THESIS

SUMMER ECOLOGY OF BIGHORN SHEEP IN YELLOWSTONE NATIONAL PARK

Submitted by

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In partial fulfillment of the requirements

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ABSTRACT

SUMMER ECOLOGY OF BIGHORN SHEEP IN

YELLOWSTONE NATIONAL PARK

A study of the summer ecology of bighorn sheep was conducted in Yellowstone National Park, Wyoming, from June 1966 to September 1967. Study objectives were to census the bighorn population, map the summer distribution, determine summer herd structure and behavior, observe daily feeding habits, and determine the effects of competition on summer ranges. The minimum number of bighorn summering in Yellowstone Park is 558. There were seven main summer herds: the NE herd, the lower Yellowstone and North park herd, the Washburn-Canyon-Specimen herd, the Gallatin herd, the NW herd, the East boundary herd, and the Bechler herd. Most summer range was in the northeast part of Yellowstone Park. Migrations to summer ranges was incomplete in some cases, and the sheep displayed tolerance for a variety of summer habitats. Ewe herd (includes yearlings):lamb ratios were 100:59 in 1966 and 100:48 in 1967. The 1967 ewe:yearling ratio of 100:28 indicated favorable yearling survival from 1966. Grasses, grass-like plants, and forbs formed the bulk of the summer diet. Carex hepburnii was the dominant plant on subalpine summer ranges and was the staple food throughout the summer. In one study site, grasses made up 80.9 and forbs 19.1 per cent of the diet. Interspecific competition was negligible during the study, but potential competition exists between

bighorn and elk for space. The greatest potential danger on summer ranges may be intraspecific competition resulting in reduced tolerance to diseases and parasites.

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CHAPTER I

INTRODUCTION

Reasons for the study

The Rocky Mountain bighorn sheep (Ovis canadensis canadensis Shaw) is a relatively rare species that once inhabited the western United States in much larger numbers. Their numbers have declined as available range has diminished. Yellowstone National Park is one of the important remaining wilderness areas for bighorn sheep. It is a stated objective of the National Park Service that "a national park should represent a vignette of primitive America." Bighorn sheep are an important component of the park's ecosystem. Knowledge of the status of a species is required before an effective management plan can be formulated. Oldemeyer (1966) recently completed a study of the winter ecology of bighorn sheep in Yellowstone Park. My study was initiated to fill in a niche of missing information on the summer ecology of the bighorn sheep.

The study objectives were to census the bighorn population in Yellowstone Park, map the summer distribution, determine summer herd structure and behavior, study summer food habits, and determine the amount of competition with other ungulate species on summer ranges in northern Yellowstone National Park.

History of bighorn sheep

The bighorn sheep are one of four groups of wild sheep living today. The other three groups are the mouflon, inhabiting parts of Europe and Asia Minor; the urial group inhabiting the area from Turkey to western Tibet; and the argali group inhabiting the area from Bokhara to Kamchatka (Zuener, 1963).

Sushkin (1925) believed that the oldest sheep is Ovis ophion, and the center of dispersal of sheep was from the area that is now Cyprus. The argali sheep (Ovis ammon) is the largest wild sheep and is probably the ancestral group of our present bighorn (Zuener, 1963).

The earliest remains of the genus Ovis in North America date from middle Pleistocene time (Cowan, 1940). Ovis nivicola of northeastern Asia probably represents the Asiatic descendant of the sheep ancestral to those of North America according to Cowan (1940). Probably Ovis nivicola reached North America across the Bering Sea land bridge in late Pliocene or early Pleistocene time, or may even have crossed the ice more recently. Once in North America, the continuous mountain chains extending from Alaska southward provided a habitat that would permit a rapid extension of range (Cowan, 1940). If natural movement did not occur, the Wisconsin glaciation during the Pleistocene may have pushed them south (Buechner, 1960). Development of the cordilleran ice cap removed the territory available to sheep in the area from 45 to 62 degrees north latitude. Northern groups were restricted to northern Alaska and differentiated into Ovis dalli while the group south

of the ice cap differentiated into Ovis canadensis (Cowan, 1940). The range of the two species of sheep in North America is now separated by about 100 miles. Ovis dalli ranges as far south as 56 degrees north latitude near the Peace River in British Columbia, while Ovis canadensis ranges north to some 120 miles south of the Peace River (Cowan, 1940).

Cowan (1940) recognized seven subspecies of Ovis canadensis in North America: Audubon bighorn (O. canadensis auduboni Audubon), now extinct; Weems bighorn (O. canadensis weemsi Goldman); Peninsula bighorn (O. canadensis cremnobates Elliot); Mexican bighorn (O. canadensis mexicana Lydekker); Nelson bighorn (O. canadensis nelsoni Merriam); California bighorn (O. canadensis californiana Douglas); and the Canada bighorn (O. canadensis canadensis Shaw).

The Canada bighorn, or Rocky Mountain bighorn sheep, is the largest of the North American bighorn sheep and carries the most massive and impressive set of horns. The type locality is near Banff, Alberta, Canada (Moser, 1962). Cowan (1940, p. 533) reported the range of the Canada bighorn: "in Canada confined to the Rocky Mountains in which it ranges north to the vicinity of Wapiti Pass some 120 miles south of the Peace River; south through western Montana, eastern Idaho, Utah, and into Colorado."

History of bighorn sheep in Yellowstone National Park

Some controversy exists concerning the abundance of the Rocky Mountain bighorn sheep (Ovis canadensis canadensis Shaw) during historical times. Early workers (Grinnell, 1928; Rush, 1932; and

others) believed that bighorn never were abundant in mountainous regions of the west. They believed that the sheep were forced into the rugged mountain areas during the late 1800's by hunting pressure and the loss of habitat to advancing civilization. Other studies and observations indicate that this may be an erroneous view. In Journal of a Trapper by Osborn Russel (Haines, 1964), mention is made of the abundance of bighorn sheep during the 1830's. This journal specifically referred to areas that are now Yellowstone National Park and to areas immediately surrounding the present park boundaries. Bighorn sheep were reported in the Yellowstone area at an even earlier date. In The Yellowstone National Park (Chittenden, 1964) it is reported that the Sheepeater Indians, a branch of the Shoshonean family lived in the park long before the white man discovered it, and their principal food was the flesh of the mountain sheep.

In the Park Superintendent's Report of 1881, Harry Yount, the Game Keeper, stated that "bighorn sheep are found on all the mountain slopes" (U.S. National Park Service). The Superintendent's Report of 1887 also contained the same observation, although no mention was made of numbers of sheep. Mills (1937), Murie (1940), and Buechner (1960) also believed that bighorn sheep were more abundant in primitive times than they have been since the early 1900's.

The decline of the Yellowstone National Park bighorn herd began during the late 1800's (Murie, 1940; Buechner, 1960). This decline was attributed to the combined effects of hunting pressure outside the park and the influence of disease, parasites, and competition

for winter range inside the park boundaries. Since 1900, the bighorn herd in Yellowstone has been relatively low. Table 1, showing numbers of bighorn sheep in the park, was compiled from park records, Mills (1937), Buechner (1960), and Oldemeyer (1966). Oldemeyer's 1966 census was taken on bighorn winter range in the northern part of the park. He estimated the herd size to be around 250 to 275. Figures given in Table 1 vary considerably in reliability and accuracy. Numbers for 1903 through 1916 are apparently estimates, and from 1922 to 1927 counts were based on estimates. Since 1927 they represent actual counts, but for reasons of weather and other factors, counts were sometimes inaccurate. Numbers for 1939 through 1955 are based on carefully conducted counts in all areas of the northern part of the park and represent the most accurate data. All counts contained in Table 1 are winter counts.

Table 1. Numbers of bighorn sheep in northern Yellowstone National Park, 1903 - 1966 (U.S. National Park Service, 1964; and Oldemeyer, 1966).

Year	Number	Year	Number
1903*	100	1934	125
1905	100	1935	126
1907	200	1936	118
1911	250	1937	175
1912	210	1938	181
1916	200	1939	219
1922**	233	1940	272
1923	200	1941	200
1923	217	1943	138
1925	195	1945	203
1926	217	1946	176
1927***	346	1948	176
1928	170	1949	144
1929	77	1955	192
1930	125	1956	121
1931	101	1961	118
1932	78	1962	148
1933	82	1966	229

*1903 to 1916 counts based on estimates.

**1922 to 1927 based on partial counts.

***1927 to 1933 based on actual counts.

CHAPTER II

PHYSICAL DESCRIPTIONS

Bighorn sheep

Conformation and size

Rams weigh from 250 to 300 pounds, and ewes weigh from 125 to 200 pounds (Honess and Frost, 1942). Moser (1962) described the bighorn as a stockily-built animal with large rams standing 42 inches at the shoulder and weighing 300 pounds, and large ewes standing 35 inches at the shoulder and weighing 130 pounds. Table 2 contains size data of bighorn sheep examined in Yellowstone National Park by Greer (1931).

Table 2. Weights and proportions of bighorn sheep reported by Greer (1931).

	Rams	Ewes
Body length	60-70 inches	54-60 inches
Tail vertebrae	5 inches	4-3/4 inches
Hind foot circumference	15-16 inches	15-1/2 inches
Height at shoulders	38-42 inches	-
Weight	200-300 pounds	125-175 pounds

Horns

The horns of bighorn sheep are true horns and increase in length and girth yearly without being shed. Moser (1962) described ram's horns as massive, and characterized by a flat spiral. The heavy bases taper very slowly. Horn size of rams measured along the front curve averages from 36 to 38 inches (Greer, 1931). The horn color varies from dull grayish-brown to yellowish (Honess and Frost, 1942).

Pelage and color

Bighorn sheep shed winter pelage resulting in a seasonal difference in appearance. Couey (1950) reported that bighorn sheep in Montana shed slowly from May to July. Moser (1962) reported that in Colorado the shedding is usually complete by June.

My observations in Yellowstone indicate that shedding is not complete until late July. Four adult ewes observed on Mount Everts on July 13, 1966 still had over 50 per cent of their winter coat remaining. Two yearling rams present had completely shed, and presented a sleek rusty brown appearance. On July 15, 1966, I observed nine adult ewes on Mount Washburn. One ewe was nearly in her summer coat, and only retained remnants of the winter coat on her shoulders. The remaining ewes still had one-fourth or more of their winter coats remaining (see Figures 1 and 2). On July 28, 1966, 14 adult ewes were observed on Mount Washburn. One ewe still retained about half of her winter pelage, but all others had shed most of their winter coats. None of the adult bighorn sheep observed during the summer of 1966 completed shedding prior to the end of July.

Figure 1. Ewe groups observed on Mount Everts on July 13, 1966 showing change from winter to summer pelage.

Figure 2. Ewe with about 40 per cent of her winter pelage remaining - July 20, 1967.

The color of bighorn sheep reported as follows by Greer (1931, p. 2), closely matches my own observations:

> Upper Parts: Brownish to grayish-brown; darkest on throat, neck, and back to end of tail; sides slightly paler than back; rump patch creamy white.
> Under Parts: Yellowish-white with broad encroachment of brown from sides and heavy wash of sooty brown on chest and sides of legs.
> Color markings of ewes are similar to rams but usually are less strongly marked.
> Seasonal variations are darker shades in the fall or late summer to much lighter coats in the spring when wear has removed the dark tip of hair.

Yellowstone National Park

Geologic history and geology of Yellowstone Park

Generally, the park can be described as a high volcanic plateau, ranging in elevation from 6,000 to 8,000 feet, bounded on all but the southwest side by high mountain ranges. The Beartooth and Snowy Ranges form the north border, the Absoraka Mountains lie to the east, the Gallatin Range forms the northwest border, and the Teton Range lies to the south. The highest elevation within the park is Eagle Peak (11,360 feet), along the east boundary in the Absoraka Range.

Viewed in relation to its geologic history, which encompasses over two billion years, only the more recent events of volcanic activity and Pleistocene glaciation have been really significant influences on the present landscape (Bauer, 1948). The oldest rock is Precambrian granite and gneiss which underlies the entire park. In the northern part of Yellowstone Park, this rock is exposed in the Hellroaring Mountain area, on the Buffalo Plateau,

and in the Slough Creek area. Elsewhere, this foundation rock is covered by other and more recent rocks.

During most of Paleozoic and Mesozoic time, seas covered the area, and a great thickness of marine sediments were deposited. These sedimentary rocks, today are exposed in the Gallatin Range.

Toward the end of the Mesozoic Era, the Rocky Mountains rose, the inland sea drained away, and the present park landscape began to take shape (Bauer, 1948). Throughout early Cenozoic time, thousands of feet of andesitic volcanic breccias were erupted and deposited to form a high volcanic plateau. By late Cenezoic time, this plateau was deeply eroded to form rugged mountains which were partially inundated by vast floods of rhyolite to form the Yellowstone Plateau (Dr. H. J. Prostka, USGS, verbal communication, 1967).

Finally, around one million years ago, during Pleistocene time, glaciers advanced and retreated over the terrain producing the land forms visible today. The Yellowstone area is still volcanically active, and additional volcanic eruptions may again overshadow the present processes of wind and water erosion which are constantly changing the landscape (Dr. H. J. Prostka, USGS, verbal communication, 1967).

The northeast portion of the park is in the western edge of the Absoraka Mountains, and is the most rugged part of the park. This mountainous area is composed primarily of stratified volcanic breccias and tuff deposited during early Tertiary time. Locally, this breccia is overlain by basaltic lavas. The intensive study areas, Thunderer and Cutoff Mountains, are composed of these stratified volcanic rocks.

Biotic communities of Yellowstone Park

Bailey (1930) described four life zones in Yellowstone Park: the Transition, Canadian, Hudsonian, and Arctic-Alpine zones. The largest area of Transition zone occurs along the Gardiner, Yellowstone, and Lamar River valleys in the northern portion of Yellowstone Park. This zone extends to 7,500 feet on SW slopes, and 6,500 feet on the NE slopes. The Transition zone is a grassland-sagebrush community. A century ago this area was covered with stands of prairie grasses. Dominant species were bluebunch wheatgrass, bluegrass, giant wildrye, and needlegrass (Harry and Dilley, 1964). It is believed that this community was originally a detached portion of the Palouse Prairie in Northern Idaho (McDougall and Baggley, 1956). Overgrazing over the last half century has modified this community, and now sagebrush is the dominant vegetation (Harry and Dilley, 1964). Bailey (1930) emphasized the value of this zone to the large ungulate species because of the relatively mild climate and light snowfall.

The Canadian zone covers the greatest part of the park from 6,500 to 8,000 feet on NE slopes and 7,500 to 9,000 feet on SW slopes (Bailey, 1930). This zone includes the three general conifer forests that occur in northwest Wyoming; Douglas-fir, Spruce - Fir forest, and Lodgepole Pine forest. Lodgepole is the most extensive forest type in the park because of a period of wide spread fires near the turn of the century (Harry and Dilley, 1964). In this zone, between the upper edge of the sagebrush-grass, and the coniferous forest lies the aspen groves.

The Hudsonian zone is a relatively narrow belt of scrubby tree growth just below timberline from 8,000 to 9,000 feet on NE slopes, and from 9,000 to 10,000 feet on SW slopes (Bailey, 1930). This zone consists of steep rocky slopes, and broad flower-covered areas where bighorn and elk summer (Bailey, 1930). These flower covered areas appear to be above timberline, but they are not, and are not considered to be true alpine meadows. Harry and Dilley (1964) call these Hudsonian zone meadows "upland herb meadows." These meadows are found on many level to south facing high plateaus and mountain ridges from 8,000 to 10,500 feet.

Bailey (1930) described the Arctic-Alpine zone as being above timberline, and devoid of timber or any upright shrubby vegetation. Timberline in Yellowstone Park is at approximately 10,000 feet (McDougall and Baggley, 1956). Buechner (1960) believed that the only true alpine meadow in Yellowstone Park was located above timberline on Mount Washburn.

Climate of Yellowstone Park

The climate of Yellowstone National Park is semi-arid, modified by the high altitude and mountainous terrain.

The summer climate in the northern part of the park is mild and dry. The average yearly precipitation at the Lamar Ranger Station is approximately 14 inches. During the summer of 1967, I recorded daily temperatures at the 10,500-foot level with a Taylor maximum-minimum recording thermometer. Table 3 contains the weather data recorded for two periods during the summer of 1967.

Table 3. Average temperatures in northern Yellowstone Park, summer 1967.

Dates	Area	Altitude	Temperatures (degrees F.) Noon	Maximum	Minimum
6-21 July	Thunderer	10,500'	61.6	66.6	44.5
7-17 August	Cutoff Mt.	10,500'	65.0	70.4	48.1

The average temperatures listed in Table 3 clearly indicate that the peak summer temperatures are reached in August, although the temperatures are mild in the high mountain country by July. The minimum temperature recorded in July was 38 degrees F., and the maximum recorded was 74 degrees F. In August, the minimum temperature was 40 degrees F., and the maximum recorded temperature was 74 degrees F.

Snowfall is heavy in the mountainous areas of northern Yellowstone Park. Annual snowfall averages nearly 150 inches between 7,000 and 8,500 feet (U.S. Weather Bureau, 1960) and is greater at the higher elevations. With the exception of lingering snowdrifts in sheltered areas, the mountain tops are generally clear of snow before the end of June.

