1969

Competition for food between mule deer and bighorn sheep on Rock Creek Winter Range Montana

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COMPETITION FOR FOOD BETWEEN MULE DEER AND BIGHORN SHEEP
ON ROCK CREEK WINTER RANGE, MONTANA

By

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B.A., University of California, 1967

Presented in partial fulfillment of the requirements for the degree of

Master of Science

UNIVERSITY OF MONTANA

1969

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Oct 23, 1969
Date

ERRATA

Page 9, paragraph 2, line 4, "73"should be "43".

Page 18, paragraph 2, line 1, "Homogencity" should be "Homogeneity".

ACKNOWLEDGEMENTS

This study was financed by the School of Forestry, University of Montana, the Montana Cooperative Wildlife Research Unit,[1] the Montana Fish and Game Department, and the American Museum of Natural History. The U.S. Forest Service provided a cabin on the study area.

I wish to thank here the many people whose cooperation and help made the study possible.

Dr. Richard D. Taber, and fellow students, Steve Berwick and Mike Aderhold, gave many helpful suggestions in the early stages of the study.

Jeff Hart helped with the summer field work. Hok Grotbo and Fred Hartkorn spent time in the field with me and gave much valuable information on the past history of game populations and land use on the study area. Dr. Bart O'Gara and fellow students, Dennis Billings, Bill Gabriel, Gerry Gill, and Per Wegge helped with the deer collections.

The residents of upper Rock Creek have supported the study in many ways. Special thanks go to Robert Neal and Larry Clark and their families for their assistance and hospitality while I lived on the study area.

My wife, Else, did most of the microtechnique work for the food habits studies. Kenneth Greer of the Wildlife Investigations Laboratory, Bozeman, made available his facilities and help for food

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1/ U.S. Fish and Wildlife Service, Montana, Fish and Game Department, University of Montana and Wildlife Management Institute cooperating.

habits analyses of rumens. Drs. David Worley and William Hawkins of the Veterinary Laboratory, Bozeman, provided advice and assistance with the parasite and disease work.

Dr. Howard E. Reinhardt and Dr. James Bailey gave advice on statistics. Dr. Bart O'Gara and Dr. James Bailey provided much editorial help in the preparation of the thesis. Dr. Lee Eddleman, Dr. Philip Wright, Dr. W. Leslie Pengelly, Professor Melvin Morris and Mr. Reuel Jansen read and offered suggestions on the thesis. The advice and encouragement of Dr. E. T. Bennett during the entire study is gratefully acknowledged.

Special thanks go to Dr. James Bailey, Dr. Bart O'Gara and my wife, Else, who gave generously their time and advice and whose support and encouragement made the study possible.

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I

INTRODUCTION

The Rock Creek winter range in western Montana has supported substantial herds of mule deer (*Odocoileus hemionus*) and bighorn sheep (*Ovis canadensis*) (Berwick 1968). Berwick (*op. cit.*) described the area: its geology, soils, flora and fauna, climate, and land use history. He believed that the number of deer wintering on the area had been increasing in recent years, being around 800 animals in 1968. The sheep herd, on the other hand, has declined drastically (Berwick *op. cit.*). My own sight observations indicate a minimum of ten sheep remaining as of January, 1969.

In response to the sheep decline, two graduate students from the School of Forestry, University of Montana began study of the sheep herd in December 1966. Aderhold (1968), whose field work ended in December 1967, reported on the history, condition, and status of the sheep herd. Berwick (1968), in a broad ecological study based on field work through April 1968, described factors limiting the sheep herd. He suggested that mule deer were competing seriously with sheep for food and that the herd should be reduced to permit the sheep population to increase to 200 animals, the estimated number present before 1965.

The objectives of my study were: (1) to investigate the competition for food between bighorn sheep and mule deer, (2) to evaluate the effect of increased numbers of deer on the sheep decline at Rock Creek, and (3) to predict the effect of mule deer on any recovery of the sheep population.

A. Competition among Ungulates

Clements and Shelford (1939) define interspecific competion as "the active demand by two or more species for a common resource that is limiting." Miller (1967) distinguishes two types of competition, interference and exploitation.

Interference refers to any activity which either directly or indirectly limits a competitor's access to a necessary resource. Feeding territories defended by many birds are examples of interference. In ungulates this form of competition between species has seldom been reported and does not appear to be very common.

