Chapter 7

Mountain Goat (*Oreamnos americanus*)

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I. INTRODUCTION –

A. History in Wyoming – The mountain goats currently found in Wyoming are not generally considered native to the State, but originated from transplants in Montana and Idaho. In the conterminous U.S., the species' distribution was historically limited to northern Idaho, northwestern Montana and Washington. Archaeological evidence has confirmed mountain goats were present in western, central, and southeastern Wyoming during the late Pleistocene approximately 10,000 to 15,000 years ago (Laundre' 1990, Guenzel 1978, Guilday et al. 1967, Anderson 1974). Although evidence of more recent habitation is generally lacking, some historical accounts contain reports of isolated observations. A U.S. Army hunting party in the southern Teton Range of Wyoming reportedly killed a mountain goat in the late 1940s (Cooke 1947-1948), and a map produced by Hornaday (1914) entitled "Distribution of the White Mountain Goat," depicts an "actual occurrence" in the Teton Range near Jackson, Wyoming. The assertion mountain goats were present in Colorado prior to 1900 is given credence by some historical documents (Irby and Chappell 1994), which increases the likelihood they may also have been present in Wyoming.

However, additional investigations have yielded no substantive evidence that goats were present in Wyoming before the existing populations became established. Although some early trappers and explorers mentioned "goats" in their journals, biologists believe these reports referred to bighorn sheep as the terms were used interchangeably and light colored, wild sheep were occasionally confused with goats (Walpole 1997). An earlier investigation whether mountain goats were historically present in Wyoming concluded they were not (Skinner (1926). More recent investigations have reached the same conclusion (Laundre' 1990, Varley and Varley 1996, Schullery and Whittlesey 2001).

B. Current Status – The Department currently recognizes 2 distinct herds of mountain goats in Wyoming. The Beartooth Herd became established after the Montana Department of Fish, Wildlife and Parks transplanted 14 goats into the Rock Creek drainage near the Wyoming-Montana border in 1942 (Cooney 1946). The Palisades Herd originated from 5 goats the Idaho Department of Fish and Game transplanted into the Palisades Creek drainage near the Wyoming-Idaho border in 1969 (Hayden 1989). Current population objectives for the Beartooth and Palisades Herds are 200 and 50 goats, respectively. Both populations are interstate herds, which can complicate management and requires coordination between state wildlife agencies. McWhirter (2004) provides a detailed account of these transplants and their subsequent expansion into Wyoming.

C. Natural History –

1. Productivity – Mountain goats breed between early November and mid-December (Geist 1964). Characteristically, males move among groups of females, tending estrous nannies for 2-3 days (DeBock 1970, Chadwick 1983). In some populations, nannies reach sexual maturity at age 2 and produce their first kid at age 3 (Peck 1972, Stevens 1980, Bailey 1991). In other populations, breeding is delayed until age 3 (Festa-Bianchet et al. 1994). This delay in sexual maturity dramatically reduces the potential for rapid growth in a mountain goat population (Lentfer 1955, Hayden 1990). Twinning rates are generally low, but can be higher in expanding populations on high quality ranges (Holroyd 1967, Hibbs et al. 1969, Hayden 1989, Foster and Rahs 1985, Houston and Stevens 1988). Nannies rarely bear triplets (Hayden 1989, Hanna 1989, Lentfer 1955, Hoefs and Nowlan 1998).

   Mountain goat kids are precocious and begin to consume forage and ruminate within days after birth (Brandborg 1955, Chadwick 1983). Nannies with new kids spend the first 2 weeks in seclusion, and then congregate in nursery groups along with other nannies and kids. Nursery groups often include yearlings. However, 2 year-old billies generally leave the nursery herd and become solitary or form small bachelor groups. Kids remain with their mothers through their first winter. The presence of the mother is thought to increase survival of kids, although orphaned kids are known to survive (Foster and Rahs 1982). From the time goats reach sexual maturity, reproductive success generally increases until age 8, after which it declines (Stevens 1980, C.A. Smith 1984, Bailey 1991).

   Productivity is often described by one of the following ratios: kids per100 adults; kids per 100 non-kids (older goats); or kids per 100 females. Managers should interpret such data cautiously, as ratios of kids per 100 adults are frequently reported from classifications in which yearlings are not distinguished from adults, meaning the ratio is actually kids per 100 "older goats." Productivity varies markedly among locations and among years (Table 1). Bailey and Johnson (1977) determined productivity of introduced herds ranged from 36-100 kids:100 non-kids (average = 59:100). In native herds, kid:non-kid ratios ranged from 9-52:100 (average = 28:100). Population density also influenced goat reproduction (density dependence). For example, Adams and Bailey (1982) documented kid production declined as populations increased in Colorado.

   When goats are classified as kids and non-kids, sex composition is not determined. Therefore, kid:non-kid ratios can be imprecise measures of productivity due to unknown and variable composition of males. In one example, non-hunted and heavily hunted herds of mountain goats had kid:non-kid ratios of 32:100 and 31:100, respectively (Hebert and Turnbull 1977). However, the unhunted/lightly hunted herd had a kid:female ratio of 82:100, while the heavily hunted herd had a kid:female ratio of 52:100. When it is possible to obtain more detailed classification information,

kid:female and yearling:female ratios provide additional information that is useful to monitor populations.

Table 1. Productivity (kids:100 non-kids) of mountain goats from locations throughout the species' range.

