WINTER MOOSE POPULATION CHARACTERISTICS DURING PRE-FLOODING STAGES OF HYDRO-ELECTRIC DEVELOPMENT IN BRITISH COLUMBIA

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Abstract: Winter moose population characteristics were studied from 1977-1983 in the Columbia valley region of east-central British Columbia, an area currently experiencing hydro-electric development. The area population of approximately 250 moose was stable during the study. A total of 2016 moose observations in 1182 groups were made using intensive ground observation and helicopter survey methods. Mean group size was negatively correlated with time over the winter period. Cow-calf milk units were part of 74% of groups with ≥2 moose. Winter age composition averaged 27.7% calves, 16.8% yearlings and 53.6% adults. Sex ratios of calves and yearlings were equal while adult sex ratios averaged 40 bulls/100 cows. There were significant declines in calf/cow ratios and twinning rates over the winter period. Population parameters were rate of increase of 0, gross productivity of 57%, and net productivity of 20%. There was 67% calf mortality during the first year of life. Yearling recruitment of about 42 moose was approximately equal to adult mortality.

Hydro-electric dam construction and associated reservoir pondage area clearing have had minimal effect on moose populations to date. This study provides baseline data to be used in assessing impact of fall 1983 reservoir formation on the resident moose population.

British Columbia Hydro and Power Authority (BCHPA) is a Provincially owned Crown corporation responsible for supplying the majority of electric power requirements of British Columbia. In 1977, BCHPA began construction of a major hydro electric power development on the Columbia River near Revelstoke in east-central British Columbia. The 136 km.^{2} impoundment will stretch 149 km. between previously completed reservoirs and is scheduled to be flooded during the fall of 1983 (Fig. 1). Because mountainous terrain and heavy snow accumulations limit moose to low elevation winter range the project is expected to produce significant impacts on resident moose populations.

Studies designed to determine local aspects of moose ecology in relation to ongoing developments have been underway since 1977. This paper represents the first contribution of a series of reports describing results of the moose impact assessment program. Aspects of herd age and sex composition, group size, productivity and mortality during the 6 year pre-flooding stage of development are examined herein.

Moose are comparitively new residents, having arrived in the study area sometime during the late 1940's (Munro, 1947; Peterson, 1955). Local guide outfitter E. Wallis recalls seeing moose as early as 1950 and estimates that populations increased rapidly to "near the present level" by the end of the decade. During this study, populations have remained fairly constant at 250 - 275 moose (Bonar, unpub. data).

STUDY AREA

The study area includes the watershed of the Columbia River between Revelstoke and the Mica Dam in east-central British Columbia.

