody>
</table>
RESULTS

Population size and density

The stratification flight for the Raft survey (MU 3-40) occurred 25 January 2009, and the helicopter survey took place on 6 days from 29 January to 6 February. Weather conditions during the stratification flight were excellent with clear skies. Weather conditions for the survey flights were variable but generally good to excellent, ranging from overcast to clear skies, with light winds. Three survey days were delayed due to early morning fog that generally burned off by noon. Temperatures ranged from −9 to +2 °C. Snow cover was complete in all SUs surveyed, and varied both by elevation and among valleys due to micro-climate variation.

During 2.2 hours of stratification flight we counted 15 moose and recorded 187 groups of tracks. Final SUs averaged 19.6 km² in size (±0.69, 12.1−28.8 km², n=34). We surveyed all 5 high-density SUs, 8 of 15 medium-density SUs, and 3 of 14 low-density SUs. We flew 22 hours, and spent 15.5 hours on survey, average survey intensity was 2.9 minute/km² (±0.15; range 2.0−4.1 min/km²). We counted 250 moose in 135 groups (range 1−11 moose/group; Fig. 2, Table 2).

The naive (uncorrected for sightability) estimate was 323 moose (Table 2). When the sightability correction was applied, our estimate was 424 moose (±95 moose or 22% [90% CI]; 329−519 moose; CV=0.13; Table 2). The overall sightability correction factor was 1.31. Corrected density averaged 0.63 moose/km² within the survey area.

Table 2. Moose population estimate statistics for MU 3-40, Raft River area, North Thompson, Jan-Feb 2009.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Stratum 1 (high)</th>
<th>Stratum 2 (medium)</th>
<th>Stratum 3 (low)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of SU in stratum</td>
<td>5</td>
<td>15</td>
<td>14</td>
<td>34</td>
</tr>
<tr>
<td>No. of SU surveyed</td>
<td>5</td>
<td>8</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Total stratum area (km²)</td>
<td>106.0</td>
<td>305.3</td>
<td>266.2</td>
<td>677.5</td>
</tr>
<tr>
<td>Area of surveyed SUs (km²)</td>
<td>106.0</td>
<td>167.9</td>
<td>50.1</td>
<td>324.0</td>
</tr>
<tr>
<td>Moose observed</td>
<td>178</td>
<td>68</td>
<td>4</td>
<td>250</td>
</tr>
<tr>
<td>Uncorrected (naive) estimate</td>
<td>178</td>
<td>124</td>
<td>21</td>
<td>323</td>
</tr>
<tr>
<td>Sightability correction factor</td>
<td>1.29</td>
<td>1.36</td>
<td>1.15</td>
<td>1.31</td>
</tr>
<tr>
<td>Corrected population estimate</td>
<td>231</td>
<td>168</td>
<td>25</td>
<td>424</td>
</tr>
<tr>
<td>Standard error</td>
<td>32</td>
<td>45</td>
<td>9</td>
<td>55</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>0.14</td>
<td>0.27</td>
<td>0.39</td>
<td>0.13</td>
</tr>
<tr>
<td>Corrected density (moose/km²)</td>
<td>2.18</td>
<td>0.55</td>
<td>0.09</td>
<td>0.63</td>
</tr>
</tbody>
</table>

MU 3-40 moose inventory, Jan-Feb 2009
Figure 2. Moose inventory study area for Management unit 3-40, 29 Jan-06 Feb 2009. Red dots are moose observations scaled from 1 to 11 animals. High density stratum shown in red shading, medium density shown in green shading, and low density stratum shown in light blue shading. Blocks surveyed are shown with cross-hatching.
Composition and distribution

The estimated bull:cow ratio was 73:100 and cow:calf ratio was 37:100. Average sightability corrections were similar between cows (1.18) and bulls (1.16), but higher for calves (1.32). Unclassified animals were generally in thicker cover and had a higher average sightability correction (2.17). Accounting for unclassified animals (all adults), we estimated approximately 153 bull moose for the survey area. One set of twin calves was observed in the Raft drainage. One radio-collared cow moose was also observed during the survey in the lower Raft. Moose were distributed throughout a 670 m elevation band ranging from 425–1100 m, with 80% of the moose observed <800 m (Fig. 3).

Table 3. Observed and estimated (corrected for sampling and sightability) sex and age classification and ratios for moose for MU 3-40, Raft River area, North Thompson, Jan-Feb 2009. The "observed" ratios were corrected for sampling using MOOSEPOP. The "estimated" ratios were corrected for sightability using AERIAL SURVEY, and should be more accurate at the MU level.

