PRUDENT AND IMPRUDENT USE OF ANTLERLESS MOOSE HARVESTS IN INTERIOR ALASKA

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ABSTRACT: Liberal antlerless moose (*Alces alces*) hunts which allow the take of substantial numbers of largely female moose have been controversial and divisive since the Alaska Department of Fish and Game instituted ill-timed, liberal antlerless hunts in the early 1970s that contributed to a precipitous population decline. Thus, we initially found the governing, citizen (non-agency) advisory committees largely skeptical of implementing liberal antlerless harvests in the early 2000s in Game Management Unit 20A (Unit 20A). To help justify the hunts, we focused on presenting information about the notably low nutritional status of the current moose population relative to moose populations worldwide. However, to gain broader credibility and trust, we needed to directly address public perceptions regarding former "mismanagement" of antlerless hunts, including admitting past mistakes that contributed to long-term poor hunting opportunities. We subsequently presented major differences between recent antlerless hunts and those in the 1970s. Specifically, we contrasted relevant circumstances between the 2 time periods, including moose population trajectories, harvest rates of males and females, survey techniques and related technology, winter severity and frequency, and reproductive rates. Illustrating the major, time-period differences in these parameters was key to assuring the public that harvest of female moose could be prudent. By directly addressing public anxieties, we were successful in gaining and maintaining public support for liberal antlerless hunts in Unit 20A. Subsequently, our success in Unit 20A has helped ease recent expansion of antlerless hunts into adjacent areas.

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Key words: Alaska, *Alces alces*, antlerless, harvest rates, management, moose, overharvest, population trajectory, productivity, winter severity.

We provide an example where decades-old, and at times imprudent moose (*Alces alces*) management had an overwhelming influence on the implementation of current management strategy. The moose population in Game Management Unit 20A (Unit 20A) increased to an estimated 23,000 moose in the early 1960s following large-scale wildfires in the early 1940s, federal predator control in the 1950s, and low bull-only harvests (Rausch et al. 1974, Gasaway et al. 1983). A dramatic population decline to an estimated 2,800 moose occurred by early winter 1975. Causes for the decline included at least 5 harsh winters between 1961 and 1975, accompanying high rates of predation, and liberal harvest of female moose in 1972-1974, simultaneous with increased numbers of hunters, improved access, and increased use of snow machines and airplanes (Gasaway et al. 1983). In this system where black bears (*Ursus americanus*), brown bears (*Ursus arctos*), and wolves (*Canis lupus*) are all significant predators on moose, Boertje et al. (2007) defined liberal antlerless harvest as harvests ≥2.0% of the prehunt moose population. In retrospect, managers underestimated the effects of predation especially during harsh winters, and therefore the severity of the decline during the mid-1960s to mid-1970s, and mistakenly promoted liberal harvests of female moose, in part, to improve productivity. In response to intense public pressure concerning mismanagement that contributed to the depressed population and reduced hunting opportunity, the Alaska legislature in 1975 granted veto authority for antlerless hunts to the majority of the locally affected citizen (non-agency) advisory committees (Young et al. 2006).

Following the population decline, a period of growth ensued from 1976-2003. Causes for the increase included state wolf control (1976-1982, 1993-1994), public harvest of predators, predominantly conservative bull-only harvests, and nearly 3 decades of mostly mild winters (Boertje et al. 1996, 2009). By November 2004, Unit 20A had the highest moose density (~1.3 moose/km^2) in Alaska for any equivalent-sized area.

Given the high and increasing moose density and related poor nutritional status (Boertje et al. 2007, 2009), the relevant primary goals of the Alaska Department of Fish and Game (ADFG) were to 1) protect the moose population's health and habitat, and 2) fulfill an intensive management (IM) mandate for achieving high levels of harvest (Alaska Statutes 2009). In order to meet these objectives, it was necessary to reduce the population through harvest of substantial numbers of cows, because bull:cow ratios were already at or below the objective of 30 bulls:100 cows (Young and Boertje 2004, Young et al. 2006, Young and Boertje 2008, Boertje et al. 2009). To gain public support for these antlerless moose hunts, ADFG needed to convince local citizen advisory committees that 1) the hunts were required to achieve the department's goals, and 2) management "mistakes" that occurred in the 1970s would not be repeated.

