MOOSE AND THEIR MANAGEMENT ON WIND RIVER INDIAN RESERVATION, WYOMING

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Abstract: At the request of the Shoshone and Arapahoe Indian Tribes, the U.S. Fish and Wildlife Service hired a wildlife biologist in 1978 to determine the status of wildlife populations on Wind River Indian Reservation (WRIR) in Wyoming and to develop a wildlife management plan for the Reservation. Information on population size and composition, distribution, habitat use, and food habits of moose on WRIR was collected from May 1978 to October 1981. Historical information regarding former moose numbers and distribution was obtained by interviewing long-time Reservation residents. Approximatley 75 moose remain in the Wind River Mountains (WRM). A viable moose population no longer exists in the Owl Creek Mountains (OCM). An estimated 13 moose were harvested annually by Tribal members from 1978-1981. In both the WRM and OCM, moose numbers are reduced from population levels during the 1950s and early 1960s, despite little change in habitat availability or quality. Unregulated hunting by Tribal members appears responsible for the decline. Population objectives of 135 moose in the WRM and 55 moose in the OCM were recommended to the Shoshone and Arapahoe Tribes. Other management objectives are also proposed.

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Investigations of the present status and distribution of big game species, including Shiras moose (Alces alces shirasi), on the Wind River Indian Reservation (WRIR) were initiated in 1978 by personnel of the U.S. Fish and Wildlife Service at the request of the Shoshone and Arapahoe Tribes (Smith 1981, 1982a). Quantitative information had not

previously been collected, and hunting regulations and other management programs were lacking on WRIR. As a result of wildlife and habitat inventories conducted from 1978-1981, status reports and management recommendations for moose (Smith 1982b) and other species were prepared and presented to the Shoshone and Arapahoe Tribes. This paper highlights the findings and recommendations regarding moose.

STUDY AREA

The WRIR was established by Act of Congress in 1863 (Smith 1982a) and is located in west central Wyoming. It totals 890,000 ha consisting of a large portion of the Wind River watershed, including the Owl Creek Mountains (OCM) in the north and the east slope of the Wind River Mountains (WRM) in the western part of the Reservation. Elevations range from 1,370 m in the Wind River Basin to over 3,750 m in both mountain ranges. Habitats range from fertile bottomlands, sagebrush (Artemesia spp.) desert, and rolling grassland foothills to lodgepole pine (Pinus contorta) and Douglas fir (Pseudotsuga mensiesii) forests, and towering glacial-carved peaks.

METHODS

Aerial censuses in fixed-wing aircraft and helicopter were the primary methods used to determine moose distribution, habitat use, numbers and population structure. Moose surveys were generally conducted in conjunction with censuses of elk, deer, and bighorn sheep, and data were recorded similarly (Smith 1980). All known and potential big game winter habitats were surveyed on WRIR but efforts to locate moose were concentrated in drainage bottoms and south-facing slopes. Moose were classified through the first week of

February each winter. Thereafter, most bulls had shed their antlers and classification of bulls and cows was not attempted unless the presence or absence of the white vulval patch could be confirmed. Incidental ground observations made by U.S. Fish and Wildlife Service and Tribal Fish and Game personnel were catalogued. Records of the Tribal Fish and Game Department were reviewed to compile harvest data on moose from 1978-1981.

Questionnaires concerning fish and wildlife topics were mailed in 1980 to 3,818 enrolled members of the Shoshone and Arapahoe Tribes, both male and female, 14 years of age or older. One question asked respondents if they hunted moose. Another question asked respondents to rank the importance of each big game species on WRIR. Some 618 Shoshones and 583 Arapahoes responded (a 39.2 and 26.0 percent response rate respectively) and their answers were tallied.

Food habits of moose utilizing winter ranges in the WRM were determined by the fecal microhistological analysis technique described by Sparks and Malecheck (1968) and Free et al. (1970). One fecal pellet from each of 25 moose pellet groups was collected and combined into one composite sample. Pellets were collected from a variety of habitats utilized by moose throughout the year. However, they were collected in areas most often frequented by moose during winter and spring and, therefore, should be considered to reflect winter-spring diets of moose in the WRM. During the laboratory analysis at the Composition Laboratory at Colorado State University, 20 fields were read on each of five slides prepared from the composite sample.

Historical information about moose on WRIR was obtained through tape recorded interviews of long-time Reservation residents.

HISTORICAL PERSPECTIVE

Moose Numbers and Distribution

The moose is apparently a relative newcomer to Wyoming. Even in northwestern Wyoming, where the majority of Wyoming's moose live today, Osborne Russell's diary mentions other game animals but does not mention the presence of moose during the 1830s and early 1840s (Haines 1955). Houston (1968) wrote that there were few if any moose in the Jackson Hole and Yellowstone areas of Wyoming before 1850. Ritchie (1978) noted the same was true of southeastern Idaho and quoted publications by Curtright (1969:439), Kock (1941), and others to suggest that moose in Montana may have furnished the stock that spread into Idaho and Wyoming during the mid-1800s, and that numbers were still low in the early 1900s. Houston (1968) felt that establishment of the Jackson Hole moose populations may have resulted from moose emigrating from Yellowstone Park shortly before 1912. It was estimated that there were 2,000 moose in northwestern Wyoming in 1915, 3,725 in 1923, and almost 5,000 in the state in 1926 (Blaisdell 1965).

Regarding the early Reservation period (after 1868), Murphy and Murphy (1960) wrote that when stores of buffalo meat ran low towards the end of the winter, the Shoshones supplemented their diets by hunting elk, antelope, deer and rabbits. No mention was made of moose. But in discussing summer subsistence activities during the same period of time, those authors said moose and elk were hunted by small parties in the high mountain parks and forests of the Wind River, Teton, and Owl Creek Mountain Ranges.

It seems unlikely that moose would have spread to the OCM and east side of the WRM before reaching the Jackson Hole area. Although there is no recorded information about moose on WRIR during the 1900s, Reservation residents who were interviewed generally agreed that moose were scarce prior to 1930. However, during the 1930s, they occupied their present distribution and became quite abundant during the 1950s in the WRM, the western two-thirds of the OCM and wintered along the Wind River and Little Wind River as far downstream as the towns of Arapahoe and St. Stephens (Fig. 1). Beginning in the 1960s, moose numbers declined, primarily due to over-hunting (Smith 1982a, 1982b).