Intensive study areas

The Thunderer

The Thunderer (Figure 3), is a prominent terrain feature in northeast Yellowstone Park bounded on the east by Cache Creek, and the west by Soda Butte Creek. Raising to a peak of 10,554 feet

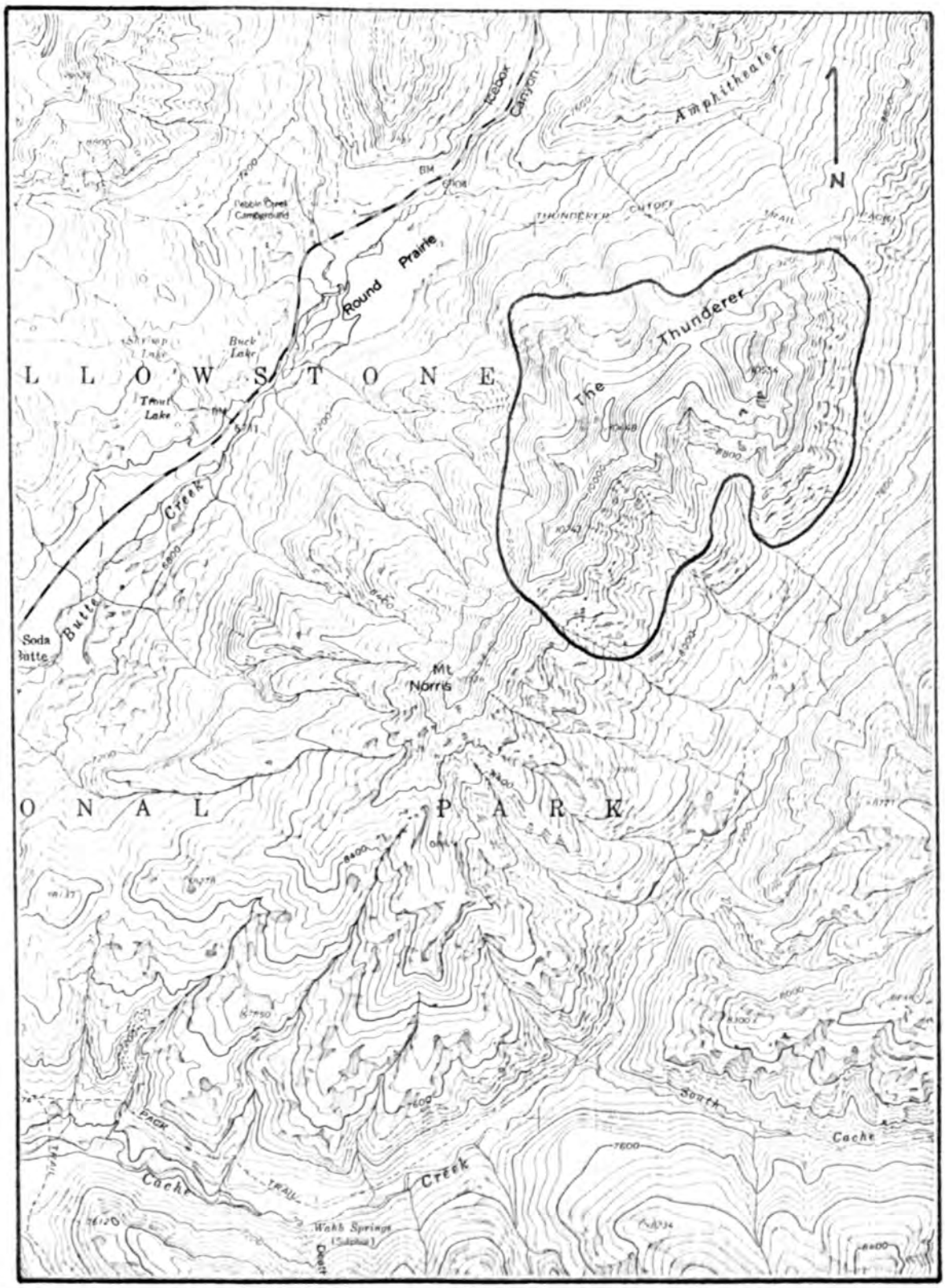

Figure 3. Intensive study area on The Thunderer in NE Yellowstone National Park.

from the valley floor about 3,500 feet below, The Thunderer was summer range for both ram and ewe groups.

The bedrock of The Thunderer is volcanically derived sedimentary rocks: sandstones, conglomerates, and tuffs. This bedrock is capped by basaltic lava flows. The sedimentary layers date from the middle Eocene epoch. The subdued, subalpine meadow tops are the old erosion surfaces dating from Miocene to early Pliocene time. During the late Pliocene epoch, the area rose and streams incised the area initiating the present topography. During Pleistocene time, glaciation deepened and widened the valleys producing steep slopes, and landslides caused by melting ice helped to form the present cliffs (Dr. H. J. Prostka, USGS, verbal communication, 1967). Differential weathering has eroded out the less resistant interbedded tuffs and volcanic sandstones, while the more resistant volcanic breccias, conglomerates, and basalt flows remained to form the present ledges, overhangs, and caves used by bighorn sheep. The top of The Thunderer, and the north, east, and west slopes respectively, are shown in Figures 4, 5, 6, and 7.

The vegetative cover of the portions of The Thunderer used by bighorn sheep for summer range is typical of the subalpine areas in Yellowstone Park. Scattered stands of stunted and deformed White-bark Pine (Pinus albicaulis), Sub-alpine Fir (Abies lasiocarpa), and Engleman Spruce (Pices engelmannii) grow to within 200 feet of the summit. White-bark Pine was in much greater numbers than the other two species. Carex hepburnii was the dominant grass-like plant while cinquefoil (Potentilla nelsoniana) was the dominant forb and the most conspicuous plant when I was on The Thunderer in July.

Figure 4. The south facing cirque on top of The Thunderer.

Figure 5. Aerial photo of the north wall of The Thunderer.

Figure 6. The east slopes of The Thunderer.

Figure 7. The west slopes of The Thunderer.

Cutoff Mountain

Cutoff Mountain (Figure 8) also is located in the northeastern portion of Yellowstone Park. The mountain is a continuation of the Druid Peak - Mount Hornaday complex and extends just north of the park boundary. Cutoff Mountain is bounded on the east by Pebble Creek and the west by Slough Creek. The slopes of Cutoff Mountain rise to the 10,691-foot summit nearly 3,700 feet from the valley below. The gently sloping top and shear sides of Cutoff serve as summer range for more than 50 ewes, lambs, yearlings, and young rams.

The geology and geologic processes that formed Cutoff Mountain are identical to The Thunderer with the exception that Cutoff is not capped by a lava flow. The vegetative cover of Cutoff Mountain also was very similar to The Thunderer. The major differences were that trees were scarcer on Cutoff, and Arenaria obtusiloba was the dominant forb. Figures 9 and 10 show the top and east slopes respectively of Cutoff Mountain.

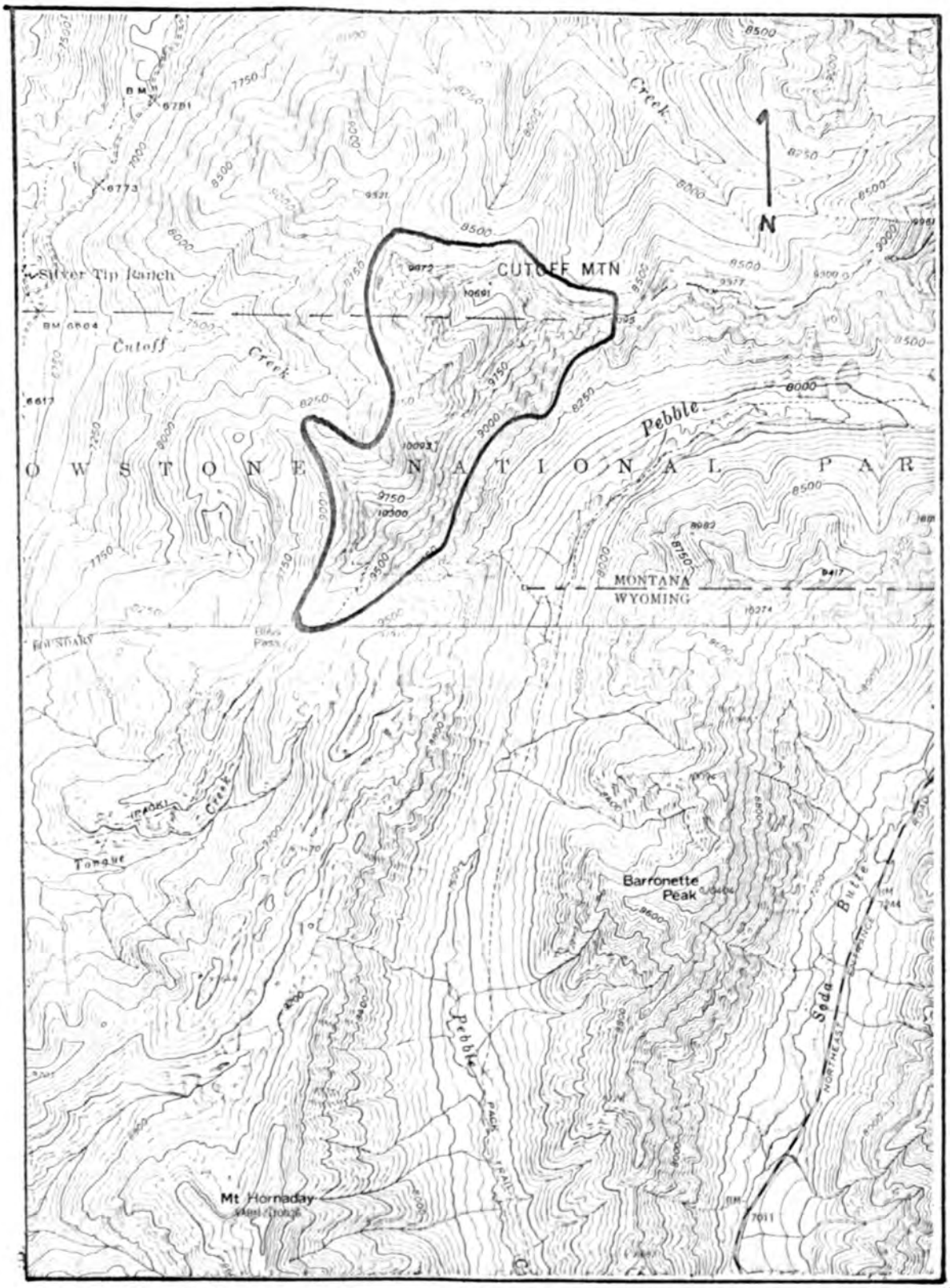

Figure 8. Intensive study area on Cutoff Mountain in NE Yellowstone National Park.

Figure 9. The south facing cirque on the top of Cutoff Mountain.

Figure 10. The east slopes of Cutoff Mountain.

CHAPTER III

METHODS AND MATERIALS

Census and distribution

Aerial survey

Aerial reconnaissance was chosen as the primary method to determine the summer distribution, and to census the bighorn sheep in Yellowstone National Park. Prior to beginning the actual census, three important steps were taken. First, Park Service records were reviewed to determine locations of past bighorn observations. The locations of these past observations then were grouped with suspected bighorn summer range and designated as search areas. Finally, low level aerial photos of the search areas were studied through a stereoscope. Later, this step resulted in quicker recognition of terrain features when the aerial survey was conducted.

A Piper Super Cub (PA-18), with a 150 H.P. engine, was used to conduct most of the aerial survey. This aircraft was selected because of its low operating cost and suitability for aerial census in rugged, mountainous terrain. On two flights, a Cessna 180 was used because of its greater range. On these flights the primary emphasis was on spotting herds. All flights were conducted with Mr. Roger Stradley as pilot, and myself as observer.

Since the objectives of the survey were to locate and count as many sheep as possible on the summer range in Yellowstone National Park, an intensive search was conducted of terrain features and drainages, rather than just a sample of the area. Lentfer (1955) used a similar search technique to study the distribution of the mountain goat in the Crazy Mountains of Montana, and Thomas (1957) reported on this method of aerial survey used in Wyoming bighorn sheep management.

All flights were conducted shortly after sunrise to take advantage of early morning bighorn activity and better flying conditions. Designated search areas were systematically surveyed, and each was completed before moving to the next area. The first approach was made at 100 to 200 feet over the top of the terrain feature, following the contour, and 100 to 200 feet to one side. Contours were flown at 500 foot intervals down to the 6,000 foot level. An indicated airspeed of 80 MPH was maintained while searching. This speed permitted easy spotting and classification of bighorn sheep. When necessary, the band was circled, and another approach was made at 60 MPH with reduced power to verify counts and classifications.

Three classifications were used: rams, lambs, and ewes. The bighorn classified as ewes included yearlings of both sexes because no attempt was made to distinguish yearlings from the adults. Thomas (1957) called this group the ewe herd.

The sound and approach of the aircraft often frightened the sheep into timber or under rock ledges where they would remain

motionless. Low approaches below their suspected location while varying the engine speed often drove them into the open so numbers and classification could be determined.

Since most areas were surveyed more than once, the largest number of each classification found on a terrain feature was used as the census figure. All aerial observations were recorded on an aerial survey form (Appendix A).

Ground survey

A ground survey was conducted during the summer of 1966 in the northern portion of Yellowstone Park to supplement the census and distribution data from the aerial survey, to determine the extent of distribution, and to compare ground and aerial counts.

An assistant, Mr. Tom O'Shea, and myself, backpacked into bighorn summer ranges along the Lamar, Soda Butte, and Yellowstone River drainages after aerial surveys were completed. The Quadrant Mountain - Bannock Peak area was also searched on foot. The ewe group summering on Mount Washburn was checked at intervals throughout the summers of 1966 and 1967.

The distribution and movement of herd units on the different terrain features was determined primarily by noting tracks and pellet groups. Observations of bighorn bands for periods ranging from two to four days to determine preferred areas were also included in this portion of the study. The bighorn sheep were observed at distances varying from 20 feet to one-half mile with the aid of 7x50 binoculars or a Bausch and Lomb 15-60x Balscope 60 spotting scope.

The distribution of bighorn sheep in Yellowstone Park was marked on United States Geological Survey 1:125,000 shaded relief maps of Yellowstone National Park. The line denoting distribution on the different terrain features is not an absolute limit of distribution. The line represents the approximate boundary of the area used during the summer months by bighorn sheep in that area as determined from aerial and ground observations.

Ground observations

During the summer of 1967, intensive ground observations were made in two key study areas: Cutoff Mountain and The Thunderer. From July 5-22, 1967, my assistant and I camped on The Thunderer, and from August 7-17, 1967, we camped on Cutoff Mountain. In addition to the observation time on these two areas, seven days were spent observing the bighorn sheep on Mount Washburn in August 1967, and a one-day trip to the Amethyst Mountain area was made to classify the large bighorn herd in the area. All daily activity data observed during these field periods was recorded on a field observation form (Appendix B).

Behavior and activity patterns

The day was broken into four parts for activity analysis: 8-11 a.m.; 11:01-2 p.m.; 2:01-5 p.m., and 5:01-8 p.m. Individual activities of feeding, bedding, or other activities were timed, and distance traveled during the activity was estimated to the nearest five meters. In the case of group activities, timing was started

when 50 per cent or more of the herd group was engaged in a specific activity. This method of observation is similar to that reported by Hibbs (1965).

Range analysis

The purpose of the range investigation was to sample the vegetation density, plant composition, percentage of bare soils, and percentage of area covered by litter on selected summer range sites in each intensive study area. The step-point method of sampling was used (Evans and Love, 1957; and National Academy of Sciences - National Research Council, 1962) because of its speed and applicability to uniform vegetative types such as alpine and subalpine meadows.

The area sampled was purposely selected from areas that received heavy grazing pressure by bighorn sheep. Ten parallel transects were laid out 10 feet apart in the approximate center of the area selected for sampling. A 100-foot steel tape was used to delineate the transect, and points one foot apart were sampled. Each point was established by placing a No. 1 knitting needle into the ground perpendicular to the foot markers on the left edge of the steel tape. Plants encountered on the transects were identified except for mosses and lichens. Bare ground, litter, and rock also were recorded, and frequencies of hits on each were calculated. All range surveys were recorded on a field form (Appendix C).

Food habits

Food habits and preferences were obtained by observing and identifying 1,000 grazed plants in each area sampled by the

step-point transects. This method was not intended to provide quantitative data, but it did give an indication of food habits. Brazda (1953), and Saunders (1955) also found this method successful.

Also, 1,000 grazed plant observations were made on Mount Washburn in areas recently vacated by feeding bighorn sheep. These data are compared with a description of the range composition determined by visual inspection.

Population dynamics

With the exception of classifications obtained during the summer of 1967 while on ground reconnaissance, all population dynamics data were gathered during aerial surveys. These data provide herd structures based on rams, lambs, and the "ewe herd" (including yearlings). The data gathered during the summers of 1966 and 1967 by me are supplemented by census and classification data obtained in March 1965 (Oldemeyer, 1966) and March 1967 by the National Park Service (unpublished census information).

CHAPTER IV

CENSUS AND DISTRIBUTION

Census

A combination of air and ground counts was used to census the bighorn population on summer ranges in Yellowstone Park. In 1966 only the northern third of the park was searched. In 1967 I searched the entire park, except the southwest corner. Aerial counts were the primary source of census data.

To accurately estimate wild mammal populations is difficult at best. Bighorn sheep scattered over vast areas of rugged terrain are hard to enumerate, particularly from fixed-wing aircraft. Sumner (1948), Edwards (1954), and others compared air and ground counts and generally, found the air counts lower. However, with few exceptions my aerial counts were higher than ground counts. Lentfer (1955), who used a similar aerial and survey technique for mountain goats, also had higher aerial counts.

Erickson and Siniff (1963) statistically evaluated factors influencing aerial surveys on brown bear and pointed out that many variables and factors could bias biological interpretations of aerial data. To obtain the best data from an aerial survey, a study of this type would be necessary for the particular species and habitat being investigated. Animal behavior patterns, type of

habitat, aircraft type, pilot skill, observer experience, weather conditions are among the variables that can bias results.

The preceding background made me aware of the limitations of aerial census techniques. The intensive search conducted was designed to reduce some variables and eliminate others. Flights were conducted in a suitable aircraft flown by a competent pilot only during ideal weather conditions. The effects of animal behavior and habitat types were reduced by repeated flights over the same area.

Although I did not evaluate the effects of variables as did Erickson and Siniff (1963), I believe the intensive searches conducted by an experienced pilot and observer produced relatively reliable census data. Nevertheless, because of the uncontrolled variables mentioned earlier, the figures I have presented represent the minimum bighorn population present on summer ranges in Yellowstone.

To reduce the likelihood of making duplicate counts, I eliminated all groups from the final census that were counted in one area and had the remotest chance of moving to another area. An example of this was the 1967 census on Mount Washburn. A herd of 31 sheep was observed in August; however, only 16 sheep were added to the census because sheep previously counted on the south bank of the Yellowstone River, and a group on the west rim of Yellowstone Canyon could not be found. These two groups totalled 15 sheep and were considered part of the Washburn herd.

Census data for the summers of 1966 and 1967 are shown in Tables 4 and 5. Table 4 indicated the maximum number of sheep

Table 4. Census of bighorn sheep in northern Yellowstone National Park, summer 1966.

