THESIS

WINTER ECOLOGY OF BIGHORN SHEEP IN YELLOWSTONE NATIONAL PARK

Submitted by

John L. Oldemeyer

In partial fulfillment of the requirements
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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY John L. Oldemeyer

ENTITLED "Winter ecology of bighorn sheep in Yellowstone National Park"

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

Committee on Graduate Work

[redacted]

Major Professor

[redacted]

Head of Department

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[redacted]

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ABSTRACT

WINTER ECOLOGY OF BIGHORN SHEEP
IN YELLOWSTONE NATIONAL PARK

A bighorn sheep study was conducted on the northern winter range of Yellowstone National Park, Wyoming from June 1965 to June 1966. The objectives of the study were to census the bighorn population, map the winter bighorn distribution, determine plant composition and utilization on important bighorn winter ranges, observe daily feeding habits, and assess the effect of competition on bighorn sheep. Two hundred twenty nine bighorn sheep wintered on the northern winter range. These herds were located on Mt. Everts, along the Yellowstone River, on Specimen Ridge, and along Soda Butte Creek. The ewe to ram ratio was 100:78, the ewe to lamb ratio was 100:47, and the ewe to yearling ratio was 100:20. Range analysis was done on MacMinn Bench, Specimen Ridge, and Druid Peak. Range condition was best on Specimen Ridge and poorest on Druid Peak. Grass utilization varied from 50 per cent on MacMinn Bench to over 80 per cent on one key area on Druid Peak. Browse utilization was over 60 per cent throughout the winter range. Grasses made up 61.4, forbs 17.2, and shrubs 21.5 per cent of the bighorn's diet. The most important forage plants were bluebunch wheatgrass (Agropyron spicatum), Idaho fescue (Festuca idahoensis), phlox (Phlox sp.), Douglas rabbitbrush (Chrysothamnus viscidiflorus), and winterfat (Eurotia lanata). Competition between elk and bighorn sheep was mild during the study. Because of lighter than normal

snowfall, elk were not forced to occupy bighorn winter ranges. Competition with elk was greatest on Specimen Ridge, where over 200 elk spent most of the winter.

John L. Oldemeyer
Department of Fishery and
Wildlife Biology
Colorado State University
Fort Collins, Colorado
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My wife, Carole, patiently typed and read the manuscript and recorded range composition data for me in the field. Her patient understanding and encouragement and enjoyment of life in Yellowstone National Park added much extra pleasure and satisfaction to the study.

FRONTISPIECE

"Scarface"

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Chapter I

INTRODUCTION

Little has been done in Yellowstone National Park to manage Rocky Mountain bighorn sheep (Ovis canadensis canadensis) since the studies during the late 1930's and early 1940's by Mills (1937) and Gammill (1941). Therefore, little is known today about bighorn sheep ecology in Yellowstone. After the elk (Cervus canadensis nelsoni) reductions of 1962-63 in the Park, biologists felt that knowledge was needed about other ungulates in Yellowstone, especially the bighorn sheep. It was hoped that a bighorn study conducted as soon as possible after the reduction of elk and a similar study some time later would indicate changes in ecological conditions relative to bighorn sheep in Yellowstone National Park. Future improvement of conditions for bighorns also could result from findings of this initial study.

Many factors of bighorn ecology were available for study; however, objectives were limited to five. These were: 1) census the bighorn sheep population in the northern part of Yellowstone National Park to determine the size of the population and the sex and age ratios, 2) map the winter distribution of bighorn sheep in the northern part of Yellowstone National Park, 3) determine the plant composition on key bighorn wintering areas and the utilization of certain key grass and browse species on those areas, 4) observe the daily feeding habits and activity patterns of the bighorn sheep on their winter ranges, and 5) observe the effect of competitive forces on bighorn winter ranges and assess the effect of competition on the bighorn sheep.

Most of the field research took place from October 1965 to June 1966. However, portions of the summer preceeding that period were spent

obtaining information about the range composition and summer distribution of bighorn sheep.

The first written record of bighorn sheep in Yellowstone is probably that of Osborne Russell, "...these stupendous rocks, whose surface is formed into irregular benches rising one above the other from the vale to the snow, dotted here and there with low pines and covered with green herbages intermingled with flower with the scattered flocks of Sheep and Elk carelessly feeding or thoughtfully reposing beneath the shade..." (Haines, 1955, p. 63). This scene probably occurred in the Hoodoo Basin on the east border of the Park. Before Russell's travels in what was to be Yellowstone National Park, the Sheepeater Indians made considerable use of bighorn sheep. The Sheepeater Indians took their name from bighorn sheep which were plentiful in the Indian's surroundings and which furnished the tribe its chief source of food (Frost, 1941). In Yellowstone, the Sheepeaters lived on Specimen Ridge above Crystal Creek and at the confluence of Lava Creek and the Gardiner River. These two areas are both near high bighorn sheep population centers today.

The 1877 Annual Report of the Superintendent (p. 842) mentioned that in no other part of the west was there such an abundance of elk, moose, and mountain sheep as in Yellowstone. He also reported that hundreds of thousands of hides of bighorn sheep, elk, and antelope were removed between 1870 and 1875. However, Rush (1932) thought that game animals were scarce in the Park until the mid 1870's. A. Bart Henderson prospected in the upper Lamar River area in the early 1870's. In his journal (p. 55) he remarked that near the head of the Lamar River, he saw "Mountains covered with sheep." In his trips down the Yellowstone

River from its confluence with the Lamar, he mentioned killing bighorn sheep for food.

Rush (1932) reported bighorns to be abundant along Mt. Norris in 1881. Mills (1937) wrote that in 1887, sheep were found in all mountain ranges of the Park. Even at that early date, bighorns were becoming accustomed to man near Coal Mine Flats, and the Superintendent's Annual Report (1887, p. 13) noted that they were not too wild.

During the early 1900's all game animals were fed hay to keep them through the winter. This was continued through 1918. In 1913, two sheep were killed because of disease presumed to be sheep scab (Superintendent's Annual Report, 1913, p. 13). Disease again took its toll in 1928 when 31 bighorns were found dead of scabies and lungworm infections (Superintendent's Annual Report, 1928, p. 12). The population was down in 1928 to 170 from 346 bighorns counted the previous year. However, it was estimated that there were 500 bighorn sheep in the Park at that time. In 1929, only 77 bighorns were counted. I assume the population was heavily reduced by disease.

Gammill (1941) estimated that the average number of bighorn sheep in the Park from 1903 on was about 200. Table 1 shows estimates of bighorn numbers from 1903 to 1955.

Buechner's (1960) 1955 aerial census of sheep in the Park resulted in 192 bighorns counted. He also reported that winter ranges in northern Yellowstone were seriously depleted and that severe winter overgrazing by elk might be the limiting factor on bighorn sheep populations.

Park Biologists have taken several steps to promote the welfare of bighorns in Yellowstone. These steps are: 1) bighorn sheep losses from

Table 1. Number of bighorn sheep in northern Yellowstone National Park, 1903-1955 (Mills, 1937; Superintendent Yellowstone National Park Annual Reports; Buechner, 1960)

Year	Number	Year	Number
1903[1]	100	1933	82
1905	100	1934	125
1907	200	1935	126
1911	250	1936	118
1912	210	1937	175
1916[2]	200	1938	200
1922	233	1939	228
1923	200	1940	272
1924	217	1941	200
1925	195	1942	139
1926[3]	215	1943	138
1927	346	1945	206
1928	170	1946	176
1929	77	1948	176
1930	125	1949	144
1931	101	1953	170
1932	79	1955	192

[1]Number based on estimates, 1903-1916
[2]Number based on partial counts, 1922-1926
[3]Number based on actual counts, 1927-1955

hunting inside the Park have been eliminated; 2) bighorn sheep hunting outside the Park is more closely regulated; and 3) effective steps have been taken to maintain ungulate populations in the Park within the carrying capacity of the range (U.S. National Park Service, 1964).

Chapter II

PHYSICAL DESCRIPTIONS

Rocky Mountain Bighorn Sheep

A most impressive feature of the Rocky Mountain bighorn ram is its massive, curled horns. The ram's horns are characterized by a flat spiral curl, heavy base and slow taper (Cowan, 1940). They are deeply corrugated on the dorsal surface and the points usually are battered and broken (Whitney, et al, 1904). The ram has the largest and heaviest horns of any North American wild sheep. The ewe has short, upright, slightly curved horns.

The horns are a dark amber brown color. Horn growth is rapid for three or four years; then the annual increment becomes progressively less until the animal is eight or ten years of age. Food shortage during January or February is a likely cause for the sulcus which occurs with each year's horn growth (Wishart, 1958).

The Rocky Mountain bighorn is a large sheep of square build and short legs. It has a short tail, tapered muzzle and the front hooves are larger than the hind (Wishart, 1958). Honess and Frost (1942) noted that there is a wide cleavage between the two digits and a hard rim around the outer edge of the hoof. These features apparently enable the animal to move with greater sureness over steep, rugged terrain. Moser (1962) listed the mature bighorn ram as weighing between 200 and 300 pounds, and standing 41 inches at the shoulder. The mature ewe is smaller, stands about 35 inches at the shoulder, and weighs from 125 to 175 pounds.

Cowan (1940) described the color of the Rocky Mountain bighorn as wood brown. In the late summer the upper parts are blackish- to greyish-brown with a somewhat darker neck, throat and back. The outside of the legs and lower flanks are paler than the back, the rump patch is creamy-white, the tail is black, and the face is usually lighter than the body. The belly is whitish-yellow, and the legs and chest are nearly the same color. The mammae are sparsely haired and the underside of the tail is bare. Rams are slightly darker than ewes, and the color of the winter coat is much lighter than the late summer and fall coat (Honess and Frost, 1942).

The pelage of the adult bighorn contains a loose inner layer of wool and a dense outer layer of coarse guard hairs. The coat is shed each year in the spring about mid-May (Ogren, 1954; Wishart, 1958). Lambs are creamy white until the first shedding, and there is no distinctive rump patch. After shedding, the color is darker and a conspicuous rump patch is present.

Biotic Communities

The greater part of Yellowstone National Park is a high plateau lying approximately 8,000 feet above sea level. Many peaks rise to the Alpine Zone, and several rivers cut down into the Transition Zone from this plateau. The nearly rectangular park lies in the northwest corner of Wyoming with narrow strips overlapping into Montana and Idaho.

Four life zones occur in Yellowstone National Park. During the winter, bighorn sheep were observed most often in the Transition Zone. The Canadian Zone was occupied by the bighorns primarily during the

late fall and late spring when they were moving between summer and winter range. The Hudsonian and Arctic-Alpine Zones were occupied during the summer.

Transition Zone

The largest portion of the Transition Zone in the Park occurs in the valleys of the Gardiner, Lamar, and Yellowstone Rivers. It occurs up to 7,500 feet on southern exposures and 6,500 feet on northern exposures.

This zone is treeless except along the rivers where a narrow band of Douglas-fir (Pseudotsuga menziesii), Rocky Mountain juniper (Juniperus scopulorum), narrow-leaved cottonwood (Populus angustifolia), willow (Salix sp.), birch (Betula sp.), and alder (Alnus sp.) occur. In the open areas big sagebrush (Artemisia tridentata), balsam root (Balsamorrhiza sagittata), lupine (Lupinus sp.), larkspur (Delphinium sp.), penstemon (Penstemon sp.), geranium (Geranium sp.), Indian paintbrush (Castilleja sp.), bitterroot (Lewisia sp.), cinquefoil (Potentilla sp.), and wind flower (Anemone sp.) grow (Bailey, 1930).

Characteristic animals in this zone are the pronghorn (Antilocapra americana), Uinta ground squirrel (Citellus armatus), bushy-tailed woodrat (Neotoma cinerea), white-tailed jack rabbit (Lepus townsendia), northern skunk (Mephitis mephitis), Lewis' woodpecker (Asyndesmus lewis), kingbird (Tyrannus sp.), common crow (Corvus brachyrhynchos), Brewer's blackbird (Euphagus cyanocephalus), vesper sparrow (Pooecetes gramineus), western warbling vireo (Vireo gilvus), and sage thrasher (Oreoscoptes montanus) (Bailey, 1930). This zone has less severe winters than the rest of the higher zones in the Park. In normal winters, bison (Bison

bison), elk (Cervus canadensis), and mule deer (Odocoileus hemionus) winter in the zone along with the bighorn sheep.

Canadian Zone

The plateau level of the Park lies in the Canadian Zone at the middle elevations of 7,500 feet to 9,000 feet on the south facing exposure and 6,500 feet to 8,000 feet on the north facing exposure. Lodgepole pine (Pinus contorta) is the dominant tree and covers nearly three-fourths of the total Park area (McDougall and Baggley, 1956). Other important trees in this zone are Engelmann spruce (Picea engelmanni), subalpine fir (Abies lasiocarpa), and aspen (Populus tremuloides).

Moose (Alces alces), mule deer, elk, pine squirrel (Tamiasciurus fremonti), golden-mantled ground squirrel (Citellus lateralis), yellow-bellied marmot (Marmota flaviventris), porcupine (Erethizon dorsatum), snowshoe hare (Lepus americana), marten (Martes americana), wolverine (Gulo luscus), grizzly bear (Ursus horribilis), and black bear (Ursus americanus) are all characteristic mammals of the zone. Characteristic birds are spruce grouse (Canachites canadensis), blue grouse (Dendragapus obscurus), three-toed woodpecker (Picoides tridactylus), Clark's nutcracker (Nucifraga columbiana), pine grosbeak (Pinicola enucleator), pine siskin (Spinus pinus), Audubon's warbler (Dendroica auduboni), and mountain chickadee (Parus gambeli) (Bailey, 1930).

Hudsonian Zone

The Hudsonian Zone lies at the elevational range of 9,000 feet to 10,000 feet on the warmer south facing exposures and 8,000 feet to

9,000 feet on the colder north facing exposures. It is largely composed of steep, rocky slopes and broad, open areas where bighorn sheep and elk find summer range.

Scrubby, white-barked pine (Pinus albicaulis), Engelmann spruce and subalpine fir occur in scattered patches. Dwarf willows and current (Ribes sp.) make up the shrubs. The flowering plants include lupine, dwarf phlox (Phlox sp.), larkspur, low forget-me-not (Myosotis alpeotris), and Jacob's ladder (Polemonium foliosissimum).

Most of the mammals in this zone extend up from the Canadian Zone in distribution. The birds are summer visitors and those typical of the zone are alpine three-toed woodpecker, junco (Junco sp.), Clark's nutcracker, and white-crowned sparrow (Zonotrichia leucophrys) (Bailey, 1930).

Arctic-Alpine Zone

The Arctic-Alpine Zone is found above the Hudsonian Zone and is treeless. Some of the permanent snow fields are on the verge of being glacial formations because of their depth and hardness. The main shrub is dwarf willow. Buttercup (Ranunculus sp.), forget-me-not, cinquefoil, and western yarrow (Achillea lanulosa) color the hillsides. The black rosy finch (Leucosticte atrata) breeds on the rocky slopes (Bailey, 1930).

Geology and Mountain Systems

The first fossils found abundantly in Yellowstone are dated back as far as the Paleozoic Era. The Mesozoic Era is represented by shales and sandstone such as those forming Mt. Everts. The latter part of this era brought the initial uplifting which was to form the Rocky Mountains.

The great geological events which helped form the Yellowstone National Park of today occurred during the Cenozoic Era. During the early part of this era there were many cycles of active volcanism and quiet. Numerous volcanos were located in, and formed, the Absoraka Mountains on the eastern border of the Park. Mt. Washburn also was an active volcano during this time. Rivers and streams flowed during the quiet periods. Growth, burial by volcanic debris, petrification and preservation of forests occurred over and over again. The fossil forests on Specimen Ridge contain evidence of twenty different forests.

Approximately 15 million years ago, volcanos again became active. With the cooling of this last active volcanism, hot springs and geysers became a part of the environment in Yellowstone (Bauer, 1948).

The Pleistocene Ice Age undoubtedly covered the vast part of Yellowstone National Park (Alden, 1928). It glaciated the Park during three periods--early, mid, and late Pleistocene. Either the plateau itself was a place of ice accumulation or the ice from the Absoraka and Snowy Mountains was confluent at its maximum stages and extended southwestward covering the great plateau.

The vast flow of ice from the northern half of the Absorakas advanced down the Yellowstone Valley from Junction Butte overrunning the site of Gardiner. The ice flow was joined by ice from the Gallatin Range. A well marked terminal moraine is crossed by the Cooke City road in the lower valley of the Lamar River near Junction Butte.

The Absoraka Mountains border the Park on the east. Many peaks in the system rise to above 10,000 feet in elevation. One of the best known mountains in Yellowstone National Park is Mt. Washburn, the tallest mountain in the Washburn range, which lies between the Gardiner River

and the Yellowstone River. The Gallatin Range lies in the northwest corner of the Park. Electric Peak in that range is the highest mountain in Yellowstone National Park at 10,992 feet elevation.

Climate

The northern arid region of the West influences the climate of the Park. It is modified by high altitude and mountainous topography. The Park is more humid than lower surrounding country and the extremes of heat and cold are less pronounced (Chittenden, 1924).

Temperatures during the summer seldom reach the nineties, and the average maximum temperatures are in the high seventies during July. Summer night temperatures are cool and usually drop into the thirties before sunrise. Winters are cold and temperatures are below freezing most of the time. January is usually the coldest month and has a monthly average of 12F. Temperatures frequently are below zero and the coldest temperature recorded on the study area was -58F in 1943. There are occasional mild periods in the winter when the daytime temperatures reach into the forties (U.S. Weather Bureau, 1960). The minimum temperature during the study was -13F at Tower Fall Ranger Station. The winter before the study, the minimum temperature was -49F at Lamar Ranger Station.

