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Distribution and Ecology of the Desert Bighorn Sheep in Southeastern Utah

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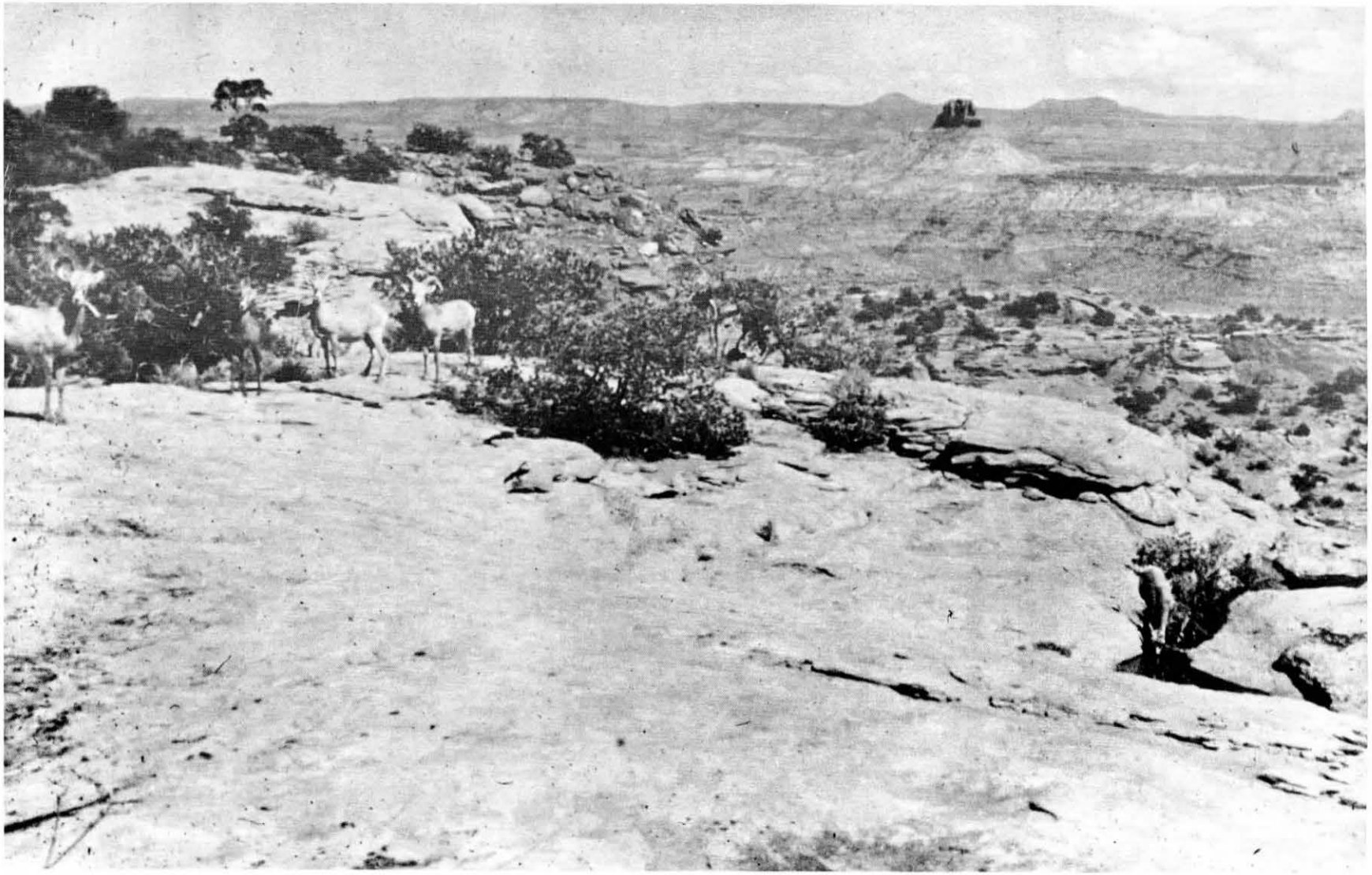

Frontispiece

Desert bighorn sheep on Wingate Mesa. In right foreground a two month old lamb is drinking water. Water is a critical factor in the survival of desert bighorn sheep.

DISTRIBUTION AND ECOLOGY OF THE DESERT BIGHORN SHEEP IN SOUTHEASTERN UTAH

by

Lanny O. Wilson

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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in

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Lanny O. Wilson

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Distribution and Ecology of the

Desert Bighorn Sheep in Southeastern Utah

by

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Utah State University, 1968

Major Professor: Dr. Jessop B. Low
Department: Wildlife Resources

In May 1965, the first investigation and research on the native desert bighorn sheep in Utah was undertaken. The study was centered in the White Canyon area, San Juan County, in southeastern Utah. Seven other areas along the Colorado River were found to have smaller reminant populations of desert bighorns.

The White Canyon population was determined to be between 124 and 144 desert bighorns (Ovis canadensis nelsoni), excluding lambs.

The desert bighorns in southeastern Utah return from surrounding range lands each year to the same areas, known as lambing grounds, to give birth to their lambs. Ewes under one year of age were not known to breed. Rams over one year of age, although believed physiologically capable of breeding, were not observed doing so.

The longevity of the bighorns was estimated at approximately 13 years. A relatively static population probably exists with a 50-50 ram-ewe ratio in the White Canyon area.

Pneumonia, predators and lack of free water were believed to be responsible for the high lamb mortality found in the desert bighorn population.

The lack of some nutrient in the diet is thought to be the reason for the high lamb susceptability to pneumonia. Predators and the lack of the free water were believed to be major factors in lamb survival.

The lack of available free water was found to be the greatest limiting factor to the bighorn population. Competition for forage and water by cattle and deer was found to be a major factor limiting bighorn populations. Internal parasites were found in numbers great enough to be detrimental to the sheep.

All plant communities occupied by the sheep were found to be climax communities. On the south side of White Canyon the vegetation was in excellent condition and was in poor condition on the north side. Bighorns graze slightly more than they browse.

Recommendations for the management of the desert bighorn sheep in southeastern Utah include continued studies, water developments, hunting rams over seven years of age, predator control and livestock reductions.

(234 pages)

INTRODUCTION

The bighorn sheep is an animal most frequently used as a symbol of the wilderness. He inhabits some of the most rugged terrain found on the North American continent and lives where few other ungulates could survive. To see a bighorn sheep in the twentieth century is an experience one never forgets, because there are so few and they are found only in a limited number of remote areas.

Bighorn sheep classification

Bighorn sheep are classified into two broad categories according to the climatic region in which they are found. The category "desert bighorn" has been applied to the population in the more arid regions of Utah, New Mexico, Arizona, Texas, Nevada, California and northern Mexico (Cockrum, 1961). Because of the habitat type utilized by the bighorn sheep in southeastern Utah, these animals can only be classified as "desert bighorn sheep." Subspecies in the desert bighorn category are: Ovis canadensis mexicana, nelsoni and cremnobates (Hall 1946).

The "Rocky Mountain bighorn" category refers to those animals living in the high mountainous areas of Colorado, Utah, Wyoming, Nevada, Montana, California, Oregon, Washington, North Dakota and parts of Canada. Those subspecies belonging to the "Rocky Mountain bighorn" category are: Ovis canadensis canadensis, and Ovis canadensis californicus.

The problem

In past years in remote areas along the Colorado, Green and San Juan rivers of southeastern Utah, an occasional bighorn sheep had been observed

by explorers, prospectors, cowboys and miners. Because bighorn sheep sightings were so few, the Utah State Department of Fish and Game did not believe they could justify the expense of an investigation of the bighorn at that time.

In the late 1940's and early 1950's uranium was discovered in and around the White Canyon area which drains west into the Colorado River. With a tremendous influx of prospectors and miners in the region, many bighorn sheep sightings were reported to Utah Fish and Game personnel. As the number of sightings increased, the Utah Fish and Game Department initiated the first research of the desert bighorn sheep in Utah (Homer Stapley, Principal Biologist, Big Game).

Objectives of study

With the consent and support of the Utah State Department of Fish and Game, the first study of the desert bighorn sheep in southeastern Utah was undertaken by the writer on June 6, 1965. The project was further supported and directed by the Utah Cooperative Wildlife Research Unit. The objectives of the study were:

1. To determine the subspecies, distribution and number of bighorn sheep in suitable habitats of drainages of White, Fry, Red and Dark canyons.

2. To determine the condition of the range utilized by the bighorn sheep.

3. To determine the factors affecting productivity of the bighorn sheep.

4. To determine the water distribution, natural salt licks, food preferences, daily and seasonal movements of the bighorn sheep.

Research procedures

The total time spent in the field by the author to fulfill the above objectives was 270 days. Approximately 80 days were spent in the field from June 6, 1965, to September 10, 1965; 153 days from March 16, 1966, to August 1, 1966; and 37 days from October 15, 1966 to November 21, 1966. Headquarters for the study were at Fry Canyon, Utah, 57 miles southwest of Blanding, Utah.

The major portion of the study was undertaken on foot and by jeep; however, horses and mules were used for 14 days.

Subspecies determination of the bighorn sheep in southeastern Utah was made from skulls collected in the field and borrowed from local residents, from photographs, and by studying the distribution of bighorn sheep already classified in adjacent areas. All skulls collected were sent to Dr. Stephen Durrant, Professor of Mammalogy, University of Utah, for measurements.

The past and present distribution of the bighorn was determined by reviewing the literature of early explorers along the Green and Colorado rivers and by personal interviews with local residents and personal sightings. A bighorn sheep sighting form was sent to all government agencies who were directly concerned with land management and big game management along the Colorado River and its tributaries.

In the spring of 1966 a census of the bighorn sheep population was made by the researcher. A total of 34 consecutive days were spent in making the census. Dark Canyon, the northermost boundary of the study unit, was not included in the census because of its inaccessibility.

Range condition and plant communities were determined by 10-foot-square quadrats. The two principle physical features used to determine

transect locations were geological formation and slope exposure.

Plants were collected throughout the course of the study and were identified by personnel of the Intermountain Herbarium at Utah State University.

The decimating factors operating on the bighorns were determined by fecal examinations for internal parasites, bone analyses from dead bighorn sheep found in the field, predator scat examinations, and observations in the field. One bighorn ewe was sacrificed for a necropsy to determine disease and parasites harbored by the bighorns.

Water distribution, natural salt licks, food preferences, daily and seasonal movements were determined by following the sheep, tracking, and searching for bighorns. The use of binoculars and a 20X spotting scope were very useful in this portion of the study. Bighorn behavior was noted as they were being observed.

Competition of the bighorns with other range ungulates was observed in the field by observing the plants eaten by other ungulates as compared to plants eaten by bighorns.

REVIEW OF LITERATURE

There are few published research papers dealing exclusively with desert bighorn sheep.

John Russo (1956) conducted research on desert bighorn sheep in Arizona. His recommendations were: (1) develop and improve water sources; (2) eliminate feral animals, especially burros, from desert bighorn sheep range; (3) have stringent grazing control on bighorn sheep range; (4) carry out predator control if necessary; (5) restock desert bighorns in suitable habitats; (6) have limited hunting of surplus mature rams; (7) make an annual population census and evaluation.

The Desert Bighorn Council Transactions contain some of the most important contributions to the knowledge of the desert bighorn. The first Desert Bighorn Council meeting was held in 1957, and the papers and transactions have been published annually since that time. The main objective of the Council is to stimulate studies in all phases of life history, ecology, management and protection, recreational and related economic values of the desert bighorn, including studies of species that may be seriously detrimental to the bighorn. Over 150 papers pertaining to all aspects of the ecology, life history and management of the desert bighorn sheep can be reviewed in the Transactions at this time. Those who have made outstanding contributions in the Desert Bighorn Council are: Gale Monson, Fish and Wildlife Service; Al Ray Jonez, Nevada Fish and Game; John P. Russo, Arizona Fish and Game; Clair Aldous, Desert Game Range; Ralph and Florence Welles, National Park Service; Rex Allen, Bureau of Animal Disease and Parasites, New Mexico; and Charles C. Hansen, Desert Game Range.

The Wildlife Monograph, The Bighorn Sheep in the United States, Its Past, Present and Future, by Helmut Buechner (1960), covers a major literature review plus extensive field research. Population dynamics of bighorn sheep are discussed in some detail as are the population and distribution of the bighorn by states. Management practices for desert and Rocky Mountain bighorns are reviewed. Buechner notes, "a high lamb mortality is characteristic of stable bighorn populations and should not cause concern in well established herds that perpetuate themselves."

The Bighorn of Death Valley by Ralph and Florence Welles (1961) deals primarily with the life history of the desert bighorn (Ovis nelsoni). They found that available water for the bighorn was the greatest limiting factor. Disease and parasites play a minor role in the welfare of the Death Valley herd. An average annual lamb loss of 90 per cent was attributed to malnutrition. Contrary to other studies in desert habitats, Welles does not believe the feral burros in Death Valley are posing any threat to the welfare of the bighorn. Human encroachment was found to be the biggest detriment to bighorn welfare in California.

Cowan (1940) was a major contributor to the bighorn sheep literature when he classified all bighorn sheep populations in the United States into species and subspecies.

There have been no bighorn sheep studies made on the Colorado River and its tributaries of non-introduced bighorn sheep in Utah.

THE WHITE CANYON STUDY AREA

White Canyon is in the west-central portion of San Juan County, Utah. Headquarters for the study were at Fry Canyon, Utah, approximately 57 road miles west of Blanding, Utah, and 80 road miles southeast of Hanksville, Utah (Figure 1).

The entire study area is a gentle westward-dipping plateau which is deeply cut by Dark Canyon on the north and Red Canyon on the south. White Canyon runs through the center of the area (Figure 2). The Colorado River and Lake Powell are the western boundary, and the Abajo Mountains form the eastern boundary.

On the north side of White Canyon there are several mesas, and between each of the mesas there are deep tributary canyons which meander into White Canyon. Fort Knocker, Short, Long, Gravel, Cheesebox, Hideout, and K and L canyons are all part of the tributary system (Thaden, Trites, Finnell, 1964). White Canyon and its tributaries range from 200 to 500 feet in depth (Gregory, 1938). In addition to the mesas, there are many small buttes which have descriptive names like the Cheesebox or Wedding Cake Butte.

On the south side of White Canyon, Fry Point and Fry Mesa mark the southeastern portion of the study area. To the east of Fry Mesa is a large rolling tract of pinyon and juniper woodland which extends to Grand Gulch. To the west of Fry Mesa, Fry Canyon runs in a north-westerly direction as a tributary canyon of White Canyon. White Canyon and Red Canyon are separated by a high divide called Wingate Mesa. It extends

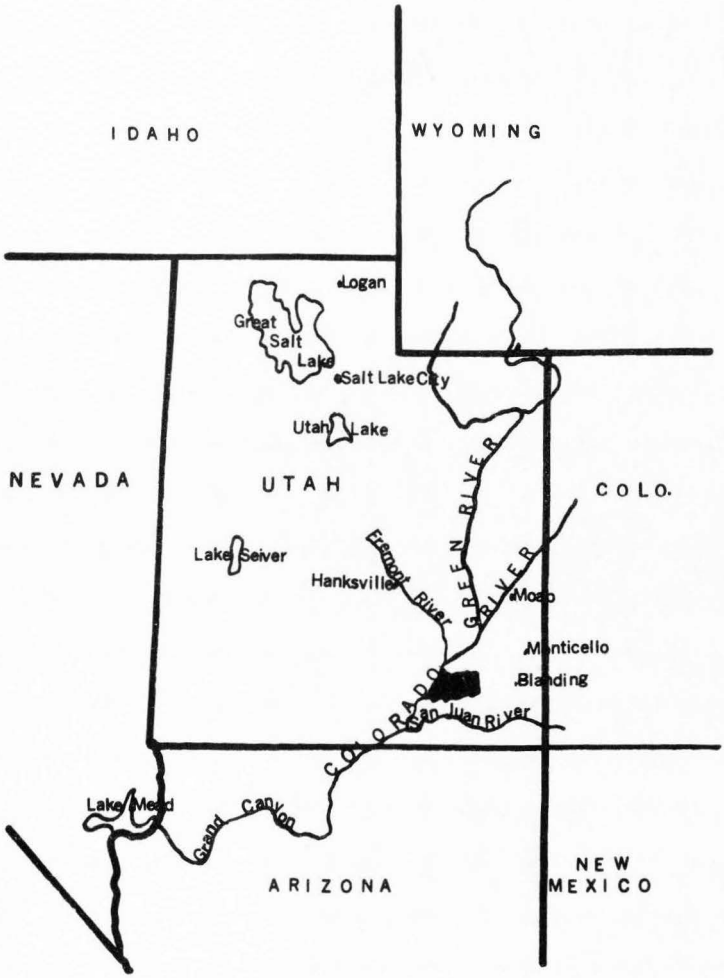

Figure 1. White Canyon study area in San Juan County, Utah, shown in black.

from the center of Fry Canyon in a north-westerly direction to Blue Notch Canyon, a distance of about 15 miles. Blue Notch Canyon drained south into Red Canyon in the past, but the water level in Lake Powell has risen until Blue Notch Canyon now drains directly into the lake.

Directly to the south of Fry Mesa and at the head of Fry Canyon, Wingate Mesa is broken into three isolated rock remnants called Tables of the Sun. The most southeastern remnant is called the Sun Dial by local residents. Running west of the Tables of the Sun are high, isolated buttes which are similar to the Tables of the Sun, but this portion of the area is cut by many meandering deep canyons which drain southwesterly into Red Canyon.

Running in a southwesterly direction into Red Canyon are five canyons which have their beginning on the top of Wingate Mesa, and which divide Wingate Mesa into five distinct arms. The canyons from west to east are: Wilson Canyon, Mahon Canyon, Rainbow Canyon, Piute Canyon and Blue Canyon (Figure 24).

West of Wingate Mesa are a series of canyons, all of which drain west into Lake Powell. Isolated mesas, almost barren of vegetation, stand between each of the canyons.

Many of the mesas and canyons in the White Canyon study area have not been named. Names have been given to some of the un-named mesas and canyons by the writer for more convenient reference.

Climate

The White Canyon area is very arid with summers hot and dry and winters cool and dry. The annual precipitation ranges from two to eight inches with an average of about four inches. A decrease in temperature

Figure 2. White Canyon study area in San Juan County, Utah. Jacob's Chair Mesa and other mesas on the north side of White Canyon are easily recognized.

and an increase in moisture occurs to the north and east of Fry Canyon, while the annual precipitation decreases and the temperatures increase south and west to Lake Powell.

Temperatures below 32 degrees Farenheit are rare in the winter for the major portion of the area and normally occur only one or two days of the year. Snowfall in the winter is light, but occasionally a snowfall up to 12 inches will occur. Snow on the ground usually persists for only a few days throughout most of the area but remains for longer periods of time on the north and west facing slopes of the mesas. The bulk of the moisture comes from the latter part of July through February.

Spring begins in late March or early April when temperatures range in the 70's and 80's. From the middle of June to September, high daily temperatures are always in the 90's and many days exceed 100 degrees Farenheit. Temperatures as high as 129 degrees Farenheit have been recorded (Thaden, et al, 1964). Little to no moisture falls from April through July, but by mid-July to October occasional thunder storms occur. During summer thunder storms flash floods sometimes occur in the canyons.

Generally, winds are from the west and southwest during the summer, but the bulk of the thunder showers come from the east and southeast, accompanied by a change in the wind direction.

A three year record of climatological data recorded at Hite, Utah, for the years 1958, 1959, and 1960 is shown (Table 1).

Geology and soils

There are five distinct geological formations readily visible in the White Canyon area: Cutler Formation, Moenkopi Formation, Chinle Formation, Wingate Sandstone, and the area above the Wingate which includes the Kayenta Formation and the Navajo Sandstone.

Table 1. Climatological data recorded at Hite, Utah, for 1958, 1959 and 1960[a]

Year	Month	Average maximum temp. °F	Average minimum temp. °F	Highest temp. °F	Lowest temp. °F	No. Days precipitation for month	Total Precipitation for month inches
1958	January	49.2	25.1	60	30	6	.25
	February	58.8	34.7	74	25	2	.30
	March	58.4	37.2	67	26	2	.32
	April	71.4	44.5	85	33	1	.18
	May	88.9	56.5	100	47	2	.43
	June	97.8	65.3	105	55	0	.00
	July	100.0	69.8	109	61	1	.08
	August	101.5	72.7	109	61	0	.00
	September	90.3	62.2	103	49	2	.59
	October	79.4	48.1	91	33	2	.30
	November	61.9	33.1	78	16	0	.00
	December	55.6	26.7	69	21	0	.00
1959	January	50.4	24.4	62	9	0	.00
	February	54.8	32.2	65	22	2	.60
	March	66.3	34.8	76	21	0	.00
	April	77.2	47.0	91	36	1	.10
	May	84.2	57.0	98	43	1	.07
	June	-	-	-	-	-	-
	July	103.0	73.5	109	60	1	Trace
	August	97.7	68.6	105	59	2	.56
	September	88.5	59.6	103	46	3	.60
	October	77.7	45.2	88	40	4	.98
	November	-	-	-	-	-	-
	December	-	-	-	-	-	-

Table 1. Continued

Year	Month	Average maximum temp. °F	Average minimum temp. °F	Highest temp. °F	Lowest temp. °F	No. days precipitation for month	Total precipitation for month inches
1960	January	41.9	24.1	55	14	4	.91
	February	52.0	28.4	62	21	4	Trace
	March	69.7	38.1	82	26	1	.01
	April	76.2	45.4	90	33	1	.18
	May	85.6	52.6	98	39	2	.58
	June	98.7	64.4	104	58	0	.00
	July	102.7	70.5	108	60	2	.37
	August	100.8	67.4	107	59	0	.00
	September	93.3	61.5	100	52	4	.23
	October	-	-	-	-	-	-
	November	-	-	-	-	-	-
	December	-	-	-	-	-	-

[a]United States Department of Commerce, 1960, 1961, 1962.

Cutler Formation. The Cedar Mesa sandstone forms the bulk of the Cutler Formation. The Cedar Mesa sandstone varies in depth from 200 to 500 feet in White Canyon. The sandstone consists of quartz cemented by lime and is the chief formation from which White Canyon has received its name. In color the sandstone is cream white and weathers buff, tan or yellow brown (Gregory, 1938). It is estimated that the maximum depth of the Cedar Mesa sandstone in White Canyon is 980 feet.

Above the Cedar Mesa sandstone rests the Organ Rock standstone. De-Chelly sandstone and Haskinnini members form the broad, relatively flat, plain that slopes gently to the mesas (Gregory, 1938).

Moenkopi Formation. The Moenkopi Formation is part of the Triassic age group. Most of the Moenkopi Formation is made of thin-bedded fine grained sandstone and shale beds. The color is dominantly a chocolate brown but includes a few white sandstones. It is easily recognized as it usually forms a vertical cliff from 175 to 375 feet in thickness with an average thickness of 300 feet, and rims the lower portions of all the mesas found in the area.

Chinle Formation. The Chinle Formation rests upon the Moenkopi Formation and belongs to the upper Triassic age group. It is composed of a thick sequence of brilliantly colored limestones, claystone, sillstone, sandstone, arkose and conglomerate beds. Generally, the lower part is sandy, clayey and limey; and the upper part is sandy (arkose) and silty. The Shinarump member is the most important uranium bearing unit in the area and is easily recognized when present as it forms cliffs of bare rock, whitish in color and found as the first distinct bench above the Moenkopi Formation. The Chinle erodes to form slopes leading up to the Wingate sandstone.

Wingate Sandstone. The Wingate sandstone is the lowest formation of the Glen Canyon group and belongs to the Triassic age. It forms an unscalable vertical cliff which averages about 300 feet in height. The Wingate Sandstone is predominantly a pale, reddish-brown fine grained, quartz sandstone. The Wingate Formation rims the upper portion of the Wingate Mesa on the southwest side of White Canyon, and the Tables of the Sun. The mesas on the north side of White Canyon do not show the Wingate Sandstone as it has eroded away except for a small portion which remains on Jacob's Chair Mesa.

Kayenta Formation and Navajo Sandstone. The Kayenta Formation and the Navajo Sandstone Formation rest on the Wingate Sandstone. Both belong to the Jurassic age. The Kayenta Formation is dark-red, maroon or lavender in color and is made up of beds of sandstone, shale and limestone.

The Navajo Sandstone is found only in a few isolated areas resting on the Kayenta Formation on Wingate Mesa. The Navajo Sandstone and Kayenta Formation are not easily separated in many areas, but the Navajo Sandstone is easily recognized as large, rounded knobs upward to 600 feet high when it is exposed (Gregory 1938: Thaden, et al, 1964).

Figure 3 shows the various geological and soil formations as they appear from the bottom of the canyons to the top of the adjacent mesas.

Wildlife

The majority of the animals found in the desert are nocturnal and rarely seen. The common rodents recorded from the area include: chipmunk, antelope ground squirrel and red squirrel.

Durrant (1953) Mammals of Utah lists 13 species of bats known to inhabit the southeastern corner of Utah.

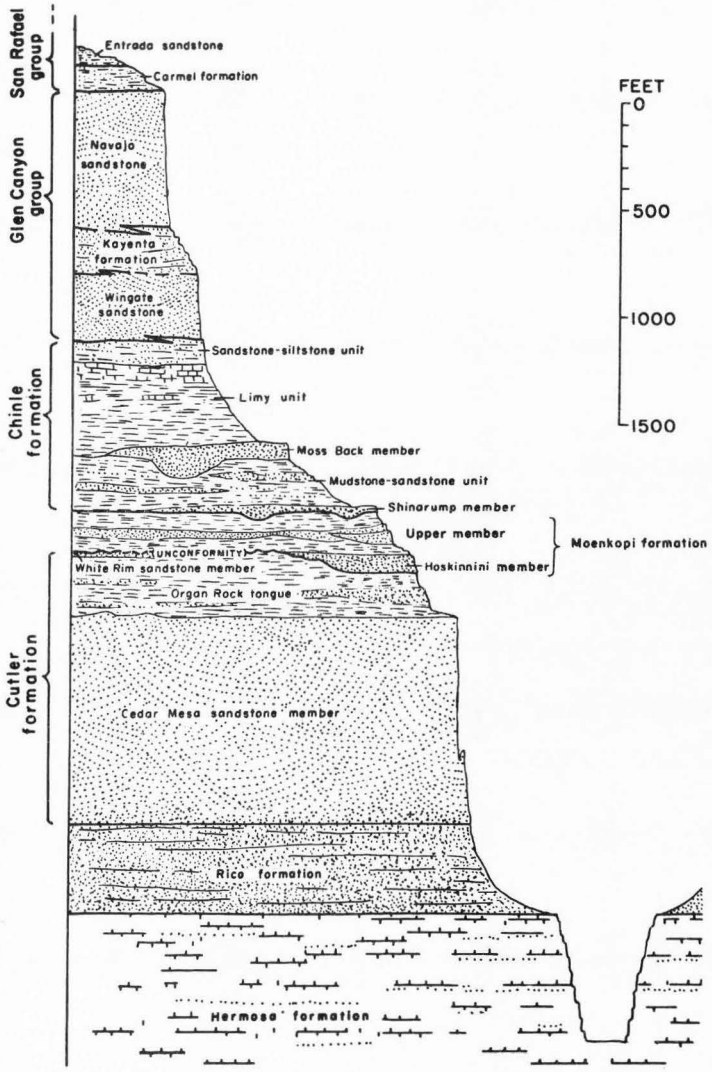

Figure 3. Generalized profile of the sedimentary units exposed in the White Canyon area (Thaden, et al, 1964).

A large deer herd winters on the mesas on the northeast side of White Canyon on the large pinyon-juniper tract east of the Tables of the Sun, and on the Tables of the Sun, and upper Fry Canyon. There is a small deer population in the heavy pinyon-juniper area on Wingate Mesa, and occasionally a deer is seen in Red Canyon.

The bobcat, coyote, gray fox and red fox are the most common mammalian predators recorded. Occasionally a ringtail cat was observed. In the course of the study only one mountain lion was sighted, but a high mountain lion density reportedly still persists on the west side of Lake Powell, adjacent to the study area.

Cottontail rabbits are seen daily, but blacktail jackrabbits are rarely seen.

The turkey vulture, red-tailed hawk, hummingbirds, cliffswallows, pinon jays, morning doves, and desert sparrows are the most common birds encountered.

The White Canyon area abounds with reptiles of which the collared lizard is probably the most numerous. Other lizards commonly seen are: leopard lizard, and chuckwalla or mountain boomer.

The western and the sidewinder rattlesnake are the two poisonous snakes found in the area.

Lists of the known mammals, birds and reptiles found throughout the White Canyon study area are given in Tables 18, 19 and 20.

Land use and administration

Mining. At the present time there are six uranium mines operating in the White Canyon area employing approximately 15 people. Several uranium mines not presently in operation are scheduled to be reopened in the future.

The Four Aces Copper Mine was in operation during the course of the study but was closed July 1966. A new copper mine was recently opened in Blue Notch Canyon. A copper mill was opened in 1965 in Fry Canyon with approximately 10 persons being employed in the total copper mining operation.

Livestock. All the land within the entire study area is managed by the U. S. Bureau of Land Management except for the land within the Glen Canyon Recreation Area adjacent to Lake Powell which is managed by the U. S. National Park Service.

Six-hundred cattle and 30 horses are permitted from October 15 through June 30, from Fry and White Canyon north to Dark Canyon and west to the Colorado River and Lake Powell. Since 1962 only 300 cattle and 20 horses have been utilizing this range (Mahon, personal communication).

No domestic sheep or goats are grazed legally in the White Canyon area, but a small herd of feral goats runs wild on the western end of the study area adjacent to Lake Powell.

During the course of the study approximately 30 to 40 cattle were grazed in Red Canyon. Red Canyon shows heavy overgrazing from the past, because as many as 100 cattle were grazing there yearly until 1964. When Lake Powell reaches capacity, 100 cattle will be alloted in Red Canyon from October 15 through March 30 (Mahon, personal cummunication).

Recreation. The Glen Canyon Recreation Area borders Lake Powell but, as yet, has undergone little development. The number of visitors utilizing the northern portion of Lake Powell for boating, water-skiing, fishing and sightseeing is increasing annually. A road and concession are to be constructed just west of Castle Butte, and the project should be completed in the next 5 years.

Deer are hunted with moderate success on the areas on the north side of White Canyon and in the area of the Tables of the Sun during the regular Utah deer season. Desert bighorn sheep are not presently hunted (1966), at least legally.

Natural Bridges National Monument is visited yearly by thousands of vacationers, and with the completion of new roads and facilities it is expected that the annual number of visitors will be greatly increased.

The completion of the new bridges across the Colorado and Dirty Devil rivers in June 1966, has made the entire White Canyon area available to many more visitors.

Vegetation

The vegetation in the White Canyon area is typical of the Lower and Upper Sonoran Zones as described by C. Hart Merriam (1898), and the shrub vegetation and desert woodland vegetation types as described by Munz and Keck (1960). These authors classify the flora of California into 11 vegetative types of which there are 29 plant communities.

The northern and eastern portions of the White Canyon area would be typical of the Upper Sonoran (Merriam, 1898) or the pinyon-juniper community of the desert woodland type (Munz and Keck, 1960). Typical plants found in this portion of the study area and in the other two vegetation classifications are: pinyon-pine (Pinus edulis), Utah juniper (Juniperus osteosperma), cliffrose (Cowania mexicana), Cercocarpus sp., Purshia sp. and Yucca sp.

The sagebrush shrub community and the shadscale shrub communities of the shrub vegetative type (Munz and Keck, 1960) are typical of the southern and western portions of the White Canyon area. Most of this

portion of the area would still fall within the Upper Sonoran classification by Merriam (1898), but the vegetation adjacent to the Colorado River and Lake Powell would be best described as Lower Sonoran. Munz and Keck (1960) list 21 species of plants characteristic of the sagebrush shrub and shadscale shrub communities of which 13 species are common in the White Canyon area. These plants are: big sagebursh (Artemisia tridentata), and Chrysothamnus viscidiflorus, shadscale (Atriplex confertifolia), bud sage (Artemisia spinescens), winterfat (Eurotia lanata), snakeweed (Gutierrezia sp.), Kochia sp., Grayia spinosa, Tetradymia spinosa, Atriplex canescens and Purshia tridentata.

The vegetation in the White Canyon area is discussed in detail in the chapter entitled Plant Communities and Bighorn Sheep Habitat.

PAST AND PRESENT DISTRIBUTION OF BIGHORN SHEEP SPECIES

Bighorn species in Utah

Three primary criteria were used to determine the species of bighorn sheep in southeastern Utah: (1) the present distribution of the bighorn sheep species in the United States, (2) morphological and skull characteristics of the bighorns and, (3) the habitats utilized by the different bighorn sheep populations.

The Nelson's bighorn or desert bighorn (Ovis canadensis nelsoni Merriam) is found in Death Valley, California, and less than 100 miles east of Death Valley it is a resident of the Desert Game Range in southern Nevada. Approximately 70 miles southeast of the Desert Game Range in the Lake Meade area, the Nelson's bighorn is regularly sighted. Up the Colorado River in Grand Canyon National Monument the Nelson's bighorn is also a resident.

Northeast of Grand Canyon National Monument approximately 100 miles up the Colorado River into southeastern Utah, in the White Canyon area, bighorn sheep are found. Between the White Canyon area in Utah and Grand Canyon National Monument in Arizona bighorns are still present in remnant bands. From past sightings by Escalante, Fremont, Powell (op cit) and others, it is known that bighorn sheep were found in this area in substantial numbers. There is no reason to believe that any species of bighorn sheep other than the Nelson's is found in southeastern Utah. All four areas mentioned where the Nelson's bighorn is thriving are similar in their desert type climate, topography and vegetation.

In comparing measurements of the Nelson's or desert bighorn (Ovis canadensis nelsoni) to the Rocky Mountain bighorn (Ovis canadensis canadensis) there are a number of differences separating the two species. Nelsoni differs by being smaller in body size and having a smaller skull. The horns of the males are more slender, paler and with the tips more strongly everted than in canadensis (Hall, 1946).

The skull of male canadensis is larger in all measurements except nasal length, nasal width, maxillary breadth and length of the upper molar series. Basilar length, orbital breadth, mastoidal width, width of palate, pre-alveolar length and post dental length are all signficantly greater in canadensis (Cowan, 1940).

The skulls of a Rocky Mountain bighorn and a Nelson's bighorn are shown in Figure 4. Both animals are approximately the same age and the differences in the skulls and horns are easily recognized.

The horns of the females are larger in nelsoni than in O. canadensis (Hall, 1946) and in both sexes nelsoni has a much paler pelage, larger ears and a smaller rump patch than canadensis (Cowan, 1940).

All skulls collected in the southeastern Utah area were sent to Dr. Stephen Durrant, Mammalogist at the University of Utah. He stated:

> There is no reason that the bighorn sheep in southern Utah do not belong to the species nelsoni. All skulls from that area more closely fit nelsoni than any other species, but no one has stated the range of variation in any bighorn species. From the limited number of skulls collected at this time I cannot say positively what species of bighorn is present but I do believe it is nelsoni. I do not believe a bighorn from southern Utah could survive in a true Rocky Mountain bighorn's habitat and that a Rocky Mountain bighorn could not survive in the desert bighorn's habitat in southeastern Utah (Durrant, 1966, personal communication).

The Rocky Mountain bighorn sheep is known to inhabit the upper Green River in northern Utah and Colorado, (Durrant, personal interview),

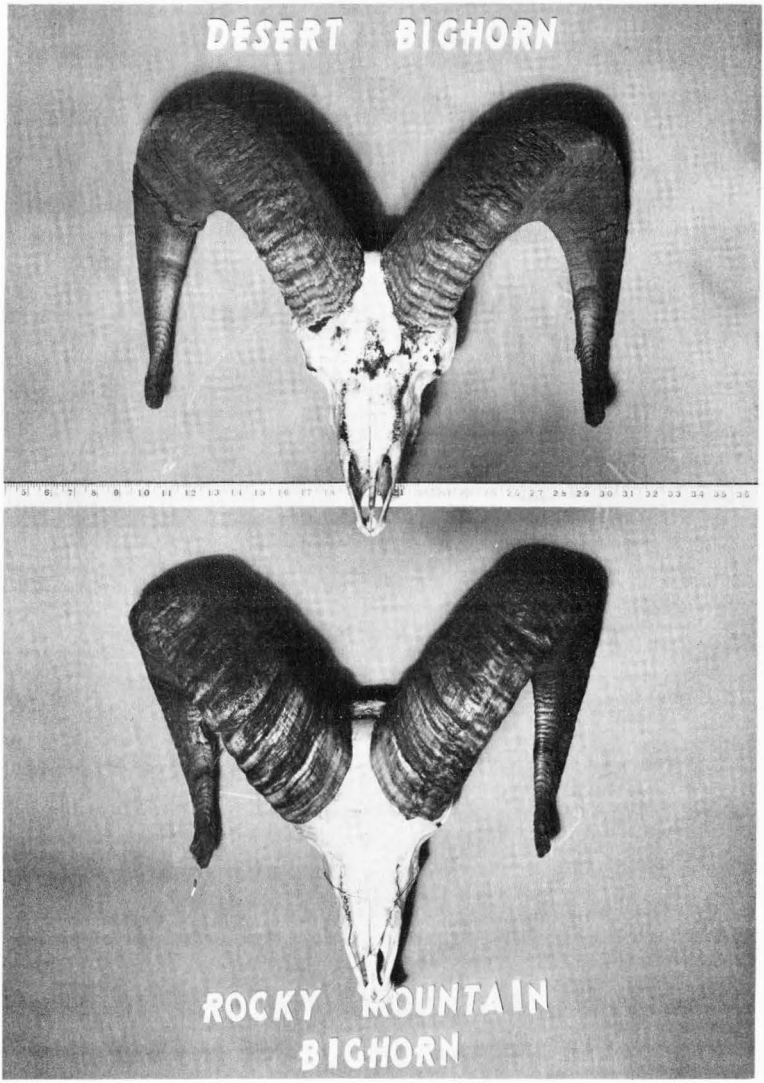

Figure 4. Comparison of a desert bighorn skull collected in White Canyon, San Juan County, Utah, with a Rocky Mountain bighorn skull.

but Cowan speculated where the species of nelsoni and canadensis meet in Utah.

