HISTORY OF MOOSE MANAGEMENT IN WYOMING AND RECENT TRENDS IN JACKSON HOLE

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ABSTRACT: Moose are believed to have entered Wyoming from Montana and Idaho within the past 150 years. Moose did not become established in Jackson Hole until the early 1900s. In 1903, the Wyoming State Legislature closed moose hunting seasons. In 1908, agency reports indicate moose were distributed along the Tetons, the upper Yellowstone River, and at the head of the Green River. By 1912, population estimates increased to 500 moose and the hunting season was reopened. Moose began to occupy portions of the Wind River Range during the 1930s and became quite numerous by the 1960s. Moose were first introduced in the Bighorn Mountains in 1948. Moose moved into the Medicine Bow Mountains from Colorado in the 1980s. Moose presently occupy habitats in western, north central, and southeastern Wyoming. Statewide, managers recognize 14 distinct herd units. Each herd has a postseason population objective that is set according to biological, sociological, and political considerations. Population estimates are based on aerial surveys, hunter harvests, and age structure of the harvest. Check stations are utilized to monitor harvest rates and collect data from harvested animals along exit routes from popular hunting areas. Wyoming currently utilizes population modeling, indices, and in some cases sample estimates such as sightability models to estimate moose populations. The 2001 statewide population was estimated at approximately 13,657 moose. The statewide population objective is 14,650 moose. Hunting seasons in Wyoming are traditionally conservative and hunter success has generally remained in the 80–90% range. A harvest questionnaire is sent annually to all moose permit holders. Response is typically 80%. Harvest data are used to calculate hunter success, days of hunter effort per moose harvested, total harvest, and harvest composition. In 2001, a total of 1,379 hunters harvested 806 bulls, 337 cows, and 72 calves. These hunters had an 89% success rate and spent an average of 6.2 days hunting / animal harvested. In 2001, a total of $360 per moose was generated from license revenue while management costs were $411 per moose. A restitution value of $7,500 for illegally taking moose has been established. Statewide, a total of 2,308 moose were classified in 4 herd units and the calf:cow ratio was 35 calves per 100 cows and the bull:cow ratio was 62 bulls per 100 cows. Statewide, populations have remained relatively stable, however, in the Jackson area moose populations have declined in recent years. License quotas have decreased from an average of 410 licenses during 1991 –1995 to 248 during 1999 – 2003. Calf:cow ratios declined from a 1963 – 1993 average of 48 calves:100 cows (SE=8.9) to a 1998 – 2003 average of 34:100 (SE=8.3) Low pregnancy and twinning rates have been reported in this herd. Habitat changes and predator population increases are thought to be contributing to this decline.

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George Shiras III described a mountain race of moose during his explorations in Yellowstone National Park, from 1908 – 1910. In honor of Shiras, Nelson (1914) named the Yellowstone moose *Alces alces shirasi*. Moose in the Yellowstone region continue to be a keystone species among Wyoming Wildlife and symbolic of Wyo-

ming's wildlife heritage.

History in Wyoming

Few if any moose were believed to exist in the Yellowstone and Jackson Hole areas of Wyoming prior to 1850 (Houston 1968) and moose that populated Wyoming were thought to have migrated from Montana (Koch 1941, Spaulding 1956, Curtright 1969, Schladweiler 1974). Between 1834 and 1843, Osborn Russell kept detailed records of his travels and observations in western Wyoming where moose are now found in abundance yet he did not mention them in his journals. Moose likely increased and expanded shortly after Russell's travels. In July, 1872, members of the Hayden expedition killed a cow and a calf moose while camped in Jackson Hole (Reeves and McCabe 1998). On the west side of the Teton Mountains, Richard (Beaver Dick) Leigh mentioned the abundant moose sign he observed and the encounters he had with moose during June 1875 (Blair 1987).