Precipitation in the study area generally is low. The yearly average at the Lamar Ranger Station is 13.73 inches. This is the lowest in the Park. Snowfall is heavy in the mountains. Annual snowfall between 7,000 feet and 8,500 feet averages nearly 150 inches, while in the valleys, such as at Lamar and Tower Fall Ranger Stations, snowfall averages between 85 and 96 inches annually (U.S. Weather

Table 2. Lamar Ranger Station weather summary and snowfall at Tower Fall Ranger Station, 1964-1966

Month	Mean Temperature				Precipitation				Monthly Snowfall			
	38 Year Mean	1964	1965	1966	38 Year Mean	1964	1965	1966	38 Year Mean	1964	1965	1966
	Degrees				Inches				Inches			
January	12.1	9.9	16.9	16.0	1.03	1.04	1.67	0.38	17.1		38	15
February	17.3	10.5	*	15.1	0.86	0.77	0.27	0.27	12.2		12	13
March	23.5	17.8	12.9	23.9	1.02	1.17	0.24	0.28	14.9		8	4***
April	35.2	34.3	36.6	34.1	1.11	0.50	1.00	1.13	7.7		9	6
May	44.9	44.2	42.4	46.3	1.72	1.47	0.70	1.14	2.5		6	7
June	51.5	48.6	51.2		2.17	3.86	2.02		0.8			
July	58.2	59.0	56.4		1.39	0.87	1.81					
August	56.0	53.2	54.4		1.48	1.28	2.16					
September	48.2	46.4	*		1.27	0.27	2.36		2.1			
October	38.7	39.1	*		1.06	1.22	0.44		5.2	*		
November	43.3	27.5	*		0.95	1.22	0.42		11.4	18**	4	
December	15.1	15.2	18.9		0.92	1.30	0.75		13.0	20	26	
Year	35.4				14.98	15.02	13.84		87.0			

*Unavailable
**Total on November 7-30
***Total of March 14-31

Bureau, 1960). Table 2 shows weather data for the study area. It is readily apparent that snowfall during the fall and early winter of 1964-65 was heavier than in 1965-66 which was the winter of this study. A comparison of the maximum snow depths at Tower Fall Ranger Station shows that in January of 1965 there were 34 inches of snow on the ground, but in December of 1965 there only were 14 inches. Later, in April of 1965 there were 26 inches compared to 5 inches in April 1966. During the period from November 1964 through January 1965, 76 inches of snow fell at Tower Fall while during the same period of this study only 45 inches fell. In November 1964 near record snowfalls occurred in the northern part of Wyoming. These snowfalls undoubtedly led to the deep snow accumulations of that winter. Total snowfall during the study was slightly more than 77 inches while total snowfall the preceeding winter was over 111 inches.

The Study Area

The study area was in the northern fifth of Yellowstone National Park and was bordered on the north and east by the northern and eastern Park boundaries respectively. The western and southern borders were not as clearly defined. The southern border extended as far south as Mt. Washburn in the summer, but $44^{\circ}50'$ north latitude was the southern border in the winter. The western border was a diagonal line from Reese Creek to where the southern border crosses the Dunraven Pass road (Figure 1).

In general, the major rivers in the northern part of the Park flowed through the study area. These drainages are: Pebble Creek, Soda Butte Creek, Lamar River, Yellowstone River, and Gardner River.

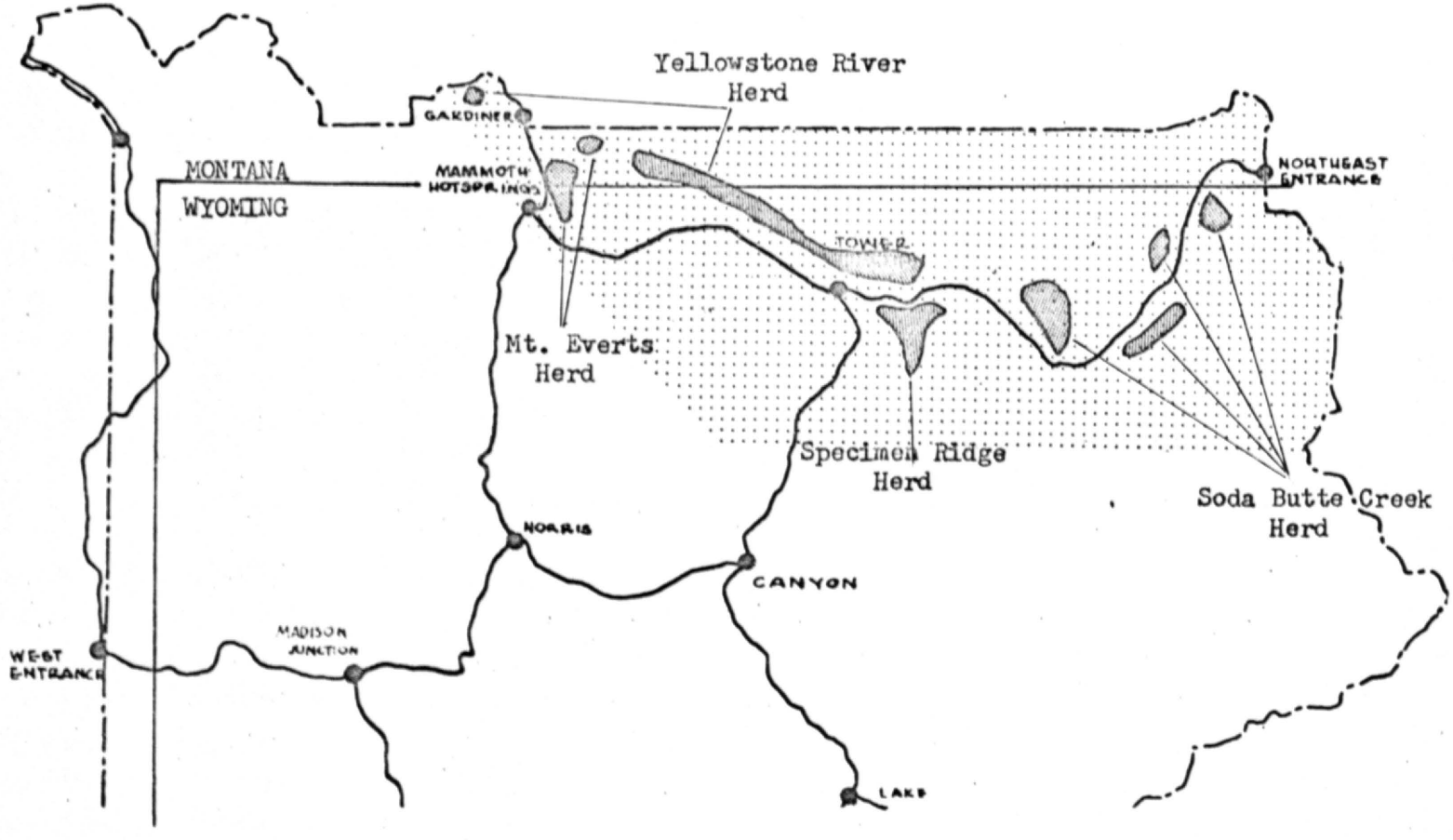

Figure 1. Northern part of Yellowstone National Park showing study area (dotted area) and winter distribution (dark hatching area) of bighorn sheep, 1965-66.

Soda Butte Creek and the Lamar River are the primary drainages in the eastern part of the bighorn study area. The Lamar River rises nearly due east of Yellowstone Lake outlet and flows northwesterly until it joins Soda Butte Creek, its major tributary, near Soda Butte. It then flows westerly and joins the Yellowstone River near Junction Butte. The Yellowstone River flows in a northerly direction from Yellowstone Lake. At its junction with the Lamar River it turns and flows west. The Gardner River, which drains the area between the Gallatin and Washburn Mountains, joins the Yellowstone River near Gardiner, Montana and is the second largest tributary to the Yellowstone in the Park (Chittenden, 1964).

Range Study Sites

During the summer of 1965, I selected three areas for range study plots. These three areas were MacMinn Bench, Specimen Ridge, and Druid Peak. Two sites were selected on each area for sampling vegetation. The sites were chosen for uniformity of vegetation, nearness to bighorn escape habitat, and previous sightings of bighorn sheep on the sites. The bighorn sightings were made during the April 1965 helicopter census of the bighorn population.

Eagle's Nest Rock

The lowest site was located near Eagle's Nest Rock on MacMinn Bench at an elevation of approximately 5,900 feet. The site was north facing and had an eight degree slope. It was located immediately adjacent to steep cliffs, and sheep beds were located at the edge of the cliffs.

MacMinn South Slope

A south facing slope on a ridge leading from MacMinn Bench to the cliffs of Mt. Everts was the second site chosen on MacMinn Bench. This slope, which faced S55W, had a 12 degree slope, and was 6,000 feet in elevation. This site was the one farthest away from escape habitat of all sites. Pronghorn and mule deer were seen on the site during the early spring and year-old elk droppings were abundant.

Quartz Creek

A range study plot was located on Specimen Ridge near Quartz Creek. Elevation of the site was approximately 7,400 feet, and it faced S45W. It had an 18 degree slope and was bounded on the south, southwest, and west by cliffs or very steep terrain. Sheep used this site in conjunction with cliffs and winter range between Quartz and Agate Creeks.

Crystal Creek

A higher site was located on Specimen Ridge near cliffs west of Crystal Creek. The site had a 21 degree slope, faced S10E, and was at an elevation of approximately 7,800 feet. During the study, bighorns and elk often were observed feeding near each other on this site.

Druid South Slope

The south facing slope of a prominent knob on the eastern most ridge leading to Druid Peak was the lower site on Druid. The elevation was approximately 8,300 feet. This site faced due south and had a slope of 26 degrees. Abundant sign of bighorn occupation occurred on the ridge leading up to this site.

Druid Ridge

The highest site was located on the same south facing ridge as the Druid South Slope site, at an elevation of 8,500 feet. This site faced S25E and had a four degree slope. The site was longer and narrower than any of the other sites; therefore, fewer and longer transects were used in sampling.

During October 1965 two additional sites were sampled for range utilization. One of these sites was on top of a northwest facing ridge on MacMinn Bench, and the other was on a low ridge leading to Specimen Ridge and bordering the Yellowstone River across from Tower Fall. In May 1966 two additional sites were sampled for utilization. One was located on the Druid Peak ridge on a southwest facing slope at approximately 7,800 feet elevation. The other was located near the Coal Mine on MacMinn Bench. These four additional sites were selected to give information which could not be obtained from the original sites.

Chapter III

METHODS AND MATERIALS

Observation from the ground was the primary method of obtaining data. The field forms that were used are shown in Appendices A-E. Since a primary concern was a census of the bighorn population, a Bausch and Lomb Balscope 20-60X and 7X35 binoculars were used extensively for locating and observing bighorns. The location and number of rams, ewes, yearlings, and lambs were recorded for all sightings of sheep (Appendix A). The total number of bighorns in each group was recorded as well as the sex and age (lamb, yearling, adult) of each animal. Snow depth on north and south slopes and in the immediate vicinity of the herd groups was recorded to the nearest inch. Observations of food habits, which are discussed later in this chapter, were recorded on the form and on a Supplemental Food Habits Form (Appendix B). Elk, pronghorn, mule deer, and bison were recorded as competitors when they occurred in the vicinity of bighorn sheep, and they were classified as to their proximity to bighorns.

An additional form, the Bighorn Habitat Observation Form (Appendix C), was used to record the following: time of observation, weather, terrain, exposure, closeness to escape terrain, activity, group size, and type of group (ewe, ram, or mixed).

The Cooke City road ran through the study area and many helpful observations were made from the car. However, most observations were made while I was in bighorn habitat. Snowshoes were used to traverse deep snow.

Observations by Helicopter

Helicopters were used several times during the study. In April 1965, a bighorn census on the northern winter range was conducted by the Park Service in conjunction with an elk census. All observers working in the elk census recorded the location and number of bighorn sheep observed. In addition, one day was devoted to finding bighorn sheep in areas not covered during the elk census. This included most of the northeastern part of the Park. The discussion of distribution and census covers the results of the April census.

During the winter of 1965-66 I used helicopters to help locate bighorns on the Yellowstone River from Slough Creek to Gardiner. Two helicopters, one flying near the river and one higher on the slope, flew along the northern side of the river, and the location and number of bighorns were recorded.

Plant Composition

A range composition sample was needed to discover what plants occurred on the bighorn winter range and the per cent of occurrence of each species in the total plant composition. Density was determined for the less dominant species, and frequency of occurrence was determined for all species occurring in the sample.

Five, temporary, parallel transects were established on each of the six winter range sites separated by predetermined, random distances. Two methods were used to sample vegetation; they were the point-step method, and 2X5 decimeter quadrats. For sampling by the point-step method, one hundred points were located on each transect at one pace intervals. A total of 500 points were sampled. At each pace a number 9

knitting needle was placed in a notch in the toe of my boot and pushed toward the ground. Any object touched at ground level was recorded in one of the following categories: plant (species), litter, erosion pavement, rock, moss, or bare ground. A plant species was recorded only when the pin hit the basal stems of forbs and shrubs. When the point hit within the living, basal portion of bunchgrasses, the species was recorded (Appendix D). Evans and Love (1957) thought that 300-500 points were sufficient to encompass the variability in a site in which the vegetation is essentially of one type. They also thought that point-step sampling was rapid, accurate and objective in sampling botanical composition.

At every tenth point along the transects, a 2X5 decimeter quadrat was placed on the ground. Within the quadrat I counted and recorded the number of plants of each genus which occurred, except the abundant bunchgrasses which were marked as absent or present (Appendix E). According to Daubenmire (1959) 40 to 50 plots produced closely reproducible results. A total of 50 plots were sampled.

Range Utilization

According to Gammill (1941) grasses made up most of the winter diet of bighorn sheep in Yellowstone. Grass utilization was determined on the original six winter range sites and on four other sites. Two of the latter four were selected in spring 1966 after I had observed the distribution of the bighorns during the winter. The other two sites were sampled in the fall with the original six sites. Three grasses were sampled on eight sites and two grasses on the two spring sites. The grasses sampled were those most abundant on each site. Two sampling

methods were used. These were height-weight relationships as shown in the Region 1 gauge and the grazed plant method. These two methods are described in the 1963 Forest Service Range Analysis Handbook and by Cole (1958). The Region 1 gauge uses height-weight tables to estimate utilization. The grazed plant method is based on the relationship between per cent of the plant height grazed and per cent weight used. It is suitable only for species for which utilization curves are developed. The measurements needed are: ungrazed plant heights, per cent of plants with seed heads (spiked plants) and without (spikeless plants), stubble heights, and per cent of grazed plants. Measurements of plants on the elk winter range by Biologist William Barmore and myself were compiled to determine a desirable sample size. I found that 50 measurements were adequate in most cases to obtain less than a 10 per cent error of the mean height at the 95 per cent confidence level. Therefore, 50 heights each were obtained on the ungrazed spiked and spikeless plants and on grazed plants. Where the per cent of spiked plants and grazed plants was less than 10 per cent, 50 plants were not always measured because of the difficulty of finding enough plants. One hundred plants were sampled to determine the per cent spiked plants and per cent of grazed plants. Two paced transects were run on each site. Twenty-five height measurements were made and 50 plants were examined for spikes and grazing on each transect.

On eight of the sites, ungrazed plant heights and per cent of spiked plant measurements were taken before grazing in October. The other measurements were taken in May after most of the bighorns had begun to move toward the summer range.

Two browse plants were important bighorn sheep food items. Winterfat (Eurotia lanata) was heavily browsed on MacMinn Bench and Douglas rabbitbrush (Chrysothamnus viscidiflorus) was browsed on the rest of the range. On all sites at which grass utilization was measured, browse utilization was estimated. On MacMinn Bench winterfat utilization was estimated and on all others, rabbitbrush utilization was estimated. Fifty plants per site were examined on two transects. The per cent of twigs that were browsed was recorded.

Pellet Group Count

To determine animal use I counted ungulate pellet groups on each site and classified them as to species. On MacMinn Bench pronghorn, mule deer, and bighorn sheep used the same areas, and the pellet groups of the three species were lumped because I could not accurately distinguish between the three. Five, 87.1 foot long transects were laid out with a steel tape on each site. Pellet groups were counted within a five foot wide strip on each side of the tape. The total area sampled per site was 1/10 acre.

Food Habits

Food habits data were obtained by examination of bighorn feeding sites. After a fresh snow I located areas in which sheep had been grazing and identified each freshly grazed plant in the area. Sugden (1961) thought that this method gave a good picture of the bighorn's diet. Each grazed or browsed plant was counted as an observation. While this method is rapid, it gives best results only when there is fresh snow, and it provides no quantitative data for the volume of each forage

species eaten. Only the frequency of grazing each species is determined, and this may provide an indication of the bighorn's preference for certain plant species.

Chapter IV

POPULATION AND DISTRIBUTION

Summer

Approximately three weeks were spent during the summer of 1965 attempting to locate bighorns on the summer range. Most of the bighorns were found in the Hudsonian or Arctic-Alpine Zones of the mountains in the northeast part of the Park.

Several observations were made on areas that are not considered typical bighorn sheep summer range. A group of ten ewes, lambs, yearlings, and young rams spent the summer on Mt. Everts which is at an elevation of 7,800 feet. Except for the open grassy ridges on top of Mt. Everts, this area is steep, rocky terrain with open Douglas-fir overstory. The groups on Sepulcher Mountain, Hellroaring Mountain and Fossil Forest Ridge inhabited similar terrain to those on Mt. Everts. Smith (1954) reported that some bighorns on the Salmon River in Idaho inhabited open timber types at low elevations.

Considerable bighorn summer range occurs in the high mountains on the east border of the Park; however, no bighorns were observed or reported south of Cache Mountain. Mr. Hal Prostka, U.S. Geological Survey, who accompanied me on several overnight trips, flew over the high mountains in that area by helicopter and reported that he did not see any bighorn sheep south of Cache Mountain.

I observed a total of 138 individual bighorns on the summer range. Table 3 shows locations and number of bighorns on the summer range.

Table 3. Observations of bighorn sheep on the Yellowstone National Park summer range, 1965

Location	Rams	Ewes	Yearlings	Lambs	Unclassified	Total
Abiathar Peak					3	3
Barronette Peak	1	5		2		8
Cache Mountain					5	5
Chalcedony Creek	2	2		2		6
Cutoff Mountain		2			18	20
Fossil Forest Ridge	1	3	1	3		8
Hellroaring Mountain		3		1		4
Mt. Everts	4	2	1	3		10
Mt. Hornaday	2	17		3	2	24
Mt. Washburn	1	11		4		16
Sepulcher Mountain		2		1		3
The Thunderer	22	5		4		31
Total	33	52	2	23	26	138

Winter

Bighorn sheep on the northern winter range were divided into four herds. The habitat occupied by each herd was characteristic of the herd and was distinct from the others. The four herds were the Mt. Everts, Yellowstone River, Specimen Ridge, and Soda Butte Creek herds. The winter bighorn distribution is shown in Figure 1. Population numbers are shown in Table 4. A total of 229 individual bighorn sheep were located on the winter range. On Druid Peak and Abiathar Peak sheep were not recorded for fear of duplication. Probably some more occurred there than were recorded. Certainly there were areas that were not observed that may have contained bighorn groups. However, I believe that the total number of bighorn sheep on the northern winter range was not more than 275 and probably was nearer 260.