Area & Terrain feature	Rams	Ewes*	Lambs	Ewes lambs**	Unk.	Total
NORTHEAST HERD						
Amphitheater Mt.	4	25	18	-	-	47
Barronette Peak	11	8	6	-	1	26
Cache Mt.	16	4	-	-	-	20
Cutoff Mt.	4	12	5	22	-	43
Meridian Peak	-	2	-	-	-	2
Needle Mt.	3	-	-	-	1	4
Republic Pass	-	6	3	-	-	9
The Thunderer	19	6	3	-	-	28
Wolverine Peak	-	7	3	-	-	10
Sub-Totals	57	70	38	22	2	189
LOWER YELLOWSTONE & NORTH PARK HERD						
Hellroaring Mt.	-	14	8	-	-	22
Lower Buffalo Plateau	-	9	7	-	-	16
Mt. Everts-Rattle Snake Butte	-	11	4	-	-	15
Sepulcher Mt.	-	10	6	-	-	16
Sub-Totals	0	44	25	0	0	69
WASHBURN-CANYON-SPECIMEN HERD						
Fossil Forest	-	8	6	-	-	14
Mount Washburn	-	15	12	-	-	27
Sub-Totals	0	23	18	0	0	41
GALLATIN HERD						
Bannock Peak	12	-	-	-	-	12
Bighorn Pass	1	-	-	-	-	1
Quadrant Mt.	3	-	-	-	-	3
Sub-Totals	16	0	0	0	0	16
NORTHWEST HERD						
Bighorn Peak	1	14	5	4	-	24
Meldrum Mt.	-	3	2	-	-	5
Sheep Mt.	2	-	-	-	-	2
Sub-Totals	3	17	7	4	0	31
TOTALS	76	154	88	26	2	346

*This classification includes both ewes and yearlings of both sexes.

**Includes ewes, yearlings and lambs.

Table 5. Census of bighorn sheep in Yellowstone National Park, summer 1967.

Area & Terrain feature	Rams	Ewes	Lambs	Total
NORTHEAST HERD				
Abiathar-Amphitheater	4	25	10	39
Barronette Peak	16	9	6	31
Bison Peak	9	-	-	9
Druid-Hornaday-Cutoff	3	43	14	60
Meridian-Sunset-Wolverine	1	15	9	25
Mountain south of Republic Pass	8	-	-	8
The Thunderer	23	13	7	43
Sub-Totals	64	105	46	215
LOWER YELLOWSTONE & NORTH PARK HERD				
Electric Peak	-	1	-	1
Hellroaring Mountain	4	3	-	7
Lower Buffalo Plateau	-	3	3	6
Mount Everts	-	10	2	12
North bank Yellowstone	-	18	9	27
South bank Yellowstone	1	2	1	4
Sepulcher Mountain	1	12	6	19
Slough Creek	2	-	-	2
Sub-Totals	8	49	21	78
WASHBURN-CANYON-SPECIMEN HERD				
Agate Creek	-	2	-	2
Amethyst Mt. - Deep Creek - Fossil Forest	24	51	18	93
East rim Yellowstone Canyon	-	9	6	15
West rim Yellowstone Canyon	-	6	6	12
Opposite Calcite Springs	-	3	1	4
Mount Washburn	-	15	1	16
Sub-Totals	24	86	32	142
GALLATIN HERD				
Bannock Peak	7	-	-	7
Quadrant Mountain	9	-	-	9
Sub-Totals	16	0	0	16
NORTHWEST HERD				
Bighorn Peak	-	10	2	12
Black Butte Creek	1	-	-	1
Meldrum Mountain	-	1	1	2
Sheep Mountain	3	7	4	14
Specimen Creek	-	5	1	6
Sub-Totals	4	23	8	35

Table 5. Continued

Area & Terrain feature	Rams	Ewes	Lambs	Total
EAST BOUNDARY HERD				
Eagle Peak	-	3	-	3
Mount Schurz	5	4	3	12
North of Reservation Peak	5	-	-	5
Plentycoups Peak	23	-	-	23
Table Mountain	-	17	5	22
The Tridents	-	7	-	7
Sub-Totals	33	31	8	72
TOTALS	149	294	115	558

Note:

This table just represents a minimum census. It does not represent the maximum number of sheep observed on each terrain feature.

observed on terrain features. Movement was negligible during the census period, and previous sightings were confirmed before new counts were made. However, movement was a factor during the longer census period in 1967, so Table 5 contains adjusted counts for the terrain features listed. Adjustments were made in the manner described previously for Mount Washburn. The maximum numbers of sheep observed in 1967 are listed in Table 6 and compared with maximum numbers in these areas in 1966.

The variation between both summers' census data indicates the problems of aerial census techniques rather than reflecting a population change. I consider the 1967 census more complete and efficient than in 1966 and attribute this to pilot and observer experience leading to improved technique along with a more complete search of potential bighorn summer ranges. Table 7 compares both summers' aerial survey results and indicates the improvement obtained in 1967.

Based on a variety of observations and subjective judgement, I estimate that actual numbers range from 10 to 100 per cent higher than those listed for the seven herd units. The most intensive effort was in the northern part of Yellowstone Park, and the 1967 census of 451 (excluding the Northwest herd and the East boundary herd) probably represents 80-90 per cent of the population. The 1967 census of 45 sheep in the Northwest herd may represent 65-75 per cent of the population. The least intensive search was along the East boundary, and the count represents no more than half of the sheep using these summer ranges. I made no attempt to census the

Table 6. Maximum number of bighorn sheep observed on terrain features searched in summer 1966 and 1967.

Terrain Feature	Maximum Numbers of Sheep 1966	1967
Abiathar-Amphitheater Mountains	47	39
Amethyst Mt.-Deep Creek-Fossil Forest	14*	93
Bannock Peak	12	9
Barronette Peak	26	31
Bison Peak	0	9
Bighorn Peak	24	12
Cache Mountain	20	0
Druid-Hornaday-Cutoff Mountains	43	60
Electric Peak	0	1
Hellroaring Mountain	22	25
Lower Buffalo Plateau	16	6
Meldrum Mountain	5	2
Meridian-Sunset-Wolverine and ridge connecting to Cutoff Mountain	12	35
Mount Everts	15	12
Mount Washburn	27	31
Mountain south of Republic Pass	0	19
Needle Mountain	4	0
Quadrant Mountain	3	9
Republic Pass	9	20
Sepulcher Mountain	16	19
Sheep Mountain	2	14
The Thunderer	28	43
Yellowstone Canyon	9	27
Yellowstone River (north of Tower)	0	31

*In 1966, only the Fossil Forest area was checked carefully, although the entire area was quickly searched.

Table 7. Comparison of summer 1966 and 1967 bighorn sheep aerial observations in Yellowstone Park.

Flight	1966 Duration* (minutes)	1966 Bighorn observed	1967 Duration* (minutes)	1967 Bighorn observed
1	180	100	285	178
2	90	14	75	34
3	255	76	240	108
4	240	93	300	15
5	240	95	300	86
6	240	17	305	133
7			310	190
8			360	158
9			155	174
10			255	243
11			255	186
12			285	158
TOTALS	1,245	395	3,025	1,663

*Duration includes flight time from take-off to landing.

Note:

1966 sheep observed/minute of total flight time - 0.32.
1967 sheep observed/minute of total flight time - 0.55.

sheep reported summering in the Bechler region of southwestern Yellowstone Park, but ranger reports indicate that at least 15-25 sheep are present.

Distribution

I designated bighorn sheep on summer ranges as seven herds: the Northeast herd, the lower Yellowstone and North park herd, the Washburn-Canyon-Specimen herd, the Gallatin herd, the Northwest herd, the East boundary herd, and the Bechler herd (Figure 11). These herd designations are based on geographical locations and consist of few to many "true" herds defined as "groups of large animals feeding, living, or moving together."

Repeated aerial flights and ground searches were conducted to determine the limits of distribution with the exception of the Bechler herd. This group has been reported several times by rangers. The Bechler herd inhabits the vicinity of Mountain Ash Creek according to ranger reports.

The Northeast herd

This herd occupies the high mountains of the northern Absoraka Range along the Soda Butte, Pebble Creek, and Cache Creek drainages (Figure 12). This region was typical bighorn summer range with high subalpine meadows and broken cliffs and ledges. The sheep usually occupied the meadows and ridges above 9,000 feet. The area inhabited by the NE herd was the main bighorn summer range in Yellowstone Park.

The sheep on Barronette Peak and Mount Norris-The Thunderer stayed in these areas throughout the summer. Sheep wintered on the

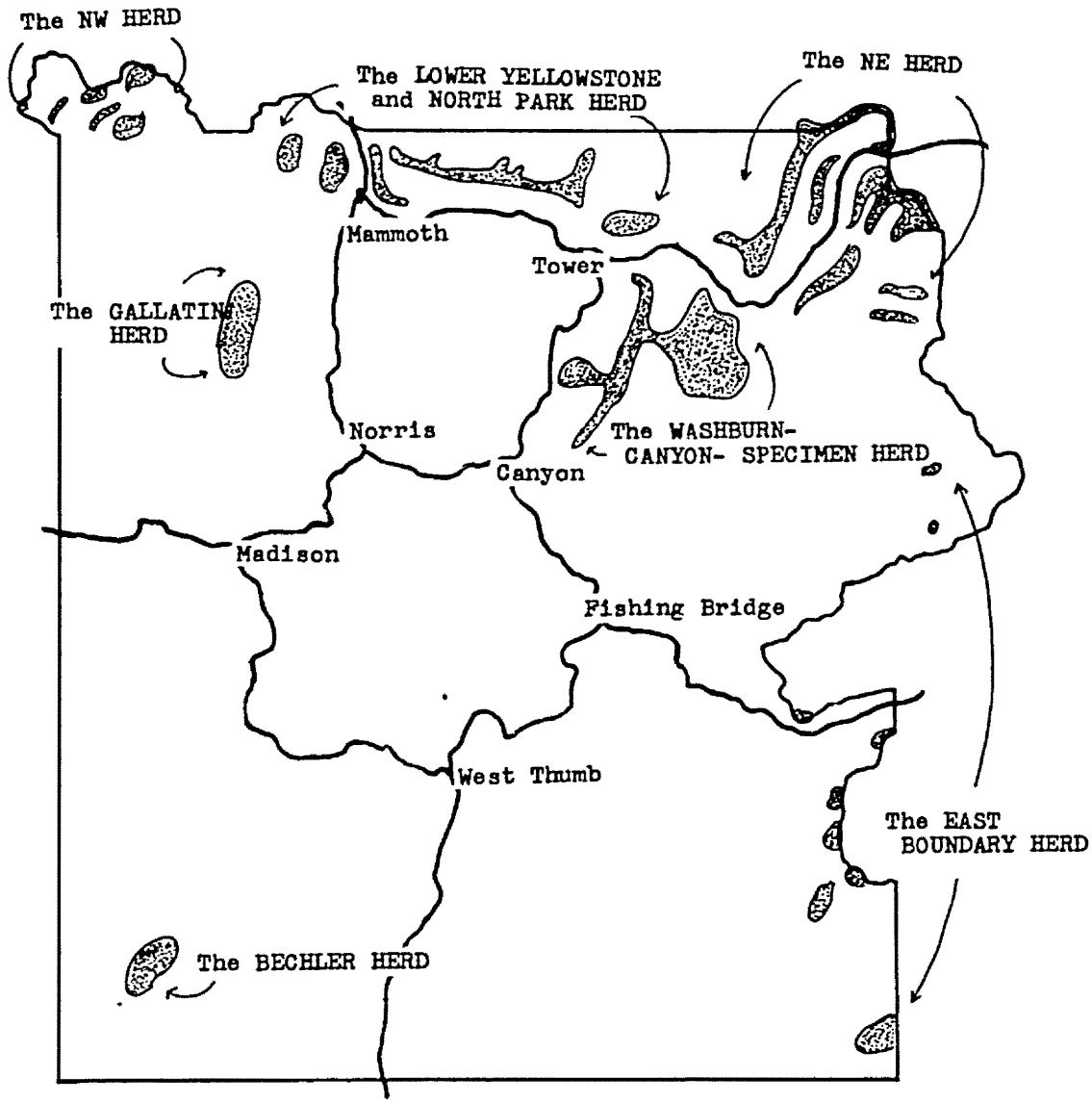

Figure 11. Major bighorn sheep summer ranges in Yellowstone National Park, 1966 and 1967.

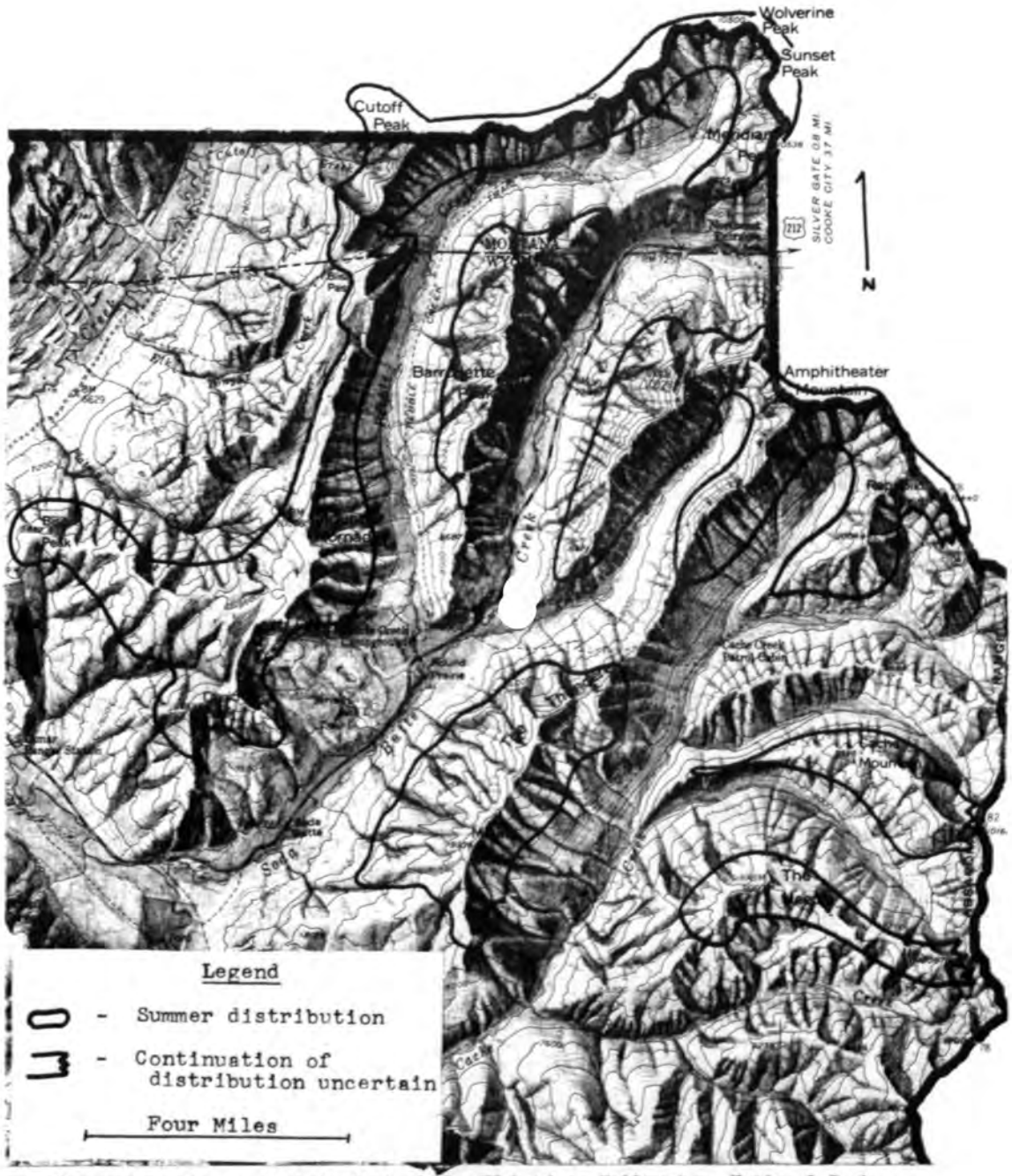

Figure 12. Summer distribution of the NE herd in Yellowstone National Park, 1966 and 1967.

lower slopes of these mountains and only moved a short distance to summer ranges. When I began observing on June 17, 1967, sheep were on the west exposures of Mount Norris and the east exposures of Barronette Peak at approximately 8,000 feet. Ewes were either lambing or in small groups in rugged terrain consisting of cliffs, broken ledges, and scattered timber.

Sheep occupying the Mount Hornaday-Cutoff Mountain and the Abiathar-Amphitheater complexes were more mobile than other sheep in the NE herd. I found sheep low on Druid Peak, the east exposures of Mount Hornaday, and below 8,000 feet on all exposures of Abiathar-Amphitheater during June flights in 1967. Lambing grounds occur on the east slopes of Hornaday and the west and southwest exposures of the Abiathar Peak area. Movement to summer ranges did not begin until July. The Cutoff Mountain summer herd ranged south along the east side of Hornaday and north along the boundary ridge to Meridian Peak (Figure 12). Searches in late June 1967 revealed a lack of tracks on snow-covered north exposures along the park boundary. This led me to believe that most sheep summering in northeastern Yellowstone Park are also winter residents in the park. When the Abiathar-Amphitheater herds moved to summer range, they also ranged freely. Some days, the sheep were concentrated in the south-facing cirque on Amphitheater Mountain, but often, they were scattered in small bands on all exposures and extended along the NE boundary ridge south to Republic Pass and perhaps further. Sheep along this boundary were probably were joined by sheep from Wyoming winter ranges.

The sheep observed in 1966 on Cache Mountain and The Needle were not seen in 1967 and may have been transients from Wyoming.

The lower Yellowstone and North Park herd

This group occupied the area that was winter range for the Mount Everts and Yellowstone River herds reported by Oldemeyer (1966). Throughout the area, summer migrations were incomplete, and the sheep stayed on or near their winter ranges. The highest place where I found bighorn was the top of Hellroaring Mountain, elevation 8,512 feet. Generally, the sheep were seen around 7,000-7,500 feet. The small group staying on Mount Everts apparently never wandered past the Turkey Pen area, but the sheep along Yellowstone River frequently moved along the river and its drainages (Figure 13). Summer range of the lower Yellowstone and North Park herd consisted of open sagebrush-grassland interspersed with open Douglas-fir forests, and some small patches of open grassland.

Sheep on Sepulcher Mountain and Electric Peak also were included in this herd although they were distinct groups (Figure 15). Oldemeyer (1966) found sheep wintering along Reese Creek (Figure 15), but believed that they also moved north of the park boundary to the vicinity of Devil's Slide during winter. I never observed sheep on Sepulcher Mountain or Electric Peak early in the summer, so they probably did move in from winter ranges north of the park.