STUDY AREA

The study area, Unit 20A, is in interior Alaska immediately south of Fairbanks (Alaska, USA) across the Tanana River, and is centered on 64°10′N latitude and 147°45′W longitude (Fig. 1). Unit 20A encompasses 17,601 km^2, but only 13,044 km^2 contains topography and vegetation characteristic of moose habitat; the study area was described in detail by Gasaway et al. (1983). The northern portion consists of the northern lowlands (Tanana Flats) with elevations ranging from 110-300 m. The southern portion consists of the northern foothills and mountains of the Alaska Range with elevations varying up to 4000 m. Lowland vegetation is a mosaic of shrub and young forest dominated seres, climax bogs, and mature black spruce (*Picea mariana*) forest. Vegetation in the hills, foothills, and mountains grades from taiga at lower elevations into shrub dominated communities with alpine tundra at higher elevations. The climate is typical of interior Alaska where temperatures frequently reach 25° C in summer and -10° to -40° C in winter. Snow depths are generally >80 cm. Boertje et al. (1996) and Keech et al. (2000) described the physiography, habitat, climate, and factors limiting moose in 1963-1997. Young and Boertje (2004) described hunter access, moose seasons, and bag limits from the 1960s through the early 2000s, moose population status from 1997-2003, and the use of calf hunts to increase yield. Young et al. (2006) detailed the regulatory and biological history of moose from the 1960s through the early 2000s, and described impediments and achievements of managing moose for elevated yield in Unit 20A. Moose in Unit 20A (1997-2005) exhibited the lowest nutritional status documented for noninsular, wild moose in North America (Boertje et al. 2007). Boertje et al. (2009) described how predation and reproduction affected the harvest of moose in 1996-2007. Young and Boertje (2008) described the use of selective harvest strategies to recover low bull:cow ratios in Unit 20A.

METHODS

We defined harvest rate as (estimated harvest)/(prehunt population estimate). Estimated harvest was calculated as reported harvest × 1.15 to lend consistency to past studies (Gasaway et al. 1983, Boertje et al. 1996). The prehunt population estimate was calculated as the estimated November population size + esti-