Exploitation refers to utilization of a resource. Many northern ungulate herds are limited by availability of palatable foods nutritious enough to sustain the animals through winter. Competition among these animals, if present, will normally consist of exploitation of winter food. The competitive ability of a species will depend on the ability of the population to acquire and utilize food efficiently for survival and reproduction. The competitive ability will thus be determined by the anatomical, physiological, and behavioral adaptations of the species.

B. Comparative Biology of Bighorn Sheep and Mule Deer

Evolution, Zoogeography, Status. Buechner (1960) and Cowan (1940, 1956) describe the evolution and zoogeography of bighorn sheep and mule deer. Ancestors of the North American representatives of the genera Odocoileus and Ovis evolved in Asia and migrated to the New World via the Bering Strait during Late Tertiary and Pleistocene times. Similarly, the ancestors of both mule deer and bighorn sheep survived

Pleistocene glaciation in southern refugia. With retreat of the glaciers both species dispersed and are now widespread, although within its geographic range the bighorn is much more localized in distribution.

In historic times mule deer have thrived and even increased after an initial period of decline (Leopold 1953). The bighorn, on the other hand, has decreased to a fraction of its original number (Buechner 1960).

Habitat preference, Migration, Dispersal. Bighorn sheep are typical of rugged, precipitous areas adjoining and interspersed with open grassland (Capp 1968). Sheep are extremely reluctant to leave the protection of rocky areas. This is possibly due to their evolution with wolves to which they were vulnerable when away from their open, rocky habitat. However, in areas where all wolves have been eliminated sheep are seldom observed far from the cover of rocks.

Mule deer occupy a wide range of habitats, being typical of open forests and open brushlands on steep and rugged terrain. In particular, deer thrive where fire, logging, flooding, and other disturbances continually renew forest succession and produce an interspersion of cover types (Cowan 1956). In general, mule deer are much more likely to be found in or adjacent to forests than bighorn sheep.

Both species normally migrate twice a year. In northern mountain areas they typically move in the fall to lower elevations and concentrate on winter ranges where food is more available, snow depths are less, and weather is less severe than at higher elevations. Sheep and deer populations are generally limited by availability of food on winter ranges. Normally, it is on these areas that interspecific and intraspecific competition for food is greatest.

The two species differ greatly in their ability to disperse to new areas. Mule deer have a social organization partially based on family groups, each consisting of a doe, her single or twin fawns, and her yearling offspring. In the spring the yearlings leave the family group (Dorrance 1966) and these animals may disperse into new areas (Robinette 1966). Bighorn sheep are more gregarious. Geist (1967) has described the behavior patterns that limit the ability of mountain sheep to disperse into new areas. Sheep tend to stay in bands year-round. The young learn migratory routes and seasonal movement patterns from older animals. No particular age class leaves the bands or is driven off, and dispersal into new ranges is rare.

Food habits. Bighorn sheep are typically grazers relying heavily on grass throughout the year, while deer are basically browse and forb eaters (Capp 1968). However, under certain circumstances deer will eat considerable amounts of grass (Nellis and Ross 1969). Likewise, sheep have been reported to eat substantial quantities of browse (Welles and Welles 1961, McCullough and Schneegas 1966). Both species eat green forbs when available and it appears that when food is limited both can be opportunistic in their feeding habits. However, in general, sheep rely on and seem to prefer grass during all seasons, whereas deer seem to prefer forbs and browse (Table 1).

Reproduction. Both species are promiscuous. Female deer typically breed first when $1\frac{1}{2}$ years old and fawn at 2 years. Twins are normal on good range. On poor range twins are less common (Robinette 1956). Bighorn sheep seldom breed until $2\frac{1}{2}$ years old and twins are extremely rare. However, under favorable circumstances yearlings may breed

(Woodgerd 1964). Furthermore, twins may be more common. Spalding (1966) reported that 4 out of 12 bighorn sheep killed by cars in southern British Columbia carried twin fetuses. In general, however, the biotic potential is much higher in deer than in sheep.