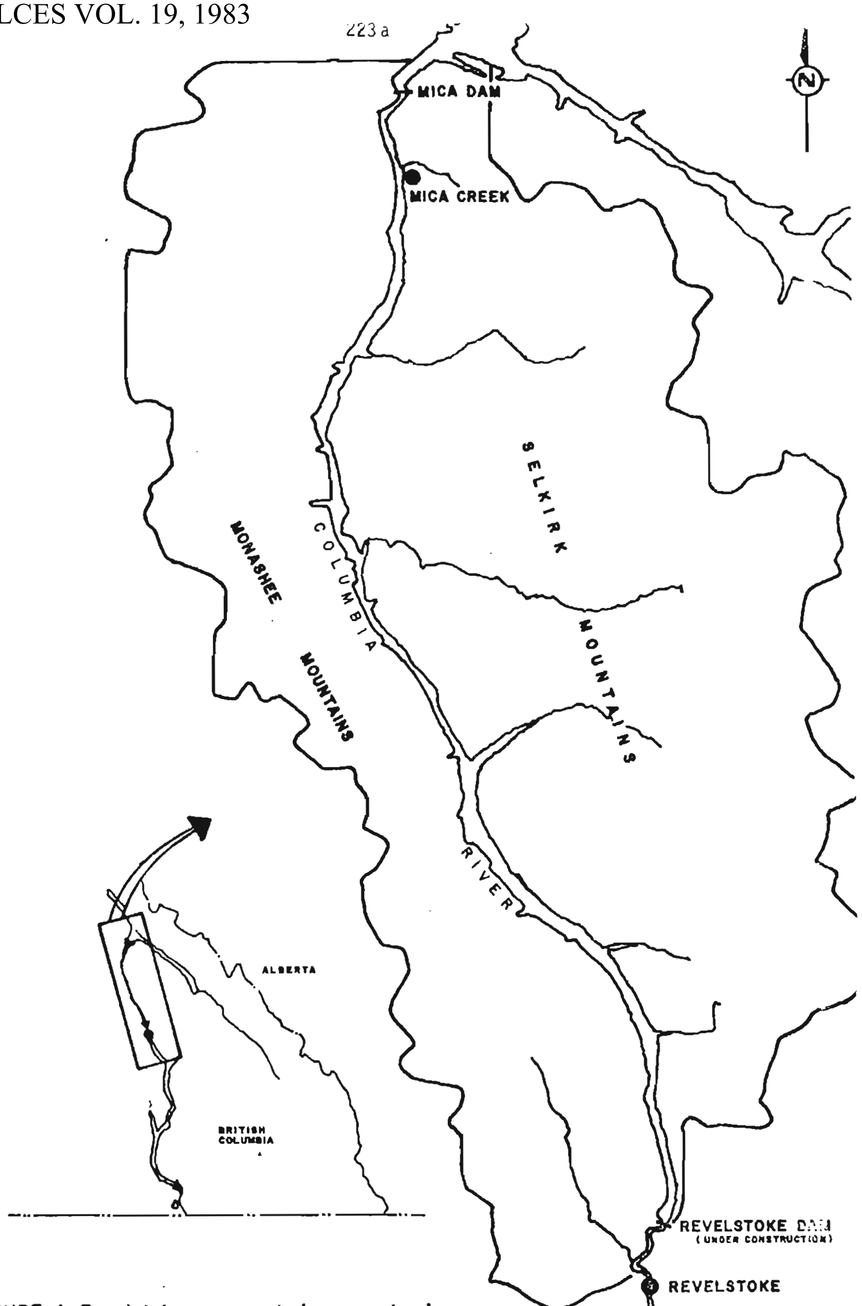

FIGURE 1: Revelstoke moose study area showing proposed reservoir.

Physiography of the area includes a predominance of tilted landscapes ranging in elevation from 349 m at Revelstoke to 3706 m at Mt. Chapman. The Columbia River runs from north to south in a narrow valley bordered by the Monashee Range to the west and the Selkirk Range to the east. Glacial shaping has strongly influenced the area. Many tributary streams are contained within hanging valleys with steep gradients near their mouths. Terraces, aluvial fans and riparian floodplains are present within the mainstem valley and larger tributaries, and represent the only areas of shallow slope.

Surficial deposits are mainly till and glacio-fluvial materials, with some glacio-lacustrine deposits in localized areas (Achard 1973). Soils are generally shallow and of low productivity. Ortho humo-ferric podzols predominate, with some acidic organics and regosols on alluvial deposits (ERC 1976).

The area is within the Interior Wet Belt climatic region, with relatively high precipitation throughout the year. Annual precipitation averages 105 cm (including 381 cm snow) at Revelstoke and 146 cm (737 cm snow) at Mica Creek. Snow depths on moose winter range usually surpass 100 cm and occasionally exceed 200 cm for short periods. The mean annual temperature at Revelstoke is 7.2°C with monthly averages between -5.9°C in January and 19.4°C in July. At Mica Creek the mean temperature is 4.2°C, varying from -10.4°C (January) to 17.1°C (July).

There are three biogeoclimatic zones in the study area. These are the Interior Western Hemlock (<u>Thuja plicata</u>) Zone, the Engelmann Spruce (<u>Picea engelmanni</u>) Subalpine Fir (<u>Abies lasiocarpa</u>) Zone, and the Alpine

Zone (Krajina 1969). Vegetal characteristics are discussed by Paish (1974) and ERC (1976).

Most of the area is covered with mature coniferous forests. Seral stages are present on extensive logged and burned areas as well as avalanche paths and along watercourses in riparian associations.

METHODS

Two methods were used to survey moose from November-April during the winters of 1977-78 to 1982-83. A Bell 206-B helicopter was used to conduct aerial surveys after fresh snowfalls from December-March. The pilot and 3 observers all searched for moose or fresh tracks after which a search was made to locate any moose present. Age-sex composition and group size were determined for each aggregation where individuals were within 50m of each other. Sex of adult (≥1½ yrs) moose was determined using the white vulval patch technique (Roussel 1975) and by the presence of antlers or pedicels on males. Moose were assigned to calf, adult cow, or adult bull age classes. Antlered bulls were separated into yearling or adult (>1½ yrs) classes based on antler characteristics. Yearling bulls typically had 2 or 3 fork antlers or spikes with little or no paddle development.

