Chapter 5

Moose (*Alces Alces shirasi*)

Doug Brimeyer

I. <u>INTRODUCTION</u> – George Shiras III described a race of moose inhabiting mountainous regions of the western U.S. during his explorations from 1908-1910 in Yellowstone National Park. In honor of Shiras, Nelson (1914) named the Yellowstone moose *Alces alces shiras.*

A. <u>History in Wyoming</u> – Moose are believed to have entered Wyoming from Montana and Idaho within the past 150 years. Moose became established along the Teton Mountain Range and in Jackson Hole during the late 1800s. Numbers declined following early settlement. Hunting seasons were closed from 1903-1911. The 1908 Annual Report of the State Game Warden indicated moose were distributed along the Teton Mountains, the upper Yellowstone River and at the head of the Green River. Moose hunting seasons were reopened in 1912. Blunt (1950) estimated 500 moose inhabited Wyoming in 1912, principally in the in northwest region.

Moose began to occupy portions of the Wind River Range during the 1930s, and became quite numerous by the 1960s. Afterward, the population began to decline. From 1935 through 1948 the legal harvest totaled 1515 moose. In addition, moose were often mistaken for elk and accidentally killed. Managers estimated the statewide population was 3,210 in 1940.

Historically, moose were relocated to establish new populations in Wyoming and elsewhere. Twenty-nine moose were captured in the Jackson area and released in the Bighorns in 1948, 1950, 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 dispersed from the Colorado population into southeast Wyoming and by 2000, a huntable population had become established in the Snowy Range.

B. <u>Current Status</u> – Moose currently occupy habitats in western, north central and southeastern Wyoming. The statewide population objective is 12,370. Managers estimated the statewide population was approximately 14,028 in 1998. Hunting seasons have been conservative in Wyoming and hunter success has generally remained in the 80-90% range. In 1998, regulations were changed to prohibit hunters from taking a cow moose accompanied by a calf. This action was taken to improve recruitment by increasing survival of dependent calves.

C. Natural History Information –

1. Range of Productivity – Productivity of moose varies considerably among occupied habitats within Wyoming, and among years. At the low end, 24 and 26 calves per 100 cows were classified in the Jackson and Dubois herd units, respectively, in 1996. At the high end, 63 and 58 calves per 100 cows were classified in the Lander Herd Unit in 1995 and 1998, respectively. Generally, statistically adequate classifications of moose are difficult to obtain except in the Sublette and Jackson herds. The average calf:cow ratio was 46 calves per 100 cows in this herd during the 1994-1998 period. Statewide, the calf:cow ratio was 48.7 calves per 100 cows following the hunting season in 1998, based on 3,843 moose classified in 7 herd units

   The age at which cow moose reproduce varies from 1.4 to 2.4 years (Schwartz 1992) and can be delayed to 3.4 years in poor quality range (Albright and Keith 1987). Pregnancy and twinning rates also vary depending on habitat quality and population density. Pregnancy rates ranging from 60-100% have been reported in various moose populations (Schwartz, 1998). Berger (2003) reported an average pregnancy rate of 75% from 1995-1998 in the Jackson Hole area. Twins were not observed during Berger's study. However, 1-2% of cows were observed with twins in the Jackson and Targhee herd units during the 1999 post-hunt period. Houston (1968) reported a 4% twinning rate in the Jackson area. Schladweiler and Stevens (1973) reported a 16% twinning rate in Montana.

2. Range of Natural Mortality – Calf mortality rates of 40% prior to the hunting season, and 15-25% afterward (over-winter) are used in population simulation models for Wyoming moose herds. As large predators become established in Wyoming, we expect mortality rates will increase. Van Ballenberghe (1987) reported an annual survival rate of just 10% for calves in areas where predators were abundant. Conversely, survival rates as high as 67% have been reported for calves in non-hunted populations where predators were absent (Mytton and Keith, 1981). In 1999, Berger (2003) documented calf survival rates of 73% (10 of 14) during the first two months of life and 50% (7 of 14) through the winter period in the Jackson area. Survival of radio-collared, adult cow moose was 80% during 1999 and 2000, 91% in 2001 and 62% in 2002. Annual survival of adult moose transplanted to southwestern Colorado was 94 and 83 percent for males and females respectively (Olterman and Kenvin 1998).