Table 4. Location and numbers of bighorn sheep on northern Yellowstone winter ranges, 1965 and 1966

Location	Total 1965	Total 1966	Rams	Ewes	Yearlings	Lambs	Unclassified
Mt. Everts	48	50	16	20	4	10	
Mt. Everts		6	6				
MacMinn Bench		34	6	17	3	8	
Rattlesnake Butte		10	4	3	1	2	
Yellowstone River	48	49	13	16	3	6	
Reese Creek	6	5	3	1		1	
Deckard Flats	9	8					8[1]
Crevice Creek	6	7	5	2			
Cottonwood Creek	9	11	5	2		1	3
Hellroaring Creek	13						
Slough Creek	5	18		11	3	4	
Specimen Ridge	34	48	14	17	5	12	
Lower Specimen Ridge		11	1	4	2	4	
Crystal Creek		28	9	8	3	8	
Quartz Creek		9	4	5			
Soda Butte Creek	92	84	26	36	6	14	
Druid Peak	36	30	8	16	2	4	
Mt. Norris	20	24	14	5	2	3	
Barronette Peak	11	12	1	6	1	4	
Abiathar Peak	25	16	3	9	1	3	
Total	222	229	69	89	18	42	11

[1] ewes and lambs

Mt. Everts Herd

The Mt. Everts herd occupied three general areas during the winter. During the breeding season and for most of the winter, the majority of the sheep stayed on MacMinn Bench. The three-quarters square mile area of grassland on MacMinn Bench offered the large groups of sheep ample, available forage (See Figures 2 and 3).

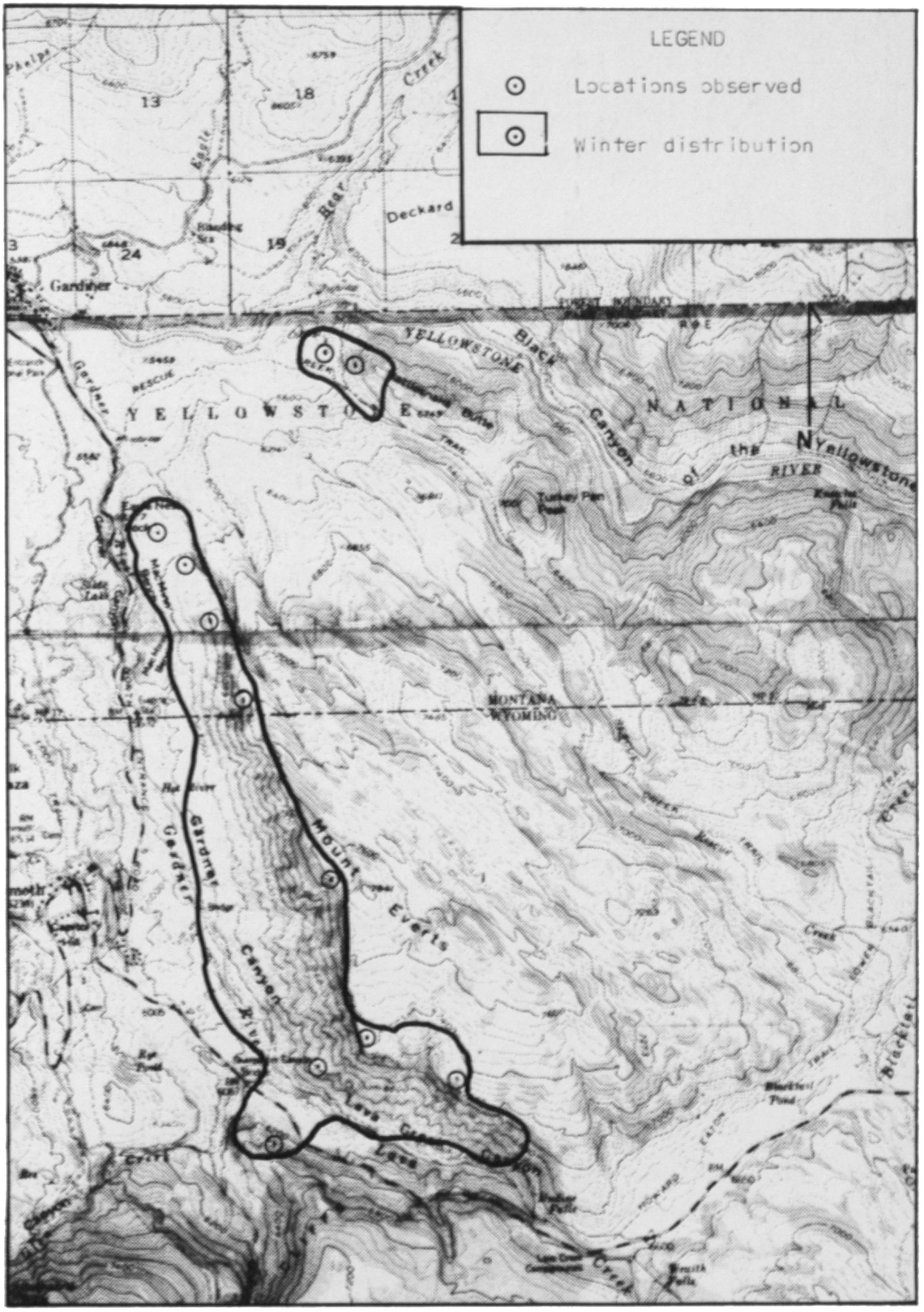

Figure 2. Distribution of bighorn sheep on Mt. Everts, Yellowstone National Park, 1965-1966.

Figure 3. Typical winter range of the Mt. Everts bighorn sheep herd, Yellowstone National Park.

Figure 4. Typical winter range of the Yellowstone River bighorn sheep herd, Yellowstone National Park.

Up to ten bighorns spent much of the winter on the west side of Rattlesnake Butte. During late December several large rams mingled with the ewes on Rattlesnake Butte, but for the most of the winter this was a ewe group.

On January 25, I observed two mature rams on the long ridges running from Mt. Everts to the Gardiner River near Sheepeater Bridge. After the breeding season these large mature rams moved from MacMinn Bench to Mt. Everts for the remainder of the winter. Small groups were regularly observed on top of Mt. Everts near the edge of the cliffs. However, the snow cover on the top was greater than on the ridges and on MacMinn Bench which were as much as 1,500 feet lower in elevation.

When Buechner (1960) censused the bighorn population in 1955 he counted 33 bighorns on Mt. Everts compared to 50 during this study. In 1940, Gammill (1941) counted 103 sheep on Mt. Everts. Perhaps the severity of the winter has something to do with the number of sheep in this herd. However, the number of sheep in 1965 did not differ greatly from 1966, and the 1965 winter was much more severe.

The bighorns in the MacMinn Bench group have long been famous for their lack of apparent fear of humans and the ease of which they are photographed. Perhaps because of their lack of fear, they often were observed far from cliffs and steep terrain offering escape cover. There was no forest canopy on most of the Mt. Everts sheep habitat.

Yellowstone River Herd

The Yellowstone River herd was dispersed over a long, narrow strip of river. The Reese Creek bighorn group, though several miles below the Deckard Flats group, occupied habitat similar to the rest of the

herd. It probably did not mix with the rest of the herd. The group of sheep farthest up the river was near Slough Creek approximately 24 miles east of Reese Creek (See Figures 4-8).

Except for small areas of open grassland at Crevice Creek, Cottonwood Creek, and Deckard Flats, the bighorn habitat was composed of open sagebrush-grassland near rock outcrops or open Douglas-fir on steep south facing slopes. Forty nine sheep wintered in six groups along the river. During the 1965 aerial census, the area was very thoroughly observed using helicopters, and 48 bighorns were counted. However, in 1955, Buechner (1960) counted 74 sheep along the river in an area much the same as that occupied by the Yellowstone River herd.

The bighorn group at Reese Creek was located at the lowest elevation of any group in the Park. This was 6,328 feet. It was one of the few wintering groups to move outside the Park. Sheep summering in the Electric Peak area probably move to Reese Creek and farther north out of the Park as far as Devils Slide.

The groups from Deckard Flats to Slough Creek very likely exchanged members with the adjacent group. However, I doubt if a bighorn starting the winter at Deckard Flats ever finished the winter as far away as Slough Creek.

From Reese Creek to Deckard Flats the bighorn habitat was composed primarily of dense, sagebrush-grassland near rock outcrops. The terrain from Deckard Flats to Hellroaring Creek is steep, rugged terrain with a south exposure and open Douglas-fir canopy. The eighteen bighorns between Little Buffalo Creek and Slough Creek occupied three ridges. All three areas were characterized by sagebrush slopes adjacent to rugged, rocky southwest facing terrain.

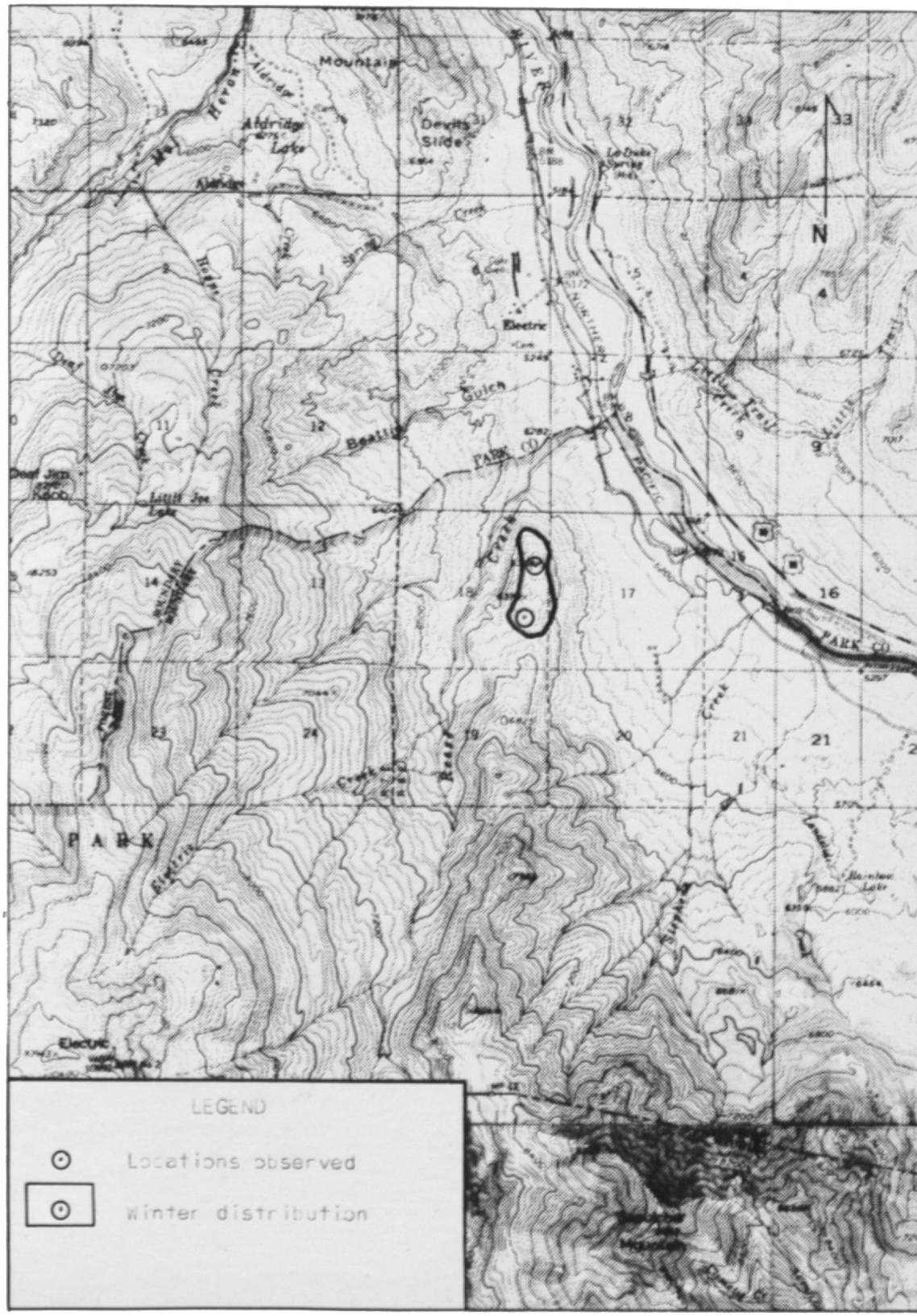

Figure 5. Distribution of bighorn sheep on Reese Creek, Yellowstone National Park, 1965-1966.

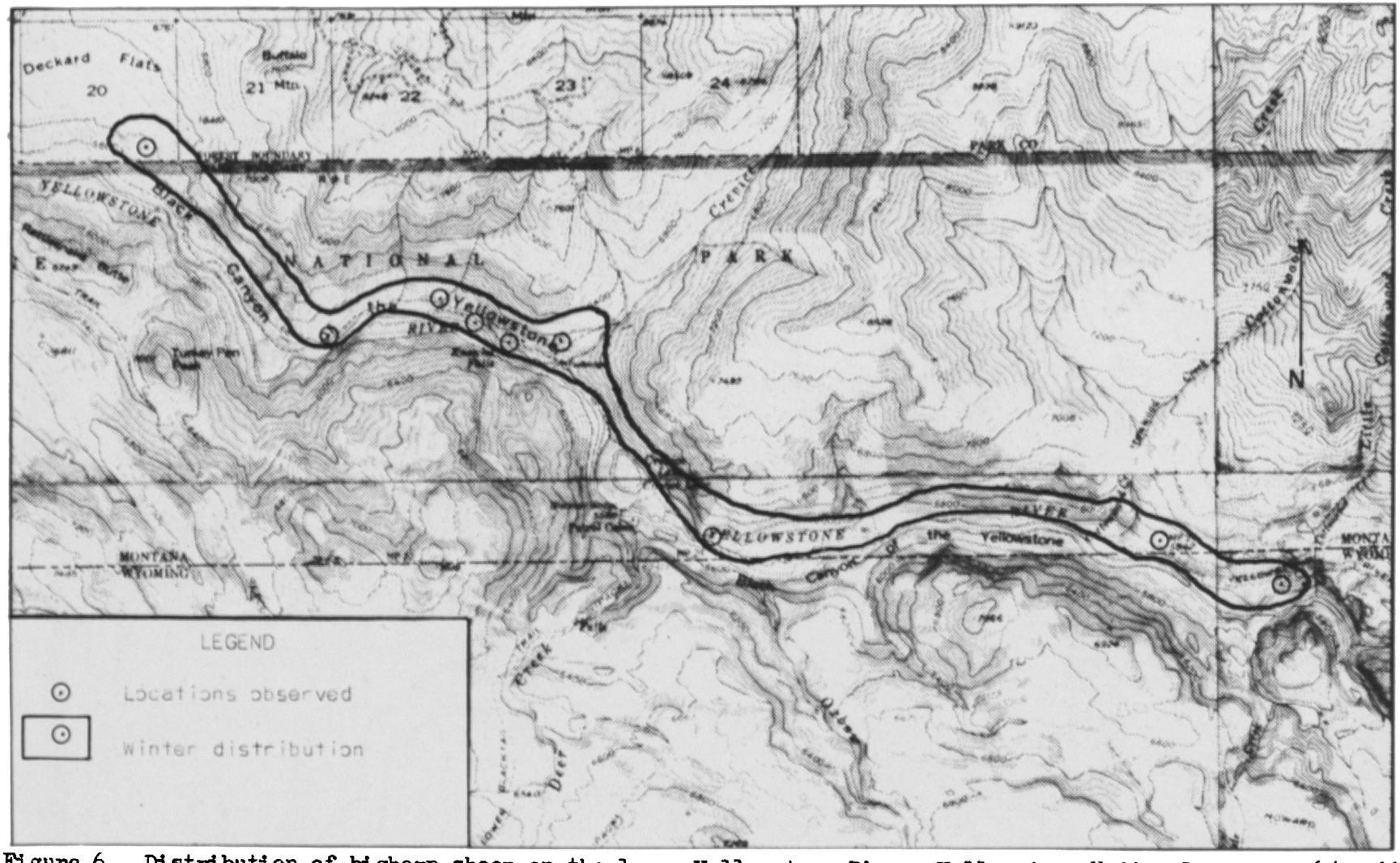

Figure 6. Distribution of bighorn sheep on the lower Yellowstone River, Yellowstone National Park, 1965-1966.