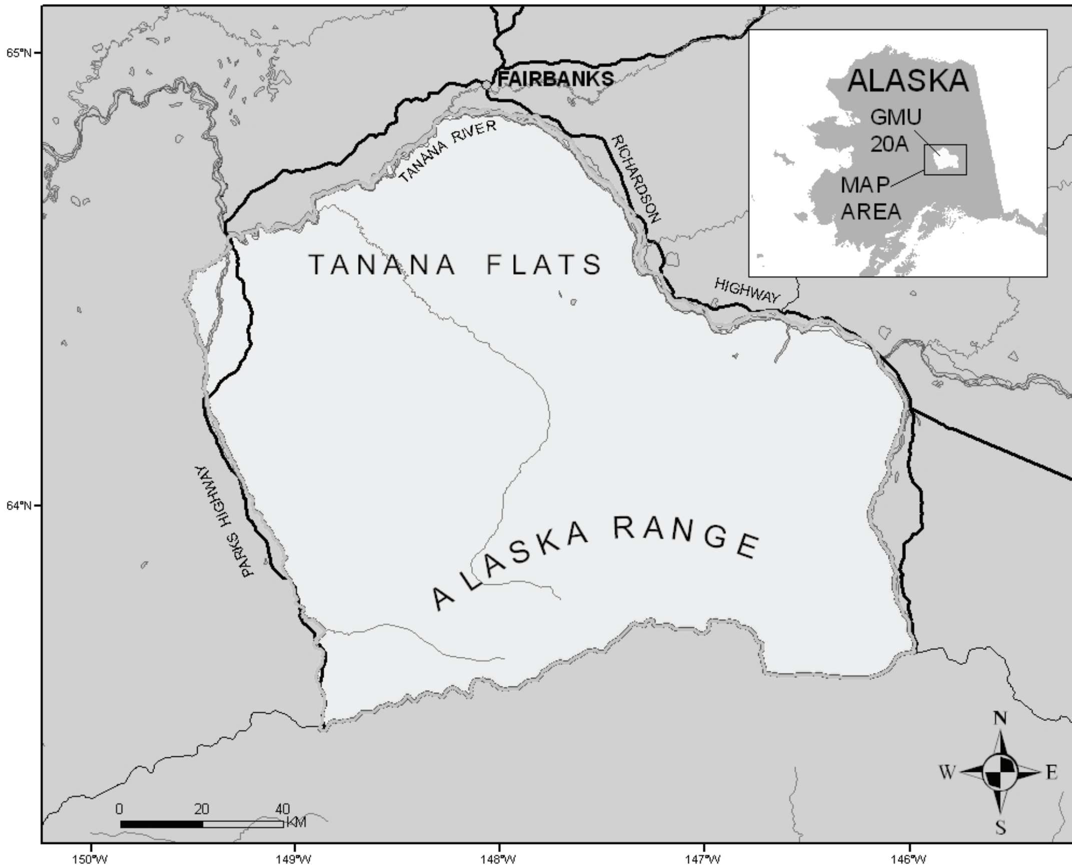

Fig. 1. Location of Game Management Unit (GMU) 20A in Interior Alaska.

mated harvest. We used estimated harvest and prehunt moose population estimates reported by Gasaway et al. (1983) for years 1963-1978, Boertje et al. (1996) for years 1979-1994, and unpublished data for years 1995-2009. Gender-specific harvest rates were calculated as (estimated harvest per gender)/(prehunt moose population estimate). We monitored the annual moose harvest and gender of the harvest using a mandatory harvest report card system with reminder letters (Schwartz et al. 1992, Boertje et al. 1996).

We used the November moose population estimates reported by Gasaway et al. (1983; years 1963-1978), Boertje et al. (1996; years 1979-1994), and Boertje et al. (2007; years 1996-2006). In 2008 and 2009 we flew 158 and 116 of the 987 sample units available using methods described by Boertje et al. (2007). We did not conduct moose population estimation surveys in 1995, 2002, or 2007, but used interpolations from adjacent years. Since 1999 we used spatial statistics to estimate moose abundance (DeLong 2006, Kellie and DeLong 2006, Ver Hoef 2008) and applied a sightability correction factor of 1.21 (Boertje et al. 2009). To estimate the finite annual population growth rate (λ), we fitted population estimates during 1996-2004 and 2003-2009 with a trend line using mixed effects models (Ver Hoef 1996, DeLong and Taras 2009). We estimated finite annual population growth rates for the overall population and, in order to reduce variability and improve precision, the adult female (≥1 year-old) segment of the population.

We calculated twinning rate as the number of adult females observed with ≥2 newborns divided by the number of adult females observed with ≥1 newborn (Boertje et al. 2007). Staff flew late May or early June surveys in the central Tanana Flats during 43 years from 1960-2009 to estimate moose twinning rates. Staff flew transect surveys during 1-day to 4-day periods in Bellanca Scout or Piper PA-18 aircraft with both an observer and pilot searching for newborns; staff circled to determine if twins were present.

To evaluate which winters were severe (i.e., winters defined as those with ≥80 cm accumulated snow depth, Coady 1974) we used snow data reported by Gasaway et al. (1983; winters 1959-1960 through 1978-1979), Boertje et al. (1996; winters 1979-1980 through 1993-1994) and the National Weather Service at Fairbanks, Alaska and archived by the Alaska Climate Research Center, Geophysical Institute, University of Alaska (Alaska Climate Research Center 2010; winters 1994-1995 through 2009-2010).

RESULTS

To address concerns of committees with veto authority over antlerless hunts, we documented 5 major differences (Table 1) between moose management in the early 1970s versus the early 2000s:

1. The moose population was clearly declining prior to the 1970s liberal antlerless harvests (Fig. 2). In contrast, prior to initiation of the 2004 liberal antlerless hunts, we estimated that the moose population increased (λ = 1.053, SE = 0.013, 1996-2004) from approximately 11,500 to 17,800 and cows (λ = 1.04, SE = 0.015, 1996-2003) from approximately 7,700 to 11,000 (Fig. 3 and 4).
2. During 1996-2003 the population grew with overall harvest rates averaging 5.1% (3.5-6.5%) and female harvest rates averaging 0.6% (0-1.1%; Fig. 3 and 4). During 2004–2007 the population declined with overall harvest rates of 7.0% (6.3-7.5%) and female harvest rates of 3.5% (3.1-4.2%; Fig. 5). During the liberal antlerless hunts in 1972-1974 harvest rates averaged 14.2% (10.4-18.5%) overall and 6.7% (4.3-9.5%) for females (Fig. 6).