Mortality. Mortality patterns are difficult to characterize for either species since they vary greatly with range condition, hunting pressure, and predation. It appears that the young and very old are most vulnerable in both species (Davis 1938, Cowan 1950, Buechner 1960, Einarsen 1956, Taber and Dasmann 1958). Relatively few animals survive to old age and animals under two years suffer the heaviest losses.

Bighorn populations are characterized by violent fluctuations in numbers due to epidemic disease, in particular the "lungworm-pneumonia complex" discussed by Buechner (1960). Epidemic disease among mule deer has seldom been reported but is known to occur (Cowan 1946).

Limiting factors, Population control. Many studies have shown that lightly hunted mule deer populations in northern areas are limited primarily by winter food (Hill 1958). Decreased availability of adequate winter food causes mortality directly by starvation and also increases susceptibility to other mortality factors such as disease, predation and accidents.

Population control in bighorns is not as well understood. Buechner (1960) suggested that the "lungworm-pneumonia complex" may limit sheep populations even without the prerequisite of malnutrition. However, he states that the disease does function to control population in a density-dependent fashion because epidemic mortality is more frequent and causes a higher percentage of mortalities in very dense populations. The relationship between range condition and lungworm disease is not well understood. Both Buechner (1960) and Bandy (1968) note that mass mortality due to lungworm is most prevalent on low altitude ranges. Buechner (1960) states that only on such ranges do the vegetation and climate allow populations to reach high densities. The implication is that sheep herds at high altitudes, like most northern herds of mule deer, are limited by available winter food as determined by range condition and severity of weather.

Summary. Although bighorn sheep and mule deer evolved in nearly the same geographic areas at about the same time, they have adapted to quite different niches.

The bighorn sheep has adapted to rocky areas interspersed with grassland. It is reluctant to leave these areas, does not disperse rapidly into new regions, has a comparatively low biotic potential, and in most areas has declined in historic times as disturbance by man has increased.

The mule deer, on the other hand, has adapted to successional vegetation in mountainous and forested areas and is found in greater abundance and in a greater variety of habitats than is the bighorn. The mule deer has a higher biotic potential, a good dispersal mechanism and in general has thrived where man-caused disturbance such as logging and fire have altered the environment.

In spite of such divergent adaptations, in certain areas and at certain times the two species share resources and are thus at least potential competitors.

C. Review of Studies of Bighorn Sheep-Mule Deer Competition

Most research on sheep-deer competition has been limited to measuring overlap in food habits and has not investigated the more difficult problems of determining: (1) what foods or resources limit the populations, (2) whether competition is by means of interference or exploitation as defined by Miller (1967), or (3) whether competition is reduced by differential use of habitat types.

There is very little evidence that interference plays a significant role in mule deer-bighorn sheep competition. Smith (1954), Russo (1956), Sugden (1961), and Berwick (1968) have observed sheep and deer feeding, bedding and fleeing together. In most instances, each species appears to be completely indifferent to the other except that alarm reactions in one species may be noticed or reacted to by the other. However, Sugden (1961) stated that although bighorn sheep and mule deer frequently fed together, they more often tended to feed apart. Furthermore, Hunter and Kinghorn (1950) describe an incident of apparent dominance of bighorn sheep over mule deer in which a band of sheep chased some antlerless mule deer from hay. The available evidence thus suggests that interference, although present, is no more than a minor element in mule deer-bighorn sheep competition.

Several studies of mule deer and bighorn sheep have found competition by exploitation to be of little significance in limiting sheep populations. Cowan (1947), in a study of ungulate competition in Jasper National Park, observed feeding animals during the winter and found the bighorns eating 83 percent grass and 7 percent browse, while mule deer ate 15 percent grass and 79 percent browse. He concluded that, due to differences in spatial distribution, the degree of competition was even less than the small overlap in food habits indicated. He noted that deer were eating more grass and less browse due to range deterioration and suggested that when deer are forced to increase their intake of grass they compete more seriously with sheep. Likewise, Flook (1964), working in Banff and Jasper National Parks, found sheep relying mostly on grass and deer mostly on browse during winter; he concluded that competition between the two species was minimal. In both studies, the workers assumed that the forage most heavily relied upon was limiting each species.

Jones (1950) suggested that competition from mule deer might adversely affect bighorn sheep of the Sierra Nevada in California. However, McCullough and Schneegas (1966) in a brief survey found that, even though sheep appeared to feed heavily on browse, overlap in food utilization was minimal due to spatial separation of the two species.