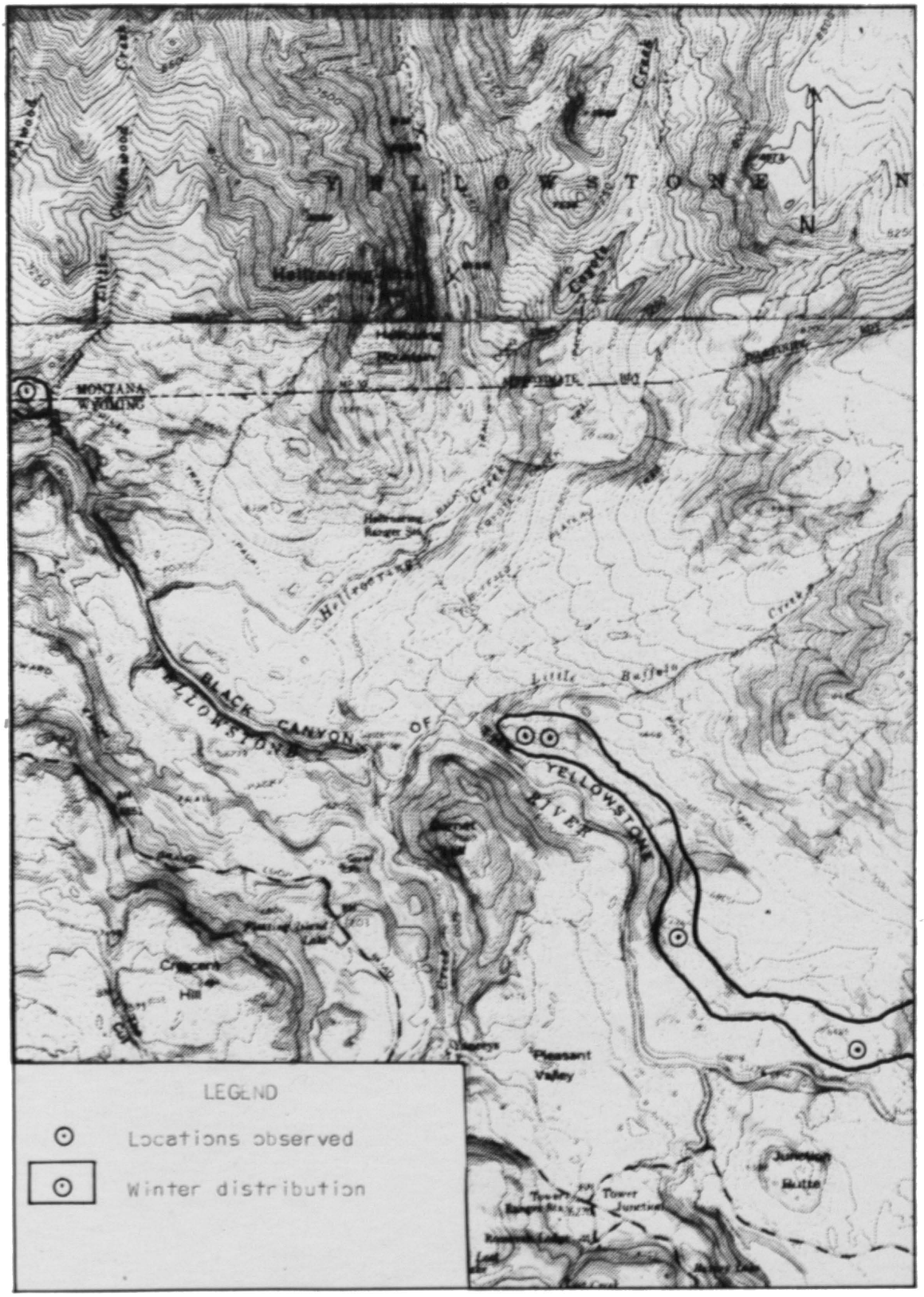

Figure 7. Distribution of bighorn sheep on the upper Yellowstone River, Yellowstone National Park, 1965-1966.

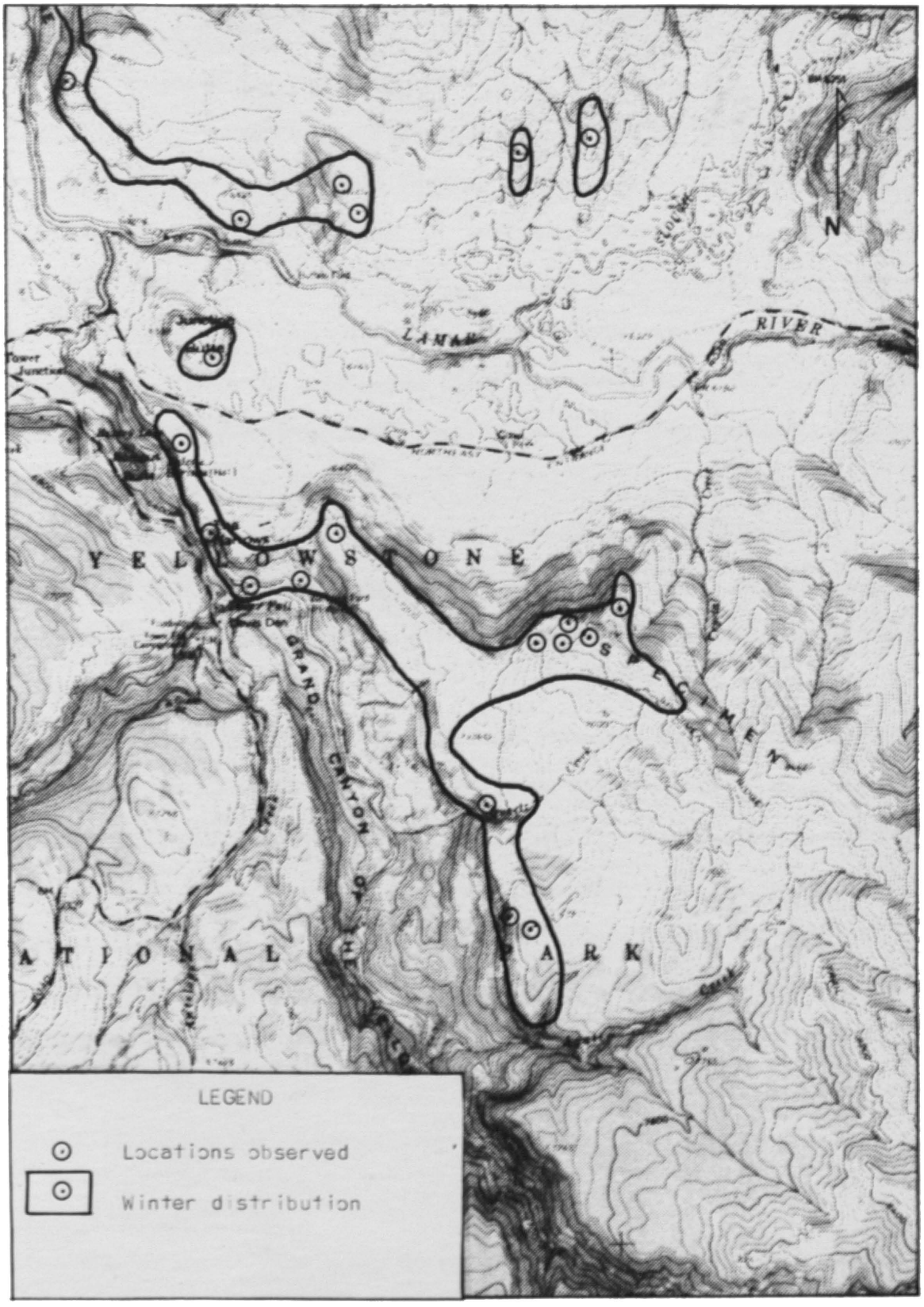

Figure 8. Distribution of bighorn sheep near Slough Creek and on Specimen Ridge, Yellowstone National Park, 1965-1966.

Specimen Ridge Herd

The Specimen Ridge herd was made up of 48 bighorn sheep. Gammill (1941) counted 73 bighorns on Specimen Ridge in 1940. Only 34 bighorns were counted in the April 1965 census. Few bighorns were counted in 1965 on Crystal Creek which was the most used winter area for the herd in 1966. In an area of about 12 square miles of terrain probably less than one square mile was available bighorn habitat during the winter. Sheep did not move to the Crystal Creek area until snows were over eight inches deep on Lower Specimen Ridge. Most of the herd stayed on Crystal Creek during the most severe part of the winter. Up to ten sheep remained on Lower Specimen Ridge and Junction Butte. A very small amount of forage was available there because of the deep snows. Another small group wintered at Quartz Creek and the Agate Creek cliffs (Figures 8 and 9).

Specimen Ridge is a large sagebrush grassland with a south facing exposure. The sides bordering the ridge on the west and north drop off sharply into a Douglas-fir forest. Snow was light throughout the winter in the narrow strip of bunchgrass grassland which exists between the sagebrush and the forest. In many places steep cliffs occur between the grassland and the forest. These were the primary areas of bighorn occurrence. Sheep spent little time in the sagebrush because of the deep snows, and they went into the forest only to escape danger and in the early spring when movements were freer due to snow free terrain.

Soda Butte Creek Herd

The valley of Soda Butte Creek is bordered by low shoulders of Druid Peak, Mt. Norris, The Thunderer, Barronette Peak, and Abiathar

Figure 9. Typical winter range of the Specimen Ridge bighorn sheep herd, Yellowstone National Park.

Figure 10. Typical winter range of the Soda Butte Creek bighorn sheep herd, Yellowstone National Park.

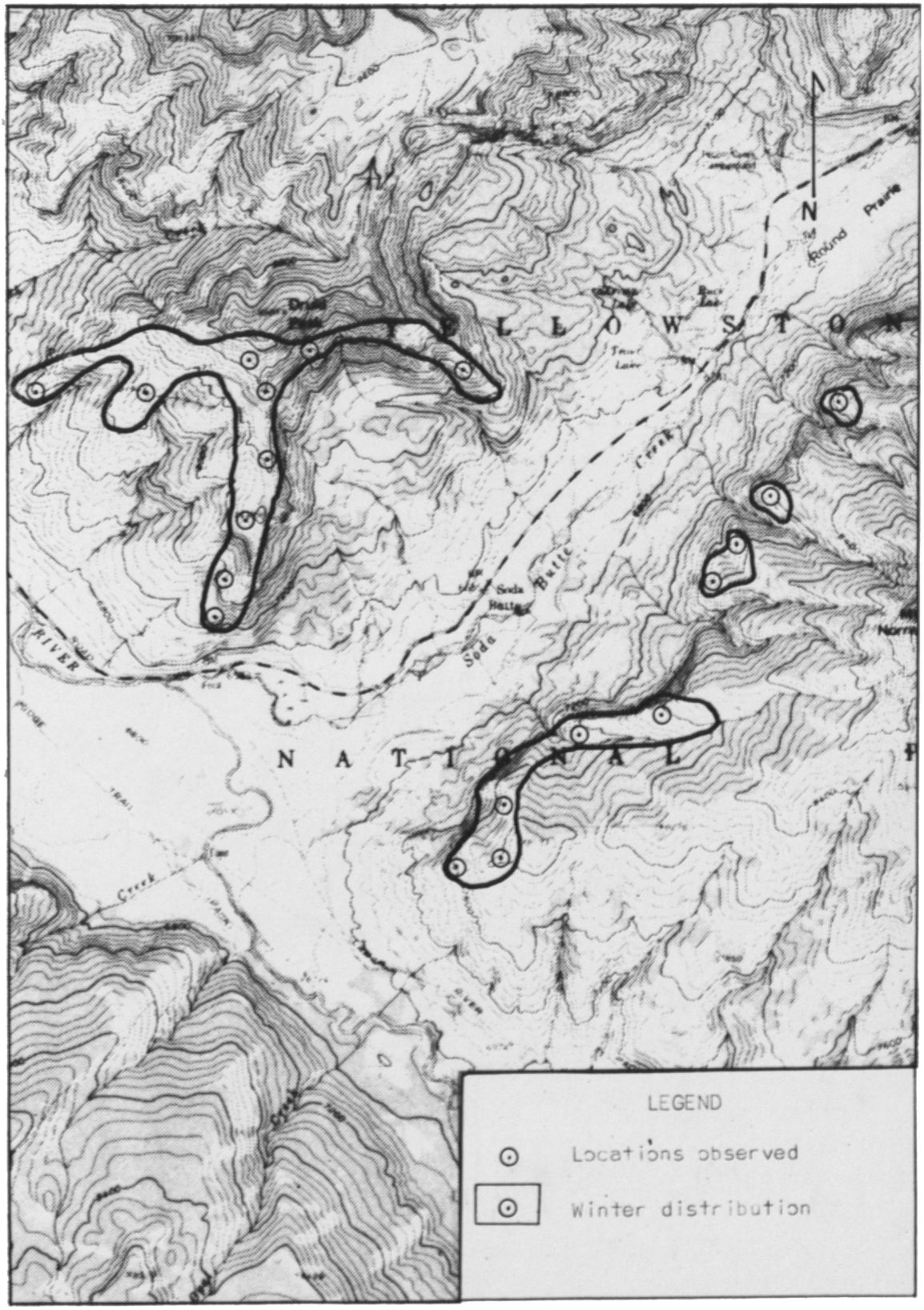

Figure 11. Distribution of bighorn sheep on lower Soda Butte Creek, Yellowstone National Park, 1965-1966.

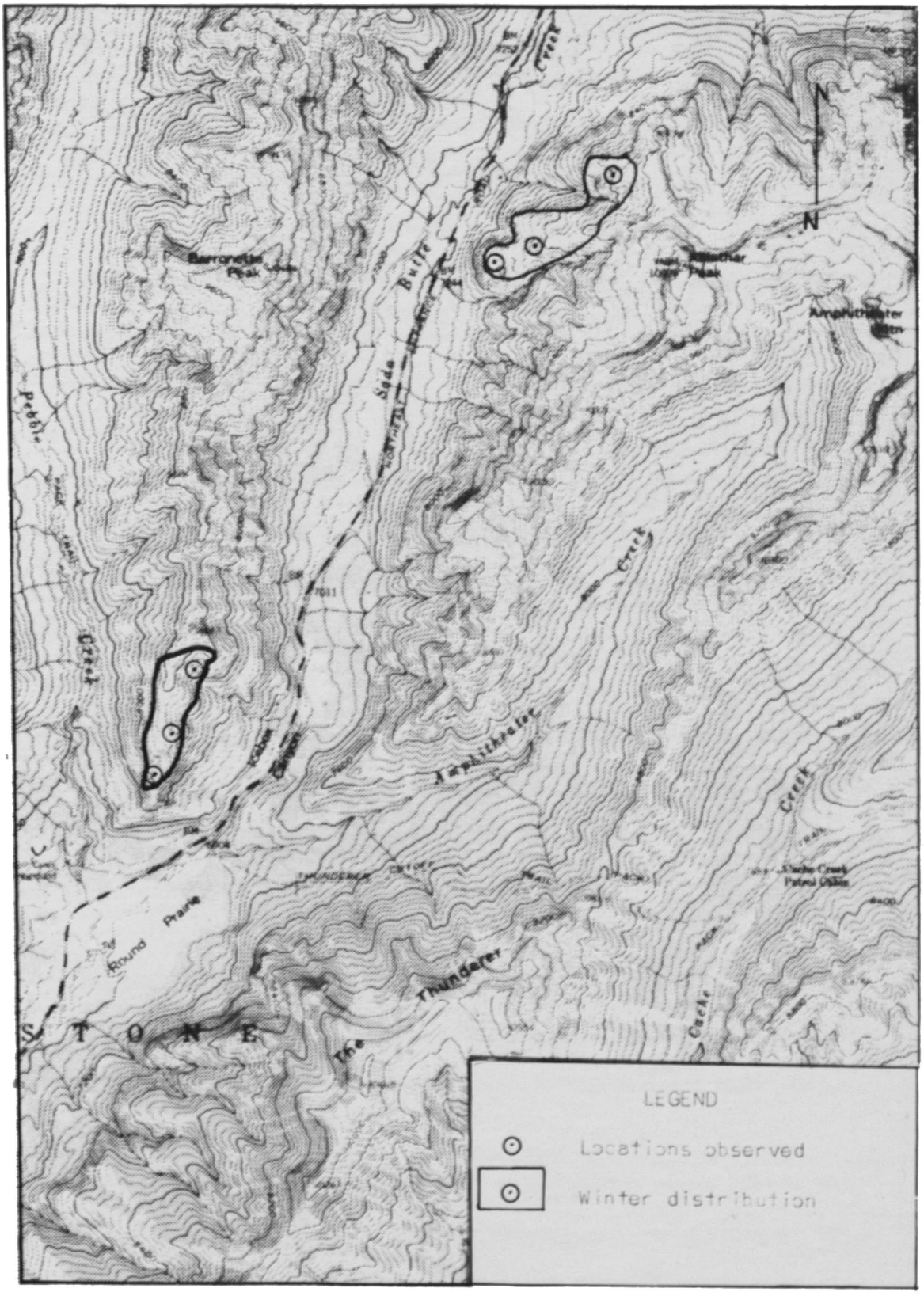

Figure 12. Distribution of bighorn sheep on upper Soda Butte Creek, Yellowstone National Park, 1965-1966.

Peak (Figures 10 and 11). Many of these shoulders were occupied by bighorn sheep during the winter. The terrain is extremely steep and rugged, and sheer cliffs are present. Windblown ridges which produced little forage formed the bighorn winter range. The range is bordered on one or several sides by the rugged escape terrain.

Eighty four bighorns wintered in four groups along Soda Butte Creek. In 1955, Buechner (1960) counted only 11 bighorns on Mt. Norris and Barronette Peak, while thirty six were observed on the two areas during this study.

The easternmost south facing ridge of Druid Peak contained the most sheep in the herd. During the winter sheep moved from 8,600 feet to 7,600 feet elevation to find available forage. This area was one of the most confined sheep habitats in the Park and very little forage was available because of the deep snows.

The west facing slopes of Mt. Norris provided bighorn winter range. The ridges leading from Mt. Norris and The Thunderer end abruptly in sheer cliffs or steep, rocky outcrops. Group size varied from a ewe group of eleven to several single mature rams on very limited snow-free areas.

The south sloping ridge from Barronette Peak ends abruptly above Pebble Creek campground in rugged precipitous cliffs. Twelve sheep moved into the area in early January and remained until snow melted upridge in the spring.

A small butte-like projection afforded winter range low on the north side of Abiathar Peak. Twenty five sheep were counted in this area during the April 1965 census. However, only 16 sheep were observed there in 1966.

Chapter V

THE WINTER RANGE

Plant composition and utilization, animal use, and snow cover were determined on the sample sites (described in Chapter II) on MacMinn Bench, Specimen Ridge, and Druid Peak. The sites represented typical bighorn winter range on the three areas. Results of the plant composition samples are shown in Tables 5-7, and results of the plant utilization and pellet group sample are shown in Table 8.

MacMinn Bench

Plant Composition

Two major plants on MacMinn Bench were not found on the two other areas. Needle-and-thread grass (Stipa comata) occurred with a frequency of 73 per cent on MacMinn Bench. Only sedge (Carex sp.) and bluebunch wheatgrass (Agropyron spicatum) were more frequently sampled. Winterfat (Eurotia lanata) was the major shrub on MacMinn Bench. I did not observe it on any other part of the bighorn winter range.