Ground surveys on the same areas and during the same periods were conducted using binoculars and a 20-45X zoom spotting scope. Sex of calves was determined where possible using antler knobs and/or urination posture as definitive criteria. There was no difference ($P > 0.10$)

between results obtained by the 2 methods and data were collated to be analyzed on a monthly basis.

Hunting statistics were obtained from B.C. Fish and Wildlife Branch Harvest Questionnaire returns.

RESULTS AND DISCUSSION

Moose populations have remained stable at 250-275 animals during the study period (Bonar, unpubl. data). The population is isolated by rugged mountains to the east and west and reservoirs to the north and south. Ongoing tagging studies (Bonar, unpubl. data) indicate that most moose are largely non-migratory except for summer use of adjacent higher elevation habitats.

Group size and composition

Observations were made of 2,016 moose in 1,182 aggregates of 1-8 individuals (Table 1). Differences in mean group size among months between years and between winters were not significant ($P > 0.10$). Group observations were summarized by month to show trends (Table 1). Mean group size was negatively correlated with time over the winter period ($r = 0.9252$ $P < 0.01$), declining from 2.0 in December to 1.5 in April. The overall mean group size of 1.7 is similar to averages from Alaska, Minnesota and Montana (Peek et al. 1974). Groups with 1-3 moose accounted for 97.8% of all observations. Eleven of 27 groups with ≥4 moose were observed in December including the 3 groups ≥6 moose.

Table 1. Group size composition of Columbia River moose during winter period 1977-78 to 1982-83.

Month	N	No. of Groups	Mean Group Size	% total no. moose by group size 1	2	3	4	5	6	7	8
Nov.	59	31	1.9	35.5	38.7	25.8					
Dec.	357	179	2.0	40.2	33.0	20.8	3.9	0.6	0.6	0.6	0.6
Jan.	765	453	1.7	47.0	38.9	12.6	1.3	0.2			
Feb.	410	245	1.7	46.5	41.2	9.8	2.5				
Mar.	394	253	1.6	54.9	35.6	8.7	0.4	0.4			
Apr.	31	21	1.5	61.9	33.3		4.8				
Total	2016	1182	1.7	47.6	37.6	12.5	1.8	0.3	0.1	0.1	0.1

There was no difference ($P > 0.10$) in percentages ($\bar{x} = 12.2$, range 11.2-15.3) of single bull moose in total monthly populations over the winter period. However, bulls comprised 81.8% of single moose in November and declined to 36.0% by March (Table 2). There was a corresponding increase in percentages of single cows and calves that was expected as over-winter breakup of cow-calf units and calf mortality contributed to an increase in the number of singles in the population.

Table 2. Group composition of Columbia River moose during winter period 1977-78 to 1982-83.

Month	Single Moose N	Cow %	Bull %	u/c %	Calf %	Moose Groups ≥ 2 N	cow calf	cow 2 calf	Other [1]
Nov.	11	9.1	81.8	9.1		20	45.0	35.0	
Dec.	70	31.4	57.2	10.0	1.4	108	38.0	19.5	15.7
Jan.	213	34.3	44.2	17.4	4.2	240	48.3	11.7	13.8
Feb.	116	40.5	44.0	9.5	6.0	131	55.7	12.2	6.9
Mar.	139	45.3	36.0	10.8	7.9	114	52.6	10.5	6.1
Apr.	13	15.4	15.4	61.5	7.7	8	75.0		12.5
Total	562	37.0	43.8	14.1	5.2	620	49.2	13.6	10.8

1. Other groups with at least 1 cow-calf component

Discrete cow-calf or cow-2 calf milk units accounted for 62.8% of those groups ≥ 2 moose (Table 2). Additionally, 10.8% of other groups had at least 1 milk unit as part of their composition. These data support earlier conclusions that the milk unit is the basic social unit in moose populations where calf survival is high (deVos et al. 1967).

Age and sex composition

There was little difference between years in the percentage of calves in the winter population (Table 3). Calves averaged 27.7% (range 26.8-35.2%) of all moose observed. This is within the range of percentages from other studies (Edwards and Ritcey 1958; Pimlott 1959; Bishop and Rausch 1973; Hauge and Keith 1981). Calves declined over the winter period as a proportion of the total population (Table 4) but this decline was not significant ($P > 0.10$).

Table 3. Age-sex composition of moose between years during winter in the Columbia River drainage 1977-78 to 1982-83.

