Chapter 6

Bighorn Sheep (*Ovis canadensis*)

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I. INTRODUCTION - Historically, bighorn sheep occupied suitable habitats throughout much of Wyoming (Honess and Frost 1942, Buechner 1960). Early taxonomists classified 2 subspecies: "Audubon's" and "Rocky Mountain" bighorn sheep (Cowan 1940). Audubon's sheep inhabited mountain ranges, badlands, and rimrock breaks in eastern Wyoming. They tended to be non-migratory, fulfilling seasonal habitat needs within comparatively limited yearlong ranges. This subspecies was extirpated from Wyoming by 1907 (Cowan 1940, Honess and Frost 1942, Morris 1979).

Rocky Mountain sheep occupied the western mountain ranges of Wyoming. They were characteristically migratory, generally wintering in low elevation foothills and summering in alpine habitats above 10,000 feet. As the state was settled in the mid 1800s, Rocky Mountain bighorns declined precipitously throughout traditional low elevation ranges. Buechner (1960) listed several causes including excessive market hunting, disease (primarily scabies), competition with livestock, and encroachment by settlers into available winter range. Despite these factors, Rocky Mountain bighorns apparently flourished in remote high mountain habitats until domestic sheep were brought to montane pastures during the 1880s. Smith (1982) concluded bighorns were greatly reduced by disease and competition for forage after huge flocks of domestic sheep were brought from Oregon to the southeastern Wind River Mountains in approximately 1880. Similarly, Hornaday (1908) and Honess and Frost (1942) described die-offs from scabies presumably contracted from domestic sheep.

Sixteen herd units are currently defined to manage bighorn sheep in Wyoming. The Department's Bighorn Sheep Working Group considers 8 of these "Core Native Herds" that should receive highest management priority. Core herds include the Clarks Fork, Francs Peak, Jackson, Targhee, Trout Peak, Wapiti Ridge, Whiskey Mountain, and Yount's Peak populations. The other 8 herds were established in historic sheep range by transplanting sheep from the Whiskey Basin Herd. In most cases, herds that started as transplants have remained relatively stagnant or even declined after an initial rapid expansion. Since these herds are performing beneath expectations, the Bighorn Sheep Working Group recommends management emphasis should be directed primarily to core native herds.

II. CENSUS

A. Herd Classifications/Trend Counts

1. Rationale – Managers use data from herd classifications to estimate lamb survival, yearling recruitment, and sex composition. These data are also incorporated into

POP-II computer models to estimate population size and predict effects of future harvest strategies.

2. Application – Ground or aerial surveys are conducted to classify bighorn sheep, as circumstances warrant. Ground classifications should be done in late-November through mid-December, after hunting seasons, when bighorn sheep are concentrated on winter ranges and rams are rutting. Sheep can be observed for longer periods from the ground, so observers should attempt to classify all sheep according to specific age and sex categories. Record the total numbers of rams, ewes, yearlings, and lambs observed. Male and female yearling sheep can be difficult to distinguish, however, personnel should attempt to do so. Geist (1971) also defined 4 age classes of adult rams (Fig. 1). When possible, classify all adult rams observed during ground surveys according to these 4 categories.

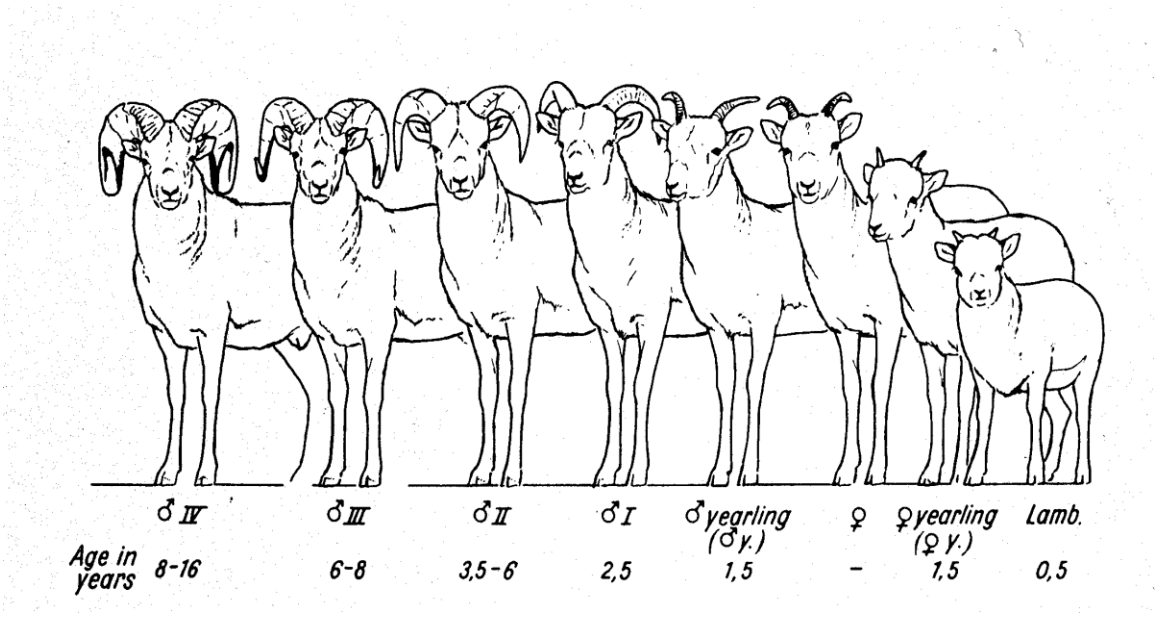


Fig. 1. Bighorn sheep age and sex characteristics. Note that animals form a cline in body and horn size, and the adult female is very similar in external appearance to the yearling ram. The above drawing is taken from Geist 1968.