II. CENSUS – Moose are the least social ungulate in Wyoming, often observed alone or in small groups. Department personnel documented an average group size of 2.2 moose (range 1-15, n = 358 groups) during sightability flights in the Jackson area in 1998 and 1999. Moose also tend to segregate according to sex and age, making some classes of animals more difficult to observe than others (Peek et. al., 1974). These behaviors pose unique challenges for managers attempting to census moose. Because of small group sizes and distribution in diverse vegetation cover, it is impossible to obtain a total count of moose. Even attempting to count most of the moose in a population is difficult and expensive. Moose populations are currently estimated based on population models, population indices, and in some cases, sampling approaches such as sightability models.

Data required to model populations include: age and sex classifications, harvest composition and mortality rates (refer to Appendix IX – Big Game Population Modeling). Managers should consult literature and field studies to derive appropriate values for modeling parameters.

A. Preseason Classifications –

1. Aerial Classifications –

a. Rationale – Prior to the hunting season, it is difficult to observe and classify an adequate sample of moose. However, moose in some herds are more visible at that time than after the hunting season when they move into dense, conifer habitats. Preseason classifications are used to estimate recruitment of calves in the fall, as well as bull:cow ratios. The data are applied to align population simulation models.

b. Application – In areas where pre-season classifications are advantageous, they can be done most effectively from a helicopter (WGFD 1998). Conduct preseason classifications over a weeklong period in July or August. A shorter timeframe reduces the likelihood of duplicate observations. Use consistent survey techniques each year so results can be validly compared among years. Schedule flights in early morning and limited them to 2-3 hours. Always follow protocol outlined in the Aircraft Operation Procedures and Safety Policy of the Wyoming Game and Fish Commission’s Policy Manual (WY Game and Fish Commission 2005).

c. Analysis of Data – Express ratios as calves per 100 cows and bulls per100 cows.

d. Disposition of Data – Data from moose classifications are processed and distributed as described in Chapter 1, Section II.A.1.d. (Pronghorn – Pre-season Classifications). Use a hand-held GPS to determine locations of observations, and then download the coordinates based on the NAD (North American Datum) 1983 geographic reference. UTM Coordinates are downloaded into a Microsoft Excel spreadsheet or transcribed by hand to a Wildlife Observation Form. The spreadsheet should contain fields for each location (waypoint) and separate fields to record the numbers of moose classified as cows, calves, bulls and unclassified adults. Records can also be saved as a Microsoft Access data file and imported directly into ArcView for mapping applications. Records of observations help managers identify important habitats and their proximity to potentially conflicting land uses such as subdivisions, roads, energy developments, recreational areas, and timber sales.

2. Ground Classifications –

   a. Rationale – Pre-season classifications are done from the ground in some herd units with low moose densities and where aerial surveys are not feasible due to budget constraints.

   b. Application – Refer to Section II. A. 1.b. of this chapter, and related discussions in Chapter 1, Section II.A.2.b. (Pronghorn – Ground Classifications). Select routes that afford reasonably complete coverage of occupied habitats. The same routes should be followed in successive years. Conduct surveys 2-3 hours in the early morning. Look for moose while driving at slow to moderate speeds, and stop periodically to glass from vantage points. Classify and record all moose observed.

   c. Analysis of Data – Refer to Section II. A. 1.c of this chapter and related discussions in Chapter 1, Section II.A.2.c. (Pronghorn – Ground Classifications). Sample sizes obtained from ground classifications of moose are typically small. In addition, survey routes generally do not provide random or systematic coverage of occupied habitats. These limitations can result in imprecise or biased classifications, which should be considered when data are analyzed.

   d. Disposition of Data – Refer to Section II. A. 1.d, of this chapter and related discussions in Chapter 1, Section II.A.2.d. (Pronghorn – Ground Classifications).