Location	kids:100 non-kids	Source
Kenai Peninsula, Alaska	20-44	Del Frate and Spraker (1994)
Southeast Alaska	15-47 (avg.=28.6)	Porter (2002)
Southeast Alaska	2-36 (avg.=22.9)	Barten (2002)
British Columbia (various locations)	7.7 – 27.5 (avg.=18.2)	Hebert and Turnbull (1977)
Similkameen Mountains, British Columbia	8-60 (avg.=25.8)	Bone (1978)
Eagles Nest Wilderness, Colorado	48	Thompson and Guenzel (1978)
Selway River, Idaho	28	Brandborg (1955)
Absaroka Mountains, Montana	29-60 (avg.=38.4)	Swenson (1985)
Absaroka Mountains, Montana	25-47 (avg.=34.6)	Varley (1996)
Absaroka Mountains, Montana	17-39	Lemke (2004)
Gallatin Mountains, Montana	13-48	Lemke (2004)
Square Butte, Montana	29-70 (avg.=47.8)	Williams (1999)
Glacier National Park, Montana	42	Petrides (1948)
Yellowstone National Park, Montana/Wyoming	36	White (2003)
Wallawa Mountains, Oregon	0-61 (avg.=28.7)	Coggins and Matthews (2002)
Washington (various locations)	27-58 (avg.=35.0)	Michalovic (1984) from Johnson (1983)

Kid:female ratios reported from British Columbia ranged from 15-73:100 and averaged 40:100 (Hebert and Turnbull 1977). In Idaho, Brandborg (1955) documented kid:female ratios ranging from 22-79:100, while Anderson (1940) reported 73 kids:100 females in Washington. Kid:female ratios in the Sawtooth Range of Montana ranged from 46-78:100 (M.J. Thompson 1981) and 49-67:100 in the Absaroka Range (Varley 1996). Yearling:female ratios in British Columbia were 3-41:100 and averaged 16:100 (Hebert and Turnbull 1977). Brandborg (1955) documented yearling:female ratios of 10-39:100 along the Salmon and Selway Rivers in Idaho. Varley (1996) reported yearling:female ratios that ranged from 17-47:100 in the Absaroka Mountains of Montana.

2. Natural mortality – Mountain goats have adapted to harsh environments through a strategy that focuses more on the survival of individual goats than on production of

offspring (Hayden 1990). Many researchers hypothesize severe winters and their impact on forage availability and energy expenditures are the principal factors leading to mortality among mountain goats (Dailey and Hobbs 1989). Adams and Bailey (1982) demonstrated a negative correlation between snow depth and kid:adult ratios. On the other hand, a positive relationship was detected between reproductive rates and total winter precipitation 1.5 years prior to birth (Stevens 1983). In Alaska, severe winters were associated with poor reproduction the following spring (Hjeljord 1973).

Annual mortality rates in Alaska were 29% for yearlings, 0-9% for prime age classes 2-8, and 32% for goats older than 8 years (C.A. Smith 1986). Goats older than 8 died primarily from predation or other natural factors, while hunting was the major source of mortality among prime-age goats. Annual mortality in Alberta was 28% for yearling males and 16% for yearling females (Festa-Bianchet and Cote' 2002). Mortality of 4-7 year old males was 5%, but increased dramatically after 8 years. Between ages 2 and 7, mortality of females was 6%. After mortality and emigration, only 39% of yearling males remained in the population as 4 year olds. In a rapidly growing population in Idaho, kid mortality was only 12% and yearling mortality only 5% (Hayden 1989). However, mortality of marked kids in the Black Hills of South Dakota was 40%; annual mortality of yearling and older goats was estimated to be 14% (Benzon and Rice 1988).

Mortality of young goats can be high during their first winter. Kid and yearling mortality during a severe winter was 73% and 59%, respectfully, compared to only 27% and 2% during a mild winter (Rideout 1974a). During a series of severe winters in Colorado, kid mortality reached 56% and kid:adult ratios dropped from 48:100 to 14:100 (R.W. Thompson 1981). Populations declined 82-92% following severe winters in coastal British Columbia (Hebert and Langin 1982).

Grizzly bears (Festa-Bianchet et al. 1994, Jorgenson and Quinlan 1996, Cote' and Beaudoin 1997), wolves (Fox and Streveler 1986, C.A. Smith 1986, Jorgenson and Quinlan 1996, Cote' et al. 1997), mountain lions (Brandborg 1955, Rideout and Hoffman 1975, Johnson 1983), coyotes (Brandborg 1955), golden eagles (Brandborg 1955, B.L. Smith 1976), and wolverines (Guiguet 1951) are predators of mountain goats. In west-central Alberta, annual mortality of juveniles was 42% (Smith et al. 1992). Most of the mortality took place before November. Grizzly bears were the most significant predator of young mountain goats (Festa-Bianchet et al. 1994). Collectively, wolves, grizzly bears, and mountain lions accounted for 88% of the mortality. In Alaska, goat remains were found in 62% of wolf scats (Fox and Streveler 1986). On the other hand, only 2% of wolf scats from Banff National Park, Alberta, contained goat remains (Huggard 1993). In Yellowstone National Park, only 2 of approximately 3,000 prey animals killed by wolves (confirmed) were mountain goats (D.W. Smith, National Park Service, pers. comm.).

Because of the precarious habitats goats frequent, accidental deaths from falls, avalanches or rockslides, and being struck by lightning are relatively common events

(Brandborg 1955, Hayden 1990, Roop 1996, Hanna 1989). The oldest goats recorded in the literature were 14-15 year old males and 16-18 year old females (Cowan and McCrory 1970, Festa-Bianchet and Cote' 2002).