Sheep can be classified from aircraft between mid-December and mid-March, depending on snow conditions and distribution of animals. Although fixed-wing aircraft have been used in the past, helicopters provide a much stabler and safer platform from which to classify sheep in Wyoming. Hughes 500 or Bell Jet Ranger helicopters are recommended for higher elevations. Piston-fired Hiller 12E or turbo-charged Bell 47 helicopters can be used at lower elevations to reduce the cost of surveys. During aerial surveys, personnel should record the total numbers of adult rams, ewes, and lambs observed. If it is possible to distinguish yearling rams, they should be recorded as a separate category.

In some herd units, sheep are classified most effectively by a combination of aerial and ground surveys. The Whiskey Mountain and Yount's Peak Herd Units are especially suited for concurrent surveys. Observers have excellent vehicle access to large concentrations of sheep wintering at low elevations in these herds. However, large numbers of sheep also winter at scattered high-elevation sites that are accessible only by air. In such circumstances, ground surveys and flights should be scheduled as concurrently as possible to avoid duplicate counts of groups that may move between high and low elevation winter habitats. Data from both surveys are combined to estimate sex and age ratios for the herd unit.

Sheep population trends can be tracked through time based on classification surveys if a consistent protocol is followed. Specifically, the surveys must take place at the same time of year, under similar conditions, and must cover the same winter ranges. A trend count represents the number of animals observed under a given set of conditions. It is not a total count. Climatic conditions and observer biases (detection rates) change from year to year so varying proportions of animals are missed. Therefore, trend analyses should be based on data from years in which environmental conditions (i.e., snow cover, cloud cover, temperature, wind speeds, etc.) are reasonably comparable. Trend counts provide corroborating data to verify and refine population models.

3. Analysis of Data – Estimate the ratios of rams and lambs per 100 ewes based on classification data. If rams were classified as yearlings and adults, distinguish these age groups in the ram:ewe ratios. Herd composition data are incorporated into POP-II models.

4. Disposition of Data – Enter classification data in applicable Job Completion Report databases. These data and the population simulation model are analyzed and discussed in the Annual Job Completion Report.

III. HARVEST MONITORING AND AGE DETERMINATION

A. Harvest Survey - Refer to Appendix III.

B. Mandatory Head Registration

1. Rationale – A mandatory registration system was instituted to discourage illegal possession and trafficking of bighorn sheep heads. The system retains permanent records of harvested and found heads so they can be traced and identified as legal, if necessary. Since sheep heads must be physically presented for registration, managers are able to determine the actual ages, sexes, and horn measurements of sheep taken by hunters each year. Other harvest related data such as location, effort (days expended per animal harvested), number of other sheep seen, date, and type of harvest (legal, illegal, firearm, archery) are recorded as well.

2. Application – The heads of all sheep that are legally harvested, and the skulls and horns of sheep that are found dead (i.e., "pick-up" heads), must be presented at a Department Regional Office or Headquarters for tagging and measurement within 15 days of the date the sheep was possessed. Persons who acquire an unmarked sheep head that was taken prior to the Department's registration program are also required to present the head for registration within 15 days. Pertinent data are recorded on a Kill Record and Registration Form (Fig. 2). Each set of horns is assigned a unique identification number imprinted on an aluminum plug. The plug is inset with glue in a countersunk hole drilled in the back of one horn. The hunter is given the option of selecting which horn (right or left) he wants plugged. This will often depend on the position the head will be mounted. Harvested heads are marked with a silver plug stamped in the following sequence: WYO-(3-digit number)-(year of harvest). Pick-up heads are marked with a red plug stamped in the following sequence: (3-digit number)-WYO-P (for pick-up head). Heads acquired prior to the Department's registration program are similarly marked with a silver plug stamped with the following sequence: WYO-(3-digit number)-PRE. Standard metal game tags issued by the Department are attached to ewe and lamb skulls. After the head is registered, record the following information on a Wildlife Observation Form: date, age and sex, hunt area, cause of mortality (if known), and location.