B. Postseason Classifications –

1. Aerial Classifications –

   a. Rationale – Accurate age and sex ratios are required to analyze herd dynamics and reliably estimate moose populations. Aerial surveys are the most practical means of classifying moose over large areas and diverse cover types. Aerial surveys enable managers to meet sampling assumptions better than ground surveys, and generally yield more observations per unit effort.

   b. Application – Post-season classifications are conducted from a helicopter during the December-February period. Schedule flights during periods of complete snow cover, preferably within a few days of fresh snowfall. Ideally flights should last 2 –3 hours to reduce observer fatigue and should be scheduled to coincide with peak moose activity. During severe weather, moose may forage throughout the day. Always follow protocol outlined in the Aircraft Operation Procedures and Safety Policy of the Wyoming Game and Commission’s Policy Manual (WY Game and Fish Commission 2005).

      Surveys should cover representative areas of riparian, deciduous and conifer habitats occupied by moose. Partial or incomplete surveys of an area may result in a biased composition estimate. In Alaska, Gasaway et al. (1986) determined classifications that were conducted during surveys designed for population estimation purposes provided higher, more representative calf:cow ratios than did less intensive, composition surveys.

Assign each moose encountered to one of the following classes: bull, cow, calf, or unclassified adult. Also tally cows with calves and note those accompanied by twins. Body size tends to be the most useful criterion for identifying calves. Use head features to avoid misclassifying large calves as yearlings. Calf moose have relatively small ears and a short, pointed nose by comparison with the larger, bulbous nose of an adult moose. Calves also tend to remain close to the cow (30-40 yards) and will follow close behind her when disturbed (Timmerman and Buss, 1997). We recommend observers use at least 2 primary or secondary criteria to determine the sex of adult moose. Timmerman and Buss (1997) summarized criteria used to identify sex and age groups. The primary criteria are antler or pedicel scars, vulva patch, behavior, and bell shape and size. Secondary criteria include: group composition, facial coloration, body conformation, pelage coloration, head position when the moose is moving, and position of the legs when the moose rises from its bed. 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.

c. Analysis of Data – Postseason composition ratios should be expressed as calves and bulls per 100 cows and bulls per 100 cows.

d. Disposition of Data – Refer to Section II.A.1.d in this chapter and related discussions in Chapter 1, Section II.A.2.d. (Pronghorn – Ground Classifications).

2. Ground Classifications –

a. Rationale – Ground surveys may be warranted to classify herd units with low densities of moose, and where aerial surveys are not feasible due to budget constraints. Ground classifications of moose are done in a manner similar to that described for mule deer (Chapter 2, Section II.B.2).

b. Application – Refer to Section II. A.1.b. of this chapter and related discussions in Chapter 2, Section II.B.2.b. (Mule Deer – Ground Surveys).

c. Analysis of Data – Report classification results as calves per 100 cows and bulls per 100 cows.

d. Disposition of Data – Refer to section II. A.1.d. of this chapter and related discussions in Chapter 1, Section II.A.2.d. (Pronghorn – Ground Classifications).

3. Wyoming Moose Sightability Model –

   a. Rationale – Observers detect only a portion of a moose population during aerial surveys. However, correction factors can be developed to compensate for visibility biases associated with vegetation cover, terrain, group size, observer skill, etc. Based on procedures described by Unsworth et. al. (1991), Anderson (1995) developed a sightablity model for moose in Wyoming. Sightability surveys are based on a stratified sampling approach to improve accuracy and precision of population estimates, and to reduce costs.