> I examined six skulls from the Green River near the mouth of the Yampa River, and one from Grand County, 35 miles north of Green River, P. O., Utah. In cranial length two adult males of this species are well within the range of variation for canadensis and larger than the largest measured skulls of mexicana and nelsoni, they resemble canadensis also in maxillary width and length of upper molar series but in the small size of the nasals, they some approach toward mexicana. The horns are more slender than in either mexicana or canadensis which may or may not be a tendency toward nelsoni. The single adult female skull similarly shows almost complete agreement with canadensis, the sole point of difference being the reduced size of the nasals (Cowan, 1940, p. 541).

When the sheep sightings listed in Table 31 are plotted on a topographical-vegetational map of eastern Utah, 98 per cent of the sightings fall outside of the heavily forested areas or higher elevations south of Green River, Utah, to the Utah-Arizona state line (Figure 5). It is this area which I believe was occupied by the Nelson's bighorn species.

Above the junction of the Price and Green rivers to the Yampa River as seen in Figure 5, sightings are randomly spaced, some falling on desert tracts while others are located at the highest elevations. It is in this area that I believe the nelsoni and canadensis species integrated in Utah. It is in this range that Cowan obtained bighorn sheep skulls showing characteristics of both canadensis and nelsoni.

Past distribution

The past distribution of the desert bighorn sheep along the Colorado and Green rivers was determined by review of the literature and from personal interviews. Colored pins representing bighorn sheep sightings in the literature and from interviews were placed in a topographical-

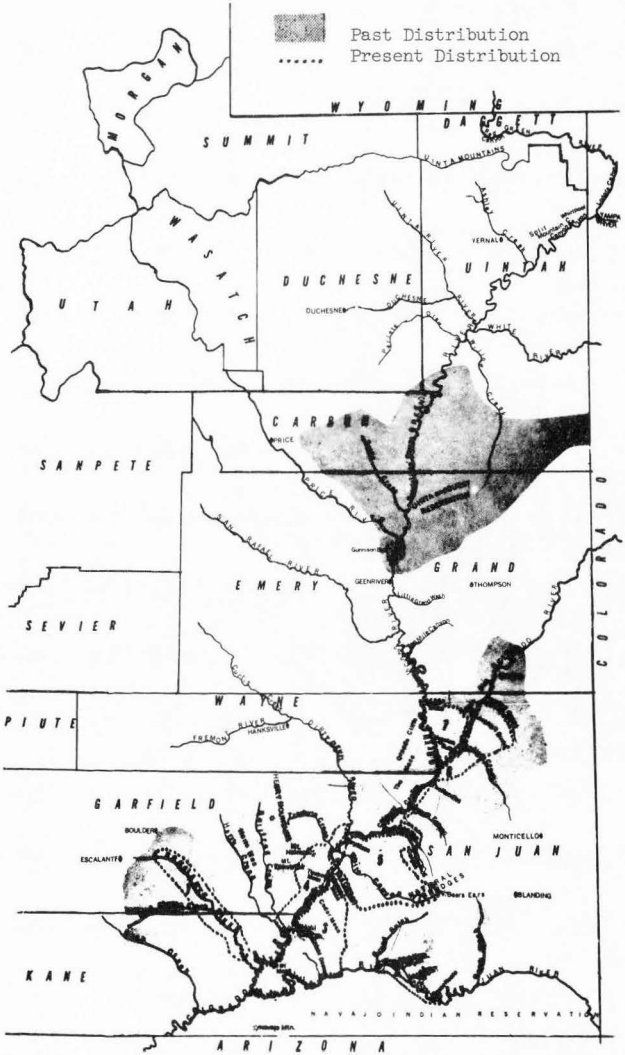

Figure 5. Past and present desert bighorn sheep distribution along the Colorado and Green Rivers in Utah.

vegetational map. A total of 259 sightings were obtained and are listed in Table 31. The past distribution is shown on the map in Figure 5. The names of the canyons, mesas, creeks and buttes seen on the map are those in which desert bighorn sheep were sighted. All other topographical features have been omitted except in a few instances where additional reference points were necessary.

In the southeastern portion of Utah several sightings were obtained from the Utah-Arizona state line to the point where a break in the distribution can be noted in Emery and Grand counties. At the break in the distribution there is a flat, arid, desert tract where no canyon topography is available as bighorn sheep habitat. No bighorn sheep sightings were obtained from this desert tract.

A similar flat, desert tract about 50 miles wide exists from approximately the point where the Uintah and Ouray Indian Reservation begins to a point just below Split Mountain Canyon. Only one bighorn sheep sighting was made in this desert tract. Again, this area is not typical of the type of terrain bighorn sheep are known to inhabit. A band of bighorn sheep was sighted by Frederick Dellenbaugh in 1871 at the mouth of the White River. Powell in 1869 traveled up the White River for some distance; later followed by Fremont in 1884. Neither explorer mentioned seeing any sign of bighorns along the White River, or on the Green River for some distance on either side of the mouth of the White River. Dellenbaugh probably saw a small band of bighorns following up or down the Green while migrating from some adjacent area.

History and factors causing reduction of the bighorn sheep

The earliest record of the presence of desert bighorn sheep in Utah along the Colorado and Green rivers comes from the prehistoric

Indian group, the Basketmaker. Pictographs of bighorn sheep have been found in the Four Corners area of Utah which date back 1500 to 1900 years (Martin, Quimbly and Collier, 1947). Pictographs made by the Basketmakers and petroglyphs of later Indians in the White Canyon area always picture the bighorn sheep. Never have I seen a pictograph or petroglyph that did not picture the bighorn sheep, and on one rock in Natural Bridges National Monument the bighorn is depicted 47 times. Some anthropologists believe that the number of bighorn sheep pictured can be used as a relative index to the bighorn population in the area (Dixon and Sumner, 1939).

The first written record of bighorn sheep in the United States was by Francisco Vasquez de Coronado when he wrote from the pueblo of Zuni, New Mexico, in 1540, "there are sheep as big as horses with large horns and little tails." He said he had seen some of the horns, "the size of which was something to marvel at" (O'Conner, 1959, p. 72).

The first written record of bighorn sheep along the Colorado River in Utah comes from Fray Silvestre Velez de Escalante when he wrote in his diary on November 8, 1776, "through here wild sheep live in such abundance that their tracks are like those of great flocks of domestic sheep. They are larger than the domestic breed, are of the same form, but much swifter." This was written the day after the Escalante party forded the Colorado River at the famous Crossing of the Fathers on the rim above the Colorado River which is just a few miles north of Glen Canyon Dam.

The next written record of the presence of bighorn sheep in Utah on the Colorado and Green rivers was by J. W. Powell. In 1869, Powell was at the mouth of the Yampa River on the Green River and wrote about a trail made by Indian hunters "who come down here in certain seasons

to kill mountain sheep" (Powell, 1869). Powell sighted bighorns at this location, and later members of his party killed two desert bighorn sheep in Cataract Canyon on the Colorado River.

Fremont in 1871 was the next explorer to travel down the Green and Colorado rivers. A number of bighorn sheep sightings were recorded by Dellenbaugh, a member of the Fremont party (Dellenbaugh, 1926).

At a later date the desert bighorn sheep played a major role in the lives of the Mormon pioneers who settled in Bluff, and later in Blanding. On December 8, 1879, a party of scouts in advance of the main party of the "Mormon Hole-in-the-Rock Pioneers" were out trying to find a route to Montezuma Creek. George Hubbs tells the following story:

> The second day, having crossed the river (Colorado), we made a little trail to get out, and then traveled over a bench to what is called The Slick Rocks or Lookout Rocks. Just before reaching these rocks a herd of mountain sheep, fourteen in number came up and followed us for some distance. They were curious to know what kind of animals we were! While cooking breakfast the next morning at Lookout Rock, one of the animals came within fifteen feet of our campfire and stood watching us. I tried to catch it with a pack rope, but it was very active in dodging the lasso. I could have shot it, but I thought the animals were too pretty to kill. I followed it for some distance; it seemed to draw me down in the rocks until I finally got to the bottom of the rocks about a mile from camp; there the animal left me. I climbed back up the rocks and soon learned that Brother Sevey and Morrill had been trying to find a way to get down these rocks, and had returned to camp reporting that we could go no farther. I told them I had already been clear to the bottom. They told me to swallow breakfast and lead out, and they would follow. This seemed to be the only passage down these slick rocks.

The mountain sheep had helped the men accomplish the impossible, getting down slick rock (Parkins, et al, 1957, p. 25).

There is no question that the bighorn was found almost the length of the Colorado and Green Rivers in substantial numbers. No one can be positive just when the major decline occurred, but it appears that the

reduction in numbers and range was caused by a number of factors.

Pneumonia-lungworm complex and scabies. Domestic sheep are carriers of the scabies mite and lungworm. Prior to the coming of the white man to the United States with domestic sheep, the bighorn sheep had never encountered the scabies mite or the lungworm, and therefore the sheep were highly susceptible to both. Buechner (1960) and Cowan (1940) agree that these two parasites were responsible for the major reduction in numbers of the bighorn sheep in the United States. Beuchner (1960, p. 6) notes that "the principle reduction seems to have occurred in the latter half of the nineteenth century." The principle reduction of the bighorn in Utah appears to have taken place about the same period.

Domestic sheep were brought into Utah prior to 1840, but it was about 1860 that Burton (1940) wrote, "in the basin of the Green River, 50 miles east of Fillmore City, there is a fine wool producing country, 7,000 square miles in area" (Neff, 1940, p. 275). It must have been shortly after 1860 that large numbers of domestic sheep were brought into the lower Green River and upper Colorado River, many of which could have carried lungworm and scabies.

By 1863, the Indians already had large numbers of domestic sheep in southeastern Utah (Kelly, 1953). On May 17, 1884, the Navajo Indian Reservation was re-established as far north as the San Juan River down to its mouth at the Colorado River (Taylor, 1931). Much of this area was excellent bighorn sheep range in the past, and the release of the scabies mite could have been a major factor in reducing the number of bighorns in this portion of Utah. It is doubtful that lungworm played a role in the reduction of bighorns in southern Utah as lungworm was not found in the bighorns in the present study or in Arizona (Russo, 1956).

In these arid regions there are no land snails to act as intermediate hosts for one of the stages of the life cycle of the lungworm.

The Indians in the past were not rigidly confined to grazing their livestock on the reservation and trespassed onto adjacent lands. In July of 1966, I saw 400 sheep and goats in trespass off the reservation in what was once excellent bighorn sheep range.

Competition with domestic livestock. With the settlement of many homesteads and ranches in the latter half of the nineteenth century along the Colorado and Green rivers in Utah, the numbers of cattle and sheep increased proportionately. Generally, bighorn sheep will not occupy ranges heavily used by domestic livestock and often will move to less desirable sites (Barmore, 1962). Shortly after 1863 the Indians on the Navajo Indian Reservation were forced to reduce their livestock numbers because the land on the reservation could no longer support the present number of domestic animals they then owned (Kelly, 1953).

With overgrazing by domestic sheep, cattle and horses, both wild and domestic stock are more susceptible to parasites and disease due to poor nutrition. With an increase of sick animals in a population, and all in a poor nutritional state, some disease could have reached epidemic proportions.

Illegal hunting. In southeastern Utah, illegal hunting has been a major factor leading to the reduction of the bighorn sheep. Sightings of Indians from the Navajo and Ute Indian Reservations hunting bighorn sheep off the reservation are common among the old time residents (Albert Lyman; Jim Scorup; Wiley Redd; Jacob Young; Rye Butts, all personal communications). All of the past residents of the White Canyon area put the bulk of the blame for the reduction of bighorn sheep numbers on the Indians.

In the fall of 1942 Navajo Indians were seen leaving White Canyon with three pack ponies carrying bighorn sheep hides. It was estimated that the three ponies carried between 60 and 70 hides. In the same year the hides of 10 bighorn sheep were found buried in the sand at Jane's Tank on Cedar Mesa (Scorup, personal communication).

All of the blame for the reduction by hunting does not rest with Indians. Several ranchers between Moab and Blanding openly admitted they had hunted and killed bighorn sheep. One rancher told his hired men to shoot any bighorn sheep they saw because "they eat grass our cattle need." The number of bighorn sheep killed by local livestock men was a major contributing factor leading to the decline of the bighorn.

All of the persons interviewed stated that the number of bighorn sheep now present along the Colorado and Green rivers is a mere remnant of what were present from the latter 1880's to 1940.

About 1940 uranium was discovered along the Colorado River and its tributaries in southeastern Utah. This brought a tremendous influx of prospectors into the country from Moab, Utah, south into Arizona. It was estimated by a local newspaper that at one time there were 10,000 prospectors in San Juan County, Utah (Virginia Wyers, personal communication). In many of the old prospector camps and mines, bighorn sheep bones were found by the researcher. Later, when many of the uranium mines were in operation in the 1950's, many of the miners hunted bighorn sheep on their days off for something to do (Dale Tadytin, personal communication).

From all the information available it appears that illegal hunting has been a major factor in the reduction of the bighorn sheep along the

Colorado and Green rivers.

Present distribution

Figure 5 shows eight localities where desert bighorn sheep presently remain. Only in the White Canyon area is the number of bighorn sheep known at this time. To locate the present areas only bighorn sheep sightings since 1960 were used, but other areas could exist.

(1) Escalante River. Three bighorn sheep sightings were obtained from different points along the Escalante River. Few sightings were obtained in this locality as I was so far removed from the area.

(2) Goosenecks of the San Juan River to Grand Gulch. The area around the Goosenecks of the San Juan River was noted by past residents as being bighorn sheep range. The earliest sighting obtained from this area was made in 1878 by Chris Christianson (1965, personal communication). Since 1960, bighorn sheep have been sighted on five occasions. In interviewing a Navajo Indian 80 years of age, Carl Mahon, Bureau of Land Management, Range Technician, noted that the Navajo had seen bighorn sheep below the Goosenecks on the San Juan on several occasions since he was a boy. Many years ago he saw as many as 60 in one herd. In December of 1965 he saw bighorns at the same location (Carl Mahon, personal communication).

Kenny Ross, a local resident, said he had seen bighorn sheep beds 2 to 3 feet deep that were still being used by bighorn sheep (Ross, personal communication).

(3) Junction of San Juan River and Colorado River to Mancos Mesa. This area is historically bighorn sheep range and was investigated by the author. Since 1960 bighorn sheep have been sighted on five occasions. I

spent a total of 10 days looking for bighorn sheep in this region and noted the fresh tracks and beds of bighorns at nine different locations. In topography the vegetation and terrain is much the same as Wingate Mesa in the White Canyon area. This region is remote and extremely difficult to negotiate, and for this reason few people ever visit the more inaccessible sections. It is in the Mancos Mesa country that the majority of the reports of bighorn sheep hunting by Navajo Indians were made. Occasionally Indians still cross the San Juan River to hunt.

(4) Halls Creek to the Dirty Devil River. Sightings of bighorn sheep have been made at six points since 1960 from Halls Creek to the Dirty Devil River on the west side of the Colorado River. All of the sightings were on or within a few miles of Lake Powell. In June 1966, I spent one day in this area and found the beds and tracks of seven bighorn sheep on the rim above Lake Powell about 7 miles north of Ticaboo Mesa.

Many domestic sheep are still grazed on adjacent ranges west of the area in which the sightings were made. The loss of range, competition for food, and the presence of disease and parasites from the domestic sheep are probably some of the reasons the population of bighorns in this area remains low. A high population of mountain lions is known to inhabit this area and 44 were shot or trapped during the winter of 1964 (Claude Simons, personal communication). Predation by mountain lions, bobcats, and coyotes could be another factor in keeping this population down.

(5) White Canyon area and population estimate. In the spring of 1966 a census was made in the White Canyon area by the author to determine the number of bighorn sheep. During the 34 days taken to run the census,

28 rams, 30 ewes and 12 yearlings were observed and classified. Five more bighorn sheep were sighted but not classified, and the fresh tracks of 28 bighorns were counted during the census for a total of 103 bighorn sheep. Lambs were not included during the census since many of the ewes had not lambed at the time the census was being taken.

The census was conducted to minimize duplicate counting. In two instances sheep were sighted in two adjacent areas on consecutive days; only the larger number of sheep was recorded in the census.

On three occasions in Wilson Canyon, Rainbow Canyon and Blue Canyon, bighorn sheep tracks were encountered crossing my jeep tracks made the day before, but the animals were never sighted. The number of bighorns making the tracks were counted in the census since there was no chance these sheep had been previously sighted.

Because the terrain is so difficult to traverse and sight bighorn sheep in, it was realized that many of the sheep were not sighted during the census. For example, on June 29, 1966, three weeks after the conclusion of the census for the area north of White Canyon, 27 bighorns, not including lambs, were sighted on Found Mesa. The 27 sheep sighted in this one herd exceeded by 11 bighorns the total number of sheep counted on the north side of White Canyon. During the census none of the canyons on the north side of White Canyon were traveled because three to four additional weeks would have been required and the possibility of duplication would have been greatly increased.

It is my opinion that between 60 and 80 per cent of the bighorn sheep were encountered during the census, which would give an estimate of 124 to 144 adult bighorns in the spring of 1966 in the White Canyon study area (lambs are not included in this estimate).

(6) Dark Canyon to Spring Creek east of the Colorado River. A substantial number of bighorn sheep can still be found on the east side of the Colorado River between the south rim of Dark Canyon and Spring Creek. Many local residents in Blanding and Monticello are certain that as many or more bighorn sheep exist in this locality than in the White Canyon area (Jacob Young, Garland Douglas, Carl Mahon, personal communications). A total of 10 sightings have been obtained from this locality since 1960.

In the spring of 1966 10 days were spent with Carl Mahon between Dark Canyon and Gypsum Canyon to determine habitat utilized by bighorn sheep. During the 10 day period eight bighorn sheep were sighted, tracks were found at 29 different locations, and on two occasions sheep were heard running on a canyon rim below but observation of the sheep was impossible. It appeared that the bighorn sheep in this country is restricted to the canyons during the spring, summer, and fall. The bighorns appear to use the rims above the canyons during the winter. Only on two occasions were natural seeps or tanks found. The lack of water is undoubtedly the reason the sheep are confined to the canyons during the dry portion of the year. All the tracks and beds found were old and appeared to have been made during the winter. Only twice were fresh tracks found on the canyon rim.

The Dark Canyon, Spring Creek locality is typical desert bighorn sheep habitat, and it is my opinion that a substantial number of bighorn sheep are still inhabiting the area at this time.

(7) Confluence of the Green and Colorado rivers above Steer Mesa and White Rim. Four bighorn sheep sightings have been obtained from this small area. In January of 1966 Carl Tangreen (personal cummunication)

sighted 25 bighorn sheep in one herd at the confluence of the Green and Colorado rivers. It appears that a substantial population of desert bighorn sheep still inhabit this locality because of the many unconfirmed reports of sheep sightings.

In interviews with Kenny Ross and Malcomb Ellington (personal communication) both said that they rarely failed to see bighorn sheep in this area while floating down the Green River. Ellington has made the trip from Green River, Utah, to Hite, Utah, 22 times. Typical of all the other areas, this location is extremely rough and rarely visited except by visitors on the rim above which is far removed from the habitat of the bighorn sheep.

(8) Junction Butte. One bighorn sheep sighting was obtained from this section on the Green River. In the winter of 1964, Carl Wadsworth saw 13 bighorn sheep southeast of Junction Butte. I have been told by Conservation Officers that this section of the Green River is rarely visited by anyone.

BEHAVIOR

Some of the behavioral characteristics of bighorn sheep in southeastern Utah are reported in other chapters where the behavior of the bighorns plays a role in other areas of study.

Normal daily movements

The daily movement of the desert bighorn is variable in the White Canyon area, which is apparently typical of desert bighorns found elsewhere. For the most part, the daily movement during the summer is closely associated with water. From July 1, 1965 until September 6, 1965, an adult ewe with a lamb, two yearling ewes, one two year old ram and one three year old ram remained in a 10-square-mile area in upper Hidden Valley. On the 14 different days these bighorns were observed, they utilized one of three water holes. Twice after heavy rains this band traveled up an old road at the head of Hidden Valley and utilized the north arm on top of Wingate Mesa which is rarely inhabited by adult rams (Frontispiece).

In the summer of 1966 the tanks in the bottom of Hidden Valley, used by the bighorns the year before, were filled with sand, and only one ewe and lamb used the upper Hidden Valley area sporadically throughout the summer.

In the summers of 1965 and 1966 the majority of bighorn sheep sighted were within a range from about one-half to one mile from water (99 per cent confidence limits .61 to 1.14).

Generally from June 1 through September 15, the bighorns utilize

those ranges which are adjacent to available water. The bighorns rarely move from these ranges and do so only when the available waterholes go dry (Figure 6). After a heavy rain, when water is abundant in the small rock depressions throughout the White Canyon area, the bighorns are able to move into other ranges until the shallow pools of water are evaporated or used up.

Throughout the summer of 1965 and early summer 1966, bighorn ewes, lambs and small rams were sighted in Rainbow Canyon on each visit. This canyon is approximately six miles long and three miles wide. After July 9, 1966, no bighorn sheep were sighted or were any tracks or droppings found. The only available water source in Rainbow Canyon was a small seep which had gone dry, and the bighorns were forced to move to other areas where water was available.

On the north side of White Canyon sporadic use between the mesas and canyons were observed. Bighorns were sighted on the mesas within two days after heavy rains. In most instances they were sighted back on the mesas one day following a rain. There are no permanent water sources on any of the mesas on the north side of White Canyon. Shortly after the small rock basins go dry, the bighorns are forced to return to the canyons for water. On five occasions bighorns were sighted traveling from the mesas to the canyons for water. On two occasions a band of ewes and lambs were followed to White Canyon where the animals watered and returned to Found Mesa within a day. The total distance traveled was approximately five miles.

On four occasions on the south side of White Canyon ewes which had lambs were followed to and from a spring the same day. The shortest distance traveled for a round trip was six miles and longest distance

Figure 6. Bighorn ewes, lambs and a small ram going to water in Hidden Valley, August 6, 1965. Note the small size of the two month old lamb compared to the two year old ram.

traveled was 14 miles. On all four occasions the lambs were left bedded in the rocks.

Two or three weeks after a heavy rain it is not uncommon to see ewes and lambs wandering up and down the bottom of the maze of tributary canyons leading into Red Canyon, searching for water. On 47 occasions ewes and lambs were tracked in these canyons for distances from three to 9 miles. The sheep traveled steadily, not stopping to eat. None of these animals on the 47 occasions was ever sighted.

On June 19, 1966, fresh tracks of six bighorn sheep were found in the mouth of Mahon Canyon. The bighorns followed the second tributary canyon leading into Red Canyon. They followed this canyon into Red Canyon proper and turned west. The bighorns continued west to Warm Spring, and then turned south to the talus slopes below Mancos Mesa. The sheep traveled a total distance of seven miles before reaching a small pool of water adjacent to Warm Spring. The tracks indicated four adult bighorns and two lambs. These animals were never sighted, but at one point they crossed the tracks made by my jeep about one hour earlier. No rain had fallen in this area since March 29, 1966.

Similar observations of rams were made on the top of Wingate Mesa. For the most part the rams have to depend on water stored in the sandstone tanks on the large slick rock areas and in the bottom of the canyons.

A total of 39 days were spent observing lambs and ewes that were within two miles of water during the summer of 1965 and 1966. On all these occasions the ewes, lambs and small rams bedded below the Wingate Sandstone Cliff on the talus slopes. They left their beds just prior to dawn.

The sheep fed laterally and down hill toward the canyon bottoms. Between 8:30 a.m. and 10:00 a.m. the sheep would generally lie down for 1 to 3 hours and then would resume feeding. Usually between 1:00 p.m. and 3:00 p.m. they would again lie down for 1 to 3 hours. Upon rising they would feed uphill toward the Wingate Sandstone Cliff, where they would again make their beds for the night. On two occasions the same beds were used on two consecutive nights.

During the course of the day while the sheep were feeding, they would take short periods of rest from 30 seconds to 45 minutes, at irregular intervals. Many times while they were lying down for longer periods of time they would rise and graze a few minutes and again lie down. In many instances they would return to their original beds, but occasionally they would paw out new ones or make no bed at all.

On 39 days the ewes, lambs, and small rams always went to water between 10:00 a.m. and 3:30 p.m. On three occasions the bighorns watered just before dark and then traveled rapidly up the talus slope below the Wingate Sandstone Cliff to make their beds for the night.

The mature rams tended to follow a more regular daily routine. During the 21 days spent with rams, they would leave their beds prior to dawn and begin feeding. They would generally feed until 9:30 a.m. or 10:30 a.m. and then lie down for 2 or 3 hours, breaking these periods of rest to stand and look around and sometimes graze for a few minutes. Rams were observed watering between 11:00 a.m. and 3:00 p.m. The rams would generally leave their mid-morning beds and travel directly to water and usually return to the same area. Sometimes they would continue on to new areas after they had taken a drink. Rams usually utilize much larger areas and tended to travel longer distances than ewes and lambs.

They were not seen going to water daily when water was available to them. Figure 7 shows a typical tank sight utilized by rams on top of Wingate Mesa.

The normal feeding, resting and watering procedures of the desert bighorns observed in southeastern Utah seem to be typical of desert bighorns in other states (Russo, 1956; Devan, 1958; and Welles, 1961). If there is one point all researchers of desert bighorn sheep agree on it is the fact that bighorns are very unpredictable. No one day I ever spent watching bighorn sheep was exactly like any other day. Each day I observed the desert bighorn in Utah I saw them react differently to a given situation or do something I had not seen them do previously.

The ewes, lambs, and small rams on the north side of White Canyon tend to wander long distances and do not show the same characteristic of utilizing a small home range as compared to the ewes, lambs and small rams on the south side of White Canyon. Lack of any permanent water is the main difference between the two areas and I am certain available water is responsible for the differences in bighorn behavior.

Only one month was spent in the study area in the early winter. During this time bighorns were sighted at waterholes or within two miles of permanent water. After a heavy rain and snow on March 10, 11, 1966, bighorns were seen watering the following two days even though air temperatures were cool.

By March 16, 1966, the bighorn sheep were restricted to areas where they were commonly found during the summer of 1965. No moisture had fallen since the latter part of February. On March 27, 1966, rain and light snow showers occurred for two days. After the moisture and cold many of the sheep were sighted in areas never utilized in summer.

Figure 7. These big tanks, which hold several hundred gallons of water, are utilized by desert bighorn rams until the water level gets below two and a half to three feet from the top of the tank.

By April 8, 1966, just nine days after the last moisture, the bighorns were again restricted to ranges adjacent to water as no moisture fell in the White Canyon area until July 29, 1966.

Night movement

A total of 17 nights were spent by the writer from 50 to 200 yards from bighorn sheep. In the morning the sheep were almost always within 100 yards of where they were seen making their beds the previous evening. On several occasions the sheep were heard moving around during the night. August 15, 1965 and June 22, 1966 were both bright moonlight nights and the bighorns moved from their beds. On both occasions the sheep were over 1000 yards from the area where they bedded the night before. On August 18, 1965, a moonlight night, at 11:15 p.m. a ewe and a lamb were sighted moving about 50 yards from the location where I was sleeping on the talus slope under the Wingate Sandstone Cliff.

Gale Monson (1964) reported that bighorn sheep were sighted moving after dark on nine occasions, two nights in which there was no moonlight. He concluded: (1) Night time travel appears to be mainly by rams, and long distance travel occurs mainly during the rutting season. (2) There is evidence that long-distance movements are caused by seasonal lack of water or food - especially of water in Death Valley (Welles, 1961).

No nights were spent with rams exclusively during the summers of 1965 and 1966. During the rut, one night was spent with three ewes, two lambs and four rams. The following morning the sheep were sighted approximately 25 yards from the point where they had bedded the night before.

Effects of temperature and storms

Bighorns will lie down during the day wherever they happen to be at the time. I have seen the sheep lying out in the open when temperatures were well over 100° F. On many occasions I have seen the animals travel from 50 yards to a quarter of a mile to some preferred bedding spot which was generally in a shaded overhang or shallow cave. Rams tend to utilize these shaded areas much more than do ewes and lambs. Similar observations were made by Russo (1956) and Welles (1961).

On two occasions I followed single ewes to small caves created by huge boulders, and once I jumped a small lamb bedded about 20 feet back in an old uranium mine tunnel.

When bighorns are in these shallow caves they are practically impossible to see. Twice I stood on a rim and directly below me a large ram was bedded. On both occasions neither the ram nor I was aware of each other until I jumped off the rim. Once I barely missed jumping on top of one of the rams.

On only one occasion was any difference in the daily behavior of the bighorns due to the presence of a storm noted. On August 14, 1965, at approximately 3:15 p.m., threatening clouds were approaching rapidly from the southeast. It became increasingly dark and was quite apparent that it was going to rain. The ewes, lambs and small rams left their beds and began moving up the south facing slope of Hidden Valley to an arroya filled with huge boulders. The sheep traveled rapidly, not stopping to graze and by the time the first rain drops were falling, 15 minutes later, the sheep were well up the slope in a large boulder area.

Beds

It is a characteristic of all bighorn sheep to paw out the large

rocks and all vegetation where they wish to lie down. This trait has been noted by most researchers of bighorn sheep. Generally these beds are roughly two or three feet long and one to two feet wide. It is common for the bighorns to rise from their beds and then defecate in them.

Many times bighorns in southeastern Utah will not paw out a bed before lying down for short periods of rest during the day. At times the sheep will select large boulders or rims to lie on where they have an excellent view of the surrounding terrain.

I have sometimes seen ewes take 10 minutes to make a bed for the night. Night beds are easily recognized by the presence of three to seven piles of droppings in them. It appeared that rams tend to return to the same night bedding locations more than ewes. Deep beds with numerous droppings were seen on several occasions. In almost every case a large ram was seen either leaving or returning to one of these beds.

Social structure

While watching bighorn sheep for any period of time, one can only be surprised at what appears to be outward aggression between individuals in a band. Ewes or rams will often have short periods of butting which rarely exceed two minutes. Many times these matches are to gain a choice location for feeding or a shrub or some other plant, but at times they occur for no apparent reason. Usually, one animal with no apparent warning will hook or charge another bighorn in the band. On some occasions I believe these brief bouts are a form of play, but at other times it appears that the butting is used to maintain some type of peck order.

Generally, the largest animal in a band would be the leader. This observation does not agree with Welles (1961, p. 72 and 73) who states,

> Certainly superior physical strength or prowess plays no part in attaining the position of leadership. Old Mamma was obviously the poorest physical specimen of the band, and, in common with many leaders we have known, much the older.

During the summer of 1965 a small dark yearling ewe was commonly seen with the small band of bighorns that stayed in upper Hidden Valley. Whenever the yearling would approach any of the older adult bighorns they would immediately charge her and drive her away. Whether or not her exceptionally dark pelage played a roll in the reaction of the other sheep toward her, I could not say. By the fall of 1966, although the ewe still retained her dark pelage, she was obviously the leader of the band of sheep that had continually harassed her the year before.

The leader of bachelor groups of rams was always the largest bighorn, and usually the oldest.

Bighorns, whether a band of ewes and lambs, or rams, when frightened always took flight immediately and with few exceptions strung out in single file. The largest animal of the band lead and the rest of the animals followed in decreasing order of size. On a large petroglyph, Figure 8, in White Canyon in Natural Bridges National Monument, this behavioral trait was also recorded hundreds of years previously by an Indian. During the rut, when mature rams were with the ewes and lambs, this behavioral trait did not persist. At this time, the large rams followed behind the ewes and lambs.

Senses

Russo (1956, p. 37) wrote, "Vision is the most acute and most reliable of the sheep's senses. From personal experience it is concluded that the

Figure 8. Petroglyph showing bighorn sheep in decreasing order of size.

animal's power of vision is many times greater and sharper than humans." This statement agrees with my observations as well as Honess and Frost (1942), Welles (1961) and Smith (1954).

There are differences of opinion concerning the sense of smell in bighorn sheep, but most researchers of bighorn sheep agree it is poor. On several occasions I have observed bighorn sheep lying down and periodically one of the animals would rise and face the wind with its nose extended at a 90 degree angle, obviously sniffing the wind. When lying down facing the wind, a sheep frequently would not rise but would extend his head in the same manner. Rams were observed testing the wind much more than ewes and lambs.

On April 21, 1966, I sighted ten mature rams on the Sandstone Knobs area on top of Wingate Mesa. The wind was at my back and toward the rams. Periodically one of the rams would rise with his head and neck extended toward the wind. I was approximately 400 yards from the rams and was sure they had not seen me. After an hour the sheep became increasingly nervous, scenting the wind at shorter intervals. I lit a cigarette, and in a matter of a few seconds all ten rams were on their feet with noses in the air. In a few minutes the sheep began moving rapidly away from my location. I am sure none of the rams ever located me.

Many biologists who have done research on bighorn sheep agree that the auditory sense is well developed, but that bighorns pay no attention to rolling rocks (Russo, 1956; Honess and Frost, 1942). Again, my observations conflict with these authors because rolling rocks were my greatest enemy in trying to stalk bighorn sheep. In every instance the sound of a rolling rock would bring the bighorns to their feet, if they

were lying down, and on 16 occasions the animals took instant flight. Sonic booms by jet airplanes would sometimes startle the bighorns, but on other occasions the sheep would pay no attention to them.

Reaction to man

I found it was easier to approach the bighorns and get much closer if I stayed in the open where the sheep could see me at all times. This peculiarity seems to be typical of most sheep as reported by Covey (1950), Russo (1956), Devan (1958) and Welles (1961). Normally the bighorn sheep in southeastern Utah would stand and watch an oncoming human, but on a few occasions the sheep took instant flight. Bighorns were always unpredictable as to which way they would react when I approached them. On one occasion, after sighting bighorns in Rainbow Canyon, I tracked the animals for over three miles. The running tracks were still evident when I left them. In every instance when bighorn sheep began running due to my presence, they were resighted only at long distances. Many times bighorns will jump upon a large boulder to gain a better observation point, when a human approaches (Figure 13).

Memory

Bighorns definitely have a memory. No one can appreciate this fact until they have spent several hours tracking them. I tracked a band of seven bighorns across the northeast portion of Found Mesa for about two and one half miles. Although there was no apparent trail, whenever the sheep came to small rises which could have a steep dropoff on the other side, the bighorns would always turn to one side or the other before going over the rise. Other similar hills had a gentle slope leading down the other side and the sheep would continue right on. In every

instance they turned before going over these rises with drops of 30 to 40 feet on the other side, not going up to the top of the rise to see if there was a dropoff or a gradual slope on the other side. I made similar notes for the entire period I was in the field, and at no time except when the sheep were badly frightened did they ever go over one of the dropoffs. At no time could I detect any difference between those hills with dropoffs on the other side from those with gradual slopes until I walked over and looked.

In the case of adult ewes and rams, I have followed or tracked the animals to waterholes for several miles across several small canyons and arroyos where there were no apparent visible trails.

Alarm sound

Sounds made by bighorn sheep are noted in the chapter entitled Lamb Crop, Survival and Productivity. When extremely nervous, frightened or wanting to warn other bighorns of approaching danger, a sound was always given from the throat which sounded like two rocks being scraped together. This was always accompanied simultaneously by the stamping of one of the front feet. When the alarm sound was given, the other sheep would become instantly alert and many times flee for a short distance before locating the danger.

Welles (1961) reported seeing bighorns in Death Valley stamp their feet when they were nervous but did not interpret it. On a trip to Yellowstone National Park during February, 1966, I stamped my feet on a rock trying to imitate the sound I had heard given by the bighorns in the White Canyon area. Although approximately 20 people had been within 50 yardsof the bighorns for approximately 20 minutes talking and

taking pictures, the sheep were in instant flight after I stamped my feet on the rock.

Distribution and seasonal movement

There is no migration of bighorn sheep on the south side of White Canyon, but there is a seasonal shift in utilization of range toward the lower areas during the winter. During the spring, summer and fall the ewes, lambs and small rams mainly utilize the talus slopes under the Wingate Sandstone Cliff or Wingate Mesa to the Shinarump Formation with very little use below the Shinarump Formation on the Moenkopi. On only two occasions in two years were ewes and lambs known to have gone on top of Wingate Mesa, and this was in an area rarely used by rams.

From the latter part of September until the latter part of April, ewes and lambs were commonly seen in all geological formations below the Wingate Sandstone Cliff. During the majority of the day during the winter the sheep can be found on the Shinarump and Moenkopi Formations.

From the latter part of October until approximately the first of March, the majority of the rams on the south side of White Canyon remain off the top of Wingate Mesa. The rams tend to spend a great deal of their time on the Shinarump and Moenkopi Formations when they are not on the Mesa.

Utilization and movement into these lower areas depends on the available moisture. There are extremely few permanent waterholes in the Shinarump and Moenkopie Formations.

The majority of the adult rams appear to return to the top of Wingate Mesa in the latter part of February or sometime around the first of North, depending on the temperature and weather conditions.

Between March 16, 1966, and October 25, 1966, no large adult rams were sighted below the Wingate Sandstone Cliff.

On the south side of White Canyon the ewes, lambs and small rams utilize the talus slopes under the Moenkopi Cliff during the fall and winter. At about the same time many of the deer which summer on the Abajo Mountains migrate to the lower mesas and canyons. I was unable to determine if the cooler temperatures and more available water, or the increase in deer numbers, were responsible for this seasonal shift by the bighorn sheep. By the latter half of October the majority of the rams migrate down from the foothills of the Abajo Mountains and are regularly seen with the ewes and lambs.

During the late spring there is one band of bighorn sheep which migrates from the south side of White Canyon to the north side of White Canyon from Fry Mesa to Fry Point. On June 8, 1964, 15 bighorn sheep were sighted crossing Utah Highway 95 traveling south onto Fry Point. Thirteen bighorn sheep were seen crossing at the same point on June 7, 1965, and seven were seen on June 7, 1966. I followed four ewes, two lambs, and a two year old ram down the road which leads from the top of Found Mesa, across White Canyon and up Fry Point on June 7, 1966. The migration route is shown on Figure 15. I believe the one band of sheep migrate to Fry Mesa because of the permanent water available there.

Bighorn sheep sign was commonly seen on Fry Mesa throughout the summer of 1965 and 1966. The bighorns were sighted returning from Fry Mesa crossing Utah Highway 95 in September 1965. By October 15, 1966, there was no fresh sheep sign on any portion of Fry Mesa.

During the late winter, (January, February and March) bighorn sheep are again commonly sighted on Fry Mesa.