Wyoming Game and Fish Department Rocky Mountain Bighorn Sheep Kill Record & Registration (Revised 7/98)

Date of Harvest or Possession:_____ Region of Harvest:_____ Hunt Area:_____ Horn ID No.____-____ (year)

Harvest Type: Legal_____ Illegal_____ Pickup Head_____ Other_____

Location and/or Drainage:_____

Section____ Township_____ Range_____ UTM East_____ UTM North_____ UTM Zone_____

Sex:_____ Estimated Age:_____.35 years No. Days Hunted:_____

(midpoint of hunting season is approximately 0.35 years into the biological year. This does not necessarily apply to pickup heads and illegal harvest)

Name_____Phone_____ Resident _____ Non Resident ____

Address_____

City_____ State_____ Zip_____ Date Entered on WOS:_____

Was Guide or Outfitter Used (Y/N)_____ Name_____

	Left	Right
Number of Annual Rings	_____	_____
Total Horn Length	_____mm	_____mm
Length from lamb to yearling horn ring	_____mm	_____mm
Length from yearling to 2+ horn ring	_____mm	_____mm
Length from 2+ to 3+ horn ring	_____mm	_____mm
Horn Basal Circumference	_____mm	_____mm

Tip Spread:_____mm Maximum Spread:_____mm

Other Identifying Marks (note location on horn):_____

I,_____ of_____

being duly sworn, depose and say that I am the holder of Wyoming Bighorn Sheep License Number_____

and lawfully took the above sheep on_____, in Hunt Area No._____, Inspected in _____Region

_____ _____ _____

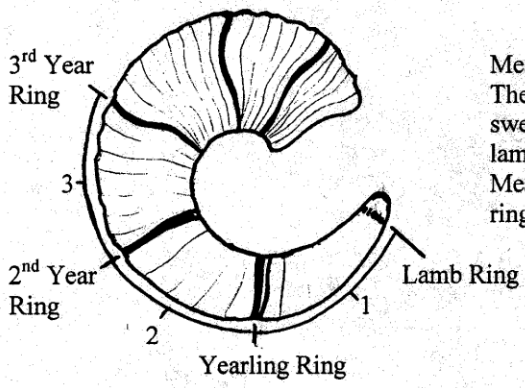
Inspected by Date Hunter or Owner Signature

Fig. 2. Bighorn sheep mandatory horn registration form.

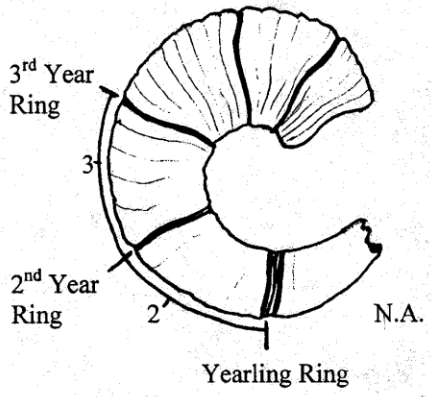
Ages of rams are determined by counting the number of annular rings on each horn. Beginning at horn tip, the lamb's horn is segment 1. The lamb segment is often missing from broomed horns of older rams, so the first visible ring may indicate the end of the second segment (Fig. 3). Occasionally, "false rings" complicate the determination of a ram's true age. These depressions encircling the horn are uncommon on segments grown before 7 years of age, but are often prominent on segments grown by rams older than 9 years. Geist (1966) concluded the true age ring is a distinct break between adjoining horn segments often present at the terminus of each segment. The correct way to measure age from the lamb ring to the third-year ring is illustrated in Fig. 3. After horns are measured and tagged, photograph the left side of the head. Print the registration number and hunter's name on the photo and attach it to the registration form.

BIGHORN SHEEP
ANNUAL RING MEASUREMENTS

Starting in 1998 three new measurements were started on bighorn sheep horns in addition to the standard horn basal circumference and total horn length measurements. These three new measurements are simply the length of the horn between the lamb ring and the yearling ring (measurement 1), the yearling ring and the 2-year ring (measurement 2) and the 2-year ring and the 3-year ring (measurement 3). ALL OF THESE MEASUREMENTS ARE TAKEN ON THE OUTSIDE PERIMETER OF THE HORN (same place as the total horn length measurement).



Measurements for horn with a lamb tip. The lamb ring is usually only a small swell of the horn and not a true ring. The lamb tip is usually < 1" long. Measurement 1 is made from the lamb ring (small swell) to the yearling ring.



Measurements for a horn with the lamb tip broomed off. Only the second and third measurements are taken. Record N.A. for first measurement on card.

Fig. 3. Bighorn sheep horn characteristics and measuring techniques.

3. Analysis of Data – Managers can evaluate results of harvest strategies by comparing the average ages and age distributions of rams harvested over periods of years. Rates of horn growth between years 1 and year 3, which are affected by weather and habitat conditions, may be useful to identify periods of stress or potential habitat issues. Kill

locations are also useful to delineate or refine bighorn distribution late summer and fall provided they are reported accurately.

4. Disposition of Data – Each regional office at which sheep are presented for registration, retains a copy of registration form. A second copy is sent to the regional office responsible for managing the herd from which the animal was taken. A third copy is forwarded to the Supervisor of Biological Services in Cheyenne. The responsible District Biologist compiles registration data annually after hunting seasons end, and then enters the data for each herd into applicable Job Completion Report databases. The data are also analyzed and discussed in the Annual Job Completion Reports.