I detected no movement from outside the park to supplement this summer herd, except on Sepulcher Mountain and Electric Peak. Some

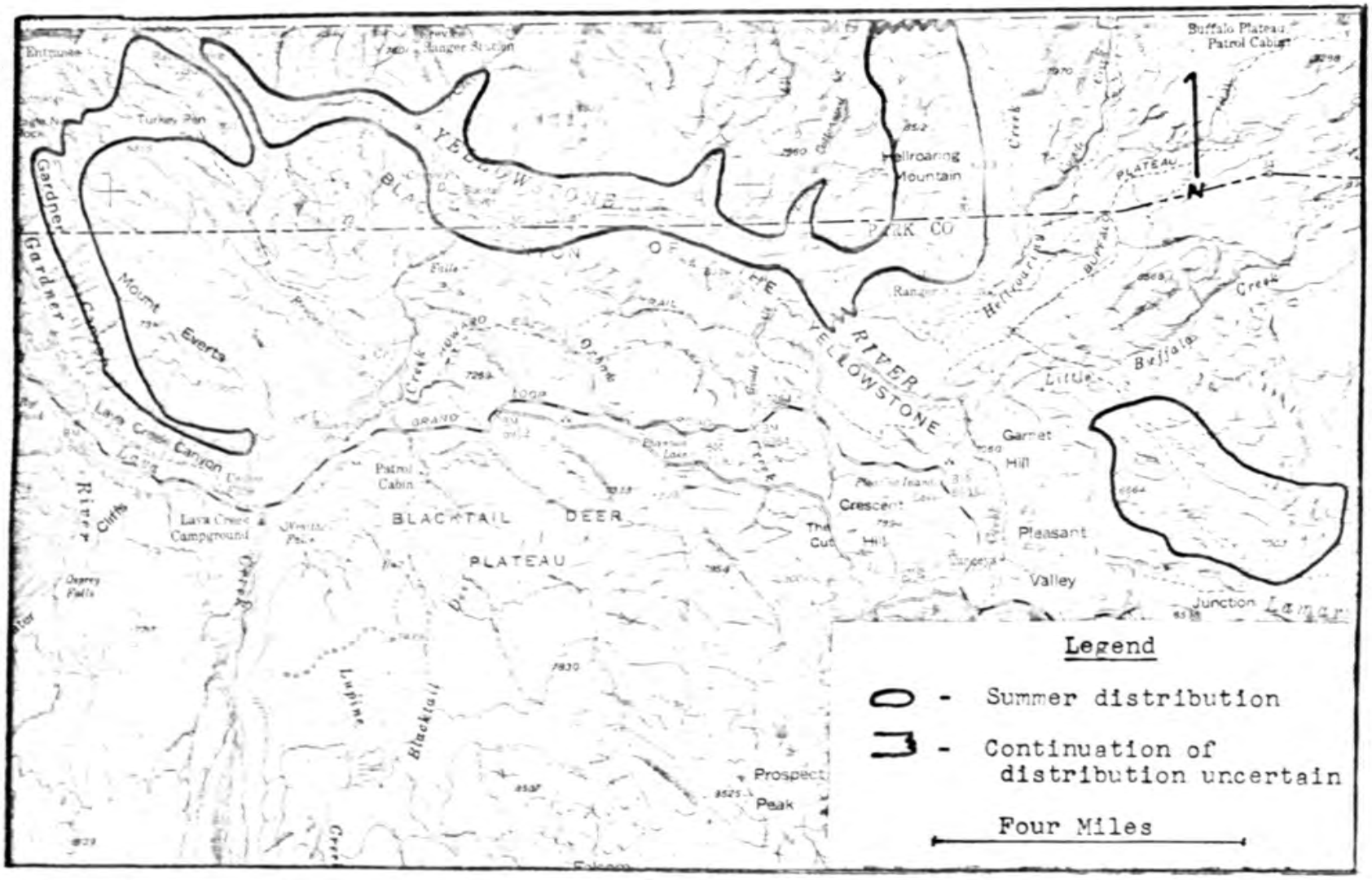

Figure 13. Summer distribution of the lower Yellowstone and North park herd in Yellowstone National Park, 1966 and 1967.

sheep may have moved just north of the park boundary on Hellroaring Mountain to summer.

The Washburn-Canyon-Specimen herd

With the exception of the sheep on Mount Washburn's alpine summer range, this herd occupied low habitats more typical of winter ranges (Figure 14). Scattered grasslands, mixed grasslands and sagebrush, and open stands of Douglas-fir covered summer ranges.

The sheep seen early in the summer along the west side of the Yellowstone Canyon later moved to Mount Washburn's alpine summer range. The small group on the east side of the canyon between Deep and Broad Creeks stayed there throughout the summer. The 93 sheep in the vicinity of Amethyst Mountain were an unexpected find. Most of these sheep were first observed along lower Deep Creek in 1967. Park Biologist William Barmore said that sheep were not known to winter there, and Oldemeyer (1966) did not find any. However, former Park Ranger Scotty Chapman informed me that he often saw large winter herds near Deep Creek. I found ewes with lambs along the cliffs of lower Deep Creek in late June 1967, and rams on the south slopes of Amethyst Mountain. By early July, the sheep moved to the top of Amethyst Mountain and the west side of Chalcedony Creek north to Fossil Forest.

The Gallatin herd

Only rams were in this herd both in 1966 and 1967. Mills (1937) believed that the rams migrated from winter range on Mount Everts and ranger reports confirm this view. Preferred summer range was Bannock Peak, and the south and east slopes of Quadrant Mountain

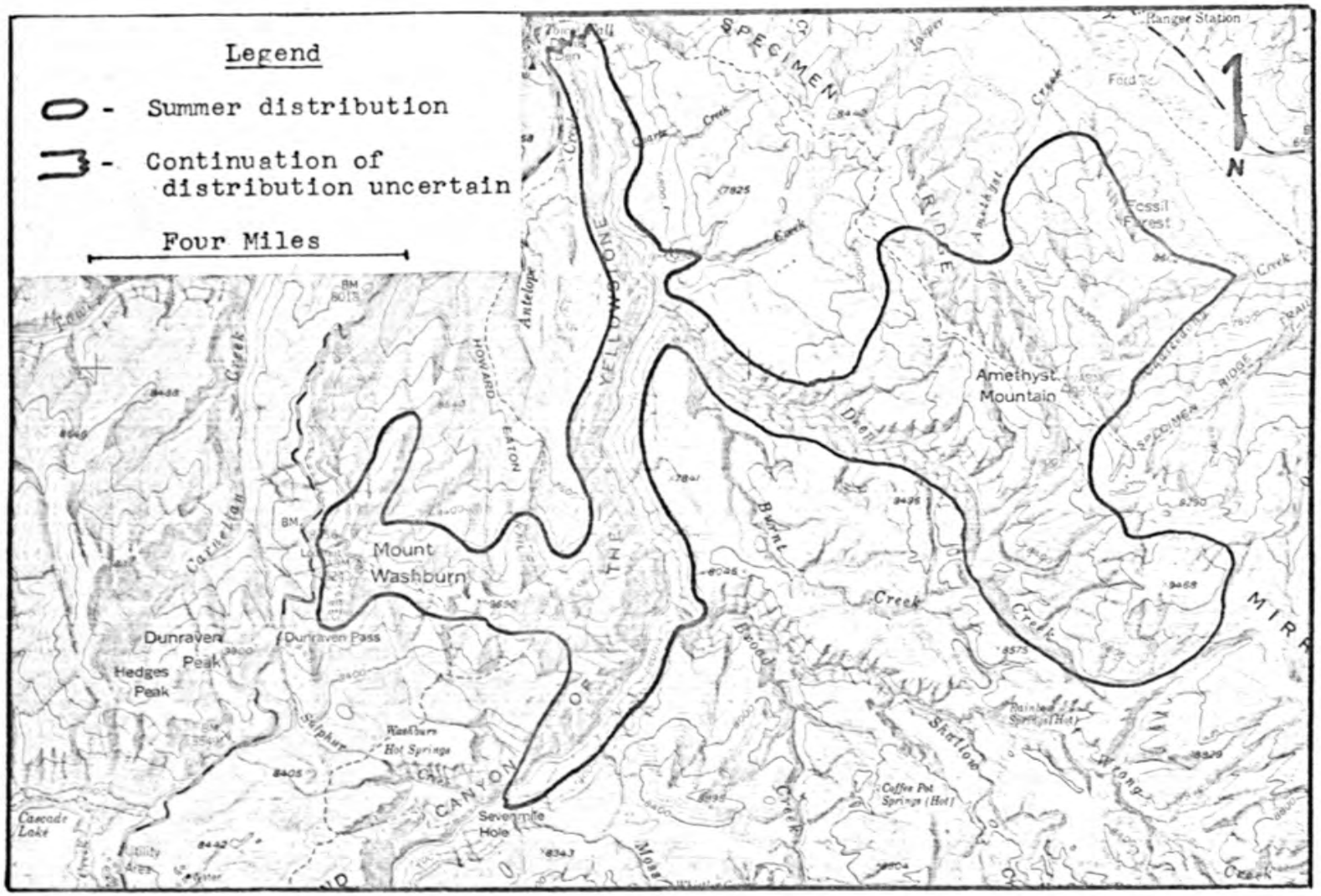

Figure 14. Summer Distribution of the Washburn-Canyon-Specimen herd in Yellowstone National Park, 1966 and 1967.

(Figure 15). Rams were seen south to Bighorn Pass and north to Fawn Pass, but never beyond these points. There are occasional summer sightings of rams near Terrace Mountain, The Hoodoos, and Golden Gate. These sheep probably drifted east from Bannock Peak or Quadrant Mountain.

The Northwest herd

The Northwest herd is located in the northwest corner of Yellowstone Park north of Specimen Creek and the East Fork of Specimen Creek (Figure 16). Terrain in this area is 500-800 feet lower than in northeastern Yellowstone Park, but the herds occupy similar summer habitats. Main summer range was on Bighorn Peak and Sheep Mountain. Although not indicated in Figure 16, summer distribution may include the entire boundary ridge west to the headwaters of Daly Creek. A lack of tracks on snow along the boundary ridge during June 1967 indicated that the NW herd also wintered in Yellowstone Park. Likely winter ranges are along the Daly, Black Butte, and Specimen Creek drainages.

The East boundary herd

Subalpine and alpine habitats in the Absoraka Range provided summer range for this herd (Figure 17). Sheep in the vicinity of Mount Schurz, Table Mountain, and The Tridents probably are year round residents of Yellowstone Park, but most of the East boundary herd is a transient population from Wyoming. Thomas (1957) also found sheep sharing range between Yellowstone Park and Wyoming.

My boundary search was superficial because I used a Cessna 180 lacking the slow-flight characteristics and maneuverability

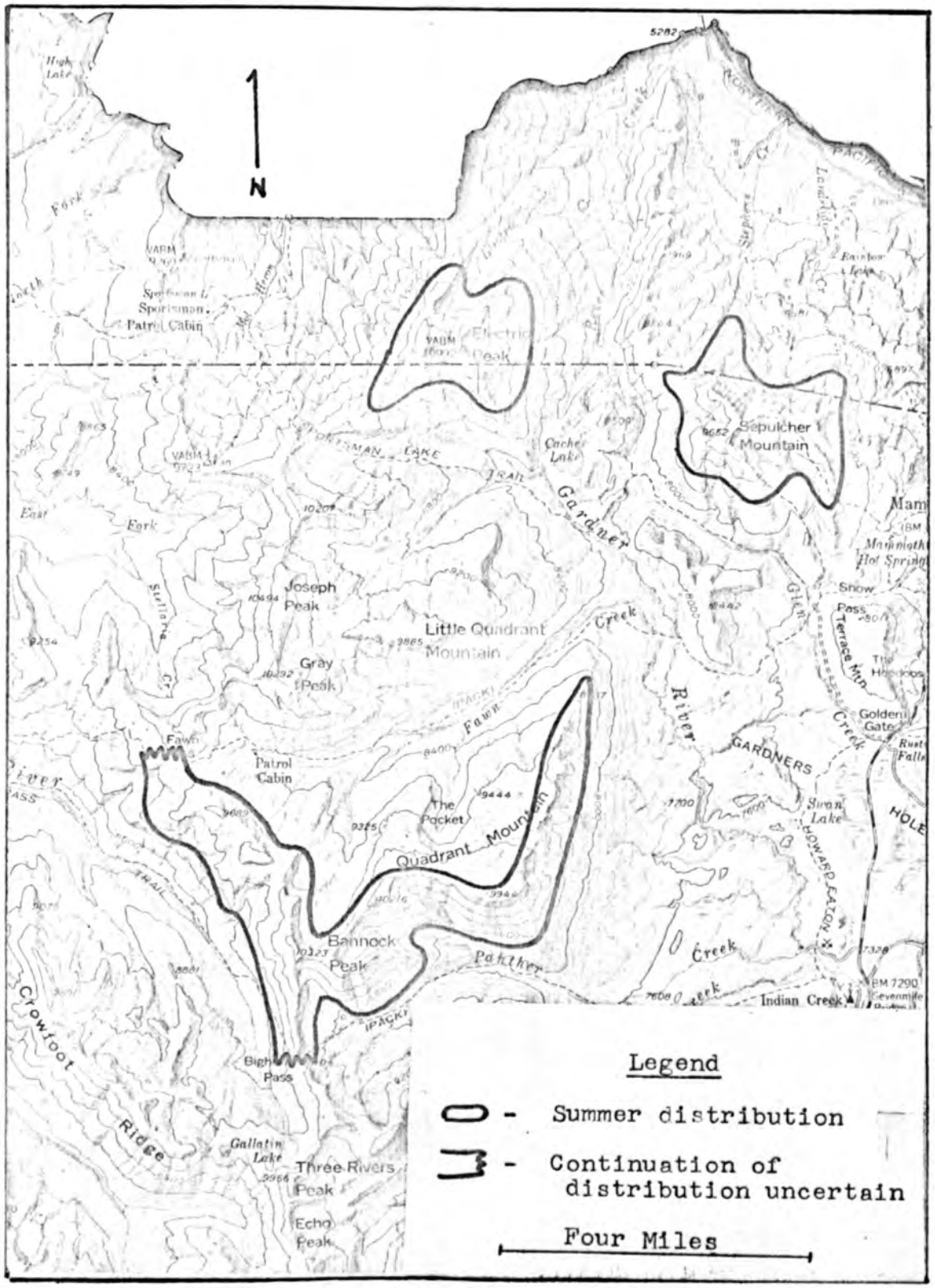

Figure 15. Summer distribution of the Gallatin herd in Yellowstone National Park, 1966 and 1967.

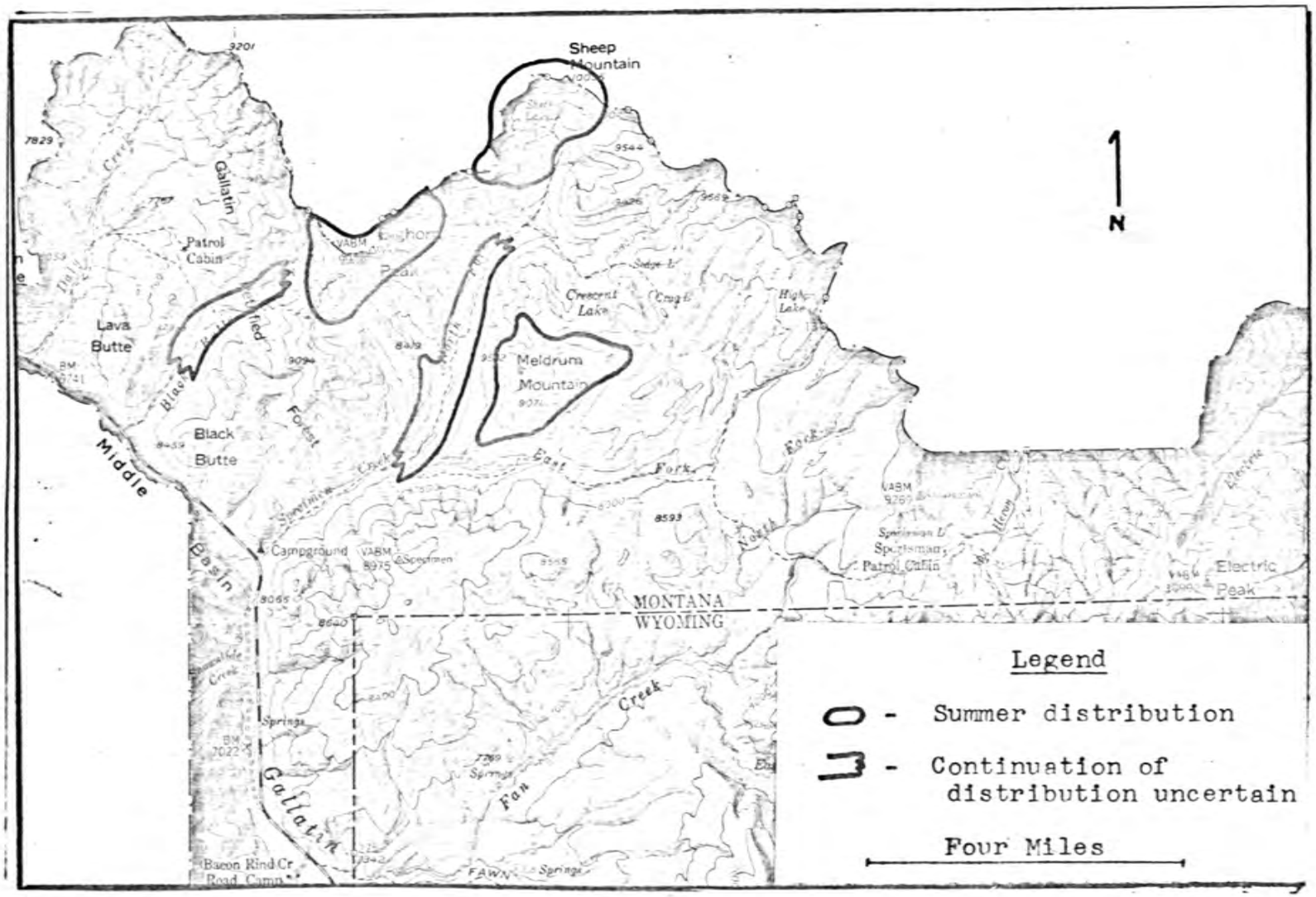

Figure 16. Summer distribution of the NW herd in Yellowstone National Park, 1966 and 1967.