Internal parasites include lungworms (Block 1970, Samuel et al. 1977, Cooley 1976), stomach worms (Boddicker et al. 1971, Johnson 1983), muscle worms (Johnson 1983, K.G. Smith 1982), cestodes (Samuel et al. 1977), and protozoans (Brandborg 1955, Shah and Levine 1964, Todd and O'Gara 1968, Johnson 1983, Mahrt and Colwell 1980). Ticks and lice have also been documented on mountain goats (Brandborg 1955, Kerr and Holmes 1966, Boddicker et al. 1971). Diseases include pasteurellosis (Brandborg 1955), contagious ecthyma (Samuel et al. 1975, Hebert et al. 1977), and capture myopathy (Hebert and Cowan 1971a, Jorgenson and Quinlan 1996). These afflictions are not generally a significant source of mortality.

3. Habitat Use – Mountain goats occupy well-defined seasonal habitats including wintering areas, yearlong habitats, spring-summer-fall areas, and parturition or "kidding" areas. They also migrate between seasonal ranges, although such movements tend not to follow distinct routes. Some seasonal migrations are merely shifts in elevation. A few longer movements of up to 24 km have been documented (Holroyd 1967, Johnson 1983). Daily movements are very limited, especially in winter. As a result winter home ranges are often quite small (Brandborg 1955, B.L. Smith 1976). Nocturnal movements are not common, but have been recorded (Rideout 1974a).

   Home ranges vary considerably. As a rule, males occupy the largest home ranges. In the Sawtooth Range of Montana, Thompson (1981) documented home ranges of 18-22 km^2 for adult males and 2-14 km^2 for adult females. In the Sapphire Mountains of Montana, Rideout (1977) documented average home ranges of adult males and females were 21.5 km^2 and 24 km^2, respectively. Joslin (1986) reported home ranges varying from 23-182 km^2 for adult males and 16-64 km^2 for adult females. In the Black Hills of South Dakota, Benzon and Rice (1988) determined adult males and females had average home ranges of 29 km^2 and 5 km^2, respectively.

   At times, goats disperse considerable distances outside traditional ranges. This type of movement (relatively common at high population densities) is typically made by young billies, and may be a precursor to range expansion. Dispersal movements of 16-93 km were documented within a high-density (14 goats/km^2) population on the Olympic Peninsula (Stevens 1980). In Wyoming, McWhirter (2004) documented bobcats moved up to 90-130 km from transplant sites in Montana and Idaho.

   Goats are found in two general habitat types, the coastal mountains of British Columbia and Alaska (Herbert and Turnbull 1977) and interior, or continental mountains of the Rocky Mountains. Goats favor alpine meadows or plateaus in close proximity to inaccessible cliffs and steep ridges (Haynes 1991, Von Elsner-Schack 1986). Goats, especially nursery groups, rarely venture more than 400 m from the

security of cliffs (Haynes 1991, Stevens 1979, K.G. Smith 1982). Coniferous forests are found within most goat ranges and provide shelter from rain, snow, and solar radiation. Conifers are also consumed as forage.

Goats are dietary generalists (Casebeer 1950, Brandborg 1955, Hibb 1967, Johnson et al. 1978, Adams and Bailey 1983). Depending upon the area, they make use of grasses, forbs, shrubs, and conifers. Johnson (1983) surmised goats select habitats that are topographically secure, and then eat what is available. Goats also make substantial use of mineral licks (Brandborg 1955, Hebert and Cowan 1971b, DeBock 1970, Stevens 1979), especially in spring. In some populations, this craving prompts goats to travel long distances (Hopkins et al. 1992), swim rivers (Singer 1978), and traverse heavily forested areas far from escape terrain (Turney and Blume 2004a.

4. Response to Harvest – Mountain goat herds are acutely susceptible to being overharvested. Although compensatory reproduction has been documented in some herds (Swenson 1985, Williams 1999), several investigators have concluded harvest mortality has had an additive effect (Hebert and Turnbull 1977, Kuck 1977, Smith 1986, Smith 1988). Cote' et al. (2001) urged cautious interpretation of population data that suggest reproduction may be compensatory. By and large, the sustainable harvest is limited due to the species' delayed sexual maturation, low productivity, and potential for high natural mortality. Reproduction is often greatly depressed in herds that are overexploited or subjected to extreme weather events. Low productivity and declining populations often continue years after hunting seasons are closed (Kuck 1977, K.G. Smith 1988). Goat herds can also respond differently to hunting pressure depending on their status within the ungulate irruption sequence of initial growth, stabilization, decline, post decline (Caughley 1970). In addition, goat populations that inhabit shrub-dominated ranges may not respond in a compensatory manner if habitats have been damaged (Swenson 1985).

   Although the impacts of harvest tend to vary among herds, many investigators have recommended appropriate harvest rates for mountain goats. In west-central Alberta, goat populations increased for a period when a constant harvest rate of 4.5-9.0% was applied, but then dramatically declined (K.G. Smith 1988). The harvest rate in an introduced population in central Montana averaged 20% with no decline in total counts (Williams 1999). Harvest rates that ranged from 5.7-23.1% and averaged 15.7% produced similar results in another introduced population in Montana (Swenson 1985). A much more conservative harvest rate of 1% has been recommended based on studies in Alberta (Festa-Bianchet and Cote' 2002). Harvest rates in British Columbia ranged from 0.36-9.0%, but purportedly could have been increased if harvest was uniformly distributed (Hebert and Smith 1986). Managers generally prescribe overall harvest rates of 3-7% in most states and provinces, but encourage minimal female harvest. Some jurisdictions have set female harvest thresholds at $\leq$30-50% of the total harvest.