Past Management

By treaty, hunting and fishing are the vested rights of the enrolled members of the Shoshone and Arapahoe Tribes. Decisions regarding wildlife and fish are made by voting members of the Tribes at General Council Meetings.

On WRIR, moose hunting has essentially remained unregulated to the present with the following exception. From 1904-1939, hunting in the ceded northern portion of the WRIR (north of Wind River) was controlled by the State of Wyoming. From 1948-1953, when a Tribal Game Code was in effect, the entire Reservation was closed to the hunting of moose (Smith 1982a). Since 1953, year-round, unregulated hunting of moose has occurred on WRIR with the exception of three resolutions passed in the 1970s to prohibit:

1) selling or trading of game meat;
2) hunting with artificial lights (i.e., spotlighting); and
3) wanton waste of game animals.

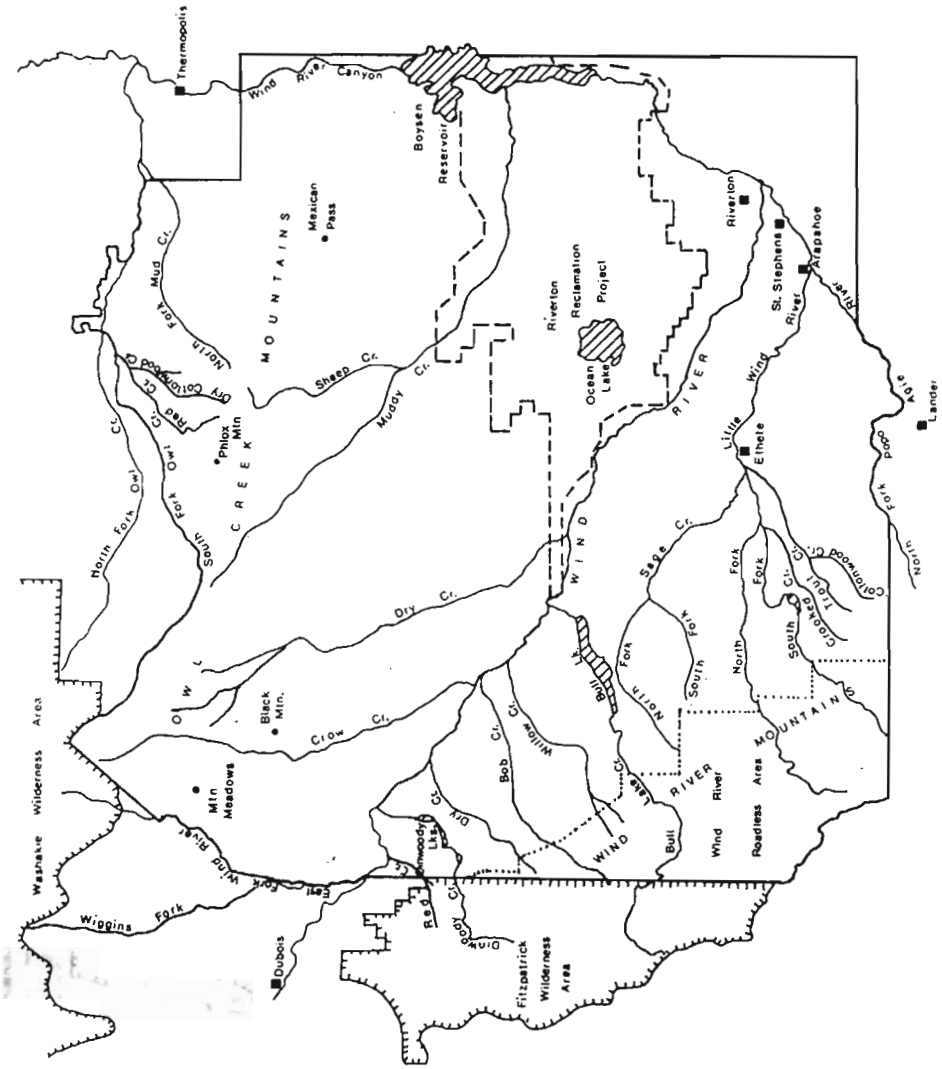

Figure 1. Drainage pattern of streams on Wind River Indian Reservation.

RESULTS

Moose Population and Distribution in the Wind River Mountains and Wind River Basin

A total of 64 moose were observed in the WRM during aerial censuses (Table 1). Another 34 ground observations of moose were recorded from 1973 to 1981 in the WRM. Seventeen of the 34 ground observations of moose occurred in Bull Lake Creek or North Fork Little Wind River (including St. Lawrence Basin) drainages. Thirty-six of the 64 moose recorded during aerial censuses were also in those drainages.

Moose were censused on winter ranges, where they were more concentrated and more visible than during summer and fall. Results of aerial surveys, conducted from November to March, and ground observations, showed that moose inhabited every major drainage of the WRM except Cottonwood and Sage Creeks (Fig. 1). They primarily winter in the lower 6-8 km of each drainage canyon (Fig. 2). Three moose were observed on January 20, 1979, during the severe winter of 1978-79 (Smith 1980, 1981), near the upper tree line at 3,100 m elevation.

Two moose observed from the air and one seen from Highway 287 were about four miles from the WRM along the lower reaches of Dry, Willow, and Bull Lake Creeks. This suggests there is some tendency for moose to move through riparian corridors of the Wind River's tributaries to lower, more snow-free areas where they are more visible and accessible to man. Several Tribal members mentioned that moose are occasionally seen and shot during winter, spring and summer along the Wind River as far downstream as the town of Riverton (Fig. 1).

During summer and fall, moose generally frequent higher elevations to the west of winter ranges in the WRM. Although the majority of

Table 1. Results of aerial censuses of moose in the Wind River Mountains (WRM) and Owl Creek Mountains (OCM), Wind River Indian Reservation, winters 1978-79 to 1980-81.