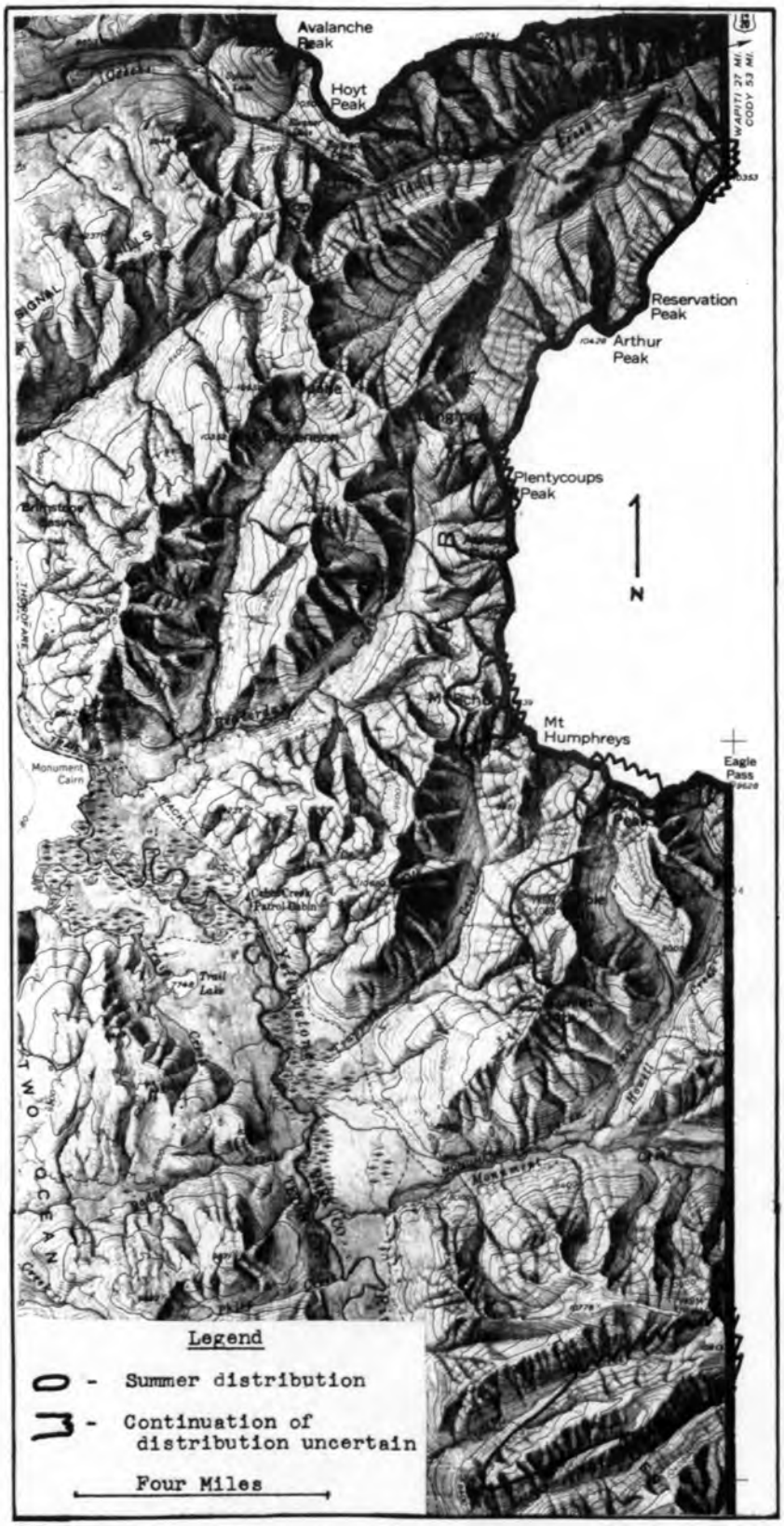

Figure 17. Summer distribution of the East boundary herd in Yellowstone National Park, 1967.

necessary to carefully search the area. The extensive area to be covered and long ferry distances necessitated using the 180 with its fast cruising speed.

I never saw sheep north of the east entrance road, but in 1966, Mr. Harry Smedes, a geologist, observed a ewe group on Hoyt Peak in August. Sheep were also found summering on Avalanche Peak, and Mr. Buster Hughes reported two ewes in the vicinity of Saddle Mountain. In 1967, seasonal rangers spotted several sheep along upper Cold Creek near Frost Lake.

CHAPTER V

BEHAVIOR

Seasonal migrations

The migration or non-migration of bighorn sheep from winter to summer ranges is a part of bighorn behavior that is characterized by different findings and viewpoints among research workers. What some workers consider a true migration, others call a seasonal drift or a an extension of winter range during summer months. Greer (1931), studying the Yellowstone herd, regarded the summer range of bighorn as merely an enlargement of the so-called winter range. Greer accounts for the drift of sheep in the park by the influence of weather conditions enlarging or diminishing the available food supply. I found that many summer ranges are an enlargement of winter ranges rather than a separate entity from the herd's winter range. Barronette Peak and Mount Norris - The Thunderer exemplify this.

I think that some bighorn herds are distinctly migratory, moving from a well-defined winter range to a well-defined summer one. However, as Mills (1937), Davis (1938), and Gammill (1941) pointed out, although the Yellowstone herd does exhibit a definite spreading out and movement from one range to another with a change in seasons, both fall and spring migrations were not always complete. I observed incomplete migrations along the Yellowstone River, on Mount

Everts, on Druid Peak, and in the Specimen Ridge area. Bighorn sheep used portions of these ranges throughout the year.

Mills (1937) listed the following five known or suspected bighorn migratory routes in Yellowstone Park: Daly Creek east to the Yellowstone River near Sepulcher Mountain and Yankee Jim Creek; South Gallatin Range northward to Swan Lake Flats, Terrace Mountain, Glen Creek, and Mount Everts; Mount Washburn to Tower Ranger Station, Cresent Hill, and Mount Everts; Upper Absoraka Range to Cutoff Mountain, Slough Creek Meadows, Lamar River, and Junction Butte; and Specimen Ridge near Quartz Creek from the east side of Yellowstone River. All of the preceding movements listed by Mills are from summer to winter ranges.

In addition to the suspected migration routes listed by Mills, I observed the following probable migration routes from winter to summer ranges: the lower slopes of Mount Norris to The Thunderer; Druid Peak to Mount Hornaday to Cutoff Mountain, and possibly from Cutoff along the boundary ridge to Meridian Peak; lower slopes of Barronette to the higher points of this area; lower Abiathar - Amphitheater to the high points of these mountains and extending along the NE boundary to the Republic Pass area (see Figure 12); and Specimen, Black Butte, and Daly Creeks to Sheep Mountain, Bighorn Peak, and along the NW park boundary (see Figure 16).

Most workers cite weather conditions as the cause of both spring and fall migrations (Honess and Frost, 1942; Smith, 1954; Moser, 1962; and others). The only exception to this view reported in the literature is held by Spencer (1943). Reporting on his study of the Tarryall herd in Colorado, Spencer noted that the sheep migrated at

the same time each year regardless of the weather conditions. Smith (1954) and Moser (1962) reported a leisurely spring migration, with the herds following a receding snowline. This view describes the spring migration in Yellowstone Park.

Couey (1950) reported that the migration to summer range began in late April or early May, and Oldemeyer (1966) agreed with these findings. I found that snow cover is probably the factor that has the greatest influence on spring migration time. By June 29, 1966, the bighorn sheep in Yellowstone were established on their summer ranges. However, in 1967, lingering snow in the high country delayed the completion of migrations to summer range until the first part of July. My first flight on June 17, 1967, found the sheep still lingering on winter ranges, usually the higher fringes, and on intermediate ranges. Lambing was still in progress, and the groups were scattered.

Most ram groups were established on summer range when the ewes were still lambing, and ewe groups were small and scattered below the high summer ranges. On June 26, 1967, a survey flight disclosed that the sheep were beginning a definite, but slow movement toward summer ranges. On July 1, sheep were on the high subalpine summer ranges in the NE part of the park for the first time, but still as singles or in small groups. The first large movement to high summer range in the NE was observed on The Thunderer on July 10, 1967.

The bighorn were still on summer ranges during early September 1966 and 1967. Oldemeyer (1966) reported that the earliest group to reach winter range in Yellowstone during his study was a ewe group that arrived on McMinn Bench by October 1. In contrast to the slow

spring migration, Moser (1962) reported that the fall migration is fast, with the sheep swiftly moving lower with the first heavy snow.

Herd composition and behavior

While on summer range, the ewe and ram groups remained separate. Generally, the ewe groups occupied more inaccessible, precipitous terrain than did the ram groups.. Blood (1963) reported this trend on bighorn summer ranges in British Columbia and attributed this terrain selection to the protection of lambs. However, several ewe groups occupied the lowest, and most accessible summer range in Yellowstone Park. Couey (1950), Smith (1954), and McCann (1956) all reported that ram groups in their study areas occupied the higher, more inaccessible terrain that did the ewe groups.

The ewe groups were composed of ewes, yearlings, lambs, and, occasionally, two-year old rams. The ram groups generally were composed of rams two years and older. However, the ram group on The Thunderer contained two yearling rams throughout the summer of 1967.

The sexes appeared to make a distinct effort to remain separate while on summer range, although in many cases the separation only involved as little as 1/4 mile distance or several hundred feet of craggy, sheer cliff. On two occasions, I observed ewes joining a larger ram group for a short period, and on one occasion, I observed three rams feeding less than 300 feet from a large ewe group.

Both times I observed ewes joining a ram group, the same ram group was involved, and perhaps one ewe was the same. On the first occasion, a ewe and yearling ram joined a herd of 15 rams on The

Thunderer. The ewe was ignored by the mature rams, but five young rams (1/2 curl or less) showed considerable interest in her. They constantly harassed the ewe while she was trying to feed by chasing her, and attempting to mount her. The ewe remained with the ram group for just under three hours; then slowly moved away until she disappeared from sight. When the ewe left, two yearling rams departed with her.

On the second occasion, two ewes joined a group of 14 rams on The Thunderer. They grazed and bedded among the rams for 90 minutes. Only one young ram showed interest in the ewes, and tried several times to mount one. This ram stayed with the two ewes, and when they moved about 200 meters away from the other rams, he followed and bedded near the ewes. The ewes and young ram grazed farther away from the ram group, and five hours after joining the group, they were about 300 meters apart from the rams. Just before the small ewe group disappeared from sight, they were joined by a full-curl ram who was not a member of the original group of 14 rams. All four sheep then grazed out of sight, and were not observed in that group structure again.

Gammill (1941) and Packard (1946) believed that bands formed in the spring remained nearly constant throughout the summer with little interchange of individuals. Recent workers report that interchange of individuals between bands is not uncommon. Buechner (1960), Simmons (1961), and Woodgerd (1964) all reported that bighorn tend to associate with individuals of similar sex and age, but the group composition is not stable. Group numbers fluctuated because of the

breaking off of individuals or groups and the interchange of sheep between bands. This is definitely the case in Yellowstone Park.

On numerous occasions, I watched groups disperse or congregate. Group separation usually occurred while feeding when a sheep headed in one direction, several followed, and the rest of the band continued on their way without any visible concern or interest in the sheep departing. When bands congregated, there was some interest displayed. The sheep would invariably sniff and inspect each other in much the same manner as strange dogs meeting. This interest was short-lived, and interrupted activity was quickly resumed.

Buechner (1960) noted evidence for a spacing mechanism during his aerial census of the Absoraka Range in Wyoming along the eastern boundary of Yellowstone Park. He found that some locations were occupied by more than one herd, but each herd had a favorite home range. Smith (1954) reported finding no distinct herds in areas of relative abundance, and this was the case in Yellowstone. I believe that herd groups occupied specific terrain features throughout the summer, but herds within the main group broke up and reformed over and over again throughout the summer. It was impossible to distinguish a certain number of herd groups containing a certain number of sheep in any one area. Rather, one could identify areas of sheep concentrations on specific terrain features or over a specific area.

Smith (1954) pointed out that the average herd size of eight reported by Baillie-Grohman (1882) was close to the average of 7.3 that he observed in spite of the reduced populations of modern herds compared to the population in the late 1800's. I computed average herd size (excluding single observations) during the summers of 1966

and 1967 based solely on aerial survey data. Table 8 contains a summary of my data:

Table 8. Average herd size of bighorn sheep on summer range, 1966 and 1967.

Year	Average herd size		
	All sheep	Ewes	Rams
1966	7.2	7.9	5.7
1967	7.6	8.1	5.8

In 1966, 92 groups totalling 660 individuals were observed during aerial surveys and only 16 single observations were recorded (eight ewes and eight rams). In 1967, 216 groups totalling 1,634 individuals were observed with an additional 29 single observations (15 rams and 14 ewes). Perhaps the close similarity between herd sizes over the two summers, and compared with the findings of other workers reflects the degree of gregariousness among bighorn sheep.

The largest ram group I observed was 24 on Amethyst Mountain on July 26, 1967. The largest ewe group was also observed near Amethyst Mountain on August 25, 1967, and contained 61 individuals (including three mature rams). About 1/2 mile away from this large group, eight additional ewes, lambs, and yearlings were located. The only group approaching this size on summer range that I found reported in the literature was a ewe group numbering 53 animals (Honess and Frost, 1942).

Daily activity

Activity patterns

"Significant in the daily life of bighorn sheep is the seeming lack of 'routine' connected with their daily habits" (Smith, 1954, p. 49). This statement sums up the daily activity patterns of bighorn sheep I observed on summer ranges. Mills (1937) reported bighorn sheep feeding at daybreak in Yellowstone Park. Feeding was continuous until the middle of the morning, then a rest was taken until noon. Afternoon activity consisted of feeding for about two hours. Another rest then was taken until about 5 p.m. A final period of feeding followed until dark, at which time the sheep bedded for the night. This description by Mills could well describe one day in the life of bighorn herd on summer range, but this is far from a consistent pattern. The "average" day spent by a bighorn herd is better described as a constant search for food broken by frequent bedding intervals. The lack of a definite "routine" is apparent in Figures 18 and 19 which show the activity patterns observed on two study areas during the summer of 1967. On The Thunderer, 4,192 minutes of group observations consisted of 47 per cent feeding, 50 per cent bedding, and three per cent "other" activities. On Cutoff Mountain, 3,172 minutes were 51 per cent feeding, 47 per cent bedding, and two per cent "other."

Table 9 shows the average and maximum lengths of feeding and bedding intervals observed on the two study areas. The intervals observed on The Thunderer are consistently larger than those observed

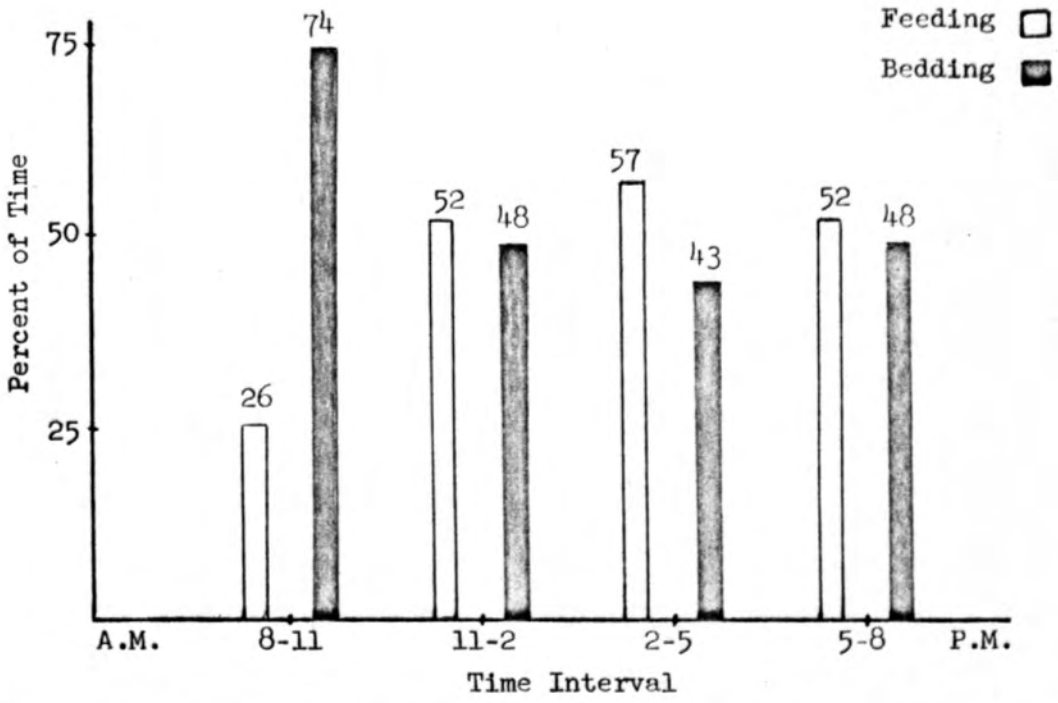

Figure 18. Daily activity of a ram herd on The Thunderer, summer 1967.

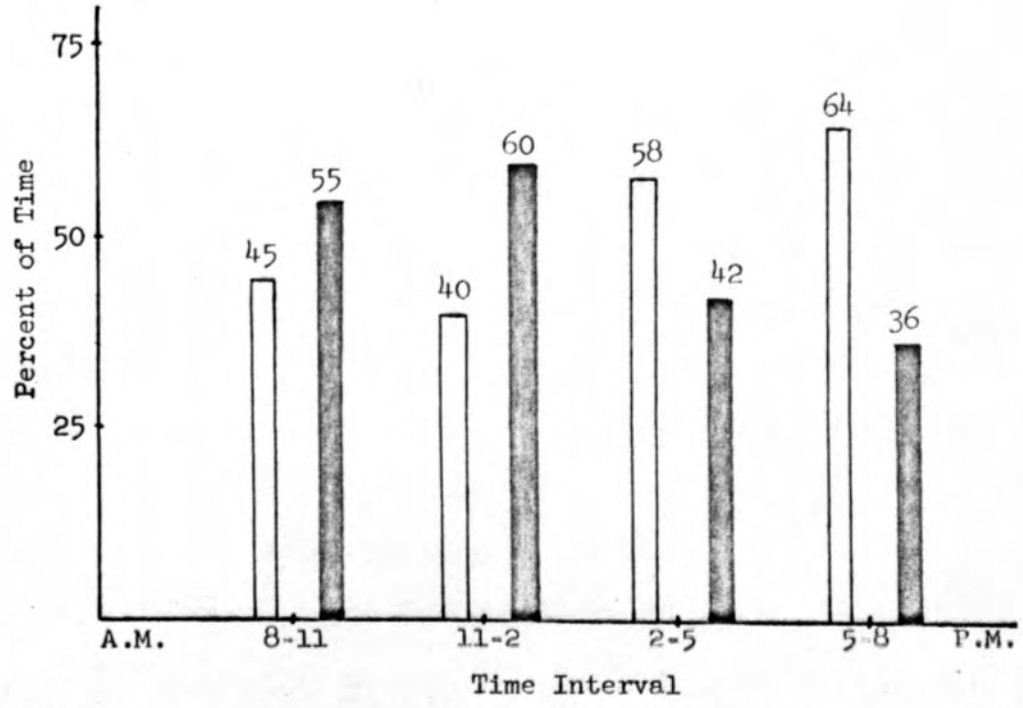

Figure 19. Daily activity of a ewe herd on Cutoff Mountain, summer 1967.

on Cutoff Mountain, and may reflect the difference in sexes observed. On The Thunderer, only ram groups were observed, and on Cutoff Mountain, only ewe groups.