C. Tooth Eruption and Wear – Specific ages of female bighorn sheep must be determined for some management applications, for example, when ewes are harvested or captured or when mortalities are encountered. Aging can be based on tooth eruption and wear patterns. Dimmick and Pelton (1996) described tooth eruption patterns in the lower jaw of bighorn sheep up to 4 years old (Table 1). Note the first incisor of bighorns is replaced at Year 1, but the second incisor is not replaced until Year 3.

Table 1. Bighorn sheep tooth eruption and replacement patterns. D = Deciduous tooth, P = Permanent tooth, ( ) = tooth is being replaced.

Age	Age in	Incisors			Canine	Premolars			Molars		
in years	months	1	2	3	1	2	3	4	1	2	3
Birth	0	D	D	D	D	D	D	(D)			
	1	D	D	D	D	D	D	D			
	6	D	D	D	D	D	D	D	(P)		
1	12	(P)	D	D	D	D	D	D	P	(P)	
	16	P	D	D	D	D	D	D	P	P	
2	24	P	D	D	D	D	D	D	P	P	
	30	P	D	D	D	(P)	(P)	D	P	P	(P)
3	36	P	(P)	D	D	(P)	(P)	(P)	P	P	(P)
	42	P	P	D	D	P	P	P	P	P	P
4	48	P	P	P	P	P	P	P	P	P	P

D. Tooth Cementum Annuli – Although managers generally rely on horn annuli and tooth replacement patterns to age sheep, adults of both sexes can be aged very accurately based on laboratory analysis of annular cementum layers (Turner 1977). The first (middle) incisors are selected for cross sectioning because they are the first permanent teeth to erupt. The technique is expensive and time consuming, and should be considered only

when detailed age data are required to address unique management or research needs. Refer to Appendix V for a detailed description of the cross-sectioning technique.

E. Check Stations and Hunter Field Checks

1. Rationale – Check stations and hunter field checks are useful sources of harvest data, including relatively unbiased data on age and sex composition, for many game species. However, data collected from bighorn sheep at check stations is of lesser importance, because the mandatory registration requirement enables managers to collect more detailed information when sheep are presented at regional offices. Hunter contacts during field checks and at check stations are valuable means of enhancing public relations and helping to assure sheep hunters comply with game laws.

2. Application – When checking harvested sheep in the field or at a check station, record the animal's age and sex and the date, hunt area, and location of harvest. Inspect the hunter's license to verify it was filled out properly.

3. Analysis of Data – Personnel should forward all data from checked sheep to the responsible District Biologist after the hunting seasons ends. The District Biologist compiles this information. The age composition of harvested sheep should be reported for each Hunt Area and Herd Unit.

4. Disposition of Data – Information obtained from field checks of harvested sheep should be entered into the responsible Biologist's Job Completion Report database and reported/discussed in the Annual Job Completion Report.

IV. NON-HUNTING MORTALITY

A. Rationale – Non-hunting mortality is not generally an important concern with respect to population management. However, large losses of bighorn sheep occasionally take place in localized situations. Disease outbreaks (especially pneumonia epizootics) or severe winter losses can impact individual populations. Other causes of mortality such as predation, vehicle accidents, and parasites don't normally have population-level impacts. Nevertheless, a herd management evaluation should include an assessment of the relative importance of various mortality agents.

B. Application – When a bighorn sheep is found dead or must be euthanized for management purposes, perform a thorough necropsy if the carcass is fresh enough. Preferably, transport the entire carcass to the Wyoming State Veterinary Laboratory (WSVL) in Laramie for this work. When it is not possible to deliver an intact carcass, personnel should attempt to perform a field necropsy. Suitable instruments are not always available in the field so some of the recommended procedures may not be possible. At a minimum collect and preserve a lung tissue sample and send a specimen to the Wyoming State Veterinary Lab (WSVL) as soon as practical if the suspected cause of death is a disease.

Ideally, conduct a full field necropsy. The following procedures will provide field personnel with the most complete data regarding the animal's condition. Record relevant information on a field necropsy form (Figure 4). Thoroughly examine the animal's pelage and collect any external parasites in a container filled with ethyl alcohol. Subjectively rate body muscle condition based on a scale of 0-5 (0 = very poor; 5 = excellent). To determine the body fat score, make 3 incisions along the animal's back: 1) at base of tail, 2) between the shoulder and hindquarter, and 3) at the shoulder. Score body fat according to the following criteria: 0 = no fat at any location; 5 = fat at location 1 only; 10 = fat at locations 1 and 2; and 15 = fat at all 3 locations. If the age cannot be determined based on tooth replacement patterns or horn rings, extract the lower middle incisors with roots intact, and submit them to the Department's Veterinary Services Laboratory in Laramie for cross-sectioning.