Table 1. Major differences in management components relative to imprudent (1970s) and prudent (2000s) moose management, Game Management Unit 20A, interior Alaska, USA.

Component	1970s	2000s
Moose population trajectory	Decreasing	Increasing
Harvest rates (% of females harvested in prehunt population)	Higher (4.3–9.5%)	Lower (3.1–4.2%)
Survey techniques to measure moose density and related technology	Unavailable	Available and proven
Frequency and severity of harsh winters	Series of harsh winters	Decades-long mild winters
Nutritional status	Higher ($\bar{x}$ = 15% twinning rates in central area 6 years prior to liberal antlerless harvest, 1966–1971)	Lower ($\bar{x}$ = 7% twinning rates in central area 6 years prior to liberal antlerless harvest, 1998–2003)

3. Moose managers in the early 1970s had inadequate survey techniques to estimate moose numbers, and therefore could not discern appropriate harvest rates. In contrast, since 1978 wildlife managers have had statistically defensible aerial survey techniques for estimating moose population parameters (Gasaway et al. 1983, Gasaway et al. 1986, Kellie and DeLong 2006).
4. Managers in the 1970s did not appropriately account for the successive years of severe winters (Fig. 7) that contributed to a sharp decline in moose (Fig. 2). In contrast, during winters 1993-1994 through 2007-2008, maximum accumulated snow depth never reached the critical threshold affecting calf moose survival (Coady 1974). Moreover, except for winters 1989-1990, 1990-1991, and 1992-1993, the Unit 20A moose population experienced a 37 year period when maximum accumulated snow depth was below the critical threshold affecting adult

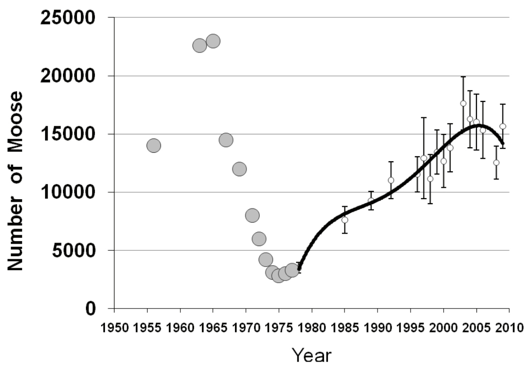

Fig. 2. Moose population trends in Game Management Unit 20A, Interior Alaska 1955-2009. Large circles were back-calculated based on an index of abundance (moose/hour) linked to the 1978 population estimate (Gasaway et al. 1983:6). Error bars = 90% confidence limits.

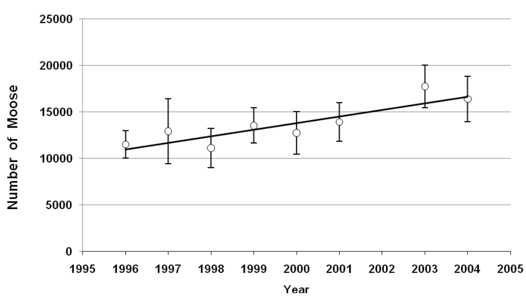

Fig. 3. Moose population trend using parametric Bayes methods, Game Management Unit 20A, Interior Alaska, 1996-2004. Error bars = 90% confidence limits; sightability correction factor (SCF) = 1.21; $\lambda = 1.053$ (SE = 0.013).