Home range

Some of the bighorn sheep definitely have a home range which they utilize during the late spring, summer, and fall. Four ewes easily recognized by distinctive horn characteristics and pelages were sighted in Blue Notch Canyon, lower Red Canyon and Hidden Valley in 1965 and 1966. Never were these animals sighted in any other area.

One ewe which was easily recognized by a badly broomed right horn was sighted on almost every visit to Rainbow Canyon during the spring and summer of 1965. The ewe was sighted back in Rainbow Canyon during the spring and part of the summer of 1966 until the only seep in the canyon dried up. On October 28, 1966, the ewe was again observed in Rainbow Canyon. One adult ewe with five distinct scars on the left side of her neck was sighted three different times in 1965 and once in 1966 on Found Mesa.

Seven easily recognized bighorn rams were seen during the spring, summer and late fall on the Sandstone Knobs on Wingate Mesa above Blue Notch and Red canyons on almost every visit to this area during 1965 and 1966. Five rams were sighted within a five mile area on Wingate Mesa from the head of Blue Canyon to the arm of Wingate Mesa which extends between Piute and Blue Canyon, during the summer of 1965 and 1966. One of these rams had badly broomed horns making for easy recognition, while another had eyes with yellow irises.

RUT, LONGEVITY, AND REPRODUCTION

Duration of rut

Sightings and sign of bighorn sheep leaving the top of Wingate Mesa for the lower country occupied by the lambs and ewes and small rams at the beginning of the rut was readily apparent in the fall of 1966. The rut of the desert bighorn sheep in southeastern Utah starts in the latter part of October. On October 25, 1966, the first adult ram with ewes was sighted on the north side of White Canyon. The first mature ram off the top of Wingate Mesa was sighted on October 26, 1966, in lower Red Canyon. On November 4, 1966, I returned to the Sandstone Knobs on top of Wingate Mesa and found fresh tracks of only one bighorn sheep. Thirteen bighorn rams were known to use this area throughout the spring and summer. Five rams were sighted and the fresh tracks of many other bighorns in this area were noted October 20, 1966. Only one other ram was sighted on top of Wingate Mesa after November 4, 1966.

Although not substantially documented, it is apparent that the rut persists through the latter part of December, and possibly into early January. In lower Red Canyon on December 28, 1965, two rams were sighted with three ewes and a lamb by Carl Mahon. Mr. Mahon said that the two rams repeatedly tried to mount one of the ewes for the short period of time he was able to watch them. The gestation period of the bighorn sheep under penned conditions on the Desert Game Range was between 173 to 175 days (Hansen, 1962). Two lambs about 3 to 4 weeks of age were sighted on July 27, 1966. This would suggest that the mating of the

two ewes would have been in the latter part of December or early January.

Ram activity

The most noticeable change in habits of the rams at the beginning of the rut is in the amount of wandering they do in search of ewes. Adult rams were sighted in all the areas occupied by ewes and lambs by November 1, 1966. Tracks of bighorn rams were observed in areas not utilized by bighorn sheep at any other time. Some rams travel long distances searching for ewes with few or no stops for feeding. On seven occasions two or three rams were seen traveling together during the rut.

I found it interesting that many times more than one ram would be with a band of ewes. When the rams accompanied the ewes little or no aggression was shown by the rams toward one another. On all but one sighting the rams were not the same size. In all instances there was one large, mature, adult ram which apparently held some type of dominance over the younger, smaller rams.

A band of bighorns was sighted the morning of November 10, 1966, in Blue Notch Canyon. The band consisted of a large, mature herd ram estimated to be eight or nine years of age, one four year old ram, a two year old ram, a yearling ram, three adult ewes, a yearling ewe and two lambs. I watched the band for three days and at no time did any of the rams attempt to mount the ewes. On two occasions other rams, two in two instances, tried to enter the band. The newly arrived rams chased the ewes, trying to mount them. The herd ram drove the other four intruding rams away (Figure 9), but apparently did not mind the presence of the original three rams, as he showed no aggression toward them. Periodically throughout the day, for the three days I observed

Figure 9. Two rams try to enter a band of ewes, lambs and small rams. The herd ram (far right) drove away the two rams, which tried to join the herd on November 13, 1966.

this band of bighorns, the younger rams would approach the ewes as if they were going to try to mount them, but no attempts were made by these rams to mount the ewes.

The few days I was able to watch rams during the rut no actual combat was observed except for brief bouts. In most instances these battles were nothing more than two rams pushing one another back and forth, and sometimes hooking with their horns or striking one another with their front hooves. The longest of these bouts lasted 5 minutes.

On one occasion a large, mature ram tried to move into a band of ewes and lambs while the herd ram was chasing away another ram. Upon seeing the new ram in the herd, the herd ram quickly returned to the lambs and ewes. The new ram, seeing the herd ram returning, had only time to brace himself and drop his head against the on coming charge of the herd ram who had not slowed his pace. Upon contact the new ram was raised upright on his hind legs. He immediately left the band with the herd ram in hot pursuit.

On one occasion I saw a mature ram approach two ewes, a lamb and a 2-year-old ram. The large ram herded the other bighorns up a small gully directly below the Wingate Sandstone Cliff. Each time one of the ewes would bolt to escape, the ram would run until he got ahead of the ewe and turn her back up the gully. This procedure lasted for over 2 hours at which time, for no apparent reason, the ram left the ewes and did not return. The ewes and lambs left the small gully traveling in the opposite direction from the ram. I do not believe either one of the ewes was in oestrous.

Rams always approached a ewe during the rut in a definite manner before trying to mount her. The head and neck was always extended,

the top of the head was parallel with his back and slightly turned to the right side. Rams always approached a ewe in a stiff legged trot or fast walk. The body posture and trot were used as a threatening posture toward other rams, although in most instances the head was slightly turned toward the left side of the body.

On eight occasions a single ram and ewe were sighted together, the ewe running ahead of the ram, and ram in hot pursuit. The ewe seemed to regulate her speed so the ram could keep up. Occasionally the ewe would stop to urinate, as many as seven times in 10 minutes. The ram would normally smell the area and urinate in the same spot. Occasionally a ram would rub his head in the urine, gouging with his horns. Welles (1960) made similar observations of the desert bighorn sheep in Death Valley, California.

Age of sexual maturity

There are no records of ewe-lambs breeding during their first year, but they do breed during their first oestrous cycle which comes during the ewe's second year (Welles, 1961). Three yearling ewes easily recognized in 1965 had lambs in the spring of 1966. Yearling ewes, but not lambs, were observed being mounted by rams in 1966, but actual copulation was not witnessed.

Welles (1961) believes that rams retain their juvenile attachment to ewes until they are three years of age, and do no breeding until they are at least three years of age. On November 13, 1966, I saw a yearling ram attempt to mount an adult ewe. The ewe charged the ram, meeting him head on. Afterward the yearling ram paid no attention to any of the ewes for the remaining two days I watched them.

On August 21, 29 and 30, 1965, a two and a half year old ram was observed trying to mount one of two adult ewes. No actual copulation took place, and after a 3-minute butting match between the young ram and a large mature ewe, the ram left the ewes and was last seen crossing the Wingate Sandstone Cliff returning to the summer home of the adult rams.

It is my opinion that yearling rams, 2- and 3-year-old rams are physically capable of breeding, but because of their small stature and size, the mature adult ewes keep them away.

Longevity

It is difficult to determine the life span of bighorn sheep in the wild. Welles (1961) states that a bighorn sheep in Death Valley that lives past its first year can expect to reach its 10th. In southeastern Utah one ram was aged in the field with 11 distinct growth rings on its horns and still appeared to be healthy. It is difficult to age older animals in the field because of the increased brooming of the horns as the sheep become older. Buechner (1960) states that bighorn sheep over 12 years of age are rarely found.

Percentage of productive ewes

Just prior to the lambing period in late April and early May I attempted to note if the ewes appeared to be carrying lambs. The only visible indication of ewes carrying lambs as compared to yearling ewes and nonpregnant ewes was the increased swelling of the abdomen, slight drooping of the belly, and increase in the size of the udder. Although this method is not completely reliable, it appeared that 76 per cent (38) of the mature ewes were pregnant.

By mid July the ewe-lamb ratio was determined to be 37 lambs per 100 ewes in 1965 and 60 lambs per 100 ewes in 1966. These ratios do not include yearling ewes. Under ideal conditions the lamb-breeding ewe ratio should have been 100:100 excluding yearling ewes (Table 2). A ratio of 60 lambs per 100 ewes is below the ratio expected for a rapidly increasing herd (Buechner, 1960), but is above average when compared with other desert bighorn sheep populations. The highest ewe-lamb ratio recorded on the Kofa Game Range by 1962 was 50 lambs per 100 ewes (Eustis, 1962). The over-all average on the Desert Game Range was found to be 50 per cent lambing success, and the highest ewe-lamb ratio recorded was 88 lambs per 100 ewes.

The yearling-ewe ratio by July 15, 1965, was 41 yearlings per 100 ewes, and 20 yearlings per 100 ewes by mid July 1966. It is apparent that the annual increment in the present herd is very low.

Effects of excessive numbers of rams, and optimum sex ratios

Carl Mahon suggested that the low ewe-lamb ratios could be partly caused by large mature rams warding off younger rams from ewes in oestrous, but doing little or no actual breeding themselves. This was observed in the study area on two occasions in a three day period. In three bighorn sheep areas in the United States, large mature rams fighting for possession of a ewe have been observed and while the two rams were fighting, a third ram covered the ewe (Russo, 1956; Smith, 1954, and Moser, 1962).

Moser (1962, p. 23) states, "The theory has been proposed several times that excessive breeding by rams may cause sterility. Physical exhaustion resulting from the strenuous activity of the rut may also have a detrimental physiological effect upon the ewes." In Colorado the average ram-

ewe ratio is now 52 rams per 100 ewes and there was little doubt that all ewes were not bred at this ratio. Russo (1956), Smith (1954) and Moser (1962) all state that the roaming by rams during the rut left little chance that all the ewes were not located by rams.

Buechner (1960) reported from extensive research of the bighorn sheep literature that one ram can serve perhaps 10 to 20 ewes. Reducing the sex ratio to 25 rams per 100 ewes requires each breeding ram to service four breeding ewes. Also, with a reduced ram-ewe ratio, younger rams would have an opportunity to do more of the breeding thus keeping the number of ewes served by one ram within reasonable limits.

The ram-ewe ratio calculated for the White Canyon area in 1965 was 100 rams per 102 ewes including yearlings of both sexes. The ewe-ram ratio calculated at the end of the summer 1966 was 100-98. From the two sex ratios calculated for both years it appears there is nearly a 50-50 ewe-ram sex ratio in the White Canyon area. This is what would be expected in an unhunted population of these big game animals.

In Wyoming, Colorado, Nevada, Arizona, Nevada, New Mexico and Montana hunting has been used to remove excess old rams, reducing the possibility of infertile rams and undue harassment of the ewes. This management tool could be used in Utah with supervised hunts.

Population trend

The population data collected for the years 1965 and 1966 are given in Table 2.

In Table 3, data from White Canyon and Mount McKinley are compared. It is apparent that the productivity is higher in White Canyon than in Mount McKinley, and so is the adult mortality. Although, not stated by

Murie (1940), it is assumed that the Dall bighorn sheep population is probably stable in Mount McKinley National Park. Since the higher productivity in White Canyon is offset by the higher annual mortality and the proportions of bighorns over seven years of age are comparable, it would appear that the population is probably stable in the White Canyon area. A stable population is one in which the mortality rate is equal to the natality rate.

It must be realized that data of this type are susceptible to error. It is extremely difficult to accurately age bighorn sheep by the growth ring method in the field.

The average annual adult mortality rate calculated from the yearling-ewe ratios is subject to a great deal of variation because only two years of data were available. Should the population be increasing and not stable, the annual mortality rate would be over estimated by using yearling-ewe ratios. Should the population be decreasing, the annual mortality rate would be under estimated.

Table 2. Summary of desert bighorn sheep population data for 1965 and 1966 in the White Canyon study area, San Juan County, Utah.

Ratio	Ratio	Sample Size	Date
Lamb-ewe[a]	37:100	37	July 15, 1965
Yearling-ewe[b]	41:100	38	July 15, 1965
Ewe-ram[c]	100:102	98	August 31, 1965
Lamb-ewe	60:100	64	July 15, 1966
Yearling-ewe	20:100	48	July 15, 1966
Ewe-ram	100: 98	103	August 31, 1966
Lamb-ewe	42:100	23	November 15, 1966

[a] Ratio excludes yearlings
[b] Ratio includes male yearlings
[c] Ratio includes yearlings of both sexes

Table 3. A comparison of White Canyon desert bighorn and Mount McKinley Dall bighorn sheep reproduction data and mortality rates.[a]

Item	White Canyon	Mt. McKinley
Lamb-ewe ratios[b] average for two years	49:100[c]	33:100
Adult annual mortality rate	23%[c]	12%
Population over[d] seven and a half	21%	20%

[a] Data from Deevey (1964).
[b] Yearling ewes not used in this figure.
[c] Based on a 41 to 100 lamb-ewe ratio in 1965 and 60 to 100 lamb-ewe ratio in 1966.
[d] Over 85 bighorn rams were aged in the field by counting the annual growth rings. Eighteen of the 85 rams were over $7\frac{1}{2}$ years of age.

LAMBS, LAMBING AREAS, SURVIVAL AND GROWTH

Lambing grounds

A characteristic of the desert bighorn sheep ewe is its tendency to return yearly to the same area to give birth to her lamb. This phenomenon has been documented in Arizona, New Mexico, Nevada and California (Monson, 1959). It could not be determined during the course of this study if ewes bearing lambs returned to the same areas yearly. Four areas were known to be utilized by ewes without lambs before the lambing season. Ewes with lambs were observed a week or two weeks later in almost the exact locations. Although not substantially documented at this time, it is my opinion that the ewes do return to the same locations to have their lambs. Ewes were seen at many of the same areas with their lambs both years of the research. These areas are commonly referred to as lambing grounds. I believe more than two years are necessary to determine these areas as lambing grounds. Other areas thought to be lambing grounds were recorded during the course of the study (Figure 15).

Red Canyon lambing grounds. On the large arms of Wingate Mesa that extend into Red Canyon, three probable lambing grounds were determined in the spring of 1966. All three areas have the same physical features. All are east and south facing slopes under the Wingate Sandstone Cliff. The vegetation is low growing and all three have a 35 to 40 degree slope. All three areas are characterized by being extremely rocky with many loose rocks making walking difficult and hazardous. It would be extremely

difficult for predators to approach without being observed or heard. None of the lambing grounds are close to water, but in the spring when the lambs are born the common grasses found on the east facing slopes are still green and succulent. Important grass species are: galleta grass (Hilaria jamesii), Indian ricegrass (Oryzopsis hymenoides), and cheatgrass (Bromus tectorum). Besides the grasses, many succulent forbs such as globemallow (Sphaeralcea sp.), aster (Aster venustus) and phacelia (Phacelia corrugata) still persist in May and early June.

These areas become warm in the early morning yet provide ample shade and protection from storms with the enormous boulders that are common in these areas. All three areas offer ample escape cover from predators if the need arises. Figure 10 shows a ewe and lamb in a lambing ground in Rainbow Canyon.

Location of lambing grounds in Red Canyon.

Area I. Southeast talus slope under the Wingate Sandstone Cliff in lower Blue Notch Canyon directly behind Castle Butte.

Area II. East facing talus slope under the Wingate Sandstone Cliff at the mouth of Wilson Canyon.

Area III. Small, extremely steep, south facing arroya between Wilson Canyon and Mahon Canyon under the Wingate Sandstone Cliff which extends into Red Canyon proper.

Other areas where ewes with small lambs were observed in May and early June in 1965 and 1966 which have the same physical characteristics of the other lambing grounds are:

Area IV. East facing talus slope under the Wingate Sandstone Cliff, in the middle of Rainbow Canyon.

Area V. East facing talus slope under the Wingate Sandstone Cliff in lower Piute Canyon.

Figure 10. Ewe and small lamb in a typical lambing ground in Rainbow Canyon, May 21, 1966.

Area VI. South facing talus slope between Blue Canyon and Piute Canyon under the Wingate Sandstone Cliff. Water runs down from a small seep for about 200 yards to a small arroya at this location.

White Canyon lambing grounds. Found Mesa was previously thought to be a lambing ground by Rodney John, local Conservation Officer, prior to 1965. He had observed ewes with small lambs on the Mesa on a number of occasions. On May 24, 1966, I sighted two ewes with very small lambs approximately two weeks of age on the extreme western end of the Mesa. From the number of tracks and beds it appeared that the two ewes had been utilizing this area for several weeks. Two ewes without lambs were observed at the same location on May 2, 1966 (Number VIII, in Figure 15).

The southwestern end of Found Mesa is deeply cut by several small canyons, some of which are 200 feet deep. The pinyon pine and juniper trees on the mesa are moderately dense, but at the location where the ewes were sighted the pinyon and juniper trees are sparse. The small canyons have high, rocky cliffs and shallow caves which offer excellent protection against storms and predators.

Vegetation in this area is predominantly galleta grass, Indian ricegrass, cliffrose (Cowania mexicana), ephedra (Ephedra viridis and Ephedra nevadensis) and roundleaf buffaloberry (Shepherdia rotundifolia). It is extremely difficult to approach a bighorn sheep in this area because of the rugged terrain, and because they predominantly use the higher rims. There is no available surface water at this location.

Two other areas that are probably lambing grounds are at the southern end of Jacob's Chair Mesa (Number VII in Figure 15) and on Lone Butte Mesa (Number IX in Figure 15). Two ewes were sighted on June 17, 1966, with one small lamb on Lone Butte Mesa. No bighorn sheep with small

lambs were sighted on the southern portion of Jacob's Chair Mesa, but Carl Mahon and I believe that this probably is a lambing area. Signs of bighorn sheep were noted on every trip made to Jacob's Chair in the spring, in 1965 and 1966, but no sightings of bighorns were made.

The lambing grounds of White Canyon and Red Canyon are typical of areas utilized by desert bighorn sheep in other states. All lambing grounds in Arizona, Nevada, California and New Mexico are far removed from water except at the San Andres National Wildlife Refuge in New Mexico (Monsen, 1959). All lambing grounds are in the most rugged and inaccessible areas within the bighorn's range and are always located where the maximum amount of terrain can be surveyed.

Association of lambs to ewes and other bighorns

The ewes tend to stay isolated from the other sheep from two weeks to a month after the lambs are born. This seems typical of desert bighorn sheep in other areas as observed by Welles (1961) in Death Valley California, and by Russo (1956) in Arizona. The ewes are wary of danger and protective of their lambs. Ewes with small lambs were sighted on seven occasions in the lambing areas in late May and early June. At each of the sightings the ewes ran or were running when they were sighted. I was never able to approach within 400 yards of a ewe with a new born lamb. When the ewe was running she regulated her speed so that the lamb could keep up.

By mid-July ewes with lambs when frightened ran so fast they always out distanced the lambs, and in two instances the lambs became completely separated from their mothers. Generally, after the ewes leave the lambing ground, they will form into small bands. At this time when they are pre-warned of a human's approach, the ewes are more apt to stand and watch or

flee for a short distance to higher ground and then watch the intruder.

After the ewes with their lambs leave the lambing grounds and form small bands, it is common to see an adult ewe with a lamb and a yearling ram or ewe. I am certain that in many instances the yearlings stay close to their mothers except for a few days prior to the lamb being born, and then they rejoin their mothers and the new lamb. Welles (1961) noted this in Death Valley and believes that in many cases the young sheep will stay with their mothers until they are three years old.

During the summer of 1965 an old ewe with a small lamb and a yearling were repeatedly sighted together in Hidden Valley. On two occasions I followed a three year old ram from the top of Wingate Mesa into Hidden Valley. In both instances the small ram joined the same ewe, on one occasion passing two other ewes while apparently looking for the old ewe. At two other sightings the same small ram was seen with the old ewe, yearling ewe, and lamb. Identification of the sheep was definite in these instances. The old ewe was unique in having a flared right horn and the small ram had a white patch of hair between his horns. It is possible that the three year old ram was the old ewe's past lamb.

On only two occasions were adult rams sighted with ewes and lambs in the summers of 1965 and 1966. One of the rams treated the lambs with complete indifference while the other ram did not like their presence. Three times when a lamb approached the old ram too closely, he chased it away. On one occasion when a small lamb was standing on a large boulder about 10 feet in height, the old ram jumped up on the rock knocking the lamb off.

On many occasions lambs were left with other ewes while their mothers fed. This seems to be typical of all bighorn sheep and has been described

by Honess and Frost (1942), Russo (1956), and Welles (1961). I have seen a band of small lambs, when alarmed, follow the ewe left to watch them as if the ewe were the lamb's own mother. In three such instances I jumped the remaining ewes and yearlings a short time later. The ewes and yearlings followed the same escape route used by the ewe and lambs previously. In all three instances I am certain the ewes and yearlings were unaware that the ewe and lambs had been frightened away earlier.

On June 27, 1966, a band of 32 ewes and lambs were accidentally startled on Found Mesa. The majority of the ewes and lambs ran across a small gully and stopped on the opposite ridge. Nine of the ewes took a different route and disappeared around a lower rim out of sight of the other bighorn sheep. In seven minutes I heard a coarse, burping, frog-like sound given in two distinct cords coming from the direction taken by the nine ewes. A few minutes later I sighted two ewes returning by the route along which they had fled. The other bighorns did not make any sounds in answering that I could hear, but I could tell by the reactions of the larger band of sheep that they knew the two ewes were returning. When the two ewes came in sight of the other bighorn sheep, two lambs left the larger band and ran to the two ewes. There was no question that the two lambs knew their mothers as both started nursing immediately. I have heard the same sound given by ewes returning to their lambs on many other occasions, and on one occasion I heard a lamb answering with a similar sound.

After the lambs are about six to eight weeks old, the ewes will often leave the lambs alone for long periods of time during the day. The procedure of the ewe leaving the lamb and returning for the lamb rarely varied and is one behavior trait which favors lamb survival.

When a lamb would tire of following its mother, it would generally move laterally through the rocks at a right angle away from the direction its mother was moving. The mother would stand and watch the lamb until it chose a spot to lie down. The mother would then appear to forget about the lamb and continue grazing. Usually the lamb was left in the morning between 9 and 11 a.m. and until late in the afternoon, 4 to 6 p.m.

Signs of the ewes showing concern about the lamb were always obvious. The ewe would stop grazing and stare back at the area where the lamb was bedded. She would then travel from a few yards to a few hundred yards at a fast walk or trot toward the lamb, stopping for several minutes periodically to graze. Upon approaching the lamb she would generally stand a few yards below the lamb for several minutes looking in all directions. After a short period of time the ewe would make the coarse, burping, frog-like sound and the lamb would rise from its bed and run to its mother. Once the lamb is bedded it will not leave its bed unless it is badly frightened. All of the ewes returned to their lambs by a completely different route than the one they had taken away from them.

Because lambs leave their mothers in a lateral direction from which the ewe is traveling, most predators would likely miss seeing the small tracks of the lamb, and lambs leave little or no scent. Because of the extreme caution of the ewe when returning to the lamb, and of the different routes taken by the ewe, a predator would not see the lamb until it was at its mother's side.

This procedure was observed without variation on eight different occasions during the course of the study.

Food and water requirements and weaning of lambs

The longest I observed lambs suckling was 22 seconds, the rest of the

time they would nibble on plants for short periods of time or spend the remainder of the time lying down or following their mothers. The lambs try to suckle several times in a day, but the ewe will generally allow the lamb to suckle only a few times (four to seven). Similar observations were made by Russo (1956) and Welles (1961).

Russo (1956) noted that lambs in Arizona were not suckling after they were two months old in a dry year, but during a wet year many were still nursing after two months of age. By the latter half of August in both years of the study the ewes were not suckling their lambs. It appears the lambs are weaned between eight and ten weeks after they are born. Lambs left hidden in the day, that did not go to water with the ewes, generally were allowed to nurse for a few seconds upon rejoining their mothers.

It is difficult to determine how important free water is to desert bighorn lambs. On the six occasions lambs were seen at waterholes they drank a large quantity of water in proportion to their size. The longest a lamb was seen drinking was for two minutes and 15 seconds, but the amount of water consumed could not be determined. All other sightings of lambs drinking free water ranged from one to three minutes. On July 7, 1966, a band of four ewes, three lambs and a two year old ram was observed in lower Blue Canyon. It was a very hot day, over 100°F., and no measurable moisture had fallen in this area since March 29, 1966. All the sheep appeared to be extremely restless, and the smallest lamb (judged to be about three weeks old) continually bleated and followed its mother for over two hours with its tongue hanging out and trying to nurse. The lamb appeared to be dehydrated and was in poor condition.

On three occasions I followed ewes which had traveled two to three miles to water, and then returned to find their lambs. However, when the lambs were observed watering with the ewes, they had not traveled more than a mile to water.

Lambs begin feeding on plants from a week to ten days after they are born. They generally feed on the same plants eaten by the mother (Russo, 1956, Welles, 1961). The earliest small lambs were seen feeding in the White Canyon area was on July 7, 1966, in Blue Canyon. The lambs were estimated to be three to four weeks of age. They were feeding on the same plant species utilized by the adult sheep with one noticeable exception. The older bighorns were continually digging for the roots or bulbs of some plant which I was not able to determine. None of the lambs were observed digging.

Obtaining feeding sightings of desert bighorn sheep lambs is difficult as they are small and easily hidden from sight by rocks, brush, grass clumps and other sheep. I believe that the list of plants eaten, and abundance eaten in Table 4 is biased to browse species. It is much easier to see exactly what browse plant is being eaten than grasses and small forbs.

From the list of plants utilized and amounts eaten by bighorn lambs in (Table 4) two items are very apparent. The two plants most utilized by the lambs are: galleta grass and blackbrush. Secondly, as the lamb progresses in age from July to mid-September, the amount of grass in the diet decreases while the amount of browse species and forbs increases.

Lambs usually rise from their nightly beds with their mothers before dawn and begin feeding. Generally they feed for two to three

Table 4. Plant utilization by desert bighorn sheep lambs in the White Canyon area in southeastern Utah.

Time period	Plant	Total minutes of feeding	Per cent of total
July 7 - August 15	Hilaria jamesii	101.0	81.5
	Elymus salina	3.0	2.4
	Bromus tectorum	1.0	0.8
	Coleogyne ramosissima	19.0	15.3
	Total	124.0	100.0
August 15 - Sept. 15	Hilaria jamesii	6.5	6.7
	Elymus salina	1.5	1.6
	Oryzopsis hymenoides	1.5	1.6
	Hymenoxys richardsoni	9.0	9.3
	Salsola kali	20.0	20.6
	Mentzelia sp.	1.0	1.0
	Coleogyne ramosissima	27.5	28.4
	Symphoricarpos longiflorus	17.0	17.5
	Fraxinus anomala	12.0	12.4
	Atriplex canescens	1.0	1.0
	Total	97.0	100.0

Table 5. Plant utilization by desert bighorn sheep lambs by major plant group in the White Canyon area, San Juan County, Utah.

Major plant group	Per cent consumed
Grasses	51.8
Forbs	13.6
Browse	34.6

hours, but much of this time is spent in keeping up with the ewes, exploring small areas within 100 yards of the ewe, and playing. The lambs would generally lie down between 8:00 a.m. and 9:30 a.m. When not attended by the ewes they would never leave their daily beds until the ewe returned for them. If in the ewes' company all day, the lambs

would rise and feed for short periods of time (10 to 49 minutes) and then again lie down. In the evenings, (4:15 p.m. to 6:30 p.m.), the lambs would begin feeding alongside the ewes until dark, at which time they would bed close to their mothers for the night. Unlike the ewes and rams, the lambs tend to feed on the same plant(s) within a small area for longer periods of time.

Survival rates for lambs

The annual survival for lambs is low for all desert bighorn sheep populations. Welles (1961) found that 90 per cent of the lambs die each year in Death Valley, California. An average of 50 per cent of the lambs die yearly on the Desert Game Range, Nevada (Hansen, 1960). Biologists at the Kofa Game Range in Arizona have found an average of one lamb per five ewes, four to five months after the lambing season (Eustis, 1962).

In the White Canyon area the yearling-ewe ratio was 41 yearlings per 100 ewes (Table 2) in the summer of 1965. By mid-July, 1965, shortly after the lambing season, the lamb-ewe ratio was 37 lambs per 100 ewes. By mid-July, 1966, the yearling-ewe ratio was 20 yearlings per 100 ewes. There was a 49 per cent lamb loss for the one year period. The lamb-ewe ratio by mid-July, 1966, was 60 lambs per 100 ewes, and 42 lambs per 100 ewes on November 15. This means approximately 30 per cent mortality for the five month period.

The high lamb mortality in Death Valley, California, was attributed to malnutrition (Welles, 1961). Lamb loss in Nevada and Arizona has been thought to be caused by accidents, intestinal parasites, pneumonia and predation.

Determining lamb mortality is extremely difficult. There was no evidence to indicate that accidents or predation were the cause of death

of the four lambs and a yearling ram found shortly after death (Figure 11). Of 13 fecal samples from lambs, all were negative for intestinal parasites. One sample was found to contain the coccidia Eimeria granulosa. This parasite is pathogenically serious only with heavy infestation and has been described in bighorns from other areas in Arizona and New Mexico (Allen, 1955). The only three factors to which I could attribute lamb loss for the spring of 1965 until the winter of 1966 were: (1) pneumonia, (2) predation and (3) an apparent nutritional deficiency.

During the summer of 1965, lambs were seen coughing on 11 different occasions, and it appeared that the lambs were suffering from acute pneumonia. Other symptoms of abnormality noted in the coughing lambs were coarse rough pelages, poor condition and loss of appetite. The spring of 1966 was especially cold and wet during the lambing season. No moisture or cold periods for any length of time existed during the spring and mid-summer of 1966, and coughing lambs were not sighted. Deming, on the Nevada Game Range, noted that lamb survival was always higher in years of clear, mild springs than in cold wet springs (Hansen, 1960).

A nutritional deficiency could be the causitive factor in the low rate of lamb survival. The lack of phosphorous in the diet of domestic sheep will eventually lead to death of lambs 2 to 12 weeks after birth (Cook and Harris, personal communication). The lack of other nutrients such as iodine, Vitamin A, or calcium could result in higher lamb susceptibility to disease and parasites. However, it was not within the scope of this study to determine if some nutrient was lacking in the diet of the lambs.

Predation is a factor in the northeast portion of the study unit.

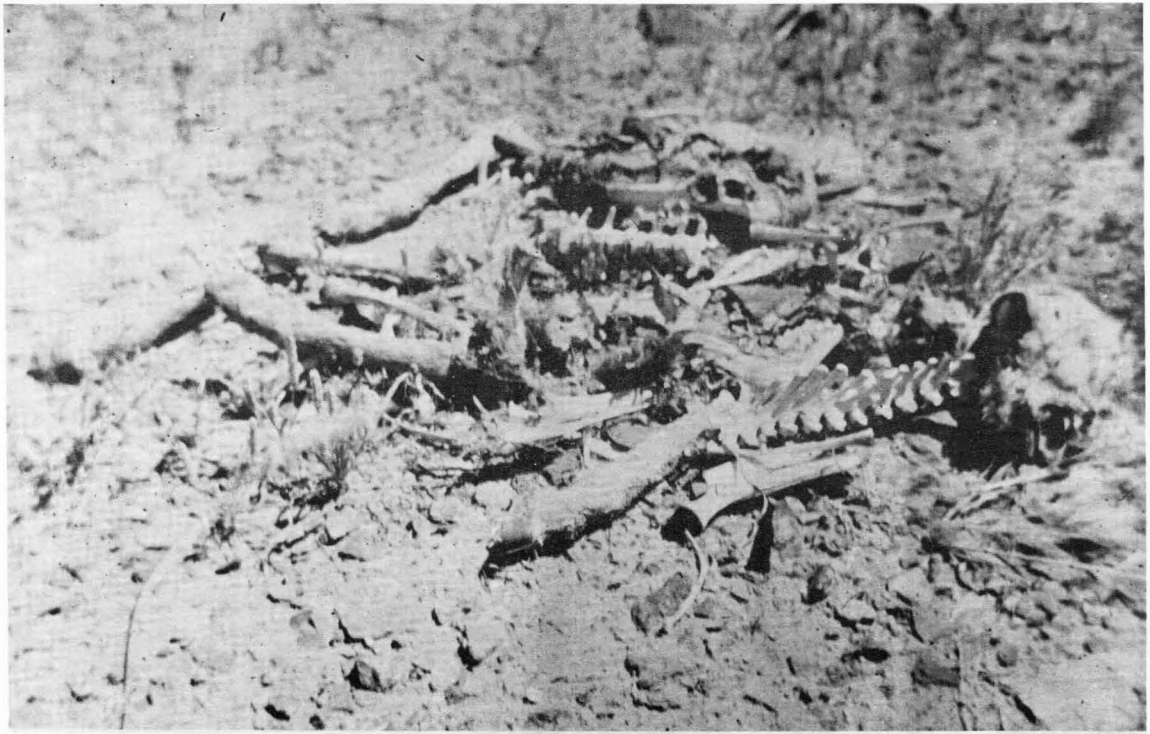

Figure 11. Dead bighorn lambs were found throughout the study area. This skeleton was intact which indicated that predation was not the causitive factor. The picture was taken in July 1966, approximately one week after death.

There is a high density of coyotes, foxes, and bobcats in this area. During the winter and early spring the coyote population is noticeably higher when the deer are on the winter range in the habitat of the bighorns. Predator scat analysis is given in Table 12.

Lamb growth

The growth rate of lambs in southeastern Utah is similar to desert bighorn sheep in California (Welles, 1961), Nevada (Hansen, 1964), and Arizona (Russo, 1956). The lambs at birth can easily pass under the ewes stomach, but by the time they are two and a half to three months old, the top of their heads reach mid-way up the ewes side. Some idea of the size of a lamb two months of age can be seen in Figure 6. By five to six months of age the top of the lamb's head will parallel the ewe's back. In Nevada, one lamb at 21 weeks of age weighed 50 pounds (Hansen, 1964). Yearling bighorn sheep are easily recognized by their more slender stature, and small horns. Yearlings are generally four to six inches shorter than the adults.

The lambs are a chocolate brown to dark, blue-gray color when born and retain this distinctive color until about one year of age. The rump patch is yellow at birth and does not begin to take on a white appearance until about four months of age. The yearling bighorn shows the characteristic pelage of the adults with one noticeable exception. In almost every instance, yearling bighorn sheep in the White Canyon area have a short, shaggy mane three to four inches long. No reference to the appearance of a mane as a distinguishing characteristic in yearling desert bighorn sheep was noted in other studies.

On young lambs small bumps are easily distinguished where the horns will protrude from the skull. Visible horns were first noticed

on lambs two and a half to three months of age. The horns at this time were one-half to an inch long. By the time the lambs are five to six months old, the horns on both sexes are two and a half to four inches long but very slender (Figure 12). The horns of yearling rams are generally six to eight inches long, but much heavier than on the yearling ewe. After the first year, male bighorn sheep are easily recognized from the females by their heavier horns.

Figure 12. Ewe with lamb approximately five months old, October 1966, in Rainbow Canyon. The horns of the lamb are about three inches long. The ewe is blind in her left eye.

PHYSIOLOGICAL REQUIREMENTS

Grazing habits and food preferences

The grazing habits of the desert bighorn are apparently not detrimental to the range under the existing densities with the exception of waterholes. Feeding bighorns take only a few bites from most plants. The desert bighorn is always moving while it is feeding although it occasionally stops at a large shrub or forb which may be fed upon for several minutes. On a few occasions I have seen bighorns feed on a large shrub such as single leaf ash (Fraxinus anomala) for as long as 20 minutes.

Galleta grass is definitely the number one grass preference of the desert bighorn during the spring, summer and fall (Figure 13). Blackbrush is the number one browse preference and is utilized the year around.

Tables 6 and 7 show the food utilization for bighorn sheep during the spring and summer months for both sexes. It is notable that the rams tend to utilize browse species more than the ewes, and forb species are utilized more by ewes. These primary differences are due to the difference in ranges utilized by the sexes during the summer.

Grass and browse species make up the greatest portion of the diet of bighorn sheep in southeastern Utah, while in Arizona forbs and grasses make up the greatest portion of the diet (Russo, 1956). A forage study on the Nevada Game Range revealed that 76 per cent of the diet was grasses, 20 per cent browse and 4 per cent forbs (Barrett, 1963).

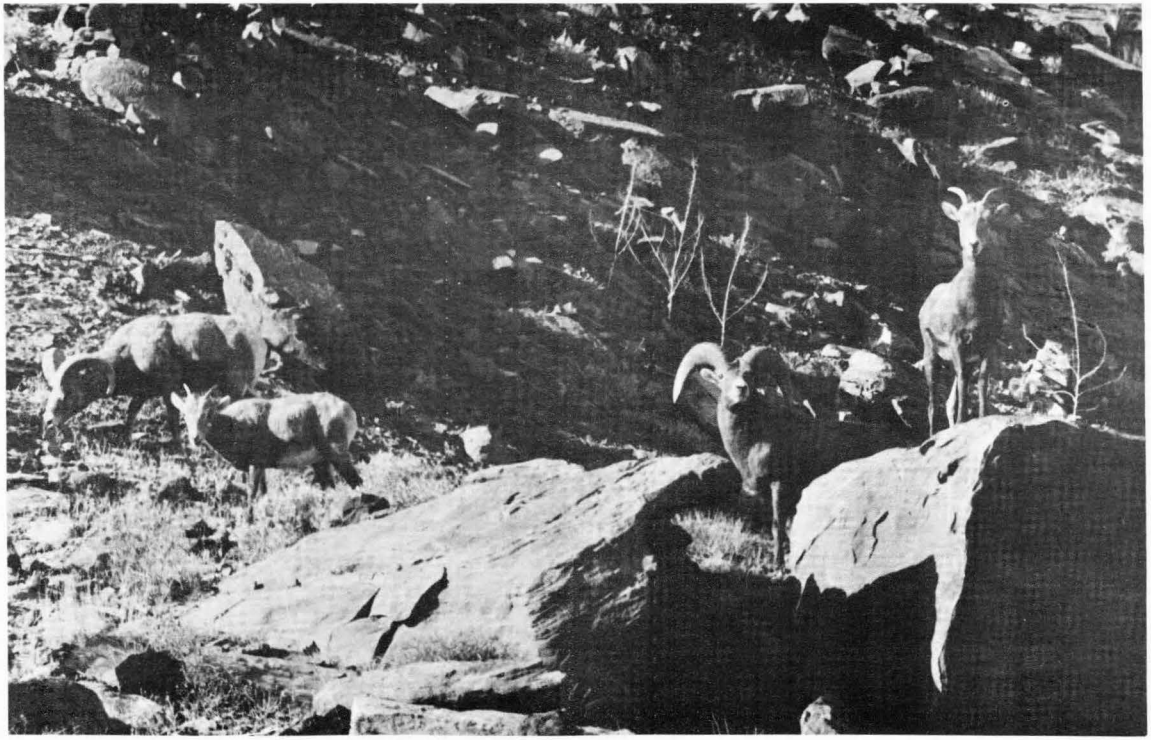

Figure 13. Bighorns feeding on galleta grass, their number one food preference. The ewe on the rock is watching the author on November 15, 1966.