The two most important forbs from the standpoint of abundance were milkvetch (Astragalus sp.) and phlox (Phlox hoodi). The Eagle's Nest Rock site had few other species, but the South Slope site contained goldenweed (Aplopappus acaulis), pussytoes (Antennaria sp.), and Douglas rabbitbrush (Chrysothamnus viscidiflorus).

The U.S. Forest Service (1963) vegetative score card for mountain grasslands rates ecological desirability of the various plant species. Phlox was the primary "least desirable" species. Goldenweed and pussytoes, two other undesirables, also occurred on the area. Least desirable

species are those usually indicative of disturbed areas. Buechner (1960) remarked that the lack of species on MacMinn Bench indicated a disturbed or unstable site. However, the mountain grassland vegetative score card lists those grasses occurring on MacMinn Bench as desirable species indicative of a climax plant community, and they were the major plant species in the plant community (Figure 13).

The relative plant density was in the "Fair" category according to the mountain grassland vegetative score card. The Eagle's Nest Rock site had a 19.8 per cent living vegetation cover while the South Slope site had almost 30 per cent living vegetative cover (Table 5). This is somewhat higher than the 15-20 per cent that Buechner (1960) reported.

Plant Utilization

Plant utilization was determined on four sites on MacMinn Bench by the Region 1 Gauge and Per Cent of Plants Grazed Method. Needle-and-thread grass, Junegrass, and Bluebunch wheatgrass were the grass species sampled for utilization. It was apparent that utilization was low, especially for needle-and-thread grass and bluebunch wheatgrass. Stoddart and Smith (1943) wrote that 40-50 per cent use of the annual production during the growing season would deplete most plants. However, they believed that plants could withstand more use during the nongrowing season. According to Cole (1958), on elk winter ranges in Montana, 50 per cent utilization of key bunchgrasses was allowable. Utilization of Junegrass was higher than Cole's recommendation. Possibly under severe winter conditions, where large numbers of ungulates were on the winter range, trampling damage would play a more important part in hindering plant growth. Utilization of winterfat was not high for vigorous plants;

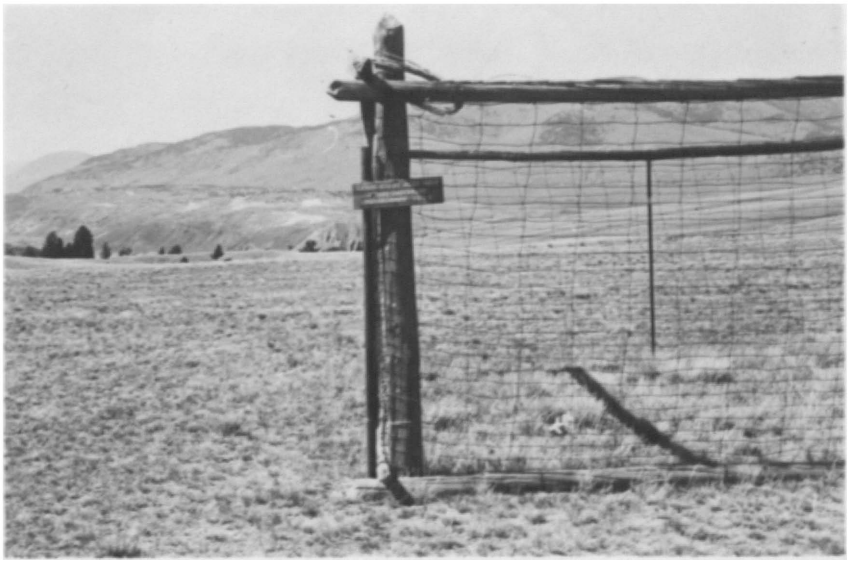

Figure 13. Range exclosure on MacMinn Bench, Yellowstone National Park. Thirty two years of protection have resulted in more ground cover within the exclosure.

Figure 14. Browsed condition of winterfat on MacMinn Bench, Yellowstone National Park.

however, this shrub is so consistently browsed to within one inch of the ground each winter that even moderate use probably has a detrimental effect (Figure 14). The maximum utilization of vigorous browse species during severe winters is 70 per cent (Cole, 1958). Smith (1954) noted that many range specialists suggest browse utilization not exceed 60 per cent of annual growth.

In April 1965, utilization of grasses and shrubs around Northern Yellowstone Photo Plot NY-5 was estimated by Barmore. Bluebunch wheatgrass utilization was approximately 80 per cent while needle-and-thread grass utilization was approximately 75 per cent. Both of these species were grazed considerably more during the winter of 1965 than the winter of 1966. This additional use of the grasses probably was the result of more elk on the range, since the number of bighorns on the range was similar both winters. Winterfat utilization was estimated at 71 per cent leader use in 1965, which is somewhat higher than the estimate in 1966.

Snow Cover

Snow depths on MacMinn Bench and Rattlesnake Butte were never great (Figure 15). However, on the top of Mt. Everts snow was as deep as 12 inches and prevented bighorns from making extensive use of the area. Snow depth was greatest on MacMinn Bench in late December, but the average depth throughout the range was only four inches. In draws and gullies snow accumulated to greater depths. On the level areas and ridge tops snow was from two to three inches deep in January, three inches deep in March, and absent by April 4. The maximum crust measured was one-half inch. From these observations, it was obvious that snow had

Table 5. Plant composition of two bighorn winter range sites on MacMinn Bench, Yellowstone National Park, 1966

	Eagle's Nest Rock			MacMinn South Slope		
	% Ground Cover	Frequency	Density Plants /m^2	% Ground Cover	Frequency	Density Plants /m^2
Bare Ground	35.3			21.8		
Erosion Pavement	0.3			8.2		
Rock	0.0			9.4		
Litter	42.0			26.6		
Moss & Lichen	2.3			4.4		
Vegetation	19.8		103.7	29.6		144.0
Grasses						
Agropyron spicatum	1.0	73		6.0	70	
Agropyron sp.	0.3	30	15.0			
Carex sp.	1.3	70	59.3	2.8	82	102.6
Koeleria cristata	7.7	73		3.8	52	
Oryzopsis hymenoides	0.0	10		0.0	2	
Poa sp.	0.3	13		2.4	44	
Stipa comata	3.0	67		5.4	78	
Total grasses	13.6		74.3	20.4		102.6
Forbs						
Antennaria umbrinella				0.0	6	2.6
Aplopappus acaulis				1.4	26	19.0
Astragalus sp.	1.3	37	9.7	4.2	46	8.2
Chenopodium sp.	0.0	3				
Phlox hoodi	3.0	43		0.8	16	
Total forbs	4.6		20.0	6.4		30.2

Table 5 continued

	Eagle's Nest Rock			MacMinn South Slope		
	% Ground Cover	Frequency	Density Plants /m^2	% Ground Cover	Frequency	Density Plants /m^2
Shrubs						
Artemisia frigida	0.3	7	0.7	1.4	30	4.0
Chrysothamnus viscidiflorus	0.0	3	0.7			
Eurotia lanata	1.3	47	8.0	1.4	30	7.0
Opuntia sp.				0.0	2	0.2
Total shrubs	1.6		9.4	2.8		11.2

Figure 15. Bighorn lamb digging through snow on MacMinn Bench, Yellowstone National Park. Bluebunch wheatgrass is sticking up several inches above the snow.

Figure 16. Sparse ground cover on MacMinn Bench, Yellowstone National Park.

little effect on bighorn movements or their ability to reach forage on MacMinn Bench. Shallow snow was common for bighorns inhabiting low elevation range in the northwest part of the study area.

Animal Use

Total animal use of MacMinn Bench appeared to be lighter than past years as evidenced by the number of this year's pellet groups compared with those remaining from previous years. Bighorn sheep came onto the Mt. Everts winter range in early October and remained there until mid-May. This represented over 200 days of bighorn use involving as many as 40 sheep per day. The average number of bighorns observed on MacMinn Bench was 25. The number of days use per acre by bighorn, deer, and pronghorn, as determined by pellet group counts, varied from 25 near the coal mine to 192 at Eagle's Nest Rock, near a bedding area (Table 8). Bighorns were the major ungulate on the range. Elk spent very little time on the range and did not come onto MacMinn Bench until a trapping operation in January failed, and the elk crossed the Bench on their way to Mt. Everts. Pronghorn occasionally were observed on MacMinn Bench, but no more than ten were observed there at any one time. Therefore, the pellet group counts, while lumping everything but elk, reflect bighorn sheep use much more than pronghorn or mule deer.

Specimen Ridge

Plant Composition

Idaho fescue (Festuca idahoensis) was more abundant on Specimen ridge than on any other area (Table 6). It occurred there with a

Table 6. Plant composition on two bighorn winter range sites on Specimen Ridge, Yellowstone National Park, 1966

	Quartz Creek			Crystal Creek		
	% Ground Cover	Frequency	Density Plants /m^2	% Ground Cover	Frequency	Density Plants /m^2
Bare Ground	18.0			11.8		
Erosion Pavement	1.4			6.0		
Rock	4.6			11.8		
Litter	44.1			30.5		
Moss & Lichen	2.2			14.2		
Vegetation	30.3		169.2	25.8		129.6
Grasses						
Agropyron spicatum	1.2	52		4.0	90	
Agropyron sp.	0.2	14		0.0	4	2.8
Carex sp.	0.7	22	7.0	1.2	72	44.4
Festuca idahoensis	6.0	100		1.6	42	
Koeleria cristata	3.0	52		2.2	56	
Poa sp.	4.0	78		4.0	76	
Total grasses	15.1		7.0	13.0		47.2
Forbs						
Achillea lanulosa	0.0	6	3.0			
Allium sp.	0.0	2	0.2	0.0	2	0.8
Antennaria umbrinella	3.4	84	43.2	1.0	38	8.6
Aplopappus acaulis	0.0	2	0.8	0.0	4	2.8
Arenaria conjesta	0.0	2	0.4	0.0	2	1.2
Astragalus sp.	3.4	82	24.0	2.8	44	15.4
Compositae	0.0	4	0.8	0.0	8	0.8
Erigeron compositus				2.0	72	27.6
Erigeron sp.	2.4	70	65.6	0.0	6	1.2

Table 6 continued

	Quartz Creek			Crystal Creek		
	% Ground Cover	Frequency	Density Plants /m^2	% Ground Cover	Frequency	Density Plants /m^2
Forbs (cont.)						
Eriogonum sp.	0.2	8	1.6			
Geum triflolium				0.0	6	1.2
Lupinus leucophyllus	0.4	24	8.0			
Orthocarpus luteus	0.0	2	0.4	0.0	8	1.6
Oxytropis sp.	0.0	2	0.2	1.2	48	8.4
Phlox sp.	3.8	74		3.6	94	
Sedum stenopetalum	0.0	8	0.8			
Total forbs	13.6		152.0	10.6		72.2
Shrubs						
Artemisia frigida	0.2	2	0.2	0.6	12	1.6
Chrysothamnus viscidiflorus	1.4	64	10.0	1.6	46	8.6
Total shrubs	1.6		10.2	2.2		10.2

frequency of 100 per cent on Quartz Creek and 42 per cent on Crystal Creek. Bluebunch wheatgrass, Junegrass, and bluegrass were the other important grasses. Average ground cover of those four grass species was 10.4 per cent. Specimen Ridge had a greater variety of forbs than did MacMinn Bench. Pussytoes, aster, milkvetch, daisy, lupine, and phlox were important forb species present. Pussytoes, fleabane, and phlox are rated as least desirable by the mountain grassland vegetative score card. The primary shrub was Douglas rabbitbrush. It had a density of 8.4 plants per square meter on the Crystal Creek site, but did not occur in the sample at Quartz Creek. Big sagebrush, which was the major shrub on Specimen Ridge, was not present on the two sites. Locations containing big sagebrush were essentially unavailable for foraging during the winter because of deep snows.

Forty two per cent of the plant hits by the paced point method were on desirable species; all of these were grass species. Thirty three per cent of the hits were least desirable species. Most of these hits were on pussytoes, phlox, and Douglas rabbitbrush. As shown in the food habits discussion, the latter two were important plants in the bighorn's diet.

The average relative plant density was 70.4 per cent for the two sites. This was the best recorded for the three areas. However, the high frequency of the "least desirables" probably indicated abuse of the vegetation by overgrazing. Buechner (1960) observed this condition on Lower Specimen Ridge where the frequency of occurrence of littleleaf pussytoes (Antennaria microphylla) was 80 per cent.

Plant Utilization

Plant utilization on Specimen Ridge differed considerably between the Quartz and Crystal Creeks sites and the Lower Specimen Ridge sample site. On Lower Specimen Ridge where needle-and-thread grass was present, utilization of that species was considerably greater than on MacMinn Bench. This was probably due to restricted range. Grass species on Crystal Creek site received the heaviest utilization on Specimen Ridge (Figures 17 and 18). The average utilization of the three species was about 65 per cent, while at Quartz Creek it was about 59 per cent. On all sites, utilization was greater than what Cole (1958) suggested was allowable. Douglas rabbitbrush, on the other hand, was heavier utilized at Quartz Creek than on the other two sites, and utilization was similar to utilization of winterfat on MacMinn Bench. This shrub receives heavy use year after year and is severely hedged.

Snow Cover

Snows became quite deep on Lower Specimen Ridge, and sheep were forced to travel and graze very near the edge of the ridge overlooking the Yellowstone River. In late December eight inches of snow covered the ground on Lower Specimen Ridge. As the winter progressed, the snow crusted wherever it was more than four inches deep, and the crust made grazing and moving difficult. Although snow was as deep as 15 inches in swales and on north slopes in mid-March, many knobs were snow free, and by early April most slopes were completely bare.

There was a light snow cover on Specimen Ridge in early November. In January snow measurements varied from 3 to 19 inches on bighorn winter range, and the Quartz Creek site was completely covered. The

Figure 17. Crystal Creek photo plot before winter grazing in October 1965, Yellowstone National Park.

Figure 18. Crystal Creek photo plot after winter grazing in May 1966, Yellowstone National Park.

site showed few tracks or other signs of activity, and I think most of the animal use on that site came before January and after mid-March. The Crystal Creek site encompassed a larger area and there were more wind-blown ridges on which sheep foraged. The northwest facing slope at Crystal Creek actually received more sheep and elk use than the south facing transect site. However, sheep never had less than three inches of snow to dig through in that area. In March, the warmer weather caused slight melting conditions which resulted in very hard, crusted snow until noon of each day. Even in shallow snow, grazing must have been extremely difficult for the sheep, especially lambs. Deep snow with crusting such as was experienced in March would have made travel and grazing nearly impossible.

Elk were observed to dig through snow as deep as 14 inches. Because they could dig through deeper snow they were able to reach lusher vegetation in swales and on north slopes.

Animal Use

A group of eight bighorns in early December was the first observed on Crystal Creek. By late December the entire wintering herd of 48 sheep had accumulated on the Specimen Ridge winter range. They were last observed there in May. This represents a minimum of 150 days use on Specimen Ridge. From early January until late March most of the herd remained on Crystal Creek. Up to 11 remained on Lower Specimen Ridge, and as many as nine wintered in the Quartz Creek vicinity.

Elk and bison were the only other ungulates utilizing the Specimen Ridge ranges. A group of ten or so bison wandered over Specimen Ridge, but rarely occupied sheep range. In mid-November a herd of 136 elk

began concentrating on the north facing slopes draining into Quartz Creek. About 30 elk were observed on the Crystal Creek transect at that time. As many as 200 were observed at one time in Quartz Creek, and these elk remained in that vicinity most of the winter. During the early morning hours one would see elk scattered throughout the entire Specimen Ridge sheep winter range. Elk remained on Specimen Ridge until mid-May and their total time there was somewhat longer than the time spent by bighorn sheep.

Pellet group counts on the three plant utilization sites indicated more elk days use per acre than bighorn days use per acre on Quartz and Crystal Creeks (Table 8). Few elk were observed on Lower Specimen Ridge, and the pellet group counts on the one site there reflect this. Sheep days use on that site was greater than on the other two sites, and this probably was the result of sheep concentrating on available range. From my observations on Specimen Ridge, the pellet group counts, while possibly not showing exact days use per acre, reflected the general intensity of ungulate use.