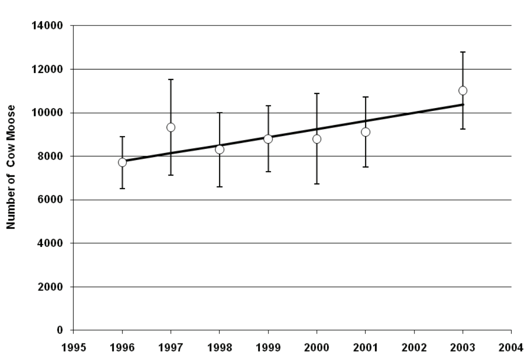

Fig. 4. Cow moose population trend using parametric Bayes methods, Game Management Unit 20A, Interior Alaska, 1996-2003. Error bars = 90% confidence limits; sightability correction factor (SCF) = 1.21; $\lambda = 1.04$ (SE = 0.15).

moose survival.

5. The poor nutritional status perceived in the early 1970s as a rationale for liberal harvests was not realized until after 1996. During the years prior to initiation of the 1970s liberal antlerless hunts (1966-1971), twinning rates averaged 15% (Boertje et al. 2007; Fig. 8). In contrast, during the 6 year period (1998-2003) prior to the initiation of recent liberal antlerless hunts, twinning rates averaged 7%.

DISCUSSION

As initial justification for liberal antlerless harvest, ADFG provided convincing information to the public on the moose population's low nutritional status (Boertje et al. 2007). During 1997-2005, moose in Unit 20A exhibited the lowest nutritional status reported at the time for wild, noninsular, North American populations, shown by: 1) delayed reproduction until ≥36 months of age, 2) low parturition rate among 36 month old moose (29%, n = 147), 3) low average multi-year twinning rates (7%), 4) delayed twinning until moose reached 60 months of age, 5) low average mass of female short-yearlings in Alaska ($\bar{x} = 155 \pm 1.6$ SE kg), and 6) high removal (42%) of current annual browse biomass (Boertje et al. 2007). When considering similarly high moose density in Unit 20A and a study area in Sweden (Cederlund and Sand 1991), recent studies (1997-2007) indicate that Unit 20A produced only 75 calves:100 cows ≥36 months of age versus 117 calves in Sweden (Boertje et al. 2009). We concluded that low nutritional status in Unit 20A resulted from the cumulative effects of having periodically high moose density in Unit 20A (Fig. 2) and a lower carrying capacity than the study area in Sweden. In order to improve productivity and increase overall harvest yields, ADFG reasoned that it would be necessary to lower the moose population by elevating the harvest rate of cow moose.

To gain broader credibility and trust among

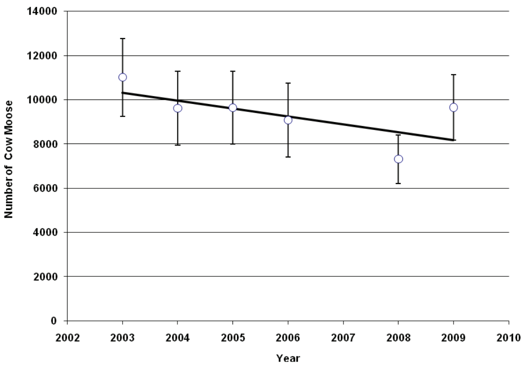

Fig. 5. Cow moose population trend using parametric Bayes methods, Game Management Unit 20A, Interior Alaska, 2003-2009. Error bars = 90% confidence limits; sightability correction factor (SCF) = 1.21; $\lambda = 0.96$ (SE = 0.021).

those citizens who remembered the results of the 1970s antlerless harvests, we needed to admit past mistakes that contributed to long-term poor hunting opportunities. We also needed to specify why past mistakes would not be repeated by identifying major differences between the current antlerless hunts and those conducted in the 1970s. Thus, we contrasted moose population status in the early 1970s with recent data and described the interim advancement in our ability to assess moose populations and habitat. We deemed the initiation of liberal antlerless harvests prudent only when 1) moose numbers were increasing, and 2) specific long-term, low nutritional indices were reached as density increased and without the effects of severe winters (Boertje et al. 2007, 2010).