Year	N	Calf %	Adult Cow %	Bull %	Bull/100 Cows	Calf/100 Cow ≥ 2½	Twinning Rate %
77-78	235	31.9	51.1	27.2	17.4	64:100	117:100	30.9
78-79	202	35.2	48.0	31.7	8.4	27:100	111:100	17.3
79-80	293	27.3	56.0	31.4	10.6	34:100	87:100	18.2
80-81	230	32.3	50.9	35.7	11.7	33:100	90:100	21.4
81-82	683	26.8	56.5	36.2	14.3	40:100	74:100	18.1
82-83	373	30.8	52.5	31.6	14.2	45:100	97:100	32.5
Total	2016	29.7	53.6	33.1	13.2	40:100	90:100	22.4

Percentages of yearlings in the winter population could not be determined using the recorded value of 8.7% because yearling males could not be recognized after antlers were dropped. Yearling percentages of December surveys when most bulls still have antlers are a better estimator of true values; because low sample sizes from individual Decembers produced a high variance data were combined and a mean value of 16.8% yearlings was used for age composition analysis.

Adults average 53.6% of the population, with 33.1% cows, 13.2% bulls and the remainder unclassified (Table 3). There were no particular trends between winters or over the winter period.

Sex of calves could not be determined by aerial survey. Both sexes had some whitish hair around the anal area and it was difficult to separate calves by sex on this basis. Antler knobs on male calves could not be reliably observed from the air even on close inspection from a helicopter.

Sex was determined for 69 calves (M = 33, F = 36) by ground observation. The ratio of this sample approached unity as expected (Peterson 1955; Schladweiler and Stevens 1973).

Antler size restrictions limited hunter harvest to bulls > 1½ years old during the study period. The protection of yearling bulls means yearling sex ratios should be equal as in calves.

Bulls only hunting was the major reason for an adult sex ratio averaging 40 bulls/100 cows (Table 3). Differences in bull/cow ratios between years were not significant ($P > 0.10$). In general, lower ratios

were recorded in years where hunter harvest of mature bulls was highest although the correlation was not significant ($r = 0.5614$, $P > .10$).

Bull/cow ratios showed a significant ($P < 0.05$) decline over the winter period (Table 4). Two factors which may partially explain this difference are 1: bulls were easier to recognize early in the winter when antlers were still carried. Apparently decline in numbers of bulls may be attributable to antlerless bulls being a greater proportion of unclassified animals as the winter progresses. At the same time, cows are easily recognized when accompanied by calves and tend to be classified more often. 2: Bulls may show different habitat utilization patterns than cows or cow-calf units and become less visible as the winter progresses. Telemetry (unpublished) in the area indicates that bulls have higher mobility, larger winter home ranges, and may move to higher elevations sooner than cows.

Table 4. Age-sex composition of moose during winter period in the Columbia River drainage 1977-78 to 1982-83.

Month	N	Calf	Adult	Cow	Bull	Bull/100 Cows	Calf/100 Cow ≥ 2½ yrs	Twinning Rate
		%						
Nov.	59	39.0	44.1	23.7	16.9	71:100	164:100	37.5
Dec.	357	30.5	52.7	30.0	19.0	64:100	102:100	33.8
Jan.	765	29.7	53.5	31.6	12.0	38:100	94:100	22.0
Feb.	410	31.0	52.2	33.[illegible]	12.2	37:100	93:100	20.4
Mar.	394	6.[illegible]	57.[illegible]	40.6	11.2	28:100	64:100	15.2
Apr.	31	29.0	54.8	22.6	6.5	28:100	126:100	14.3
Total	2016	29.7	53.5	33.1	13.2	40:100	90:100	22.0

Calf/cow ratios averaged 90 calves/100 cows (Table 3) and differences between years were not significant (P>0.10). There may be a relationship between the calf/cow ratio and winter severity but this was not examined.

Early-winter calf/cow ratios were highest (Table 4) and ratios declined significantly (P< 0.01) in following months. This trend generally did not show in data from individual years due to small sample sizes and unequal sampling effort. The average December-March calf loss was 42%.

Observed twinning rates during winter surveys varied considerably between years, averaging 22% of all cows with calves. There was a significant (P< .01) decline over winter from 34% in December to 16% in March (Table 4).