Collect samples to examine for microscopic mites by swabbing deeply inside both ears with long Q-tip swabs. Store Q-tips in a leak-proof Whirl-pak® bag. In addition, remove a piece of ear and store it in a tube filled with formalin. Use Culturettes (available from Veterinary Services) to deeply swab the animal's nasal passage. After swabbing, return the culturette to its housing and crush the bottom to release preservative. Tonsils of dead sheep should also be sampled. Collect samples by swabbing the tonsil with a sterile culture swab, then place the swab in a Port-A-Cul™ media tube (available from Veterinary Services).

After examining the sheep's body condition and collecting samples collected, open the animal and follow standard necropsy protocol. Measure the amount of fat (mm) on the heart, kidney, omentum, and xyphoid. Crack one femur, examine the bone marrow for color and texture, and collect a sample for histological examination. To determine parasite loads, collect fecal samples by removing 5-6 in of the terminal rectum containing at least 20 pellets and place it in a Whirl-pak bag.

If possible, collect at least 2 fresh lung samples from dead bighorn sheep for virus isolation and microbial cultures. Use sterile or very clean instrument to sample fresh tissues. Clean instruments are effectively sterilized by dipping them into 70-90% ethyl alcohol then burning the alcohol off. Use sterile forceps to place tissues in Whirl-pak bags. Do not add preservatives or other materials to the bags. Expel air by collapsing the bag and concurrently spinning it around the tabs at least 4 times.

Bighorn Sheep Necropsy Form

Herd name/location: _____ Animal ID (if any): _____
Location: Township _____ Range _____ Section _____ or UTM _____
WSVL accession #: _____ Date of necropsy: _____
History/signs of disease prior to death:
_____
_____
_____
_____
Estimated age: _____ Sex: _____ Weight (if available): _____
Hair coat quality: Excellent_____ Good_____ Fair_____ Poor_____ Very Poor_____
Species and number of external parasites: Collected? _____
_____
_____
Body muscle (0-5): _____ Back fat score: 0 5 10 15
mm fat on: Heart_____ Kidneys_____ Omentum_____ Xyphoid_____
Bone marrow color: _____ Texture:_____ Subjective body condition:_____
Internal exam notes:
_____
_____
_____
_____
Species and number of internal parasites: Collected? _____
_____
_____
Fetuses: _____ Weight: #1:_____ #2: _____ Sex: #1:_____ #2:_____
Crown-rump: #1:_____ #2:_____ Crown-nose: #1:_____ #2:_____

Tissues fixed:
Heart_____
Liver_____
Spleen_____
Lung_____
Tongue_____
Muscle_____
Kidneys_____
Rumen_____
Reticulum_____
Omasum_____
Abomasum_____
Ileum_____
Gonads_____
Brain_____
Pancreas_____
Ileocecal LN_____
Bladder_____
Bone Marrow_____
Retropharyngeal LN_____
Ear Notch_____
Tonsil_____
Placenta_____

Tissues taken for lab evaluation:
Fecal (parasitology)_____
Blood (red tops) X2_____
Blood (green top)_____
Blood (purple top)_____
Teeth (both Ils) for aging_____
Lungs_____
Tonsil swab in Port-A-Cul_____
Liver_____
Kidneys_____
Brain_____
Rumen contents_____
Feces_____
Fat_____
Nasal Swabs_____
Ear Swabs_____

Fetal Tissues Fixed:
Liver_____
Spleen_____
Kidney_____
Lung_____
Brain_____

Others (list):
_____
_____
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_____
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_____
_____
_____

Fetal Tissues Fresh:
Kidney_____
Eyeball_____
Abomasum_____
Spleen_____
Liver_____
Lung_____
Placenta_____

Fig. 4. Bighorn sheep field necropsy form.

Draw blood samples directly from the heart or jugular vein for complete blood counts (CBCs), serum chemistry, trace mineral analysis, and/or serologic testing. Place blood in 1 purple-topped tube (for CBC and blood chemistry), 2 red-topped tubes (1 for serology; 1 for trace mineral analysis), and 1 green-topped tube (for selenium).

Open and thoroughly examine the animal's entire gastrointestinal tract. Record the number and type of macroscopic parasites. Preserve internal parasites in formalin for later identification by the WSVL personnel. Open and examine the uteruses of ewes to determine the presence of fetuses. Record the number, sex, and weight of each fetus, as well as the crown-rump and crown-nose lengths. If reproductive problems have been documented in the herd, collect fetal tissues for histological examination. Refrigerate all tissue samples until they are transferred to the WSVL, but do not allow them to freeze.

C. Analysis of Data – Ship tissues samples to the WSVL as soon as practical after the necropsy is completed. Preferably, hand-deliver them. Most common carriers (e.g., U. S. Postal Service, United Parcel Service, or Federal Express) will not ship samples unless they are bagged and the shipping carton is insulated and protected by an outer fiberboard box. Fill extra space in the box with wadded newspapers or paper towels. Add frozen ice packs to keep samples cool and place accompanying paperwork in a separate plastic bag on top of the insulated container lid.