The first Wyoming Territorial legislature convened in Cheyenne on October 1869 and a rudimentary act for the protection of game and fish in the Territory of Wyoming was passed. This act provided for the sale of elk, deer, antelope, and mountain sheep or their young between February 1 and August 1. There was no closed season for the hunting of big game, only a restriction on the sale of game. Penalization however was through civil rather than criminal law and so the act was largely ignored. The first hunting season for big game was set in 1875 and the season ran from August 15 to January 15. In 1882 moose and mountain goat were added to the list of protected species. Section 1 of the game code read: "It shall be unlawful to pursue, hunt or kill any deer, elk, moose, mountain sheep, goat, antelope or buffalo save only from August 1 to November 15 inclusive in each year, or kill or capture by means of any pit, pitfall or trap any of the above named animals". Following early settlement, the numbers of moose declined and in 1899 the legislature enacted laws granting moose complete protection (WGFC 1948). Blunt (1950) reported that in 1903 the State Legislature granted protection for 10 years. The 1908 Annual Report of the State Game Warden indicated moose were distributed along the Teton Range, the upper Yellowstone River, and at the head of the Green River. Moose seasons were reopened in 1912. In the 1912 annual report it was estimated that there were 500 moose in Wyoming, principally in the northwest region. In 1915 a total of 19 moose licenses were sold for $160 each and 16 moose were harvested. By 1916, it was estimated that 2,000 moose roamed western Wyoming.

Between 1935 and 1948 the legal harvest totaled 1,515 moose in Wyoming. Moose were still an unusual sight, often mistaken for elk and accidentally killed. During the 1938 elk season a total of 23 moose were accidentally killed. It was also mentioned in the 1937 –1938 Biennial Report that there was an abundance of ticks on moose during the spring of 1938 (WGFC 1938). Managers estimated the population at 3,210 moose in 1940.

Moose began to occupy portions of the Wind River Range during the 1930s (Smith 1982). While natural dispersal was occurring in northwestern Wyoming, efforts were underway to expand moose distribution in other parts of the state. In 1934, 17 moose were captured in Jackson Hole. These animals were individually crated for shipping and died in transit. In 1948, 8 moose were baited into a trap and transported by trucks to the Bighorn Mountains in north central Wyoming. Several moose calves were also captured during 1948, by roping from a horse. All of the calves captured this way died in the holding corral within a month. In 1950, an additional 8 moose were

captured in Jackson and released in the Bighorn Mountains. An additional 13 moose were captured in the Jackson area and released in the Bighorns in 1974 and 1987. Twelve moose were relocated from Jackson to North Park, Colorado in 1979. Another 12 moose were transplanted to the Upper Laramie River in Colorado in 1987. Moose emigrated from the Colorado population into southeast Wyoming and by 2000, a huntable population inhabited the Snowy Range.

Artificial Feeding

Although the Department does not support supplemental feeding of moose, feeding has occurred in the past in Western Wyoming (Johnson et al. 1985). Moose feeding areas were started at the urging of landowners in areas where extensive damage repeatedly occurred to stored hay and livestock feed lines. The Wyoming Game and Fish Department is legally responsible for paying for damage to private property caused by big and trophy game.

As early as 1949 the Wyoming Game and Fish Department fed 40 moose on an emergency basis near Moran Junction. Through the late 1960s approximately 75 moose fed with private ranch horses in Grand Teton National Park. In the 1970s the feed ground was moved from the park to the Moosehead Ranch, a private in-holding within the Park. Moose were fed on this ranch from December through April. The Wyoming Game and Fish Department annually supplied 15 – 20 tons of hay for moose on this ranch through the early 1980s.

During the 1970s the Department began providing alfalfa (*Medicago sativa*) to ranchers to minimize damage to stored hay. By the early 1980s there were 5 moose feeding areas approved by the Wyoming Game and Fish Commission along with several other unofficial moose feedgrounds. Moose were fed 1 kg/day during the early winter and up to 7 kg/day by February. Feeding usually began in January and ended in mid-March. It is likely that moose only supplemented their normal browse diets at these feed lines. Most of these sites were phased out by the early 1990s.

Between 1970 and 1984, up to 586 moose were fed each year at 4 sites south of Jackson near Big Piney. These sites were located on Cottonwood Creek, Horse Creek, Beaver Creek, and the Green River (Johnson et al. 1985). The feedgrounds in these drainages were unsuccessful in eliminating damages to private property from moose. Moose generally fed at these sites and then ranged as far away as 2 miles.