   b. Application – Occupied habitat is divided into 2 or 3 survey strata within the herd unit based on expected moose densities (low, medium or high). The strata are then subdivided into sample units, each large enough to be surveyed from a helicopter in one hour. The sample units are typically 3-6 sq. mi. Stratification reduces sample variance and improves precision of population estimates. The survey is applied to a randomly selected subset of sample units within each stratum. Counts are corrected for visibility bias, and then extrapolated based on the proportionate area sampled, to estimate the number of moose within each stratum. The strata estimates are then summed to estimate the population within the herd unit. The optimum time to survey is early winter (December and January) when moose still occupy comparatively open habitats. Personnel are directed to follow procedures outlined in the Aerial Survey User's Manual (Unsworth et al. 1994) for observing and recording moose, and for evaluating vegetation cover. Classify moose and record the locations as described in Section II.B.2.b. of this chapter. Always follow protocol outlined in the Wyoming Game and Fish Commission's Aircraft Operation Procedures and Safety Policy (WY Game and Fish Commission 2005).

   c. Analysis of Data – Transcribe and enter data based on the format described by Anderson (1995). Aerial Survey Software developed by Unsworth et al. (1994) is used to evaluate Moose sightability data.

   d. Disposition of Data – See related discussions in Chapter 1 (Pronghorn), Sections II.C.4. (Aerial Trend Counts), II.D.4. (Line-transect Surveys), and II.E.4. (Quadrat Sampling).

III. HARVEST DATA –

A. Harvest Survey – All moose permit holders are surveyed after each hunting season to obtain harvest data. Typically, 75-80 percent of moose hunters respond to the first mailing. Persons who fail to respond are mailed a second questionnaire. Data from survey responses are used to estimate total harvest and harvest composition, and to develop other statistics including hunter success, effort (days per moose harvested), and total recreation days. Appendix III provides a detailed discussion of the WGFD harvest survey.

B. Age Determination –

1. Field Aging Techniques –

   a. Rationale – Younger animals are commonly underreported in the harvest survey because hunters are less likely to submit incisors from these animals for aging, and often inaccurately report them as adult cows on the harvest questionnaire. Field checks are a comparatively unbiased means of detecting of calves and yearlings in the harvest. Age data can be collected from harvested moose and non-hunting mortalities that are encountered in the field. Managers can also collect teeth for aging and can measure antlers during field checks. The most accurate means of aging moose is laboratory analysis of cementum annular rings. Although considerable material has been published regarding tooth eruption and wear patterns for aging ungulates, comparatively little technical guidance is available to age moose based on such criteria. In the field, moose can be coarsely separated into calves, yearlings or adults based on gross morphological characteristics.

   b. Application – Calf moose are identified based on body size. Yearlings are larger, but often have lightly stained lower premolars (2 and 3) and may still have deciduous upper premolars. Tooth cross-sectioning is the only reliable method for determining specific ages of adult moose. This laboratory technique requires staining and counting cementum annular rings (discussed in next section).

   c. Analysis of Data – See related discussions in Chapter 1, Section III.B.1.c. (Pronghorn – Age Determination).

   d. Disposition of Data – See related discussions in Chapter 1, Section III.B.1.d. (Pronghorn – Age Determination).

2. Tooth Cross-sectioning –

   a Rationale – Tooth sectioning is the only accurate means to determine specific ages of harvested moose (Sergeant and Pimlott 1959). Age is determined by counting cementum annular deposits that become discernable when tooth cross-sections are stained and examined under a microscope. Precise age information has several management applications. Antlerless moose taken by hunters are considered an unbiased sample of adult (yearling and older) females in the population. Accordingly, managers can estimate the age structure of the female segment based on harvested, antlerless moose. On the other hand, hunters tend to select older age classes of bulls so ages of harvested bulls are not a valid representation of the age structure of the male segment. However, the age distribution of harvested bulls is useful to assess harvest trends in relation to objectives. A persistent shift in the age composition of harvested males can indicate a need to adjust license numbers, or may provide evidence of changing moose numbers or sex ratios. Age-specific harvests data are also used to update population simulation models each year. Longer-term data sets are used to establish the initial female age structure and oldest age class for developing a population model.

b. Application – Collect both incisors from each adult moose checked in the field or at a check station. Using a sharp knife, slice deeply into the gum on each side of the teeth. The incisors can be forced forward and down with a heavy knife or pliers until the teeth separate from the gum line. Remove the teeth from the soft tissue lining along the jaw, taking care to not break off the root. The entire root is needed for cross-sectioning. Place teeth in a Department tooth envelope labeled with the species, hunt area, date of harvest, and the hunter's name and address. Submit all tooth envelopes to the Wildlife Management Coordinator.

c. Analysis of Data – See related discussions in Chapter 1, Section III.B.2.c. (Pronghorn – Aging).

d. Disposition of Data – See related discussions in Chapter 1, Section III.B.2.d. (Pronghorn – Aging).