As shown in the food habit tables, the bighorn sheep utilize a great many plant species. This seems to be typical of bighorns on desert ranges (Russo, 1956; Welles, 1961; Barret, 1964). Other plants known to be utilized by bighorn sheep in southeastern Utah but not actually observed being eaten are the flowers of Spanish bayonet (Yucca navajoa), flowers of desert princesplume (Stanleya pinnata), cliffrose, and locoweed (Astragalus sp.).

From approximately July 15 through August 15 Russian thistle commonly grows on many of the uranium mine roads throughout the White Canyon area. During this time the Russian thistle is in a green succulent stage and the bighorns graze along the mine roads, eating little else. There were also several small reservoirs built during the uranium boom which have subsequently silted full of dirt which contained dense stands of Russian thistle and fivehook bassia (Bassia hyssopifolia) during the summer of 1965. I have seen bighorn ewes and small rams travel for a mile at a steady pace to feed on these two plants in one old reservoir. During the summer of 1966, the old mine roads and reservoirs supported very little Russian thistle or fivehook bassia because there was not sufficient moisture.

During mid-summer of 1965 and 1966, adult ewes were seen many times digging for the roots or bulbs of some plant. This was always common after long periods of rain and extremely high temperatures. Whenever the bighorns were seen digging, they were always in the Shinarump Formation. I observed this at six different locations, but was never able to determine what root the sheep were digging for. On July 19, 1966, in lower Blue Canyon I watched the bighorns digging and eating these roots intermittently over an 11 hour period. It is possible

they were digging for the bulbs of weakstem mariposa (Calochortus flexuosus) as this plant was not seen growing in any other soil type.

Many forbs when eaten are dead and completely dried out. These plants included: sego lily (Calochortus nuttallii), twist-flower (Streptanthus cordatus) and thistle (Cirsium sp.), only the seed stalks of pingue actenia (Hymenoxys richardsonii) and aster were eaten.

Table 9 gives the plants eaten by bighorn sheep for November 10 and 11, 1966. The most noticeable change in the diet from the summer is the heavy utilization of Indian ricegrass. After the heavy rain and snow on November 8 and 9, 1966, the bighorns fed primarily on Indian ricegrass for the following three days. Prior to this time when the sheep fed on Indian ricegrass they would graze in a circle around the base of the ricegrass plant eating the new and tender green shoots. Many times much of the old, dead, dry material was consumed. After the heavy rains in November the sheep generally consumed the entire ricegrass clump leaving few or no seed stalks. It is my opinion that when the grass is thoroughly soaked it is more palatable.

On March 29, 1966, five ewes feeding on a south-facing talus slope below the Wingate Sandstone Cliff were feeding and moving rapidly trying to stay ahead of one another as they fed. I was unable to determine what plant they were so anxious for, but I believe it was the new green shoots of galleta grass or cheatgrass.

During the late spring, summer and fall the seed stalks of galleta grass and cheatgrass were readily consumed, only a few bites were eaten from rabbitbrush to snakeweed. When the sheep were feeding on desert trumpet only the flowers and flower stems were eaten.

When gathering feeding data by watching bighorns feed on different

range plants, it is much easier to see exactly what shrubs and larger forbs are being consumed; therefore, I believe Tables 6, 7, 8 and 9 are biased toward browse species. I also believe that cheatgrass may be eaten more than what is actually shown as it is commonly found growing in galleta grass clumps, and there is no way of knowing when the cheatgrass is consumed with the galleta grass. The same is true of Nevada bluegrass as it is found growing in close association with salina wildrye.

Table 10 lists the plants found in the White Canyon area that have been reported being eaten by desert bighorn sheep in other areas but were not seen being eaten in the White Canyon area.

Water requirements

The water requirements of the desert bighorn sheep have received considerable attention from biologists, but definite conclusions are lacking. There are, however, two points on which all researchers of desert bighorn sheep agree. (1) Available free water is important to bighorn sheep at critical periods of the year; these critical periods are not necessarily during the warmest time of the year. Bighorns were observed on the Desert Game Range in Nevada breaking and eating ice at a waterhole in February. This observation was made after a long period of no snow fall (Monson, 1947).

(2) Most desert bighorn biologists agree that moisture and the related succulence of the plants are more important factors in determining free water utilization than temperature.

As previously mentioned, each time ewes with sucking lambs were within a mile of free water in the White Canyon area in the summer of 1965 and 1966, they utilized the water source daily. Similar observations were made by Russo in Arizona (Monson, 1957).

Table 6. Plant utilization by bighorn rams from March through November in the White Canyon area, San Juan County, Utah.

Plant	Minutes per plant	Per cent of total
Grasses		
Hilaria jamesii	338.0	25.2
Oryzopsis hymenoides	125.0	9.3
Elymus salina	48.5	3.6
Bromus tectorum	14.5	1.1
Stipa speciosa	1.0	0.1
Total for grasses	427.0	39.3
Browse		
Coleogyne ramosissima	258.0	19.2
Fraxinus anomala	207.0	15.4
Symphoricarpos longiflorus	48.0	3.6
Ephedra sp.	39.0	2.9
Cowania mexicana	25.0	1.6
Atriplex canescens	3.0	0.2
Pinus edulis	2.0	0.2
Tamarix gallica	2.0	0.2
Atriplex confertifolia	2.0	0.2
Juniperus osteosperma	1.5	0.1
Salix sp.	1.0	0.1
Artemisia spinescens	1.0	0.1
Shepherdia rotundifolia	1.0	0.1
Dalea thompsonae	1.0	0.1
Chrysothamnus sp.	0.5	t[a]
Total for browse	592.0	44.1
Forbs		
Salsola kali	110.0	8.2
Bassia hyssopifolia	73.0	5.4
Unidentified forbs	26.0	1.9
Hymenoxys richardsonii	10.5	0.8
Kochia americana	1.0	0.1
Streptanthus arizonicus	1.0	0.1
Gutierrezia microcephala	1.0	0.1
Calochortus nuttallii	0.5	t[a]
Total for forbs	223.0	16.6
Grand total	1342.0	100.0

[a] t = value of less than 0.1 per cent

Table 7. Plant utilization by bighorn ewes from March through November in the White Canyon area, San Juan County, Utah.

Plant	Minutes per plant	Per cent of total
Grasses		
Hilaria jamesii	469.5	27.7
Oryzopsis hymenoides	69.0	4.1
Elymus salina	42.0	2.5
Bromus tectorum	21.0	1.2
Stipa speciosa	3.0	0.2
Total for grasses	604.5	35.7
Browse		
Coleogyne ramosissima	310.5	18.3
Fraxinus anomala	202.0	11.9
Symphoricarpos longiflorus	81.0	4.8
Atriplex confertifolia	17.0	1.0
Cowania mexicana	15.0	0.9
Ephedra sp.	12.0	0.7
Chrysothamnus sp.	5.5	0.3
Atriplex canescens	2.0	0.1
Pinus edulis	2.0	0.1
Total for browse	647.0	38.1
Forbs		
Salsola kali	259.0	15.3
Bassia hyssopifolia	113.0	6.7
Hymenoxys richardsonii	25.0	1.5
Unidentified forbs	15.0	0.9
Mentzelia pumila	11.0	0.7
Gutierrezia microcephala	4.0	0.2
Kochia americana	4.0	0.2
Calochortus nuttallii	3.0	0.2
Sphaeralcea munroana	3.0	0.2
Eriogonum inflatum	2.0	0.1
Astragalus sp.	2.0	0.1
Yucca navajoa	0.5	t[a]
Cirsium sp.	0.5	t[a]
Eriogonum sp.	0.5	t[a]
Streptanthus arizonicus	0.5	t[a]
Total for forbs	443.0	26.1
Grand total	1694.5	99.9

[a] t = value of less than 0.1 per cent

Table 8. Plant utilization by bighorn sheep (both sexes) October 15-21, 1966, in the White Canyon area, San Juan County, Utah.

Plant		Minutes per plant	Per cent of total
Grasses			
	Hilaria jamesii	85.0	54.7
	Stipa speciosa	8.0	5.2
	Bromus tectorum	6.0	3.9
	Cryzopsis hymenoides	2.0	1.3
Total for grasses		101.0	65.1
Browse			
	Coleogyne ramosissima	50.0	32.2
	Atriplex confertifolia	4.0	2.6
Total for browse		54.0	34.8
Forbs			
	Hymenoxys richardsonii	0.5	0.3
Total for forbs		0.5	0.3
Grand total		155.5	100.2

There was no way of determining how much water was consumed during a drinking period. It was difficult to observe bighorns drinking as most of the existing waterholes are in small steep-walled arroyos or gullies. The bighorns were always very wary in going into these waterholes. They were seen approaching and retreating from these watering areas five or six times before actually drinking. Sometimes one of the bighorns would remain back on a higher elevation adjacent to the waterhole, acting as a sentinel.

The longest period of time a bighorn ewe was observed drinking without pausing was three minutes and fifteen seconds. The longest a ram drank continually was three minutes and thirty-five seconds. The

Table 9. Plant utilization by bighorn sheep (both sexes) for November 10 and 11, 1966, in the White Canyon area, San Juan County, Utah.[a]

Plant		Minutes per plant	Per cent of total
Grasses			
	Oryzopsis hymenoides	222.0	28.8
	Hilaria jamesii	45.0	5.8
	Bromus tectorum	44.0	5.7
Total for grasses		311.0	40.3
Browse			
	Coleogyne ramosissima	406.0	52.6
	Atriplex confertifolia	25.0	3.2
	Atriplex cuneata	2.0	0.3
	Dalea sp.	1.0	0.1
	Ephedra viridis	1.0	0.1
Total for browse		436.0	56.3
Forbs			
	Unidentified forbs	10.0	1.3
	Phacelia corrugata	9.0	1.2
	Sphaeralcea munroana	4.0	0.5
	Hymenoxys richardsonii	2.0	0.3
	Aster venustus	0.5	t[b]
Total for forbs		25.5	3.3
Grand total		771.5	99.9

[a] November 8 and 9, 1966, it rained and snowed.
[b] t = value of less than 0.1 per cent.

longest a lamb was observed drinking was for two minutes and fifteen seconds. All the animals had been to the same water source the day before.

In an experiment on the Desert Game Range, six captive sheep consumed an average 1.3 gallons of water per sheep, per day for a period of 17 days. Temperatures ranged between 59° F. and 89° F. during this time.

Table 10. Plants utilized by bighorn sheep in other areas but not utilized in the White Canyon area. [a] [b]

	Scientific name	Common name
Grasses		
	Bouteloua gracilis	blue grama
	Bromus rubens	red brome
	Distichlis spicata	saltgrass
	Elymus canadensis	Canada wildrye
	Juncus balticus	Baltic rush
	Sporobolus airoides	alkali sacaton
Browse		
	Artemisia tridentata	big sagebrush
	Berberis sp.	Oregon grape
	Cercocarpus intricatus	little-leaf mahogany
	Chrysothamnus nauseosus	rubber rabbitbrush
	Chrysothamnus viscidiflorus	Douglas rabbitbrush
	Ephedra nevadensis	Nevada jointfir
	Ephedra torreyana	Death Valley ephedra
	Eurotia lanata	winterfat
	Grayia brandege	spineless hopsage
	Rhus trilobata	skunkbush
Forbs		
	Castilleja chromosa	Indian paintbrush
	Eriogonum sp.	Eriogonum
	Euphorbia sp.	Euphorbia
	Lappula redowski	hackelia stickweed
	Lepidium fremonti	peppergrass
	Mirabilis sp.	four-o-clock
	Oenothera sp.	evening primrose
	Plantago sp.	Indian wheat

[a] Common names according to Kelsey and Dayton (1942).
[b] All plants listed are found in the White Canyon study area.

Two and one half gallons of water were the most consumed by one animal at one drinking time while 1.5 gallons were the least amount of water consumed at one drinking time (Koplin, 1960).

The importance of water in relation to bighorn sheep movements and range utilization has been previously discussed, but water is not evenly distributed and range utilization is far from uniform. Two large canyons, Hidden Valley and Rainbow Canyon both of which have an estimated 40 square

miles of excellent bighorn sheep cover and forage, were completely abandoned by bighorn sheep during the summer of 1966, due to the lack of available water. Figure 14 shows the lower portion of Rainbow Canyon. During the latter part of the drought of 1966, in late July, bighorn sheep were sighted in nine different localities in which either bighorn sheep or sheep sign had not been previously noted. It was obvious these animals were searching for water.

On the Desert Game Range bighorns water at least every three to five days under maximum temperatures and minimum green feed conditions (Grove, 1961). Welles (1961, p. 36) states "in simplest terms, the demand for water increases as the supply decreases," in Death Valley, California.

Water locations and distribution

Water sites which have permanent annual water are sparse in the White Canyon area. Table 11 gives the known permanent water locations utilized by desert bighorns and the number of proposed permanent water locations for each area. The proposed water developments were inventoried by Carl Mahon and the researcher. The present waterhole sites and proposed water development sites are shown on Figure 15.

On all the mesas on the north side of White Canyon there are no permanent water sources. The bighorns must travel from the mesas down to the canyons where seeps, springs and large tanks are abundant. The sheep which winter on Found Mesa migrate in the spring to Fry Mesa and remain near a small reservoir. When the reservoir becomes dry the sheep move to the southern portion of Fry Mesa where two seeps provide permanent water.

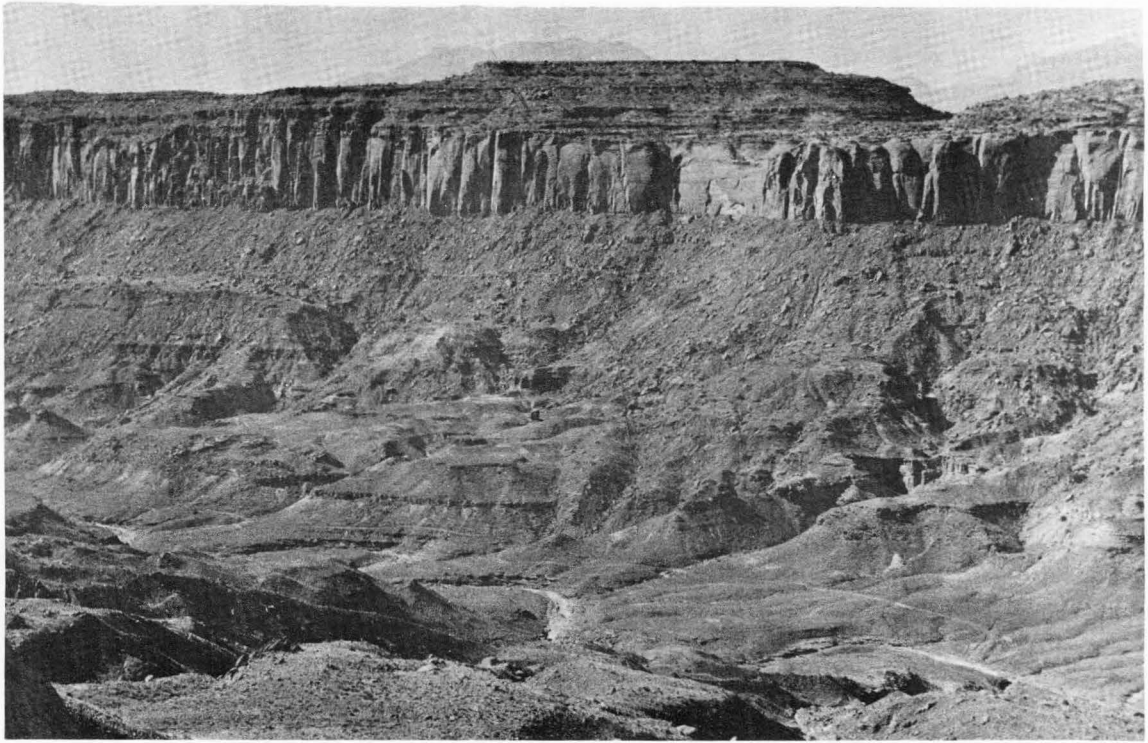

Figure 14. Rainbow Canyon was abandoned by bighorn sheep during the summer of 1966 because of the lack of water. This picture was taken in August 1966.

Table 11. Present waterhole locations and proposed waterhole developments for desert bighorn sheep in the White Canyon area, San Juan County, Utah

Location	Present number of waterholes used by desert bighorns	Length of time available water present	Proposed number permanent water developments needed[a]
Dark Canyon Mesa	1	Winter early spring	1
Jacobs Chair Mesa	1	2 months	3
Found Mesa	2	1-4 weeks	3
Fry Mesa	2	1½-2 months	3
Top of Wingate Mesa	3	Spring, winter,	11
	Numerous small tanks which have water intermittantly	1-2 weeks	
Blue Canyon	1	Year long	1
Piute, Blue Canyon Junction	1	Year long	1
Piute Canyon	0	---	2
Rainbow Canyon	1	Year long except when severe drought	2
Mahon Canyon	1	Year long	1
Wilson Canyon	1	Year long	1
Lower Red Canyon	2	Late fall, winter	1
Mouth of Wilson Canyon	1	Year long	1
Junction of Blue Notch Canyon and Hidden Valley	1	Year long	1
Blue Notch Canyon	2	Year long	2
Hidden Valley	2	Late fall, winter	2
Totals	22		36

[a] In the fall of 1966, Carl Mahon, Range Technician, Bureau of Land Management, and the author inventoried all the proposed water sites in the White Canyon area. At each water development site, the materials and time needed to develop each permanent water location were estimated. The proposed water development locations are shown on Figure 15.

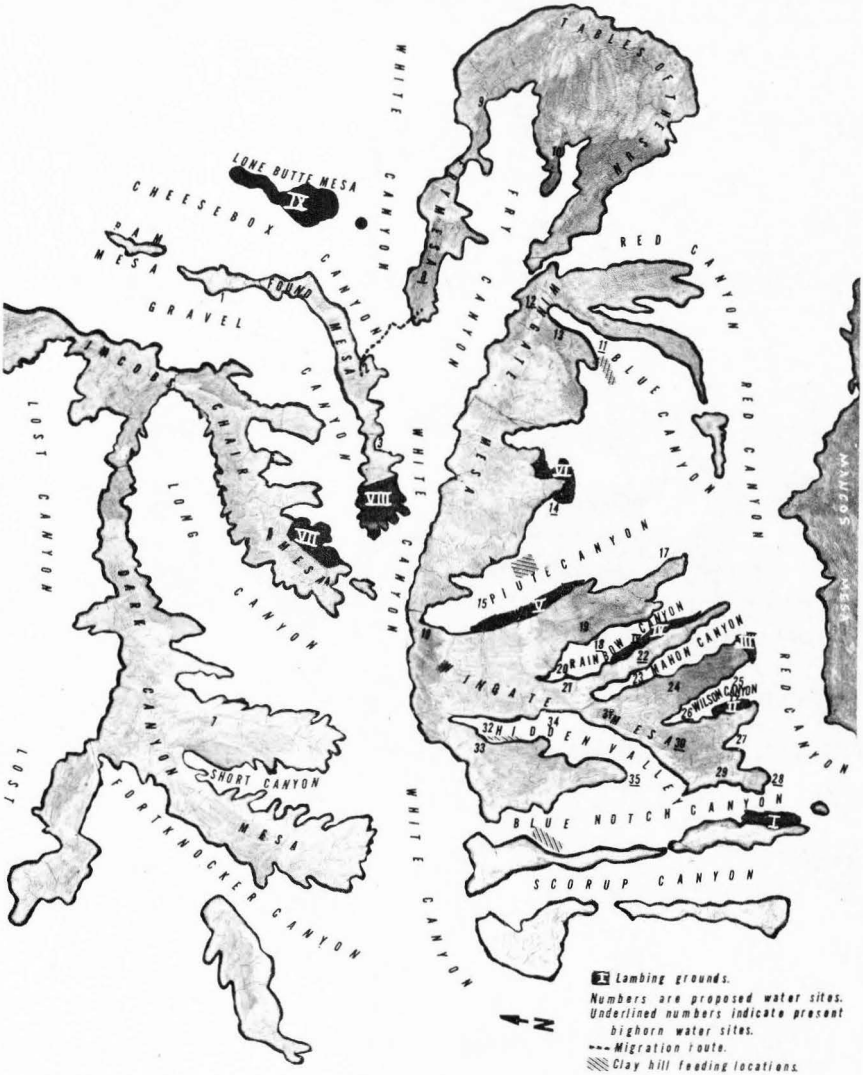

Figure 15. Lambing grounds, water sites, migration route and clay hill feeding locations in the White Canyon area.

On top of Wingate Mesa at the head of Blue Canyon there is only one permanent spring. It went dry on August 1, 1965, and July 6, 1966. At this spring, and many seeps and springs in the White Canyon area, there are large cottonwood trees (Populus angustifolia)(Figure 17). On the San Luis Rey River, California, one acre of cottonwood trees transpire approximately 9,000 gallons of water per day, as an average for the entire year (Tacher, personal communication). Under the extremely hot, dry conditions which exist in the White Canyon area the large cottonwood trees transpire so much water there is none left to reach the surface.

There are numerous seeps and springs throughout the White Canyon area that have available surface water during the late fall and winter, but at no other time.

The bighorn sheep that stayed in lower Scorup and Blue Notch Canyons during the summers of 1965 and 1966 utilized the water in Lake Powell. The rising water of Lake Powell has inundated all but two areas suitable as bighorn sheep habitat. Feral goats have been utilizing one of the areas and the bighorn sheep have been utilizing the area at Castle Butte. When the concession stand and paved road are completed at Castle Butte, all bighorn sheep habitat in the White Canyon area adjacent to Lake Powell will be lost.

There is a large spring (Warm Spring) in lower Red Canyon which is a permanent water source. The water from Warm Spring is foul tasting and I believe it contains high concentrations of magnesium sulfate. During 1965 and 1966 bighorn sheep were forced to utilize this water source on three occasions.

Figure 15 shows all the known permanent water and proposed water development locations in the White Canyon area. Many of the proposed

water development locations appear to be relatively close together, but in all cases those water sites on the mesa and below the mesa are separated by the 100 to 200 foot vertical Wingate Sandstone Cliff. Figures 16 and 17 show two typical waterhole locations for future permanent water.

Shedding

By the first of July, 1965, few bighorn sheep that had not shed their winter coats were sighted in the White Canyon area. It is easy to recognize shedding bighorns as loose patches of hair, especially on the legs, are clearly visible.

On June 27, 1966, 34 bighorns were sighted on Found Mesa, many which appeared to be in poor condition and only a few of the animals were beginning to shed. On July 22, 1966, in Blue Canyon, four ewes were sighted that were just beginning to shed their winter coats.

During the spring and summer of 1965 considerable moisture fell in the study area whereas the spring and summer of 1966 were quite dry. Shedding could be correlated directly to the amount of available moisture, or indirectly to the amount of moisture affecting the nutrition in the plants. Hansen (1964) reported that wet ewes and possibly old or sick animals appeared to shed later on the Nevada Game Range. He did not believe he had enough information to make any definite conclusions on the shedding of bighorns from his limited observations.

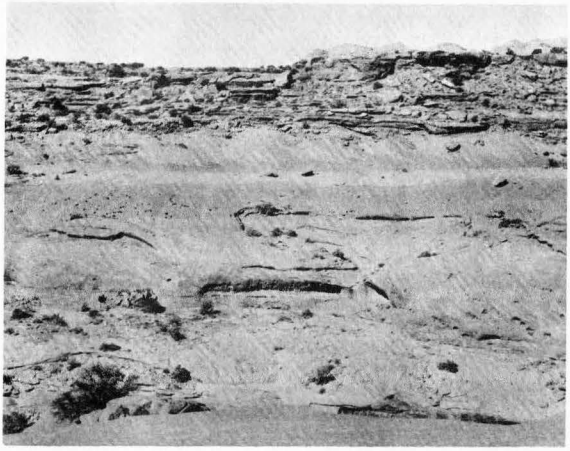

Figure 16. Slickrock areas such as the one shown were chosen for tank development sites. This area is located above the Wingate Sandstone Cliff.

Figure 17. Seep sites like the one shown were chosen for water development as they are located in the heart of the bighorn sheep habitat. Note the cottonwood trees which transpire all the water before it reaches the surface in the summer.

COMPETITION WITH OTHER ANIMALS AND HIGHWAY DISTURBANCES

While I was in the White Canyon area in the summers of 1965 and 1966 I did not observe bighorn sheep in close association with any other large ungulates.

Degree of competition with deer

Deer are the only big game animals in the White Canyon area that compete with the bighorn sheep for forage and water. Competition is greatest through the winter months, primarily October through March. The greatest competition between bighorns and deer occurs on the canyons and mesas on the north side of White Canyon. The last deer sighted on the north side of White Canyon in the heart of the bighorn sheep range was on April 21, 1966. The first large number of deer sighted which had migrated down from the Abajo Mountains was on October 20, 1966. There are a few deer that remain permanently on Fry Mesa. Approximately seven deer were known to have remained on Dark Canyon Mesa through the summer of 1966 and five on Jacob's Chair Mesa. No deer or deer sign was noted on Found Mesa, Ram Mesa or Lone Butte Mesa after April 25, 1966.

On the north side of White Canyon four deer were commonly sighted throughout the summer of 1966. In upper Red Canyon five deer were sighted on several occasions in the vicinity of Warm Spring, both in 1965 and 1966.

The extreme western arm of Wingate Mesa between upper Red Canyon and Blue Canyon supports a substantial number of deer throughout the

year. Some deer are always present from the head of Blue Canyon on the arm of Wingate Mesa between Blue Canyon and Piute Canyon. The number of deer utilizing the eastern portion of Wingate Mesa is not known, but there were probably well over 100 deer present on the mesa during 1965 and 1966. Many of these deer migrate down Wingate Mesa as far as the arm of Wingate Mesa between Rainbow Canyon and Piute Canyon. From April 28, 1966, until November 13, 1966, deer were not sighted west of the arm of Wingate Mesa between Piute and Blue Canyons.

During the period March 16 to April 15, 1966, bighorn sheep were not sighted on any of the mesas on the north side of White Canyon. Deer were sighted on the mesas on every visit to the area for the same period of time. I could never determine exactly why the bighorns leave the mesas during the late winter and early spring but I believe the increase in deer numbers force the bighorns to move down into the canyons. Deer are relatively aggressive toward bighorn sheep on the Nevada Game Range and have been observed driving desert bighorn sheep from water and forage (Welles, 1961).

The browse species are the principal plants utilized by both deer and bighorn sheep in southeastern Utah. The plants with high to moderate duel use are: cliffrose, singleleaf ash, longflower snowberry and black-brush. Plants with moderate to light duel use are: skunkbush, shadscale and juniper. These plants are very important to the bighorns on the north side of White Canyon due to the sparse grass cover. In many areas, especially on the talus slopes under the Moenkopi Cliff on the north side of White Canyon and on Found Mesa, Jacob's Chair Mesa and Ram Mesa proper, many of the browse species are dead or dying from over utilization (Figure 18).

Figure 18. Bighorn sheep on Jacob's Chair Mesa in an area heavily utilized by deer in the winter. Notice the sparseness of vegetation. Picture taken October 25, 1966.

The average distance between deer and bighorn sheep during the spring and summer of 1965 and 1966 averaged 8.1 miles with a range of 2.5 miles to 13.8 miles at the 99 per cent confidence limits. Deer and bighorn sheep were never sighted together or on the same ranges in Death Valley, California (Welles, 1960).

On October 31, 1966, bighorn sheep were sighted within a half mile of seven deer. It appears from my limited observations that deer and bighorn sheep utilize many of the same ranges during the winter due to the increase in deer numbers. Deer and bighorn sheep have been observed feeding together in other localities (Russo, 1956; Sugden, 1961). In the Big Hatchet and San Andres Mountains in New Mexico desert bighorn sheep and deer compete for 100 per cent of their diet. Deer did not utilize all the plants that bighorn sheep did, but bighorns utilized all the plants that deer fed on (Gordon, 1957).

Competition between cattle and bighorn sheep

In 1958 a desert bighorn sheep ram was commonly seen with a herd of cattle in upper Red Canyon (Utah Fish and Game Magazine, 1958). Certainly this is the exception rather than the rule. Bighorn sheep and cattle were never sighted together through the course of the study, and the average distance bighorns were sighted from cattle was 6.4 miles with a range of 2.9 miles to 9.9 miles with 99 per cent confidence limits.

Cattle are not grazed on the north side of White Canyon from June 30 until October 15, yearly. Competition for forage between cattle and bighorns occurs primarily on the talus slopes under the Moenkopi Cliff and on the southern portion of Fry Mesa. Competition for water, where water is available, occurs in the canyon bottoms and at the few seasonal seeps in the Moenkopi talus arroyos.

Competition between cattle and bighorns on the south side of White Canyon is heaviest in Red Canyon. Approximately 40 cattle utilized Red Canyon from its extreme northeastern point to Warm Spring. Cattle have greatly over utilized this area and no bighorn sheep were ever sighted in this section of Red Canyon. Tracks of bighorn sheep were noted on three occasions in this range. East of Warm Spring, cattle or cattle sign were not found. Bighorns were sighted on every visit to this area and tracks and droppings were always numerous. No difference in topography, climax vegetation or available water exists in the area east of Warm Spring in Red Canyon. The lack of cattle was the only noticeable difference between the two areas.

During the early spring, for short periods after heavy rains in the summer, and during the winter, cattle from Red Canyon move up the canyons which drain from Wingate Mesa. Generally the cattle graze on the Moenkopi and Shinarump formations. It is at these times that the majority of the competition between cattle and bighorns occurs on the south side of White Canyon.

The primary plants utilized from heavy to moderate by both cattle and bighorn sheep are: galleta grass, Indian ricegrass, salina wildrye, cheatgrass, blackbrush and summer cypress.

It appears that cattle tend to compete with Rocky Mountain bighorn sheep more than with desert bighorn sheep (Honess and Frost, 1942; Smith, 1954, and Buechner, 1960).

Competition between feral goats and bighorn sheep

There are approximately 45 feral goats utilizing the range on the long point which extends into Lake Powell between Scorup Canyon and

lower White Canyon. Bighorn utilization was low on the extreme eastern border of the feral goat range. Neither bighorns nor bighorn sign were observed in the area utilized by the feral goats. Historically, bighorns were known to have inhabited this area.

Influence of man and Utah Highway 95

Reactions of bighorn sheep to man and machinery are highly variable, but in most cases bighorns remain elusive and well removed from man and his machinery. Prior to 1964 bighorns were commonly seen crossing Utah Highway 95 throughout the White Canyon area. During 1965 and 1966, bighorns were known to cross Highway 95 on five occasions. Four of the crossings were made by the band of bighorns which migrate from Found Mesa to Fry Mesa in the spring, and back to Found Mesa from Fry Mesa in the fall. One ram was sighted just below the Happy Jack Mine on November 14, 1965. Highway traffic has greatly increased since the spring of 1966, because the bridges spanning White Canyon, the Colorado River and the Dirty Devil River have been completed.

Much of the area on Wingate Mesa directly above Highway 95 is approximately 1 air mile from the highway, but there are only two known trails over the Wingate Sandstone Cliff that parallels the highway. When recording the distance bighorn sheep were sighted from Highway 95 for statistical analysis, the distance traveled to one of the two trails was used. Bighorn sheep in 1965 and 1966 were sighted on only one occasion on the north-facing talus slope below the Wingate Sandstone Cliff paralleling Highway 95. The mean distance bighorns were sighted from Highway 95 was 11.9 miles (99 per cent confidence limits 1.3 miles to 22.7 miles). Eight miles in the White Canyon area means traversing some extremely rugged terrain.

On June 7, 1965, Rodney John, Utah Fish and Game Biologist, watched an adult ewe make her bed approximately a half mile away and above Highway 95, while a large ore truck passed on the road below. The ewe was above the truck and commanded an excellent view of the surrounding terrain, and apparently paid little attention to the ore truck or other vehicles on the highway below. Similar observations of bighorns showing little concern about automobiles were made by Welles (1961) in Death Valley.

In the spring of 1965, both old and fresh bighorn sheep tracks and droppings were commonly found in Natural Bridges National Monument. Bighorn sheep were sighted in the Monument prior to this time. Construction was started in the summer of 1965 to build new roads and a housing development. Although observations have continued, bighorn sheep have been sighted on only one occasion in the Monument since the construction began.

The other extreme was reported during the construction of the new bridge spanning White Canyon. Two ewes and a small ram were sighted daily in the same locality for over a week while the bridge was under construction. The bighorns were not seen after the dynamite for construction was detonated.

MORTALITY AND FACTORS AFFECTING MORTALITY

Predation

It is extremely difficult to determine the role predation by coyotes, bobcats, eagles, foxes and mountain lions plays as a decimating factor on any big game population. A small lamb could be completely consumed by a coyote, bobcat or mountain lion leaving no trace of the lamb. Table 12 gives the data obtained from 110 bobcat and coyote scats. Predator scat analysis only tells what the predator has been feeding on. There is no way of knowing from scat analysis if the animal consumed was killed by the predator or found dead by the predator.

Table 12. Analysis of coyote and bobcat scats from the White Canyon area, San Juan County, Utah.

Content	Number of scats	Per cent of total
Rodent and rabbit	82	74.6
Deer	18	16.4
Bighorn sheep	10	9.1
Total	110	99.1

Coyotes. Coyotes are abundant in the White Canyon area, and coyote densities are high on the north side of White Canyon. On August 1, 1965, 13 coyotes were seen traveling together on Found Mesa. Nine coyotes were sighted in a pack on Fry Mesa on August 29, 1965, and 12 were sighted traveling the road below Ram Mesa on October 21, 1966. Every day I was in the field in 1965 and 1966 fresh coyote tracks of more than one coyote were noted. Coyote tracks and droppings were always much more dense through the early spring, winter and late fall when the deer that spend

their summers on the Abajo Mountains migrate to the lower range occupied by the bighorn sheep.

All nine fresh coyote scats that contained bighorn sheep remains were collected on the north side of White Canyon between March 22 and June 29. This data suggests the mortality of bighorn sheep is probably highest at this time. It is during this period that coyote densities are at a maximum. Two of the scats with bighorn sheep remains were collected on Jacob's Chair, one on Dark Canyon Uranium Mesa, four on Found Mesa, one from Lone Butte Mesa and one from Ram Mesa. In one instance the whole knee joint of a small lamb was found in a coyote scat collected on Found Mesa.

Seventeen of the 18 fresh coyote scats which contained deer remains were collected on the north side of White Canyon between March 21 and July 10. These dates are almost identical for the period that bighorn sheep remains were noted.

Wolves were not sighted during the course of the research, but on several occasions extremely large tracks and droppings of either wolves or wild dogs were found on the north side of White Canyon. Some of the long time residents of the White Canyon area claim there are still wolves remaining in the area. On April 11, 1966, four yearling deer and two two-year-old deer were found dead on Lone Butte Mesa. All had been killed by a wolf or wild dog and only one of the deer had been consumed.

It is the general consensus of workers dealing with coyote-bighorn sheep relationships that coyotes, under the right conditions, are capable of killing bighorn sheep. However, coyotes rarely, if ever, pose a threat to the welfare of bighorn sheep except under high coyote densities. Few witnesses have seen actual predation of bighorn sheep by coyotes (Smith,

1954; Russo, 1956; Monson, 1957; Buechner, 1960 and Elliott, 1961.

Bobcats. Bobcats are abundant throughout the White Canyon area but scats are difficult to find as they are usually buried. The remains of one bighorn sheep were found in a bobcat scat collected from Blue Canyon. From 110 scats collected only 14 were from bobcats.

Bobcat tracks and sightings, although noted almost daily in the White Canyon area, were not as abundant as coyotes. Predation by bobcats on young desert bighorn sheep was thought to be a major decimating factor to the bighorns in Arizona (Russo, 1956; Monson, 1957). Actual observations of bobcats killing bighorns or having killed desert bighorn sheep were reported from the Nevada Game Range, Kofa Game Range, Arizona (Monson, 1957), Kaibab Plateau, Arizona (Elliott, 1961) and Texas (Elliott, 1961).

Predation by bobcats on desert bighorn sheep, particularly lambs, can become critical, and two observers reported mature rams killed by bobcats (Elliott, 1961 and Goldman, 1961). "On the basis of the Desert Game Range, it becomes apparent that the control of bobcats has been one of the elements of management which has contributed to the welfare of the bighorns" (Elliott, 1961, p. 85).

Mountain lions. Mountain lion scats were not obtained from the White Canyon area, as mountain lions are not abundant on the east side of the Colorado River in the Lake Powell area. High densities of mountain lions have been reported on the west side of the Colorado River (Simons, personal interview).

I sighted a mountain lion on March 29, 1966, in upper Blue Notch Canyon. Running tracks made by the cougar and the running tracks of four ewes and two lambs were found together on March 30, 1966. I followed

these tracks for about a mile and found where the cougar, unsuccessful, had given up the chase. On April 1, 1966, I found the tracks of a running cougar on the rim of one of the tributary arroyos which drain into Blue Notch Canyon and the tracks of a running mature bighorn sheep in the bottom of the arroyo. As the arroyo widened, the distance between the cougar and the bighorn increased until the cougar apparently gave up the chase. The last time I noted the cougar's tracks was April 2, 1966.

It is the general opinion of all researchers of the desert bighorn that mountain lions can and do kill bighorns when given the opportunity (Blaisdell, 1961).

Golden eagles. Golden eagles were sighted four times in 1965 and 1966 in the study area, but golden eagles were seen on numerous occasions in adjacent areas.

Eyewitness accounts of golden eagles preying on bighorn sheep were reported by Russo (1956) and Kennedy (1948) in Arizona. Sightings of eagles diving at or killing bighorn lambs, and in one instance a yearling bighorn, were made by Smith (1954) in Idaho, and Cottam in Nevada (Jantzen, 1961). However, eagle predation on bighorn sheep is not considered a major limiting factor to bighorn populations by most bighorn sheep researchers (Jantzen, 1961).