Druid Peak

Plant Composition

The same four grasses (bluebunch wheatgrass, Idaho fescue, Junegrass, and bluegrass) that were on Specimen Ridge were abundant on Druid Peak. Idaho fescue and Junegrass occurred with the highest frequency (Table 7). Those two grasses also were hit most often by the paced point samples. A total of 8.9 per cent of the ground cover was made up by the grasses. More forbs were sampled on Druid Peak than on any other area. Ballhead sandwort (Arenaria conjesta), fernleaf fleabane (Erigeron compositus),

Table 7. Plant composition on two bighorn winter range sites on Druid Peak, Yellowstone National Park, 1966

	Druid South Slope			Druid Ridge		
	% Ground Cover	Frequency	Density Plants /m^2	% Ground Cover	Frequency	Density Plants /m^2
Bare Ground	16.6			17.6		
Erosion Pavement	5.2			10.8		
Rock	18.6			20.4		
Litter	30.6			20.4		
Moss & Lichen	7.2			9.8		
Vegetation	21.8		181.4	21.0		86.2
Grasses						
Agropyron spicatum	1.8	82		0.2	30	
Carex sp.	1.6	48	102.6	0.4	30	50.6
Festuca idahoensis	2.4	60		2.0	66	
Koeleria cristata	4.0	76		3.8	56	
Poa sp.	1.6	44		3.8	56	
Total grasses	11.4		104.4	10.2		75.4
Forbs						
Achillea lanulosa	0.2	14	3.6	0.0	10	4.4
Allium sp.				0.0	2	0.6
Antennaria umbrinella	0.4	10	1.4	3.4	44	32.2
Aplopappus acaulis	0.4	10	2.0	1.0	10	4.0
Arenaria conjesta	0.2	14	3.6	1.6	60	23.2
Arnica sp.				0.2	6	4.0
Aster elegans	0.4	28	6.6			
Astragalus sp.	2.3	32	8.6	0.4	6	3.4
Compositae		10	1.8	0.2	10	2.2

Table 7 continued

	Druid South Slope			Druid Ridge		
	% Ground Cover	Frequency	Density Plants /m^2	% Ground Cover	Frequency	Density Plants /m^2
Forbs (cont.)						
Erigeron compositus	0.8	58	16.2	0.4	26	7.0
Erigeron sp.				0.0	6	1.6
Eriogonum andium				0.2	8	1.2
Eriogonum sp.	0.0	4	0.8			
Geum trifolium				0.8	4	0.4
Linum lewisii	0.0	28	6.6			
Lupinus leucophyllus				0.4	6	4.4
Orthocarpus luteus	0.0	40	15.4	0.0	22	9.0
Oxtropis sp.	0.8	32	7.2	0.0	8	1.2
Phlox sp.	4.7	68		1.6	48	
Potentilla sp.				0.2	16	2.4
Sedum stenopetalum				0.0	18	4.0
Total grasses	10.2		75.0	10.8		114.6
Shrubs						
Artemisia frigida	0.0	2	0.2			
Chrysothamnus viscidiflorus	0.2	12	1.4			
Symphoricarpos albus	0.0	2	0.4			
Total shrubs	0.2		2.0			

Table 8. Grass and browse utilization and pellet group counts on important bighorn sheep winter ranges in Yellowstone National Park, 1965-66

	Mt. Everts				Specimen Ridge			Druid Peak		
	Eagle's N.R.	Upper Ridge	Upper Slope	Coal Mine	Quartz Creek	Crystal Creek	Lower S.R.	South Slope	Upper Ridge	Lower Slope
	%	%	%	%	%	%	%	%	%	%
Grass Utilization										
Stipa Utilization										
R-1 Gauge	5	6	1				15			
% Plants grazed	9	27	0				51			
Koeleria Utilization										
R-1 Gauge	62	61	62	12				78	39	
% Plants grazed	68	72	63	16				78	47	
Poa Utilization										
R-1 Gauge					42	41				
% Plants grazed					54	63				
Agropyron Utilization										
R-1 Gauge		26	2	7	58	76	35	94		39
% Plants grazed		51	0	19	72	76	75	81		67
Festuca Utilization										
R-1 Gauge					58	64	50	71	41	53
% Planta grazed					68	73	57	80	46	67
Browse Utilization										
Eurotia	68	60	58	60	--	--	--	--	--	--
Chrysothamnus	--	--	--	--	85	79	82	97	--	--

Table 8 continued

	Mt. Everts				Specimen Ridge			Druid Peak		
	Eagle's N.R.	Upper Ridge	Upper Slope	Coal Mine	Quartz Creek	Crystal Creek	Lower S.R.	South Slope	Upper Ridge	Lower Slope
	Days use per acre									
Animal Use (Pellet Group Counts)										
Bighorn Sheep	--	--	--	--	22.3	30.0	59.2	126.2	13.9	38.5
Elk	0	1.5	0	3.1	60.8	35.4	1.0	3.9	13.1	6.2
Bison	0	0	0	0	0	0	1.0	0	0	0
Bighorn, deer, pronghorn	192.3	67.7	37.7	25.4	0	0	0	0	0	0

blueflax (Linum lewisii), and yellow owlclover (Orthocarpus luteus) occurred with moderate frequencies. Phlox was still the most frequently occurring forb in the winter range. The density of fernleaf fleabane was 11.1 plants per square meter, and yellow owlclover had a density of 12.3. The Druid Peak area had few shrubs. Density of the most common shrub, Douglas rabbitbrush, was only 1.4 plants per square meter. Common snowberry (Symphoricarpos albus) was sampled for the first time on the Druid South Slope site.

The plant composition of Druid Peak rates poorest of the three areas according to the mountain grassland vegetative score card. There were fewer hits by the paced point sample on the desirable grasses and proportionately more on the intermediate and least desirable forbs and shrubs. Ballhead sandwort and fernleaf fleabane were both "least desirable" species. Phlox and pussytoes were the two most common least desirable plants indicating abuse of the vegetation.

Relative plant density varied considerably between the two sites. On the Druid South Slope site the relative plant density was second highest of any site, while on the Ridge site it was lowest. Possibly this was due to the lack of litter covering the ground.

Plant Utilization

Plant utilization on the Ridge site was the lowest on the area and averaged 43 per cent. Utilization on the Lower Slope site was nearly 56 per cent and was similar to utilization on the rest of the winter range. Heaviest grass utilization of the ten sites sampled was on the South Slope site where average grass utilization was approximately 81 per cent. Continued utilization of this nature over a period of several

years would have a detrimental effect on the vegetation because of the soil compaction in the area, root stress, and extreme cropping of the plants. Douglas rabbitbrush was abundant enough to sample only on the South Slope site where 97 per cent of the leaders were browsed. It was severely hedged throughout the site.

Snow Cover

Snow limited sheep use on Druid Peak more than on any other area. The narrow ridge was blown free or partially free of snow most of the winter, but the west facing slope leading to the ridge contained deep snows. In mid-November, the South Slope site was covered with about one inch of snow, while surrounding areas were covered with 15 inches. Throughout most of the winter, snow was seldom over four inches deep on top of the ridge immediately after a fresh snowfall. Depths in surrounding areas increased from 15 inches. As the winter progressed, snow cover on the higher parts of the ridge accumulated and sheep were forced to move down the ridge to remain in terrain where they could forage and move without excessive difficulty. In years of heavy snows, many reports were made of the Druid sheep going as low as the road to Northeast Entrance. In 1966 no such observations were made, and I do not believe the sheep moved that low.

Animal Use

Few elk used the winter range occupied by bighorns on Druid Peak. Bighorns were first observed on the ridge in early December and remained there until early May. Thirty-two bighorns spent a little more than 150 days in the area. Distribution was not as widespread on Druid Peak as on some of the other areas. The pellet group counts on the South

Slope site were very high and second only to the combination of pronghorn, mule deer, and bighorn counted at the Eagle's Nest Rock site on MacMinn Bench (Table 8). While the site was not a bedground, it was within one-half mile of all the critical sheep range on Druid Peak, and it contained the largest amount of open vegetation on Druid. Elk use as indicated by the pellet group counts was low. The Ridge site reflected the most elk use, and that area was not used by sheep late in the winter because of the deep snow.

Chapter VI

ECOLOGY

Reproduction

Bighorn rams began to mingle with ewe groups after they moved from the summer range. On Mt. Everts first contact between the sexes occurred on the winter range. In the eastern part of the study area this first occurred between the summer and winter ranges in areas similar to what Smith (1954) called the intermediate range. Where this occurs probably depends upon when and how much snow falls during the fall. Seven young rams (half curl or less) joined the ewe herd on MacMinn Bench before October 1. They showed sexual interest in the ewes. By the first of November mature rams were on MacMinn Bench (Figure 19). The rams generally chased the ewes no more than 100 yards. The height of the rut came around the first of December. Couey (1950) reported that the peak of rut occurred in late November in Montana. In mid-January rams were still showing active sexual interest in ewes, but by late January the rams began to form separate groups again and remained apart from the ewe groups. Smith (1954) noted that rams on the Salmon River in Idaho showed interest in ewes as late as January, but he did not believe that copulation occurred.

Rams were a handsome sight to behold during the rut. Their dark brown coat was glossy and their neck was swollen. When approaching a ewe, the ram lowered his head and neck, tilted his head to one side, stretched out his nose and curled back the upper lip. If the ewe did not move away from the ram, he would simply stand facing her with his head extended and upper lip curled back (Figure 20). If she moved away,

Figure 19. Bighorn ram mingling with ewes during the breeding season.

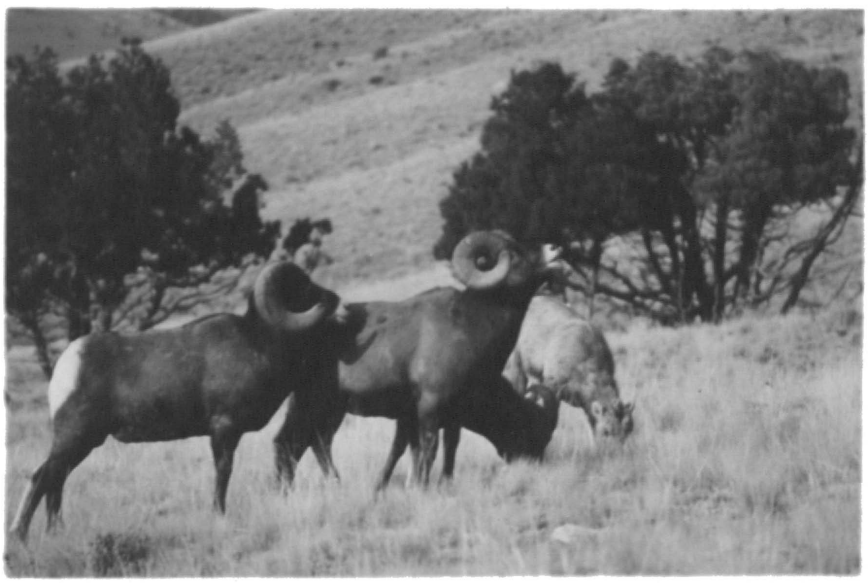

Figure 20. Two bighorn rams during the breeding season.

he followed directly behind, but if she started grazing, he often grazed too. If the ewe ran or he could force her to run by his close presence, several other rams would join the first ram and a chase would begin.

The lead ram often stopped chasing the ewe to fight the next ram following. Only in the height of the rut did I see two large mature rams in combat. A large ram and a smaller one or two younger rams often butted heads before the height of the rut. On Druid Peak two rams (1/2 to 3/4 curl) butted heads 11 times in less than 45 minutes. The two were completely separated from the other bighorns. They would graze for a minute or so, then one (usually the ram on the uphill side) would put his head on the other's back and kick it in the belly with his forefoot. When this stopped, the two nibbled a blade or two of grass, took several steps away from each other, reared into the air, turned, and crashed into each other with a resounding blow.

Smith (1954) and Moser (1962) spoke of the ewe being bred by more than one ram. This is probably the case more often than not. However, Ogren (1954) compared the sexual contact of bighorn sheep to Seton's (1927) second degree monogamy where the ram and ewe continue together during the mating season, then separate completely. On several occasions I observed a ewe and ram separate from the rest of the sheep. However, they did not remain together throughout the entire mating season.

Yearling and two-year-old rams did not participate in the breeding activities. While the rams with heavy, large horns had the fighting advantage, the younger rams had the advantage in stamina and speed of chase. On one occasion a full-curl ram was chasing a ewe, and a

three-quarter curl ram was closely following. The larger ram often stopped to butt the younger ram. After this happened several times, the younger ram dodged aside and began the chase after the ewe. The older ram was unable to keep up with the pace set by the younger one. Woodgerd (1964) collected two yearling rams during the breeding season and found that they had abundant viable sperm in the testes. It appears, then, that rams are sexually mature by 18 months, but whether they copulate with ewes at that age is not known.

Rams were not observed breeding lamb or yearling ewes. Yearling ewes were often pursued a short distance by rams, and one lamb ewe was chased by a ram. She urinated and the ram quit chasing her after smelling the urine. Several minutes later, he began chasing her again, but never mounted her. Woodgerd (1964) discovered that most two-year-old ewes produced lambs during the rapid population growth period on Wildhorse Island in Montana. Smith (1954) and Moser (1962) found evidence that some ewes bred at 18 months.

Lambs were born in late May and early June in Yellowstone National Park. The gestation period was 180 days. Pregnant ewes moved into the most rugged, inaccessible terrain available to lamb. Three lambing areas were the cliffs of Mt. Everts, the ridge running eastward from Druid Peak, and the Abiathar Peak winter range. Most research workers have found that twin births were exceedingly rare in bighorn sheep. However, Spaulding (1966) examined twelve ewes and found that four of the ewes were carrying twin fetuses. On Specimen Ridge one ewe almost always was followed by two lambs which may have been twins.

Food Habits

Forage preferences of the Yellowstone sheep were determined by examination of feeding site similar to that described by Saunders (1955) and Sugden (1961). Bighorns were followed when they were feeding, and all freshly grazed plants were recorded as a feeding observation. This method relied on a snow cover to produce the most accurate results.

It was apparent that sheep exercised a certain selectivity in their grazing habits. Once a hole was cleared in the snow to make plants available, the animals usually grazed only selected species. Preference varied from animal to animal and day to day. The best examples were seen on MacMinn Bench. I followed one ewe which grazed on nothing but Junegrass. During the same observation period a young ram wandered from one winterfat plant to another, browsing only on that species. During one observation period in December, sheep showed preference for needle-and-thread grass and winterfat. In a January observation period, Junegrass and milkvetch were the plants grazed most of the time.

Tables 9 and 10 show the results of the food preference observations. Grass and grass-like plants made up 61.4 per cent of the total observations, forbs 17.2 per cent, and shrubs 21.5 per cent. Schallenberger (1965) used feeding site observations to determine bighorn food preferences in the Sun River Canyon, Montana. He found that the mean percentages for instances of plant use were 36 per cent for grasses, 21 per cent for forbs, and 43 per cent for browse species.

Table 9. Monthly food habits of bighorn sheep in Yellowstone National Park, 1966

Species	Month				
	Nov.-Dec.	Jan.	Feb.	March	Total
	%	%	%	%	%
Grasses and grasslikes					
Agropyron spicatum	31.3	24.6	18.9	24.4	24.5
Carex sp.	0.2	1.6	3.5	7.3	3.3
Festuca idahoensis	3.4	9.3	9.2	10.2	8.7
Koeleria cristata	6.0	8.1	7.7	5.8	7.1
Poa sp.	6.4	3.5	6.9	5.9	5.3
Stipa comata	8.6	5.9	14.2	12.0	9.6
Total grass and grasslikes	57.1	57.3	63.6	67.5	61.4
Forbs					
Astragalus sp.	0.2	4.3	0.8	1.3	2.2
Lupinus sp.	2.6	3.3	3.9	0.8	2.6
Phlox sp.	2.2	6.8	6.6	7.9	6.4
Other forbs	4.1	6.2	8.1	5.2	6.0
Total forbs	9.1	20.6	19.4	15.2	17.2
Browse					
Artemisia frigida	2.1	1.6	0.8	2.6	1.8
Artemisia tridentata	3.1	0.8	2.8	1.2	1.6
Chrysothamnus viscidiflorus	15.8	6.5	3.3	7.9	7.7
Eurotia lanata	12.9	12.4	8.1	5.6	9.7
Other browse	0.0	0.8	2.0	0.0	0.7
Total browse	33.9	22.1	17.0	17.3	21.5
Total observations	583	1534	752	1131	4000

The main forage plant grazed by bighorn sheep in Yellowstone was bluebunch wheatgrass. It made up 24.5 per cent of the total observations. Other important grasses in the sample were needle-and-thread grass, Idaho fescue, Junegrass, and bluegrass. Bluebunch wheatgrass was utilized less on MacMinn Bench than the other three areas even

Table 10. Area food habits of bighorn sheep in Yellowstone National Park, 1966

Species	Area			
	MacMinn Bench	Specimen Ridge	Druid Peak	Mt. Norris
	%	%	%	%
Grasses and grasslikes				
Agropyron spicatum	11.2	33.4	27.1	31.8
Carex sp.	0.6	3.4	8.2	1.5
Festuca idahoensis	0.0	12.1	10.9	19.6
Koeleria cristata	12.3	3.0	7.0	3.7
Poa sp.	5.6	5.3	5.9	3.5
Stipa comata	24.6	5.0	0.0	0.0
Total grasses	56.2	63.6	65.3	61.8
Forbs				
Astragalus sp.	3.0	2.3	0.9	2.2
Lupinus sp.	0.1	3.6	3.1	6.1
Phlox sp.	1.3	5.7	13.2	10.0
Total forbs	6.5	17.6	26.2	27.6
Browse				
Artemisia frigida	3.5	1.9	0.0	0.0
Artemisia tridentata	3.1	0.1	1.3	2.6
Chrysothamnus viscidiflorus	0.8	16.7	3.7	8.0
Eurotia lanata	29.9	0.0	0.0	0.0
Total browse	37.3	18.8	8.4	10.6
Total observations	1295	1292	909	459

though its frequency of occurrence was similar on all three areas. Needle-and-thread grass composed almost 25 per cent of the observations on MacMinn Bench and evidently was preferred over bluebunch wheatgrass. Both species occurred with high frequencies in the plant composition sample. On Specimen Ridge, Druid Peak, and Mt. Norris, bluebunch wheatgrass and Idaho fescue were grazed most frequently. The two

species composed between 38 and 51 per cent of the total observations on those areas.

The major forbs in the bighorn's diet were phlox, milkvetch, and lupine. Phlox was the most frequently grazed forb. On Druid Peak and Mt. Norris phlox was grazed more than elsewhere; however, it occurred in the plant composition sample more frequently on Specimen Ridge than on Druid Peak.

Two shrubs were important items in the bighorn's diet. On MacMinn Bench, 31.8 per cent of the observations were of winterfat. Douglas rabbitbrush was important throughout the rest of the range. Heaviest browsing of Douglas rabbitbrush was on Specimen Ridge, where its frequency of occurrence in the plant community was greatest, compared to MacMinn Bench and Druid Peak.

Gammill (1941) observed somewhat different winter food habits of Yellowstone sheep. Plant species that he mentioned were those most commonly found on the Mt. Everts area, and I assume that his conclusions were based on findings in that area. While bluebunch wheatgrass and needle-and-thread grass represented the greatest per cent of the plant community, he found that bighorn use of them was only moderate. Junegrass, Idaho fescue, and bluegrass were less common but were heavily grazed. Winterfat was the most heavily utilized shrub, and Douglas rabbitbrush received little use.

Habitat

The habitat occupied by 152 groups of bighorns was described as to exposure, terrain, vegetative type, and distance of the group from escape terrain (Table 11). A total of 1,204 bighorn sheep made up the

Table 11. Bighorn sheep habitat preferences on Yellowstone National Park winter ranges, 1965-66

Habitat	Activity			
	Resting	Grazing	Fleeing	All Activities
	Per cent			
Exposure				
South	32*	17	42	27
Southeast	0	0	0	0
Southwest	18	21	23	20
West	23	39	34	29
East	5	1	0	2
North	22	21	0	22
Terrain				
Steep	31	35	51	39
Rocky	12	13	36	14
Ridge top	45	35	13	36
Hilly	7	14	0	8
Level	6	4	0	4
Vegetative type				
Timber	10	16	73	13
Grass	81	75	27	78
Shrub	9	9	0	9
Escape habitat				
Occupying	35	17	85	26
Less than 100 yards	54	67	13	60
100 yards-$\frac{1}{4}$ mile	11	16	2	14

*Thirty two per cent of the animals observed resting were on south facing slopes

152 groups. In general, bighorns preferred south, southwest, and west facing slopes on steep rocky terrain or ridge tops. Most sheep occupied grasslands within 100 yards of escape terrain. Schallenberger (1965) observed bighorns on southeast facing slopes 33 per cent of the time, while in Yellowstone they were rarely found on southeast or east facing slopes.