Table 9. Feeding and bedding intervals observed on two areas in Yellowstone Park, summer 1967.

Activity	The Thunderer*	Cutoff Mountain**
	(Time in minutes)	
Feeding - average length	34	27
maximum length	125	90
Bedding - average length	40	30
maximum length	124	114

*Ram groups.

**Ewe groups.

Movements

Seton (1927) indicated that bighorn sheep on Mount Everts and Mount Washburn in Yellowstone Park had a summer range of 2 - 3 miles, and this is similar to the range I observed. Davis (1938), studying bighorn summer activity in Yellowstone Park reported a home range averaging 3/4 miles and ranging up to 1-1/2 miles. Greer (1931) reported that in Yellowstone, daily movements generally are limited to small areas. Simmons (1961) also reported that sheep remain within a relatively small area during spring and summer. Studying the Poudre River bighorn herd in Colorado, Simmons found a daily movement of 842 yards with a standard error of 109 yards (the maximum distance between two sightings of one individual, a yearling ram, was 2-1/4 miles). I found that the daily home range of the bighorn sheep was usually

1/4 to 1/2 mile. However, this daily home range often was extended by movements as far as two miles. The usual summer home range was two to three miles, but sometimes it extended as far as six to ten miles if the terrain permitted. A good example of this extended seasonal home range is the Mount Hornaday-Cutoff Mountain complex that further extends northeast along the boundary ridge to Wolverine, Sunset, and Meridian Peaks (see Figure 12). Well-defined sheep trails extended all along this area indicating that the sheep freely moved throughout the area. Although I could not identify individual sheep or herds, repeated observations found herds scattered throughout the area on some days, and concentrated on or near Cutoff Mountain on other days.

Night activity

I found only one discussion or mention of night activity in the literature I reviewed. Moser (1962) reported that bighorn in Colorado were observed feeding near a bedground after most of the herd bedded. Most authors reported that bighorn activity begins before or around sunrise, and the sheep bed for the evening when darkness falls.

I observed bighorn feeding well after sunset on The Thunderer until total darkness prohibited further observations. Terrain restrictions and safety prevented extensive night observations. However, on Mount Washburn, the accessibility and tolerance of the sheep permitted some close night observations, but, tourist activity

during the day often influenced the sheep's activity patterns and this may have some bearing on the night activity.

On August 3, 1967, on Mount Washburn, just before total darkness set in at 9:30 p.m., 12 sheep appeared below the fire lookout tower on the summit. All but two sheep were observed feeding at 10 p.m. and at 10:30 p.m., three sheep were still feeding near the lookout. At 11:30 p.m., all 12 sheep were bedded. Those sheep were again observed at 5:15 a.m. before sunrise, and all were bedded near where they were last observed, but some movement had occurred during the night. By 5:40 a.m., the sheep had moved nearly 250 meters from their bedding site, and all were feeding.

On August 25, 1967, three sheep were approached at 12:25 a.m. It was not possible to tell if the sheep were feeding or bedded, but when first observed, they were standing and watching my assistant. The sheep stood and watched for eight minutes, and one ran out of sight while the other two began feeding. Feeding continued for nine minutes then the sheep bedded. Seven minutes later, the two sheep were disturbed by the flashlight and ran out of sight. Near the same area at 2:12 a.m., a single ewe was feeding. She immediately spooked and ran from sight when she was approached.

On three other occasions during August on Mount Washburn, I attempted to get night activity observations without success. In each case, I watched the sheep from 1/2 mile away with a spotting scope until total darkness. After a one hour delay intended to let the sheep settle down for the night, I would approach the area, and the sheep were gone. When observed at first light the following

morning, the sheep were found anywhere from 1/4 to 1/2 mile away from where they were last observed at dark.

My limited night observations indicate that bighorn continue feeding after dark, and move as far as 1/2 mile during the night. I feel they do go to bedgrounds for the evening, but are probably up and feeding at intervals throughout the night. However, their movements probably are limited to the immediate vicinity of the bedgrounds. Intensive feeding activity and movement probably does not resume until first light in the morning.

The sheep were more wary at night than during the day. When closely approached, the sheep would snort frequently, a sound that was never heard during the day. This sound may have expressed fear or served as a warning to others in the herd. The bighorn fled quickly when approached at night, and apparently can travel over the rocks as rapidly and as well as during the day.

Play

Greer (1931), working in Yellowstone, reported that young are given to playful antics, but he had never seen adults at play. Simmons (1961) reported observing all ages and sexes indulging in various degrees of play. Most play activities reported were described as running or butting games.

I did not observe any play activity between ewes and lambs. However, on numerous occasions, I watched lambs playing among themselves. Usually, the play involved running around, butting heads, and occasionally, the lambs attempted to mount each other. The

play activity was always a short duration, and never gave any appearance of being an organized activity. Rather, it appeared to be a spontaneous reaction to the antics of one lamb. The frequency of play activity showed a marked decrease by middle August when the lambs were about two months old.

I observed one period of prolonged play lasting 40 minutes among 11 rams. The activity took place on a snowbank about 60 meters long (Figure 20), and involved wild charging back and forth across the snowbank. Numerous skidding stops that sent up a spray of snow and repeated leaps into the air with all feet leaving the ground left no doubt that the rams were thoroughly enjoying themselves. Often, several sheep would gather around and take turns butting heads with an intensity approaching the famous breeding behavior of bighorn rams. Several times, this butting was interrupted by rams attempting to mount each other.

Smith (1954) also described sheep playing in the snow, but the activity only involved running and skidding across the snow. Simmons (1961) reported rams trying to mount each other in the summer and considered it "homosexual" behavior.

Bedgrounds

Bighorn sheep bedgrounds can be grouped into two distinct types: a daybed and a nightbed. Sheep may be found bedded at any time during the day, and the daybed is wherever they happen to be feeding. Simmons (1961) described similar bedding habits for the Poudre herd in Colorado. With few exceptions, the sheep would

Figure 20. Eleven rams playing on a snowbank on The Thunderer on July 20, 1967.

attempt to excavate a shallow depression with from two to eight pawing motions with their front feet prior to bedding. This trait was even noted when sheep were bedding on rocky outcrops or in the paved parking lot on the summit of Mount Washburn.

Simmons (1961) found that bighorn sheep in Colorado began a steady directional movement about one hour before sunset to established bedgrounds, but rarely used the same bedground two nights in a row. Moser and Pillmore (1960) reported sheep moving to established bedgrounds at dark. However, Davis and Taylor (1939) reported no established and regularly used bedgrounds.

Moser (1962) stated that sheep used bedgrounds not out of choice or preference; rather they grazed in the direction of the nearest bedground as evening drew near. The Yellowstone bighorn herd acted in the same manner. Bedgrounds were numerous, and the sheep used the one closest to their feeding location near evening. Generally, the night bedding sites were on steep rocky sites near or on the crest of a ridge. The most important criteria appeared to be rocky sites with good visibility in at least one direction, usually down slope. All bedgrounds met this criterion even if they were not located near the crest of a ridge.

Honess and Frost (1942) reported that the choice of bedgrounds can be influenced by weather, and I observed this on several occasions in Yellowstone. Bedgrounds protected by overhanging ledges, or small stands of timber served as bedding sites during extended period of inclement weather. Bedgrounds used during inclement weather were always below the crest of a ridge, but not always on the lee side of the storm.

Escape behavior

Honess and Frost (1942) and McCann (1956) reported the use of cliffs, rimrocks, and ledges for escape terrain. McCann added that there is no confusion on approach of danger, flight being immediate and direct. The herding instinct of bighorn sheep appears to be an aid when facing danger. Greer (1931), Murie (1940), and Smith (1954) noted bighorn herding at the approach of danger. I observed an immediate herd tightening when bighorn suspected danger approaching. Their escape route appeared to be definite but, surprisingly enough, the nearest cliffs or ledges were not always selected. On The Thunderer, I startled a group of rams that were bedded about 50 meters from the west rim that offered excellent cliffs and ledges for escape. Since I had previously observed sheep using these cliffs for escape terrain, I assumed the rams would do the same. However, these rams immediately fled to the east, and used cliffs along the east rim 1/4 mile away as their escape terrain.

Reaction to aircraft

It was a rare occasion if a bighorn stood calmly and observed the aircraft passing overhead. The usual reaction was fear and immediate flight. Overhanging rock ledges, crevices, and caves were used for cover, but the preferred escape cover from aircraft were scattered stands of timber. When the sheep reached the security of timber, they usually stood motionless and repeated buzzing rarely moved them from their stand.

Ewes were very concerned about the security of lambs, and often would use deep crevices to protect the young rather than flee

to the protection of timber. On one occasion, a lamb less than 24 hours old and still very wobbly was with two ewes on the east slope of The Thunderer. When we made a low pass in the Super Cub, the ewes forced the lamb under a small crevice and then fled along the cliffs, leaving the lamb behind. Another close pass was made, and the ewes continued to run, but the lamb remained motionless under the crevice. On another occasion, a large ewe group fled nearly 250 meters along the east cliffs of Amphitheater Mountain when we approached. When a deep overhanging ledge was reached, the lambs went underneath, and the ewes formed a protective wall in front of the ledge (Figure 21). In an effort to confirm our lamb count, we made four close passes with our wingtip less than 75 feet from the sheep, but could not force the ewes to leave.

I believe that the aircraft's sound is the major element feared by the sheep. I observed a large ewe group display concern when they heard an aircraft long before the aircraft was visible. The sheep looked intently for the source of the noise, and did not relax until the aircraft was sighted five miles south of their position and nearly 2,000 feet lower. This observation strengthened my conclusion that we could approach the sheep closer if we reduced power and glided in. Flight in the higher powered and noisier Cessna 180, 182, and 205 always caused greater alarm among the sheep.

Figure 21. Ewe group on east wall of Amphitheater Mountain protecting lambs from a Super Cub.

Tolerance of other species

Greer (1931, p. 10) described the relationship of Yellowstone bighorn to deer, elk, moose, buffalo, and antelope, and stated that: "Sheep are not fearful of other game animals and mingle with them to some extent, particularly antelope and deer, but their attitude for other species is indifference." On summer range, I observed bighorn in close proximity to elk, deer, and antelope on several occasions, and their attitude is best described as indifferent. There was no social contact involved, and each species appeared to go about their own business without concern for the presence of other species.

Small mammals, particularly the Pika (Ochotona princeps) and the Yellowbelly Marmot (Marmota flaviventris) often were in close proximity to the sheep. These animals would run past bedded or grazing sheep less than 10 feet away. Again, with only two exceptions, the sheep appeared unconcerned and indifferent. One exception involved a ewe bedding near her lamb. Three marmots were running back and forth for several minutes when the ewe leaped up and chased one of the marmots for several feet. The ewe immediately bedded again, and permitted the marmots to run past her without further concern or action on her part. The other exception involved a lamb and marmot alternately chasing each other around rocks near the summit of Mount Washburn for 45 seconds. This playful activity ended when the marmot scurried under some rocks and did not reappear. Two adult ewes observed this activity with considerable curiosity from 15 meters away, but made no effort to interfere or participate.

Reaction to humans

Tolerance of human activity is at best an unpredictable aspect of bighorn behavior. Smith (1954) reported that bighorn are more wary on summer range and I agree with him. Lambs and yearlings were more wary than adults, but I found that ram groups were always more wary than any ewe group I approached. Couey (1950) and Smith (1954) both reported the tendency of bighorn to become more alarmed of man when further away, but showed apparent disregard when man was close. This was not the case with the Yellowstone herd on summer range. The sheep were most wary when I was not fully visible or if I startled them by appearing suddenly at close range. On many occasions, a bighorn group let me approach as close to them as I cared, but on some occasions, the same group would spook when I was still 300 meters away. I also found that single animals or small groups were more wary and likely to stampede than a larger group.

There is no doubt that sheep do become used to the presence of humans and show little fear. Geist (1967) found that sheep he spent long periods of time with would eat from his hand, follow him about, and even play "hide and seek" with him. On Mount Washburn in Yellowstone Park, the ewe group that summers there had accepted the presence of humans and tourist busses. Busses are sometimes forced to halt for sheep bedded on the road, and tourists can readily approach the sheep for photographs. Mike Michaelis, the fire lookout on Mount Washburn during the summer of 1967, even enticed a lamb to lick table salt from his hand on two occasions.

CHAPTER VI

ECOLOGY

Summer habitat

Honess and Frost (1942) described typical bighorn sheep summer habitat as sheer and broken rim rocks which command a good view of the surrounding country. Smith (1954), speaking of the Bighorn Crags in Idaho, stated that summer range is the subalpine position between spruce-fir and alpine tundra. Smith stressed the importance of recognizing the many micro-habitats existing within subalpine ranges. In some ranges, sheep spend the summer within the upper limits of the ponderosa pine zone according to Smith. Smith also found sheep using winter range throughout the summer. McCann (1956) in his study of the Gros Ventre range, described summer range as high plateau-like mountain tops well above timberline. The summer range of California bighorn sheep in southern British Columbia ranged from 6,000 to 8,000 feet, but often no distinction could be made between winter and summer ranges (Blood, 1963).

The above introduction serves to indicate the variety of habitats frequented by bighorn sheep in the summer. This "flexibility" of summer range choice was one outstanding characteristic of the Yellowstone herd. In most areas, the sheep spent the summer on so-called "typical" summer range consisting of open subalpine meadows

around 10,000 feet with many rocky ledges and cliffs to serve as escape terrain. In some areas, however, sheep summered on their winter ranges or on intermediate areas from 7,500 to 9,000 feet. Summer ranges varied from the alpine meadows of Mount Washburn and the subalpine meadows on the mountains in the northeastern part of Yellowstone Park, to the banks of the lower Yellowstone River.

Some controversy exists concerning bighorn sheep using timber. McCann (1956) found that timbered areas were not used by sheep. All areas used in the Gros Ventre range were broken and craggy. Smith (1954) and Nichols (1956) found sheep using timber without hesitation for shelter during inclement weather and for shade and relief from heat. I also found that sheep entered scattered stands of timber without concern both for protection from inclement weather and to seek relief from heat. Some summer ranges such as Hellroaring Mountain and the Amethyst Mountain-Fossil Forest areas were completely in scattered timber with no open subalpine areas.

The most important criterion for bighorn habitat appeared to be the presence of rocky outcrops, ledges, or cliffs. Summer ranges were found at all altitudes in the park from 6,200 to 11,000 feet, and most vegetative types were used. However, all ranges had the presence of rocky areas in common. The rocky areas did not have to be broken, craggy areas, or extensive cliffs and ledges, but some rock exposures were always present.

In an effort to determine if there was any preference for exposure, I recorded the locations where I observed sheep during aerial surveys. Table 10 shows the results obtained during two flight periods. During the June 17-July 1 period, the sheep had not

arrived on summer range and lambing was still in progress. By the July 24 - August 2 period, most sheep were occupying summer ranges. The most obvious preference was for the top of whatever summer range the sheep were on. Of the east, west, and south exposures that were used most by the sheep during the first period, only the southern exposures continued to be frequently used during the second period. During the winters of 1965 and 1966 in Yellowstone, Oldemeyer (1966) found that for all activities, the south, southwest, west, and north exposures were most frequently used. The west exposure was only used two per cent of the time.

Table 10. Exposure preferences of bighorn sheep on summer ranges in Yellowstone Park, 1967.

	June 17-July 1, 1967		July 24-August 2,1967	
Exposure	Number of Sheep	Per Cent	Number of Sheep	Per Cent
East	175	24.0	6	1.0
West	162	22.2	17	2.8
South	153	20.9	127	22.1
Top	68	9.3	334	58.1
Southeast	50	6.8	0	0.0
North	41	5.6	3	0.5
Northeast	39	5.3	0	0.0
Northwest	23	3.2	20	3.5
Southwest	18	2.5	68	11.8
Totals	729		575	

Plant composition and food habits

Plant composition

Ten 100-foot step-point transects consisting of 1,000 observations each were performed on The Thunderer and Cutoff Mountain. These transects were not intended to sample the entire summer area, rather to determine plant composition on selected sites that were preferred bighorn sheep feeding areas. Plant composition on The Thunderer in July 1967, and on Cutoff Mountain in August 1967 is compared in Table 11. Because of the selective nature of my sample, the results do not represent the plant composition of the entire summer range with its numerous micro-habitats. However, I think the results do typify the range composition found throughout the high subalpine summer ranges found in northeast Yellowstone Park, and along the east park boundary.

Plant composition was not determined in conjunction with food habits on the Mount Washburn summer range. However, visual inspection indicated that the composition was similar to that found on The Thunderer and Cutoff Mountain. On Mount Washburn, Carex hepburnii was the dominant grass-like plant and Arenaria obtusiloba the dominant forb. Buechner (1960) described the summer range on Mount Washburn and stated that Carex elynoides and Silene acaulis dominated. Other abundant species noted by Buechner were Arenaria obtusiloba, Carex petasata, Luzula multiflora, Poa rupicola, Potentilla diversifolia, Saxifraga rhomboidea, and Trisetum spicatum. The species that Buechner identified as Carex elynoides is probably the species that I identified as Carex hepburnii (identification

Table 11. Plant composition of two selected sites on The Thunderer and Cutoff Mountain, Yellowstone Park, summer 1967.

	Frequency of Occurrence (Per Cent)	
	The Thunderer*	Cutoff Mountain**
Bareground	16.0	10.1
Litter	9.3	9.2
Rock	10.8	9.8
GRASSES AND GRASS-LIKE		
Carex albo-nigra	1.7	0.0
Carex hepburnii	15.8	13.6
Carex illota	0.0	8.5
Deschampsia caespitosa	0.3	0.0
Festuca brachyphylla	0.1	0.0
Luzula spicata	0.0	4.7
Poa alpina	0.3	0.0
Poa cusickii	0.1	0.0
Poa rupicola	1.3	1.5
Sitanion hystrix	0.0	0.2
Trisetum spicatum	0.1	1.5
Unidentified grasses	2.0	0.7
Totals	21.7	30.7
FORBS		
Arenaria obtusiloba	3.0	9.4
Artemisia scopulorum	2.4	1.6
Aster haydeni	0.0	0.2
Astragalus alpinus	5.3	8.2
Astragalus miser	1.3	0.1
Draba andina	0.0	0.3
Erigeron simplex	3.2	4.1
Mertensia alpina	3.0	0.7
Myosotis alpestris	1.0	0.0
Penstemon glaber	0.0	1.6
Phacelia alpina	0.8	0.0
Phacelia leucophylla	0.1	0.0
Phlox multiflora	1.1	4.5
Potentilla diversifolia	11.3	3.5
Saxifraga bronchialis	0.0	0.5
Saxifraga rhomboidea	0.4	0.3
Sedum stenopetalum	0.0	0.9
Smelowskia calycina	0.7	0.0
Unidentified forbs	1.3	0.5
Totals	34.9	36.4
MOSSES	7.3	3.8
Totals	100.0	100.0

*1,000 observations on July 16, 1967.