Foxes. Two reports of desert foxes killing desert bighorn lambs were reported in Arizona (Russo, 1956). In both cases the lambs were only a few days old.

The kit fox is abundant in the White Canyon area, but scats from kit foxes were not collected. Although not a serious threat to bighorn sheep lambs, a fox could take a young lamb if given the opportunity.

Internal parasites and disease

A total of 220 bighorn sheep fecal samples were collected shortly after defecation. Of these samples 192 (87 per cent) were negative for cestode proglottids or eggs, roundworm eggs or larvae, intestinal nematodes, lungworms, coccidial oocysts or protozoan oocysts. Seven internal parasites were identified.

Eimeria granulosa. This coccidia is found in the small intestine. This coccidia is found in domestic sheep and goats and has been found in other wild sheep populations. It is pathogenically serious only with heavy infestations. E. granulosa has been described in bighorns from other areas in Arizona (Allen, 1960), New Mexico (Allen, 1955), and Idaho (Smith, 1954).

Eimeria pallida. This is a coccidia found in the small intestine. Normally this coccidia is found only in domestic sheep and goats. This is the first time it has been reported from any bighorn sheep population in the United States, Canada or Mexico. Pathogenically it is serious only with heavy infestation (Chandler, 1962).

Skrjabinima sp. This is a nematode found in the large intestine. This is probably Skrjabinema ovis and is found in domestic sheep, goats and other populations of bighorn sheep. Little is known of its pathogenesis and life cycle. Skrjabinema has been found in bighorn sheep in New Mexico (Allen, 1962), and Idaho (Smith, 1954).

Cooperia sp. This is a hookworm found in the lumen of the intestine. This parasite may cause a condition known as verminous gastroenteritis or black scours. Severe infestation is the result of poor nutrition and young animals succumb to it. With serious infestations, ewes will not give adequate milk. This organism is commonly found in domestic goats,

sheep, cattle and bighorn sheep in New Mexico (Chandler, 1962 and Allen, 1961).

Wyominia tetoni. This is a tapeworm found in the bile ducts and duodenum of bighorn sheep. This is a parasite found exclusively with bighorn sheep causing some debility in old sheep (Chandler, 1962 and Allen, 1960). Wyominia has been found in most bighorn sheep herds throughout the United States (Allen, 1961, 1962; Honess, 1942b, Smith, 1954).

Moniezia sp. This is a tapeworm found in the small intestine. It is probably Moniezia benedeni or Moniezia expansa which have been reported from other bighorn sheep populations (Allen, 1961). This organism has a life stage which lives in mites, and the infected mite must be ingested by domestic cattle, sheep, goats or bighorn sheep. These organisms remain in the animal for short periods of time (Olsen, 1959). Moniezia has been reported in bighorn sheep from Idaho (Smith, 1954), Nevada and New Mexico (Allen, 1961).

Thysanosoma actinioides. This is a parasite called the fringed tapeworm and is frequently found in the gall ducts, gall bladder, biliary canals of the liver, duct of the pancreas and in the small intestine. It may cause obstruction of the bile ducts, pancreatic ducts and derangement of the liver resulting in impaired digestion (Hagner, et al, 1938). This organism has been reported in bighorn sheep in Arizona (Russo, 1956).

None of the parasites were found in sufficient numbers to be of a serious threat to the welfare of the bighorn sheep. The maximum number of coccidial oocysts per gram of feces was six and for Skrjabinima eggs, two per gram of feces. Four tapeworm proglottids was the maximum number found in a fecal sample.

Of the eight bighorn sheep known to be parasitized by the tapeworm

Wyominia tetoni, seven were rams and one was an unclassified animal thought to be a ram.

Low precipitation and the almost complete absence of dew are two of the factors which cause parasite numbers to be low. The dispersal state of the two Eimeria sp. is passed from one sheep to another by fecal contamination of water and forage. The cestodes Wyominia, Moniezia and Thysanosoma are assumed to have an intermediate stage in a grass-dwelling insect or mite (Chandler, 1962; Honess, personal communication).

Although the majority of the bighorn sheep fecal samples were examined for lungworm eggs or larvae, no trace of this organism was found. It is believed that the lack of land snails in the White Canyon area, which are necessary for one of the life stages of the lungworm, is the primary reason for no infestations. Russo (1956) reported a similar observation in Arizona.

In the summer of 1966, 400 domestic sheep and goats were found on the north side of the San Juan River in an area adjacent to the study area. From 40 fecal samples collected from the domestic sheep and goats many contained coccidia. Transmission of some of the parasites from domestic sheep and goats into the bighorn sheep population could have been effected by their utilization of the same ranges.

Cattle and bighorns have utilized many of the same ranges in the past few years, especially during the late fall and winter. Parasites from the cattle could have been transmitted to the bighorn sheep.

Feral goats live in the White Canyon area primarily west of Scorup Canyon, but the goats have been sighted as far east as Blue Notch Canyon (Call, personal communication). The possibility exists that E. pallida, E. granulosa and Skrjabinema sp. were transmitted to the bighorns from

the goats as all the bighorn sheep found harboring these parasites were from Blue Notch and lower Red Canyons.

On March 22, 1966, a four year old ewe was shot and immediately taken to the Diagnostic Laboratory, Colorado State University. The animal arrived at the laboratory 17 hours after it was killed. The ewe was small compared to the other four ewes and three yearlings present in the herd. The pelage of the animal was dry and rough and did not have the sheen of the other ewes and yearlings. The ewe was slender in body conformation and did not appear to be pregnant from all exterior appearances. The necropsy report from the Diagnostic Laboratory is listed below. Dr. Harold Breen of the Diagnostic Laboratory, Dr. Robert Bergstrom and Professor Ralph Honess from the University of Wyoming performed the necropsy.

Necropsy report. A. 1. Malocclusion of the premolars and molars with no evidence of any wear. All the teeth had extremely sharp spinous processes making mastication practically impossible.
2. Pulmonary congestion.
3. Pleuritis (fibrinous adhesions of the parietal and visceral pleura).
4. Atrophied liver.
5. Hyperemic intestinal mucosa (post parietal of the small intestine).
6. Grossly normal fetus (about 2/3 to 2/3 plus through gestation period) in the uterus.
7. Some congestion of the small intestine with the possibility of coccidiosis.

B. Cultures
1. All tissues of the fetus, except the liver, showed no growth of bacteria except a Bacillus which was found in the liver. This was probably a post mortum contaminant.
2. Intestines - Bacillus, Escherichia coli, and Alpha streptococcus.
3. Liver - Staphylococcus sp.
4. Lung - Beta streptococcus, Escherichia coli, Bacillus.
5. Lymph node - Staphylococcus sp.

Note: The only organism of any possible significance was the Beta streptococcus found in the lungs.

C. Fecal samples taken from the colon. No roundworms, eggs or larva of any parasites found.

The most notable abnormality of the four year old ewe was the lungs. The lungs were small and completely adhered to the body wall and diaphragm showing the ewe previously had suffered from severe pneumonia. Beta streptococcus is a pathogenic bacteria belonging to a group of streptococci which can cause tonsillitis, scarlet fever and bronchial pneumonia. Some of the streptococci can assume a major pathogenic role when normal resistance is markedly reduced (Hagen, 1961).

Throughout the spring of 1965 lambs were repeatedly sighted with rough coats, feeding little, and coughing severely (Figure 19). I suspected at the time that many of the lambs had severe cases of pneumonia. Lamb mortality for the spring and summer of 1965 and winter of 1965 and 1966 was approximately 46 per cent. However, no lambs were observed coughing in the spring and summer of 1966 which was unusually dry. The possible organism causing much of the mortality could have been Beta streptococcus.

After a heavy rain and snow storm on November 8 and 9, 1966, one distinctive ewe was sighted without her lamb on November 10, 1966. The lamb was not sighted again although I watched this ewe continually for the following three days. A dark ewe with a healthy lamb was observed for the same period of time; the lamb coughed repeatedly and did not run and play as I had seen it doing prior to the storm. The lamb fed little and lay down whenever it was not traveling to keep up with the other bighorns.

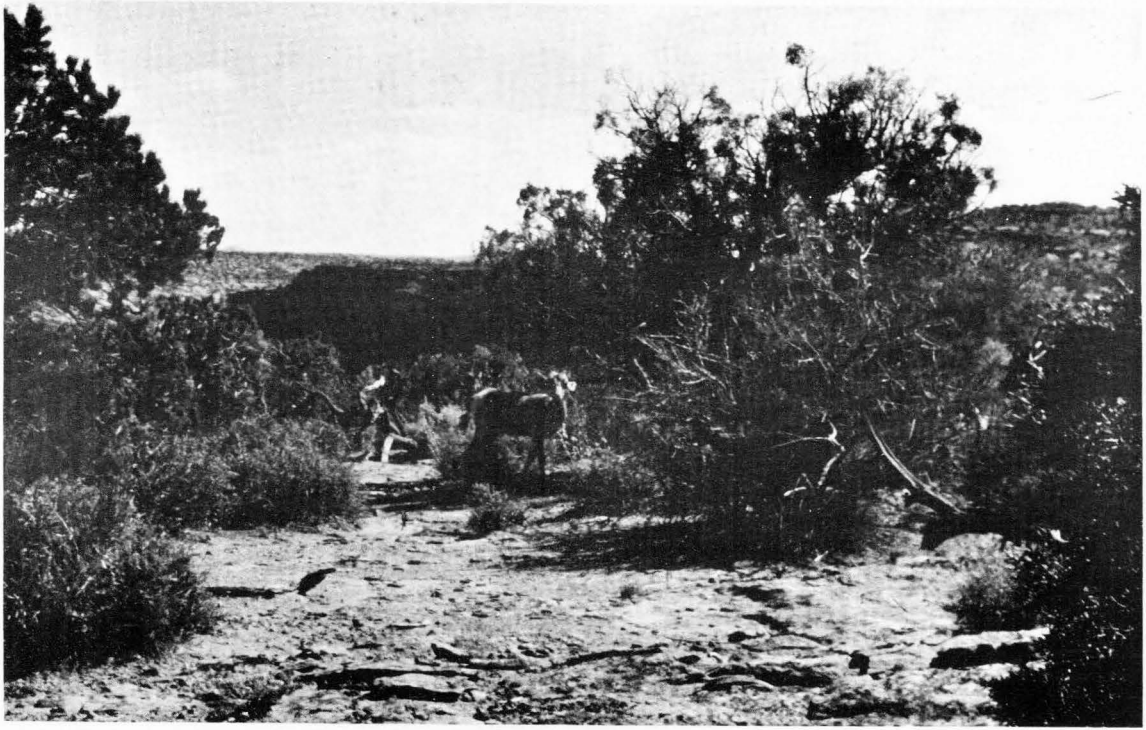

Figure 19. Small lamb in poor condition with a rough, coarse pelage, and was sighted coughing. Picture taken August 15, 1965.

Honess (1942a) killed a bighorn lamb in Wyoming which was inactive and had a rough coat. This animal had a severe case of bronchial pneumonia and the only organism harbored by the lamb was an unidentified streptococcus bacterium. The range utilized by the bighorn sheep population from which this lamb was killed was in poor condition.

The apparent susceptability of the desert bighorns in southeastern Utah to pneumonia could be caused by the lack of adequate nutrition during the summer, or by the lack of some nutrient.

Accidents

Because of the roughness of the terrain inhabited by bighorn sheep, accidents are not uncommon to the animals. A dead ewe was found that had fallen off a cliff on the Desert Game Range (Johnson, 1958).

On July 5, 1965, I found a seven year old ram that had apparently slipped and fallen over a 100 foot cliff. The skull and most of the skeleton were lying in the top of a juniper tree directly below the cliff. Smith (1954) found a large ram which had fallen and hanged itself in a tree.

On one occasion I saw a large mature ram jump on a large boulder approximately 10 feet high. The ram collided with a small lamb which was on top of the boulder, knocking the lamb off. The lamb landed on its feet and was apparently unhurt. Had the same incident taken place where the lamb would have fallen on some large boulders, or from a greater distance it would have been injured or killed.

Rams fighting and chasing ewes during the rut are another source of possible accidents.

At the present time there is little danger to desert bighorn sheep from automobiles on Utah Highway 95. When the highway is paved and with

an increase in the bighorn sheep population, the danger to bighorns by automobiles will be greatly increased.

Rolling rocks dislodged by bighorn sheep are a constant threat to the other bighorn sheep. On November 14, 1966, I watched a large boulder which weighed several hundred pounds, dislodged from the talus slopes under the Wingate Sandstone Cliff, barely miss an adult ewe.

Mineral deficiencies

An apparent mineral deficiency in the bighorn sheep's diet exists in the White Canyon area. The first indication of the lack of some nutrient in the bighorns' diet was reported from Professor Ralph Honess, Parasitiologist at the University of Wyoming. While doing parasite analyses of fecal samples from desert bighorn sheep in the White Canyon country, he noted that many of the samples contained large quantities of clay. On July 29, 1965, I watched four ewes, two lambs and a three year old ram travel for about two miles without stopping to graze. When the sheep reached a large clay hill they started pawing and eating large quantities of clay. The ewes and ram ate the clay for 22 minutes, eating no vegetation, whereas the lambs did not eat any of the clay. The clay hill is located in Hidden Valley.

Similarly, Carl Mahon on December, 1965, watched two ewes eat large quantities of clay in Blue Notch Canyon. A sample of the soil collected from the site contained a trace of soluble phosphorous. Bighorns were observed eating clay at similar sites in Blue Canyon and Piute Canyon (Figure 15).

It is not unusual for bighorn sheep or domestic sheep to eat small quantities of soil periodically at different times of the year (Honess and Cook, personal communications) but it is irregular for any animal to

eat large amounts of soil routinely throughout the entire year.

Honess and Frost (1942) found large quantities of clay in 14 bighorn sheep droppings collected in Wyoming. It was believed that the bighorns were eating the clay for sodium at old livestock salting locations. Identical observations and conclusions were reported by Packard (1946) in Rocky Mountain National Park, Colorado. During the same study in Colorado bighorns were observed to eat large quantities of mud at Sheep Lake. The mud contained calcium in greater amounts than in any other area of the park.

While watching five rams in Cataract Canyon on the Colorado River in Utah, I saw one ram repeatedly butt a large, pale yellow boulder and eat the flaked-off chips. The ram also licked the rock. Russo (1956) made a similar observation in Arizona.

On June 17, 1965, I watched a mature ewe nibbling and chewing on a large deer antler throughout the day. She would leave the antler periodically to graze, but she always returned for it. I watched these bighorns for over six hours as the animals traveled approximately two miles; when I left the band of ewes and lambs, the old ewe was still carrying the antler.

In January 1966, Carl Mahon placed a bale of alfalfa hay and a block of sodium salt in three locations in the White Canyon area. Block salt without hay was placed at two other sites. The alfalfa hay was eaten at two of the locations, but the salt was not touched. Alfalfa is highest in calcium of all the common livestock feeds but also has considerable phosphorous (Maynard, 1962). I checked the salt blocks for signs of sheep utilization throughout the spring and summer of 1966 but at no time was the salt eaten. Bighorns had stepped over the blocks of salt at three of the salting sites. Russo tried a similar experiment

with sodium, iodized and phosphorous salt in Arizona, but after two years there was no evidence that the salt had been licked (Russo, 1956).

Sodium salt is sought after by bighorn sheep in Colorado (Packard, 1946), Idaho (Smith, 1954) and Wyoming (Honess and Frost, 1942), but it apparently is not lacking on desert ranges occupied by bighorn sheep.

In an enclosure in Texas five desert bighorn sheep utilized two 33-pound blocks of Moorman mintrate salt in six weeks. Moorman mintrate salt contains 42 per cent protein, all the known essential minerals, Vitamin A, Terramycin and 14 per cent salt. Since the salt was placed in the enclosure (1962) lamb mortality has ceased and reproduction has been high (Hailey, 1962, 1964). Fifteen bighorns are now utilizing 50 to 60 pounds of the Moorman mintrate salt monthly at this time with no apparent ill effects (Hailey, personal communication).

Poisonous plants

Poisonous plants are rarely considered as a decimating factor to any wildlife species. The threat of these plants is always present in the White Canyon area, many of which are abundant. Table 13 lists the known plants poisonous to domestic livestock found in the White Canyon area (Muenscher, 1951).

Three of the plants listed are very abundantly found throughout the bighorn sheep range. Threadleaf snakeweed can be found in almost every habitat type. It is defintely increasing in abundance where cattle have been over-utilizing the range in White Canyon proper and Red Canyon. In many areas several hundred acres of snakeweed can be found. Threadleaf snakeweed can cause poisoning when it is eaten in large amounts. Snakeweed is thought to be responsible for a high per-

centage of abortions in domestic stock in the southwest (Cook, 1951).

Table 13. Poisonous plants found in the White Canyon area, San Juan County, Utah.[a]

Scientific name	Common name
Gutierrizia microcephala	threadleaf snakeweed
Hymenoxys richardsonii	pingue actinea
Lupinus polyphyllus	Washington lupine
Oxytenia acerosa	prickly acerosa
Lupinus kingii	kings lupine
Lupinus caudatus	tailcup lupine
Delphinium sp.	larkspur
Zagadenus paniculatus	foothill deathcamus
Sarcobatus vermiculatus	greasewood

[a] (Cook and Stoddart, 1951)

Table 14. Plants capable of causing mechanical injury to bighorn sheep in White Canyon area, San Juan County, Utah.[a]

Scientific name	Common name
Bromus tectorum	cheatgrass
Opuntia (and other genera)	cactus
Stipa spartea	porcupine grass

[a] (Cook and Stoddart, 1951)

Pingue actinea is very common throughout the bighorn sheep range. Bighorns have been sighted feeding on the seed stalks of this plant. The effects of eating this plant by domestic livestock appears to be cumulative in domestic sheep. The toxic properties are more pronounced in drought years (Cook and Stoddart, 1951).

There are several species of locoweed (Astragalus sp.) in the bighorn sheep range. It is not known if any of the locoweed species found commonly on the east and south facing talus slopes are of a poisonous nature

as little work on the chemical properties of the locoweeds has been completed at this time.

On October 28, 1966, a ewe and lamb were sighted in Rainbow Canyon. The ewe was blind in the left eye and the eye was very inflamed and swollen (Figure 12). No external appearance indicated that the ewe had fallen or cut the eye. It was assumed that the animal lost the eye by coming in contact with some sharp object such as a spine of a shrub or cactus plant.

Illegal hunting

Illegal hunting is not as extensive at this time (1965-1966) as it has been in the past. On June 21, 1965, the remains of what appeared to be a mature ram were found on Jacob's Chair Mesa. The intestines and the lower parts of the legs were the only portions of the animal not taken and tracks of a vehicle to and from the remains were still prominant.

The hides, lower parts of the legs and intestines of two bighorn sheep were found on Found Mesa on March 19, 1966. Several human tracks leading to and from the remains of the bighorns indicated that more than one trip was necessary to pack the heads and quarters of the animals off the mesa.

Black gnats

Generally from the latter part of May through the first of July, biting black gnats of the family Ceratopogonidae are very abundant throughout the White Canyon area. When the gnats bite they leave a sore similar to a mosquito bite, but more severe in nature. The gnats are not deadly from the accumulation of several bites, but are extremely annoying to the bighorn sheep. During the peak of abundance which lasts

for at least two weeks, bighorns frequently ran for temporary relief from the gnats. The bighorns would graze from two to five minutes and then would run a few yards to several hundred yards trying to avoid the gnats. Generally shaded coves and overhangs under cliffs were sought out by the bighorns when resting to avoid the gnats. The resting periods were generally short as the bighorns were forced to run to a different location to temporarily avoid the gnats.

Three observations were made of rams standing on a large slick rock area on Wingate Mesa where a persistant breeze gave them relief from the gnats. On one occasion I saw seven rams stand on a large slick rock area for over three hours. Many of the bighorns are in poor condition at the end of the gnat season.

PLANT COMMUNITIES AND BIGHORN SHEEP HABITAT

Since game management is in large measure dependent on the understanding of animal habitat, a description and classification of habitat variation in the White Canyon area was undertaken. The habitat types described were found useful in stratifying animal use patterns.

The area studied has had very little disturbance by white man and his animals. The vegetation sampled can be considered in a climax condition but the dissected topography has not allowed climate to exert its influence to the utmost. Therefore, the polyclimax definitions of Daubenmire (1947) best describe the patterns studied. That collective area which is occupied by a certain climax plant community - a plant association - has been termed a "habitat-type" (Daubenmire, 1947). It was found that essentially the same association in terms of species composition but differing in total density and cover exist on the various geological formations. Therefore, the plant associations were further divided by geological information. The plant associations names begin with descriptive geological terms and are followed by a listing of the most important species in the several plant community synuseae. The uniform stratigraphic evaluations and the considerable geological influence on plant environments in this arid region make this approach feasible.

Dark Canyon Mesa, Jacob's Chair Mesa, Ram Mesa, Lone Butte Mesa, and Fry Mesa all possess similar vegetation patterns. All the mesas on the north side of White Canyon rise from a level plain. The plains are

all bisected by the various canyons. Three geological formations are easily distinguished on the mesas; (1) the talus slope under the Moenkopi Cliff, (2) shale area above the Moenkopi Cliff, and (3) Shinarump which rises on top of the Moenkopi Formation (Figure 20). All the geological formations were sampled for vegetation patterns. All slopes regardless of the direction in which the slope faced were sampled, but the majority of the quadrats were run on those slopes with the greatest exposed surface area and receiving the greatest amount of bighorn utilization. Tables 15 and 16 show the three dominant plant species with respect to slope exposure and geological formation. Throughout the White Canyon area dominant species of plants can be found restricted to particular slopes in different geological formations.

The canyons on the north side of White Canyon were not studied in detail as these areas utilized by bighorn sheep are spotty; further, the terrain does not lend itself to quadrat sampling and animal use.

Vegetation in relation to geology

Moenkopi talus - salina wildrye, galleta habitat type. This habitat type is occupied by a relatively complex plant association. The talus slopes under the Moenkopi were formed from colluvium from the geological formations that have eroded away from above. The soils vary from clays to shales with intermixed sandstone. The most common surface soils were from shales and sandstones. All slope exposures were represented in the sampling.

Pinyon pine and juniper dot the talus slopes under the Moenkopi Formation, and in some instances dense stands of these trees are common. On the south and east facing exposures galleta grass and Indian ricegrass

Table 15. The three most dominant plant species in relationship with slope exposure and geological formation on the north side of White Canyon, San Juan County, Utah.[a]

Geological formation	Slope exposure				
	North	South	East	West	Flat
Chinle	juniper Ephedra viridis salina wildrye	juniper snakeweed galleta grass	juniper ephedra desert needle-grass	pinyon juniper snakeweed galleta grass	pinyon juniper big sagebrush cryptantha
Moenkopi	juniper Ephedra viridis salina wildrye	juniper shadscale galleta grass	juniper skunkbush galleta grass	pinyon juniper Ephedra viridis salina wildrye	juniper snakeweed salina wildrye
Talus slope under Moenkopi	juniper Ephedra viridis salina wildrye	juniper snakeweed galleta grass	juniper skunkbush galleta grass	pinyon juniper singleleaf ash salina wildrye	none

[a] Plants are listed in order of decreasing dominance.

are the two most common grasses found. Salina wildrye is the most common grass found on the north and west facing slopes. Other common plants found in this community are: cliffrose, ephedra, squawbush, snakeweed, blackbrush, singleleaf ash, desert needlegrass (Stipa speciosa), desert princesplume (Stanleya pinnata) and shadscale.

Table 21 gives the quantitative and qualitative data obtained for this community.

The bighorn sheep utilization in this community is light during the summer and winter and is heaviest in the late fall. Deer use this area

Table 16. The three most dominant plant species in relationship with slope exposure and geological formation on the south side of White Canyon, San Juan County, Utah.[a]

Geological formation	Slope exposure				
	North	South	East	West	Flat
Above Wingate Sandstone	black-brush ephedra Indian rice-grass	black-brush shadscale galleta grass	juniper black-brush galleta grass	black-brush ephedra Indian rice-grass	pinyon juniper black-brush prickly pear
Talus slope under Wingate Sandstone	juniper black-brush salina wildrye	black-brush shadscale galleta grass	ephedra shadscale galleta grass	shadscale galleta grass salina wildrye	none
Shinarump	black-brush shadscale galleta grass	ephedra desert trumpet galleta grass	ephedra shadscale galleta grass	black-brush shadscale galleta grass	black-brush shadscale galleta grass
Moenkopi	black-brush ephedra galleta grass	ephedra shadscale cheat-grass	black-brush summer-galleta grass	black-brush shadscale galleta grass	black-brush shadscale galleta grass

[a] Plants are listed in order of decreasing dominance.

excessively during the winter, and many of the areas show heavy overuse. The bighorn graze down from the Moenkopi and Shinarump formations during the day but rarely bed down for the night in this habitat type. This area receives some of its heaviest use during the summer days when the sheep move from the mesas to the canyons to water. The talus slopes under the Moenkopi Formation are extremely steep and rough and afford

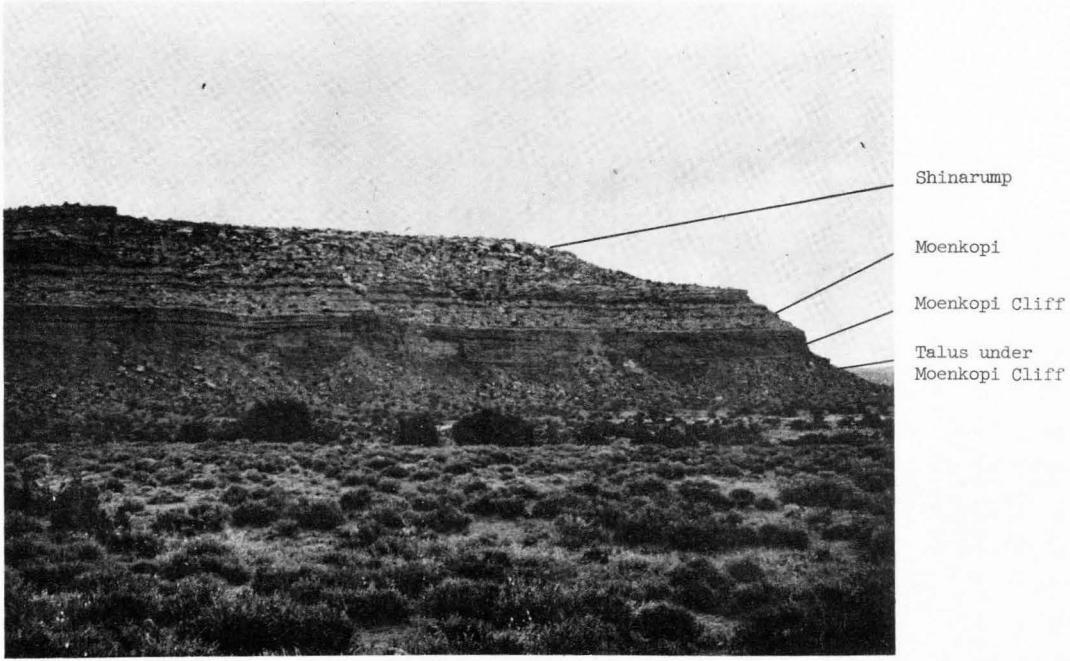

Figure 20. Talus under the Moenkopi, Moenkopi and Chinle habitat types on the north side of White Canyon.

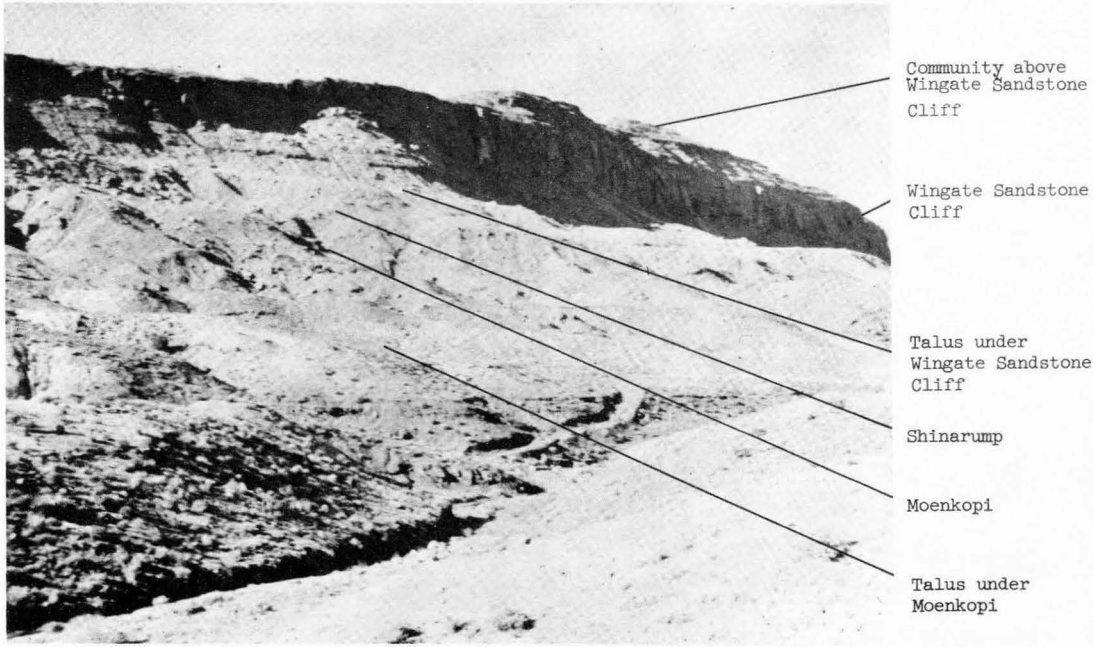

Figure 21. Moenkopi, Chinle and talus under the Wingate Sandstone communities.

excellent escape cover for the bighorn. Rock cover on these slopes is sparse and rarely exceeds 50 per cent of the surface area.

Moenkopi - salina wildrye association. The plant community above the Moenkopi Cliff is easily recognized on the mesas on the north side of White Canyon and on Fry Mesa. The area occupied by this community extends from the top of the Moenkopi Cliff to the base of the Chinle. The soil is derived from shale and sandstone and is dull red in color. The Moenkopi is easily differentiated from the whitish-blue, clay soil of the Chinle. On Found Mesa, Ram Mesa and portions of Fry Mesa, the Chinle has been completely eroded away and this community is the top of the mesa.

Vegetative cover was found to be the most sparse of all the communities sampled, and averaged 69.4 per cent bare ground per 50 square feet. Pinyon pine, and juniper trees are found throughout this community making it extremely difficult to sight bighorn sheep. Bighorns commonly bed on the rims above the Moenkopi Cliff in this community. The bighorns utilize this community more than any other during the spring, summer, and fall. It is in this community that many of the ewes have their lambs in the spring.

Galleta grass is the most common grass found on the south and east facing slopes, and salina wildrye on the north and west facing slopes. Throughout the entire community Ephedra viridis, snakeweed and blackbrush are commonly found in association with the pinyon and juniper trees. Other plants commonly found in this community are: roundleaf buffaloberry, singleleaf ash, squawbush, corymbed (Eriogonum corymbosum), shadscale, cliffrose and rabbitbrush.

As the mesas on the north side of White Canyon extend to the northeast, the pinyon and juniper trees become increasingly dense with a corresponding rise in elevation. This is easily observed on Jacob's Chair Mesa. And as the junipers and pinyons increase, the amount of bighorn sheep utilization decreases. Rams on the north side of White Canyon tend to utilize the east end of dense pinyon-juniper areas at the base of the Abajo Mountains.

The large deer herds that summer in the Abajo Mountains migrate to this habitat and the Shinarump during the winter. Over utilization of this plant community by deer is excessive and many of the shrubs such as cliffrose, longflower snowberry, Ephedra viridis, roundleaf buffaloberry and blackbrush are dying from excessive overuse. I believe that the majority of the bighorn sheep move to the canyons during the winter because of the excessive competition for forage brought about by the deer during the winter.

Table 22 in the appendix gives the detailed information about this plant community.

Chinle - Utah juniper/salina wildrye/galleta association. The Chinle community is small in total surface area compared to the Moenkopi and rests directly above the Moenkopi. The soil is a blue gray clay, and in many areas has an exposed white sandstone rim which is known as the Shinarump. In many locations the Shinarump has eroded away leaving enormous white sandstone boulders strewn across the ground.

The Chinle is relatively flat on top and has dense stands of pinyon and juniper. The pinyon and juniper trees are more dense in this community than in the Moenkopi community below it, averaging 3.7 trees per 50 square feet with densities as high as 10 trees per 50 square

feet. In many areas big sagebrush (Artemisia tridentata) can be found growing in close association with the pinyon and junipers on the level portions on top of some of the mesas. The sagebrush plants rarely exceed a height of two feet.

On the south facing and east facing slopes the ground cover by plants is approximately 25 per cent less than on the north and west facing slopes. Galleta grass and Indian ricegrass are abundant on the south and east facing slopes with an average ground cover of 3.7 per cent. Salina wildrye and galleta grass form dense mats on many ranges on the north and western slopes.

Other plants distributed throughout the Chinle community are: Ephedra viridis, roundleaf buffaloberry, snakeweed, blackbrush, shadscale, cliff-rose and pingue actinea (Table 23).

Bighorn sheep use the Chinle community a great deal, but not to the extent that they use the Moenkopi, as the total surface area is small in proportion to the Moenkopi and the pinyon and juniper cover is heavier.

Deer damage is excessive to the vegetation on the north side of White Canyon. Some deer stay permanently on Fry Mesa but not in large numbers and the vegetation shows little overuse.

The south side of White Canyon west of Fry Mesa is excellent bighorn sheep habitat but varies greatly in mesa formation. The same geological formations, talus slopes under the Moenkopi, Moenkopi, and Chinle are all present, but two more geological formations are present above the Chinle: talus slopes under the Wingate Sandstone, and the area above the Wingate Sandstone. Due to the presence of the Wingate Sandstone Cliff, plus the increase in elevation, slope exposure on the talus slope under the Wingate has distinct plant communities.

The following five habitat types are located on the south side of White Canyon, west of Fry Canyon, and extending as far south as the bottom of Red Canyon to Lake Powell (Figure 21).

Moenkopi - shadscale/galleta association. The south side of White Canyon differs in topography from the north side. Only the north slope of Wingate Mesa has a well developed talus slope under the Moenkopi Cliff. The north Moenkopi talus is never or rarely used by bighorn sheep because it is adjacent to Utah Highway 95.

The Moenkopi - shadscale, galleta grass community reaches its maximum development in the bottom of Blue Canyon, Rainbow Canyon, Wilson Canyon, Mahon Canyon, Blue Notch Canyon, Scorup Canyon and the mouth of Hidden Valley where soil derived from shale and the sandstone of the Moenkopi Formation is visible.

Plant cover in this habitat type is sparse but averaged seven per cent more ground cover than the Moenkopi community on the north side of White Canyon and Fry Mesa. The most common plants are: galleta grass, shadscale, ephedra mostly Ephedra nevadensis, bud sagebrush (Artemisia spinescens), blackbrush, summercypress (Kochia sp.), snakeweed and four-wing saltbush (Atriplex canescens). In many areas stands of desert needle-grass are common, but the desert needlegrass does not play an important role in the vegetative composition of the entire community.

During the spring some of the common forbs found growing in this community are: weakstem mariposa (Calochortus flexuosus), phacelia (Phacelia crenulata), and aster. Many of the dead flower stems could still be recognized in this community in the late summer.

Bighorn sheep use this community little during the spring, summer and fall, but utilize this community most during the winter. Snow cover

during the winter remains only a day or two in this community and ample forage is always readily available. The blackbrush in Blue Notch Canyon and portions of the other canyons that drain south into Red Canyon show some hedging by bighorn sheep in the winter, but the plants are healthy and do not show signs of overuse (Table 24).

Table 23 gives the quantitative and qualitative data for this community.

Shinarump - blackbrush/galleta association. On the south side of White Canyon the lower portion of the Chinle Formation is rimed by Shinarump. The soil below the Shinarump to the dull red Moenkopi Formation and upward to the talus slopes of the Wingate is a dark gray clay. The ground surface is dotted with gray and black sandstone rocks. Although small in total surface area this community is important to the lambs and ewes throughout the year and is an important wintering area.

Like the Moenkopi Formation below it, the Shinarump Formation has few or no juniper or pinyon pine. Blackbrush is the most conspicuous plant in this community and averages a little more than four per cent of the ground cover. Galleta grass is the most abundant plant and averages more than 20 per cent of the ground cover.

Other plants commonly found in association with blackbrush and galleta grass are: salina wildrye on the west slopes and north facing slopes, shadscale, ephedra, bud sagebrush, cheatgrass, snakeweed and prickly pear cactus (Opuntia sp.).

In the spring, five forbs that are commonly seen in this formation are: sego-lily (Calochortus nuttallii), tuffed evening primrose (Oenothera caespitosa), Douglas chaenactis (Chaenactis douglasii), phacelia (Phacelia corrugata) and heartleaf twistflower (Streptanthus cordatus).

After a steep rise from the Moenkopi Formation the main portion of the Shinarump community is a broad, gently rolling plain that slopes slightly upward toward the talus slopes under the Wingate Sandstone Cliff. This broad plain reaches its maximum development in Piute and Blue Canyons.

Ewes, small two to three year old rams, and yearling bighorn sheep were commonly sighted in this community prior to the lambing season in late March and April. Although it was difficult to determine, it appeared that the bighorn sheep were feeding on the new growth of cheatgrass and galleta grass. These two grasses become green in the spring earlier than in any of the other communities, probably from the water holding capacity of the clay soils, and because the soils warm up more readily because of their dark color.

After the lambs are born on the talus slopes under the Wingate adjacent to the Shinarump - blackbrush, galleta grass community, the ewes and lambs are commonly seen utilizing this community throughout the summer and winter.

Although the Shinarump community receives year around use from bighorn sheep, there are no signs of over utilization at this time.

Table 25 gives the quadrat data obtained from this community type.