Location	Year	# Census Hours (# Flights)	Number of Moose Observed					Moose/Hr.	Males:100 Females:Young	Young: 100 Adults
			Young	Cows	Bulls	Uncl.[a]	Total			
WRM	Winter 78-79	19.0 (6)	7	13	3	16	39	2.1	23:100:54	
WRM	Winter 79-80	7.0 (2)	3	7	6	2	18	2.6	86:100:43	
WRM	Winter 80-81	15.6 (2)	2	4	1		7	0.4	25:100:50	
WRM	TOTAL	41.6 (10)	12	24	10	18	64	1.5	42:100:50	35:100
OCM	Winter 78-79	12.2 (4)	1	1	0	0	2	0.2		
OCM	Winter 79-80	9.2 (3)	3	6	0	0	9	1.0		
OCM	Winter 80-81	12.7 (4)	0	0	0	0	0	0		
OCM	TOTAL	34.1 (11)	4	7	0	0	11	0.3	0:100:67[b]	67:100[b]

[a] Animals not classified

[b] Based on a total of 3 cow and 2 calf moose because the three observations during winter 1979-80 were the same 3 moose each time.

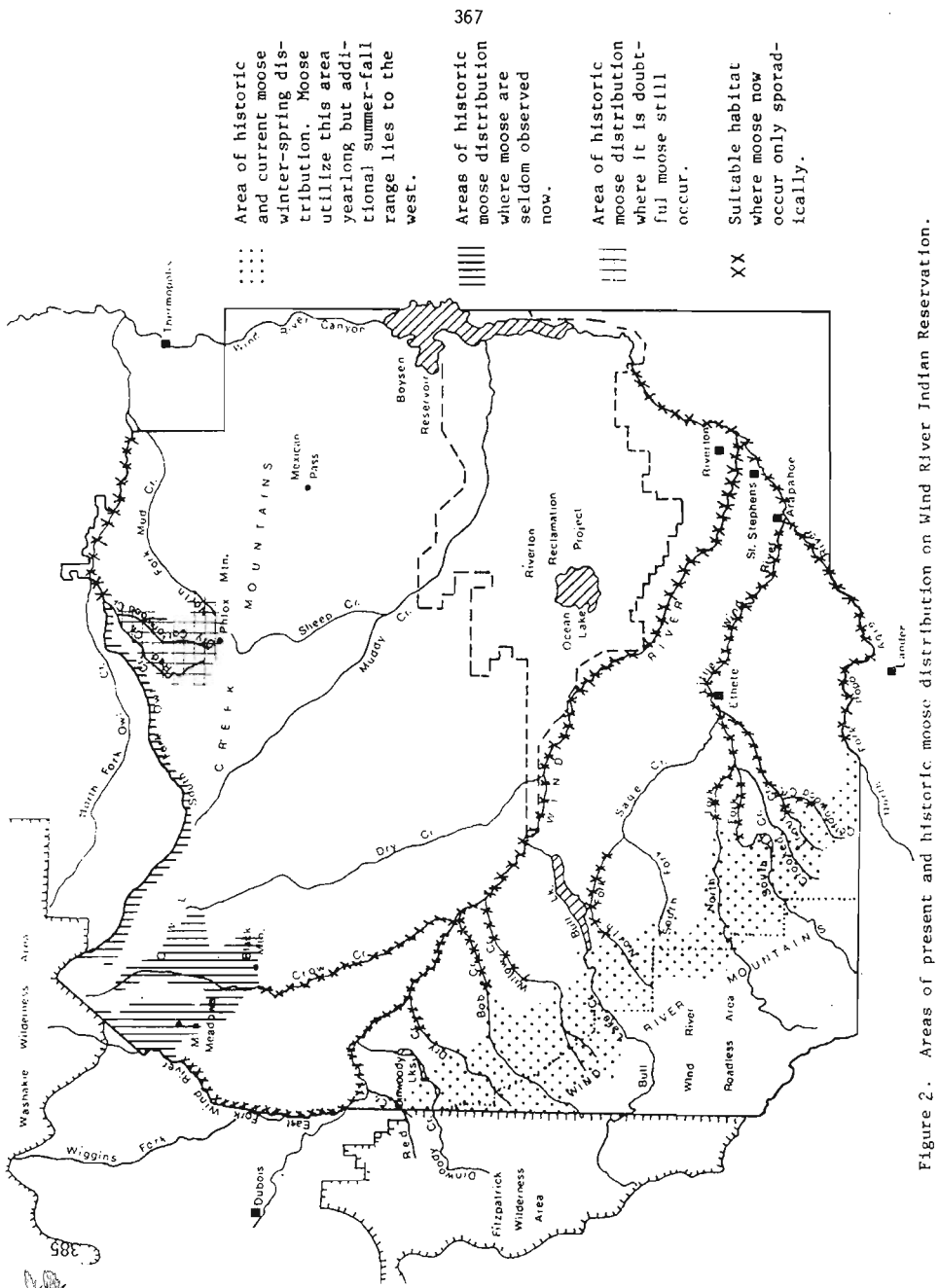

Figure 2. Areas of present and historic moose distribution on Wind River Indian Reservation.

observations were made in Bull Lake Creek and North Fork Little Wind River Drainages, they have been observed in most other drainages, and I found moose sign while hiking through moose habitat in most drainages.

For all flights during winters 1978-79 to 1980-81, 64 moose were observed in 41.6 hours of censusing for an average of 1.5 moose observed/hour (Table 1). The largest number of moose counted during any census over the WRM was 15 observed during 4.5 hours in February 1980. The largest number of moose observed in any drainage of the WRM was 9 in Dry Creek during February 1980, followed by 6 in North Fork Little Wind River and 5 in Bull Lake Creek drainages during winter 1978-79.

During aerial surveys, moose were seen in North Fork Little Wind River (including St. Lawrence Basin) on 8 of 10 censuses, in Dry Creek on 4 of 10 censuses, and in Bull Lake drainage on 3 of 10 censuses. We observed moose on only one flight in other drainages.