It was imperative that population size and trajectory be monitored diligently and credibly. To assist with credibility issues, we solicited a representative private citizen with a seat on a local advisory committee to participate in and become knowledgeable with the population surveys, and to help describe the surveys at key committee meetings. A lay person's involve-

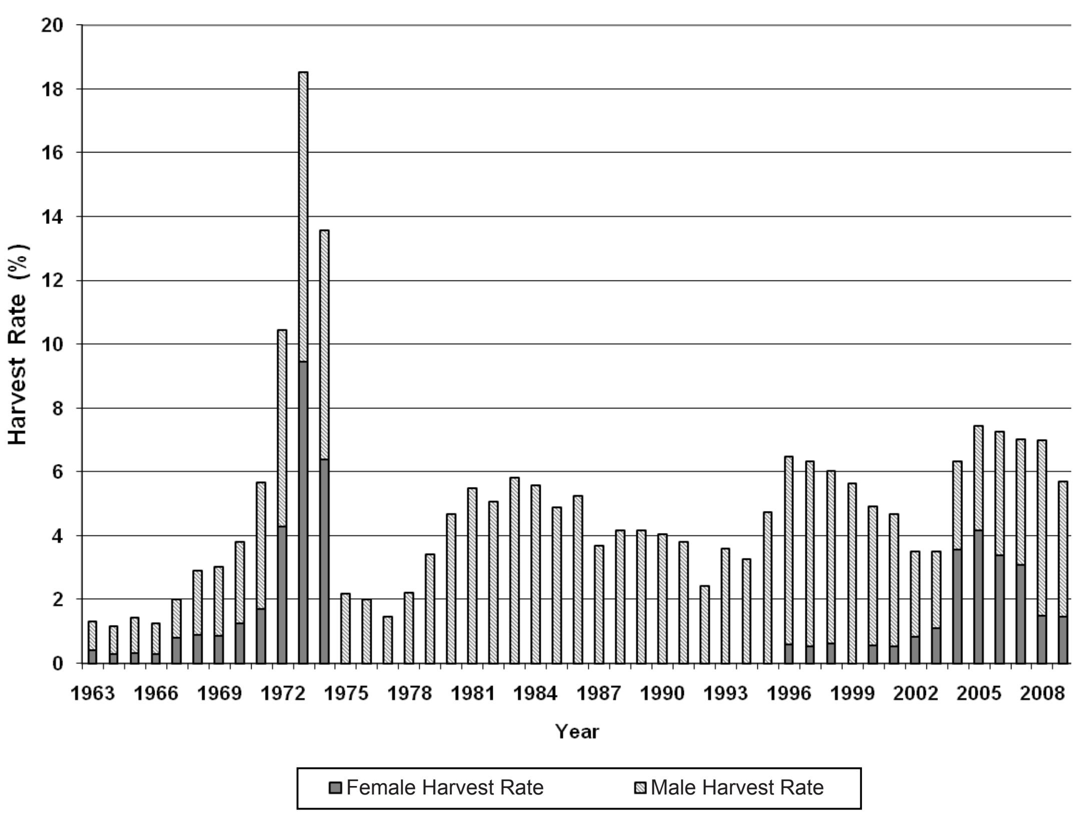

Fig. 6. Gender-specific harvest rates of moose, Game Management Unit 20A, Interior Alaska, 1963-2009.

ment and perspective reduced the adversarial nature of the meetings and improved credibility. We also described the historical advancement in a manager's ability to track population trend with confidence. In the 1970s moose were surveyed using moose/h counts in a few, small moose-concentration areas which left managers with no reliable way to confidently assess large-scale population trajectories or to estimate harvest rates. Only in the late 1970s, after simultaneous moose/h counts and large-scale surveys were conducted, did Gasaway et al. (1983) use extrapolation to back-calculate the 1970s population trajectories. In contrast, in the early 2000s we sampled randomly selected, GPS-defined, 5.8 mi^2 survey units throughout the study area, and sample units were selected from both low- and high-density strata to improve confidence in the combined total estimate (DeLong 2006). We also combined estimates from several years to improve our confidence in detecting trend (Ver Hoef 2008). These population estimation techniques greatly improved the scientific basis for moose management in the 2000s.

In addition, radio-telemetry was not generally available to wildlife managers in the early 1970s, but was a common tool for monitoring moose by the 2000s. Prior to beginning liberal antlerless hunts in 2004, we had 8 years of age-specific productivity and survival data for radio-collared yearling and older moose, and 2 years of calf mortality studies in Unit 20A. We incorporated those data into a simple quantitative model to illustrate why the population was increasing (Boertje et al. 2007, 2009). Moreover, during the antlerless hunts from 2004-2009, we continued using radiocollared moose to monitor age-specific productivity, survival, causes of mortality, unreported harvest, and wounding loss (Boertje et al. 2009).