Bighorn activities at the beginning of an observation were recorded according to resting, feeding or fleeing activities. Bighorns were observed most often on south facing slopes when resting. East and southeast slopes were occupied only 5 per cent of the time. Ridge top terrain was the primary resting place 45 per cent of the time, probably because of the good view of surrounding terrain. Grass was the primary vegetative type used in both resting and feeding. Open timber and browse types were occupied primarily along the Yellowstone River and very rarely elsewhere. Eighty-nine per cent of the resting sheep were in or within 100 yards of escape terrain.

Bighorns in Yellowstone fed primarily on ridge tops or steep terrain located on west and southwest facing slopes. Three-fourths of the feeding activities took place in a grass type within 100 yards of escape habitat. A comparison between the habitat occupied by the two activities shows that south facing slopes were preferred for resting and west facing slopes for feeding. Bighorns moved farther away from escape terrain to feed than they did to rest; however, ridge tops were preferred terrain for both resting and feeding.

Frightened bighorns moved into steep rocky timbered terrain to escape from danger. I found that they quickly ran under large trees when helicopters came into the vicinity. It often was difficult to get them to leave the safety afforded by the trees. When suddenly approached near the edge of a cliff or extremely steep terrain, they quickly ran to the cliffs where few other animals could follow at the fast pace they set.

Competition

"Interspecific competition is any interaction between two or more species populations which adversely affects their growth and survival," (Odum, 1959, p. 230). Blood (1959) wrote that the degree of competition with bighorn sheep depended on the extent to which sheep and other ungulates grazed the same areas, the extent to which they preferred the same forage species, and the supply of preferred forage in relation to the number of grazing ungulates.

McCann (1956) observed that bighorn sheep tend to suffer in any competition from other grazing animals. Most other herbivores range widely in search of food while bighorns appear to be bound psychologically within their limited boundaries.

Competition with Elk

Green (1949) found that elk seriously compete with bighorns in Banff National Park both in the summer and the winter. The result of winter competition in some areas was that sheep abandoned the range under elk pressure and wintered on inferior range. He believed that elk competition tended to break bighorn groups into small bands and to force bighorns onto edges of the range where inferior forage was all that was available. However, Couey (1950) thought that competition was not as serious as it appeared, because bighorns naturally occupied the more precipitous areas that were not frequented by elk.

Bighorn-elk competition is not new in Yellowstone National Park. Mills (1937) found that the winter range in Yellowstone was so depleted by elk that bighorns were forced to eat short grasses all winter, and that they cropped plants so closely that the plants were uprooted.

Gammill (1941) reported that bighorn winter range was used as winter range by large numbers of elk, deer, and pronghorn. On Specimen Ridge elk were the principal competitors, and removal of even small parts of the scarce vegetation was important because of the restricted range utilized by the bighorn. Murie (1940) noted that competition for forage was severe each winter. He reported that bighorns subsisted on range so heavily utilized that elk avoided it after taking the "cream of the crop."

Elk occupation of bighorn habitat did not appear extensive during the study. Bighorn range apparently did not appeal to elk, and they frequented it only after fresh, deep snowfalls. McCann (1956) found that elk moved to windswept ridges and directly competed with bighorns for forage when the snows became heaviest. Elk and bighorns were in direct competition only when elk invaded range occupied by bighorns, and it did not appear that elk forced sheep onto the edges of the range as Green (1949) reported. However, bighorns often delayed moving onto the feeding areas from bedding areas in cliffs when elk were on the range early in the morning. Had elk been forced to remain on this bighorn range because of deep snows, the bighorns would have had less available forage.

Competition was present in several bighorn wintering locations: Little Cottonwood Creek, Little Buffalo Creek, Slough Creek, Crystal Creek, Quartz Creek, Druid Peak, and Mt. Norris. Competition west of Little Cottonwood Creek was light because snowfall was not great enough to force elk this low on the winter range. A herd of elk escaped from an elk trapping operation near Gardiner, and this probably was the only reason any elk occurred on MacMinn Bench. Competition on MacMinn

Bench in 1966 did not occur to the extent that Mills (1937), Murie (1940), and Gammill (1941) reported. The greatest bighorn-elk competition occurred on Crystal Creek, Quartz Creek, and Mt. Norris. Up to 50 elk were observed grazing in the immediate vicinity of sheep on Crystal Creek during the winter. Elk were observed in the immediate vicinity of bighorns on twenty different days. The Quartz Creek and Mt. Norris locations often received early morning elk use but in numbers smaller than those on Crystal Creek.

Cowan (1947) compared the food habits of elk and bighorns. Elk ate 97 per cent grasses, and 3 per cent browse while bighorns ate 83 per cent grasses, 10 per cent forbs, and 7 per cent browse. Table 12 shows the results of elk rumens examined from December to March during the winter of 1962-63. That winter was rather mild as was the winter of this bighorn study, and food habits for the two winters likely are comparable. The fact that the elk food habits data were derived from rumen analysis means that direct comparison with bighorn food habits was impossible. However, it appeared that elk grazed grass and grass-like species to a greater extent than sheep. Competition with bighorns is increased when elk increase their intake of grasses (Cowan, 1947). Lupine was one of the primary forbs identified in the rumen analysis. Phlox appeared to have been less important for elk than for bighorns. Very little Douglas rabbitbrush was identified in the samples while Oregon grape (Berberis repens) appeared to be the most important shrub species to elk. Elk rumen analysis from the winter of 1961-62 indicated that big sagebrush and Chrysothamnus sp. may have been more important to elk during a heavy winter.

Table 12. Winter food habits of Yellowstone elk as determined by rumen analysis[1]

Forage	Month			
	December	January	February	March
	Per cent in sample			
Total Conifers	1.8	2.4	5.4	2.6
Total Browse	6.2	6.5	4.7	5.5
Total Forbs	7.9	1.3	1.6	4.3
Total Grasslikes	84.1	89.8	88.2	87.1
Total Others	tr.	tr.	0.1	0.5

[1]Rumens analyzed and data furnished by Ken Greer, Montana Fish and Game Commission, Bozeman, Montana. Data for each month was based on 20 or more elk.

The supply of important forage species can be detected by the degree of utilization of those species. Blood (1959) noted that competition for the forage species did not begin until the utilization of the species reached the point considered "proper". Pellet group counts and personal observations indicated that so few elk occupied bighorn range on Mt. Everts and Druid Peak that any competition occurring was more likely to be intraspecific than interspecific. Utilization of grasses and browse on MacMinn Bench indicated that over-utilization did not occur, and no demand for forage in short supply existed. However, on Druid Peak, where grass utilization on the South Slope site was about 80 per cent, there was a demand for forage in short supply. This demand was made almost entirely by bighorns; little demand was made by elk.

On Specimen Ridge competition existed between elk and bighorns. Grass utilization over 50 per cent and browse utilization over 70 per cent indicated that key plants were used beyond the "proper" amount.

Winter conditions more severe than those experienced during the study likely would result in increased elk-bighorn competition. Both

species would be forced on more restricted range, and more direct competition for the same forage plants would seem likely. Because elk are more mobile and more numerous than sheep, they would have the advantage in securing enough food to meet their needs and could rapidly deplete the range of forage.

Competition with Other Ungulates

Pronghorn and mule deer were the two other most numerous ungulates on the northern bighorn range. Pronghorn were very numerous on the old target range below and north of MacMinn Bench. As many as 140 pronghorn were observed at one time in that area. However, I never observed more than eight on MacMinn Bench at one time, and usually there were none in direct competition with bighorn sheep. Pronghorn came into occasional contact with the bighorns near Rattlesnake Butte.

Deer were most numerous on the lower sagebrush-grassland ranges. In early winter they were observed as high as Druid Peak. Later in the winter deer were observed at Little Buffalo Creek, but most were lower along the Yellowstone River. Deer competition was greatest in the Deckard Flats and Reese Creek areas. Seventy-one mule deer were observed on Deckard Flats on March 21 and 57 were counted on Reese Creek on January 20. Those on Reese Creek competed with sheep to a greater extent than did those on Deckard Flats. Range on Reese Creek appeared to be better deer range than bighorn range, and perhaps the bighorn sheep were the intruders.

Competition between bighorn sheep and pronghorn and mule deer was light and of no consequence to the bighorns. During a more severe winter pronghorn and deer possibly would be of less consequence,

because they would move to even lower elevations, while bighorns would remain in relatively the same areas.

Predation

The most numerous large predator in Yellowstone National Park is the coyote. During the winter, bears are dorment and have no influence on bighorn populations. Few, if any, mountain lions inhabit the Park.

In general, bighorn sheep paid little attention to coyotes when the coyote was not between the bighorn and escape habitat. I observed coyotes near bighorns seven times during the study. On the Agate Creek cliffs two coyotes sat within 50 feet of nine grazing sheep. The bighorns were next to the cliffs and showed no concern over the closeness of the coyotes. However, on Crystal Creek 15 bighorns were over the ridge from escape terrain, and three coyotes approached them from the direction of the cliffs. When the coyotes appeared over the ridge, the bighorns immediately formed a close group and sprinted over the ridge toward the cliffs.

On several occasions, a bighorn would suddenly run a short distance toward a coyote. On all occasions, the coyote immediately ran from the bighorn. This may indicate that when coyotes chase bighorns, they are trying only to find a weak animal. There was no evidence that any bighorn were killed by coyotes, but on Crystal Creek a lamb had a flap of skin dangling from its throat and may have been an intended coyote victim.

The March 1943 Monthly Report of the Superintendent noted that three coyotes killed a large and apparently healthy ram in the Hoodoos. Murie (1940) thought that coyotes killed very few bighorns in Yellowstone

and that those were probably old and weak animals or lambs. He thought that coyotes were an unimportant mortality factor on bighorns.

Grizzly and black bears are potentially a predatory force in the spring when they first come out of dormancy. It there is still snow cover, bears may be more important as a predator. Park Ranger Gary Brown reported that he watched a very large black bear try to maneuver a group of bighorns on Druid Peak into a position to kill one. The bear was unsuccessful. On Crystal Creek a group of bighorns moved along a trail in the cliffs while a yearling grizzly sat in the cliffs above the sheep and watched them go by. Blood (1959) reported that a black bear killed a ten-year-old California bighorn ewe in British Columbia. I examined the bones and skin of a young ram on Druid Peak during the summer of 1965. The skin was rolled off the carcass much like a bear would do it. However, there was no indication as to how the ram had died. In general, bears probably exerted little influence as a mortality factor to bighorns in Yellowstone.

Disease

A major factor in the survival and health of bighorn sheep is freedom from disease and parasites. Two factors which determine the degree of harshness of a parasite-host relationship are nutritional state of the host and stress of climatic conditions (Honess and Winter, 1956). Forrester and Senger (1964) observed that seasonal variation in the harshness of lungworm infection in bighorn may be connected with changes in type of food, stress associated with harsh winter weather, breeding, pregnancy, and lambing. According to Wright and Thompson (1934) elk competition in Yellowstone National Park was thought a

major factor in lowering resistance of bighorn sheep to disease because of poorer forage conditions.

Dikmans (1935) reported the first case of lungworm due to Protostrongylus stilesi in bighorn sheep from Yellowstone National Park. According to Forrester and Senger (1964), lambs are very susceptible to lungworm infection. Forrester (1960) sampled 500 bighorn fecal samples from western Montana and found that 96 per cent contained lungworm larvae. Forrester and Senger (1964) reported that all of the 20 fecal samples they examined from the Yellowstone bighorn herd contained lungworm larvae. The average number of larvae per 100 mg of dry feces was 36 from Yellowstone sheep compared to 97 in the Ural-Tweed herd of Montana and to the average of 16 for the 500 samples examined. A dead lamb was found on MacMinn Bench in April 1965. The lungs were examined by the Montana Game and Fish Commission at Bozeman. The report stated that the animal had a heavy lungworm larval infection, but no adult nematodes could be found. The larvae probably belonged to the genus Protostrongylus and the infestation could have been associated with the cause of death. No external markings were found on the animal, but bone marrow indicated the animal was not in poor nutritional condition (Victor Barnes, personal communication, July 1966).

No other dead sheep were found in good enough condition to collect lung samples. Several bighorns were observed coughing in much the same way as described for lungworm infestations. An especially small lamb was observed coughing when it first came to MacMinn Bench. This animal could not run more than a few yards without stopping to cough. However, the lamb was still alive at the end of the winter, and I assume the winter did not result in a nutritional deficiency harmful to the lamb.

Population Dynamics

Rates of increase and decrease of populations are influenced by the birth rate, death rate, and age ratio of the population. The rate of increase equals the natality minus mortality. In new populations mortality will be low and the natility near maximum. After the population reaches the optimum size at which the environment can maintain, mortality will increase, and the population becomes stable. Buechner (1960) described a stable population as one in which the yearly fluctuation is less than 20 per cent. The Yellowstone bighorn population most likely has reached this stable category. The 1965 and 1966 censuses showed little change in population size, and the change from 192 in 1955 to 222 in 1965 is less than 20 per cent.

Until recently, evidence indicated that the maximum increase could be only one lamb per ewe per year. Spaulding (1966) examined 12 ewes killed by cars in southern British Columbia. Eleven were pregnant and four carried twin fetuses. The indication here is that there potentially could be more than one lamb per ewe per year. Woodgerd (1964) found that ewe-lamb ratios immediately after the lambing season were 100:76. This appears to be similar to other reported ewe-lamb ratios. Mortality is heavy the first year. Woodgerd obtained a ratio of 100:33 from six to eleven months after lambing. Ewe-lamb ratios in Yellowstone during the winter census were 100:47. Buechner (1960) thought that high lamb mortality was a biological characteristic in stable bighorn populations, because mature populations "perpetuate themselves from year to year." Table 13 shows winter sex and age ratios as reported by several researchers.

Table 13. Winter sex and age ratios of six bighorn sheep herds

Source	Location	ewe:ram	ewe:yearling	ewe:lamb
Gammill (1941)	Yellowstone	100:71*		100:37*
Smith (1954)	Idaho	100:74	100:31	100:54
Buechner (1960)	Yellowstone	100:41*		100:35*
Moser (1962)	Colorado	100:53	100:24	100:41
Woodgerd (1964)	Wildhorse Is.	100:129		100:33
Oldemeyer	Yellowstone	100:78	100:20	100:47

*Yearlings lumped with ewes.

Highest mortality in bighorn populations occurs between conception and the end of the first winter. Several factors influence survival through the first year. Smith (1954) observed that lamb counts between June and August were down following a winter of deep snow and low temperatures. Following milder winters, counts during the same period resulted in significantly higher ewe-lamb ratios. This indicated that the ewe's winter health may have had a direct influence on the health and survival of the lamb at birth.

Woodgerd (1964) gathered data which suggested that lambs born later in the lambing season had a better chance for survival. Ogren (1954) reported that heavy spring rainfall may have contributed to lamb mortality. Cowan (1947) reported that intensified malnutrition in the winter would have a profound effect on the survival from birth to a year old.

The ewe-lamb ratio in Yellowstone was relatively high. This indicates that the winter of the study was not so severe that many lambs died because of malnutrition or diseases resulting from the effects of malnutrition. The ewe-yearling ratio was low in comparison with that found by Smith (1954) and Moser (1962). This low ratio may have been

the result of the previous severe winter in Yellowstone when deep snows and low temperatures prevailed, and sheep were probably in poor condition.

In a polygamous species, such as bighorn sheep, a 100:100 ewe-ram ratio is not necessary for breeding of all receptive ewes. Smith (1954) thought that where there were many small isolated groups of ewes, the ratio should not be less than one ram to three ewes. Few sex ratios show less than one ram to two ewes. Woodgerd (1964) found that rams out numbered ewes on Wildhorse Island and thought this was normal for unhunted bighorn herds. Yellowstone data have never borne this assumption out. Woodgerd found that lamb sex ratios were nearly even a few days after birth. This indicates that ewes on Wildhorse Island were more susceptible to mortality than rams. In Yellowstone the opposite was true.

Chapter VII

BEHAVIOR

Seasonal Migration

Early September snowstorms probably caused Yellowstone bighorns to begin fall migrations. Spencer (1943) thought that sheep in the Colorado Tarryalls migrated in October over the same routes and at the same time regardless of weather conditions. Moser (1962) attributed the fall migration entirely to weather conditions as did Honess and Frost (1942) and Smith (1954). Snow covering forage on the summer ranges probably would initiate the migration. By October 1, a ewe group numbering 34 was on the winter range at MacMinn Bench. This was the earliest migration to the winter range. One of the latest groups to reach the winter range was the group migrating to Specimen Ridge. They were not on the lower range until early December.

Geist (1964) reported that older animals lead younger animals to the same seasonal ranges year after year. Ewes identified on Mt. Washburn during the summer were observed on MacMinn Bench during the winter and back on Mt. Washburn the following summer. However, whether the entire herd stays together is not known.

Distance of migration in Yellowstone varied considerably due to topography. The bighorns summering on Mt. Washburn made one of the longest migrations when moving to Mt. Everts. The minimum distance of this migration was 18 miles. Smith (1954) reported a maximum migration distance of 25 miles for bighorns in Idaho. On the other hand, sheep summering on The Thunderer moved only two or three miles to the lower ridges of Mt. Norris to spend the winter.