Aerial survey results indicated a winter bull:cow:calf ratio of 42:100:50, or a population comprised of 22% bulls, 52% cows, and 26% calves. Composition of ground observations recorded throughout the year was 19 bulls, 7 cows, and 4 young or 271:100:57. Four animals were not classified. A number of the ground observations were reported by hunters who either saw or killed the moose reported. The high ratio of bulls may have resulted from hunters reporting bulls more frequently than antlerless animals.

Moose Population and Distribution in the Owl Creek Mountains

Only 11 moose were observed during aerial censuses over the OCM from 1978-1981 (Table 1). The limited number of ground observations of

moose in the OCM during recent years, the scarcity of moose pellet groups, and the limited amount of browsing on willows in riparian habitat further indicate that at present a viable moose population does not exist in the OCM.

All moose observed during aerial surveys were in the Mountain Meadows area just east of East Fork Wind River (Fig. 1). Another 5 ground observations of moose (9 moose total) were recorded from 1973 to 1981 in the OCM by U.S. Fish and Wildlife Service and Tribal Fish and Game Department personnel. Those observations were in East Fork Wind River, South Fork Owl Creek and Crow Creek drainages. Residents noted that moose are seldom seen in the lower half of South Fork Owl Creek, although they are still common off the Reservation in North Fork Owl Creek. Moose have not been seen in the Red and Dry Cottonwood Creeks since the early 1970s. A ground survey of Red Creek revealed no moose sign.

In Crow Creek, an important area for moose during the 1950s and 1960s, no moose were observed during aerial surveys, nor were moose tracks seen. The last known observation in that drainage was of a cow moose, observed about four miles north of Black Mountain in August 1978 that was shot less than a week later.

Food Habits and Habitat Use

During aerial censuses, the habitat type in which moose were observed was recorded (Table 2). Riparian and aspen woodland habitats accounted for 75% of observations.

Based on fecal pellet samples collected in a variety of habitats and analyzed microhistologically, 95.6% of the moose diet during winter

Table 2. Winter habitat use by moose on Wind River Indian Reservation, Wyoming, based on results of aerial censuses from 1978-1981.

Habitat Type	Number (Percent) of Moose Observed		
	Owl Creek Mtns.	Wind River Mtns.	Total
Riparian	8 (72.7)	35 (61.4)	43 (63.2)
Aspen/Willow Riparian	3	15	18
Conifer/Aspen Riparian	0	3	3
Willow/Alder Riparian	5	17	22
Aspen Woodland	3 (27.2)	5 (8.8)	8 (11.8)
Open Canopy Forest	0	10 (17.5)	10 (14.7)
Limber Pine	0	2	2
Limber/Lodgepole Pine	0	2	2
Conifer/Aspen	0	6	6
Closed Canopy Forest	0	0	0
Burn	0	5 (8.8)	5 (7.4)
Sagebrush/Grassland	0	2 (3.5)	2 (2.9)
TOTAL	11 (99.9)	57 (100.0)	68 (100.0)

and spring in the WRM consisted of browse species (Table 3). Of the woody plants, willow contributed 92.3% to moose diets. The only non-woody plants identified in the fecal samples were 1-2 percent of wheatgrass (Agropyron smithii type), sedge (Carex spp.), and Idaho fescue (Festuca idahoensis).

Table 3. Mean percent relative density ($\bar{x}$) and standard deviations (sd) of discerned plant fragments in moose fecal samples from the Wind River Mountains of Wind River Indian Reservation. Means ($\bar{x}$) are percent composition of diets.

Plant	% Diet Composition	
	$\bar{x}$	sd
GRASSES, SEDGES, RUSHES		
Agropyron smithii (type)	1.68	1.14
Carex	1.03	0.95
Festuca	1.70	1.17
SHRUBS AND TREES		
Artemisia tridentata (type)	0.40	0.89
Pinus	0.32	0.71
Pseudotsuga	0.73	1.01
Purshia tridentata	1.46	1.68
Rosa	0.42	0.93
Salix	92.26	2.16

Hunter Harvest

Only enrolled Shoshone and Arapahoe Indians are allowed to hunt on WRIR. Because there is no licensing requirement for Tribal hunters, the number of enrolled Shoshones and Arapahoes who hunt moose or other wildlife species is unknown. In 1980, questionnaires concerning fish and wildlife topics were mailed to all Shoshone and Arapahoe Tribal members 14 years of age and older. Almost 39% of Shoshones and 35% of Arapahoes who responded said they hunted moose. Compared

to all other big game species on the Reservation, excluding bear and mountain lion, moose was ranked fourth in importance behind elk, deer, and bighorn sheep by Shoshones and fifth behind deer, elk, pronghorn, and bighorn sheep by Arapahoes.

To estimate numbers of moose killed by hunters on the Reservation annually, tag records of the Tribal Fish and Game Department were summarized. Harvested game animals need not be tagged if they are processed on the Reservation by Indian hunters. However, a Tribal game tag is needed if an animal is taken to a commercial meat processing plant or taxidermist, or transported off the Reservation.

Tribal records show that during the 4-year period from 1978-81, 35 moose were tagged by Tribal game wardens (Table 4). In the opinion of Tribal game wardens and U.S. Fish and Wildlife Service biologists working on WRIR, the percentage of hunter-killed moose that are tagged is somewhere between 50 and 85 percent (Gary Lajeunesse, Robert St. Clair, Raymond Harris and Richard Baldes, pers. comm. 1981). The average of their estimates is 69%. If this is the case, a rough approximation of the annual moose harvest can be derived from the following relationship:

$$\frac{9}{69\%} = \frac{X}{100\%}$$

Where: 9 is the average number of harvested moose tagged annually from 1978-81;

69% is the estimated percentage of hunter-killed moose tagged;

X is the total number of moose harvested; and

100% is the total percentage of moose killed.

Based on this relationship, 13 moose are harvested annually on WRIR.

Table 4. Number of moose harvested annually from 1978-1981 on Wind River Indian Reservation that were tagged by Tribal Game Wardens.