Data from annual trend counts and productivity surveys are essential to establish harvest quotas and manage goat herds toward population objectives. Mandatory checks of harvested goats are also essential to accurately monitor harvest including the sex ratio of harvested animals, and to determine hunter success. Although productivity is comparatively low, goats are polygamous. Therefore, harvest of male goats is emphasized to allow greater sustainable harvest. To encourage the harvest of billies, most wildlife agencies provide literature to mountain goat hunters informing them about how to identify sex and where to find billies.

II. CENSUS

A. Herd Classifications/Trend Counts

1. Rationale – Aerial classifications and trend surveys are the most cost effective and practical means of obtaining data to assess population status. Productivity is determined from classifications and aerial counts are used to monitor population trends. These surveys are normally conducted prior to the hunting season (pre-season). Ground surveys enable managers to obtain more detailed sex and age data, which can be used to estimate productivity and recruitment of yearlings.

2. Application – Throughout most of the year, goats remain widely scattered in rugged, partially timbered terrain, typically in groups of 5 or fewer (Hebert and Wood 1984, Varley 1996, Poole et al. 2000). This behavior makes it difficult to obtain adequate classification samples. However, goats congregate in larger groups during late spring to early summer as they stage on windswept, grassy plateaus before moving to summer ranges at higher elevations. In Wyoming, larger groups of goats can usually be found and classified in early to mid July. Weather significantly influences activity patterns, habitat use, and visibility of mountain goats. Activity peaks usually occur during clear weather at sunrise and sunset when goats use more gentle topography farther from secure terrain (Fox 1978). Avoid mornings after severe storms and lightning as goats avoid these events by moving off higher elevations. Similarly, avoid conditions under which goats seek thermal cover in timber.

   Sex cannot be reliably distinguished until mountain goats reach $\geq$ 1 year of age. Horn characteristics that distinguish sex are not apparent until age 2. Methods used to classify sex of goats in the field are: 1) observation of genitals – the male's scrotum can be seen in summer (it is obscured by long pelage in winter) and a black vulva patch is visible on females $\geq$ 1 year when the tail is raised; 2) urination posture – male goats "stretch" when urinating whereas females "squat"; 3) horn morphology – horns of the male are generally more robust than those of the female and curve gently backward throughout their length; horns of females are thinner and straighter with a backward "crook" approximately 5-7 cm from the tip.

   Adult males are generally 10-30% larger than adult females (Brandborg 1955, Houston et al. 1989) and appear stockier or heavier in the chest and shoulder. Beards

of males are also heavier and broader than beards of females. During the breeding season, males urinate on themselves and paw dirt onto their body, creating a dirty appearance. Adult males ($\geq$ 2 years) are normally solitary or consort with small groups of other males. Generally, solitary adult animals seen away from herds of nannies, kids, and yearlings, are adult males, though this criterion isn't entirely reliable (B.L. Smith 1988, Hibbs 1965). In some cases, the stage of hair molt can indicate sex and reproductive status (Brandborg 1955, Chadwick 1983). Adult males are the first to shed their winter coat, usually beginning in May. Nannies with kids are the last and often do not shed until August. Both males and females possess glands at the base of their horns. These are thought to have some function in mating behaviors (Geist 1964). The glands of males are more prominent when examined at close range.

Aerial surveys of mountain goats are conducted from slow moving, fixed-wing airplanes or helicopters. However, helicopters can disturb and displace goats, and have even caused accidental mortalities (Cote' 1996). Aerial surveys should be scheduled when fidelity to spring/summer range is at a maximum, and movements are at a minimum. These surveys should be done only when weather conditions are suitable for low level flying in alpine areas. Goats are generally classified as the number of kids and non-kids, because age and sex are difficult to distinguish accurately from an aircraft. Yearlings are included in the adult or "non-kid" segment. The observer may need to count larger groups 2 or 3 times because kids tend to hide under the nannies when the group is disturbed or agitated by a low-flying aircraft. Adult males are harder to locate, because they are usually solitary or associate in small bachelor groups during the spring/summer period. Only subadult males are commonly found within herds of nannies and kids.

Yearlings are difficult to classify from an aircraft. Only 50% of known yearlings were correctly classified during aerial surveys in Alberta – many were mistakenly classified as kids (Gonzalez-Voyer et al. 2001). Kids remain with the nanny until they are over one year old. By the second summer, kids born the prior season (yearlings) are about half adult size and 1.5 times larger than kids born in the current year. Any goat followed by a kid is a female at least 3 years old.

Aerial trend counts are done periodically to monitor status of mountain goat populations. Detection rates between 46% and 70% have been documented for aerial surveys (Smith and Bovee 1984, Cichowski et al. 1994, Poole et al. 2000, Gonzalez-Voyer et al. 2001). Therefore, trend counts represent minimum or sub-minimum estimates of the population. During the years trend counts are scheduled, they can be combined with aerial classifications. However, trend counts require expanded coverage of goat habitats beyond the areas typically sampled during aerial classifications.