**1,000 observations on August 15, 1967.

confirmed by Dr. W. E. Booth, Botany Department, Montana State University at Bozeman). I did not note the occurrence of Silene acaulis, but since the flowering season is from early July to mid-August (Craighead et al., 1963), my survey in late August may have missed its occurrence.

Food habits

Most, if not all, researchers reporting on food habits consider bighorn sheep to be grazing animals. Most workers also note that bighorn are delicate feeders, showing a preference for tender and succulent grasses and forbs. McCann (1956) reported that sheep are delicate feeders, tending to nibble. He found that the sheep did not feed on dried-out mesa tops, but sought green vegetation elsewhere. Spencer (1943) and Simmons (1961) both reported sheep having a destructive habit of pawing where they fed. I did observe some pawing and ripping of mat forming forbs such as Arenaria obtusiloba, but sheep were delicate non-destructive feeders for the most part. I never observed ripping or pawing up the sedges, grasses, and most forbs the sheep fed on. There was an apparent preference displayed for the most succulent vegetation and vegetative parts. Only the top third of sedges was consumed, and usually, only the leaves of grasses were eaten. Grass heads and stems were ignored unless the grass was just emerging and very tender. Forb parts consumed were usually the flowering heads or buds, and just a small portion of the stem. Even the act of feeding was a "delicate" activity. The sheep wandered in a seemingly aimless manner, taking a few nibbles here and there, and

moving on 10 to 20 feet to another site. Rarely did the sheep stand in one spot longer than 30 seconds.

Smith (1954) reported that from July 1 to September 30, the diet of bighorn sheep was 86 per cent grasses and forbs and 14 per cent browse. Smith also found that more grasses were used than forbs. Couey (1950) reported that grasses formed the bulk of the diet for Montana bighorn sheep. Mills (1937) reporting on bighorn food habits on Mount Washburn in Yellowstone Park, described them as delicate but versatile feeders. Mills found the following July diet: Poa sp., 60 per cent; Pedicularis cystepteridifolia, 25 per cent; Polygonum bistortoides, 5 per cent; Erigeron sp. and Eriogonum umbellatum, 5 per cent; and Picea engelmanni and Pinus albicaulis, 5 per cent.

To determine food preferences, I compiled 1,000 grazed plant observations along the transects established on The Thunderer and Cutoff Mountain to determine range composition on frequently grazed areas. Table 12 contains the results of the 2,000 grazed plant observations and indicates food preferences for those areas and time periods. I attribute the increased preference shown for grasses and grass-like plants on Cutoff Mountain to the later date the data were collected. When food habits were investigated on Cutoff Mountain, the flowering season of the early forbs had ended, and grass-like plants were the most succulent vegetation available. This preference for succulent vegetation was again suggested in the results of 1,000 grazed plant observations I collected on Mount Washburn during the last week of August 1967. Grasses and grass-like plants were only 47.4 per cent of the observations, and forb utilization had increased to 51 per cent. Perhaps this reflected a late summer drying out of

Table 12. Food preferences on two selected summer ranges in northern Yellowstone National Park, 1967.*

	Frequency of Use (Per Cent)	
	The Thunderer July 1967	Cutoff Mountain August 1967
GRASSES AND GRASS-LIKE PLANTS		
Carex albo-nigra	4.9	0.0
Carex hepburnii	51.9	54.3
Deschampsia caespitosa	0.8	0.0
Festuca brachyphylla	0.0	0.3
Luzula spicata	0.0	19.9
Poa alpina	0.2	0.2
Poa cusickii	0.3	0.0
Poa rupicola	0.2	2.7
Trisetum spicatum	0.0	1.7
Other grasses	5.5	1.8
Totals	63.8	80.9
MOSSES	0.1	0.0
FORBS		
Arenaria obtusiloba	0.3	0.1
Artemisia scopulorum	0.6	1.3
Aster haydeni	0.0	0.1
Astragalus miser	0.4	0.0
Dodecatheon pauciflorum	0.1	0.0
Draba andina	0.2	0.4
Erigeron simplex	3.3	5.1
Mertensia alpina	1.0	0.6
Myosotis alpestris	0.5	0.0
Penstemon glaber	0.0	2.3
Potentilla diversifolia	15.6	4.9
Saxifraga rhomboidea	14.1	4.3
Totals	36.1	19.1

*Food preferences are based on 1,000 grazed plant observations in each area.

the vegetation and late flowering forbs were more appealing to the sheep. But even in late August on Mount Washburn, Carex hepburnii was the most frequently grazed plant (28 per cent of observations). However, the frequencies of grazed plant observations only indicate food preferences. Because only the buds or flowering heads of forbs

were consumed by the sheep, grasses and grass-like plants formed the bulk of the summer diet. Carex sp. was the dominant plant on the summer ranges I investigated, and was the most frequently utilized plant. Preferred forbs were Potentilla diversifolia, Saxifraga rhomboidea, Erigeron simplex, and later in the summer Lupinus candicans. Although not appearing in my feeding observations, traces of mosses, lichens, and trees entered the diet of bighorn sheep on summer ranges.

Water requirements of bighorn sheep are rarely mentioned in the literature. Seton (1927) reported that water is sought once each day, preferably in the evening. An opposite viewpoint was presented by Honess and Frost (1942). They found bighorn on high summer ranges indifferent to water, often staying on a dry hillside for three days without visiting a watercourse. However, Honess and Frost did report that snowbanks provided a water source for bighorn on high summer ranges. I observed bighorn sheep frequently eating snow, and on some summer ranges, this was the only water source available. In several instances, sheep ignored water flowing from a melting snowbank and chose to eat snow instead. Puddles of water that remained in shallow depressions in rocks after rains also provided a water source for bighorn sheep on Yellowstone summer ranges.

Mineral preferences or needs have not been determined in Yellowstone Park. Greer (1931) did mention that sheep use mineral licks, but made no further observations on possible mineral use or requirements. Cowan and Brink (1949), studying natural game licks in the Rocky Mountain National Parks of Canada, found that bighorn sheep used licks most from June to August. Smith (1954) discussed the

apparent preference sheep have for minerals and reported the highest use in the spring, but apparent use throughout the year. Smith attributed some local summer drifts of bighorn herds to mineral requirements. However, McCann (1956) found no summer mineral use during his study. I only know of two instances of mineral use during my summer field work in 1966 and 1967. On August 1, 1967, seasonal Park Ranger Gary Lanchester reported observing two ewes and two lambs using a lick near the bank of the Yellowstone River just west of Little Cottonwood Creek. Lanchester reported that the area of the lick was heavily trampled and appeared to be a clay-type soil. I observed sheep licking a clay-loam soil near the summit of Mount Washburn. There was some sign of chewing or eating the soil, but most utilization of this area was licking. Sheep returned to this site almost every evening, and individuals of all ages would spend up to five minutes avidly licking the soil. A laboratory analysis of this soil disclosed the following content of soluble salts: Sodium 220 ppm, Calcium 700 ppm, and Magnesium 130 ppm. Other elements present in the soil were Phosphorus, Potash, Sulfate Sulfur, Iron, Copper, and Cobalt. Sodium and Calcium salts were slightly higher than similar soils of the area, but the analysis does not provide evidence why this particular spot was chosen as a "lick."

The bighorn herd summering on Mount Washburn also cultivated a taste for the unusual. Many of the sheep in the area licked the rock wall where the fire lookout tossed greasy dishwater. This was the only area of the wall where I observed sheep licking. Some sheep also licked the rocks that were coated by exhaust fumes from the parked tourist busses.

Competition

Andrewartha (1961) was critical of the term competition because he believed that the word failed to explain the density and distribution of species and generally was too broad in meaning. Additional criticism was leveled in the belief that using the term merely replaced a precise description of the factors involved. Andrewartha's criticism is justified in many respects, but I believe that competition is a useful term if the meaning intended is presented along with the factors of competition that are being considered. For this reason, I think it is important to delineate my views on competition before discussing the apparent and possible effects of competition on bighorn sheep summer ranges in Yellowstone Park.

Darlington (1957) called competition "the struggle for existence." This is far too broad a meaning, and fails to establish a practical description of competition. Odum (1959, p. 230) defined the meaning of interspecific competition in ecology as: "Any interaction between two or more species populations which adversely affects their growth and survival." The competitive interaction that Odum refers to can involve space, food, disease, etc., and becomes a useful definition. However, the definition tends to separate interspecific and intraspecific competition, and I believe that both should be included in one definition. The definition of competition that includes both inter- and intraspecific coactions, includes all possible ecological factors, and is not restricted by considering only needs that are in short supply is presented by Birch (1957, p. 16): "Competition occurs when a number of animals (of the same or of different species)

utilize common resources the supply of which is short; or, if the resources are not in short supply, competition occurs when the animals seeking that resource nevertheless harm one another in the process." This is a definition of competition that I adhere to.

I subscribe to the idea that competition is ever present, but in varying degrees. On the Yellowstone summer ranges, the most important competitive coactions, both at ther inter- and intraspecific levels, involve food, space, and susceptibility to disease.

Interspecific competition with elk

"The food habits of our big game are not sufficiently specialized to prevent competition among the species. Perhaps the elk, being the most omnivorous big-game animal is the most likely to bring on harmful rivalry" (Murie, 1951, p. 255). This statement by Murie emphasized one aspect of competition that generally gains the most widespread attention. Smith (1954) stated that one requirement for desirable bighorn habitat was a lack of interspecific competition to an extent that would lead to range deterioration. Smith observed that bighorn leave abused ranges to elk and deer, and that bighorn are more immediately affected by competition for food than are other species.

Competition for nutrients is a problem most often associated with winter ranges. Buechner (1960) pointed out that Rocky Mountain summer ranges are generally in good, and sometimes in excellent condition. Abundant forage is available for all the species utilizing the ranges. Packard (1946) reported that bighorn sheep shared summer range with elk in Rocky Mountain National Park, but the competition

was not detrimental because of abundant forage. However, Green (1949) found that elk presented a food competition problem both on winter and summer ranges in Banff Park, Canada.

Elk and bighorn sheep food habits overlap a great deal on summer range. Murie (1951) reported the grasses are the staple food of elk year round. Carex sp. is a regular, though small, portion of the summer elk diet, and elk are fond of a variety of forbs and seek them eagerly. I found that Carex sp., grasses, and forbs made up the bulk of the bighorn's summer diet. However, this overlap of food habits did not lead to detrimental competition on summer range, because few ranges supported elk and bighorn in close proximity to each other. On summer ranges shared by both species, the competition was still not detrimental because of abundant vegetation.

Green (1949) reported that bighorn were intolerant of elk and only on rare occasions would mingle with them. This was the case in Yellowstone, and indicates the potential existence of serious competition for space. During intensive aerial and ground searches for bighorn sheep on summer range, it became apparent that sheep were not to be found in any number in areas used by elk. Where I found sheep and elk using the same general area, there was an obvious habitat or space separation. During the summer, 1966, a band of at least 12 rams summered on the Bannock Peak - Quadrant Mountain area of the southern Gallatin Range. On July 17, 1966, I observed more than 200 elk on the rolling top of Quadrant Mountain. The rams avoided feeding on the lush vegetation covering the top of Quadrant. Instead, the rams roamed the ridges of Bannock Peak or stayed on the sides of Quadrant Mountain. This separation may have been caused by different

habitat preferences of the two species, but in other areas, notably the Amethyst Mountain area, I found sheep grazing on the rolling tops in preference to ridges or sides where the vegetation was sparser.

If competition for space exists, as I believe it does, the degree and possible effects of this competition remains unknown. An important question would be: would the sheep use these summer ranges if the elk were not present? A still more important question would be: do the sheep need these summer ranges? At the present time, winter ranges are probably the limiting factor in bighorn sheep numbers, but if winter range improvements increase the sheep population, they would require more extensive summer ranges than are presently being used.

Interspecific competition with other ungulates

If we adhere to the definition of competition requiring that the species involved "harm one another," then competition is probably non-existent on Yellowstone summer ranges, with one exception, the Chalcedony Creek - Amethyst Mountain area. In this area, 20 plus mule deer, 20-30 antelope, and 2-4 bison share a summer range with about 90 bighorn sheep and 25-30 bull elk. However, I doubt if the level of competition in this area is high enough to have detrimental effects on the bighorn population because the species generally avoid each other, and forage is plentiful. However, because of the number of species using the area, and the large numbers of bighorn sheep of all sexes and ages, this area should be closely observed for possible future detrimental effects caused by competition.

Intraspecific competition

The gregarious nature of bighorn sheep tends to increase the level of intraspecific competition. Odum (1959) pointed out that increasing levels of intraspecific competition tend to force individuals of the species to the marginal areas of their habitat. Intraspecific competition for food and space on summer ranges is presently at a low level and gives no evidence of having any detrimental effects on the bighorn population. However, I believe the most important concern with the bighorn population is the possible detrimental effect of intraspecific competition leading to an increased susceptibility to disease. Susceptibility to disease is a problem inherent in all bighorn sheep populations, and the Yellowstone herd is no exception. This problem is not apparent now, but because of its nature, it is not easily detected. For this reason, herd sizes and concentrations should be studied and closely monitored.

In summary, my study did not determine levels of competition or even the existence of competition in some cases. Interspecific competition for food probably exists in some areas, and elk are the most serious competitor. However, the detrimental effects of competition for food are probably negligible to the range because the summer ranges are generally in good condition. However, the effects of competition for food on the sheep are unknown. Potentially more serious is the apparent competition for space between bighorn and elk. The greatest potential danger lies in the intraspecific competition encouraged by the gregarious nature of the sheep.

Predation

Moser (1962) stated that "numerically the coyote is by far the most numerous predator on bighorn sheep ranges, but it is felt that predation from this source is of relatively minor importance on herd drain." Smith (1954) also shared the view that coyotes, although numerous, have little effect on bighorn sheep populations. In Yellowstone Park, Murie (1940) observed many coyotes in close proximity to bighorn on Mount Washburn, but no evidence of predation. However, coyotes do take bighorn on occasion. Murie (1940) discovered a yearling ram that had been killed by coyotes in Yellowstone Park. In March 1943, a large and apparently healthy ram was killed by three coyotes (U.S. National Park Service, 1943).

During my study, I observed two interactions between coyotes and bighorn sheep. In both cases, the sheep showed little fear of the coyote, and appeared to be capable of protecting themselves. The first incident occurred on June 28, 1967, near Calcite Springs, and involved one coyote, two adult ewes, and one lamb. The coyote was standing motionless near a deadfall about 30 meters away from the sheep. The coyote was definitely stalking, but it was not clear whether he was stalking the lamb or several nearby marmots. One ewe, with her lamb close to her side, retreated several steps and stared at the coyote with her back to the canyon rim (Figure 22). The other ewe was standing about 10 meters away from the other two sheep. Suddenly, and without any visible warning, the lone ewe charged the coyote and repeatedly attempted to strike with her front hooves. The coyote immediately fled. Within five minutes after the incident, all

Figure 22. Two ewes and lamb guarding against a coyote opposite Calcite Springs, Yellowstone Park.

three sheep were bedded, but still alert and facing in the direction the coyote fled. After 10 minutes, the ewes were placidly chewing their cuds while bedded and the lamb was grazing nearby.

The other incident took place on July 11, 1967, near the summit of The Thunderer. This encounter, lasting 21 minutes, involved 10 rams and one coyote. The coyote appeared to be more interested in play and harrassing the ram group, rather than in seeking a potential meal. The rams first observed the coyote when he approached to within 50 meters of where they were feeding. The rams ceased feeding and stared as the coyote moved away and disappeared from sight. One minute later, the coyote returned and again approached the rams. The rams banded closely together, began walking toward the coyote, and then all charged. The coyote ran about 20 meters and sat down, and the rams ended the chase. The sheep then turned their backs to the coyote and resumed feeding. For the next 14 minutes, the coyote rolled around and played with his tail like a young puppy. These antics were generally ignored by the sheep that were either bedded or feeding. Except for early in the encounter when the sheep banded close together and charged the coyote, the bighorn showed no outward signs of fear or concern at the presence of the coyote.

The only other incident that I observed between bighorn sheep and one of their reported potential predators occurred July 17, 1967, on The Thunderer. Five rams were feeding when a Golden Eagle began circling in the area. The rams all ceased feeding, stared at the eagle, and grouped tightly together. Soon after the eagle left the area, the rams continued their feeding activity and showed little concern.

Throughout my study, I never saw any evidence of actual predation. Although coyotes are common on bighorn summer ranges, I concur with other workers who believe that coyotes have little effect on bighorn populations. Mountain lions are a potentially serious predator of bighorn sheep (Smith, 1954; and Moser, 1962), but in Yellowstone Park, they are occasional visitors at the most. The smaller cats, lynx and bobcats, are scarce (if at all present) on Yellowstone summer ranges and can be excluded as serious predators. I observed three areas in Yellowstone Park where bighorn sheep share summer ranges with grizzly bears: the Gallatins, Specimen Ridge, and Barronette Peak. Although the possibility exists that predation can occur, I noted no instances, and there are no reported instances in park records. I doubt if the grizzly is a serious predator of bighorn sheep.

Disease and parasites

The bighorn sheep in Yellowstone Park certainly are not disease free, but close observations during my study did not disclose that disease is a problem at this time. I observed only one bighorn that may have been suffering from a disease. A mature ewe on Mount Washburn suffered from a heavy rasping cough similar to the described symptoms of lungworm infestation. Sometimes, while bedded, she would arise and cough 7-8 times and then bed down again. However, there was nothing about her behavior or external appearance to indicate unthriftiness. All the other sheep I observed appeared healthy and in good physical condition.

However, the Yellowstone bighorn herd does have a past record of disease problems and the herd should be watched for future problems. Greer (1931) stated that disease was the principal cause of bighorn sheep losses during the four years preceeding his report. He added that all specimens of skin and lungs submitted for laboratory examination disclosed the presence of scabies mites or hair lungworm infection. Murie (1940) observed ewes and some lambs coughing during early August and throughout the winter of 1937 in Yellowstone. Forrester and Senger (1964) examined 20 fecal samples from the Yellowstone bighorn herd, and reported that all contained lungworm larvae. Oldemeyer (1966) reported that examination of the lungs of a dead lamb found in 1965 on McMinn Bench disclosed a heavy infestation of lungworm larvae, but no adult nematodes were found.