Unofficial moose feeding sites were also started in the Gros Ventre drainage and in Bondurant along the Hoback River. In the Gros Ventre drainage east of Jackson, moose regularly frequented the Patrol Cabin elk feed ground. In the mid-1970s up to 75 moose visited the elk feed line where baled alfalfa hay was scattered. In general, moose would consume hay before elk came into the feed line and then bed down in the willows adjacent to the feed ground. Currently less than 12 moose visit this feed line. In Bondurant along the Hoback River, moose were fed in 2 locations on private land. The first was near the town of Bondurant and the other was on Jack Creek.

CURRENT STATUS AND MANAGEMENT

Moose presently occupy habitats in western, north central, and southeastern Wyoming (Fig. 1). Statewide, managers recognize 14 distinct herd units. Each herd unit contains a discrete population for which emigration and immigration between adjacent herds accounts for less than 10% of the herd unit's population. Hydrologic divides, major rivers, and other natural and man-made barriers generally constitute herd unit boundaries. Herd units are further

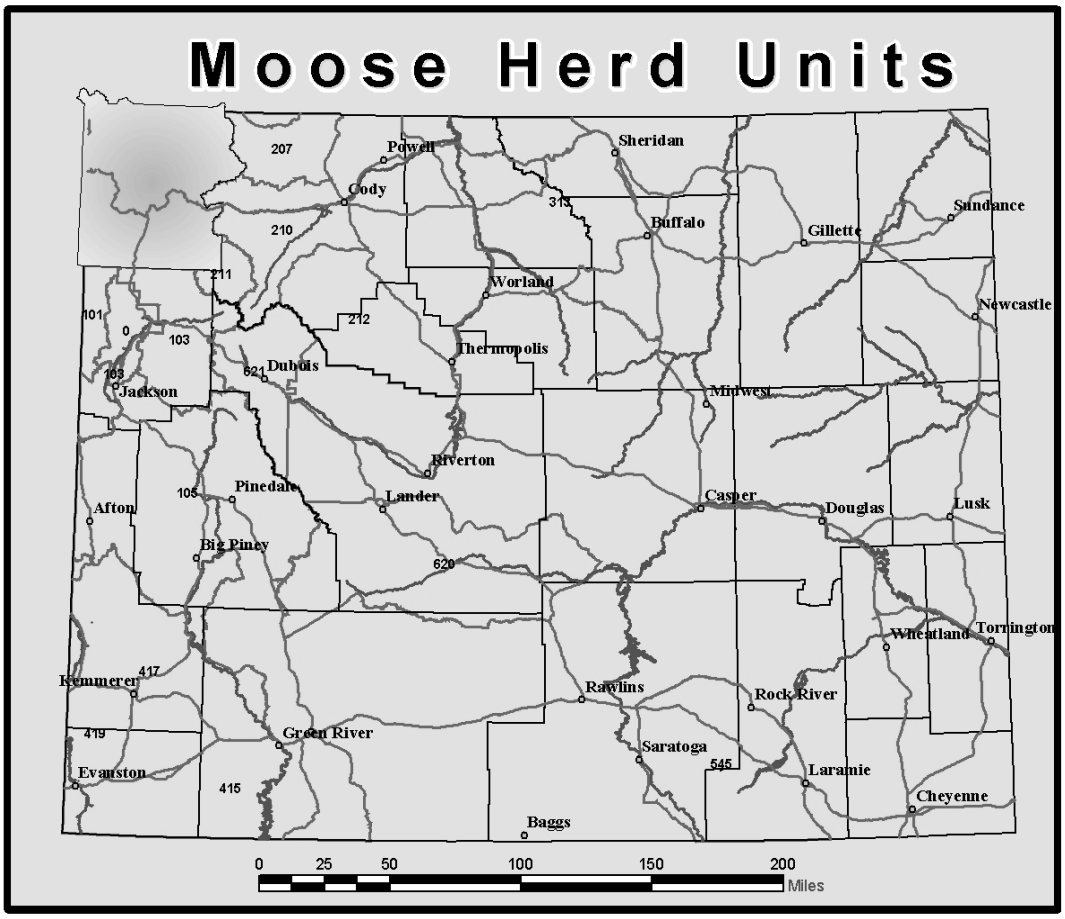

Fig. 1. Delineated moose herd units in Wyoming 2003.

subdivided into hunt areas to provide management flexibility. There are a total of 41 hunt areas in Wyoming. Each herd has a postseason population objective that is set according to biological, sociological, and political considerations. Statewide, managers estimated this population at 13,657 moose in 2001. The statewide postseason population objective was 14,650 moose.