D. Disposition of Data – Personnel at the WSVL will perform relevant tests on bighorn tissue samples and report results to the responsible District Biologist. The biologist should summarize data from all necropsies in applicable Annual Job Completion Reports.

V. DISTRIBUTION AND MOVEMENTS

A. Rationale – Biologists require detailed information about distribution, migration patterns, and habitat use of bighorn sheep to effectively manage populations. The Department began compiling seasonal distribution data in the early-1970s. However, distribution and habitat use can change through time, in response to weather trends, succession, and land uses. Accordingly, managers should periodically update seasonal range delineations when shifts in bighorn sheep use areas are documented.

B. Application – Sheep locations are obtained from aerial classifications, ground observations, harvest records, and studies involving marked animals. As data are accumulated, record locations on Wildlife Observation Forms using Universal Transverse Mercator (UTM) Coordinates. Approximately every 5 years, District Biologists should update seasonal range overlays for bighorn sheep herds.

C. Analysis of Data – Applicable location records can be retrieved from the Wildlife Observation System, and incorporated into a Geographic Information System (GIS) database. Specific data used to define or update seasonal ranges are sorted based on relevant observation dates and in some cases, based on years of normal to severe climatic conditions. The Department generally maps seasonal ranges on 1:100,000 scale,

transparent overlays. However, seasonal range maps are also being digitized for GIS applications. Seasonal range terminologies are described in Appendix VI.

D. Disposition of Data – After seasonal range overlays are updated, the responsible District Biologist should distribute copies to the Supervisor of Biological Services and to local jurisdictions of federal resource agencies. The District Biologist also retains copies for his own reference and use.

VI. CAPTURE, MARKING, AND TRANSPLANTING

A. Capture

1. Trapping

a. Rationale – In Wyoming, bighorn sheep are captured for the following purposes: marking, collection of biological samples for testing, and to obtain stock for reintroductions. Capture methods usually involve luring or driving sheep into traps. The most successful type of trap has been the drop net. For over 20 years drop nets have been successfully used to capture sheep at the Whiskey Mountain Wildlife Habitat Management Area near Dubois. Nearly 2,000 bighorn sheep have been captured, marked, and transplanted (Hurley 1996). The Department currently owns 2 complete drop net traps, both stored and maintained by the Lander Region.

Bighorn sheep can also be captured effectively with portable drive nets and either permanent or portable corral traps depending on topography and goals of the capture operation. These types of traps have been used successfully in other western states (Coggins 1999). Consult Kock et al. (1987) for information regarding how various capture techniques and operations affect bighorn sheep physiologically.

b. Application – Trap sites should be readily accessible and situated so personnel will be screened from approaching animals. Erect drop nets and corral traps on relatively flat slopes to assure the equipment functions properly. Place corral traps on drained areas to prevent ice buildup. Sheep are baited onto the trap site. Second cutting alfalfa hay and apple pulp are extremely effective. Trapping is generally most successful between December 15 and March 1. At that time, bighorns are usually concentrated on lower elevation winter ranges.

The drop net used at Whiskey Mountain is a 70 X 70 ft canopy comprised of four, 35 X 35 ft nets clipped together. The perimeter of the net is fitted with 3/8 in nylon rope to provide support. A steel ring is fastened to the junction of the 4 smaller nets. The center pole is a 20-ft section of heavy steel pipe. The 4 corner posts are 12 ft sections of heavy steel pipe. Two steel guy cables support each corner post and a guy cable extends from the top of each corner pole to the top of the center pole. The posts and guy lines form a rigid superstructure that supports

the net. The completed trap is stable in high winds often encountered at Whiskey Basin during winter. Refer to Emmerich et al. (1982) for a description of the electronic triggering system for this trap.

c. Analysis of Data – Refer to Section VI. B. 1. c. (Marking).

d. Disposition of Data – Refer to Section VI. B. 1. c. (Marking).

2. Netgunning

a. Rationale – Several companies now specialize in wildlife capture with netguns fired from helicopters. When conducted by trained professionals, aerial netgunning is a rapid, very efficient way to capture bighorn sheep. Depending on terrain and sheep densities, an experienced crew can capture, mark, and release 30-50 animals in a day. Netgun crews can also collect biological samples. Given adequate instruction, a good crew can distribute collars throughout an entire seasonal range within a herd unit in little time.

b. Application – After contracting services of a wildlife capture firm, provide the pilots and capture crews maps on which targeted capture locations are marked. It may be acceptable to ride in the helicopter before the capture operation begins, to orient the crew and identify capture sites. However, for safety reasons, Department personnel should not be involved as crewmembers once the operation is underway. Depending on the company's inventory, the Department may need to supply ear tagging pliers and other capture equipment.

Most netgun operations involve marking, and releasing animals at the capture site. However, captured animals can also be transported to a central location for processing or relocation. When animals are transported, they can be tranquilized to reduce stress. Trailers or other equipment used to relocate bighorn sheep should be equipped as described in Section VI. C. (Transport) of this chapter.

c. Analysis of Data – Refer to Section VI. B. 1. c (Marking).

d. Disposition of Data – Refer to Section VI. B. 1. c (Marking).