3. Check Stations –

a. Rationale – Check stations enable managers to examine larger samples of harvested animals along egress routes from popular hunting areas. In addition, field personnel are afforded the opportunity to contact sportsmen, monitor compliance with hunting regulations, and respond to questions from the public regarding access, hunting opportunities, management issues and Department operations.

b. Application – Check stations should conform with the Wildlife Division's "Guidelines for Establishment and Operation of Wildlife Check Stations." Refer to Attachment 1 in Chapter 1 (Pronghorn).

c. Analysis of Data – See related discussions in Chapter 1, Section III.C.3. (Pronghorn – Field Checks and Check Stations).

d. Disposition of Data – See related discussions in Chapter 1, Section III.C.4. (Pronghorn – Field Checks and Check Stations).

IV. MORTALITY ESTIMATION (NON-HUNTING) –

A. Incidental Observations –

1. Rationale – Moose die naturally from many causes including: accidental falls, drowning, fight-related injuries, breaking through ice, parasitic infections, diseases,

predation, exposure, and starvation. Non-natural mortalities most commonly result from accidents such as vehicle collisions, fence entanglements, or entrapment in pits. Other sources of non-natural mortalities (excluding legal harvests) can include poaching, unintentional capture in leg snares, or poisoning, for example, at a contaminated water source. The magnitude of losses can be significant but difficult to estimate. Natural and accidental mortalities can equal or exceed the legal harvest (Child, 1997). It is important to document and record mortalities to identify potential problems and to assist agencies with making sound decisions regarding land uses and development proposals. For example, 11 moose were killed in 1997 along a five-mile stretch of Wyoming Highway 390. As a result, additional signing was posted and a recommendation was forwarded to modify the design of right-of-way fences.

2. Application – See related discussions in Chapter 1, Section IV.A.2 (Pronghorn – Mortality Estimation).

3. Analysis of Data – See related discussions in Chapter 1, Section IV.A.3 (Pronghorn – Mortality Estimation).

4. Disposition of Data – See related discussions in Chapter 1, Section IV.A.4 (Pronghorn – Mortality Estimation).

B. Weather Severity Indices – See related discussions in Chapter 1, Section IV.C. (Pronghorn – Weather Severity Indices).

C. Winter Mortality Transects – See related discussions in Chapter 1, Section IV.B (Pronghorn – Mortality Transects).

D. Documentation of Mortality Agents – See related discussions in Chapter 1, Section IV (Pronghorn – Mortality Estimation).

V. DISEASES AND PARASITES – Moose are susceptible many parasites and diseases. A detailed account of diseases and their implications is available in *Diseases of Wildlife in Wyoming* (Thorne et al. 1982) and in the *Pests, parasites and diseases* (Lankester and Samuel 1997).

A. Potential Diseases – Moose co-evolved with many disease and parasitic organisms. Under most circumstances, infections remain sub clinical and do not affect the overall population. Only a few diseases and parasites have the potential to impact moose at a population level. These include winter tick (*Dermacentor albipictus*), the arterial worm (*Elaeophora schneideri*), and in eastern North America, the meningeal worm (*Parelaphostrongylus tenuis*).