Yoakum (1966), studying rumen samples taken July through November from nine mule deer and nine desert bighorns on the Desert Game Range, Nevada found minimal food overlap. He found deer eating 77 percent browse, 23 percent forbs, and only a trace of grass, while sheep were eating 65 percent grass, 6 percent forbs and 29 percent browse. He also found that the animals' preferences were quite different. Preference indices (percent of each forage class in rumen divided by percent of the available forage represented by each forage class) for sheep were 1.7 for grass, 0.4 for forbs and 0.6 for browse. Indices for deer were 0 for grass, 1.5 for forbs and 1.7 for browse.

Other workers found more competition. Halloran and Kennedy (1949) showed that in New Mexico bighorn sheep and mule deer food habits overlapped, and they stated that the species compete for food. Constan (1967) studied mule deer-bighorn sheep food competition in Gallatin Canyon, Montana, and concluded that in spite of differential food preferences and habitat selection some overlap existed. Winter feeding-site observations indicated bighorns utilizing 72 percent grass, 17 percent forbs and 8 percent browse. Rumen analyses for the mule deer during the same period indicated utilization of 16 percent grass, 19 percent forbs and 61 percent browse. Constan (op. cit.) indicated that some competition between the animals existed.

Schallenberger (1966) working on the Sun River winter range, Montana, concluded that mule deer and bighorns competed for food where their ranges overlapped. Winter feeding-site observations indicated that bighorns were eating 36 percent grass, 21 percent forbs and 73 percent browse. It is noteworthy that on this range the principal bunchgrasses were very heavily grazed, perhaps accounting for the lower percent utilization of grass by sheep.

It is clear from Table 1 that there can be substantial overlap in bighorns and mule deer utilization of forage classes. However, the overlap in food habits is much less than such data indicate because of differential range utilization and differential utilization of plant species within forage classes. Furthermore, overlap leads to competition only if the resource is limiting one species or the other.

Table 1. Food habits of mule deer and bighorn sheep in areas of coexistence.

Area	Season	Technique	Species	Percent of Diet: Grass and Grasslike Plants	Percent of Diet: Forbs	Percent of Diet: Browse	Source
Jasper National Park Alberta	Winter	Animal Observation	Bighorn Sheep	83	10	7	Cowan (1947)
			Mule Deer	15	6	79	
Desert Game Range, Nevada	July-November	Rumen Analysis	Bighorn Sheep	65	6	29	Yoakum (1966)
			Mule Deer	0	23	77	
Sun River, Montana	Fall	Rumen Analysis	Bighorn Sheep	87	9	2 1/	Schallenberger (1966)
	Winter	Feeding Site Observation	Bighorn Sheep	36	21	43	
			Mule Deer	5	22	73	
Gallatin Canyon, Montana	January-March	Feeding Site Observation	Bighorn Sheep	72	17	8	Constan (1967)
			Mule Deer	7	29	62 1/	
		Rumen Analysis	Mule Deer	16	19	61 2/	
Rock Creek, Montana	October-May	Rumen Analysis	Bighorn Sheep	90	7	3	Berwick (1968)
	November-April	Rumen Analysis	Mule Deer	32	38	28 3/	

1/ Total not equal to 100 percent due to rounding off.
2/ Total not equal to 100 percent; remaining 4 percent was Equisetum.
3/ Total not equal to 100 percent; remaining 2 percent was lichen.

II

METHODS AND MATERIALS

The level of competition between bighorn sheep and mule deer was investigated by analyzing range use, food habits, and limiting factors of each population.

A. Range Use

Vegetative mapping. During summer 1968 I mapped the winter range by floristic and physiographic features using the method of Küchler (1955). In addition I ran six transects using the method described by Berwick (1968) to determine floristic composition of the winter range. A work-study student with a background in botany assisted me in this work, which took approximately six weeks.

The transects each consisted of 50 one ft^2 quadrats. A one ft^2 plot frame was thrown into the type to determine the first sample site. Five rows of ten samples each, spaced evenly throughout the type, completed the sampling. The percent of the plot covered by each plant species, using a modified canopy coverage estimate, was recorded. The herbage was gathered so that no ground was visible between the leafage, and the percent coverage was estimated from the 50, 30, 20, 10 and $2\frac{1}{2}$ percent wire divisions of the plot frame.