Population Census and Modeling

Population estimates are based on population simulations along with population indices and in some cases sample estimates such as sightability models. Since 1976, WGFD has been modeling big game populations using POP-II or its precursors (Hnilicka and Zornes 1994). Models are useful tools for estimating populations and evaluating harvest strategies. Modeling assumptions for POP-II include: (1) effects of emigration and immigration are negligible; (2) natural mortality rates affect all age cohorts in a predictable linear fashion; (3) estimates of sex and age classifications, harvest, natural mortality, and wounding loss mirror reality; and (4) effects of density-dependent or other feed-back mechanisms are negligible (Bartholow 1992, Guenzel 1994). Population modeling requires data collected by field personnel including herd classifications, harvest composition, and mortality rates, and are validated using trend count data. Population

estimates prior to 1976 are based on trend counts only.

Accurate age and sex ratios are needed to analyze herd dynamics and reliably estimate moose populations. Aerial surveys are the most practical method of classifying moose over large areas and diverse habitats during the post hunt period. Aerial surveys often enable managers to meet sampling assumptions and more observations are recorded per unit effort than during ground surveys. All aerial surveys follow protocol outlined in the Aircraft Operation Procedures and Safety Policy of the Wyoming Game and Fish Department Policy Manual (WGFC 2002).

Aerial surveys utilizing fixed-wing aircraft were first initiated in 1952 (WGFC 1952). Previous surveys were conducted from the ground or incidentally during aerial surveys for elk. Currently WGFD conducts helicopter surveys to classify herds by sex and age and to conduct trend counts. Surveys are flown annually or biennially during the winter months when moose are concentrated on winter ranges. Summer helicopter surveys are conducted in the Bighorn Herd Unit when moose are in more open habitats. Desired sample sizes are calculated on herds to produce an 80% confidence interval $\pm$ 10 percent for sex and age classification ratios.

Moose are the least gregarious of all Wyoming ungulates and are often observed alone or in small groups. During winter sightability flights in the Jackson area during 1998 and 1999, the average group size was 2.2 moose per group (range 1-15) out of 358 groups observed. In addition to small group size, moose are often segregated by sex and age making some classes of animals more difficult to observe than others (Peek et al. 1974). Because of group size and their distribution in various habitats, it is uneconomical to get a total count of moose. Adequate samples are usually only achieved on the larger moose herds. On smaller herds, ground or fixed-wing surveys are often conducted.

Preseason classifications are conducted by helicopter surveys in some herds because moose are more visible during the preseason period than during postseason when animals move into conifer habitats (WGFD 1999). Preseason classifications are conducted over a week period in July or August. A shorter time frame is used to avoid duplicate counts. Consistent survey techniques are utilized to make valid comparisons from year to year. Flights are conducted in early morning and limited to 2-3 hours in duration. Preseason classifications are used to estimate fall recruitment, verify population trend, and used in population simulation models. Ground classifications are done in some herd units due to low moose densities and budget constraints.

Postseason classifications are conducted during December through February. A helicopter is generally used, however ground classifications may be warranted in herd units with low moose densities and due to budget constraints. Surveys are conducted when good snow cover is present, preferably within a few days of fresh snow. Surveys cover representative areas of riparian, deciduous, and conifer habitats frequented by moose. Partial surveys of an area may produce biased composition estimates. In Alaska, Gasaway et. al. (1986) determined that classifications that were conducted during surveys designed for population estimation purposes resulted in higher, more representative calf:cow ratios than did less intensive composition surveys.

All moose encountered during aerial surveys are assigned to one of the following classes: bulls, yearling bulls, cows, calves, or unclassified adults. In addition, cows with calves are tallied and those having twins are noted. Body size tends to be the most useful criteria for identification of

calves. Head features are used to avoid classifying large calves as yearlings. Calf moose have relatively small ears and short, pointed noses compared to the larger bulbous nose of an adult moose. Moose calves also tend to remain close to the cow and will often follow close behind her when disturbed. During the post hunt period observers identify 2 or more criteria when sexing adult moose. The criteria include: antler or pedicel scars, vulva patch, behavior, bell shape and size, group composition, and body conformation. Not all females have the characteristic vulva patch and some males have a small light brown area that can be mistaken for a vulva patch. Timmermann and Buss (1998) provide a summary of the different criteria helpful in identifying the sex and age of moose.

