MANAGEMENT ALTERNATIVES FOR UTAH MOOSE

W.H. Babcock, J.F. Kimball, J.A. Rensel
Utah Division of Wildlife Resources
515 East 5300 South, Ogden, Utah 84403

and

M.L. Wolfe
Department of Fisheries and Wildlife
Utah State University - UMC 52
Logan, Utah 84322

ABSTRACT: Since the mid-1960's moose (*Alces alces*) numbers have increased significantly in northern Utah. Previous studies of the principal population, located on the north slope of the Uinta Mountains, estimated winter range carrying capacity. This report examines two proposed management alternatives, maximum-yield and trophy management. Manipulation of the adult sex ratio by sex-discriminate harvests produced changes in herd productivity. During the period 1964-1971 the mean bull:cow ratio observed in winter counts was 1:2.2 and the mean productivity was estimated at 74 calves/100 cows. Following an artificial adjustment in the bull:cow ratio to approximately 1:3.6, the mean productivity was estimated at 46 calves/100 cows. Returning the bull:cow ratio to pretreatment levels appears to have increased productivity. A parallel study of antler charactristics in relation to age, indicated that moose attained 80-85% of observed maximum growth at 4-5 years

of age. The proposed management alternatives are evaluated considering these results.

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The expansion of moose (*Alces alces*) into Utah occurred relatively recently. Bailey (1944) considered the southern limits of established populations of the Shiras subspecies (*A. a. Shirasi*) to be in the vicinity of Kemmerer and Lander Wyoming. By the early 1950's, however, a resident population of moose was established on the north slope of the Uinta Mountains of northern Utah. This population has served as the nucleus for the establishment of moose in adjacent areas.

In 1956, the Utah Division of Wildlife Resources initiated annual aerial censuses of the Uinta North Slope population with counts fluctuating between 53 and 93 during the following decade (Table 1). Thereafter, however, the growth rate of the herd accelerated rapidly, with the population exceeding 300 animals by the early 1970's. Due to the relatively restricted areal extent of winter range on the Uinta North Slope, winter food supply was considered to be the primary factor that would ultimately limit the population. Based on this premise, an investigation was initiated in 1969 in which the primary objectives were to determine: (1) key browse species utilized by moose during the winter months; (2) the areal extent, density and utilization of those browse species by moose; and (3) the carrying capacity for moose of the key browse species

Table 1. Winter counts and legal harvest for the Uinta North Slope moose herd, 1957-1980.

	Midwinter trend count[a]				Annual harvest[c]		
Year	Bulls	Cows	Calves	Total[b]	Bulls	Cows	Calves
1957	9	19	10	59	0	0	0
1958	0	0	0	52	7	0	0
1959	9	28	16	53	5	0	0
1960	10	50	24	84	10	0	0
1961	6	21	20	65	8	0	0
1962	15	52	19	90	7	0	0
1963	--------No Count--------				9	0	0
1964	25	38	25	91	8	0	0
1965	23	37	33	93	8	0	0
1966	9	21	15	45	5	0	0
1967	15	33	29	87	10	0	0
1968	19	63	51	133	9	0	0
1969	36	94	67	198	19	0	0
1970	--------No Count--------				18	0	0
1971	72	141	94	308	30	0	0
1972	66	136	91	293	69	0	0
1973	47	126	69	242	52	0	0
1974	48	178	69	296	13	0	0
1975	44	167	78	291	16	0	0
1976	47	160	83	290	45	0	0
1977	--------No Count--------				20	16	2
1978	88	201	102	391	55	16	0
1979	86	198	114	398	21	48	17
1980	109	193	133	435	33	16	5

[a]Beginning in 1964 counts were made with helicopters.
[b]Totals include unclassified animals.
[c]Beginning in 1970, figures include Wyoming harvest.

available on the winter range.

Wilson (1971) found Drummond's willow (*Salix drummondiana*) and Geyer's willow (*S. geyeriana*) to be the primary winter browse species for moose. These two species accounted for 92.0% and 4.7%, respectively of all observed winter feeding occurrences and comprised 59% and 31%, respectively, of all the willow on the study area. Based on these figures, and estimates of the average daily energy requirements for moose as well as the caloric capacity of the key browse species, Wilson (1971) estimated the carrying capacity of the winter range as the equivalent of 445 adult animals for a 6-month period. Although this estimate has been subject to further refinement based on the results of subsequent studies (cf. Babcock 1977), it has served as an operational carrying capacity for the management of this herd.