<table>
<thead>
<tr>
<th></th>
<th>Cows</th>
<th>Calves</th>
<th>Bulls</th>
<th>Unclass. adults</th>
<th>Total</th>
<th>Calves:100 cows (90% CI)</th>
<th>Bulls:100 cows (90% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>140</td>
<td>46</td>
<td>98</td>
<td>39</td>
<td>322</td>
<td>33 (27–39)</td>
<td>70 (58–81)</td>
</tr>
<tr>
<td>Estimated</td>
<td>161</td>
<td>60</td>
<td>117</td>
<td>86</td>
<td>424</td>
<td>37 (26–48)</td>
<td>73 (58–88)</td>
</tr>
</tbody>
</table>

The majority of moose were observed in open habitat types (74%), consisting of deciduous mixed (39%), old cutblock with advanced conifer regeneration (24%), recent cutblock (5%), road (3%), riparian shrub (2%) and river (1%). Only 24% of the moose observed during the survey were in conifer forest habitats.

Figure 3. Elevation distribution of moose observed during Management unit 3-40 survey, 29 Jan-06 Feb 2009.

MU 3-40 moose inventory, Jan-Feb 2009
Other species

Mule deer were observed frequently during the survey, and groups were recorded but classification and counts were not attempted. Locations of wintering groups of mule deer were provided to the MoE to help refine mule deer winter range mapping. One lynx (*Lynx canadensis*) was observed on a ridge off the east Mad River in amongst wintering mule deer. One wolverine (*Gulo gulo*) track was observed in the mid-Raft drainage traveling along the open riparian corridor. Mountain caribou are generally found at higher elevations (> 1,200 m) during this time of year and none were observed during the survey or ferry flights throughout the study area.

Based on our observations and confirmed by GPS/radio-telemetry, a single pack of 11 wolves was observed on 2 consecutive days in the Raft drainage. On 31 January we observed the pack (9–10 individuals estimated) on a moose kill in a regenerating cutblock along a forest service road (800 m elev.) near McCorvie Creek. On 01 February we observed the same pack 5 km further upstream traveling along the riparian corridor (720 m) of the Raft River (11 individuals counted). An individual in this pack was collared on 29 January as part of an on-going predator-prey research project in mountain caribou range (BC MoE, unpub. data). We also observed 2 moose kills (powerline and forest service road) on 04 February above the North Thompson near Avola and consequently observed 2 bedded wolves nearby. Numerous wolf tracks were recorded in the mid-Raft drainage and North Thompson valley bottom near Avola, and 3–5 sets of tracks were seen 5 km west of the community of Blue River.

DISCUSSION

Survey methods

The survey for moose in MU 3-40 was conducted using standardized techniques and methodology similar to recent surveys in southern BC (*Gyug 2005, Poole 2006, Serrouya and Poole 2007, Stent 2009*). Survey methodologies, including estimates of sightability, were standardized and reviewed regularly with all personnel involved. Sampling effort averaged 2.9 min/km², which is consistent with previous surveys noted above.

The vegetation cover sightability correction for the survey was 1.31. Sightability correction values from recent surveys in the Kootenays have ranges from 1.27 to 1.79 (Poole 2006, Serrouya and Poole 2007, Stent 2009). Heavily timbered MUs in the Purcell and Columbia mountains required between 3.8–4.0 min/km² of survey intensity (Poole 2006, Serrouya and Poole 2007). The lower correction factor is probably realistic, and equates well with the open habitat types that most moose were observed in. Snow depths in the study area were higher than usual, which may have result in lower elevation use by moose, with 80% observed below 800 m elevation. Previous winter surveys (classification counts) observed moose in a wider elevation band, with proportionately more animals up to 1,200 m (MoE, unpub. data). No fresh moose tracks were observed above 1,100 m during upper boundary transects of SUs and ferry flights.

A key component to conducting a successful SRB inventory is to ensure stratification is accurate (Gasaway et al. 1986). This has little implication to the variance estimate in the high stratum when all SUs are surveyed (resulting in no sampling variance), but has greater impact on medium and low strata. Generally, the assigned stratification for the Raft survey was acceptable. Lack of recent snowfall for several days before the stratification flight may have compromised our stratification due to lingering moose tracks that may have looked recent during the flight. In addition, snowfall occurred during the survey, totalling approximately 30 cm over several days, which may have influenced moose movements and distribution.

Population status, composition and distribution

This was the first time a SRB moose survey was conducted for MU 3-40, making historic comparisons difficult, although moose observations were recorded during the 2005 moose composition
The 2009 SRB survey estimate for MU 3-40 is 424 moose (±95 moose [90% CI]), which is greater than the current estimate of 300 moose (MoE, unpub. data).

Management of moose populations based on the boundaries of current wildlife management units can be problematic, because the bottom of drainages and height-of-land are used for boundaries. MU 3-40 has approximately 72% (184 km of 254 km) of its boundary following riparian corridors. Wintering moose populations frequently use low elevation valley bottoms and are not restricted by riparian corridors. Due to the above average snowpack at low-elevations in late January-early February 2009, many moose were concentrated on winter ranges in MU 3-40. These moose likely share summer and transitional ranges with other adjacent MUs. Recent work using radio-collared moose in and adjacent to the study area reveals that moose will travel up to 50 km during fall/winter migrations overlapping 2 or more MUs (BC MoE, unpub. data).