Classification results are recorded by location on a hand-held GPS and then downloaded to a Microsoft Excel spreadsheet and mapped using various software programs such as ArcMap, ArcExplore, and All Topo. Location records help managers identify important habitats and their proximity to human development, recreational areas, timber sales, etc.

In some herd units, a Wyoming Moose Sightability Model has been utilized to calculate a population estimate using correction factors that compensate for effects of vegetation cover, group size, etc. Utilizing procedures described by Unsworth et al. (1991), Anderson and Lindzey (1995) developed a sightablity model for moose in Wyoming. Sightability surveys are designed to sample a portion of a stratified survey area in order to improve accuracy and precision of population estimates while reducing survey costs. The survey is conducted in early winter (i.e., December and January) when moose are still located in open habitats. Procedures outlined in the Aerial Survey User's Manual (Unsworth et al. 1994) are followed when observing and recording moose and evaluating vegetation cover. Data are then transcribed and entered into the model based upon the format described by Anderson and Lindzey (1995), and evaluated using the Aerial Survey Software (Unsworth et al. 1994).

The Wyoming sightability model was utilized in 1996 – 1997 on a portion of the Jackson herd unit. Estimates from 1996 – 1998 indicate that an average of 63% of moose were observed during helicopter surveys in willow, cottonwood, and coniferous habitat. In Colorado, Bowden and Kufeld (1995) observed 58% of radiocollared moose during helicopter surveys.

Herd Unit Statistics

Statewide, the calf:cow ratio was 35 calves per 100 cows following the hunting season in 2001. A total of 2,308 moose were classified in 4 herd units. Typical lower to upper ranges include 31 calves per 100 cows in the Jackson Herd Unit and 45 calves per 100 cows in the Lander Herd Unit. Adequate classification sample size at the 80% confidence level is regularly obtained in only the Sublette Herd Unit. The average calf:cow ratio was 43 calves per 100 cows in this herd during the 1997-2002 period. The bull:cow ratio was 63 bulls per 100 cows statewide with a high of 68 bulls per 100 cows in the Lincoln Herd Unit. A total of 37 bulls per 100 cows were reported in the Lander Herd Unit. The 1997 – 2001 average in the Sublette herd was 63 bulls per 100 cows.

The age at which cow moose first reproduce varies from 1.4 to 2.4 years (Schwartz 1992) and may be delayed to 3.4 years in poor quality range (Albright and Keith 1987). In Jackson Hole, Houston (1968) reported a yearling pregnancy rate of 5 – 6 % in Jackson Hole during the 1960s. More recently it is suspected that female moose reproduce at age 3 in Jackson Hole. A 2% twinning rate was observed

during the 1999 post hunt period in the Jackson and Targhee Herd Units. Houston (1968) reported a 4% twinning rate in the Jackson area during the 1960s.

Range of Natural Mortality

For population simulation models in Wyoming, we estimate calf mortality rates at 10 – 25% preseason. Post hunting season calf mortality rates range from 15 – 25%. As large predator populations become established in Wyoming, mortality rates used in population modeling rates are likely to change. Simulation models in Wyoming utilize a 98 – 100% survival rate for adult females and a 100% survival rate for adult males during the pre-hunt period. Age and sex specific survival rates between 85-100% are used for simulation models in Wyoming during the winter period.

Hunting Seasons

Hunting seasons in Wyoming have been conservative and hunter success has generally remained in the 80 – 100% range. In an effort to improve calf moose survival, hunting regulations were changed in 1998 to prohibit hunters from taking a cow moose accompanied by a calf. This action was taken to improve survival of dependent calves and increase recruitment. At the beginning of the hunting season, all moose hunters are sent a packet of information that includes a hunter survey card, a tooth collection box, and instructions for tooth removal.

In 2001 a total of 1,379 hunters harvested 806 bulls, 337 cows, and 72 calves. These hunters had an 89% success rate and spent an average of 6.2 days hunting / animal harvested. In 2001, a total of $360 per moose was generated from license revenue while management costs were $411 per moose. Wyoming Statute §23-6-204(e) grants the Wyoming Game and Fish Commission authority to recommend to courts the amount of restitution for the value of wildlife taken in violation of Title 23, the Game and Fish Act, that the court might impose as a penalty on any person. In 2003 the Commission established a $7,500 restitution value to courts for individual animals. The restitution value was derived from average costs incurred and/or lost to the State. They include hunter expenditures, management costs, license revenue, and other commercial revenues.