3. Immobilization

a. Rationale – Immobilizing drugs can be used to capture small numbers of bighorn sheep in specific locations. Drugs can also be used to sedate sheep while they are in traps and while they are being transported to release sites.

b. Application – Refer to Kreeger (1996) and Appendix VIII for a discussion of various immobilizing agents, their effects on bighorns, and dosage rates. A variety of delivery instruments including rifles, pistols, blowguns, and jab sticks are used to administer drugs. By darting animals from a helicopter, managers can

capture greater numbers of sheep throughout all seasonal ranges. However, aerial darting is usually more effective when animals congregate on winter habitats. If sheep are darted from the ground, they can be baited into a more limited area to reduce costs and save time. Alfalfa hay from 2nd or 3rd cuttings and apple pulp are highly effective baits.

c. Analysis of Data – Maintain detailed records of each immobilization event. Record the type of drug used; dosage; the animal's age, sex, and approximate weight. Document induction times to help refine dosages in the future. Similarly, document the length of time an animal remains immobilized.

d. Disposition of Data – Provide Department Veterinary Staff records from each bighorn sheep. Summarize results of each operation in applicable Job Completion Reports.

B. Marking

1. Neckbands and Ear Tags

a. Rationale – Seasonal observations of marked sheep provide essential data to delineate spring, summer, and/or fall ranges of sub-populations that were trapped on specific winter habitats. Managers can develop harvest strategies targeting specific herd segments based on these data. Sheep are also marked to detect interchange across herd unit boundaries and to estimate harvest rates, natural mortality rates, or longevity.

b. Application – When marking sheep for individual identification, use neckbands and symbols that can be readily seen and read. Each animal should be marked with unique symbol patterns to prevent duplication. In addition, use different colored neckbands at each site. For some applications, numbered, cattle ear tags are suitable to identify individual animals. Colors of ear tags should also correspond to specific trap sites.

Numbered aluminum ear tags should be fitted to both ears of sheep that are marked with neckbands. Tags should also have return instructions imprinted. Sheep sometimes shed neckbands and other types of collars, but seldom lose both ear tags.

c. Analysis of Data – Following each trapping and marking operation, personnel should conduct an extensive monitoring/survey effort to observe marked animals. Enter UTM coordinates of each observation into a Microsoft Access database. Construct GIS layers depicting animal distribution to identify and refine seasonal ranges, migration routes, and herd unit interchange.

d. Disposition of Data – Immediately after each marking operation, forward records to the Supervisor of Biological Services for inclusion in the Department's Marked

Animal Database. Records should at a minimum include: dates animals were captured and marked; species, condition, ages and sexes of marked animals; description of markers including types, colors, numbers, and symbols; and locations of trap sites (UTM coordinates) and release sites if different. Summarize the following information in applicable Job Completion Reports: trapping records, marked animal observations, harvest returns, and other reported mortalities of marked animals.

2. Radio Telemetry

   a. Rationale – Collars with telemetry transmitters cost more than traditional neckbands, however they yield data of substantially greater quantity and quality. Modern telemetry systems are capable of recording and storing thousands of individual locations. This high-density, geographic data enables Biologists to accurately chart daily activity patterns, habitat selection, seasonal distribution, migration corridors, and many other parameters without disturbing the animal once it has been collared.

   b. Application – Transmitter collars are fitted on bighorns during capture operations. To improve visibility, a rubber-impregnated neckband material can be attached with pop-rivets to the standard transmitter collar. These 4-inch wide sheaths are available in various colors and can be numbered to identify individual animals.

   c. Analysis of Data – Several computer programs have been developed to plot telemetry locations and calculate home range sizes. Each program has strengths and weaknesses depending on how many observations of marked individuals are in the data set. Software technology is also continually evolving. Biologists should consult the Cooperative Fishery and Wildlife Research Unit in Laramie, Wyoming for advice regarding the most relevant versions.

   d. Disposition of Data – Immediately after each marking operation, forward records to the Supervisor of Biological Services for inclusion in the Department's Marked Animal Database. Records should include: dates animals were captured and marked; species, condition, ages and sexes of marked animals, description marking devices including types, colors, numbers and symbols; and locations of traps (UTM coordinates) and release sites if different. Summarize the following information in applicable Job Completion Reports: trapping records, marked animal observations, harvest returns and other reported mortalities of marked animals.

C. Transplanting

1. Guidelines for Transplanting Bighorn Sheep within Wyoming – For many years, the Department routinely transplanted bighorn sheep into suitable habitats within Wyoming. Transplants were done either to re-establish populations in vacant, historically occupied habitats or to augment poorly performing herds. In recent years,

increasingly complex issues, such as land use changes, landowner concerns, and habitat suitability, have affected the Department's consideration of sheep transplants. In 2001, the Department and the Domestic Sheep/Bighorn Sheep Interaction Working Group devised guidelines to assist planning and coordination of bighorn sheep transplants.