Migration routes were not established. However, Mills (1937) listed four migration routes he had observed bighorns in Yellowstone to follow: 1) Daly Creek east to the Yellowstone River near Sepulcher Mountain and Yankee Jim Creek; 2) South Gallatin Range north to Swan Lake Flats, Terrace Mountain and Mt. Everts; 3) Upper Absoraka Range to Cutoff Mountain, Slough Creek meadows, Lamar River and Junction Butte; 4) Specimen Ridge near Quartz Creek from the east side of the Yellowstone Canyon. Several other migration routes were: Cutoff Mountain to Mt. Hornaday to Druid Peak, Abiathar and Amphitheater Peaks to lower Abiathar Peak, The Thunderer to the slopes of Mt. Norris, and Barronette Peak to the ridges of Barronette above Pebble Creek campground. These appeared to be natural routes from the highest part of a mountainous ridge to the lower parts of that same ridge. The routes offered almost continuous rocky terrain with few if any wooded areas to pass through.

Not all bighorn sheep moved between summer and winter ranges. Gammill (1941) observed sheep that remained the entire year on Mt. Washburn, Mt. Everts, Terrace Mountain and Druid Peak. I do not believe bighorns remained on Mt. Washburn the entire year; however, a ewe group of 11 ewes remained on Mt. Everts during the year, and at least one ewe was on Druid Peak winter range much of the summer.

Couey (1950) reported that the spring migration to the summer range began in late April or early May prior to lambing. This was true for the Yellowstone bighorns. Rams began moving before the ewes. Rams on Mt. Everts moved to the Gardiner River south of the Sheepeater Bridge, then to Terrace Mountain in late April. Their attempts to migrate were temporarily stalled by an early May snowstorm which caused them to return to the Gardiner River area. A group of ten rams which

moved to a rock outcrop along the Lamar River across from Specimen Ridge in early April left that area in early May, probably crossing the Lamar River and going to the rocky points next to Slough Creek.

Herd Composition

Throughout most of the year, rams and ewes remained in separate groups and did not mingle. The ewe groups consisted of the lambs, yearlings, young rams, and ewes. The ram groups were composed of the larger rams, usually with more than one-half curl. In October the sexes began mingling together, and rams and ewes were often observed grazing side by side. In late January the rams began re-forming their groups and separating from the ewe groups. Young rams that had been with the ewe groups up to the breeding season left the ewes for the ram groups after the breeding season. On two occasions, late in the winter, a ram lamb was observed with a group of six rams which had separated from the ewes on Crystal Creek. This group of rams appeared to make a definite effort to remain apart from the ewe group although both were confined to a relatively small area because of the deep snow surrounding the area. McCann (1956) observed that the two sexes appeared to make a positive effort to remain apart during the summer and late fall. This appeared true during the winter in Yellowstone, too.

The size of the herd groups varied greatly. The average size of the 152 groups classified was 8.7 animals. Sixteen single animals were observed and only three of these were ewes. The largest group was made up of 38 sheep and was observed during the breeding season on Specimen Ridge. The largest ewe group observed was composed of 32 animals. Smith (1954) suggested that there were no definite herds in areas of

relative bighorn abundance on the Salmon River sheep range in Idaho. On Mt. Everts, five groups were observed on one day; several days later the entire herd was together in one group. This was true to a lesser extent with the Yellowstone River and Specimen Ridge herds whose distribution was governed more by deep snow than was the Mt. Everts herd. Of the bighorns in the Soda Butte Creek herd, only those on Mt. Norris moved between groups and exchanged group composition.

Daily Activities

Activity Patterns

Throughout the winter the numbers of bighorns feeding and resting and the time of observation were recorded. Two peaks of feeding appeared to occur. A morning feeding period was from 10:00 a.m. to 1:00 p.m., while the afternoon peak was from about 3:00 p.m. until about dusk. From 1:00 p.m. until 3:00 p.m. most sheep were found resting. At almost any time of the day some sheep were feeding while the others were lying down. Blood (1963) found that there were three peaks of activity in the winter, while Mills (1937) thought that when snow was deep, sheep grazed the entire day.

Weather often affected the feeding activities. On both Upper Chalcedony Creek and Mt. Norris, bighorns were observed to move into shelter when snow and wind began. After the storm was over, they moved back into the open to resume feeding. Small patches of conifers and deep ravines were used as shelter from snow and wind.

Local Movements

Simmons (1961) observed local drift or limited migration during the day. He observed Poudre River bighorns to have a mean daily cruising radius of 832 yards. He also observed that they moved constantly while grazing. Blood (1963) reported that California bighorns moved about one-eighth mile per day. During the early winter, Yellowstone bighorns were not restricted in their movements and sometimes moved up to a mile in a day. However, when deeper snows restricted them, daily movements fell into the one-eighth mile category described by Blood. Bighorns on MacMinn Bench were much less restricted than those at higher elevations and were free to move throughout the bench all winter. Their daily movements were somewhat greater than sheep elsewhere on the northern winter range.

Limited movements resulted in most sheep spending night after night in the same bedding areas. This was especially true on Specimen Ridge, Druid Peak, Mt. Norris, Barronette Peak, and Abiathar Peak where snow placed so much restriction on movement.

Interrelationships with Other Animals

Bighorns came into contact with other animals--often with complete indifference. They were observed grazing close to or even side by side with elk, pronghorn, mule deer, and bison. The flightiness of pronghorn or any other animal sent sheep into flight before they normally would have fled. Pronghorns dashing across MacMinn Bench often sent complacently grazing bighorns running for steeper terrain.

Bighorns seemed to hold no fear for other animals except when the other animal was between it and escape terrain. Three sheep were

grazing away from the cliff at the Druid South Slope site when three elk approached the site from the ridge near the cliff. The sheep immediately began grazing toward the elk and the cliff, and when they were about 50 feet from the elk, they suddenly dashed toward the cliff. Once at the cliff, the bighorns again began grazing. Coyotes were observed standing or sitting within 20 feet of sheep grazing near escape terrain. Coyotes caused concern only when they were between the bighorn and escape terrain or when the sheep were not close to escape terrain.

According to Moser (1962) magpies could be found in the vicinity of bighorns at almost any time of the year. I observed magpies sitting on bighorns several times. On the slopes of Crevice Creek two magpies flew from the back of one sheep to another. When the bighorn tossed its head the magpies flew to another. The picking that magpies do on the sheep's back reportedly is for ticks and mites. Smith (1954) noted that this may cause sores on the bighorn as it does on domestic livestock.

Chapter VIII

MANAGEMENT

The objectives of the National Park Service are to protect and manage all the naturally occurring resources in such a way that their continuance is assured. Certainly bighorn sheep, with relatively small numbers, should be near top priority in preservation. In Yellowstone National Park, where the species naturally occurs, and probably always has occurred, it cannot be left to struggle along on its own. Management objectives should be not only to maintain present numbers, but to increase the population size if at all possible. Bighorn sheep are among those species with lower birth rates. Unlike mule deer and pronghorn, they seldom produce twins. Unlike elk, they do not have large population numbers which assure large numbers of offspring each year. Therefore, the environment must be managed so that hostility toward bighorns is not severe. In this way the reproductive potential can more likely be achieved. Proper management of the vegetation resources on which bighorns feed may be a first step in prolonging the natural existence and increasing sizes of those populations in Yellowstone.

In many locations in which bighorn populations are present, hunting is an important management tool in reducing surplus rams and in scattering herds into smaller groups. The value of scattering is to keep large groups from accumulating on limited ranges. In the National Parks hunting is not allowed and management to control and manipulate populations must be performed in ways other than by hunting. Information about the vegetation on bighorn winter range is necessary and valuable in properly evaluating the influence animals have on their surroundings.

Improvement trends also may be detected, especially with the large scale elk reductions which have taken place and with any reduction taking place in the future. The primary management recommendation for bighorn sheep in Yellowstone National Park is that permanent range study transects be installed on important wintering locations, and that these transects be sampled at five-year intervals. Three important locations are the key winter ranges examined during this study: MacMinn Bench, Specimen Ridge, and Druid Peak. Two other locations would produce additional important data about bighorn winter ranges: the southern-most end of Mt. Norris and lower Little Buffalo Creek.

During the summer of 1966, the biologists at Yellowstone National Park began sampling vegetation with 2X5 decimeter plots and 10-point frames on line transects. This combination appeared to be more efficient and accurate than the combination I used, and I suggest it be used to sample vegetation on bighorn winter ranges in the future. In conjunction with the permanent transects, pellet group counts and utilization estimates on key plant species should be made annually to establish a trend on ungulate use.

Censuses of the bighorn population are necessary to keep abreast of population fluctuation and trend over a period of years. In the past, bighorn censuses have been conducted in conjunction with the elk censuses. Since it is difficult, at best, for observers during the elk census to look for bighorn sheep at the same time, I suggest that the bighorn census be taken separately from the elk census. Observers or counters should be experienced personnel who can differentiate bighorn sex and age groups from the air. These censuses should be taken no

less than once every three years. More frequent censuses would be preferable. Helicopters, though expensive, would provide the most accurate transportation for censusing. The maneuverability of the helicopter is ideal in helping sex and age bighorn sheep.

Although competition between bighorns and elk was light during the study period, continued reduction of the elk population is recommended until critical winter ranges begin to improve. A severe winter probably would result in large numbers of elk moving onto bighorn winter range in direct competition with sheep. Bighorn populations in Yellowstone never will increase permanently until there are adequate winter ranges for larger populations during severe winters. As long as there are large populations of elk on critical bighorn winter ranges, this increase will never come.

Further research into bighorn winter ecology is needed. The U.S. National Park Service (1964) recommended studies which cover all facets of bighorn ecology. Of prime need is further research into the relationships between bighorns and other ungulates. Only general hypotheses can be made about the influence other ungulates, especially elk, have on bighorns under severe winter conditions. Since these conditions are most likely to have a detrimental effect on the bighorn population in Yellowstone, their influences should be closely examined.

Chapter IX

SUMMARY

Bighorn sheep have been an important part of the wildlife in Yellowstone National Park for many years. Early trappers, miners, and Indians depended on bighorns to a large extent for food and clothing. In the last half century numbers of bighorn in Yellowstone have not been high. While some estimates put populations as high as 500 animals, the largest counted population was 346 animals, and within two years the number fell to 77. The average number of bighorns on the range over the past 20 years has been approximately 186.

This bighorn sheep study was conducted in Yellowstone National Park, Wyoming during the period June 1965 to June 1966. The objectives of the study were to census the bighorn population, obtaining age and sex ratios; map the winter distribution of sheep; determine plant composition and plant utilization on important winter ranges; observe daily feeding habits; and assess the effect of competition on bighorn sheep.

The study was conducted in the northern fifth of Yellowstone National Park. In general, the study area was divided by the important rivers in that part of the Park. These rivers were Pebble Creek, Soda Butte Creek, the Lamar River, Yellowstone River, and Gardiner River. Three areas were located for the range study; they were MacMinn Bench, Specimen Ridge, and Druid Peak. Four range study sites were established on MacMinn Bench, three on Specimen Ridge, and three on Druid Peak.

Other than a helicopter census in April 1965, and brief helicopter use during the winter of the study, all work was done on foot. A sample

to determine range composition was conducted using the point-step method and 2X5 decimeter plots. Utilization of key grass species was determined by using the Region 1 Gauge and grazed plant method. Browse utilization was estimated on each site by determining the per cent of twigs browsed on each of 50 plants. Pellet group counts were made on each site to estimate animal use. Food habits data were obtained by feeding site examination. Examinations after fresh snowfall were found to provide most accurate results.

Yellowstone bighorns wintered in four types of habitat. The 50 bighorns on Mt. Everts occupied MacMinn Bench most of the winter. The area was a rolling grassland, and bighorns were seldom close to escape terrain. Open sagebrush grassland near rocky outcrops and steep open timbered slopes were characteristic habitat occupied by the 49 bighorns along the Yellowstone River. This habitat extended over 20 miles from Reese Creek to Slough Creek. Specimen Ridge is a large sagebrush grassland bordered on the north and west by steep slopes of Douglas-fir. A narrow bunchgrass grassland lies between the timber and the browse, and bighorns utilized this grassland almost exclusively because of the deep snows elsewhere on the ridge. Adjacent timbered slopes and cliffs offered escape terrain to 48 bighorns. The valley of Soda Butte Creek is bordered by low windblown shoulders of several mountains. Many of these shoulders and ridges were occupied by some of the 84 bighorns in that area. Winter range was narrow bands of grassland on ridge tops between steep cliffs and deep snows at the edges of the ridges.

During the winter, 229 bighorns were counted on the northern winter range. This was an increase of seven from the helicopter census of April 1965.

Six winter range sites provided locations for sampling plant composition, plant utilization, and animal use. On MacMinn Bench needle-and-thread grass and winterfat were important for both range composition and utilization. The relative plant density was "fair" with grass species constituting desirable species and most forbs falling in the least desirable category. Plant utilization over the bench was in an allowable range, except for Junegrass which received over 60 per cent utilization. Snow cover on critical bighorn range was light. Bighorns were the most numerous and long-staying ungulate on the range.

On Specimen Ridge snow cover had more influence in governing bighorn distribution than the snow cover on MacMinn Bench. Idaho fescue and Douglas rabbitbrush were more important on Specimen Ridge than elsewhere on the winter range. The relative plant density was highest on Specimen Ridge; however, pussytoes, fleabane and phlox were important range plants. Utilization on the area was higher than Cole (1958) thought allowable. Both grasses and browse received heavy utilization. Elk were more numerous on Specimen Ridge than on any other area, and they were on the winter range longer than the bighorns. Pellet group counts showed more elk than bighorn use on Crystal and Quartz Creeks.

Bighorns were the sole ungulate using the Druid Peak bighorn range. Deep snows next to the ridge tops greatly confined bighorns and limited their distribution. Plant composition was poorest on Druid Peak. More intermediate and least desirable forbs and browse were sampled. Plant utilization varied greatly. The South Slope site grasses received over 80 per cent utilization and Douglas rabbitbrush received 90 per cent utilization of current annual growth.

Breeding activities began in October when half-curl rams reached the winter range. The height of the rut did not occur until early December. The gestation period was 180 days, and ewes moved into the most rugged terrain available in late May to lamb.

The largest portion of the bighorn's diet was composed of grasses. Grasses made up 61.4, forbs 17.2, and shrubs 21.5 per cent of their diet. Bluebunch wheatgrass was eaten by bighorns more often than any other plant species. Other important grasses were Junegrass, needle-and-thread grass, Idaho fescue, and bluegrass. Phlox was the most important forb. Milkvetch and lupine also were important forbs used for food. Winterfat and Douglas rabbitbrush were highly preferred browse species. Winterfat was browsed only on MacMinn Bench and Douglas rabbitbrush elsewhere.

Habitat occupied by 1,204 bighorns was described as to exposure, terrain, vegetative type, and distance from escape terrain. Sheep preferred south, southwest and west facing slopes in steep rocky terrain or ridge tops. Grasslands within 100 yards of escape terrain were the preferred vegetative type; however, sheep quickly moved into timber when frightened.

Total competition between elk and bighorns in Yellowstone during the study was mild. Elk and sheep were not forced to occupy the same ranges for long periods of time because of the light snowfall. Elk used sheep range on Quartz Creek, Crystal Creek, and Mt. Norris more than any other areas in the northern range. Elk tended to paw through deeper snow in search for better forage than they could find on bighorn range. This reduced competition for the same forage species. Grass and browse utilization over much of the range was not within acceptable limits,

indicating some shortage of forage. MacMinn Bench was not overgrazed, while Specimen Ridge and Druid Peak were overgrazed. Competition on Druid Peak was intraspecific. Competition on Specimen Ridge was between elk and sheep. Competition between bighorn sheep and pronghorn and mule deer was light and probably of no consequence to sheep. Other limiting factors such as predation and disease had little effect on bighorns during the winter.

The Yellowstone bighorn population is stable, and it fluctuates very little from year to year. The ewe-lamb ratio was relatively high at 100:47. The ewe-yearling ratio (100:20) was lower than most other researchers had reported. Most indications were that the previous year's lamb crop suffered high mortality. The ewe-ram ratio was 100:78. Some researchers have reported that the ratio should favor rams in unhunted herds; however, bighorn population data in Yellowstone have never supported this.

The date of arrival on the winter range varied from October 1 to early December. The longest known migration was from Mt. Washburn to Mt. Everts, a minimum distance of 18 miles. Spring migration began in late April and early May.

Proper management of bighorn sheep in Yellowstone is essential to increase the population. Permanent range study transects should be installed. Preferable locations would be MacMinn Bench, Specimen Ridge, and Druid Peak. In conjunction with these transects, plant utilization and pellet group counts should be made annually. Helicopter censuses of the bighorn population on the winter range should be made at least every two or three years. These censuses should be made separate from

elk censuses. Continued reduction of the northern Yellowstone elk herd is necessary until the winter ranges respond to lower ungulate use. Further studies on elk-bighorn relationships are desirable.

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APPENDICES

APPENDIX A

Bighorn Sheep Field Form

Location _____ Index No. _____

Weather _____ Observer _____ Date _____

Number of Rams: Ewes: Lambs: Yearlings: Other:

Competitors	Immediate Vicinity	Adjacent	Present

Snow Depth		Food Habits						
		Species Observation						
Edge								
North Slope								
South Slope								

Remarks: _____

APPENDIX B

Supplemental Food Habit Observation Form

Location _____ Index No.____

Species Observations

APPENDIX C

Bighorn Sheep Habitat Description Form

Index Number														
Time														
WEATHER														
Clear														
Cloudy														
Snowy														
Windy														
	Number of Sheep													
EXPOSURE														
South														
Southeast														
Southwest														
West														
East														
North														
TERRAIN														
Steep														
Rocky														
Ridge top														
Hilly														
Level														
VEGETATIVE TYPE														
Timber														
Grass														
Shrub														
ESCAPE HABITAT														
Occupying														
100 yards														
100 yds-¼ mile														
¼ mile														
ACTIVITY														
Resting														
Grazing														
Fleeing														
OTHER														

APPENDIX D

Point Quadrat on Paced Transect

Area: _____ Transect Bearing: _____

Site: _____ Observer: _____

Transect: _____ Date: _____

Plant Species:	Hits	Total
Grasses:		
Forbs:		
Shrubs:		
Litter:		
Bareground:		
Rock:		
Erosion pavement:		

APPENDIX E

2X5 Decimeter Quadrats

Area: _____ Transect Bearing: _____

Site: _____ Observer: _____

Transect: _____ Date: _____

Plant Species:	Quadrat										Total
	1	2	3	4	5	6	7	8	9	10	
Grasses:											
Forbs:											
Shrubs:											