B. Management /Public Safety – Hunters often question the edibility of game meat after they have observed a parasite or abnormal condition. The public should be informed virtually all wild animals have parasites (including viruses and bacteria). Most parasites coevolved with host organisms and generally serve to strengthen the population by reducing the survival of weaker individuals. Very few infectious organisms are transmissible from moose to humans. Transmission of Brucellosis and Toxoplasma is possible but unlikely. The tapeworm Echinococcus granulosus, can infect humans after the final association with a canid host. The larval stage of Echinococcus occurs in the lungs of moose and can infect coyotes, wolves and dogs. Tapeworm eggs shed in the canids' feces are infectious to humans.

C. Identification – Hunters commonly report internal and external parasites to Department personnel who may offer a general diagnosis. However, a necropsy and analysis are required for definitive diagnosis. The Wyoming State Veterinary Lab in Laramie performs these services.

D. Collection and Handling of Tissue Samples – If managers suspect a moose is infected with a parasite or disease the moose should be collected and transported to the Wyoming State Veterinary Lab. If euthanasia is necessary, the animal should be dispatch with a single shot behind the ear near the base of the skull. A rifle or shotgun and slug are suitable. The entire animal should be sent to the lab if transportation is feasible within several hours of the animal's death. Due to the size of moose and distance to the lab, the carcass often spoils before tissue samples can be collected. Biological samples can be collected and shipped in accordance with procedures outlined in the Wildlife Forensic Field Manual (Adrian, 1992).

VI. DISTRIBUTION AND MOVEMENT –

A. Incidental Observations –

1. Rationale – Moose distribution and movement patterns have been documented and mapped to varying degrees throughout Wyoming. More detailed, current information is needed on most herds to help managers deal with increasing development, winter recreation, and habitat modifications.

2. Application – During aerial and ground surveys, moose locations can be recorded as waypoints on a hand held GPS unit, then downloaded a Microsoft Excel Spreadsheet, or transcribed to Wildlife Observation Forms (Appendix I). Guidelines for mapping animal distribution are outlined in Appendix VI. Also see related discussions in the Antelope Techniques Chapter.

3. Analysis of Data – See related discussions in Chapter 1, Section V.C.3. (Pronghorn – Distribution and Movement, Incidental Observations).

4. Disposition of Data – See related discussions in Chapter 1, Section V.C.4. (Pronghorn – Distribution and Movement, Incidental Observations).

B. Other Sources of Distribution Data – Moose distribution and movement patterns should be documented during aerial surveys and telemetry studies. Aerial surveys are the best method to observe moose in remote areas and dense vegetation. As locations from various times of the year are accumulated, a database should be constructed to help managers identify important seasonal habitats. Biologists should record and manage data as described in Section II.A. (Preseason Moose Classifications).

Franzmann et al. (1976) analyzed habitat preferences of Alaskan moose based on pellet group counts. In Wyoming, pellet groups have been recorded to determine the presence or absence of moose in areas where projects or land use developments are proposed.

VII. SEASONAL RANGE IDENTIFICATION –

A. Rationale – Seasonal ranges are mapped within each moose herd in Wyoming. Maps are maintained at Regional Offices and the Cheyenne Headquarters. Biologists and others use distribution maps for planning purposes and to assess potential impacts of proposed land uses.

B. Application – See related discussions in Chapter 1, Section V (Pronghorn – distribution and movement).

C. Analysis of Data – See related discussions in Chapter 1, Section V (Pronghorn – distribution and movement).

D. Disposition of Data – See related discussions in Chapter 1, Section V (Pronghorn – distribution and movement).

VIII. TRAPPING, MARKING AND TRANSPLANTING –

A. Trapping Adults –

1. Rationale – Adult moose are trapped chiefly for the following purposes: collect biological information; affix marking devices or transmitters; and relocate individuals for depredation/nuisance control or reintroduction. Managers mark moose to evaluate their distribution and movements. Before the advent of chemical immobilization and an efficient delivery system, physical restraint was the only method available to capture moose (Pimlott and Carberry 1958).