Lacking moose population estimates, managers in the early 1970s could not estimate harvest rates, thus had no practical experience with determining prudent harvest rates. Instead

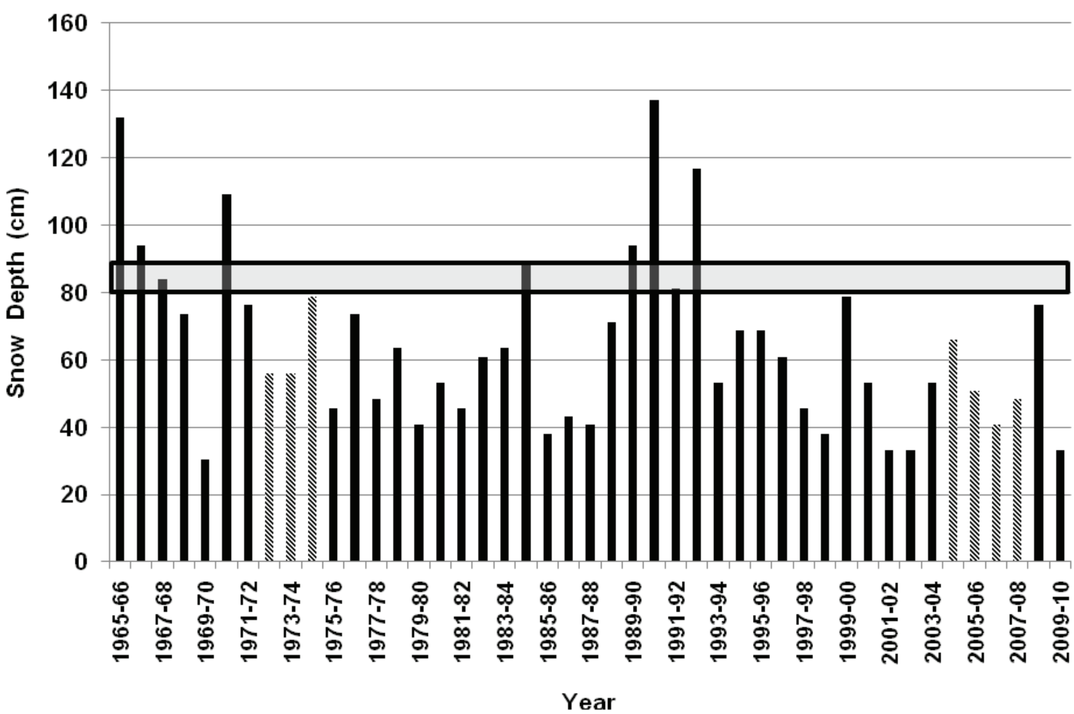

Fig. 7. Maximum accumulated snow depth (cm) during winters 1965-1966 through 2009-2010. Fairbanks, Alaska. Hashed vertical bars represent years with liberal antlerless harvests. Horizontal bar represent critical snow depth thresholds for calf (80 cm) and adult (90 cm) moose (Coady 1974).