Data from vegetative mapping and transects plus Berwick's data on floristic composition and forage production were used to make a habitat map. The winter range was divided into 38 areas consisting of six vegetation types.

Animal observation. From January through March, 1969 I lived on the study area and all observations of sheep and deer were recorded noting location, number and activity. Areas in which both deer and sheep occurred were routinely checked. Whenever sheep and deer were seen in close proximity their behavior was observed and recorded to evaluate competition by interference.

Weather observation and measurement. A thermograph was kept at the Wyman Ranch adjacent to the winter range. Throughout the winter snow depths were recorded on the winter range. Data on temperature and snow depths were used in interpreting seasonal changes in habitat use and food habits.

B. Food Habits

Food habits of deer and sheep were determined by rumen analysis, microscopic analyses of feces, and direct observation of feeding animals and feeding sites.

Rumen analysis. Mule deer rumens were obtained from 3 hunter-killed animals, 24 animals collected by shooting under permit from the Montana Fish and Game Department, and 18 carcasses found in the field. The rumen samples were preserved in 10 percent formalin and sent to the Montana Fish and Game Department Wildlife Investigations Laboratory at Bozeman for analysis. At the lab, a one quart sample from each rumen was washed through a 1/8-inch mesh screen to remove small particles. The remaining material was separated and identified, and the volume-percent of each species was determined by water displacement. I made all identifications.

Pellet analysis. Food habits of deer and sheep were analyzed by counting microscopic fragments of plant epidermis in fecal pellets. Croker (1959), Hegg (1961), Storr (1961), Martin (1964) and Stewart (1967) have analyzed food habits of herbivores by counting epidermal remains of plants in feces. The assumption is that the percentage of epidermal remains in the feces will be correlated with the percentage of the plant in the animal's diet.

Fecal pellets were collected from sheep observed in the field and from collected mule deer. To identify epidermal fragments, dry pellets were first soaked for one day in water. Fresh pellets and those kept in plastic bags could be used without soaking. Five pellets from each animal were crushed and macerated. The crushed material from each pellet was placed on a slide under a cover slip. Under a microscope a field of view of the slide was chosen without looking through the eyepiece. The microscope was then focused and at 100X magnification every piece of epidermis whose pattern was visible was classified as conifer, monocotyledon, or dicotyledon. Classification was based on: (1) characteristics observed in the epidermis of reference slides of key forage species from the Rock Creek range, and (2) characteristics described in literature by other workers. When all classifiable epidermis had been tallied another field of view was chosen. This process continued until 20 pieces of epidermis from each of the five pellets per animal had been classified. Results for five slides were used to calculate the mean percentage for each forage class in fecal remains for each animal. Variation among percentages of forage classes on five slides was used to estimate sampling error.

Animal and feeding-site observation. Whenever possible deer and sheep were observed feeding. The amount of time spent feeding on forage classes or species was noted as were the prevailing weather conditions.

When possible, feeding-sites were examined. The feeding animals were located and the area was observed after they had left. The number of plants of each forb and grass species and the number of twigs of each browse species that had been eaten was tallied.

C. Limiting Factors

Factors which Berwick (1968) suggested were limiting the sheep and deer herds were investigated by analyzing food and nutrition, incidence of disease, physical condition, reproduction, and mortality of both species.

Food and nutrition. The possibility that food was limiting sheep or deer was investigated by examining quantity and quality of available food during winter. In fall, milacre plots in five rows of eight plots were established on each area. In September and October bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), and fringed sage (*Artemisia frigida*) were clipped, oven-dried and weighed from every other plot. In March and April, the other 20 plots on each area was clipped and the plants were dried and weighed. Idaho fescue was not clipped in spring because I found the technique unsatisfactory for this species. One area clipped in the fall was not reclipped in spring due to time limitations.

In spring, utilization of bluebunch wheatgrass was measured in three of the same four locations by grazed stem counts (Anon. 1963) and by the gauge method described by Cole (1958). One hundred plants were used in each area for each technique.

The nutritional quality of available forage was investigated by collecting and chemically analyzing key forage species, rumen contents from deer, and feces from both deer and sheep.