	Number Tagged				
Year	Young	Adult[a] Females	Adult[a] Males	Other (Males[b] or Females)	Total
1978		1		8	9
1979		3	1	4	3
1980		1	1	8	10
1981	1	3	4		8
Average	0.25	2.0	1.5	5.0	8.75

[a]Yearling and older

[b]Neither age nor sex recorded

The age and sex of only 14 of the 35 tagged moose were recorded. In 1981, 8 harvested moose that were tagged were classified. Four were bulls, 3 were cows, and one was a calf. Locations of kills were recorded for only 9 animals from 1978-81, 8 of those were in 1981. A cow was killed in Bob Creek of the WRM in 1980. In 1981, one came from the WRM, 6 came from the OCM and one was killed along the Little Wind River near Ethete. Of the 6 killed in the OCM, all were shot along boundary streams--5 in the western OCM and one near Arapahoe Ranch along South Fork Owl Creek.

Tagged moose were harvested every month except February, March, and April. However, 69% were killed during the months of September through December. The cow moose killed along the Little Wind River in 1981 was shot in August and several other moose, that weren't tagged, were killed during spring and summer in the Wind River Basin.

DISCUSSION

Present Population in the Owl Creek Mountains

A viable resident moose population does not exist at present in the OCM. Although a few moose continue to be harvested each year in the western OCM, most of those have moved onto the Reservation from the north and west and are generally killed near the boundary drainages of East Fork Wind River and South Fork Owl Creek. In the State of Wyoming's Hunting Unit 6, which lies west of WRIR, the moose population is estimated at 200 and is presently stable (Anon. 1981). Some excellent moose habitat occurs in the western OCM along the East Fork, Crow Creek, and Owl Creek drainages and north of Phlox Mountain in Red, Dry Cottonwood, and North Fork Mud Creeks (Fig. 2).

A resident moose population could be reestablished in the OCM and provide more recreational opportunites for Tribal members. The fact that moose have continued to move into the OCM, despite unregulated hunting, attests the quality of the habitat available and the nature of moose in adjacent areas to strike out and utilize available habitat. Because cows and calves, as well as bulls, have been observed and killed in the western OCM during the past several years, stock for a resident population is available. Only the conditions for population establishment and growth are lacking.

Present Population in the Wind River Mountains and Basin

Moose remain well-distributed in low densities throughout the WRM of WRIR. In only 5 small drainages were moose not observed. Although little is known about the daily and seasonal movements of moose on WRIR or interchange between drainages, it is hypothesized that moose

use all drainages with suitable habitat in the WRM at least intermittently (Fig. 2).

All recorded observations of moose in the Wind River Basin were in or adjacent to riparian habitats. Moose probably follow riparian corridors when in the basin and sometimes remain undetected for long periods of time. If they crossed open expanses of sagebrush or agricultural land, it is unlikely they would ever be able to reach locations as distant from mountains as the towns of Arapahoe and Riverton without being shot.

The relative density of moose in the WRM on WRIR is considerably less than in the WRM south of the Reservation. Aerial surveys were conducted by personnel of the Wyoming Game and Fish Department in Hunting Units 2 and 30, south of the Reservation on the east slope of the WRM, once each winter during winters 1979-80 and 1981-82. Total numbers of moose observed and moose observed per hour during those surveys (Table 5) can be compared with results of aerial surveys from WRIR (Table 1).

Table 5. Results of aerial censuses of moose conducted by personnel of the Wyoming State Game and Fish Department in Hunting Units 2 and 30 south of Wind River Indian Reservation from 1980-82 (from Anon. 1981 and J. Emmerick pers. comm. 1982).

Date	# Census Hours	# Moose Observed	# Moose Observed Per Hour
January 30, 1980	4.4	101	23.0
January 20, 1981	3.0	51	17.0
February 1 & 5, 1982	6.0	138	23.0
Total (Average)	13.4 (4.5)	290 (96.7)	(21.6)

Some aspects of the censuses on and off the Reservation were not comparable (Smith 1982b). LeResche and Rausch (1974) discussed the significance of several survey conditions on the accuracy and precision of aerial moose censuses. However, comparing the results of only those pairs of flights which most closely duplicate survey conditions, 5-7 times as many moose/hour were counted off the Reservation as on the Reservation. Given a moose population of 220-250 moose in Wyoming's Hunting Units 2 and 30 (Emmerick, pers. comm. 1982), it follows that there are fewer than 50 moose in the WRM of WRIR. With liberal allowances for the variables involved in making such comparisons, a maximum winter population of 75 moose may remain in the WRIR's WRM.

Those drainages believed to support the largest numbers of moose (North Fork Little Wind River, Bull Lake Creek and Dry Creek) are the ones with the most extensive and least accessible moose habitat.

The Wind River, the lower reaches of its WRM tributaries and lower Crow Creek offer food, water, and cover for moose and mild winter conditions due to shallow snow depths. Willow, chokecherry (Prunus virginianus), redosier dogwood (Cornus stolonifera), and a variety of wetland sedges and forbs are among the preferred food plants of moose available in those riparian corridors. Despite the habitat, few moose utilize those drainages due to the year-long hunting that prevails. Because the density of people and roads are greater in the Wind River Basin than in the mountains, moose cannot remain undetected for long and many of those that migrate to the Basin probably are killed.

Population Productivity and Structure

The only information regarding productivity of moose on WRIR is mid-winter calf:cow ratios. Calf:cow ratios of WRM moose (50:100) are

slightly lower than those reported for other Shiras moose populations (Knowlton 1960, Peek 1962, Houston 1968, Dorn 1969, Ritchie 1978, Anon. 1981). Lower calf:cow ratios of 33:100 (Cowan 1950) and 36:100 (Pimlott 1959) have been reported for Canadian moose.

Gross productivity and potential rate of increase of the moose population on WRIR cannot be calculated without knowing reproductive rates and age class structures as well as sex ratios of the population. Collection of reproductive tracts and lower jaws from harvested moose would provide the information presently lacking for calculation of gross productivity and rate of increase (Schadweiler and Stevens 1973). Gross productivity is a good indication of population health and data concerning ovulation or pregnancy rates (which are easier to obtain than post-partum reproductive rates) have been shown to correlate with the winter nutritional level of cow moose (Schadweiler and Stevens 1973, Pimlott 1959).