Ectoparasites apparently were a source of irritation to the bighorn sheep throughout the summer. I observed sheep of both sexes scratching themselves on shrubs, small trees, rocky outcrops, and with their hind feet. On several occasions, ectoparasite harassment caused the sheep to leap from bedding sites and run for 20-30 meters. Invariably, they would scratch themselves vigorously when they stopped running. While bedded, tail and ear flicking were constant, combined with a continuous twitching of the entire body, particularly the flanks and shoulders.

Lambs, more than adults, seemed to be bothered by ectoparasites. On days when the adults appeared to be little disturbed, the lambs would often scratch themselves with their hind feet. Usually lambs only scratched their head and ears, but the adults attempted to

scratch all accessible parts of the body, particularly along the back and head.

Population dynamics

Natural populations are either growing, stable, or declining. The rate of increase of a population depends on the actual birth rate and death rate. A growing population is characterized by a lower death rate than birth rate, and as the population reaches a level of stability, the rates will nearly balance. My study produced no information on death rates, and little information on population age structure; however, comparison of census data over the years, and analysis of ewe:lamb, ewe:yearling, and ewe:ram ratios give an indication of the status of the population. I purposely excluded data from the NW herd and the East boundary herd because these data do not permit comparison with earlier studies.

Early workers in Yellowstone Park (Mills, 1937; and Gammill, 1941) reported a large loss of lambs in late summer or early fall resulting in low yearling recruitment to the population. Ewe:lamb and ewe:yearling ratios from other herds (Table 13) indicate that this is a typical situation in most bighorn herds. Buechner (1960) believed that high lamb mortality was a biological characteristic of stable bighorn populations.

Table 14 compares the ewe:ram, ewe:lamb, and ewe:yearling ratios from my study in 1966 and 1967, and the data reported from the winter of 1966 in Yellowstone (Oldemeyer, 1966). The term ewe herd used in some of the ratios includes ewes and yearlings grouped together.

Table 13. Ewe:lamb and ewe:yearling ratios from several bighorn herds

Source	Year	Ewe:lamb	Ewe:yearling
Gammill (1941)	1934	1:0.61	
(Yellowstone Park)	1937	1:0.62	
	1938	1:0.62	
Smith (1954)*	1949	1:0.54	1:0.26
(Idaho)	1950	1:0.78	1:0.13
	1951	1:0.75	1:0.08
	1952	1:0.74	1:0.30
Woodgerd (1964)**	1959	1:0.74	1:0.48
(Wildhorse Island, Montana)	1960	1:0.70	1:0.56
	1961	1:0.76	1:0.27
	1962	1:0.85	1:0.27

*The ewe:yearling counts cited by Smith were not considered representative of a true cross section of the herd. Smith believed that winter counts were more representative because the yearlings mingled most freely in heterogeneous groups during early winter.

**The ewe:yearling counts cited by Woodgerd are winter counts.

Table 14. Comparison of sex and age ratios in Yellowstone Park from winter 1966(Oldemeyer, 1966) and summer 1966 and 1967 (Woolf)

Ratio*	Winter 1966	Summer 1966	Summer 1967
Ewe:ram	1:0.78	-	-
Ewe herd:ram	1:0.63	1:0.51	1:0.47
Ewe:lamb	1:0.47	-	1:0.59
Ewe herd:lamb	1:0.39	1:0.59	1:0.48
Ewe:yearling	1:0.20	-	1:0.28

*Ewe herd includes ewes and yearlings grouped together.

Smith (1954) reported that mature rams were "consistently less observable" than females and juveniles during the summer. Although I cannot project my ewe herd:ram ratios to comparable ewe:ram ratios, I suspect that the sex structure of the Yellowstone herd reported by Oldemeyer (1966) is accurate. Oldemeyer reported that his observed winter ewe:lamb ratio of 1:0.47 was relatively high, and attributed this to a mild winter in 1966. He attributed the low ewe:yearling ratio of 1:0.20 to a more severe winter in 1965. Assuming that Oldemeyer's ewe:yearling ratio reflected the true herd status, my observed ewe herd:lamb ratio in 1966 would reflect a good lamb crop comparable to the higher ratios reported in Table 13.

The summer 1967 ewe herd:lamb ratio is smaller than the 1966 ratio. I believe this reflects a more severe winter in 1967 than in 1966. Smith (1954) also suggested a correlation between severity of winters and the successful bearing of young. However, the lamb crop still was satisfactory if my observed summer 1967 ewe:yearling ratio is projected to the entire herd.

Of the 339 ewes, yearlings, and lambs that were included in the 1967 census in northern Yellowstone Park, 153 were classified by close ground observation. Eighty-two ewes, 48 lambs, and 23 yearlings produced the ewe:lamb and ewe:yearling ratios shown for summer 1967 in Table 14. The relatively low ewe:lamb ratio of 1:0.59 is difficult to explain. The winter of 1967 may have limited the successful bearing of young, or lamb mortality in early July through

August may have occurred unnoticed. I think that the sample of the population I classified is an accurate representation of the population status.

Buechner (1960) thought that a stable bighorn sheep population is characterized by a yearly fluctuation less than 20 per cent. Oldemeyer (1966) expressed the belief that the Yellowstone population is in this stable state, and cited the change from Buechner's census of 192 in 1955 to his census of 222 in 1965 was less than 20 per cent. Table 15 compares winter 1966 and 1967 counts (Oldemeyer, 1966; and U.S. Park Service, 1967), and summer 1966 and 1967 counts from my study. The most important comparison is the total for each year, with the current summer lamb crop subtracted from the summer counts. I am convinced that my census data reflect a bighorn population that winters and summers in Yellowstone Park. My study indicated that migration onto park summer ranges from Montana or Wyoming was negligible except along the East park boundary. Any herds found along the boundary in the NE portion of the park that may have come from winter ranges in Wyoming were excluded from both 1966 and 1967 censuses. Therefore, census data presented in Table 15 should reflect the same winter herd counted in 1966 and 1967. The winter 1966 and summer 1966 counts are very close and appear to confirm my conclusions. However, the difference between my summer 1966 count (315 including current lamb crop) and the Park Service winter 1967 count raises some questions. I think the difference can be explained by the census efforts involved. My search was more intensive and was limited only to bighorn sheep. The Park Service figure was obtained in conjunction with the elk census and

does not represent an intensive search effort solely for bighorn sheep. The striking increase of the summer 1967 census over the 1966 census in the same area can again be mostly attributed to census technique. In 1967, I made a more extensive and intensive search. The increased direct count obtained in 1967 resulted from finding populations on ranges that were never searched in 1966. However, the census technique used probably does not account for the entire difference in counts. I think that the population may be slightly increasing in response to a series of relatively mild winters and slightly improved winter range conditions resulting from the Park Service elk management program. The limited population data available at this stage only permits conjecture. Trend counts and accurate classifications should be continued to determine the true herd status.

Table 15. Comparison of winter 1966 and 1967 and summer 1966 and 1967 counts for the northern Yellowstone bighorn herd*

	1966		1967	
	Winter	Summer	Winter**	Summer
Rams	69	73		112
Ewe herd	107	137		240
Lambs	42	81		99
Unclassified	11	24	___	___
Total	229	315	231	451
Total less the summer lamb crop	229	234	231	352

*Winter 1966 from Oldemeyer (1966)
Winter 1967 from U.S. Park Service (1967)

**No classification was made during the census.

CHAPTER VII

MANAGEMENT RECOMMENDATIONS

Present bighorn sheep numbers in Yellowstone Park are small compared to early numbers. Bighorn sheep reproduce at a slow rate, and recent populations are characterized by an uncertain status. Because the majestic bighorn sheep is comparatively rare in the United States, and Yellowstone Park is an important remaining wilderness area for this native species, management should favor the bighorn whenever possible. Antelope, bison, elk, and mule deer are often seen by Yellowstone Park visitors; however, park visitors rarely see the bighorn. For these reasons, bighorn should be favored in management plans and every effort made to maintain, and if possible, increase the numbers of this species in Yellowstone Park.

Summer ranges are generally in good condition and adequate for the present population. However, a problem does exist on the over-used northern Yellowstone winter range. The winter range most likely limits the current bighorn population. Oldemeyer (1966) recommended a continuation of the elk control program to reduce winter range abuse, and I concur with him.

Because of the present satisfactory condition of bighorn summer ranges and the inaccessibility of sheep on summer range, management is best limited to surveillance of bighorn status on important areas in northern Yellowstone Park. Key areas are: Amethyst Mountain-

Chalcedony Creek, Mount Norris-The Thunderer, Barronette Peak, and Cutoff Mountain-Mount Hornaday. These areas provide summer range for more than 200 sheep and should be accurate indicators of the population status.

Emphasis should be on a trend count, and a "ewe herd" to lamb ratio. The most economical way to monitor the population is an intensive aerial search using a Piper Super Cub, or other fixed-wing aircraft with similar capabilities. Summer flights should follow the northern Yellowstone winter counts conducted in alternate years. Then, winter and summer bighorn counts and herd structures can be combined to present an adequate picture of herd status. However, the winter census should be modified. The present technique is to count all species at once, with emphasis on elk. Sex and age classes are determined for elk, but only numbers of other species are recorded. Concentration on a single species will permit the observer to record important sex and age class data as well as numbers. Also, a more effective search will result if the observer concentrates on a single species and thoroughly searches all potential habitat for that species. The present multiple winter counts tend to emphasize elk winter habitat and bighorn winter ranges are less intensively searched.

Assuming that a suitable combination of aircraft, pilot, and observer are available, proper technique will decide the success or failure of the surveillance effort. The survey should be flown in late July, after the sheep are established on summer range and most lambing is over. Flights should begin 30 minutes after sunrise to take advantage of early morning bighorn activity. The duration should be less than four hours to prevent eyestrain and impaired

efficiency. Surveys should not be flown in overcast or turbulent conditions because of unsatisfactory results and increased hazards.

The best search pattern begins with a pass over the high point of a terrain feature followed by descending 500 foot contour intervals until the observer is satisfied that all potential habitat has been searched. Maintain an indicated airspeed of 80 m.p.h. and no more than 200 feet terrain clearance. After herd locations are known, gliding approaches at 60 m.p.h. using reduced power will permit a closer approach and a more accurate count and classification. Often, sheep will remain motionless in timber or under ledges. Repeated "buzzing" will sometimes move them and permit a count and classification.

Repetition is the key to a successful survey. When searching key areas, passes at the same flight level will often disclose sheep missed on the first pass. To reduce the possibility of duplicate counts, the observer should attempt to keep track of sheep seen on earlier passes, and recount if in doubt. It is important to thoroughly search each key area at least three times. Five flights, each lasting about four hours, will be sufficient to carefully count and classify sheep on the key areas. Time required to search each key area is variable and should be left to the observer's experience and judgement. The approximate cost including ferry time will be $100 for each flight.

Rapid die-off of apparently "healthy" herds usually occurs unexpectedly, and this is a possibility in Yellowstone Park. Harmful effects of interspecific or intraspecific competition may occur, but are difficult to detect. Many bighorn populations are managed by

hunting to scatter herds, and reduce range abuse cause by over-crowded conditions. Because hunting is not permitted in Yellowstone Park, alternate methods must be found to prevent unmanaged herd growth that could eventually cause a population decline. I suggest a trapping and transplanting program that would limit herd sizes in some areas yet would increase the overall population by establishing new ranges. Potential release sites are historical bighorn ranges in the Red Mountain, Big-Game Ridge, and Two-Ocean plateau areas of southern Yellowstone Park. Additional release sites could be found along the East park boundary. Prior to release, investigations of forage composition, abundance, and availability in winter would be essential to choose the best sites. Extensive use of these areas by elk for summer range would also have influence on choice of release sites.

Additional research is needed with emphasis on environmental factors critical to the survival, reproduction, and potential increase of bighorn sheep in Yellowstone Park. Although summer ranges are presently adequate, they require periodic evaluation to determine range trends and condition. I believe that a migration study is of primary importance at this time. Only when herd units, and the limits of their winter and summer ranges are known, can an effective management plan be implemented. Current migration knowledge is based on some fact and much conjecture. A study with marked animals or radio telemetry is needed to establish migration patterns with accuracy. Sex ratios, age classes, lamb production, and yearling survival could be determined for each herd unit and related to different components of winter and summer ranges. Management efforts

then could be directed at specific factors limiting the successful recruitment of new individuals to the population. Conceivably, some herds are limited by factors not influencing other herds. A migration study to establish herd units will help determine this and aid in developing an effective management program.

CHAPTER VIII

SUMMARY

Early in the history of Yellowstone National Park, bighorn sheep were a significant part of the native fauna. The decline of the bighorn herd in Yellowstone began in the late 1800's because of outside hunting pressure, influences of disease, and competition for winter range inside park boundaries. Since 1900, the population has been relatively low with a high census of 346 reported in 1927 and a low of 77 reported in 1929.

My summer study began in June, 1966, and lasted until early September, 1967. Study objectives were to census the population, map the summer distribution, determine summer herd structure, observe daily feeding habits, and determine the effects of competition on summer ranges.

The primary method used to determine herd distributions and to census the population was an intensive aerial search conducted in a Piper Super Cub. This aerial search was supplemented by ground searches on all bighorn ranges in the northern portion of Yellowstone Park, excluding the NW boundary area. Extended field trips were made on two intensive study areas during the summer of 1967 to observe food habits and daily activity. Step-point range transects of 1,000 points each were measured on selected areas on each of the two study

sites to determine plant composition. The data was used in conjunction with 3,000 grazed plant observations to determine summer food preferences.

Three-hundred and forty-six bighorn sheep were counted on summer ranges in the northern third of Yellowstone Park in 1966. In 1967, the census was both more intensive and extensive, and 558 sheep were counted in all areas of Yellowstone Park except the Bechler region. The main summer concentration of bighorn sheep was in the NE corner of Yellowstone Park.

Seasonal migrations were incomplete in some cases. Most of the lower Yellowstone and North park herd did not migrate and spent the summer on or near their winter ranges. The longest migration known was about 20 miles from Mount Everts to Mount Washburn. Migration was complete by early June in 1966, but not until early July in 1967. Apparently the date and speed of summer migrations are affected by weather and snow depths on summer ranges. The ram groups usually completed the summer migration while ewes paused to lamb on winter or intermediate ranges.

The sexes made a distinct effort to remain separated while on summer ranges although I did observe two instances of ewes joining a large ram group for several hours. I found that herd groups were not stable throughout the summer. Groups continually splintered off, formed new groups, or joined other groups. Ewe groups consisted of ewes, lambs, yearlings of both sexes, and rams up to two years old. Ram groups generally consisted of rams two years and older, but yearling rams were observed with ram groups. Average herd size for all observations was 7.5 in 1967. Ewe groups were larger than ram

groups with respective average herd sizes of 8.1 and 5.8 in 1967. The largest ram group observed was 24 while the largest ewe group numbered 61.

The daily activity of bighorn sheep centered around a search for food broken by frequent bedding periods. Daily activities were leisure and lacked any apparent routine. Average feeding intervals were just over 30 minutes long and average bedding intervals were closer to 40 minutes long. Some feeding activity and movement after dark was noted, but the extent of nocturnal activity remains unknown. Daily home ranges were around 1/4 - 1/2 mile, and the summer home range was usually 2 - 3 miles. But in several cases, the summer home range extended 6 - 10 miles.

Bighorn sheep appeared to be flexible in their choice of summer habitat. I found sheep at all elevations from 6,200 - 11,000 feet and in most vegetative types found in the park. Sheep entered timber without hesitation for shelter during inclement weather, to seek relief from heat, and for escape. The most important criteria in summer habitat selection appeared to be the presence of rocky outcrops.

Subalpine summer ranges were generally in good condition. The dominant plant found was Carex sp. and this plant also served as the mainstay of the bighorn's summer diet. An apparent preference was displayed for succulent vegetation and dried-out vegetation was ignored. Grazed plant observations indicated a frequency of use for grasses and grass-like plants of 63.8 per cent in middle July, 80.9 per cent in middle August, declining to 47.4 per cent in late August. Increased forb utilization in late August probably reflected a

preference for more succulent late flowering forbs. However, grasses and grass-like plants formed the bulk of the summer diet in terms of volume consumed.

Direct interspecific competition for food or other nutrients was negligible on summer ranges in Yellowstone Park, but a less obvious competition for space may exist between sheep and elk. Potentially, intraspecific competition leading to a reduced resistance to disease holds the greatest danger for sheep on summer ranges.

No predation was noted on summer ranges, and the sheep appeared thrifty and free of disease symptoms. The population of sheep in Yellowstone is at least stable, and may be increasing slightly in response to a series of relatively mild winters and improved winter range conditions resulting from the Yellowstone Park elk management program. Ewe herd (including yearlings):lamb ratios of 100:59 and 100:48 were observed in 1966 and 1967 respectively. In 1967, a ewe: yearling ratio of 100:20 was observed with most observations compiled in late summer. Using this ratio to convert the ewe herd:lamb ratios to ewe:lamb ratios, indicated a lamb crop comparable to other healthy bighorn populations.

Park Service management objectives should include periodic surveys to determine population size, structure, and trends. This should be coupled with a continuous research program to learn more of the habitat and population ecology of the bighorn herd.

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A P P E N D I C E S

APPENDIX A

AERIAL SURVEY DATA

Flight No. _____ Date _____ Take-off _____ Land _____

Area _____ Weather _____ Duration _____

_____ _____ Cost _____

Type aircraft _____ Pilot _____ Observer _____

Location	Time	Slope	Altitude	Herd Size	Rams	Ewes	Lambs	Unk.

COMMENTS:

APPENDIX B

BIGHORN SHEEP OBSERVATION FORM

No. _____ Date _____ Area _____ Slope _____ Veg. Type _____

Number of sheep observed ___ Rams ___ Ewes ___ Lambs ___ Yearlings___

Time begin _____ Time end _____ Duration _____

Weather _____

Activity			No. of	Time				
Feeding	Bedding	Other	Sheep	Start	Stop	Length	Movement	Miscellaneous

COMMENTS:

APPENDIX C

STEP-POINT TRANSECTS

Area _____ Transect No. _____ Bearing _____ Observer _____

Date _____ Slope _____ Vegetative Type _____

PLANT SPECIES	HITS	TOTAL
GRASSES		
FORBS		
MOSSES		
LITTER		
BAREGROUND		
ROCK		