Estimates of kid survival and yearling recruitment are based on ratios of kids and yearlings to females, and this type of information may improve managers' confidence

in population assessments and trend analyses. When more precise sex and age ratios are desired for population management, classifications must be done from the ground at close range. Typically, biologists are able to obtain larger classification samples during late spring or summer when goats congregate on traditional ranges and are more accessible. In addition, sex and age can be distinguished more easily after goats have shed their long winter pelage. Ground counts targeting specific areas may also be useful to classify scattered groups missed during aerial counts.

3. Analysis of Data – Kid: adult ratios estimated from aerial classification data provide coarse information about herd productivity. Ratios of yearlings, lambs, and adult males to adult females are obtained from ground classifications and provide more refined data on productivity, recruitment, and herd dynamics. Productivity and recruitment information can be compared to series of data from prior years to detect population trends and responses to harvest, climate, changing habitat conditions, and other environmental factors. Results of trend counts are analyzed in conjunction with classification data to estimate the minimum population size and to evaluate performance (e.g., productivity) of the population.

4. Disposition of Data – Data from classifications and trend counts are recorded on Wildlife Observation Forms and entered in the appropriate JCR database. The responsible biologist summarizes herd composition data and trend counts in the annual JCRs for the applicable herd unit.

III. HARVEST SURVEY AND AGE DETERMINATION

A. Harvest Survey – Consult Appendix III (Harvest Surveys), Section II.D (In-house Surveys).

B. Mandatory Registration of Mountain Goat Heads/Horns

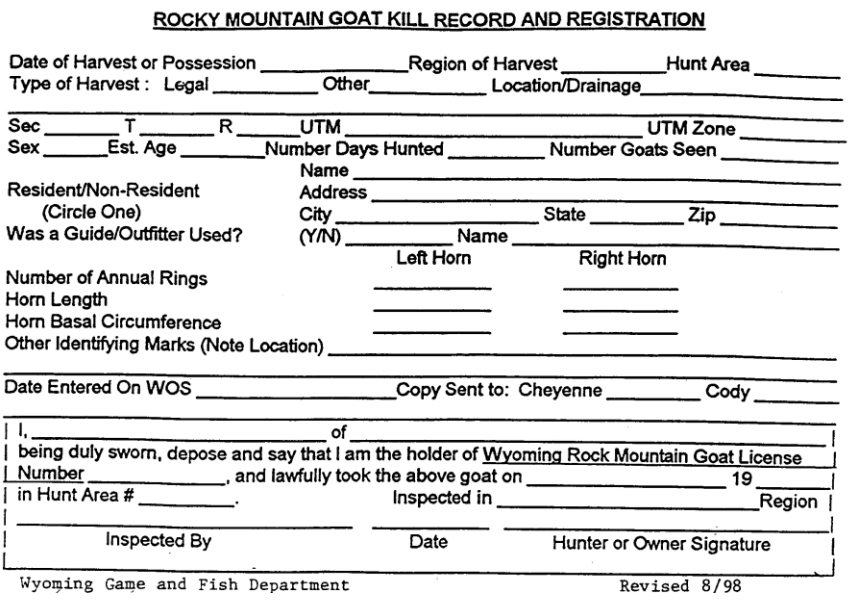
1. Rationale – Accurate harvest statistics are vital to properly manage populations of mountain goats. Prior to 1998 all goat hunters were surveyed by mail to obtain harvest information. However, responses were inconsistent and some non-respondents and persons who returned incomplete or illegible surveys could not be reached to conduct a follow-up survey. To obtain more complete harvest information, in 1998 the Department implemented a regulation requiring mandatory registration of mountain goat heads.

2. Application – Persons who legally harvest a mountain goat are required to register the skull or horns attached to skull plate at a Department Regional Office within 15 days of possession. Department personnel record the following data on a Kill Record and Registration Form (Fig. 1): hunter's identification and contact information, sex and age of the mountain goat, horn measurements (length and basal circumference), location where the goat was harvested, days of hunting, and number of other mountain goats seen. Although numbered plugs are affixed to bighorn sheep horns at

the time they are registered, mountain goat horns are not plugged, nor are photographs taken.

Each harvested goat is aged based on visible horn annuli (Stevens and Houston 1989). Mountain goats do not form a distinct ring the first year, so the actual age is the number of horn rings plus one (Fig. 2). For example, a goat harvested in the fall is 5 years old if 4 rings are visible. When inspection of horn annuli is not possible (e.g. broken horns), age can also be determined from tooth eruption and wear patterns (Table 2).

Mountain goats can also be aged precisely based on laboratory analysis of annular cementum layers. The first (middle) incisors are selected for cross sectioning because they are the first permanent teeth to erupt, and they are relatively easy to extract. This technique is expensive and should be considered only when detailed age data are required and inspection of horn annuli is not possible. Consult Appendix V (Aging) Section III (Laboratory Techniques Based on Cementum Annuli).



ROCKY MOUNTAIN GOAT KILL RECORD AND REGISTRATION

Date of Harvest or Possession _____ Region of Harvest _____ Hunt Area _____
Type of Harvest : Legal _____ Other _____ Location/Drainage _____
Sec _____ T _____ R _____ UTM _____ UTM Zone _____
Sex _____ Est. Age _____ Number Days Hunted _____ Number Goats Seen _____
Name _____
Resident/Non-Resident (Circle One) Address _____
City _____ State _____ Zip _____
Was a Guide/Outfitter Used? (Y/N) _____ Name _____

	Left Horn	Right Horn
Number of Annual Rings	_____	_____
Horn Length	_____	_____
Horn Basal Circumference	_____	_____

Other Identifying Marks (Note Location) _____
Date Entered On WOS _____ Copy Sent to: Cheyenne _____ Cody _____

I, _____ of _____
being duly sworn, depose and say that I am the holder of Wyoming Rock Mountain Goat License Number _____, and lawfully took the above goat on _____ 19 _____ in Hunt Area # _____. Inspected in _____ Region

Inspected By _____ Date _____ Hunter or Owner Signature _____

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Fig. 1. Wyoming Rocky Mountain Goat Kill Record and Registration Form.