Bull:cow ratios based on mid-winter aerial classifications were lower in the WRM than those reported for most other Shiras moose populations (Knowlton 1960, Peek 1962, Houston 1968, Dorn 1969, Ritchie 1978). The one exception was the Wyoming moose population adjacent to the WRIR in the south end of the WRM where only 14-15 bulls:100 cows were classified using techniques and under conditions similar to those used on the Reservation (Anon. 1981 and Emmerick, pers. comm. 1982). That moose population has been hunted on a limited permit basis for antlered animals only from 1973-1980 (Anon. 1981). On the Reservation, where moose hunting is unregulated and it appears that moose are killed primarily for meat rather than for trophies, differential hunting mortality has probably not altered the

population's sex ratio. The bull:cow ratio recorded during aerial surveys is believed to be lower than actually occurs in the population for the following reasons: 1) Lone bulls were spotted on several occasions in areas of more rugged terrain and farther west in WRM drainages than cows were generally observed. Cowan (1950) and Dorn (1969) also noted that bulls in British Columbia and Montana ranged at higher elevations in winter than the main herds. It would seem that lone bulls in rugged terrain would more often be missed during aerial censuses than cow/calf groups in riparian habitats where most were "expected" to be. 2) Lone moose were often in terrain which made close observation from fixed-wing aircraft impossible. As a result, young bulls may occasionally have been misclassified as cows on occasions when their small antlers (Peek 1962, Houston 1968) were not apparent and presence or absence of a vulval hair patch was not certain. 3) The composition of the hunter harvest from 1978-1981 was 75 bulls:100 cows. Given that the moose population is at a low level, that Tribal hunting of moose appears to be primarily for meat, and that the most accessible moose is the one most likely to be killed by an opportunistic Indian hunter, it is likely that bulls may actually be harvested at a rate proportional to or less than their occurrence in the population. This would hold true especially during winter and spring hunting when bulls remain in more remote areas than cows, according to aerial census information. Both of the tagged moose harvested away from mountainous area during 1981 (one near Ethete, the other on lower South Fork Owl Creek near Arapahoe Ranch) were cows. 4) The composition of the 30 classified moose from ground observations was 271 bulls:100 cows:57 calves. Although the calf:cow ratio is similar to that on and adjacent to WRIR, a far greater percentage of

bulls were reported. Peek (1962) and Pimlott (1959) reported the sex ratios of moose obtained during summer from ground observations were not reliable due to differential use between sexes of open habitats. Bulls were observed more often in open cover than cows--especially cows with calves. Thus, classifications based on summer ground observations alone tend to over-estimate the number of bulls and under-estimate the number of calves. Eighty percent of our 30 classified ground observations were made from July to November.

On WRIR where there is an apparent lack of hunter selectivity, the sex ratio for adult moose may approach 1:1. This hypothesis should be verified by more intensive classification counts in the future. But for the present, a herd composition of 100 bulls:100 cows: 50 calves in the WRM (40% bulls, 40% cows, and 20% calves) is the best estimate available.

Mortality Sources

Natural Morality

Franzmann (1978) stated that "Populations of moose in good habitat respond with high initial calf production and, in most instances, can absorb mortality from severe winters, predation, regulated hunting, poaching, disease, competition, and accidental deaths."

Moose carcasses were not found on WRIR from 1979-1982. Although predation, disease, parasites and accidents (natural and road kills) do not apprear to be of significance to moose on the Reservation or in the immediate vicinity of the Reservation, they remain uninvestigated at this time.

Competition from other big game species and/or livestock is probably not of concern on WRIR. Diets of moose and other large

herbivores on WRIR overlap minimally (Smith 1982b). Should whitetail deer populations increase in the future and expand into important moose winter ranges, there is potential for direct competition between the two species (Smith and Berner 1982).

Among natural causes, mortality resulting from the energy-draining effects of severe and prolonged winters probably has the greatest effect on moose populations in Wyoming. Houston (1968) reported over-winter calf losses (as evidenced by changes in calf:cow ratios) ranging from zero percent during a mild winter to 59 and 20% respectively during an average and a severe winter. Crusted snow during the average (in terms of snow depth) winter were believed to contribute to the high loss. Houston (1968) found that 65% of moose found dead on winter ranges were calves and another 24% were cows 8½ and more years of age. On WRIR, carcasses of dead moose were not found or reported during the past 4 years. During the severe winter of 1978-79, over 50% of the Reservation's pronghorn antelope population is believed to have perished and 60% of elk calves in the WRM died (Smith 1981 and 1980). It is likely that prolonged cold and deep snow conditions of such a winter would create hardships for moose and predispose them to above normal winter losses also. Houston (1968) estimated that an average of 20% of moose calves entering winter did not survive in the Jackson Hole area.

Because of the good condition of the available habitat, low density of wintering moose, and relatively milder winters on the east slope of the WRM compared to Jackson Hole area, it seems that average over-winter mortality of moose calves would be less than 20% on WRIR.

The 50:100 winter calf:cow ratio determined for WRM moose is not useful in assessing annual mortality or recruitment of calves. It is only an average of several ratios obtained over 3 winters during the November to March period in which a percentage of winter mortality occurs. It is not possible to say what percentage of the over-winter calf mortality had occurred when the calf:cow ratio reached 50:100.

In the following section on Hunter Harvest, I have estimated that 50 calves:100 cow moose survive winter.

Hunter Harvest

Given the present small population of moose and an estimated annual harvest of 13 animals, hunting is the number one cause of mortality of moose on WRIR. Franzmann (1978) wrote that moose populations in 1978 in North America were generally stable or increasing in available habitat. He added that, "Local declines are experienced from the single impact or combined impacts of severe winters, predation, neurological diseases and excessive harvest." Neurological disease is not known in Wyoming moose (Dr. T. Thorne pers. comm. 1982), wolves and grizzly bear do not occur in the WRM of WRIR, and 4 of 5 winters on WRIR from 1978-1982 have been mild or average based on average winter temperatures and total snowfall. Yet no recovery in moose numbers has been apparent during that time. Excessive harvest of this big game species--whose large size, excellent meat, tolerance of man, and demonstrated proclivity on WRIR to migrate to low elevation riparian areas of the Wind River Basin make it a preferred and easy target--has all but eliminated it from the OCM and sharply reduced its numbers in the WRM during the past 10-15 years.