Given the finite nature of the winter carrying capacity, various directions for future managment were considered. One alternative was a maximum yield system, in which the maximum number of cows and calves would be carried through the winter and the majority of the adult bulls would be removed from the herd during the fall hunting seasons. Kimball and Wolfe (1978) reported that under a similar management system for elk (*Cervus elaphus*), the heavy hunting pressure directed toward the adult male segment resulted in higher mortality rates and restricted

the male harvest to younger age classes, generally precluding the opportunity to see, or harvest, an older trophy type bull.

A second alternative considered was to manage the herd to produce a greater number of older age "trophy-type" bulls. Under such a program, in order to meet the constraint of a finite carrying capacity, some of the females in the winter herd would be replaced by younger males, in order to allow these bulls to survive to the fourth or fifth year when we suspected they would produce trophy type antlers. Replacing cows with bulls would reduce the number of calves produced each spring and consequently reduce the potential annual harvest. On the other hand, the opportunity to view or kill a trophy animal would be enhanced. Considering the limited number of animals available for harvest under either system and the recreational use of the area by hikers and fishermen, we felt that the second approach might serve a greater public, including both consumptive and non-consumptive recreationsists.

In an effort to visualize the components of these two management alternatives, ie. age structure of the male segment, estimated calf production and harvest potential, we developed simplistic simulation models of two sustained yield programs (Table 2). The models were based on the following assumptions: (1) calf production would remain at

Table 2. Preliminary analysis of the composition and potential harvest of the Uinta North Slope moose herd under two hypothetical sustained yield systems.[a]

	Bulls						Cows					
	y	2	3	4	5+	T	y	2+	T	Calves	Total	% Yield
Bull:cow ratio = 1:4												
Summmer	77	33	15	6	5	136	77	236	313	204	654	
Harvest	-43	-19	-8	-4	-4	-78	-19	-58	-77	-50	-205	46%
Winter	34	14	7	2	1	58	58	178	236	154	448	
Bull:cow ratio = 1:2												
Summer	68	41	25	15	24	173	68	210	278	180	631	
Harvest	-27	-16	-10	-6	-9	-68	-16	-52	-68	-44	-180	40%
Winter	41	25	15	9	15	105	52	158	210	136	451	

[a]Assumptions:

1. Winter carrying capacity = 450 animals;
2. Calf production = 65 calves/ 100 cows;
3. Harvest figures for both antlered and antlerless (A-) segments are proportional to the occurrence of respective age classes in the population and include crippling losses;
4. All classes are run with no natural mortality.

previously observed levels; (2) hunter harvest of various age classes would be proportional to their respective occurrence in the population; (3) no natural mortality would occur; and (4) all surplus animals would be removed by hunters in the fall in order to reduce the population to the winter carrying capacity of 450 animals.

A more, realistic evaluation of the feasibility of these two systems was subject to at least two underlying questions. The most important of these was the degree to which (if any) a modification of the sex ratio, associated with the maximum yield system might affect the reproductive rate. On this point the literature is not in total agreement. Studies in British Columbia (Hatter 1950) and Alaska (Brooks 1963, Atwell et al. 1963, Rausch and Bratlie 1965, and Bishop and Rausch 1974) indicate that substantial imbalances of the sex ratio in favor of the female component have not detrimentally affected calf production in these areas. However, in Quebec Crête et al. (1981) observed that unbalanced sex ratios diminished productivity. Since the Uinta North Slope herd was below its estimated carrying capacity and other factors did not appear to be limiting population growth, a unique situation was presented to test the effects of experimental manipulation of the sex ratio on herd productivity.

The second question of importance in the assessment of mangement alternatives was that of what constitutes a

trophy animal, particularly with respect to antler development in relation to age.

The majority of the data presented here were collected under a Wildlife Restoration Project (W65R.D., Segments 19-29).

STUDY AREA AND METHODS

The Uinta Mountains extend approximately 240 km in an east-west direction along the northeastern border of Utah with Wyoming and into extreme northwestern Colorado. The average width of the mountain range is 55 km. The North Slope Moose Herd Management Unit encompasses ca. 2100 km^2 of the mountain range, bounded on the west and east by the Bear River and Burnt Fork Creek, respectively, and on the south by the mountain peaks that form the drainage divide; the unit extends approximately 25 km into Wyoming (Fig. 1). Nearly 70% of the area of the management unit is administered by the U.S. Forest Service, with the remainder under private ownership. Elevations range from 2200 m to over 3900 m, with 26 peaks exceeding the latter elevation. Timberline occurs at an elevation of approximately 3300 m.