Productivity

Limited information on pregnancy rates was obtained from a sample of 9 adult cows killed by accident or other causes during the December-April period. All of these moose were pregnant with visible fetuses and 7 (78%) were carrying twins. Additionally, 1 radiocollared cow bore twins 4 years of 5 and another 3 years in a row. Although this constitutes very limited evidence it appears that production of calves by adult cows in this area may be higher than in most other areas studied. Edwards and Ritcey (1958) sampled 20 adult cows during the winter period in Wells Gray Park and found all bearing calves including 9 (45%) pairs of twins. In Montana, a sample of 80 pregnant adult cows contained 13 (16%) pairs

of twins (Schladweiler and Stevens, 1973), and in Newfoundland 25 (14%) of 182 adult cows were carrying twins (Pimlott, 1959).

Since the size of the moose population has remained stable the rate of increase is 0. The adult cow (≥2½ yrs) population of approximately 80 animals could produce as many as 142 calves, a gross productivity rate of 57%. However, the calf/cow ratio declines by the following March from the 1.78 calves/adult cow to 0.64 calves/adult cow leaving net production of 20%. Since the yearling percentage of the population averages 17% there is an average annual recruitment of about 43 moose to the population.

Mortality

The large decline in calf/cow ratios between spring and early winter surveys are probably due mainly to predation. Many recent studies (LeResche 1968; VanBallenberghe 1979; Franzmann and Schwartz 1980; Hauge and Keith 1981; Gasaway et. al. 1983) have demonstrated high calf mortality during the first 6 months of life that was attributable to predation primarily by wolves _Canis lupus_, black bears _Ursus americanus_ and grizzly bears _Ursus arctos_. Moose/predator ratios for these species at Revelstoke are approximately 35.7 (wolf), 0.50 (black bear), and 1.25 (grizzly bear). Potential calf moose predators outnumber the entire moose population by a 2.8:1 ratio.

Calf/cow ratios remain nearly equal during the December-February period, then decline sharply to 64 calves/100 adult cows in March (Table 4). Most of this late-winter decrease is due to "winterkill" and is mainly a function of snow accumulations >100 cms that increase calf mortality disproportionately to that of longer-legged adults. Many of these mortalities are accidents where calves get bogged down in windfall or ravines and cannot escape due to deep snow. Calf mortality patterns are not affected by wolf predation. Similar declines manifest over the 40% segment of the moose population that is subject to winter wolf predation and the remaining portion where wolves are not present.

In summary, approximately 142 calves produced by 80 adult cows decline 64% to 51 by March of the year following birth at which time calves are 20% of the moose population. Another 3% (9 moose) loss occurs during the second summer because yearlings comprise about 17% of the early-winter population. Yearling recruitment balances adult mortality to produce a stable population.

An average of 21 adult bulls are harvested each year (Table 5). Other recorded mortalities include roadkills, tagging losses, winterkill and accident and illegal kill. When combined these losses amount to 30 animals annually or about 71% of yearling recruitment.

The annual moose kill by 7-10 wolves could equal 59-84 using an estimated moose kill per wolf per month of 0.70 (Bergerud et. al. 1983). Although little wolf predation has been observed 59% (N = 29) of wolf scats examined contained moose remains. In this area wolves also prey on beaver Castor canadensis, caribou Rangifer tarandus, and possibly on mule deer Odocoileus hemionus and mountain goats Oreamnos americanus. If moose makes up about 60% of the diet then the estimated wolf kill is probably closer to the 35-50 range.

Table 5. Recorded Mortality of Columbia River moose 1977-1983

Year	hunting[1]	roadkills	tagging mortality	winterkill+ accidents	illegal kill	total
77-78	15	5		1		21
78-79	39	4		3		46
79-80	18	3		6		27
80-81	19	5	1		2	27
81-82	12	3	4	8		27
82-83	(22)	4	1	1	2	30
total	125	24	6	19	4	178
average	21	4	1	3	1	30

1. estimated kill (B.C. Fish and Wildlife data)

SUMMARY

Age and sex ratios of the population have remained stable over a 6 year period. Percentages of calves, yearlings and adults in the population approximate many other published observations. However, the estimated reproductive rate and twinning rate during winter surveys appear to be much higher than in most other North American studies. High calf mortality contributes to yearling recruitment that equals adult mortality.

Removal of vegetation from the reservoir pondage area starting in 1978 has had no measurable effect on moose populations largely because animals still utilize cleared areas that rapidly regenerate browse and a series of high quality habitats that were reserved from clearing until just prior to pondage area flooding. As these areas will no longer be available starting with the 1983-84 winter moose will be forced to use remant winter range that may be of lower quality. This may contribute to

a decline in resident moose numbers and associated changes in population characteristics. The present study was designed to provide baseline data and will be useful in measuring expected changes during the future.

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