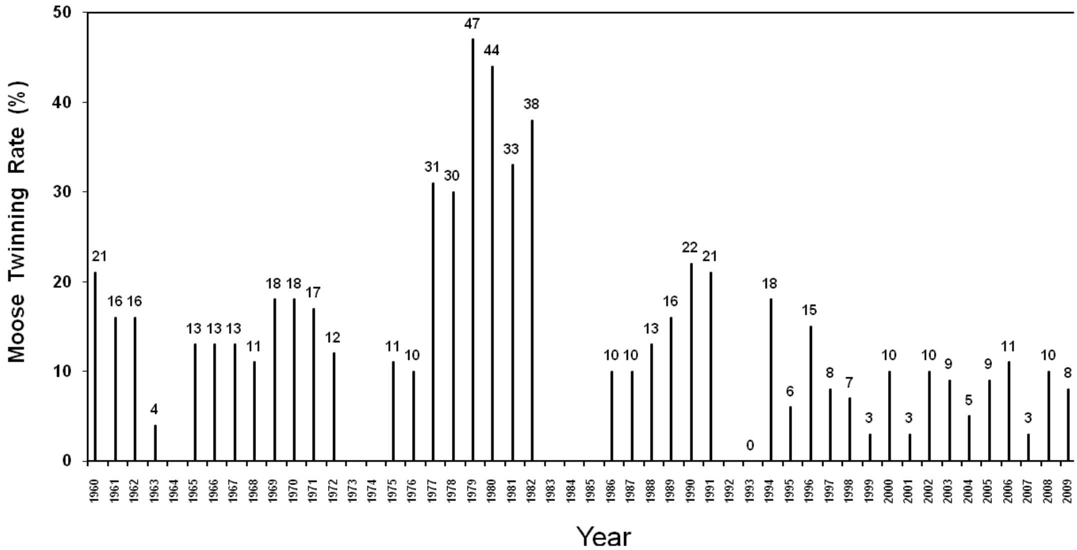

Fig. 8. Moose twinning rates, Game Management Unit 20A, Interior Alaska, 1960-2009.

managers relied on a prevailing management philosophy from Scandinavia where harvests were being elevated to cope with increasing moose numbers and corresponding reduced nutritional status. However, the Scandinavian systems were largely free of large predators, had abundant moose forage due to widespread clearcutting, and were not experiencing severe winters (Lavsund et al. 2003). Recent comparisons showed the moose population in Unit 20A could sustain a 5% harvest of the prehunt population in 1996-2004, whereas the moose population in Sweden could sustain a 33% harvest of the prehunt population, with calves constituting 48% of the harvest (Cederlund and Sand 1991, Lavsund et al. 2003, Boertje et al. 2009). These differences were not incorporated in Alaska's 1970s moose management, so managers erred in advocating liberal antlerless harvests, particularly immediately after a series of severe winters (Fig. 6 and 7).

Lastly, we benefitted from 40 years of comparative data in Unit 20A and elsewhere which allowed us to develop a convincing strategy for prudent liberal harvest of female moose, based largely on relative nutritional status (Boertje et al. 2007, 2009, 2010). At this time, prudent management in Unit 20A included preventing a reoccurrence of the extremely high moose densities of the mid-1960s that compromised nutritional status. Thus, it is rewarding that the 2004-2006 liberal antlerless harvests led to a slight decline in the moose population, as desired (Fig. 2 and 5). In addition, this history led to recommendations for future managers; specifically, for any study area in inland Alaska where moose numbers gradually increase and twinning rates gradually decline to a 2 year average of <20%, female moose should be harvested in increasing numbers to stabilize population size. As population size is stabilized by harvest, we envision maintaining a 2 year average twinning rate between ~10-17% (Boertje et al. 2010). If the 2 year average twinning rate declines to ≤10%, harvest should be slightly increased to reduce population size. This strategy appears to both manage moose responsibly below long-term carrying capacity and provide for elevated yield.

CONCLUSIONS

Modeling indicated recent liberal antlerless hunts were vital to keeping the moose population from growing to the unsustainable high levels observed in the mid-1960s. The key to achieving these liberal harvests and decreasing moose numbers was overcoming skepticism related to the ability of ADFG to responsibly manage harvest of female moose. Overcoming skepticism entailed admitting to mistakes of the 1970s to show ADFG was cognizant of past management mistakes and had incorporated what was learned into present-day moose management strategies. Given the opportunity to provide the historical rationale for the overharvest of female moose also allowed us the unique opportunity to explain how severe winters and accompanying high predation played a more significant role in the 1960s and 1970s decline (Rausch et al. 1974, Gasaway et al. 1983, Boertje et al. 1996). This history was crucial to convincing the public that moose could not be "stockpiled" and that elevated antlerless harvest of an increasing, high-density moose population experiencing nutritional effects was prudent. Equally important, this Unit 20A history eased the expansion of antlerless harvests into adjacent urban and agricultural areas (Boertje et al. 2010). Increased antlerless hunting opportunities in the 2000s were consistent with the mandate to manage for elevated yields and to meet the fiduciary responsibility of ADFG to protect the health and habitat of the moose population over the long term.

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