Topographic, climatic and vegetative characteristics of the management unit have been described in detail by Wilson (1971) and Babcock (1977). Observations (N = 280) of 25 telemetered moose between 1973 and 1980 (Babcock, unpublished) indicated that nearly 90% of the year-round

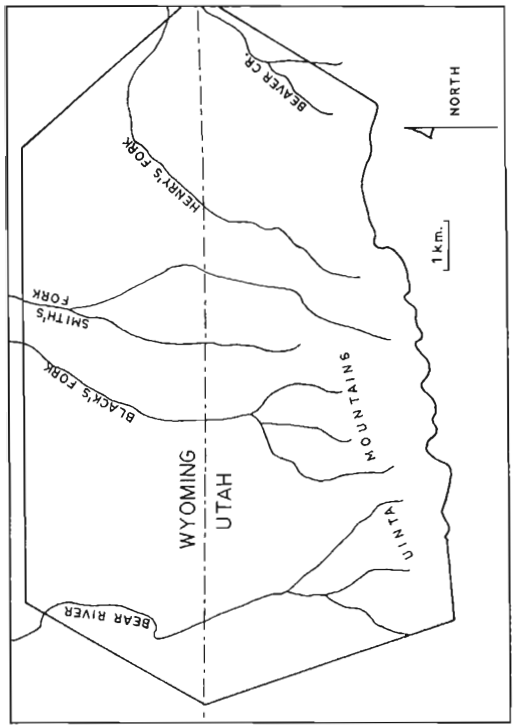

Figure 1. The North Slope Moose Herd Management Unit showing the major drainages and the relationship of the herd unit to Wyoming.

moose distribution occurs between elevations of 2300 m and 3000 m. Lodgepole pine (*Pinus contorta*) constitutes the dominant vegetation type over much of the Uinta North Slope, but is interspersed with quaking aspen (*Populus tremuloides*) and Engelmann spruce (*Picea engelmannii*), the latter species occurring primarily at higher elevations. The unit is dissected by numerous drainages, lakes and ponds with associated riparian zones and grass-sedge (*Carex* spp.) meadows. Stream gradients are moderate and many creek beds widen to form extensive willow bottoms, often interspersed with cottonwood (*Populus angustifolia*) at intermediate and lower elevations. Wilson (1971) documented the occurrence of six willow species on the management unit, of which Drummond's occurred with the greatest frequency, followed by Geyer's and Wolf's willow.

Between 1958 and 1978, 899 moose were removed from the Uinta North Slope population in legal hunter harvests (Table 1). This figure included 641 animals in Utah harvests and 258 animals (since 1970) in Wyoming. Prior to 1977, only bull permits were issued in Utah, at which time it became necessary to harvest both sexes in order to effect a manipulation of the sex ratio as described below. As estimated from hunter reports, known illegal kills comprised only 4 percent of the known decrements to the population since 1958, undoubtedly a conservative figure. During the 1960's and 1970's, areas adjacent to the North

Slope unit also experienced increasing moose populations. Some of this population growth was attributable to dispersal of animals from the North Slope unit, but ingress of animals from Wyoming undoubtedly was also a contributing factor. A total of 31 moose were removed from the North Slope population in 1973 and 1978 for transplants into other areas of Utah and Colorado.

Indices of total population size as well as estimates of herd sex ratios and productivity (i.e. cow-calf ratios) were obtained routinely from mid-winter aerial trend counts conducted annually from 1957 to 1980 (Table 1). Fixed-wing aircraft were employed for these surveys through 1963, but helicopters were used thereafter, because of the greater accuracy in counting and classification afforded by the latter aircraft. Poor snow conditions precluded reliable counts in 1963, 1970 and 1977, and budgetary constraints resulted in no counts during the two most recent winters (1981 and 1982).

Our evaluation of the effects of sex-ratio manipulation involved comparison of calf production indices prior to and following treatment within the same population, rather than the conventional approach of comparison between treatment and control populations or segments thereof. This experimental design was dictated by the relatively small size and integrity of the population involved. A 5-phase experimental program was designed.