Although the 2005 composition survey did not provide absolute abundance estimates, it did provide moose classification for portions of MU 3-40 that were surveyed. Calculations based on the 2005 raw classified survey data provides a bull:cow ratio of 83:100 and a calf:cow ratio of 43:100, which suggests a healthy, stable or increasing population indicative of a lightly harvested population and good calf survival (Lemke 2005). Lemke (2005) noted that a small sample size and lack of consistent time series data preclude any definitive conclusions for determining population trends. The 2009 Raft survey provides corrected ratios slightly lower than in 2005, with a 73 bull:100 cow ratio and 37 calf:100 cow ratio. The BC wildlife harvest strategy (MELP 1996) states that to maintain high moose productivity and avoid declines in pregnancy rates, bull ratios should be above 30 bulls:100 cows. Maintaining a 50 bull:100 cow ratio has been suggested to provide a greater margin of safety from declines in reproduction for low-density populations (Timmermann 1992). The 2009 Raft survey bull:cow ratio exceeds both these recommended ratios and may be indicative of a lightly hunted population (Hatter 1998). The calf:cow ratio required to maintain a stable population in the absence of hunting has been estimated to be 25 calves:100 cows (Bergerud 1992), but may be as high as 30-45 calves:100 cows in harvested populations depending on the adult harvest and natural mortality rates (Hatter and Bergerud 1991). The 2009 Raft survey calf:cow ratio is slightly under the long-term regional average of 40 as set out by MoE managers in the Thompson Region (Lemke 2005).

The observed 2009 Raft survey calf:cow ratio of 49:100 for the lower Clearwater corridor SUs (includes areas adjacent to the community of Clearwater) was much higher than the combined Raft/Mad/North Thompson SUs with 26 calves:100 cows. No wolves or moose kills were observed near the community of Clearwater or along the lower Clearwater corridor, whereas 2 known wolf packs and 3 moose kills were observed in the Raft River and North Thompson drainages, which may have played a factor in the different ratios between these areas (Fig. 4). One railway killed moose was also recorded near Avola, BC, which had been scavenged by a pack of wolves.
Another factor that may have increased variability in moose numbers among the SUs was the presence of a pack of 11 wolves in the Raft drainage. On 29 January, a wolf from this pack was captured and outfitted with a GPS collar in the upper-Raft drainage near Stratton Creek. After 2 days it traveled, presumably with the pack, approximately 24 km downstream to where we observed the pack on 31 January and the next day 5 km north along the riparian flats of Raft River. Three SUs were surveyed (2 Med, 1 Low) where the wolves occurred in the mid- to upper-Raft and only 7 moose were observed, while we observed 101 moose in 3 SUs (2 High, 1 Med) surveyed downstream of where the wolves stopped their travel. Likely, the above average snowpack played a large role in moose movements and distribution during this time, but it is striking to note that where the wolf pack terminated their downstream travel that moose numbers increased abruptly and substantially (Fig. 5). Kunkel and Pletscher (2000) found that the density of moose in southeastern BC was greater at sites where moose were killed by wolves than at control sites, and moose that space out can apparently increase their odds of survival. Our observations in the Raft support these findings with moose spaced out in areas where wolves roamed and were congregated downstream of where moose kills were located.
Figure 5. Map of wolf #44 GPS locations and general movements (green squares) in relation to moose groups (red dots scaled from 1-11) in the Raft River drainage, 29 Jan-15 Feb 2009.
MANAGEMENT IMPLICATIONS

No previous surveys for absolute abundance of moose have been completed for MU 3–40. Therefore, no obvious population trends can be inferred from the data, but previous classified count indices have remained relatively stable with 2009 data showing only slightly lower bull and calf ratios. These ratios are still above general recommended ratios for maintaining stable healthy moose populations (Timmermann 1992, Hatter 1998).

Our population estimate of 424 moose seems reasonable considering MU 3-40 had above average snowdepths, which likely concentrated moose from surrounding areas onto low-elevation high quality winter ranges in the study area. We recommend that continued monitoring of moose populations in the North Thompson using formal standardized inventory methods be conducted on a regular basis (every 3–5 yrs).

Wolves may be a significant factor in reducing the calf:cow ratios in the Raft, Mad, and North Thompson drainages, as suggested by the increased number of moose kills and wolf observations in these areas during the 2009 survey. Any planned predator reduction without similar reduction in primary prey will likely result in the rapid return of predators to their previous level (Bergerud and Elliot 1998, Hayes et al. 2003). Likewise, any rapid reduction in alternative prey, either through hunting or a severe winter, will likely result in increased predation risk on caribou. Managers should consider both these factors when attempting to manage the predator/prey system. Research investigating the dynamics of multi-predator/prey ecosystems in mountain caribou range in the North Thompson is on-going.

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LITERATURE CITED


MU 3-40 moose inventory, Jan-Feb 2009


Poole, K. 2006. Moose inventory of Management Units 4-22 (Bull River) and 4-20 (St. Mary River), East Kootenay, January 2006. Unpublished report prepared for British Columbia Ministry of Environment, Cranbrook, British Columbia.