During the hunting season, hunter check stations and random field checks give managers an opportunity to collect biological data from harvested animals along exit routes from popular hunting areas. In addition, check stations enable field personnel to contact sportsmen, monitor regulation compliance, and improve public relations by informing the public of Department operations (WGFC 2003).

Age data are collected from harvested animals by inspecting and/or collecting the front incisor teeth of harvested moose. Specific ages of harvested moose are determined from sectioned teeth (Sergeant and Pimlott 1959). Aging is based on counting cementum annuli, which can be microscopically examined in the tooth cross-sections. This information has several management uses. Harvested antlerless moose are considered an un-biased sample of yearling and older age classes within the female segment of the population. Accordingly, managers can estimate the age structure of the female segment using age data from harvested, antlerless moose. Ages of harvested bulls do not represent a valid age structure of the male segment because hunters tend to select older age classes. However, the age distribution of harvested bulls is useful to assess current harvest trends in relation to harvest objectives. Multiple-year shifts in age composition of the male harvest may indicate a need to adjust license numbers, or may provide evidence of changing moose numbers or sex ratios. Age-

specific harvests are incorporated into population simulation models each year. Longer-term age data can be used to determine the oldest age classes and female age structure for population modeling purposes. In 2001, 578 male and 237 female tooth samples were collected during the hunting season. A total of 508 (89%) of the antlered animals were 1 – 7 years of age and 60 (11%) of the antlered samples were older than 8 years of age. The average of males ≥ 1 year of age was 4.8 years old and the oldest male in the harvest was 12.3 years of age. Of the antlerless harvest excluding calves, 185 (84%) were 1 – 7 years of age and 34 (15%) were older than 8 years of age. The average of females ≥ 1 year of age was 4.6 years old and the oldest female in the harvest was 18.3 years of age.

Following the hunting season a second harvest questionnaire is sent to all moose permit holders who did not return survey cards. Initial response is typically 75-80%. Nonrespondents are contacted by phone. Harvest data are used to calculate hunter success, days of hunter effort per moose harvested, total harvest, and harvest composition. Questionnaire results are considered accurate.

Distribution and Movement

Moose distribution and movement patterns have been documented and mapped in varying degrees throughout Wyoming. Distribution information is used to determine seasonal ranges for each herd. Biologists and others use distribution maps to develop comments on proposed land use developments and other planning purposes.

JACKSON MOOSE TRENDS

Statewide, populations have remained relatively stable, however, in the Jackson area moose populations have declined in recent years. The Jackson Moose Herd is located in northwest Wyoming and encompasses 2,000 square miles. The area covers the Gros Ventre, Buffalo Fork, and Upper Snake River drainages in Teton County.

The Jackson Herd Unit is primarily public land. The majority of moose in this herd spend spring, summer, and fall at mid-to-high elevations and drift down drainage to winter ranges along the Gros Ventre, Buffalo Fork, or Snake Rivers. Some moose stay at higher elevations and winter in the spruce/fir zone.

Upland vegetation communities in the herd unit include Subalpine fir (*Abies lasiocarpa),* Englemann spruce (*Picea*