The pretreatment phase spanned the interval between 1964 and 1971 during which the weighted mean bull:cow ratio (among yearlings and adults) was 1:2.2. An increased removal of bulls during the following two years was employed to effect a shift in the sex ratio to approximately 1:4. The time intervals 1972-1973 and 1974-1977 were considered as transition and treatment evaluation periods, resectively. Throughout these periods, bulls were removed during a September hunting season, which was designed to precede the peak period of rutting activity. Consequently, we assumed that the possible effects of altered sex ratios on reproductive performance would be manifested in the cow-calf ratios observed in classification counts conducted at least one full year (ie. 15-16 months) later. Another transitional phase began in 1977, with the legal harvest including a significant fraction of cows, in an effort to restore the bull:cow ratio to the level (1:2) that existed in the herd before 1972. The experimental plan called for the final phase (1981-1984) to serve as an evaluation period following restoration of the pretreatment sex ratio.

Information on herd age structure and antler measurements was obtained during the annual hunting seasons from 1972 to 1980. Report data cards and plastic sample bags were mailed to moose permit holders prior to the hunting season each year. Hunters also received

instructions on procedures for extracting incisors and measuring antlers. Drop stations were set up at various locations in or near the hunting unit for hunters to deposit samples. Hunters were requested to make the following antler measurements: greatest spread, number of points, minimum beam circumference and palm length and width. Estimates of the age of the animals killed (bulls and cows) were obtained from counts of cementum annulations of sectioned incisors by the method described by Sergeant and Pimlott (1959).

RESULTS AND DISCUSSION

Effects of Sex Ratio Modification

Productivity indices observed in relation to manipulations of the adult sex ratio are shown in Table 3. Distortion of the bull:cow ratio from approximately 1:2 to 1:3.6 resulted in a 38 percent reduction ($P < 0.05$) in the weighted mean productivity from 74 calves/100 cows observed during the period 1964-1971 to 46 calves/100 cows following manipulation. Evaluation of the effects on productivity of a return to the pretreatment (ie. 1964-1971) level is more complicated. As noted previously, the usual mid-winter inventories could not be conducted in 1981 and 1982 due to budgetary constraints. Accordingly, the productivity indices from the reported counts probably reflect the

Table 3. Productivity indices (calves/100 cows) observed in relation to the adult sex ratio of the Uinta North Slope moose herd.

Period	Weighted mean bull:cow ratio	Weighted mean $\bar{x}$ productivity indes (calves/100 cows)
Pretreatment (1964-1971)	1.0:2.2 (626)	74[a] (678)
1974-1977	1.0:3.6 (644)	46[b] (735)
1979-1980	1.0:2.0 (586)	63[a] (638)

Numbers in parantheses are samples sizes; values with identical superscripts denote no significant ($P < 0.05$) difference between means.

effects of the transition period. Moreover, these counts indicate that the herd is approaching its estimated carrying capacity. Possibly, reproductive performance in the population may have been depressed by density dependent effects. These variables notwithstanding, the mean productivity index (63 calves/100 cows) observed in 1979 and 1980 was significantly higher ($P < 0.05$) than the weighted mean index for the interval following initial distortion of the herd sex ratio. A review of weather records for the North Slope throughout the study period indicate one unusually severe winter (1972-73) and two unusually mild winters (1966-1967 and 1977-1978). Because these unusual winters occurred during the pretreatment period, or in the transitional period, we did not consider weather extremes to be a significant factor in this study. Considering the available evidence, we conclude that calf production in this moose herd was significantly depressed when the bull:cow ratio was reduced to 1:3.6.

This finding is consistent with that of Crête et al. (1981) in Quebec. Markgren (1974) suggested that in northern Sweden, where moose densities are relatively low, an unbalanced sex ratio would diminish the fertilization rate. In Quebec Crête (1983) postulated that the decreased calf production associated with a reduced bull:cow ratio could be a function of low moose density (0.1 km^{-2}) and closed forest vegetation (as opposed to some areas of

Alaska), which impedes harem formation.

Thus, we recognize that the observed reduction of calf production in the Uinta North Slope herd associated with a distorted sex ratio may be ephemeral, reflecting a relatively low density in comparison to some other areas of North America. A conservative estimate of density during the rutting period can be obtained from the projected size of the summer population (600) and the total area of the North Slope Management Unit (2000 km^2), which yields roughly 0.3 moose km^{-2}. Conceivably, at higher densities, the effects of an imbalanced sex ratio on reproductive performance would be less significant.