2. Application –

a) Corral Traps – Very stout corral traps are required to physically restrain moose. Consequently, this method has had limited utility in the past. Corral traps and trip mechanisms are described by Franzmann and Schwartz (1997). Corral traps are costly and labor intensive to construct. Operation of these traps requires a substantial personnel commitment for the number of moose trapped, and animals captured experience high mortality rates. From 1934 to 1953, 230 moose were captured in corral traps in Michigan, Wyoming, Newfoundland and Alberta. Of those, 133 were relocated, 35 escaped and 62 (27%) died (Pimlott and Carberry 1958).

b) Aerial Net-gunning – Net guns have been deployed from helicopters to capture moose (Carpenter and Innes 1995). This method is more efficient, economical, and better adapted to sample animals across a broad area. From 1993-1995, net-guns were used to capture a total of 392 moose were captured in North America, by a firm called Helicopter Wildlife Management. Overall, mortality at the time of capture was less than one percent.

c) Analysis of Data – See related discussions in Chapter 1, Section VI.A.1.c. (Pronghorn – Corral Traps).

d) Disposition of Data – See related discussions in Chapter 1, Section VI.A.1.d. (Pronghorn – Corral Traps).

B. Trapping Juveniles –

1. Rationale – Telemetry methods are commonly used to study movements and mortality of calf moose (Franzmann et al. 1980). Telemetry offers many advantages over conventional marking and observation methods. In particular, telemetry gives managers the capability to follow and relocate calves, and to detect mortalities soon after they happen. However, managers should consider potential biases when interpreting telemetry data. Capture and handling stress may directly increase mortality. Human scent and activity at the capture site can attract predators' attention. In addition, transmitters and marking devices can alter behavior and increase visibility of moose calves, making them susceptible targets for predation. Methods to control these biases include using appropriate telemetry equipment and not including moose calves in the sample until several days after they are captured and marked.

2. Application – A helicopter provides the most efficient means of capturing neonatal moose. After a cow and calf are located, the helicopter is maneuvered to chase the cow away from the calf. The helicopter is then landed and the capture crew exits to restrain and collar the calf. While the calf is being processed, the helicopter returns to the air and is maneuvered to keep the cow at bay. The cow will generally return to the calf after the capture operation is completed. If not, the helicopter can be used to herd her back to the calf (Ballard et al. 1979). Calves have also been captured with a helicopter net-gun during the winter period in Wyoming and Colorado (Olterman et al. 1994).

3. Analysis of Data – See related discussions in Chapter 1, Section VI.1.c. (Pronghorn – Corral Traps) and Section VI.2 (Pronghorn – Fawn Capture).

4. Disposition of Data – See related discussions in Chapter 1, Section VI.1.d. (Pronghorn – Corral Traps) and Section VI.2 (Pronghorn – Fawn Capture).

C. Chemical Immobilization –

1. Rationale – Moose are difficult to restrain unless they are chemically sedated. Modern procedures enable mangers to quickly and efficiently immobilize moose for safe handling.

2. Application – We currently recommend the synthetic drug, carfentanil, to immobilize moose in Wyoming. Various other drugs used in the past had significant drawbacks. Two early drugs were nicotine salicylate and succinylcholine. Both are paralytic drugs with very narrow ranges of effectiveness. In addition nicotine salicylate often had unpredictable effects. Houston (1968) used Succinylcholine chloride to immobilize Shiras moose. The Department used this drug during the 1970s and 1980s, to remove problem moose from urban settings in the Jackson area. Approximately 25% of moose immobilized with succinylcholine chloride died from respiratory failure during capture (Crawford pers. comm.). Capture-All, is a concentrated powder form of ketamine hydrochloride and xylazine. Capture-All hydrated with xylazine hydrochloride was also used to immobilize moose in urban settings, but this drug was not effective unless administered in very large doses. It required a lengthy 3-5 hour recovery period. Telazol hydrated with xylazine was used with limited success. However, moose that were agitated at the time of administration often escaped or had to be roped and physically restrained. Lengthy recovery periods were also required.