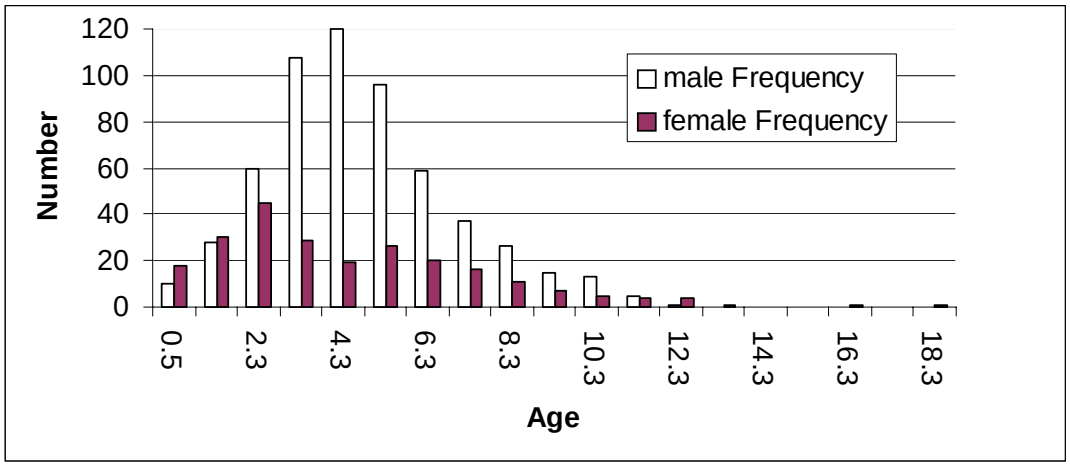

Fig. 2. Male and female age frequency in the 2001 harvest of the Jackson Moose Herd.

engelmanni), Lodgepole pine (*Pinus contorta*), Douglas fir (*Psuedotsuga menziesii*), and aspen (*Populus tremuloides*). Riparian areas are characterized by cottonwood (*Populus angustifolia*) and willow (*Salix* spp.). Extensive stands of mountain big sage (*Artemisia tridentata)* and antelope bitterbrush (*Purshia tridentata)* are found in a portion of Jackson Hole north of the town of Jackson. The bitterbrush is used extensively by moose in fall and spring and when available during the winter. Elevation of occupied habitat ranges from 6,000 - 10,000 feet.

Population simulations indicate that this population has declined from a high of 3,500 moose to 2,100 moose from 1992 through 2003. Since 1981, a Bell 47 helicopter has been used to classify moose. A total of 477 moose were classified in 2001: 161 bulls (34%), 240 cows (51%), and 74 calves (16%). Herd ratios were 67 bulls:100 cows:31 calves (Fig. 2). The bull:cow ratio was higher than 2000 (64 bulls:100 cows) and the 1996 - 2000 average (66 bulls:100 cows). The calf:cow ratio observed in 2001 was lower than 2000 (39 calves:100 cows) and the 1996 - 2000 average (36 calves:100 cows).

Lower moose numbers were most apparent on winter ranges located 30 miles north of Jackson in the Buffalo Valley. Between 1985 –1989 an average of 335 moose were observed on winter range in the Buffalo Valley. Between 1995 – 1999 an average of 183 moose were observed on this same winter range and between 2000 and 2002 an average of 123 moose were classified.

Correspondingly license quotas have also decreased. Between 1991-1995 an average of 410 licenses were issued in the Jackson Moose Herd Unit. From 1999 – 2003 the average number of moose licenses was 248. A total of 145 moose licenses are proposed for 2003 (Table 1). Calf:cow ratios declined from a 1963 – 1993 average of 48 calves:100 cows (SE=8.9) to a 1998 – 2003 average of 34:100 (SE=8.3).

While moose numbers have declined over time, it is thought that the large predator populations have increased. The cause and effect of the predator/prey relationship

Table 1. Jackson moose license quotas, harvest, trend count, and population estimates 1991 - 2003.

	1991	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Antlered licenses	290	265	240	180	195	200	205	205	205	205	200	185	135
Antlerless licenses	205	200	190	135	150	145	115	105	95	80	60	45	10
Total permits	495	465	430	315	345	345	320	310	300	290	260	265	145
Antlered harvest	213	188	181	164	163	170	159	142	153	158	159	136	
Antlerless harvest	180	176	139	130	138	117	93	92	69	62	48	30	
Hunter success (%)	80	80	78	93	88	87	81	76	74	78	80	74	
Days/animal	6.5	6.4	7.4	4.8	6	6.2	6	7.3	11.7	8.49	7.8	10.1	
Trend count	683	927	757	975	970	803	712	815	830	589	480	513	
Calf:cow ratio	44	43.3	34	58.5	37.5	25.7	36.2	42.6	35.1	39.2	30.6	21.1	

between moose and grizzly bears is largely unknown in the southern portion of the Yellowstone ecosystem. It is thought that moose pregnancy rates are low (~75 %) because of present habitat conditions and that moose calf survival is being influenced by the recolonization of large carnivores. An increased effort is being made to monitor pregnancy rates in other portions of the Jackson Herd.

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