Harvest Age Structure and Antler Characteristics

The composite age distribution of 249 bull moose harvested on the Uinta North Slopes herd unit during the period 1972-1979 is given in Table 4. The 2.5-and 3.5-year age classes comprise over 50% of the male harvest, and yearlings apparently were not removed in proportion to their probable occurrence in the populations. This anomaly may be due in part to a Utah regulation requiring that antlers be at least as long as the ears for an animal to be legal. Such a distinction may be difficult for hunters to make in case of yearlings. In fact, antlers on some yearling animals simply may be overlooked by hunters.

Antler measurements were obtained from 90% (224) of

Table 4. Age structure of 249 bull moose harvested the Uinta North Slope moose herd unit, 1972-1979.

Year	Calf	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5+	Sample Size
1972	0	4	21	17	6	2	1	1	0	0	1	53
1973	0	2	15	16	3	1	5	2	0	0	0	44
1974	0	4	4	3	1	0	0	0	0	0	0	12
1975	0	1	6	1	3	1	1	0	0	0	0	13
1976	0	13	5	6	7	3	2	3	0	1	0	40
1977	1**	2	5	9	4	0	1	0	0	0	0	22
1978	2	11	12	8	6	0	1	0	0	0	0	40
1979	0	12	0	5	5	1	0	2	0	0	0	25
Percent*	1	20	27	26	14	3	4	3	0	0	0	

*Percentages do not equal 100 due to rounding error.
**Taken during antlerless hunt.

the bulls harvested during the study. Age-specific means and ranges for the various antler characteristics are shown in Table 5. Examination of these relationships reveals that antler spread, number of points and beam circumference have reached 80-85% of the maximum mean values observed for any age class by the fourth year. Comparable levels for palm width and length are attained by the fifth year. Based on these results, we established 4.5 years as an operational threshold for a "trophy bull". Admittedly, truly trophy antlers will be limited to animals in older age classes. However, by 4.5 years, the antlers average 100 cm spread with beam and palm dimensions contributing sufficient mass to set them apart from younger bulls. Such animals probably would constitute a respectable hunting trophy for the average Utah hunter as well as a pleasant and memorable aesthetic experience when observed by most nonconsumptive recreationists.

Reevaluation of Management Alternatives

Having established that modification of the herd sex ratio did effect the reproductive rate, our initial simplistic models require adjustment. Examination of the results obtained after incorporating these adjustments (Table 6) reveals some interesting comparisons between the two management systems originally proposed. First, the number of calves produced and, consequently, the potential annual harvest under the 1:2 bull:cow ratio is

Table 5. Age-specific ranges and means of antler measurements (cm) in 224 Shiras moose from the Uinta North Slopes 1972-1979.

Age	Sample Size	Greatest Spread	Antler Points	Min. Beam Circumference	Palm Width	Palm Length
1.5	40	39.4-86.4 63.0	Spike-6 3-3	3.8-14.0 10.1	Spike-30.5 13.7	Spike-33.0 18.7
2.5	47	46.4-97.8 71.1	Spike-10 4-5	3.8-17.2 11.1	Spike-40.6 16.7	Spike-53.3 31.5
3.5	70	50.8-121.9 84.8	Spike-13 6-6	8.3-17.2 13.3	Spike-41.9 18.3	Spike-76.2 41.1
4.5	34	81.3-132.1 102.4	3-11 7-7	12.1-19.7 15.4	8.9-50.8 20.4	26.7-91.4 52.8
5.5	10	95.0-114.3 106.7	3-11 7-7	13.7-18.8 15.6	6.4-55.9 22.5	27.9-71.1 51.6
6.5	12	96.5-130.2 112.3	3-11 8-8	13.7-18. 16.2	No Palm-27.9 21.3	35.6-71.1 55.1
7.5	8	104.1-143.2 120.4	4-13 9-9	12.7-19.0 17.0	20.3-29.2 23.2	38.1-84.2 67.6
8.5	1	96.5 --	8-8 --	17.8-17.8 --	20.3-20.3 --	55.9-58.4 --
9.5	1	120.6 --	9-8 --	15.9-16.5 --	20.3-21.6 --	55.9-57.2 --
10.5	1	116.8 --	9-9 --	17.2-17.8 --	26.7-27.3 --	68.6-73.7 --