Houston (1968) calculated that a moose population with the composition, productivity, and natural mortality rate of that in Jackson Hole could sustain an annual harvest of 14% of the winter population if 70% of the harvest were males. That harvest level would remove the approximated annual male recruitment by hunters and allow for 50% of the female and 90% of the annual calf losses to occur through means other than hunting. The result would be a stable population. For the State of Wyoming as a whole, 16% annual harvest rate is predicted to maintain a stable moose population (Anon. 1977). In some areas this involves harvest of either-sex moose, and in areas with smaller, less productive moose populations, only antlered animals may be harvested.

On WRIR, it is obvious that to reestablish a moose population in the OCM, moose hunting should be prohibited until a resident herd has built up. If this is not acceptable to the Shoshone and Arapahoe Tribes, a bull-only season within the framework of the Tribal Game Code passed by the Shoshone General Council (Smith 1982a) is the minimum protection required to provide any chance for a viable moose population to develop in the OCM.

In the WRM, where a maximum of 75 moose remain, moose hunting should be restricted to bulls-only within the framework of the Tribal Game Code passed by the Shoshone Tribe. Proper harvest of the male segment of the population is roughly the recruited number of male yearlings each year. Information was not collected regarding recruitment to yearling age. Thus, the 50 calves:100 cows ratio obtained during aerial surveys is used here to estimate recruitment. Given a population of 75 moose in the WRM consisting of 100 bull:100 cows: 50 calves prior to parturition in spring (30 bulls, 30 cows, and 15

calves, there are approximately 7-8 yearling males added to the population each year. An equivalent number of males could be harvested each fall without reducing the male segment of the population. Reporting of data on harvested animals, such as numbers, ages, sexes and locations, must improve to evaluate harvests. However, it is clear that with over half the estimated annual harvest consisting of antlerless animals (Table 4) the moose population cannot increase.

Once a substantial increase in the WRM's moose population has occurred, carefully regulated hunting of antlerless moose as well as bulls may prove beneficial in maintaining herds at levels commensurate with the forage supplies on winter ranges. Periodic browse surveys to determine level of browse utilization, supplemented by population trend and composition data, would be necessary to determine if and when hunting of antlerless animals could resume.

Potential for Population Growth and Range Expansion

Sufficient data are not available regarding in-utero productivity and birth rates, as well as age structure of moose in the WRM of WRIR to calculate gross productivity of moose on WRIR, and thereby predict potential rate of increase with regulated hunting of males only. That information, as well as better classification, harvest level, and population size data, is urgently needed to promote a better understanding of the population dynamics and expected responses to management of the Reservation's moose. Consequently, no attempt will be made here to predict how long would be necessary for the moose population to reach a particular population level after

recommended management programs are implemented. However, based on the availability and quality of moose habitat on the Reservation, conservative estimates of potential carrying capacities, drainage by drainage, are offered in Table 6. Those estimates are based on the following assumptions.

1) Winter-spring habitat rather than summer-fall habitat is the controlling determinant of potential herd sizes.
2) For drainages in the WRM, all suitable habitat from 2.5 km east of the foot of the mountain slope (2.5 km east of the mouth of each canyon) on west was considered available to moose (Fig. 3).
3) For those drainages in the WRM from Dry Creek north, potential winter range both on and to the west of the Reservation was considered available.
4) For the OCM estimates, all suitable habitat within the known historic distribution was considered. Potential winter habitat both on and off the Reservation within the riparian corridors of the boundary streams (East Fork Wind River and South Fork Owl Creek) was considered available also.

In addition, the following assumptions were made.

1) Habitat availability and quality remain relatively unchanged as a result of man's activities.
2) Competition from other large herbivores does not appreciably alter the availability of the present forage supplies of browse species required by moose.

Proper regulation of hunting is a prerequisite to the realization of these potential range carrying capacities.

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Table 6. Potential winter carrying capacities for moose of drainages in the Wind River Mountains (WRM) and Owl Creek Mountains (OCM) of Wind River Indian Reservation (Wyoming).

Drainage	Estimated Carrying Capacity
WIND RIVER MOUNTAINS	
North Fork Little Wind River (including St. Lawrence Creek and Yahtic Lake drainages)	35
Bull Lake Creek	25
South Fork Little Wind River	25
Dry Creek	20
Bob Creek (including Meadow Creek)	15
Willow Creek	15
Trout Creek	10
Crooked Creek	8
Dinwoody Creek	8
Sage Creek	8
Cottonwood Creek	6
Little Dry Creek	5
Red Creek	5
Total WRM	185
OWL CREEK MOUNTAINS	
East Fork Wind River (including Reservation tributaries)	15
Crow Creek and Dry Creek (including Black Mountain)	10
South Fork Owl, Red, Dry Cottonwood and Mud Creeks	30
Total OCM	55