3. Analysis of Data – Information from registration cards is used to calculate several statistics including: overall hunter success, resident and non-resident hunter success, effort (days per animal harvested), age and sex composition of the harvest, and total recreation days (total days collectively expended by all hunters).

4. Disposition of Data –The Regional Office where each mountain goat is registered retains one copy of the registration form. A second copy is sent to the Regional Office (Wildlife Management Coordinator) that manages the herd from which the goat was harvested. A third copy is sent to the Supervisor of Biological Services at

the Cheyenne Headquarters. The responsible wildlife biologist compiles registration data annually after each hunting season. Data are summarized and entered into the appropriate JCR database. Data from goat registrations are also analyzed and discussed in the annual JCRs.

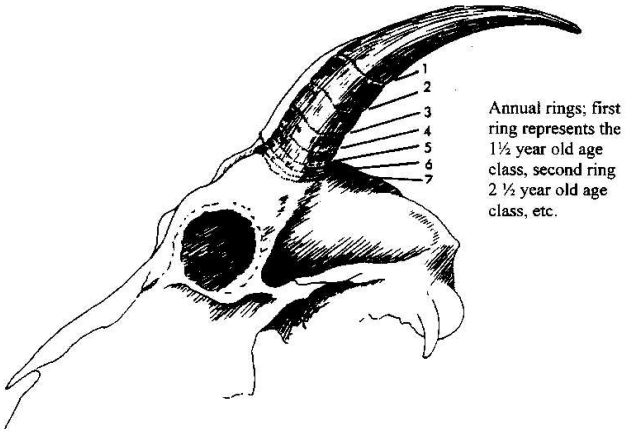

Fig. 2. Aging mountain goats based on horn ring annuli.

Table 2. Tooth eruption and replacement patterns in mountain goats (Brandborg 1955).

	Incisors			Canine	Premolars			Molars		
Age	1	2	3	1	2	3	4	1	2	3
1 Week	(D)	(D)	(D)		(D)	(D)	(D)			
6 Months	D	D	D	D	D	D	D	(P)		
10 Months	D	D	D	D	D	D	D	(P)	(P)	
15-16 Months	(P) P	D	D	D	D	D	D	P	(P)	(P)
23 Months	P	D	D	D	D	(P)	(P)	P	P	(P)
26-29 Months	P	(P)	D	D	(P)	(P)	(P)	P	P	(P)
38-40 Months	P	P	(P)	D	P	P	P	P	P	P
48 Months	P	P	P	(P)	P	P	P	P	P	P

D – Deciduous tooth
P – Permanent tooth
( ) – Parentheses indicate tooth is being replaced

C. Check Stations and Hunter Field Checks

1. Rationale – Check stations and hunter field checks are traditionally employed to enforce game laws, and to collect biological data including sex, age, and condition of harvested animals, antler/horn measurements, geographic distribution of the harvest, and biological samples for laboratory analysis. Sometimes, data from field checked animals are compared against harvest survey results to detect bias. However, data

from harvested mountain goats are obtained through the mandatory registration requirement. Check stations and field checks are impractical to monitor mountain goat harvest because few licenses are issued, most hunting is done in remote locations, and seasons are comparatively long. However, periodic field checks are valuable to assure compliance with game regulations and to enhance public relations with sportsmen.

2. Application – When checking harvested mountain goats in the field or at a check station, record the hunter's identification and license number, hunt area, date and location of harvest, and the sex and age of the harvested animal. Inspect the license to verify proper tagging procedures were followed. Advise or remind the hunter that he needs to present the head and horns for registration at a Department regional office within 15 days of the date of harvest.

3. Analysis of Data – Data from field checks should be compared against the information on the Kill Record and Registration Form to ensure accurate reporting and to identify potential enforcement violations.

4. Disposition of Data – The harvest data reported in the Annual JCRs are taken from the mandatory registrations, not field checks. If inconsistencies are found between field checks and Kill Record and Registration Forms, these should be reconciled. However, any inconsistencies that may indicate a violation should be reported to the appropriate game warden.

IV. NON-HUNTING MORTALITY

A. Rationale – Natural mortality is often quite substantial in mountain goat populations. For instance, significant losses may take place during severe winters. Accidental deaths from avalanches, falls, and lightning strikes are also common, but typically do not have population level effects. On the other hand, deaths from parasites, disease and starvation may indicate an overpopulated environment or other conditions producing physiological stress. If a goat population begins to deplete the limited resources in alpine habitats, deaths from pathogenic organisms and other secondary causes may become increasingly prevalent, and are often the first indication of population or habitat problems.

Accidental or stress-related deaths may also increase in response to human activities or disturbances such as helicopter flights, causing potential problems for the herd (Cote' 1996, Haynes 1991). It is important to maintain records of all goat mortalities and determine causes where possible.