The following steps were identified to enhance success of future bighorn sheep transplants within Wyoming. First, select a potential transplant area based on presence of essential habitat attributes. Identify Federal agency personnel, non-governmental organizations, and other public interests that should be involved. Next, have regional population and habitat biologists, the Bighorn Sheep Working Group, and Veterinary Services Section assess the feasibility, suitability, and habitat characteristics of the proposed site. Identify funding options and potential source populations of bighorn sheep. Review health histories of source stock to identify potential concerns about disease transmission. Map all seasonal and year-round habitats bighorn sheep are expected to occupy after they become established. The areas mapped should not include areas bighorn sheep are unlikely to use. Next, identify any domestic sheep use within bighorn sheep habitats and evaluate the risk of contact between the 2 species. Finally, determine a post-season population objective for the new bighorn herd.

If district personnel conclude a transplant is feasible and desirable, the responsible Region should forward Wildlife Division Administration a recommendation to proceed. After reviewing the proposal, Division Administration should forward the Director's Office a recommendation to approve the plan and regional personnel should notify the appropriate Game and Fish Commissioner. If the Commissioner supports the proposal, begin the public notification and review process by contacting potentially affected interests.

If the release site or surrounding habitats are public lands, begin contacts with Federal agency personnel and affected livestock permittees. All parties should be given a clear explanation of: 1) whether or not "buffer zones" between domestic and bighorn sheep will be sought; 2) whether or not the livestock operator will be indemnified should co-mingling between domestic and bighorn sheep lead to a disease outbreak; and 3) whether or not the livestock permittees' Federal grazing privileges could be affected by the presence of bighorn sheep. These contacts and discussions should be recorded in the official record.

If the release site or surrounding habitats include private lands, contact potentially affected landowners to discuss the issues outlined in the preceding sections. Summarize results in the official record.

After individual contacts are completed, schedule a meeting of all public land managers and private landowners/lessees who have an interest. Also invite members of the Domestic Sheep/Bighorn Sheep Interaction Working Group. If attendees support the transplant, proceed to the next step in the review process by contacting

sportsmen and conservation organizations. You should also plan media releases at this stage.

If concerns are expressed regarding the transplant, open houses or additional meetings can be scheduled to provide opportunities for additional public involvement. Locate meetings in the town nearest the transplant site and a larger, central location like Casper. Record all written and verbal comments in the public record. Forward copies of comments to Wildlife Division Administration, the Director's Office, and the Game and Fish Commission. If circumstances warrant, regional personnel involved with the transplant proposal can meet with Department Staff and/or the Commission to discuss the proposal further.

If the Commission approves the transplant, personnel should secure funding, establish a schedule, identify a source herd and acquire sheep, then complete the transplant operation. Encourage media coverage of release(s). Attach radio collars to as many released animals as feasible. Closely monitor the newly established herd post-release and lethally remove any bighorn sheep that comes in contact with domestic sheep, to prevent disease transmission.

2. Transport

   a. Rationale – Bighorn sheep transplants are expensive, labor-intensive operations to plan and carry out. Given the costs involved, it is prudent to enhance prospects for success by ensuring the sheep are transported with a minimum of stress and injury.

   b. Application – Four-horse or larger stock trailers are generally the most suitable equipment to transport bighorn sheep within Wyoming. However, a variety of other methods are also employed. Helicopters are sometimes used to transport sheep, especially from capture sites to staging areas and to inaccessible release areas. Depending on terrain at the release site, sheep can also be transported in boxes or crates mounted on pick-up trucks or flatbed railroad cars. Cover larger openings on trailers with plywood or other materials to minimize noise and other environmental stimuli. Attach panels in a manner that allows adequate ventilation when the trailer is stopped, but also affords shelter from wind, heat and extreme cold during transport. Separate ewe/lamb groups from rams either by installing dividers within a trailer, or by hauling these groups in different trailers. Trailers used to transport sheep should be low clearance to facilitate loading and unloading. Dispense wood chips, sawdust, or clean hay throughout the interior to provide traction and bed sites. Stock trailers maintained by most Department regions can be adapted to transport wildlife. Lander Region maintains a trailer (named the "Ewe Haul") that is specifically adapted to transport sheep.

   c. Analysis of Data – Refer to subsection VI. B. 1. c. (Marking).

   d. Disposition of Data – Refer to subsection VI. B. 1. d. (Marking).

3. Release

a. Rationale – When sheep are released into the wild or placed in a research facility, a paramount objective is to assure all animals safely leave the trailers, acclimate to their new environments, and experience the least possible stress and injury.

b. Application – Do not hold sheep any longer than is necessary. Upon arrival at the release site, assign personnel to assure the area is free of obstructing objects. Clear news media and other spectators from potential escape lanes. Move trailers or other transport equipment into position and release bighorns from confinement. If possible minimize noise and encourage spectators to leave the area as soon as possible so animals can adjust to their new environment. Always release animals during daylight hours.

c. Analysis of Data – Refer to subsection VI. B. 1. c. (Marking).

d. Disposition of Data – Refer to subsection VI. B. 1. c. (Marking).

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