North Wingate talus slope - salina wildrye association. This community is the least used by the bighorn sheep on the north side of White Canyon. It rises between a 20 and 40 per cent slope to the Wingate Sandstone cliffs above the Shinarump - galleta grass, blackbrush habitat type. The dominant plant is salina wildrye which forms continuous mats in many areas with little bare ground void of vascular plants. Growing in association with salina wildrye is Nevada bluegrass. Unlike the Moenkopi and Shinarump habitat types, the north facing talus

slope has a moderate density of pinyon and juniper trees which averaged 1.7 trees per 50 square feet. As Wingate Mesa extends from east to west the trees become less dense until few or no trees are present just above Lake Powell.

Blackbrush forms a border on the lower portion of the north facing talus slope under the Wingate Sandstone, but decreases in abundance as one progresses up the slope.

Galleta grass reaches its maximum growth in the sandy loam soil of this community. Other plants found throughout the north talus community are: snakeweed, shadscale, ephedra, Indian ricegrass, roundleaf buffaloberry, singleleaf ash and squawbush (Table 26).

No bighorn sheep sightings have been reported during the summer months on the north talus slope below the Wingate Sandstone on Wingate Mesa above Utah Highway 95, but few sightings have been reported by local residents during the winter. Bighorn sheep were never sighted by the researcher in this area during the course of the study. Snow remains on the eastern end of Wingate Mesa on the northern talus slope for several days after a storm. Temperatures on the north facing talus are always cooler here than in any other plant association.

The only other area of importance which has a well developed north facing talus-salina wildrye community is in Hidden Valley. Bighorn sheep were sighted on only three occasions in this area in 1965 and 1966, but evidence of bighorn sheep utilizing the area more than what was observed was always present.

South Wingate talus slope - galleta association. The south facing talus slope under the Wingate Sandstone Cliff is one of the most important habitat types utilized by ewes and lambs. These southern rocky exposed

slopes are extremely rough to negotiate. An average of 62.6 per cent bare ground per 50 square feet was found on the southern exposure. Most of the bare ground is primarily made up of sandstone rocks which have eroded away from the Wingate Sandstone Cliffs above. The rocks plus the steepness of the south facing talus slopes make excellent escape cover for the ewes and lambs while providing the maximum amount of protection at all times. Galleta grass and blackbrush are the two most important foods of the bighorn and are in ample abundance in this community.

Plants most abundant in this community besides galleta grass and blackbrush are: cheatgrass, Indian ricegrass, ephedra, shadscale, dalea (Dalea sp.) globemallow (Sphaeralcea sp.), locoweed and rabbitbrush (Table 26).

The south facing talus slopes have large exposed areas of bentonite clay where few or no plants grow. The bentonite areas are extremely dangerous for man to traverse but create no travel problems for the bighorn sheep.

The south facing talus slopes rarely have snow cover for more than a few days and offer excellent forage availability to the bighorn during the winter. This community receives year long use from the bighorn sheep population; the utilization is heavy in the summer. There is no indication of over grazing in this community at this time.

East Wingate talus slope - shadscale, galleta association. This is the most important community for ewes and lambs on the south side of White Canyon. The majority of the lambing areas are located on the east facing talus slopes. These slopes are the most difficult to negotiate and are extremely steep, averaging about a 30 per cent slope. Rock cover

is at a maximum as compared to all other communities below the Wingate Sandstone Cliff. Rocky areas are especially important to bighorns for escape cover as seen in Figure 22.

The east facing talus slopes are the warmest compared to all other communities, and the high ground temperatures are reflected by the majority of the major plant species. Many small areas have dense stands of Indian ricegrass which is one of the dominant species in the community. The most dominant plant is galleta grass and shadscale is the next most abundant plant. Cheatgrass, Ephedra sp. (mostly Ephedra nevadensis), locoweed, blackbrush, globemallow and phacelia are plants which are major species in this community (Table 28).

Pinyon pine does not grow on the east facing talus slopes. Utah juniper was found to average only 0.08 plants per 50 square feet.

The east facing talus slopes under the Wingate Sandstone are utilized from winter to mid-summer by the bighorn sheep. During the excessively hot period in mid-summer the bighorn utilization is not as great as at other times of the year.

Erosion is extremely high in this plant community because of sandy soils and slope exposure. Large areas of bentonite clay are visible throughout the association with few or no plants growing in the clay. Although the bighorns utilize this community throughout the year, the vegetation does not show any overuse.

West Wingate talus slope - salina wildrye/galleta association. The west facing talus slopes do not receive as heavy bighorn sheep utilization as do the east and south facing talus slopes under the Wingate Sandstone Formation. Galleta grass, salina wildrye, Indian ricegrass and Nevada bluegrass grow profusely in this community. The bare ground

averaged 40.6 per cent, the lowest of all communities sampled. Rock cover is sparse and affords little escape cover. Many of the east facing talus slopes have deep ravines and gulleys with hidden pockets, making bighorn sheep difficult to find. During the late fall and winter this community is utilized considerably by rams.

Like all the talus slopes, but more so in the east and north facing talus slopes, the lower border of the community is bordered by blackbrush, shadscale, cheatgrass, snakeweed, globemallow, Ephedra sp., dalea, Ephedra viridis and singleleaf ash. All these species are important and are found in high abundance in this community.

Pinyon and juniper trees are more abundant on the west facing talus slopes under the Wingate Sandstone than on the east and south, averaging 0.4 trees per 50 square feet. As the Wingate Mesa progresses from east to west, a corresponding decrease in elevation exists, and the number of pinyon and juniper trees decreases.

The data obtained from quadrats for this community is listed on Table 29.

Wingate Mesa - blackbrush/galleta association. The area above the Wingate Sandstone is the summer home for the majority of the adult rams on the south side of White Canyon. The area is a series of high rims and buttes, and affords the maximum amount of protection for the desert bighorn. Rock cover is at a maximum and averages more than 50 per cent of the surface area. Blue Canyon, Piute Canyon, Rainbow Canyon, Wilson Canyon, Mahon Canyon and Hidden Valley all have their origin on top of Wingate Mesa and are easily recognized by deep rocky gorges bisecting the mesa.

The eastern portion of Wingate Mesa is densely timbered by pinyon pine and Utah juniper with densities as high as 12 trees per 50 square feet. Big sagebrush and prickly pear cactus are the most common plants found under the trees.

The trees thin out as the mesa progresses to the west to almost zero ground cover on the southwest end of Wingate Mesa. The bighorn sheep utilization increases proportionally with the decrease in pinyon and juniper trees; and as the trees decrease in plant cover, blackbrush and galleta grass increase in plant cover. On the most eastern arm of Wingate Mesa from directly above Fry Canyon, Utah, south into Red Canyon, bighorn sheep were not sighted in 1965 and 1966, and little bighorn sheep sign was noted. There is a small deer herd that utilizes the eastern portion of the mesa past the head of Rainbow Canyon. Bighorn sheep were not sighted east of the origin of Blue Canyon but they occasionally moved into this area for a day or two as seen from their tracks.

The vegetation on top of Wingate Mesa was sampled in proportion to bighorn sheep use. A typical view is shown in Figure 23. Besides blackbrush, galleta grass, pinyon pine and Utah juniper, snakeweed, ephedra, Indian ricegrass, desert needlegrass, salina wildrye, roundleaf buffaloberry, Happlopappus sp., cryptantha (Cryptantha sp.), and Ephedra viridis are some of the more common plants found (Table 30). In many localities on top of Wingate Mesa, especially on the western portion of the mesa in loose sandy soil, large stands of blackbrush and Indian ricegrass make up a distinct vegetational pattern. Some of the blackbrush, Indian ricegrass areas are several acres in size.

Bighorn sheep utilize the blackbrush, galleta grass community with the heaviest utilization in the spring, summer and fall. Many of the

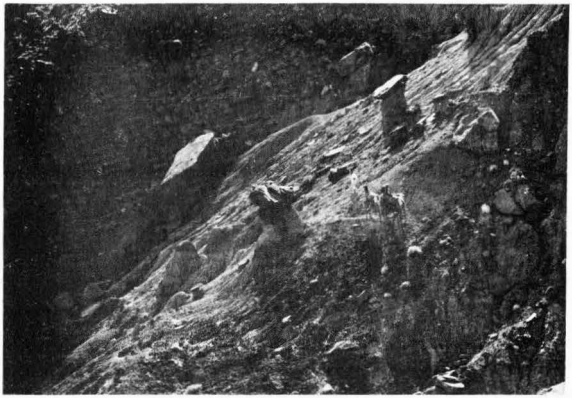

Figure 22. Bighorn sheep on a typical east facing talus slope under the Wingate Sandstone Cliff in Piute Canyon.

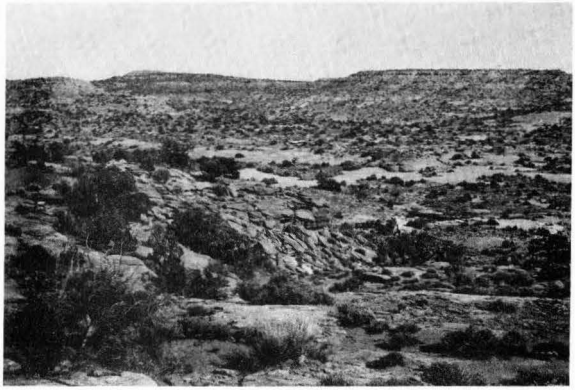

Figure 23. Community above the Wingate Sandstone Cliff on Wingate Mesa.

blackbrush plants on top of Wingate Mesa are moderately hedged from bighorn sheep use, but no signs of overuse are apparent. Many of these areas are adjacent to waterholes,and proper water distribution would relieve much of the grazing pressure in the present heavily used areas.

Discussion of plant communities

The plant communities utilized by the desert bighorn are climax plant communities. On the level plain below the mesas and above the canyons north of Wingate Mesa, blackbrush, snakeweed and Utah juniper are increasing because of past heavy overuse by cattle and horses. Many of the grasses such as galleta grass, Indian ricegrass, bottlebush, squirreltail (Sitanion hystrix), alkali sacaton (Sporobolus airoides), porcupine grass (Stipa comata), and blue gramma (Bouteloua gracilis) have decreased in abundance or completely disappeared in many areas. Signs of overuse are apparent on the ranges utilized by the bighorn sheep on the Chinle and Moenkopi communities on the north side of White Canyon where blackbrush, shadscale and snakeweed are increasing. Most of the overuse in these two communities is being brought about by heavy deer use during the winter.

Table 17 shows the distribution of the various plants found in all the communities. Many of the less abundant plants are restricted to only a few communities depending on soil or slope exposure.

All the plants collected throughout the White Canyon area are listed in Table 31.

Each time bighorn sheep were sighted a statistical data sheet was filled out. Data pertaining to slope exposure, plant community elevation, rock cover and various other information were recorded at the time the sighting was made. A direct correlation between the amount of rock cover,

Table 17. Average per cent ground cover for plant species in the various plant communities in the White Canyon study area, San Juan County, Utah

Plant species	Talus slope under Moenkopi	Moenkopi	Chinle	Moenkopi, galleta grass, shadscale	Shinarump, galleta grass, blackbrush	North talus slope salina wildrye	South talus slope, galleta grass	East talus slope, galleta grass, shadscale	West talus slope, galleta grass, salina wildrye	Top of Wingate, galleta grass, blackbrush
	Plant Communities									
	Average per cent ground cover									
Hilaria jamesii	4.0	1.5	3.5	6.9	20.2	6.9	13.6	10.3	14.6	9.9
Elymus salina	3.4	5.9	5.7		4.1	22.4	0.9		13.1	1.2
Cowania mexicana	3.0	0.4	0.6		0.3					0.3
Ephedra viridis	2.7	2.3	2.2			1.1	0.2	0.5	0.9	0.6
Rhus trilobata	2.5	1.3		0.3		0.7	t[a]		0.5	0.2
Gutierrezia sp.	2.5	2.8	1.9	0.7	0.7	1.4	0.5	0.1	1.8	1.9
Coleogyne ramosissima	2.1	1.5	1.7	1.2	4.1	3.2	3.0	1.1	0.5	8.9
Juniperus ostiosperma	2.1	3.5	6.5			2.3	0.2	0.1	0.2	1.3
Fraxinus anomala	1.8	1.1		0.1		0.8			0.7	
Oryzopsis hymenoides	1.4	0.1	0.2	0.1	0.3	1.0	3.7	1.7	4.0	1.4
Stipa speciosa	1.2	0.1	0.6	0.2			0.2	0.4	0.5	1.4
Stanleya pinnata	0.9	0.1	t[a]						0.1	
Atriplex confertifolia	0.7	0.4	1.0	3.3	2.7	1.1	2.3	4.3	3.3	
Hymenoxys richardsonii	0.6	0.1	0.5		0.2		0.3			0.2
Pinus edulis	0.5	0.8	1.2			0.3			t[a]	2.7
Chrysothamnus sp.	0.4	0.3	0.2	0.5	0.2	0.2	0.7	0.5	0.4	0.2
Haploppapus sp.	0.4	0.1	0.2							0.7
Cryptantha sp.	0.4	0.2	0.4	0.1		t[a]	t[a]			0.7
Bromus tectorum	0.3		t[a]	0.7	1.2	0.4	4.2	3.3	2.0	0.5
Sphaeralcea sp.	0.3					0.2	1.2	0.8	1.3	
Stephanomeria pauciflora	0.3							0.2		

Table 17. Continued

Plant Species	Talus slope under Moenkopi	Moenkopi	Chinle	Moenkopi, galleta grass, shadscale	Shinarump, galleta grass, blackbrush	North talus slope salina wildrye	South talus slope galleta grass	East talus slope, galleta grass, shadscale	West talus slope, galleta grass, salina wildrye	Top of Wingate, galleta grass, blackbrush
	Plant communities									
	Average per cent ground cover									
Symphoricarpos longiflorus	0.2	0.1	0.2			0.2			0.2	0.4
Shepherdia rotundifolia	0.1	1.0	2.1			0.9	t[a]		0.1	1.1
Eriogonum corymbosum	0.1	0.6				0.4				
Berberis fremontii	0.1									
Euphorbia fendleri	0.1	0.1	t[a]							
Asclepias capricorna	0.1									
Mentzelia sp.	0.1									
Eriogonum sp.	0.1	t[a]	t[a]		0.1		t[a]	0.1	0.1	
Leptodactylon pungens	0.1		0.2							
Physaria chambersii	t[a]	t[a]	0.3							0.1
Aster venustus	t[a]		t[a]	0.4		0.3	0.1	0.1	0.2	
Penstemon sp.	t[a]	t[a]				t[a]	t[a]			0.1
Astragalus sp.	t[a]	t[a]	t[a]	0.1	0.1	0.1	0.1	1.2	0.3	0.2
Brichellia scabra	t[a]									
Cirsium sp.	t[a]						t[a]			
Opuntia sp.	t[a]		0.2	0.3	0.5	0.2	0.7	0.2	0.6	0.2
Ephedra sp.		0.5	1.9	2.3	2.5	0.6	2.4	1.6	1.2	1.6
Eurotia lanata		0.1								
Amelanchier utahensis		0.1								
Kochia sp.		t[a]	0.1	1.2	0.1	0.2		0.1		

Table 17. Continued

Plant species	Talus slope under Moenkopi	Moenkopi	Chinle	Moenkopi, galleta grass, shadscale	Shinarump, galleta grass, blackbrush	North talus slope, salina wildrye	South talus slope, galleta grass	East talus slope, galleta grass, salina wildrye	West talus slope, galleta grass, salina wildrye	Top of Wingate, galleta grass, blackbrush
	Plant communities									
	Average per cent ground cover									
Artemisia tridentata			1.2							1.7
Phlox hoodii			0.1							
Lupinus sp.			0.1							
Lepidium fremontii			t[a]							
Erigeron pumilis			t[a]							
Erigeron sp.			t[a]			0.1				
Opuntia rhodantha			t[a]							0.4
Mirabilis froebelii			t[a]							2.0
Artemisia spinescens				1.3	1.2				0.1	
Phacelia corrugata				0.7	0.2			0.7		
Atriplex canescens				0.3	0.2		t[a]	t[a]	0.1	
Dalea sp.				0.3	0.1	0.5	1.2	0.2	0.9	
Eriogonum inflatum				0.3	0.2		0.3	0.5	t[a]	
Plantago purshii				0.2	t[a]			t[a]		
Abronia sp.				0.1			0.1			0.4
Eriogonum mirothecum				0.1		t[a]	t[a]			0.2
Artemisia biglovii				t[a]			0.1			0.1
Atriplex cuneata				t[a]			0.5	1.0	0.1	

Table 17. Continued

	Plant communities										
	Talus slope under Moenkopi	Moenkopi	Chinle	Moenkopi, galleta grass, shadscale	Shinarump, galleta grass, blackbrush	North talus slope, salina wildrye	South talus slope, galleta grass	East talus slope, galleta grass, salina wildrye	West talus slope, galleta grass, salina wildrye	Top of Wingate, galleta grass, blackbrush
	Average per cent ground cover									
Lycium sp.				t[a]	0.1				0.1	
Arenaria sp.				t[a]	0.1		t[a]	0.4		
Calochortus sp.				t[a]	0.1					
Coldenia hispidissima					0.3		0.4	0.3	0.1	
Atriples nuttallii					0.1		0.1			
Eriogonum wetherilli					0.1		0.1	t[a]		
Ferocactus covillii					t[a]		t[a]			0.1
Poa nevadensis						0.9		0.2	0.7	
Yucca navajoa							0.3	0.1	0.1	0.2
Townsendia scapigeria							0.1			
Sitanion hystrix							0.1	0.2		
Brickella sp.							0.1			
Berberis sp.										0.2
Atriplex sp.										0.2
Asclepias latifolia										0.2
Penstemon fremontii										t[a]
Frasera paniculata										0.1
Lepidium sp.										0.1

[a] t = value of less than 0.1 per cent

and plant community, and bighorn sheep use was found at the 99 per cent significance level. As the rock cover increased from zero to 100 per cent, the probability of sighting desert bighorn sheep in the White Canyon area increased proportionally. Approximately 81 per cent of the sightings were made on areas where the rock cover varied between 71 and 100 per cent. A positive correlation was also found with slope exposure and plant community with reference to bighorn sheep use at the 99 per cent confidence level. Sixty-nine per cent of the sightings were made on south and west facing slopes which always have the greatest per cent rock cover while 20 per cent of the sightings were made on east facing slopes, seven per cent on flat areas and three per cent on north facing slopes.

A direct correlation was found, at the 99 per cent confidence level, between the sexes of the bighorn sheep and the communities utilized by the sheep. The adult rams tend to utilize the higher, more remote areas of the White Canyon area while the ewes and lambs, plus the immature rams one to three years old, tend to utilize the steep talus slopes under the Wingate Formation on the south side of White Canyon. The lower mesas and canyons on the north side of White Canyon are used by the ewes, lambs and small immature rams. On the south side of White Canyon, during the spring and summer, 75 per cent of all the ewes, lambs and young rams sighted were on the Chinle Formation which includes the talus slopes under the Wingate. Sixteen per cent of all the ewes, lambs and small rams sighted were on the Moenkopi Formation and nine per cent were made above the Wingate Sandstone Formation. Adult rams were sighted 85 per cent of the time above the Wingate Sandstone Cliff and 15 per cent on the Chinle below the Wingate Formation.

On the north side of White Canyon adult rams three years or older were not sighted with the ewes and lambs except during the rut, and they tended to remain in the canyons and on the mesas directly south of the Abajo Mountains during the summer.

CONCLUSIONS AND RECOMMENDATIONS

Classification and investigation of other bighorn sheep areas

There is little doubt that the desert bighorn sheep in southeastern Utah is Ovis canadensis nelsoni. Its value as a big game trophy is unsurpassed in North America and its aesthetic value because of its rarity is immeasurable. All possible steps to insure the welfare of these animals should be immediately undertaken.

There are seven areas in southeastern and east central Utah that are known to have remnant bands of bighorn sheep. These areas should be investigated as soon as possible to determine the area utilized by these populations, the number of bighorn sheep present; and possible management recommendations should be forthcoming to insure the success of these populations. Desert bighorn sheep transplants should not be made until the other seven areas have been investigated (Figure 5).

Censusing

The censusing technique used to obtain the estimate of 124 to 144 bighorn sheep in the White Canyon area was not refined because of the rugged terrain. A total of 103 bighorn sheep were encountered during the census, with no known duplication. This figure can be used as the minimum number known to inhabit the area. Lambs were not counted in the census.

Future census should be done by helicopter flights to insure adequate coverage of the area, eliminate duplicate counting of bighorns, and decrease the time of the census. Counts should be made in mid-July

as the new lamb-ewe and yearling-ewe ratio could be obtained. The number of harvestable rams could also be determined if hunting is to be used as a management tool.

Lamb survival

Although it has not been completely documented at this time, there is some indication that the desert bighorn ewes in the White Canyon area return yearly to the same locations to have their lambs. All of the known lambing grounds in the White Canyon area are located in the roughest terrain which affords a ewe and lamb the maximum amount of protection from storms, predators and man.

With the completion of the new concession at Castle Butte on the shores of Lake Powell, I believe that the lambing ground located north and adjacent to Castle Butte will be abandoned by bighorn ewes. Retaining a wilderness habitat is one of the main factors necessary to maintain a bighorn sheep population.

Approximately 49 per cent of the lambs died from mid-July, 1965, until mid-July, 1966. During the five month period from July 15, 1966, to November 15, 1966, approximately 30 per cent of the lambs died. High lamb mortality is not uncommon in desert bighorn sheep populations but I believe that many of the decimating factors operating on the lambs can be curtailed.

One factor that could play a major role in lamb survival is the proper distribution of available water. Many of the ranges adjacent to the present natural waterholes are becoming over utilized because the bighorns are restricted to these areas during long periods of drought. With proper water development the ewes would be able to utilize more range and would be able to better fulfill their water requirements.

By keeping the ewes on a high nutritional level and eliminating the stress of dehydration, lambs would be born in a better nutritional state and would be healthier. Figure 24 shows the bighorn sheep distribution in the White Canyon area. It is apparent that approximately one-third of the range is being utilized because of the lack of available water.

From the large quantities of clay seen eaten and found in fecal samples, there appears to be a nutritional deficiency in the bighorn sheep in the White Canyon area. An immediate investigation should be undertaken to determine what nutrient(s) are lacking in the bighorns' diet.

It appears that bighorn lambs are highly susceptible to pneumonia, and sick lambs were sighted on several occasions. A ewe killed for a necropsy had a heavy infestation of Beta streptococcus and had suffered a severe case of pneumonia. Beta streptococcus is a bacteria which can cause bronchial pneumonia and reaches high infection in animals in a poor nutritional state.

A salting block experiment should be undertaken to determine if the bighorns favor some type of salt in preference to others. Moorman's Mintrate salt fed to transplanted desert bighorns in Texas has received large amounts of use. Fifteen bighorns in Texas are presently eating 50 to 60 pounds of the salt monthly, and 100 percent lambing success has been obtained (Hailey, 1966 personal communication). Sodium salt was tried in the White Canyon area but there was no evidence that the bighorns used it.

Predation could be a factor in lamb survival. Bighorn sheep remains were found in 9.1 per cent of the 110 predator scats colleded from

Figure 24. Summer distribution of the desert bighorn sheep in the White Canyon area, San Juan County, Utah.

bobcats and coyotes. This is the highest percentage of bighorn sheep remains found in any bighorn sheep study. On almost all desert bighorn sheep ranges, a yearly predator control program is continually carried on. With the high density of coyotes and bobcats presently in the White Canyon area, a predator control program should be initiated.

Rut, longevity, and excessive rams

The rut of the desert bighorn sheep in southeastern Utah begins in the latter part of October and probably persists into January. The gestation period of desert bighorn ewes is approximately 174 days and lambs are born from the first week in May through the first week in July. A great deal more data should be obtained on the rut to gain a better understanding of the breeding activities of the sheep and the effects of excessive numbers of rams.

Three yearling ewes easily recognized in 1965 were known to have lambs in the spring of 1966. No previous observations of yearling rams breeding have been noted in any other population, but it is my belief that yearling rams are physiologically capable of breeding, but because of their smaller size they rarely make an attempt to do so.

The ram-ewe ratio is approximately 50-50 which is what is to be expected in a relatively unhunted population of bighorn sheep.

Many researchers believe that excessive rams can be detrimental to the reproductive success of the ewes, and a higher reproductive success results following the harvest of excessive old rams. Old rams could be harvested from the herd in the White Canyon area. As a management tool for the bighorn sheep, only mature rams over eight years of age should be harvested. The age limit of eight years of age or older

ram has been successfully used in Nevada. This does not necessarily mean the taking of a three-quarter curl ram or larger. Many rams over eight years of age do not have a three-quarter curl because of excessive brooming of the horns. Figure 25 shows an old ram with less than a three-quarter curl.

Water and bighorns

The daily activity of the bighorn sheep in the White Canyon area centers primarily around the availability of water. Ewes nursing lambs went to water daily when water was available within a mile. Ewes and lambs were sighted in extremely poor condition and badly dehydrated when water was not available.

In 1966, no measurable moisture fell in the White Canyon area from March 29 until July 29. Two large canyons with ample forage were not utilized by the sheep because the waterholes dried up. Both canyons carried between 7 and 15 bighorn sheep during the summer of 1965.

Water is not only important to the bighorns during the summer but can become a critical factor at other times of the year following periods of drought. Water is the most important bighorn sheep development necessary to sustain a large population of bighorns in the White Canyon area. Not only will water help the bighorns obtain a drink when needed, but proper water development may allow the bighorns use of ranges which have received little use in the past.

Water development on the mesas on the north side of White Canyon will help to keep the bighorns on the mesas in their natural habitat for longer periods of time. This will greatly reduce the probability of death by injury or predation because predators are much more abundant on the canyon rims.

Figure 25. Desert bighorn ram over eight years old with less than three-quarter curl horns. Notice how badly they are broomed. Picture taken November 14, 1966.

Feeding habits and nutrition

The grazing habits of the present herds of desert bighorn sheep are not detrimental to the range. The bighorns eat only a few bites from each plant and are continually moving while they are feeding. The sheep will stop and feed for longer periods of time on browse species, but the tips of branches and leaves on the exterior portion of the shrub are all that is eaten. All of the habitat types occupied by bighorn sheep where cattle and deer are not found, show no over utilization at this time.

The bighorn sheep in the White Canyon area have a wide variety of food preferences. The year long, number one, food preference is blackbrush. The most important grass species during the summer is galleta grass.

More data is needed on food preferences during the winter months. With the data available on food preferences in the spring and summer from this study and with ample data on late fall and winter food preferences, a chemical analysis of the various food plants and soils would be possible. Soil analysis of the clay which the bighorns have been eating should be made. Possible steps to correct the deficiency would be possible, putting the bighorn on a better nutritional status and greatly lowering the susceptibility of the sheep to heavy infestations of parasites and disease.

Bighorns and competition

The main competitor for water and forage of the bighorn sheep in the White Canyon area is the mule deer, as both species utilize the same browse plants. A small deer population stays on the east and southeast portion of Wingate Mesa and migrates to the summer range occupied by the

bighorn rams on the Mesa. Many areas are becoming badly depleted from the heavy utilization of the major shrub species such as blackbrush, singleleaf ash, longleaf snowberry and cliffrose.

The Bureau of Land Management and the Utah Department of Fish and Game are jointly proposing to eradicate a large portion of the pinyon and juniper tract on the south and east portions of Wingate Mesa. Once the pinyon and juniper tracts are eradicated, the areas are to be reseeded to grass and browse species for the bighorn sheep. These reseedings should greatly relieve some of the areas receiving heavy utilization on Wingate Mesa. A close check on deer numbers should be kept in this area, as a substantial deer population is presently in this locality. If the deer are allowed to increase, the objective of the reseeding will be lost as excessive deer numbers in this area would reduce the utilization by bighorn sheep.

The dead trees and shrubs, when eradicated, should be burned, because bighorns are primarily found in areas which command a view of the surrounding terrain. Once the bighorn sheep population has increased to the carrying capacity of the range, this newly created habitat will become a very important factor in the number of bighorn sheep the White Canyon area can support.

On the north side of White Canyon, many of the deer that summer on the Abajo Mountains migrate to the mesas and canyons during the winter. Many of the browse species on the mesas on the north side of White Canyon are dead or dying from past overuse. An investigation should be undertaken to determine how deer numbers in the desert area could be reduced without affecting the productivity of the entire deer population in San Juan County.

Cattle do not compete for forage and water with bighorns as much as deer. The talus slopes under the Moenkopi Cliff on the mesas on the north side of White Canyon are the primary areas of competition of cattle and bighorns.

On the south side of White Canyon, the main competition between cattle and bighorns is in Red Canyon. Approximately 40 cattle remained in Red Canyon for the two years of this study. The bottom of Red Canyon west to Warm Spring is badly over-grazed by cattle. No bighorns were sighted in Red Canyon east of Warm Spring. Bighorn sheep were, however, commonly sighted west of Warm Spring in Red Canyon. Because of the deterioration of the range occupied by cattle in Red Canyon, all livestock grazing should be eliminated for the present until the range can again support livestock. Red Canyon is not cattle range, and with the removal of the cattle I believe bighorns would begin utilizing much of the area not now utilized by bighorns, cattle or deer at this time. Cattle or deer are not found on most of the steep rough areas of upper Red Canyon which is prime habitat to bighorns.

Bighorn sheep were not sighted in the range now occupied by feral goats. Historically this was once known as bighorn sheep range.

Protection

There is little evidence of the illegal hunting of bighorn sheep at this time.

The amount of uranium ore to be mined in the forthcoming years is expected to be greatly increased in the White Canyon area. Large companies are now exploring for new deposits of uranium ore and many mines not in operation at this time are expected to be reopened by 1970.

With an increase of people, the illegal hunting of bighorns will undoubtedly increase. The future welfare of the bighorn sheep in Utah rests solely with the sporting public.

SUMMARY

In the spring of 1965, the first investigation and research on the native desert bighorn sheep in Utah was initiated. The primary study area was centered around White Canyon, San Juan County, in southeastern Utah.

From records of many of the past explorers, it is apparent that bighorn sheep were found in substantial numbers along the Colorado and Green Rivers in Utah.

The primary reduction in the numbers of bighorn sheep in eastern Utah was principally caused by a loss of wilderness habitat, possible introduction of parasites from domestic livestock, over utilization of bighorn sheep range by domestic livestock and deer, and illegal hunting.

There are eight areas along the Colorado and Green Rivers in Utah in which desert bighorn sheep have been sighted since 1960. Seven of the areas have not been investigated at this time. Reminant populations of bighorn sheep could also be present in other areas of southeastern Utah but are not known because of lack of sightings at this time.

The species of bighorn sheep in southeastern Utah is Ovis canadensis nelsoni. It is believed that the bighorn sheep which are found in the northeastern portion of the state which appear to be Ovis canadensis integrated in prior times with the Ovis canadensis nelsoni in east central Utah.

A population estimate of 124 to 144 mature bighorn sheep excluding lambs was calculated for the study area. This was based on sightings

estimated to be 60 to 80 per cent accurate in the White Canyon study area. In a 34 consecutive day period of walking and jeep driving, 103 bighorn sheep excluding lambs were shown to have been present in the study area, with no possible duplication of numbers.

It is a characteristic of desert bighorn sheep ewes to return yearly to the same area to lamb. Six lambing grounds were found during the course of the study, but more than two years' observation will be necessary to determine if these are established lambing grounds. One of the lambing grounds, approximately one mile north of Castle Butte, will probably be lost to the bighorns when the new concession and paved road are completed at Castle Butte.

Three bighorn sheep yearling ewes in the White Canyon area in 1965 were known to have had lambs in 1966, although lambs six or seven months of age were not observed to breed. Yearling rams, and rams 2- and 3- years of age are believed to be physiologically capable of breeding but fail to do so because of their small size.

By mid-July in 1965 the lamb-ewe ratio was 49-100. Prior to the lambing period in 1966 it appeared that approximately 76 per cent of the ewes were pregnant; however, the number of ewes with lambs by mid-July was 60 per cent. Lamb mortality is high in the White Canyon area. By mid-July 1966, approximately 49 per cent of the lambs from the previous year had died. By mid-November 1966, 30 per cent of the lambs born in the spring of the year were dead.

It is believed that pneumonia is the causative agent for the high lamb loss. The apparent susceptibility to pneumonia could be caused by a mineral deficiency or poor food nutrition in the diet of the bighorns. Poor nutrition could be the result of the small amount of summer range

to which the bighorns are limited because of the scarcity of permanent water. Other factors believed to be of major importance to lamb survival are predators and the lack of available free water.

The gestation period for penned desert bighorn sheep (Ovis canadensis nelsoni) in Nevada was approximately 174 days. This length of time agrees with what was observed in the White Canyon area. The rut starts in the latter part of October and lasts until approximately the first week in January. Lambs are born from the first of May through the first week in July with the greatest number of lambs being born between the middle of May and the first week in June.

The longevity of bighorn sheep is approximately 10 to 12 years of age in the wild (Welles, 1961).

With less than 100 per cent lambing success and low lamb survival, the present population of bighorn sheep is probably static under the existing mortality factors.

The sex ratio of rams to ewes is about 50-50. Many bighorn sheep biologists have proposed the theory that with a 50-50 ram-ewe ratio there is an excess of mature rams, and the excessive number of rams could have an effect on low lambing success.

The main summer movement pattern of the bighorn sheep is mostly associated with water. As long as available surface water is present, the bighorns tend to stay within approximately a two mile radius of waterholes. However, as waterholes dried up bighorns were frequently observed traveling long distances to obtain water.

Although water plays the most important role in the movement of bighorns during the summer, it can also become a critical factor at other periods of the year, especially after long periods of drought.

Competition with deer and cattle is greatest during the late fall and winter months. Competition for forage and water between deer and bighorns is especially critical on the north side of White Canyon, and many areas in this canyon are showing excessive damage.

Seven parasites were collected from fecal samples and were not found in any numbers to be detrimental to the desert bighorn sheep. Predation by the high populations of coyotes and bobcats on desert bighorn sheep appears to be a significant decimating factor. Nine and one-tenth per cent of 110 bobcat and coyote scats contained bighorn sheep remains. This is a high percentage when compared to other bighorn sheep investigations. The bobcat is believed to be the greatest enemy of the bighorn. The bulk of the scats found with bighorn sheep remains were collected from the north side of White Canyon.

An apparent mineral deficiency for bighorn sheep evidently exists in the White Canyon area. High levels of clay in the feces and observations of bighorns eating large quantities of clay were noted throughout the study. Areas from which clay was eaten were all similar in their soil composition and color.

The bighorn sheep range on the north side of White Canyon is in poor condition in many areas, due to over utilization by cattle, deer and bighorn sheep. The bighorn sheep range on the south side of White Canyon is in relatively excellent condition with large areas receiving little or no utilization by cattle, deer or sheep because of the lack of available surface water.

All the plant communities utilized by bighorn sheep in the White Canyon area are climax communities at this time.

Bighorns tend to graze more than they browse; and the year long, number one, food preference is blackbrush. Galleta grass, Indian ricegrass, singleleaf ash, snowberry, ephedra, Russian thistle and fivehook bassia are the most important bighorn sheep foods. Russian thistle and fivehook bassia are only abundant during years of high precipitation.

Recommendations for the management of the desert bighorn sheep in southeastern Utah include continued investigations, waterhole developments, hunting excessive old rams, and predator control.

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APPENDIX

Table 18. Mammals known to inhabit the White Canyon study area, San Juan County, Utah.[a]

Order	Scientific name	Common name
Chiroptera	Myotis yumanensis yumenensis	yuma myotis
	Myotis lucifugus phasma	big myotis
	Myotis evotis evotis	long-eared myotis
	Myotis volans interior	hairy-winged myotis
	Myotis californicus stephensi	California myotis
	Myotis subulatus melanorhinus	small-footed myotis
	Lasionycteris noctivagans	silver-haired bat
	Pipistrellus hesperus hesperus	western pipistrelle
	Eptesicus fuscus pallidus	big brown bat
	Lasiurus borealis teliotis	red bat
	Lasiurus cinereus cinereus	hoary bat
	Crynorhinus rafinesquii pallescens	long-eared bat
	Antrozous pallidus pallidus	pallid bat
	Tadarida mexicana	Mexican free-tailed bat
Lagomorpha	Lepus californicus deserticola	black-tailed jack rabbit
	Lepus californicus texianus	black-tailed jack rabbit
	Sylvilagus nuttallii pinetis	Nuttall cottontail
	Sylvilagus audubonii warreri	Audubon cottontail
Rodentia	Tamiasciurus hudsonicus fremonti	red squirrel
	Cynomys gunnisoni zuniensis	Zuni prairie dog
	Citellus spilosoma cryptospilotus	spotted ground squirrel
	Citellus variegatus grammurus	rock squirrel
	Citellus leucurus cinnamomeus	antelope ground squirrel
	Citellus leucurus escalante	antelope ground squirrel

Table 18. Continued

Order	Scientific name	Common name
Rodentia	Eutamias minimus operarius	least chipmunk
	Eutamias quadrivittatus hopiensis	Say chipmunk
	Sciurus aberti navajo	Aberts squirrel
	Thomomys talpoides darranti	northern pocket gopher
	Thomomys bottae aureus	botta pocket gopher
	Perognathus longemembris arcus	little pocket mouse
	Perognathus flavus hopiensis	silky pocket mouse
	Perognathus apache cargi	Apache pocket mouse
	Perognathus apache apache	Apache pocket mouse
	Dipodomys ordii nexilis	Ord kangaroo rat
	Castor canadensis repentinus	beaver
	Perognathus intermedius coinitus	rock pocket mouse
	Reithrodontomys megalotis megalotis	western harvest mouse
	Reithrodontomys megalotis aztecus	western harvest mouse
	Peromyscus crinitus auripectus	canyon mouse
	Peromyscus maniculatus amoriensis	deer mouse
	Peromyscus maniculatus rufinus	deer mouse
	Peromyscus boylii rowleyi	brush mouse
	Peromyscus truei truei	pinyon mouse
	Onychomys leucogaster melanophrys	northern grasshopper mouse
	Onychomys leucogaster pallescens	northern grasshopper mouse
	Neotoma albigula laplataensis	white-throated wood rat
	Neotoma mexicana inopinata	Mexican wood rat
	Neotoma cinerea acraia	bushy -tailed wood rat
	Microtus longicaudus alticola	long-tailed meadow mouse
	Erethizon dorsatum couesi	porcupine
Carnivora	Canis latrans meamsi	coyote
	Vulpes fulva macrousa	red fox
	Urocyon cinereoargenteus scottii	gray fox

Table 18. Continued

Order	Scientific name	Common name
Carnivora	Bassariscus astutus arizonensis	ring-tailed cat
	Mustela erminea muricus	ermine
	Mustela frenata nevadensis	long-tailed weasel
	Taxidea taxus berlandieri	badger
	Mephitis mephitis estor	striped skunk
	Spilogale gracilis gracilis	spotted skunk
	Lynx refus bailyi	bobcat
	Felis concolor kaibabensis	mountain lion
Artiodactyla	Odocoileus hemionus hemionus	mule deer
	Ovis nelsoni	desert bighorn sheep

[a] (Durrant, 1952, and Woodbury, 1959).