substantially greater than under the 1:4 system. Moreover, 21% of the male harvest are animals of 4.5 years and older under the 1:2 sex ratio, as compared to only 15% under the 1:4 system. Finally, the difference in the number of "trophy class" animals in the summer population is even more pronounced with nearly twice as many "trophy bulls" in the field under the 1:2 management system. The implications of this difference for the large numbers of non-consumptive recreationists that visit the Uinta North Slopes each summer is obvious. In terms of annual days use, the level for potential non-consumptive use of the Uinta North Slopes moose herd by hikers, campers, and fishermen far outweighs its consumptively oriented use from moose hunters. The U.S. Forest Service estimates nearly 1 million visitor days use of these areas by all recreationists while the maximum use by moose hunters is less than 1000 visitor days.

From the hunters standpoint, the probability of a resident applicant "drawing out" on a moose permit in Utah is approximately 5%. A successful applicant may not apply for a second permit during his lifetime and the applicant must harvest the class of animal (bull or antlerless) for which he applied. Consequently, we feel that a desirable management objective is to carry more mature males in the herd, which will enhance the bull hunter's chance of taking a trophy animal.

Table 6. Composition and harvest of projected populations for the Uinta North Slope moose herd, incorporatiang revised estimates of calf production in relation to variations in the bull:cow ratio.[a]

	Bulls					Cows					
	y	2	3	4	T	y	2+	T	Calves	Total	% Yield
Bull:cow ratio = 1:4											
Summmer	60	31	16	19	126	61	263	324	149	599	
Harvest	-29	-15	-7	-9	-60	-11	-50	-61	-28	-149	46%
Winter	31	16	9	10	66	50	213	263	121	450	
Bull:cow ratio = 1:2											
Summer	71	42	25	35	173	72	205	277	194	644	
Harvest	-29	-17	-10	-15	-71	-19	-53	-72	-51	-194	43%
Winter	42	25	15	20	102	53	152	205	143	450	

[a]Assumptions: same as 1, 3 and 4 for Table 2.

REFERENCES

ATWELL, G., C.H. MERRIAM, and R. RAUSCH. 1963. Moose investigations. Alaska Fish Game. Pittman-Robertson Proj. Prog. Rep. W-6-R-3. 92pp.

BABCOCK, W.H. 1977. Continuing investigations of the Uinta North Slope moose herd. Utah Div. Wildl. Res. Publ. No. 77-19. 76pp.

BAILEY, A.M. 1944. Records of moose in Colorado. J. Mammal. 25:192-193.

BISHOP, R.H., and R.A. RAUSCH. 1974. Moose population fluctuations in Alaska, 1950-1972. Nat. Can. (Que.) 101:559-593.

BROOKS, J.W. 1963. The status of wilderness game in Alaska. Proc. Western Assoc. State Game and Fish Comm. 26:133-134.

CRÊTE M., R.J. TAYLOR and P.A. JORDAN. 1981. Optimization of moose harvest in southwestern Quebec. J. Wildl. Manage. 45:598-611.

_____. 1983. Évaluation des modifications apportées à la réglementation de la chasse à l' orignal au Quebec de 1971 à 1981 et perspectives d' avenir. Alces 18: (in press).

HATTER, J. 1950. Past and present aspects of the moose problem in central British Columbia. Proc. Western Assoc. State Game and Fish Comm. 13:150-154.

KIMBALL, J.F., and M.L. WOLFE. 1978. Continuing studies of the demographics of a northern Utah elk population. Pages 20-28 in M.S. Boyce and L.D. Hayden-Wing, eds. North American Elk: Ecology, Behavior and Management. Univ. Wyoming Press, Laramie.

MARKGREN G. 1974. The question of polygamy at an unbalanced sex ratios in the moose. Pages 756-758 in V. Geist, ed. The behaviour of ungulates and its relation to management. Int. Union Conserv. Nat. Nat. Res., Morges, Switzerland, New Ser. 24.

RAUSCH, R.A., and A. BRATLE. 1965. Annual assessments of moose calf production and mortality in southcentral Alaska. Proc. Western Assoc. State Game and Fish comm. 45:140-146.

SERGEANT, D.E., and D.H. PIMLOTT. 1959. Age determination in moose from sectioned incisor teeth. J. Wildl. Manage. 23:315-321.

WILSON, D.W. 1971. Carrying capacity of the key browse species for moose on the north slopes of the Uinta Mountains, Utah. M.S. Thesis. Utah State Univ., Logan. 57pp.