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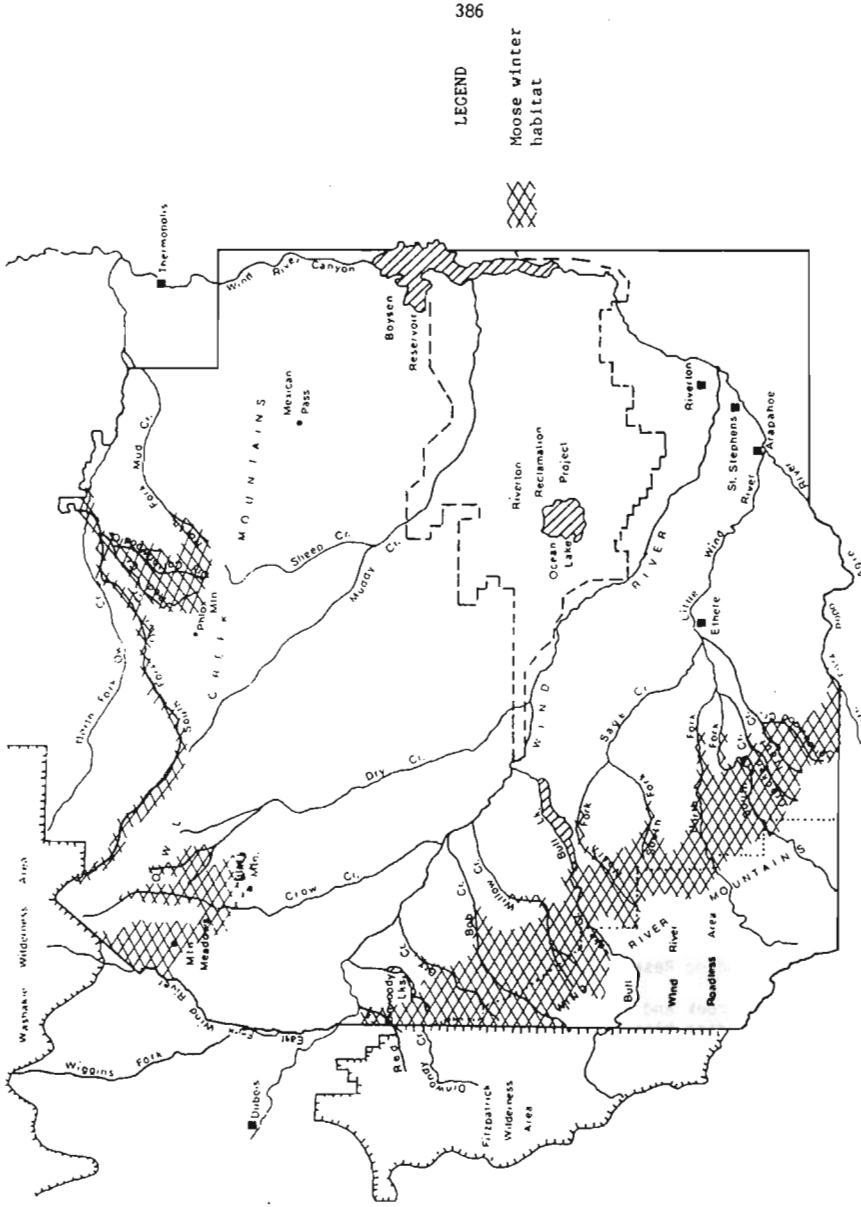

Figure 3. Distribution of moose winter habitat on Wind River Indian Reservation for which moose carrying capacity estimates were made.

In addition to the two mountain ranges of WRIR, some excellent moose habitat--mainly winter-spring range--occurs along the Wind and Little Wind River and their major tributaries beyond 2.5 km from the foot of the WRM. Those areas could provide habitat where forage availability and snow depths are more favorable to winter survival of moose than in the mountains. A closed hunting season from January 1 to September 15 would offer moose adequate winter/spring protection.

An occasional moose, such as the female killed near Ethete in September 1981, remain along the Wind River and Little Wind River during summer and fall. If the Shoshone and Arapahoe Tribes wish to protect moose year-round in those low-lying areas, no hunting of moose should occur east of Highway 287.

Habitat Management Considerations

Regarding the management of moose populations, Franzmann (1978) wrote, "The primary problem moose managers face today and in the future is the maintenance of adequate habitat. In some areas, heavy harvest combined with increasing losses to wolves and other predators may be equally important limitations to moose populations."

The present urgent need is proper regulation of hunter harvest. The secondary challenge is maintenance of the quantity, quality, and integrity of moose habitat to insure future potential of the Reservation to support moose. The demonstrated importance of riparian habitats to moose on WRIR and elsewhere in the west necessitates the protection and maintenance of intact riparian corridors for the welfare of moose. Removal of woody vegetation will reduce food supplies and cover required by moose. Building of additional roads,

or mining, energy, recreational and housing developments should be discouraged in or adjacent to currently occupied moose habitat or habitat of historic and potential future value to moose where the Shoshone and Arapahoe Tribes wish to reestablish moose (Fig. 2). These activities not only directly remove acreage from the habitat base, but they often cause moose and other big game to avoid adjacent areas of habitat.

Once adequate hunting regulations are implemented, the potential for excessive utilization of key browse species (willow according to present food habits analyses) due to increases in numbers of moose will exist. I suggest establishing several browse transects on moose winter range in the WRM and OCM and survey shrub condition and utilization using appropriate methods, such as those described by Cole (1965) and Houston (1968), at least biennially.

An important element in the ecology of moose is the availability of adequate amounts of seral shrub communities for feeding (Peek et al. 1976). In Wyoming (Gruell and Loope 1974), Idaho (Leege and Hickey 1977), and Minnesota (Peek et al. 1976), the important role that natural fire has played in maintaining a variety of successional stages, including shrub and aspen communities, in coniferous forest zones has been reviewed. Both natural fire and prescribed burning deserve study as management tools for creating and maintaining habitat diversity on WRIR for moose and other wildlife species dependent on seral stages of plant succession.

MANAGEMENT OBJECTIVES

The following management objectives, aimed at conserving and enhancing the moose resource on WRIR, are proposed.

1) Maintain the present distribution of moose in the WRM and increase the population size to 185 animals. Table 6 provides a guide to drainage by drainage herd objectives which should be attainable with proper regulation of harvest based on present potential of the habitat to support moose.

2) Reestablish a wintering moose population of approximately 55 animals in the OCM. Table 6 and Figure 3 show drainage by drainage guides for herd objectives and distribution.

3) Maintain the integrity of existing moose habitat throughout WRIR.

4) Strive for an annual moose harvest approximating the annual recruitment of yearling males. Given the population composition of WRM moose, this would equal seven or eight bull moose presently. Once the population objectives discussed above are achieved, an estimated 18 bulls could be harvested annually from the WRM and 5 from the OCM.

5) Adjust harvest regulations as necessary in the future to meet population objectives and to keep moose in balance with their food supply. Annual percent utilization should not exceed 50-60% of leaders on major browse species on winter ranges.

Smith (1982b) detailed management recommendations to the Tribes for achieving these objectives.

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