Table 19. Birds known to inhabit the White Canyon study area, San Juan County, Utah.

Scientific name	Common name
Zenaidura macroura	mourning dove
Cathartes aura	turkey vulture
Accipiter cooperii	Cooper hawk
Buteo borealis calurus	western red-tail hawk
Buteo swainsoni	Swainson hawk
Haliaeetus leucocephalus	bald eagle
Buteo regalis	ferruginous rough-legged hawk
Aquila chrysaetos	golden eagle
Falco mexicanus	prairie falcon
Falco peregrinus anatum	peregrine falcon
Falco sparverius	sparrow hawk
Falco columbarius	pigeon hawk
Asio wilsonianus	long-eared owl
Bubo virginianus pallescens	western horned owl
Strix occidentalis lucida nuchalis	spotted owl
Speotyto cunicularia hypogaea	ground owl
Sphyrapicus varius	yellow bellied sapsucker
Cryobatis villosus monticola	Rocky Mountain hairy woodpecker
Colaptes cafer collaris	red shafted flicker
Chordeiles virginianus henryi	western nighthawk
Archilochus alexandri	black-chinned hummingbird
Stellula calliope	calliope hummingbird
Selasphorus platycercus	broad tailed hummingbird
Tyrannus verticalis	western kingbird
Tyrannus vociferans	cassin kingbird
Myiarchus cinerascens	ash-throated flycatcher
Sayornis saya	say phoebe
Contopus borealis	olive-sided flycatcher
Empidonax traillii extimus	Trail's flycatcher
Eremophila alpestris laucolaema	pallid horned lark
Cyanocitta stelleri diademata	long-crested jay
Corvus corax sinuatus	American raven
Aphelocoma coerulescens woodhousei	scrub jay
Nucifraga columbiana	Clark nutcracker
Cyanocephalus cyanocephalus	pinyon jay
Molothrus ater obscurus	cowbird
Icterus bullockii	bullock oriole
Spinus psaltria	Arkansas goldfinch
Spinus tristis pallidus	American goldfinch
Spinus pinus	pine siskin
Amphispiza bilineata deserticola	black-throated sparrow
Passer domesticus	English sparrow
Pooecetes gramineus confinnis	western vesper sparrow
Chondestes grammacus strigatus	western lark sparrow
Zonotrichia leucophrys oriantha	white-crowned sparrow
Zonotrichia leucophrys gambelii	Gambel sparrow

Table 19. Continued

Scientific name	Common name
Melospiza melodia montana	song sparrow
Spizella montricola ochracea	western tree sparrow
Spizella socialis arizonae	western chipping sparrow
Spizella passerina arizonae	chipping sparrow
Spizella breweri breweri	brewer sparrow
Junco hyemalis	slate-colored junco
Junco hyemalis connectens	intermediate junco
Junco oreganus	Oregon junco
Junco mearnsi	pink-sided junco
Junco caniceps	gray-headed junco
Amphispiza bilineata deserticola	desert sparrow
Amphispiza nevadensis	sage sparrow
Melospiza melodia montana	mountain song sparrow
Melospiza lincolnii	Lincoln sparrow
Pipilo erythrophthalmus montanus	towhee
Pipilo maculatus megalonyx	spurred towhee
Chlorura chlorura	green-tailed towhee
Pheucticus melanocephalus melanocephalus	black-headed grosbeak
Guiraca caerulea	blue grosbeak
Piranga ludoviciana	western tanager
Petrochelidon lunifrons	cliff swallow
Tachycineta thalassina lepida	violet-green swallow
Stelgidopteryx serripennis	rough-winged swallow
Lanius ludovicianus excubitorides	white rumped shrike
Vireo solitarius cassinii	solitary vireo
Vireo gilvus swainsoni	western warbling vireo
Vermivora luciae	Lucy warbler
Dendroica petechia morcomi	yellow warbler
Dendroica auduboni	Audubon warbler
Dendroica nigrescens	black-throated gray warbler
Geothlypis tolmiei	tolmie warbler
Geothlypis trichas occidentalis	western yellow-throat
Icteria virens aurigollis	yellow-breasted chat
Wilsonia pusilla pileolata	pileolated warbler
Setophaga ruticilla	American redstart
Oreoscoptes montanus	sage thrusher
Dumetella carolinensis	catbird
Catherpes mexicanus conspercus	cinon wren
Salpinctes obsoletus	rock wren
Thryomanes bewickii leucogaster	baird wren
Troglodytes aedon parkmani	Parkman wren
Sitta carolinensis aculeata	slender-billed nuthatch
Sitta canadensis	red-breasted nuthatch
Sitta pygmaea	pigmy nuthatch
Parus inornatus ridgwayi	plain titmouse
Parus gambeli	mountain chickadee
Psaltriparus plumbeus	lead-colored brushtit
Regulus calendula	ruby-crowned kinglet

Table 19. Continued

Scientific name	Common name
Polioptila caerulea amoenissima	blue-gray gnatcatcher
Hylocichla guttata nana	dwarf hermit thrush
Turdus migratorius propinqua	western robin
Sialia mexicana bairdi	chestnut-backed bluebird
Sialia artica	mountain bluebird
Ardea herodia treganzia	great blue heron
Branta canadensis	Canada goose
Anas carolinensis	green-winged teal
Anas platyrhynchus platyrhynchus	mallard
Anas discors discors	blue-winged teal
Mareca americana	American widgeon
Charadrius vociferus vociferus	killdeer
Actitus mascularia	spotted sandpiper
Phalaenoptilus nuttallii nuttallii	poor-will
Aeronautes saxatalis saxatalis	white-throated swift
Corvus corax sinuatus	common raven
Certhia familiaris montana	brown cruper
Mimus polyglottos leucopterus	mockingbird
Carpodacus mexicanus frontalis	house finch
Leucophoyx thula brewsteri	snowy egret
Phalacrocorax auritus	double-crested cormorant

[a] (Gilman, 1908 Woodbury, 1959).

Table 20. Amphibians and reptiles known to inhabit the White Canyon study area, San Juan County, Utah.[a]

Scientific name	Common name
Ambystoma tigrinum	Tiger salamander
Scaphiopus hammondi	western spadefoot toad
Bufo cognatus	Great Plains toad
Bufo woodhousei	Woodhouse's toad
Bufo punctatus	desert toad
Hyla arenicolor	canyon tree-frog
Rana pipiens brachycephala	western leopard frog
Crotophytus collaris	collard lizard
Holbrookia maculata approimana	speckled carless lizard
Phrynosoma douglassi	short-horned lizard
Sceloporus graciosus graciosus	Great-basin sagebrush lizard
Sceloporus magister cephaloflavus	Utah spiny lizard
Sceloporus undulates elongatus	northern plateau lizard
Uta omata urighti	northern cliff lizard
Uta stansburiana stansburiana	northern side-blotched lizard
Sauromalus obesus obesus	western chuckwalla
Phrynosoma douglassi hernandesi	mountain short-horned lizard
Phrynosoma platyrhinos calidiarum	southern desert horned lizard
Xantusia vigilis utahensis	Utah night lizard
Cnemidophorus sacki innotatus	plateau whiptail
Cnemidophorus tigris septentrionalis	northern whiptail
Coluber constrictor	racer
Hypsiglena torquata loreala	Mesa Verde night snake
Masticophis taeniatus taeniatus	desert striped whipsnake
Masticophis flagellum	common whipsnake
Piticophis catenifer deserticola	great basin gopher snake
Thamnophis cyrtopsis cyrtopsis	black-necked garter snake
Thamnophis sirtalis	common garter snake
Thamnophis elegans vagrans	western garter snake
Crotalus viridis	western rattlesnake
Crotalus cerastes	sidewinder
Lampropeltis getulus californiae	California king snake

[a] (Stebbins, 1954 and Woodbury, 1959).

Table 21. Moenkopi talus - salina wildrye/galleta association [a]

Number of stands - 17 Number of ten foot square quadrats - 85 Total square feet measured - 850

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bare ground	66.4	86.5					
Hilaria jamesii	4.0	14.3	30.6	36.0	162	0	39.4
Elymus salina	3.4	33.5	14.1	11.6	136	0	12.7
Cowania mexicana	3.0	17.4	21.2	1.9	11	0	1.9
Ephedra viridis	2.7	8.6	25.9	1.6	5	0	1.7
Rhus trilobata	2.5	11.4	16.5	0.7	4	0	0.8
Gutierrezia sp.	2.5	15.2	25.9	3.0	20	0	3.2
Coleogyne ramosissima	2.1	20.0	12.9	1.1	11	0	1.2
Juniperus ostiosperma	2.1	13.0	18.8	0.1	3	0	0.9
Fraxinus anomala	1.8	7.7	16.5	0.1	6	0	1.0
Oryzopsis hymenoides	1.4	11.4	25.9	3.8	28	0	4.1
Stipa speciosa	1.2	11.2	18.8	4.1	42	0	4.5
Stanleya pinnata	0.9	4.8	17.7	0.1	15	0	1.6
Atriplex confertifolia	0.7	10.4	4.7	0.5	9	0	0.6
Hymenoxys richardsonii	0.6	5.4	9.4	3.2	41	0	3.5

Table 21. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Pinus edulis	0.5	2.6	16.9	0.1	5	0	0.7
Chrysothamnus sp.	0.4	2.6	8.2	t[b]	3	0	0.5
Haplopappus sp.	0.4	6.6	3.5	2.3	43	0	2.5
Cryptantha sp.	0.4	3.4	22.4	3.9	45	0	4.3
Bromus tectorum	0.3	1.7	27.1	16.3	82	0	17.8
Sphaeralcea sp.	0.3	0.8	4.7	t[b]	2	0	0.4
Stephanomeria pauciflora	0.3	3.0	4.7	t[b]	2	0	0.3
Symphoricarpos longiflorus	0.2	2.6	9.4	0.1	5	0	0.6
Shepherdia rotundifolia	0.1	2.2	3.5	t[b]	4	0	0.2
Eriogonum corymbosum	0.1	1.4	2.4	t[b]	1	0	t[b]
Berberis fremontii	0.1	1.8	1.2	t[b]	2	0	0.1
Euphorbia fendleri	0.1	0.8	9.4	t[b]	1	0	0.3
Asclepas capricorna	0.1	0.2	1.2	t[b]	1	0	0.1
Unidentified forbs	0.1	0.5	9.4	1.8	14	0	2.0
Mentzilia sp.	0.1	0.6	3.5	t[b]	1	0	0.2
Eriogonum sp.	0.1	1.0	1.2	t[b]	1	0	0.1
Leptodactylon pungens	0.1	0.8	1.2	0.4	7	0	0.4
Physaria chambersii	t[b]	0.4	15.3	0.7	7	0	0.8

Table 21. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. Plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Aster venustus	t[b]	0.6	1.2	t[b]	1	0	0.1
Penstemon sp.	t[b]	0.2	3.5	t[b]	4	0	0.2
Astragalus sp.	t[b]	0.1	2.4	t[b]	2	0	0.1
Brickellia scabra	t[b]	0.1	3.5	t[b]	1	0	0.2
Circium sp.	t[b]	0.1	1.2	t[b]	1	0	0.1
Opuntia sp.	t[b]	0.2	1.2	t[b]	1	0	0.1

[a] The information in this table was determined as follows:

Average per cent ground cover - Values were determined by totaling the ground cover by each plant species for each five quadrats and dividing by five to obtain the average ground cover within a stand. The averaged ground cover values for each plant species in a stand were then added, and the resulting figure divided by the number of stands to determine the average per cent ground cover by each plant per 50 square feet.

Maximum per cent ground cover - The numbers recorded in this column were determined by recording the highest per cent plant cover within a stand.

Per cent frequency - Values were determined by counting the number of quadrats in which the plant was found and dividing by the total number of quadrats and multiplied by 100.

Density per cent - Values were obtained by adding the total number of plants for each plant species for all plants to find the grand total of the number of plants counted. The total was divided into the total for each plants species and then multiplied by 100 per cent.

Maximum number of plants and minimum number of plants - The maximum number of plants are recorded in the maximum number of plants per 50 square feet column, and the minimum number of plants are recorded in the corresponding column.

Average number of plants - Values were determined by adding the total number of plants in each stand and dividing by the number of stands.

[b] t= value of less than 0.1 per cent.

Table 22. Moenkopi - salina wildrye association[a]

Number of stands - 12 Number of ten foot square quadrats - 60 Total square feet measured - 600

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bare ground	69.4	88.8					
Elymus salina	5.9	27.2	40.0	28.4	88	0	17.8
Juniperus osteosperma	3.5	10.0	21.7	2.3	3	0	1.4
Gutierrezia sp.	2.8	10.4	45.0	8.1	22	0	5.1
Ephedra viridis	2.3	7.8	36.7	3.6	8	0	2.3
Coleogyne ramosissima	1.5	8.0	16.7	3.2	10	0	2.0
Hilaria jamesii	1.5	6.8	26.7	36.5	85	0	22.8
Rhus trilobata	1.3	5.0	10.0	1.5	3	0	0.8
Fraxinus anomala	1.1	10.0	6.7	0.9	5	0	0.6
Shepherdia rotundifolia	1.0	5.0	10.0	0.9	2	0	0.6
Pinus edulis	0.8	7.4	10.0	0.8	3	0	0.5
Eriogonum corymbosum	0.6	3.0	11.7	0.8	3	0	0.5
Ephedra sp.	0.5	5.0	8.3	0.8	3	0	0.5
Atriplex confertifolia	0.4	2.2	8.3	1.7	9	0	1.1
Cowania mexicana	0.4	3.2	6.7	1.5	8	0	0.8
Chrysothamnus sp.	0.3	2.4	5.0	0.4	2	0	0.3

Table 22. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Cryptantha sp.	0.2	1.0	16.7	3.1	8	0	1.9
Stanleya pinnata	0.1	1.0	6.7	0.7	2	0	0.4
Hymenoxys richardsonii	0.1	0.6	10.0	0.7	1	0	0.4
Oryzopsis hymenoides	0.1	1.0	6.7	0.8	3	0	0.5
Haploppapas sp.	0.1	1.0	1.7	0.1	1	0	0.1
Symphoricarpos longiflorus	0.1	1.0	1.7	0.1	1	0	0.1
Eurotia lanata	0.1	1.0	1.7	0.1	1	0	0.1
Euphorbia fendleri	0.1	0.4	5.0	0.7	4	0	0.4
Stipa speciosa	0.1	0.8	1.7	0.1	1	0	0.1
Amelanchier utahensis	0.1	0.8	1.7	0.4	3	0	0.3
Penstemon sp.	t[b]	0.4	3.3	0.4	2	0	0.3
Physaria chambersii	t[b]	0.1	5.0	0.7	3	0	0.4
Unidentified forbs	t[b]	0.2	5.0	0.5	3	0	0.3
Astragalus sp.	t[b]	0.2	1.7	0.5	4	0	0.3
Kochia sp.	t[b]	0.1	1.7	0.1	1	0	0.1
Eriogonum sp.	t[b]	0.1	1.7	0.4	3	0	0.3

[a] See Table 21 for explanation of determination of values

[b] t = value of less than 0.1 per cent

Table 23. Chinle - Utah juniper/salina wildrye - galleta association[a]

Number of stands - 12 Number of ten foot square quadrats - 60 Total square feet measured - 600

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bare ground	58.6	77.4					
Juniperus ostiosperma	6.5	31.5	30.0	1.4	5	0	2.0
Elymus salina	5.7	22.4	28.3	15.7	100	0	22.8
Hilaria jamesii	3.5	12.0	36.7	30.0	140	0	43.9
Ephedra viridis	2.2	6.2	31.7	1.6	6	0	2.3
Shepherdia rotundifolia	2.1	8.0	23.0	1.2	4	0	1.7
Gutierrezia sp.	1.9	5.8	48.3	6.7	26	0	9.8
Ephedra sp.	1.9	8.4	36.7	2.2	8	0	3.2
Coleogyne ramosissima	1.7	19.2	11.7	1.4	20	0	2.0
Pinus edulis	1.2	5.8	25.0	1.1	5	0	1.7
Artemisia tridentata	1.2	11.4	13.3	2.8	34	0	4.1
Atriplex confertifolia	1.0	3.0	20.0	1.8	9	0	2.7
Cowania mexicana	0.6	5.0	5.0	0.4	2	0	0.6
Stipa speciosa	0.6	6.8	8.3	1.6	28	0	2.3
Hymenoxys richardsonii	0.5	2.4	33.3	5.5	22	0	8.1
Cryptantha sp.	0.4	4.8	18.3	2.7	37	0	3.9

Table 23. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Physaria chambersii	0.3	3.8	18.3	5.1	28	0	7.5
Unidentified forbs	0.3	2.4	28.3	5.3	22	0	7.7
Symphoricarpos longiflorus	0.2	1.6	13.3	1.2	10	0	1.8
Haplopappus sp.	0.2	1.6	11.7	3.6	28	0	3.7
Leptodactylon pungens	0.2	2.1	3.3	0.5	9	0	0.8
Chrysothamnus sp.	0.2	1.6	5.0	0.2	2	0	0.3
Oryzopsis hymenoides	0.2	0.4	21.7	1.4	9	0	2.0
Opuntia sp.	0.2	1.3	8.3	1.0	9	0	1.4
Kochia sp.	0.1	1.6	3.3	0.1	2	0	0.2
Phlox hoodii	0.1	1.0	1.7	0.8	14	0	1.2
Lupinus sp.	0.1	0.7	5.0	1.0	17	0	1.4
Stanleya pinnata	0.1	0.6	5.0	0.2	4	0	0.3
Bromus tectorum	t[b]	0.4	3.3	1.9	27	0	2.8
Lepidium fremontii	t[b]	0.4	1.7	0.1	1	0	0.9
Astragalus sp.	t[b]	0.3	1.7	0.2	4	0	0.3
Erigeron pumilus	t[b]	0.2	1.7	0.1	1	0	0.1
Erigeron sp.	t[b]	0.3	3.3	0.2	3	0	0.3
Aster venustus	t[b]	0.2	1.7	0.1	1	0	0.1
Eriogonum sp.	t[b]	0.3	3.3	0.2	3	0	0.3

Table 23. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Euphorbia fendleri	t[b]	0.1	1.7	0.1	1	0	0.1
Opuntia rhodantha	t[b]	0.1	1.7	0.1	2	0	0.2
Mirabilis froebelii	t[b]	0.1	3.3	0.2	3	0	0.3

[a] See Table 21 for explanation of determination of values

[b] t = value of less than 0.1 per cent

Table 24. Moenkopie-shadescale/galleta association[a]

Number of stands - 12 Number of ten foot square quadrats - 60 Total square feet measured - 600

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bare ground	63.9	92.3					
Hilaria jamesii	6.9	22.1	51.7	40.6	352	0	127.8
Atriplex confertifolia	3.3	5.4	60.0	2.9	33	0	9.2
Ephedra sp.	2.3	6.0	53.3	1.4	8	0	4.4
Artemisia spinescens	1.3	11.2	18.3	1.0	23	0	3.3
Coleogyne ramosissima	1.2	8.8	41.7	1.2	17	0	3.8
Kochia sp.	1.2	5.2	18.3	2.4	30	0	7.6
Gutierrezia sp.	1.0	3.4	33.3	1.6	10	0	5.1
Bromus tectorum	0.7	2.6	50.0	27.2	513	0	85.8
Phacelia corrugata	0.7	7.8	10.0	3.7	138	0	11.6
Chrysothamnus sp.	0.5	5.0	10.0	0.2	3	0	0.8
Aster venustus	0.4	3.7	8.3	0.3	8	0	0.8
Atriplex canescens	0.3	3.6	6.7	0.1	4	0	0.4
Dalea sp.	0.3	3.2	5.0	0.2	9	0	0.8
Opuntia sp.	0.3	0.8	18.3	0.4	4	0	1.3
Eriogonum inflatum	0.3	0.9	15.0	1.1	13	0	3.4
Rhus trilobata	0.3	3.0	1.7	0.1	1	0	0.1
Stipa speciosa	0.2	1.6	11.7	0.2	4	0	0.7

Table 24. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Unidentified forbs	0.2	0.8	38.3	6.0	181	0	1.9
Plantago purshii	0.2	1.5	13.3	8.0	254	0	25.3
Oryzopsis hymenoides	0.1	0.6	8.3	0.2	3	0	0.6
Astragalus sp.	0.1	1.0	10.0	0.4	5	0	1.2
Fraxinus anomala	0.1	0.6	3.3	0.1	2	0	0.2
Abronia sp.	0.1	0.8	6.7	0.3	11	0	0.9
Eriogonum mirothecum	0.1	0.8	1.7	t[b]	1	0	0.1
Cryptantha sp.	0.1	0.6	3.3	0.1	4	0	0.4
Artemisia biglovii	t[b]	4.2	3.3	0.1	5	0	t[b]
Atriplex cuneata	t[b]	0.2	3.3	0.1	2	0	0.2
Lycium sp.	t[b]	0.4	1.7	t[b]	1	0	0.1
Arenaria sp.	t[b]	0.1	1.7	0.1	1	0	0.1
Calochortus sp.	t[b]	0.1	1.7	0.1	1	0	0.1

[a] See Table 21 for explanation of determination of values
[b] t = value of less than 0.1 per cent

Table 25. Shinarump - blackbrush/galleta association[a]

Number of stands - 12 Number of ten foot square quadrats - 60 Total square feet measured - 600

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bare ground	58.5	82.0					
Hilaria jamesii	20.2	35.8	88.3	43.5	311	40	206.04
Coleogyne ramosissima	4.1	20.6	35.0	1.5	31	0	7.2
Elymus salina	4.1	45.0	10.0	2.9	158	0	13.8
Atriplex confertifolia	2.7	10.1	56.7	1.5	21	1	7.2
Ephedra sp.	2.5	4.8	41.7	0.9	10	0	4.3
Artemisia spinescens	1.2	11.6	13.3	0.5	20	0	2.3
Bromus tectorum	1.2	2.6	50.0	37.6	1215	0	178.5
Gutierrezia sp.	0.7	4.2	15.0	0.4	16	0	2.1
Opuntia sp.	0.5	1.8	25.0	0.3	4	0	1.5
Unidentified forbs	0.5	1.5	48.3	5.4	132	0	25.8
Cowania mexicana	0.3	4.0	1.7	0.0	1	0	0.1
Oryzopsis hymenoides	0.3	2.9	16.7	0.4	13	0	2.1
Coldenia hispidissima	0.3	2.6	5.0	0.1	6	0	0.7
Eriogonum inflatum	0.2	1.5	25.0	1.3	48	0	6.3

Table 25. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Atriplex canescens	0.2	1.8	3.3	0.4	19	0	1.8
Chrytothamnus sp.	0.2	1.2	8.3	0.1	2	0	0.4
Hymenoxys richardsonii	0.2	2.0	1.7	0.3	16	0	1.3
Phacelia corrugata	0.2	1.2	16.7	0.5	15	0	2.3
Astragalus sp.	0.1	0.9	16.7	0.6	19	0	2.8
Arenaria sp.	0.1	1.0	10.0	0.6	32	0	2.8
Atriplex nuttallii	0.1	0.8	3.3	0.1	4	0	0.5
Dalea sp.	0.1	1.0	1.7	t[b]	1	0	0.1
Lycium sp.	0.1	1.0	1.7	0.1	4	0	0.3
Calochortus sp.	0.1	0.1	6.7	0.2	7	0	0.8
Eriogonum wetherilli	0.1	0.1	1.7	0.1	3	0	0.3
Eriogonum sp.	0.1	0.1	1.7	t[b]	1	0	0.1
Kochia sp.	0.1	0.7	3.3	0.1	4	0	0.3
Plantago purshii	t[b]	0.4	10.0	0.5	24	0	2.6
Ferocactus covillii	t[b]	0.4	3.3	t[b]	2	0	0.2

[a] See Table 21 for explanation of determination of values

[b] t = value of less than 0.1 per cent

Table 26. North Wingate-talus slope: salina wildrye association[a]

Number of stands - 12 Number of ten foot square quadrats - 60 Total square feet measured - 600

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bare ground	54.3	69.7					
Elymus salina	22.4	42.0	71.7	24.9	153	9	67.2
Hilaria jamesii	6.7	22.2	58.3	49.3	224	0	132.9
Coleogyne ramosissima	3.2	17.4	26.7	1.9	20	0	5.2
Juniperus utahensis	2.3	7.2	16.7	0.4	3	0	1.0
Gutierrezia sp.	1.4	3.0	31.7	1.5	18	0	4.2
Atriplex donfertifolia	1.1	3.2	40.0	1.2	15	9	3.3
Ephedra viridis	1.1	4.0	13.3	0.5	5	0	1.4
Oryzopsis hymenoides	1.0	4.5	25.0	1.6	19	0	4.4
Shepherdia rotundifolia	0.9	5.6	11.7	0.3	2	0	0.7
Poa nevadensis	0.9	4.2	13.3	1.3	18	0	3.6
Fraxinus anomala	0.8	6.0	3.3	0.1	1	0	0.1
Rhus trilobata	0.7	4.0	3.3	0.1	1	0	0.1
Unidentified forbs	0.6	4.5	25.0	1.7	18	0	4.6
Ephedra sp.	0.6	5.2	15.0	0.6	13	0	1.5
Dalea sp.	0.5	2.8	8.3	0.2	4	0	0.6

Table 26. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bromus tectorum	0.4	1.6	28.3	12.3	123	0	33.3
Eriogonum corymbosum	0.4	4.4	1.7	t[b]	3	0	0.3
Aster venustus	0.3	1.4	16.7	0.3	4	0	0.9
Pinus edulis	0.3	1.8	6.7	0.3	5	0	0.7
Symphoricarpos longiflorus	0.2	2.8	3.3	t[b]	3	0	0.3
Kochia sp.	0.2	2.8	5.0	0.2	7	0	0.6
Sphaeralcea sp.	0.2	0.8	10.0	0.2	2	0	0.6
Chrysothamnus sp.	0.2	1.0	11.7	0.3	4	0	0.8
Opuntia sp.	0.2	1.0	6.7	0.1	2	0	0.3
Erigeron sp.	0.1	0.8	6.7	0.1	2	0	0.3
Astragalus sp.	0.1	0.6	3.3	t[b]	3	0	0.3
Cryptantha sp.	t[b]	0.4	5.0	0.2	2	0	0.4
Penstemon sp.	t[b]	0.2	5.0	0.2	6	0	0.6
Eriogonum microthacum	t[b]	0.2	1.7	t[b]	1	0	0.1

[a] See Table 21 for explanation of determination of values

[b] t = value of less than 0.1 per cent

Table 27. South Wingate talus slope - galleta association[a]

Number of stands - 12 Number of ten foot square quadrats - 60 Total square feet measured - 600

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bare ground	62.6	77.6					
Hilaria jamesii	13.6	19.2	75.0	27.2	250	0	121.9
Bromus tectorum	4.2	13.2	75.0	52.7	965	0	236.3
Oryzopsis hymenoides	3.7	20.6	61.7	3.4	57	0	15.4
Coleogyne ramosissima	3.0	16.4	28.3	1.5	22	0	6.8
Ephedra sp.	2.4	5.6	48.3	0.8	7	0	3.7
Atriplex confertifolia	2.3	8.6	60.0	1.4	28	0	6.4
Dalea sp.	1.2	6.4	16.7	0.3	5	0	1.4
Sphaeralcea sp.	1.2	8.8	21.7	1.4	41	0	6.3
Astragalus sp.	1.0	4.6	41.7	1.7	12	0	7.7
Elymus salina	0.9	2.6	16.7	1.0	34	0	4.6
Opuntia sp.	0.7	1.6	23.3	0.3	4	0	1.2
Chrysothamnus sp.	0.7	2.4	21.7	0.3	4	0	1.4
Unidentified forbs	0.5	2.4	43.3	3.6	58	0	16.3
Atriplex cuneata	0.5	2.5	18.3	0.4	7	0	1.7
Gutierrezia sp.	0.5	2.0	16.7	0.4	6	0	1.8
Coldenia hispidissima	0.4	5.1	11.7	1.1	53	0	5.1

Table 27. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plant per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Eriogonum inflatum	0.3	1.6	21.7	0.6	13	0	2.8
Yucca navajoa	0.3	1.4	6.7	0.2	5	0	0.8
Hymenoxys richardsonii	0.3	3.0	3.3	0.1	4	0	0.3
Juniperus utahensis	0.2	2.4	6.7	0.2	9	0	1.0
Ephedra viridis	0.2	1.2	5.0	0.1	4	0	0.6
Stipa speciosa	0.2	1.0	3.3	0.1	3	0	0.4
Atriplex nuttallii	0.1	0.8	3.3	0.1	3	0	0.4
Eriogonum wetherilli	0.1	1.0	1.7	t[b]	1	0	0.1
Townsendia scapigeria	0.1	0.8	3.3	0.1	5	0	0.4
Sitanion hystrix	0.1	0.8	3.3	0.1	5	0	0.4
Artemisia biglovii	0.1	0.8	1.7	t[b]	1	0	0.1
Brickella sp.	0.1	0.8	1.7	t[b]	2	0	0.2
Abronia sp.	0.1	0.5	8.3	0.2	8	0	0.8
Aster venustus	0.1	0.6	1.7	t[b]	1	0	0.1
Ferocactus covillei	t[b]	0.2	5.0	0.1	1	0	0.3
Rhus trilobata	t[b]	0.4	1.7	t[b]	1	0	0.1
Eriogonum sp.	t[b]	0.1	5.0	0.1	1	0	0.3
Arenaria sp.	t[b]	0.3	3.3	0.1	5	0	0.4
Atriplex canescens	t[b]	0.2	1.7	t[b]	1	0	0.1

Table 27. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Cryptantha sp.	t[b]	0.1	3.3	t[b]	2	0	0.2
Circium sp.	t[b]	0.3	1.7	t[b]	2	0	0.2
Eriogonum mirothecum	t[b]	1.0	3.3	0.1	6	0	0.5
Shepherdia rotundifolia	t[b]	0.2	1.7	t[b]	1	0	0.1
Penstemon sp.	t[b]	0.1	1.7	t[b]	1	0	0.1

[a] See Table 21 for explanation of determination of values

[b] t = value of less than 0.1 per cent

Table 28. East Wingate talus slope - shadescale/galleta association[a]

Number of stands - 12 Number of ten foot square quadrats - 60 Total square feet measured - 600

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bare ground	68.5	81.8					
Hilaria jamesii	10.3	27.0	78.3	25.3	236	6	119.1
Atriplex confertifolia	4.3	11.4	60.0	1.8	21	1	8.3
Bromus tectorum	3.3	13.4	81.7	59.6	1043	10	276.3
Oryzopsis hymenoides	1.7	7.0	48.3	1.4	29	0	6.8
Ephedra sp.	1.6	5.6	28.3	0.3	5	0	1.6
Astragalus sp.	1.2	6.0	35.0	1.9	55	0	9.1
Coleogyne ramosissima	1.1	9.8	11.7	0.4	17	0	1.7
Atriplex cuneata	1.0	5.4	23.3	1.3	56	0	6.3
Sphaeralcea sp.	0.8	3.4	28.3	0.8	18	0	3.6
Phacelia corrugata	0.7	5.4	3.3	0.3	12	0	1.6
Eriogonum inflatum	0.5	1.4	25.0	0.6	11	0	2.7
Ephedra viridis	0.5	3.0	3.3	0.1	2	0	0.4
Chrysothamnus sp.	0.5	5.6	5.0	0.1	4	0	0.3
Arenaria sp.	0.4	1.2	23.3	1.2	25	0	5.6

Table 28. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Unidentified forbs	0.4	1.3	36.7	3.8	87	0	15.4
Stipa speciosa	0.4	4.6	8.3	0.4	14	0	1.7
Coldenia hispidissima	0.3	1.2	10.0	0.2	6	0	1.1
Dalea sp.	0.2	2.0	3.3	t[b]	1	0	0.1
Sitanion hystrix	0.2	2.2	5.0	0.3	14	0	1.2
Opuntia sp.	0.2	1.2	10.0	0.1	2	0	0.5
Poa nevadensis	0.2	1.6	3.3	0.5	19	0	2.2
Stephanomeria pauciflora	0.2	1.8	3.3	0.1	3	0	0.3
Juniperus ostiosperma	0.1	1.6	1.7	t[b]	1	0	0.1
Yucca navajoa	0.1	1.6	1.7	t[b]	2	0	0.2
Gutierrezia sp.	0.1	0.6	3.3	0.1	1	0	0.3
Eriogonum sp.	0.1	0.1	1.7	t[b]	2	0	0.2
Kochia sp.	0.1	0.7	3.3	0.6	9	0	0.8
Aster venustus	0.1	0.6	3.3	0.1	3	0	0.3
Atriplex canescens	t[b]	0.2	1.7	t[b]	1	0	0.1
Eriogonum wetherilli	t[b]	0.3	8.3	0.3	7	0	1.2
Plantago purshii	t[b]	0.1	1.7	t[b]	2	0	0.2

[a] See Table 21 for explanation of determination of values

[b] t = value of less than 0.1 per cent

Table 29. West Wingate talus slope - salina wildrye/galleta association[a]

Number of stands - 13 Number of ten foot square quadrats - 65 Total square feet measured - 650

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bare ground	40.6	68.2					
Hilaria jamesii	14.6	43.6	69.2	34.5	416	0	151.6
Elymus salina	13.1	40.6	55.4	8.9	113	0	39.2
Oryzopsis hymenoides	4.0	11.6	67.7	3.9	51	0	17.3
Atriplex confertifolia	3.3	8.4	64.6	2.3	32	0	10.1
Bromus tectorum	2.0	5.2	70.8	41.3	888	0	181.4
Gutierrezia sp.	1.8	6.2	32.3	0.8	15	0	3.7
Sphaeralcea sp.	1.3	9.6	21.5	1.1	39	0	4.6
Ephedra sp.	1.2	4.6	35.4	0.6	8	0	2.5
Dalea sp.	0.9	6.2	12.3	0.3	7	0	1.5
Ephedra viridis	0.9	3.4	20.0	0.2	5	0	1.0
Fraxinus anomala	0.7	9.0	3.1	t[b]	2	0	0.2
Poa nevadensis	0.7	5.4	16.9	1.3	40	0	5.8
Opuntia sp.	0.6	1.8	23.1	0.3	4	0	1.2
Coleogyne ramosissima	0.5	7.0	26.2	0.7	19	0	3.1
Rhus trilobata	0.5	5.1	4.6	0.1	3	0	0.3
Stipa speciosa	0.5	4.2	12.3	0.5	21	0	2.0

Table 29. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Chrysothammus sp.	0.4	4.0	7.7	0.1	5	0	0.5
Astragalus sp.	0.3	2.4	21.5	0.8	16	0	3.6
Unidentified forbs	0.3	3.0	29.2	1.6	36	0	6.9
Aster venustus	0.2	2.2	7.7	0.1	4	0	0.5
Juniperus osteosperma	0.2	1.4	6.2	0.1	2	0	0.3
Symphoricarpos longiflorus	0.2	1.0	1.5	t[b]	1	0	0.1
Atriplex cuneata	0.1	1.6	1.5	t[b]	1	0	0.1
Atriplex canescens	0.1	1.0	3.1	t[b]	2	0	0.2
Shepherdia rotundifolia	0.1	1.0	1.5	t[b]	1	0	0.1
Eriogonum sp.	0.1	1.0	4.6	0.3	14	0	1.3
Lycium sp.	0.1	0.8	1.5	t[b]	1	0	0.1
Stanleya pinnata	0.1	0.8	1.5	t[b]	1	0	0.1
Yucca navajoa	0.1	0.8	1.5	t[b]	2	0	0.2
Coldenia hispidissima	0.1	0.6	1.5	t[b]	2	0	0.2
Artemisia spinescens	0.1	0.7	3.1	0.1	4	0	0.3
Pinus edulis	t[b]	0.4	1.5	t[b]	1	0	0.1
Eriogonum inflatum	t[b]	0.1	3.1	t[b]	2	0	0.2

[a] See Table 21 for explanation of determination of values

[b] t = value of less than 0.1 per cent

Table 30. Wingate Mesa - blackbrush/galleta association[a]

Number of stands - 13 Number of ten foot square quadrats - 65 Total square feet measured - 650

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Bare ground	65.0	78.0					
Hilaria jamesii	9.9	12.8	7.7	5.7	110	0	8.5
Coleogyne ramosissima	8.9	20.8	70.8	11.9	60	0	17.6
Pinus edulis	2.7	12.6	24.6	1.4	8	0	1.2
Gutierrezia sp.	1.9	6.0	46.2	4.6	11	0	6.8
Artemisia tridentata	1.7	7.8	24.6	2.9	15	0	4.2
Ephedra sp.	1.6	15.0	29.2	3.5	20	0	5.2
Oryzopsis hymenoides	1.4	9.5	38.5	5.2	39	0	7.6
Stipa speciosa	1.4	15.0	10.8	2.2	41	0	3.3
Juniperus osteosperma	1.3	7.0	29.2	1.6	4	0	2.5
Elymus salina	1.2	16.0	7.7	3.1	59	0	4.5
Shepherdia rotundifolia	1.1	8.0	13.9	0.6	4	0	0.8
Haplopappus sp.	0.7	5.1	10.8	3.8	43	0	5.5
Cryptantha sp.	0.7	3.9	32.3	2.6	21	0	3.9
Ephedra viridis	0.6	4.2	13.8	0.1	7	0	1.9
Bromus tectorum	0.5	5.3	10.8	31.3	580	0	46.2
Symphoricarpos longiflorus	0.4	4.0	4.7	0.3	4	0	0.4
Opuntia rhodantha	0.4	2.6	7.7	1.0	7	0	1.5