B. Application – When a dead mountain goat is reported or encountered in the field, personnel should attempt to document the cause of death. If the carcass is in satisfactory condition, perform a thorough field necropsy. If possible, transfer the entire carcass to the Wyoming State Veterinary Laboratory (WSVL) in Laramie. Consult Chapter 6 (Bighorn Sheep), Section IV.B. (non-hunting mortality) for a detailed discussion of field

necropsy techniques. Record all mortalities in the Wildlife Observation System, report and summarize them in each annual JCR, and maintain files of lab reports and lab test or necropsy results.

C. Analysis of Data – Forward all samples collected during field necropsies to the WSVL as soon as practical. Consult Chapter 6 (Bighorn Sheep), Section IV.C. (non-hunting mortality) for procedures to follow when delivering samples to the WSVL.

D. Disposition of Data – Test results from the WSVL will be sent to the responsible wildlife biologist. Summarize and discuss mortality events and necropsy results in the applicable Annual JCRs.

V. DISTRIBUTION AND MOVEMENT

A. Rationale – To effectively manage a population of mountain goats, biologists must identify herd boundaries, seasonal ranges, crucial habitats, and migration corridors. However, the species' distribution and movement patterns are difficult to study due to the rugged, remote terrain goats typically inhabit. Herd unit and seasonal range maps (overlays) are maintained in the Cheyenne Headquarters. These maps are used extensively by Department personnel to evaluate potential impacts of land use decisions and other resource agencies frequently consult them as well.. Refer to Appendix VI (Wildlife Distribution and Seasonal Habitat Mapping) for procedures to update season range overlays, and for standard definitions and keys to seasonal range types.

B. Application – Several sources of information are used to delineate seasonal ranges and movements, including marking studies, aerial and ground surveys, and incidental observations. Mountain goats congregate seasonally in large bands or nursery groups, however, most of the year they are scattered widely in rugged, inaccessible terrain. For this reason, distribution and movements are often studied with the aid of telemetry and marked animals. Standard telemetry methods are used, but rock cliffs and canyons can create signal bounces that produce inaccurate readings. Recent advances in Global Positioning System (GPS) technology have been an invaluable aid to mountain goat research (Taylor 2002, Poole and Heard 1998, Keim 2004a, Turney 2004b). Individual animals have also been marked with colored paint-balls to monitor movements, calculate sightability, and develop mark-recapture population estimates (Hanna 1989, Cichowski et al. 1994, Toweill 2003).

Systematic aerial surveys, done on a consistent basis, are the best source of information for documenting mountain goat distribution. However, incidental observations can provide useful information during times of year flights are not normally conducted. Mountain goat surveys are generally flown in mid-late summer, so there is often a gap in distribution data for the remainder of the year. Record all observations of mountain goats on Wildlife Observation Forms. Locations should preferably be described using Universal Transverse Mercator (UTM) Coordinates.

C. Analysis of Data – Applicable records are sorted and retrieved from the Wildlife Observation System, and incorporated into a Geographic Information System (GIS) to map the seasonal distribution of mountain goats. Maps representing observations collected under varying climatic conditions can be compared among years to identify seasonal ranges and to update seasonal range overlays.

D. Disposition of Data – All mountain goat observations should be entered in the Wildlife Observation System. Digital maps of seasonal habitats and migration corridors are maintained at the Cheyenne Headquarters and by the responsible biologist. Discuss significant distribution shifts in Annual JCRs. When appropriate, include distribution maps in the applicable JCR.

VI. CAPTURE, MARKING, and TRANSPLANTING

A. Capture

1. Rationale – There are several potential reasons to capture mountain goats, including: 1) affix markers such as ear tags, neckbands, or telemetry transmitters; 2) collect biological samples; 3) obtain animals for research; or 4) translocate animals to establish populations in vacant habitats or to augment existing populations. As of this writing, only one prior research project had involved capturing mountain goats in Wyoming. A future effort to capture and mark goats could improve managers' capabilities to assess population status and trends, evaluate distribution and movements, and refine herd boundaries.

2. Application – Managers have trapped mountain goats successfully with Clover traps (Clover 1956, Rideout 1974b, K.G. Smith et al. 1992), box traps (K.G. Smith et al. 1992), corral traps (Hebert et al. 1980), rope snares (R.W. Thompson 1981, Johnson and Moorhead 1982), drop nets (Rideout 1974b, Johnson and Moorhead 1982), portable cannon nets (Thompson and McCarthy 1980), and woven wire pen traps (Cooney 1946, Rideout 1974b). Salt is often used to lure goats into traps. In some instances portable traps have been constructed near artificial mineral licks, several years prior to a trapping operation (Adams et al. 1982). Please consult these publications for details regarding each technique.

   Immobilizing drugs have also been used successfully to capture mountain goats. Consult Kreeger (1997) and Appendix VIII (Immobilization) for information about various immobilizing agents and dosage rates. In some circumstances, biologists can approach goats closely enough to dart them from the ground (Haynes 1991), however this method is usually inefficient. Goats can be darted efficiently and safely from a helicopter (Nichols 1982). In one Alaska study, each goat captured required 0.64 hours of flight time. Researchers were able to place darts on target in 68% of attempts and 88% of the goats hit were successfully immobilized (Schoen 1979).

Specific precautions are necessary when mountain goats are immobilized. Goats habitually flee to precipices or other extreme terrain when they feel threatened. Any attempt to capture them in such locations can be hazardous to both the animal and researcher. Conditions that can lead to capture-related mortalities include slow induction time, poorly placed darts or partial dosage delivery, and terrain that is unsuitable for capture operations. In addition, some drugs can produce long lasting, deleterious effects. For example, Cote' et al. (1998) documented reproduction and survival were subsequently suppressed among adult females that were immobilized with xylazine prior to the rut.