   Carfentanil is administered at a dosage of 0.006 mg per lb of estimated body weight. If the capture site is close to noise and activity, such as urban settings, the muscle relaxant xylazine can be mixed with carfentanil to calm the animal. The effect of Carfentanil is rapid and completely reversible by administration of an antagonist. Carfentanil is a highly regulated, narcotic drug that is potentially hazardous to humans. Consult Appendix VIII for detailed information on dosage calculations and handling protocol.

   After a moose has been immobilized, hobble its legs and place a cover over its eyes and ears. If ectoparasites are present administer an injection of 1ml "Ivomec" per 110 pounds of estimated body weight. If the moose is to be relocated, it can be loaded in an enclosed horse trailer. Once the animal is immobilized it should be moved onto a heavy tarp and then pulled onto the trailer bed. After the moose is confined inside the trailer, administer the antagonist naltrexone hydrochloride at a rate of 100 times the dosage of carfentanil. Transport the moose to the release site and free it.

IX. POPULATION MODELING –

A. Rationale – Simulation models are a useful tool for estimating populations and evaluating harvest strategies. Adequate data must be collected annually to assess population age structure, harvest rates, and environmental factors in order to update and refine simulations. Refer to Appendix IX for a detailed discussion about population modeling.

B. Application – Appropriate or standardized ranges of model parameters are discussed in Section I.C. and Appendix IX. For additional information about population modeling, consult Timmerman and Buss (1997), Kovach et al. (1998), Bubenik and Pond (1992), Boer and Keppie (1988), Ballard et al. (1991) and Peterson (1977).

C. Analysis of Data – See related discussions in Chapter 1, Section II (Pronghorn – Census) and Chapter I, Section VII (Pronghorn – Modeling).

D. Disposition of Data – See related discussions in Chapter 1, Section II (Pronghorn – Census) and Chapter I, Section VII (Pronghorn – Modeling).

X. SETTING SEASONS – **[Reserved]**.

XI. DEPREDATION – Depredation management is discussed in the Handbook of Wildlife Depredation Techniques (Demaree et al. 1991) and in Prevention and Control of Wildlife Damage (Hygnstrom et al. 1994).

A. Depredation Concerns – Moose can damage stored crops and disrupt livestock feeding operations. In urban settings, moose occasionally damage ornamental shrubs, landscaping, and vehicles. Public safety is also a concern when moose enter subdivisions.

B. Management Implications – In some locations, liberal hunting seasons have been set to reduce moose densities on private land. Moose are generally solitary so instances of damage are often isolated. Aversive conditioning has been used to displace moose from agricultural fields. However, the effect is often only temporary. Fencing is the best option to protect private property. The Department may relocate moose when human safety becomes an issue.

XII. SUPPLEMENTAL FEEDING – The Wyoming Game & Fish Dept. discourages feeding of moose. Moose require large quantities of browse and will decimate woody vegetation adjacent to feed sites. Schwartz et al. (1980) did not believe moose could extract sufficient nutrients from diets high in fibrous material, like hay, to survive. An adequate feed ration was developed in Alaska by combining aspen sawdust with other ingredients. Moose were historically fed in western Wyoming (Johnson et al. 1985). Feeding areas were established to draw moose away from stored hay and livestock feed lines on private lands. The Wyoming Game & Fish Department is legally obligated to compensate landowners for damage caused by big and trophy game including moose. During the 1970s, the Department supplied ranchers with alfalfa (*Medicago sativa*) to feed moose that were damaging stored hay. By the early 1980s, the Wyoming Game and Fish Commission had approved five moose feeding areas and several unofficial moose feedgrounds also existed. Moose were given 1 kg of forage each day during the early winter, and up to 7 kg/day in February. Feeding generally began in January and ended by mid-March. It is likely the feeding operations only supplemented normal moose diets of browse. Most feeding sites were phased out by the early 1990s.

Damage claims decreased in the drainages where moose were fed, but it is likely population reductions and moose proof stack yards were more important factors contributing to the decrease in damage claims. Permanent stack yards are a more cost effective solution that avoids the damage feeding causes to adjoining habitat.

XIII. LITERATURE CITED –

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