Table 30. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Abronia sp.	0.4	0.5	3.1	0.3	6	0	0.5
Cowania mexicana	0.3	1.6	12.3	0.7	9	0	1.0
Hymenoxys richardsonii	0.2	1.0	4.6	0.2	1	0	0.2
Berberis sp.	0.2	3.0	1.5	0.1	1	0	0.1
Rhus trilobata	0.2	3.0	1.5	0.1	1	0	0.1
Unidentified forbs	0.2	1.0	32.3	5.9	35	0	8.7
Atriplex sp.	0.2	2.5	1.5	0.7	13	0	1.0
Chrysothamnus sp.	0.2	1.4	4.6	0.2	1	0	0.2
Astragalus sp.	0.2	1.6	6.2	0.6	6	0	0.9
Eriogonum mirothecum	0.2	1.0	15.4	1.1	6	0	1.6
Opuntia sp.	0.2	9.5	27.7	5.0	40	0	7.3
Yucca navajoa	0.2	1.2	7.7	0.3	3	0	0.8
Mirabilis froebelii	0.2	2.0	1.5	0.1	2	0	0.2
Asclepias latifolia	0.2	2.0	1.5	0.2	4	0	0.3
Ferocactus covillei	0.1	1.0	6.2	0.4	4	0	0.5
Artemisia biglovii	0.1	1.2	1.5	0.1	1	0	0.1
Frasera paniculata	0.1	1.0	1.5	0.2	4	0	0.1
Penstemon sp.	0.1	0.2	1.5	0.1	2	0	0.2
Lepidium sp.	0.1	0.4	3.1	0.4	4	0	0.5

Table 30. Continued

Plant	Avg. % ground cover per 50 sq. feet	Max. % ground cover per 50 sq. feet	Per cent frequency	Per cent density	Max. no. plants per 50 sq. feet	Min. no. plants per 50 sq. feet	Avg. no. plants per 50 sq. feet
Physaria chambersii	0.1	0.5	4.6	0.4	4	0	0.5
Penstemon fremontii	t[b]	0.1	1.5	0.1	1	0	0.1

[a] See Table 21 for explanation of determination of values

[b] t = value of less than 0.1 per cent

Table 31. List of plant species collected in the White Canyon study area, San Juan County, Utah.[a]

Family	Scientific name	Common name[b]
Aceracea	Acer negundo	boxelder
Amaranthaceae	Amaranthus blitoides	prostrate amaranthus
Anacardiaceae	Rhus trilobata	skunk-bush
Apocynaceae	Amsonia eastwoodiana	Eastwood amsonia
	Amsonia tomentosa	amsonia
Asclepiadaceae	Asclepias capricornu	antelope horn milkweed
	Asclepias latifolia	
Berberidaceae	Berberis fremontii	pendant barberry
Boraginaceae	Cryptantha ambigua	cryptantha
	Cryptantha confertifolia	cryptantha
	Cryptantha flavoculata	cryptantha
	Coldenia hispidissima	coldenia
	Euploca convolvulacea	blinduced euploca
	Lappula redowskii	hackalia stickseed
Cactacea	Ferocactus covillei	barrel cactus
	Opuntia phaeacantha	softhair prickly pear
	Opuntia rhodantha	prickly pear
Capparidaceae	Cleome lutea	yellow bee-plant
	Cleome serrulata	bee spiderflower
Caprifoliaceae	Symphoricarpos longiflorus	longflower snowberry
Caryophyllaceae	Arenaria macradenia	mountain sandwort
Celastraceae	Pachystima myrsinites	Oregon-boxwood
Chenopodiaceae	Atriplex brandegei	saltbush
	Atriplex canescens	four-wing saltbush
	Atriplex confertifolia	shadscale
	Atriplex cuneata	saltbush
	Bassia hyssopifolia	fivehook bassia
	Chenopodium album	lambsquarters goosefoot
	Eurotia lanata	winterfat
	Grayia brandegei	spineless hopsage
	Kochia americana	greenmolly summer-cypress
	Kochia vestita	gray summercypress
	Salsola kali	Russian thistle
	Sarcobatus vermiculatus	black greasewood
Compositae	Achillea millifolium	common yarrow
	Ambrosia artemisifolia	common ragweed
	Antennaria parvifolia	pussytoes
	Artemisia bigclovii	bigelow sagebrush
	Artemisia spinescens	bud sagebrush
	Artemisia tridentata	big sagebrush
	Aster leucilene	babywhite aster
	Aster venustus	aster
	Brickellia california	Californica brick-ellia
	Brickellia scabra	brickellia
	Chaenactis douglasii	Douglas chaenactis
	Chrysopsis villosa	hairy goldaster

Table 31. Continued

Family	Scientific name	Common name
Compositae	Chrysothamnus linifolius	flaxleaf rabbitbrush
	Chrysothamnus nauseosus	rubber rabbitbrush
	Chrysothamnus viscidiflorus	Douglas rabbitbrush
	Cirsium rothrockii	thistle
	Cirsium utahensis	Utah thistle
	Erigeron aphanactis	fleabane
	Erigeron argentatus	fleabane
	Erigeron flagellaris	trailing fleabane
	Erigeron pumilus	low fleabane
	Erigeron utahensis	fleabane
	Fransera acanthecarpa	ambrosia bursage
	Gutierrezia microcephala	threadleaf snakeweed
	Haplopappus heterophyllus	jimmyweed
	Haplopappus integrifolius	whaleleaf goldenweed
	Haplopappus nuttallii	Nuttall goldenweed
	Helianthella uniflora	oneflower helianthella
	Hymenoxys richardsonii	pingue actinea
	Lactuca serriola	prickly lettuce
	Lygodesmia exigua	skeletonplant
	Malacothrix glabrata	malacothrix
	Oxytenia acrosa	prickly oxytenia
	Petrodoria pumila	solidago petrodoria
	Potentilla propinqua	pussytoes
	Senecio multilobatus	lobeleaf groundsel
	Solidago canadensis	Canada goldenrod
	Stephanomeria pauciflora	wirelettuce
	Towsendia scapigera	tuffed townsendia
Convulvalaceae	Convolvulus arvensis	European glorybind
Cruciferae	Arabis holboellii	holboell rock cress
	Arabis perennans	rockcress
	Descurainia californica	tansymustard
	Draba cuneifolia	whitlewort
	Erysimum capitatum	western-wallflower
	Lepidium fremontii	desert pepperweed
	Lepidium montanum	pepperweed
	Physaria chambersii	twinpod
	Physaria newberryi	twinpod
	Sisymbrium irio	rorippa norta
	Stanleya pinnata	desert princesplume
	Streptanthella longirostris	streptanthella
	Streptanthus arizonicus	twistflower
	Streptanthus cordatus	heartleaf twistflower
	Thelypodium integrifolium	thelypody
Cupressaceae	Juniperus osteosperma	Utah juniper
	Juniperus scopulorum	Rocky Mountain juniper
Elaeagnaceae	Shepherdia rotundifolia	roundleaf buffaloberry

Table 31. Continued

Family	Scientific name	Common name [b]
Ephedraceae	Ephedra cutleri	cutler ephedra
	Ephedra nevadensis	Nevada ephedra
	Ephedra torreyana	terry ephedra
	Ephedra viridis	ephedra
Euphorbiaceae	Euphorbia fendleri	fendler euphorbia
Fagaceae	Quercus gambeli	Gambel oak
Gentianaceae	Franseria paniculata	elkweed
Geraniaceae	Erodium cicutarium	alfileria
	Geranium caespitosum	crowfoot
Gramineae	Avena fatua	wild oats
	Bromus rubens	foxtail brome
	Bromus inermis	smooth brome
	Bromus tectorum	cheat grass
	Calamogrostus scopulorum	Jones reedgrass
	Dactylis glomerata	Canada wildrye
	Distichlis spicata	inland saltgrass
	Elymus canadensis	Canada wildrye
	Elymus salina	salina wildrye
	Hilaria jamesii	galleta grass
	Oryzopsis hymenoides	Indian ricegrass
	Phragmites communis	phragmites
	Poa bulbosa	bulbous bluegrass
	Poa fendleriana	mutton bluegrass
	Poa nevadensis	Nevada bluegrass
	Poa sandbergii	Sandberg bluegrass
	Polypogon monspeliensis	rabbitfoot polypogon
	Sitanion hystrix	bottlebush squirrel-tail
	Sporobolus airoides	alkali sacaton
	Stipa comata	needle and thread
	Stipa speciosa	desert needlegrass
Hydrophyllaceae	Phacelia corrugata	phacelia
	Phacelia crenulata	phacelia
	Phacelia heterophylla	varileaf phacelia
Juncaceae	Juncus balticus	baltic rush
	Juncus torreyi	torrey rush
Labiatae	Marrubium vulgare	common horehound
Leguminosae	Astragalus amphioxys	locoweed
	Astragalus beckwithii	Beckwith milkvitch
	Astragalus moencoppensis	locoweed
	Dalea thompsonae	Thompson dalea
	Lupinus caudatus	tailcup lupine
	Lupinus kingii	kings lupine
	Lupinus polyphyllus	Washington lupine
	Lupinus pusillus	rusty lupine
	Petalostemon flavesens	yellow prairieclover
Liliaceae	Allium acuminatum	tapertip onion
	Allium brandegei	brandegee onion

Table 31. Continued

Family	Scientific name	Common name [b]
Liliaceae	Calochortus flexuosus	weakstem mariposa
	Calochortus nuttallii	sego-lily
	Eremocrinum albomarginatum	sand lily
	Linum aristatum	flax
	Linum kingii	flax
	Yucca navajoa	Spanish-bayonet
	Yucca sp.	yucca
	Zigadenus paniculatus	foothill deathcamus
Malvaceae	Sphaeralcea laxa	globemallow
	Sphaeralcea munroana	Munro globemallow
Nyctaginaceae	Abronia elliptica	sandverbena
	Abronia fragrans	snowball sandverbena
	Allionia linearis	allionia
	Mirabilis multiflora	Colorado four-o-clock
Oleaceae	Fraxinus anomala	singleleaf ash
Onagraceae	Oenothera caespitosa	tuffed evening primrose
	Oenothera lavandulaefolia	lavenderleaf evening primrose
	Oenothera pallida	pala evening primrose
Orchidaceae	Epipactis gigantea	helleborine
Papaveraceae	Corydalis aurea	golden corydalis
Papilionoideae	Melilotus alba	white sweet clover
	Petalostemon candidum	white prairie-clover
	Psoralea micrantha	scurfpea
Passifloraceae	Mentzelia multiflora	desert mentzelia
Pinaceae	Pinus contorta	lodgepole pine
	Pinus ponderosa	ponderosa pine
	Pseudotsuga menziesii	douglasfir
Plantaginaceae	Plantago purshii	wooly Indianwheat
Podypodiaceae	Adiantum capillus	maidenhair fern
Polemoniaceae	Gilia gunnisoni	gilia
	Gilia inconspicua	shy gilia
	Gilia subnuda	gilia
	Leptodactylon pungens	gilia
	Phlox gladiformis	phlox
	Phlox hoodii	Hoods phlox
Polygonaceae	Eriogonum alatum	wing eriogonum
	Eriogonum cernyum	nodding eriogonum
	Eriogonum corymbosum	corymbed eriogonum
	Eriogonum deflexum	eriogonum
	Eriogonum inflatum	desert trumpet
	Eriogonum microthecum	slenderbush eriogonum
	Eriogonum racemosum	redroot eriogonum
	Eriogonum umbellum	sulfur eriogonum
	Eriogonum wetherillii	eriogonum
Portulacaceae	Talinum brevifolium	flameflower
Rafflesiaceae	Rumex hymenosepalus	canaigre

Table 31. Continued

Family	Scientific name	Common name[b]
Ranunculaceae	Aquilegia flavescens	yellow columbine
	Delphinium scaposum	barestem larkspur
	Clematis hirsutissima	clematis
	Clematis ligusticifolia	western virginsbower
Rhamnaceae	Rhamnus betulifolia	buckthorn
Rosaceae	Amelanchier utahensis	Utah serviceberry
	Cercocarpos inricatus	little-leaf mahogany
	Coleogyne ramosissima	blackbrush
	Cowania mexicana	cliffrose
	Petrophytum caespitosum	tuffed rockmat
	Rosa manca	Manca rose
Rubiaceae	Gallium uparine	catchwad bedstraw
Salicaceae	Populus angustifolia	narrow-leaf cotton-wood
	Populus fremontii	Fremont cottonwood
	Salix exigua	coyota willow
	Salix melonopsis	dusky willow
Scrophulariaceae	Castilleja chromosa	paintbrush
	Cordylanthus kingii	birdbeak
	Pedicularis centranthera	dwarf pedicularis
	Penstemon bridgesii	bridges penstemon
	Penstemon comarrhenus	dusty penstemon
	Penstemon fremonti	Fremont penstemon
	Penstemon lentus	penstemon
	Penstemon pachyphyllus	thickleaf penstemon
	Penstemon palmeri	Palmer penstemon
Solanaceae	Datura metaloides	Sacred datura
	Lycium andersoni	Anderson wolfberry
	Lycium pallidum	pale wolfberry
	Nicotiana attenuata	coyote tobacco
Tamaricaceae	Tamarix pentandra	tamarisk
Umbelliferae	Cymopterus fendleri	chimaya
	Cymopterus purpurascens	chimaya
	Pteryxia hendersoni	pteryxia

[a] All of the plants were identified by the Intermountain Herbarium, and are in the Intermountain Herbarium, Utah State University.

[b] Common names are according to Kelsey and Dayton (1942).

Table 32. Chronological list of desert bighorn sheep sightings along the Colorado and Green Rivers in Utah, 1776 to 1966

Year of sighting	Location and remarks	Sightee
1776	Crossing of the fathers, November 8,	Escalante (Bolton 1950)
1869	Killed two sheep in Gypsum Canyon in Cataract Canyon.	Powell, J. W. (Powell 1869)
1869	Just below the mouth of the San Juan River sheep were sighted. August 1.	Bradley, George (Powell 1869)
1869	Killed two sheep, 33 miles below the mouth of the San Juan River. August 3.	Bradley, George (Dellenbaugh 1926)
1871	Sheep were sighted on the south side of the confluence of the Green and Colorado Rivers. July 3.	Dellenbaugh (Dellenbaugh 1926)
1871	Sheep were sighted on the north side of the confluence of the Green and Colorado Rivers. July 5.	Dellenbaugh (Dellenbaugh 1926)
1871	One bighorn sheep was killed in Desolation Canyon. August 17.	Dellenbaugh (Dellenbaugh 1926)
1878	Sheep were sighted at the mouth of Comb Wash.	Christensen, Chris
1879	Lookout Rocks, 14 sheep were sighted. December 18.	Hubbs, George (Perkins etal 1957)
1879	Lookout Rocks, 1 sheep sighted, December 19.	Hubbs, George, (Perkins etal 1957)
1891	Many sheep were seen in White Canyon.	Scorup, Al
1880-1890	Killed a ram on Gray Mesa.	Lyman, Albert
1900's	Many sheep seen by old timers on Gray Mesa.	Douglas
1908	Found a dead bighorn ram on Indian Creek by Frog pond, near Indian Creek Ranch.	Young, Jacob
1908	Saw many bighorn sheep in Lockhart Basin. December.	Young, Jacob
1910	Hopi Indian saw several sheep in Blue Canyon.	O'Conner, Jack(O'Conner 1959)
1910	Saw several sheep at Jacob's Chair.	Young, Jacob
1910	Saw 5 or 6 not over 10 sheep at Warm Spring in Red Canyon.	Young, Jacob
1911	Melvin and Lloyd Adams saw bighorns all the time in Red Canyon	Butt, Rey
1920's	Roy Musselman saw five bighorns by what is now called Kachina Bridge in Natural Bridges National Monument.	Douglas, Garland

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1920-1930	Bighorn sheep killed on Navajo Mountain.	O'Conner, Jack (O'Conner 1959)
1921	Three bighorn sheep were shot on Blue Mountain.	Thorne, Robert C.
1922	At the mouth of John's Canyon on the San Juan River sighted 22 ewes and lambs. Sheep were sighted all along the San Juan from Goosenecks and down river .	Navajo Indian
1922	Saw several bighorns on mesa in Red Canyon. Her father saw many in Red Canyon and White Canyon about this time. August.	Helquist, Cora
1924	Saw big ram on Mancos Mesa around John's Canyon.	Perkins, Earl
1924	Saw sheep tracks in Slickhorn Canyon.	Perkins, Earl
1926	Lone ram sighted between Upheavel Dome and Steer Mesa above Wingate rim. Fall.	McKnight, Edwin T.
1927	Three or 4 bighorn sheep sighted on White Rim, all ewes, he believed. Spring.	McKnight, Edwin T.
1932	Saw one ram and two ewes at head of Escalante River on road between Escalante and Boulder.	Ecker, Horace
1936	Found a dead four year old ram in Gypsum Canyon.	Scorup, Jim
1938	The general land survey crew counted 26 bighorns in one bunch in Lockhart Basin.	Scorup, Jim
1939	Saw 13 bighorns on Mesa northeast of Ticaboo Mesa.	Ecker, Horace
1939	Found 15 to 20 hides buried by Indians on Cedar Mesa which is in the Mancos Mesa area.	Douglas
1939	Saw one ram and 3 others in Lockhart Basin	Scorup, Jim
1939	Needles at spring in Land Canyon found ewe and lamb.	Scorup, Jim
1940	Saw 14 to 15 head at Big Notch northeast of Bears Ears.	Nives, Robert
1940	Killed a ram on the north side of Navajo Mountain.	Lehi, Dan
1940	Saw large ram killed in White Canyon.	Young, Jacob
1940-1942	Saw Navajo Indians kill bighorns in fall in White and Red Canyon all the time. Saw three horses loaded with 60 to 70 bighorn sheep hides.	Scorup, Jim
1940-1950	Always saw bighorn sheep between Dark Canyon and Gypsum Canyon on the Colorado River.	Ross, Kenny
1940's	Big ram sighted in Coyote Canyon just above Red Canyon.	Douglas, Garland

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1940's	Saw bighorn sheep in Wooden Shoe Canyon	Douglas, Garland
1940's	Saw bighorn sheep tracks on Dry Mesa and in Dark Canyon	Douglas, Garland
1940's	Saw bighorns on the mesas all of the time.	Young, Jacob
1940's	Many bighorn sheep skulls were found by Anaconda Copper Company.	Redd, Wiley
1942	Found ten bighorn sheep hides buried at James Tanks in Cedar Canyon.	Scorup, Jim
1942	Saw a two year old ewe killed on Mancos Mesa.	Scorup, Jim
1942	Saw a bighorn killed on Jacob's Chair.	Scorup, Jim
1943	Saw one ewe and a ram in nook at spring below Found Mesa.	Scorup, Jim
1943	Saw bighorn sheep tracks in Scorup and Red Canyons.	Scorup, Jim
1945	Sighted a ram traveling across country.	Johnson, Clarence
1946	Saw sheep on the east side of the Sun Dial Moss Back. April and May.	Shumway, DeLoy
1947	Saw bighorn sheep daily between Soldiers Grave and Copper Point on highway 95 construction.	Black, Hyrum
1949	Saw bighorns above the confluence of Green and Colorado Rivers.	Ellington, Malcolm
1950	Saw 20 head of bighorns (rams, ewes and a few lambs) on Jacob's Chair. Spring.	Perkins, Earl
1951	Observed 22 bighorn sheep in Hidden Valley.	Dunning, Lewis
1951	Saw bighorn sheep on the Moss Backs and found a dead one beside the road.	Redd, Wiley
1951	Jess Johnson killed a ram on the Bears Ears.	Lyman, Albert
1951	Saw two rams on Knockeye Dome. Summer.	Snyder, Lee
1954	Saw a two year old ram killed at mouth of Halls Creek by Mr. King's herder (Bricknell).	Ecker, Horace
1954	Saw three bighorns between Gypsum and Dark Canyon	Ellington, Malcolm
1955	Saw the tracks of several bighorn sheep in Lockhart Basin. There are a lot of sheep in the Lockhart area.	Douglas, Garland
1956	Saw many tracks on Mancos Mesa.	Crosby, Junior
1956	Charles Potter saw sheep in road at Randium King.	Crosby, Junior

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1958	Saw four ewes and lambs on Gray Mesa.	Tusage, Marvin
1958	Saw bighorn rams three times with cows.	Black, Leo
1958	Saw bighorn sheep in Red Gap going to the Hideout Mine.	Tate, Jack
1958	Observed three bighorn sheep just south of the Hole in the Rock on Lake Powell. Summer.	Stavley, Gaylord
1959	Adult ram sighted on Shafer Trail.	Wagner, Fredric
1959	July through mid-January sighted three ewes and two lambs almost everyday on Jacob's Chair.	Lyman, Bob
1960's	Have made 22 trips from Green River, Utah to Hite Marina since 1949 and have never failed to see bighorn sheep.	Ellington, Malcolm
1960's	Found the skeleton of a bighorn sheep by the turnoff to Natural Bridges National Mounument.	Butt, Rye
1960's	Saw a bighorn one mile north and one mile east of old bridge on the north side of the Colorado River.	Butt, Rye
1960's	Saw a large ram just below Moab, Utah.	Butt, Rye
1960's	Many of the old timers have told me about seeing mountain sheep on Gray Mesa, but there are not so many there now.	Douglas, Garland
1960's	I saw a sheep fall over a 100 foot ledge on the Moss Backs and break his neck.	Douglas, Garland
1960's	Have seen bighorn sheep at Fry Spring.	Scorup, Jim
1960's	In the Lockhart country bighorn rams used to always breed the domestic ewes. None of the lambs lived more than six weeks.	Scorup, Jim
1960's	Have seen bighorn sheep a few times around Red Lake	Young, Jacob
1960's	Sheepherders killed bighorns all of the time in the Lockhart area.	Young, Jacob
1960's	Saw bighorn sheep on Mule Creek on the Green River.	Mackie, James
1960's	Observed one ewe on Willow Creek.	Mackie, James
1950-1960's	See bighorn sheep from the Goosenecks on the San Juan River to Grand Gulch. Have seen sheep beds two to three feet deep.	Ross, Kenny

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1960's	Halls Mesa, SW¼ of T36 8, 10E, within what is now Glen Canyon National Recreation Area. Six rams.	Fields, Larry
1960's	Mesa between Two Mile and Sweet Creek Canyons west of Hite within Glen Canyon National Recreation Area.	Fields, Larry
1960's	Observed bighorn sheep on Bull Mountain, northeast portion of Henry Mountains.	Fields, Larry
1960's	Forty-Mile Wash within Glen Canyon National Recreation Area observed bighorn sheep.	Fields, Larry
1960's	Saw bighorn sheep on Bullfrog Creek which is now under water.	Fields, Larry
1950-1960's	Always saw bighorn sheep between Gypsum and Dark Canyons on the Colorado River.	Ross, Kenny
1960	One mile west of Fry Canyon Store on Utah 95 saw one ram, two ewes and two lambs.	Fields, Larry
1960	At Dirty Devil and Colorado River saw 12 bighorn sheep.	Hunt, Reo
1960-1966	Saw bighorn sheep along the Colorado and Green Rivers.	Ellington, Malcolm
1960	Observed a large ram at the Cog Mine. Winter	Nelson, George
1961	Saw bighorn sheep on Mt. Ellsworth and Mt. Holms on the east side.	Williams, Slim
1961	Saw one ewe and one yearling ram in Scorup Canyon.	Williams, Slim
1962	Fry Point, 14 bighorn sheep. Summer.	Utah Fish and Game
1963	Observed bighorn sheep in Ticaboo Canyon. Summer.	Hunt, Reo
1963	On July 30, observed tracks and fresh droppings at Hole in the Rock on the Colorado River.	Trimberger, Eugene
1963	Nine bighorn sheep were observed on December 16, at dirt reservoir five to six miles north of Fry Store.	Blanding Sportsman Club
1964	Soldier Crossing, one ram, one ewe, January 1.	"
1964	Jacob's Chair, two ewes, January 17.	"
1964	Jacob's Chair, three rams and six ewes, January 18.	"
1964	Jacob's Chair on the east side, one ram and two ewes, January 21.	"
1964	Blue Notch Canyon on the east side, one ram, three ewes and one lamb, January 23.	"

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1964	White Canyon at Soldiers Crossing, one ram and one ewe, January 24.	Blanding Sportsman Club
1964	Fortknocker Canyon, one ram and one ewe, February 13.	"
1964	Fry Point, one ram and three ewes, February 24.	"
1964	Jacob's Chair, south side above road, four rams and six ewes, February 1.	"
1964	Gravel Canyon, one ram, February 2.	"
1964	Fry Point, March 3.	Utah Fish and Game
1964	Observed 5/8 curl ram above Bayles Ranch, spring.	Mahon, Carl
1964	Cave 2 miles northeast of Fry Canyon Store, 18 ewes lambs, June.	Hancock, Norman Magna, E. M.
1964	Mouth of Hideout Canyon in White Canyon 3 miles northeast of Fry Canyon Store, 6 rams, June.	Fields, Larry "
1964	Fry Point, 10 bighorn sheep, June 8.	Blanding Sportsman Club
1964	White Canyon close to Fry Point, one ram, two lambs and eight unclassified, July 8.	Utah Fish and Game
1964	Mouth of Hideout Canyon, 11 bighorns, July 8.	Utah Fish and Game
1964	Observed two bighorn sheep running on rim above Farley Canyon, July 18.	Stavley, Gaylord
1964	Highway 95 between signs marking the Wedding Cake, three rams, four ewes and three lambs, August 18.	Utah Fish and Game
1964	South rim of Blue Notch Canyon, two rams, September 24.	Utah Fish and Game
1964	Castle Butte, one ram, October 6.	National Park Service
1964	Saw bighorn sheep between Spook and Radium King Mines. Winter.	Snyder, Lee
1964	Saw 13 bighorn sheep southwest of Junction Butte, Winter.	Wadsworth, Carl
1964	Bighorn sheep were sighted at Ferron City Dum.	Jeff, Joe Dale, Joe
1964	South rim of Blue Notch Canyon, two rams, November 7.	Utah Fish and Game
1964	Red Canyon near junction with Blue Canyon, one ewe, November 8.	Utah Fish and Game
1964	One ram and one ewe in Blue Canyon, November 9.	National Park Service

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1964	South rim of Blue Notch Canyon and junction of Red Canyon, one ram, November 10.	Utah Fish and Game
1964	Fry Point, 10-12 unclassified bighorn sheep, December.	Utah Fish and Game
1964	Blue Notch Canyon below junction with Red Canyon, three ewes, three lambs, December 30.	Utah Fish and Game
1964	Jacob's Chair, one ram, December 31.	"
1965	Cheesebox Canyon, 14 bighorn sheep sighted, February 1.	Mahon, Carl
1965	Observed 14 sheep in Cheesebox Canyon, February 1.	Espelin, Arlin
1965	Saw 10 to 14 sheep in Cheesebox Canyon, February 8.	Espelin, Arlin
1965	Saw six bighorn sheep at Maybe Spring, February 8.	Barnes, Richard
1965	West of Blue Notch in Blue Notch Canyon, five rams, March 11.	Utah Fish and Game
1965	Blue Notch Canyon near Lake Powell, two rams, March 11.	"
1965	Blue Canyon, one ewe and one lamb, March 30.	"
1965	Blue Canyon, one ewe and one lamb, March 31.	"
1965	Piute Canyon, three ewes and one lamb, March 31.	"
1965	Piute Canyon, nine ewes and lambs, April 1.	"
1965	Natural Bridges National Monument, saw a bunch of bighorn sheep.	Johnson, Florence
1965	Observed five bighorn sheep on Monument Pass, June.	Shumway, Bruce
1965	Observed 15 head of bighorn sheep on Fry Point, June.	Snyder, Lee
1965	On top of Wingate Mesa 1½ miles west of Rainbow Canyon, five rams, June 11.	Wilson, Lanny
1965	Found Mesa, north end, three adult ewes, one yearling ram and one yearling ewe, June 17.	"
1965	Ram Mesa, four adult rams, June 18.	"
1965	Rainbow Canyon, one adult ewe, one yearling ewe, two unclassified, June 24.	"
1965	Wingate Mesa, between Mahon and Rainbow Canyons, large ram, July 3.	"
1965	Three rams on top of Wingate Mesa at head of Blue Canyon, July 3.	"

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1965	Sandstone knobs above Wingate above Blue Notch Canyon, large ram, July 8.	Wilson, Lanny
1965	Four rams on Wingate Mesa, head of Blue Canyon, July 14.	"
1965	Small isolated Mesa, east of Natural Bridges housing area, yearling ewe, July 17.	Mahon, Carl
1965	Middle of Hidden Valley, two ewes, two lambs, young ram, July 24.	Wilson, Lanny
1965	Middle of Hidden Valley, two ewes and one lamb, July 25.	"
1965	Bighorn sheep ewe observed on the Shafer Trail, July 29.	Rothfuss, Ed
1965	Small ram in upper Blue Canyon, August 2.	Wilson, Lanny
1965	Two ewes, two rams, one lamb, upper Hidden Valley, August 3.	"
1965	Two ewes, two rams, one lamb, upper Hidden Valley, August 4.	"
1965	One small lamb, Rainbow Canyon, August 10.	"
1965	On Wingate Mesa, above Hidden Valley, two ewes, two rams, and one lamb, August 14.	"
1965	North slope of Hidden Valley, two rams, two ewes and one lamb, August 15.	"
1965	Hidden Valley (upper), three ewes, one lamb, one ram, August 30.	"
1965	Hidden Valley (upper), three ewes, one lamb, one ram, August 31.	"
1965	Observed 10 sheep (lambs and ewes) at Sheep Bottoms, August.	Thille, Bob
1965	One lamb, four ewes, one ram, Wingate Mesa above Hidden Valley and White Canyon, September 1.	Wilson, Lanny
1965	One, one-half curl ram, Ram Mesa, September 2.	"
1965	Saw two ewes on Fry Point, September.	Gallian, Carl
1965	Observed three to four bighorn sheep on Escalante River, September.	Ross, Kenny
1965	Saw two bighorn sheep in Hatch Canyon, September 12.	Mahon, Carl
1965	Tracks of two to 14 head of lambs and ewes in Blue Notch Canyon, October 13-15.	"

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1965	Observed a half curl ram in Steer Pasture Canyon, October 20.	Mahon, Carl
1965	Observed three bighorn sheep (two ewes, one lamb), Blue Notch Canyon, October 21.	"
1965	Saw a single ewe above confluence of the Green and Colorado Rivers on the Green River, Fall.	Holms, J.
1965	Saw a large ram at the Happy Jack Mine landing strip on Highway 95, November 14.	Staveley, Joan and Gaylord
1965	Saw five bighorn sheep below the Goosenecks of the San Juan River, December.	Navajo Indian
1965	Bighorn sheep sighted below Goosenecks on the San Juan River. He was 80 years old and said he had always seen sheep there since he was a boy and saw 60 in one herd years ago. December.	"
1965	Saw a large ram in lower Blue Notch Canyon, December 10.	Mahon, Carl
1965	Saw two rams and four ewes just above Lake Powell in lower Blue Notch Canyon, December 10.	"
1966	Lower Blue Canyon, 5/8 curl ram, January.	"
1966	Saw the tracks of one bunch of 16 bighorns and another bunch of 10 in lower Rainbow Canyon, January.	"
1966	Saw several tracks of bighorn sheep moving south in lower Red Canyon, January.	"
1966	Saw a very large bighorn sheep track above Warm Spring in lower Red Canyon, January.	"
1966	Saw fresh bighorn sheep tracks on Found Mesa, January.	"
1966	Saw fresh bighorn sheep tracks on Jacob's Chair, January.	"
1966	Saw 25 bighorn sheep from the mouth of the Green River to Anderson Butte, January.	Tangreen, Carl
1966	Saw tracks of one bighorn sheep at the head of Blue Canyon on Wingate, Mesa, January.	Mahon, Carl John, Rodney
1966	Saw bighorn sheep tracks in Steer Pasture Canyon, January.	"
1966	Saw one yearling ram in Rainbow Canyon, January.	"
1966	Bighorn sheep tracks on road from Blue Lizard Mine to Radium King Mine, January.	"

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1966	Saw tracks of six bighorn sheep in bottom of upper Blue Notch Canyon, January.	Rodney, John
1966	Saw tracks of 13 bighorns on Wingate Mesa above Blue Notch Canyon, January.	"
1966	One ram on Mossback Mesa east of Happy Jack Mine, January 15.	Wilson, Dick
1966	Found skeleton of large ram at edge of White Canyon two miles from Fry Canyon Store, January.	Wilson, Dick
1966	Saw 3/4 curl ram at Spook Mine.	Myers, Art
1966	Mossbacks above Soldier Crossing, one ram, January 15.	Utah Fish and Game
1966	Three rams and 11 ewes and lambs, 1½ miles east of Fry Point, January 18.	"
1966	Fry Point, two rams, six ewes, three lambs, January 19.	"
1966	Blue Canyon, one ewe and one lamb, January 21.	"
1966	Jacob's Chair, two bighorn sheep, unclassified, March 22.	Wilson, Lanny
1966	Upper Blue Notch Canyon, three yearling ewes, four adult ewes, March 23.	" Mahon, Carl
1966	Lower Red Canyon, just above Lake Powell, one yearling ewe, four adult ewes, March 29.	Wilson, Lanny
1966	Nineteen head of bighorn sheep seen on White Rim by Martin Ellis, March.	Atkinson, Delbert
1966	Two adult ewes, Castle Butte, April 3.	Wilson, Lanny
1966	Sandstone knobs on Wingate Mesa above Blue Notch Canyon 10 rams, April 21.	"
1966	Talus slope under Wingate between Wilson and Mahon Canyons, two adult ewes, one yearling ewe, April 23.	"
1966	Wingate Mesa between Wilson and Mahon Canyons, three adult rams, April 24.	"
1966	Upper Rainbow Canyon, old ewe, April 25.	"
1966	Piute Canyon, four yearlings, six ewes, one small ram, April 26.	"
1966	Wingate Mesa between Piute Canyon and Blue Canyon, five rams, April 29.	"

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1966	Middle Point above Cataract Canyon, five rams, May 5.	Mahon, Carl and
1966	Gypsum Canyon, unclassified bighorns as to sex and number, May 6.	Wilson, Lanny
1966	Two year old ram, mouth of Young's Canyon, May 7.	"
1966	Two adult ewes, Dark Canyon just before mouth of Lost Canyon, May 11.	"
1966	Sun Dial, two unclassified bighorns, May 13.	"
1966	Mouth of Hidden Valley, two year old ram, May 23.	"
1966	Found Mesa, west end, two lambs, three ewes, one ram, May 24.	"
1966	Ram Mesa, four adult rams, May 26.	"
1966	Five adult rams on top of Wingate Mesa above Blue Notch Canyon, June 3.	"
1966	Sighted four unclassified bighorns on the north side of Dark Canyon, June 5.	"
1966	Followed one, two year old ram, three adult ewes and two lambs from Found Mesa to Fry Point, June 6.	"
1966	Observed bighorn sheep on top rim of Fry Point, June 8	Rusch, Hubert
1966	Wilson Canyon on top of Wingate Mesa, three adult rams, June 20.	Wilson, Lanny
1966	Just under Wingate Cliff between Mahon Canyon and Rainbow Canyon, three adult ewes and two lambs, June 21.	"
1966	Mid-Rainbow Canyon, one ewe and one lamb, June 22.	"
1966	Found Mesa, 11 lambs, 15 ewes, six yearlings, June 27.	"
1966	Ram Mesa, two adult rams, June 29.	"
1966	Lone Butte Mesa, one, two year old ram, adult ewe, lamb, June 30.	"
1966	Piute Canyon, two adult ewes, one yearling ewe, one yearling ram, July 5.	"
1966	Mid-Blue Canyon, four ewes, three lambs, one two year old ram, July 7.	"
1966	Lower Hidden Valley, one ewe, one lamb, July 18.	"
1966	Castle Butte, unclassified bighorn sheep, July 22.	"

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1966	Sandstone Knobs on Wingate Mesa above Blue Notch Canyon, six rams, July 23.	Wilson, Lanny
1966	Three-quarter curl ram, head of Blue Canyon on Wingate Mesa, July 27.	"
1966	Blue Canyon, six ewes, three lambs, July 27.	"
1966	One lamb, two ewes, Piute Canyon, July 28.	"
1966	Four ewes, two lambs, and a two year old ram in Hidden Valley, October 17.	"
1966	Five rams on Sandstone Knobs on Wingate Mesa, October 20.	"
1966	Four adult ewes, one yearling ewe, one yearling ram, three lambs, two adult rams on Jacob's Chair, October 25.	Drobnick, Rudy Wilson, Lanny Mahon, Carl
1966	Adult ram and one unclassified bighorn in lower Red Canyon, October 26.	"
1966	Mouth of Wilson Canyon, one adult ram, October 27.	"
1966	Arm of Wingate Mesa between Wilson and Mahon Canyons, adult ram, October 27.	"
1966	Two year old ram between Piute and Blue Canyons, October 28.	"
1966	Large adult ram on Chinle hill between Piute and Blue Canyons, October 28.	"
1966	Two ewes, one lamb, one two year old ram in lower Blue Notch Canyon, November 2.	"
1966	Two ewes, one lamb, one two year old ram and a large adult ram in lower Blue Notch Canyon, November 3.	"
1966	Found Mesa, three year old ram, November 6.	Wilson, Lanny
1966	Two year old ram in Lower Blue Notch Canyon, November 7.	"
1966	Three ewes, three lambs, yearling ram, large adult ram in upper Blue Notch Canyon, November 10.	"
1966	Three ewes, two lambs, yearling ram, one two year old ram and four adult rams in mid-Blue Notch Canyon, November 12.	"

Table 32. Continued

Year of sighting	Location and remarks	Sightee
1966	Three ewes, two lambs, yearling ram, one two year old ram and six adult rams in mid-Blue Notch Canyon, November 13.	Wilson, Lanny
1966	Three ewes, two lambs, yearling ram, a two year old ram and eight adult rams in mid-Blue Notch Canyon, November 14.	"
1966	Three adult rams and four unclassified bighorns, Blue Canyon, November 15.	"
1966	Two ewes and five rams in Rainbow Canyon, November 16.	"
1966	Two rams, three ewes west of Wilson Canyon, November 17.	"
1966	Observed one large ram, one small ram and eight ewes and lambs on Pound Mesa, December 8.	Mahon, Carl
1966	Saw fresh sheep tracks and droppings on Jacob's Chair, December 9.	"
1966	Saw two one-half curl rams on Jacob's Chair, December 9.	"
1966	Saw fresh tracks of 18 to 20 head of bighorn sheep in Hidden Valley, December 10.	"

VITA

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Master of Science

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Major Field: Wildlife Biology

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