Avoid the rear flank when attempting to dart goats. This portion of a goat's anatomy is covered by a tough, thickened skin called a dermal shield that evolved to minimize puncture wounds from combat with other goats (Geist 1967). Goats are also known to "play possum" or "faint" by appearing limp and dead while they are handled, and then immediately jump up and run away when released (Cooney 1946, Thompson 1981). During one episode in a Wyoming study, a goat did not appear to recover after the drug "antagonist" was administered, but became immediately mobile when the blindfold was removed (Haynes 1991). Goats held in captivity for more than two days, for example during relocations, tend to succumb at an abnormally high rate. Such deaths are caused by white muscle disease or capture myopathy (Thorne, et. al. 1982, Foster 1982). Before managers attempt to capture and relocate goats, they should become thoroughly familiar with relevant literature and should consult an experienced veterinarian to obtain direction regarding immobilization and handling precautions.

In recent years, netguns fired from helicopters have become the preferred means of capturing most large ungulates. This method considerably shortens the length of time required to intercept, restrain and process animals, and does not require use of drugs. As a result, overall stress to the animal is less. However, netguns should only be used in terrain that is accessible to a helicopter crew and away from potential hazards. Some researchers have successfully maneuvered goats into suitable capture locations by "slowly pushing" them for short periods (< 1 minute) prior to capture (Poole and Heard 1998). With netguns, managers can limit pursuits to less than 5 minutes and the time required to capture and release an animal to less than 20 minutes (Poole and Heard 1998). In an Alberta study, only 1 animal was lost from 78 goats captured by helicopter netgunning techniques (Jorgenson and Quinlan 1996). Netgunning also gives managers added flexibility to select target animals (e.g. avoid nanny/kid groups) and to assure individuals are marked in a distribution that is consistent with study objectives.

3. Analysis of Data – Researchers should plan extensive field surveys following each capture and marking operation, to search for marked animals. Record UTM coordinates of each observation, and enter the information into a geo-referenced data set that can be plotted and analyzed using GIS software. Seasonal distributions of

marked animals provide documentation to identify seasonal ranges, migration routes, and population boundaries.

4. Disposition of Data – After each capture operation, forward records of all marked animals to the Supervisor of Biological Services at the Cheyenne Headquarters, who will have the data entered to update the Marked Animal Database. Each record should identify the species, sex, and age of the marked animal, capture date, description of marker (neckband, eartags, radio collars), frequency of radio collar (if applicable), location of capture site, and location of release site (if different). Summarize capture records, observations of marked animals, harvest returns, and known mortalities in each applicable JCR. If the marking effort is associated with an independent research project, include progress and final reports of the research the annual JCRs.

B. Marking

1. Rationale – Animals are most commonly marked in a population to study habitat use, seasonal distribution and movements. Marking is a particularly valuable tool for species like mountain goats, which are often dispersed in distinct subpopulations throughout occupied habitats. In some cases, mountain goats have been marked to estimate population size based on the proportion of marked animals observed in a survey sample (mark-recapture type analysis), or to develop sightability models used to adjust survey results (Cichowski et al. 1994, Smith and Bovee 1984, Poole et al. 2000, Gonzalez-Voyer et al. 2001).

2. Application – Goats have been successfully marked with various materials and devices including sheep branding paint, paintball guns, colored eartags and plastic neckbands (Rideout 1974b, Hanna 1989). Because each captured goat represents a substantial investment of cost and effort, managers often elect to fit most animals with radio-collars as the quality of data obtained is much greater. Markers such as neckbands and eartags must be visually observed to establish data points, so fewer locations are obtained. Conventional Very High Frequency (VHF) radio-collars are suitable to monitor general movement patterns and habitat use. When continuously recorded data are necessary to accurately describe habitat use, movements, survival, and response to human activities, Global Positioning System (GPS) collars are used (Poole and Heard 1998, Taylor 2002, Keim 2004b).

3. Analysis of Data – Consult Section VI.A. (Capture)

4. Disposition of Data – Consult Section VI.A. (Capture)

C. Transplanting – Although goat populations in Wyoming are the result of prior transplants by adjoining states, no effort has been made to transplant goats within Wyoming (Hurley 1996). Since there is negligible evidence mountain goats historically inhabited

Wyoming, it is unlikely future transplants will be considered in Wyoming, especially on federal lands.

VII. MODELING – Models are not currently used to simulate mountain goat populations in Wyoming because sex and age composition data needed to support a credible model are very difficult to obtain. This would require a substantial commitment of personnel and funding over several years. For management purposes, population status is monitored based on periodic trend counts and annual productivity surveys. Goats display a strong affinity to certain habitats. Nursery bands in particular are easily monitored from year to year. Consult Appendix IX (Big Game Population Modeling) to review a general discussion of population modeling.

VIII. JOB COMPLETION REPORTS – All data collected and analyzed to manage mountain goat herds, in addition to season descriptions and harvest results, are summarized in the annual JCRs prepared by the responsible regions. The format for reporting productivity data is somewhat different from that used for other species. Because adult males and females are difficult to distinguish during classification surveys, productivity is reported as juveniles per 100 adults rather than juveniles per 100 females. This format requires some modification of the graphs and tables in the standard JCR format.

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