Samples of key forage species were collected and analyzed for crude protein, crude fiber, ether extract, ash, calcium and phosphorus. All chemical analyses were done at the Chemistry Station Analytical Laboratory, Montana Agricultural Experiment Station, Bozeman using A.O.A.C. (1955) methods. Portions of at least 10 plants were used for each analysis. Samples were collected by walking a set number of paces and clipping the nearest plant. The portion of the plant which previous observations indicated the animal ate was clipped. When possible plants were clipped adjacent to the plots used to measure forage production and utilization. However, mid-winter snow conditions plus the irregular distribution of some plant species did not allow all samples to be collected in this manner.

Rumen contents from all collected deer and from 18 carcasses found in the field were also analyzed for crude protein, crude fiber, ether extract, ash, calcium and phosphorus. Each rumen sample was preserved in 10 percent formalin and later washed with tap water through six layers of cheesecloth. The remaining plant material was air-dried before analysis.

Fecal pellets, obtained from collected deer and from sheep observed defecating in the field, were analyzed for crude protein, crude fiber, ether extract, ash, calcium and phosphorus. Fecal samples from individual deer were analyzed separately while in some cases samples from several sheep were lumped in order to obtain enough material for analysis.

Parasites and disease. The role of disease in limiting the sheep and deer populations was investigated by checking internal, external and blood parasites of deer, and by counting lungworm larvae in fecal samples of both sheep and deer.

All mule deer collected or found dead were checked for obvious internal and external parasites. Blood was drawn from collected mule deer and tested for anaplasmosis, brucellosis and leptospirosis titers at the Montana Livestock Sanitary Board, Diagnostic Laboratory, Bozeman. Pellets from mule deer and bighorn sheep were collected, in the field and at the Veterinary Laboratory, Montana Agricultural Experiment Station, Bozeman lungworm larvae were removed from them by the technique of Baermann (1917) and counted.

Condition. The physical condition of the mule deer was measured throughout the winter in order to determine seasonal changes and to compare the Rock Creek deer with other herds. Standard measurements taken from collected deer were weight, body length, hind-foot length, chest girth, kidney weight, kidney fat weight, and adrenal weight. Kidney fat indices (Riney 1955) were calculated from these measurements and compared with other herds. Femur marrow was taken from 10 collected animals and from 3 carcasses and the percent compression was measured by the technique of Greer (1968). The percent of ether extract and moisture from the same samples was analyzed at the Chemistry Station Analytical Laboratory, Bozeman.

Reproduction. The reproductive tracts of collected female deer were analyzed in order to determine the degree to which reproduction might be affected by range condition or other environmental factors. Fetuses and corpora lutea were counted for comparison with other mule deer herds. Ovaries from collected deer were preserved in 10 percent formalin in the field. The ovaries were later sliced with a razor blade and the corpora lutea of pregnancy counted. The number of embryos or fetuses was counted and the weight, crown-rump length, and hind foot length of all fetuses was measured.

Mortality. The kinds of mortality and the sex and age classes most vulnerable to mortality were investigated to further elucidate factors limiting each species. All carcasses found in the field were examined to determine sex and age of the animal and probable cause of death. Lower jaws were collected from deer carcasses and aged by tooth replacement and wear. Data from 90 deer carcasses were used to construct a life table.

D. Data Analysis

Much of the statistical analysis was done at the University of Montana Computer Center on an IBM 1620 computer using programs written by me and programs available at the center. Statistical tests used are from Steel and Torrie (1960) unless otherwise noted.

The principal statistics used were one and two factor analyses of variance, chi-square tests, and simple linear correlation. Duncan's new multiple range test (Duncan 1955) was used to determine significance of differences in means when an analysis of variance showed a significant F ratio. For analyses of variance, percentage data containing mostly low numbers (0 - 10%) were tested using both transformed data and the actual values. A modified square root transformation ($x' = \sqrt{x + \frac{1}{2}}$) (Steel and Torrie 1960:157) was used. When comparable F ratios are obtained from both analyses only the untransformed data are presented.

Homogeneity of variances was tested by the F_{max} test of Hartley (1950). Where F_{max} based on the average degrees of freedom exceeded the 0.99 confidence limits I have noted this possible source of error. When heterogenous variances appeared to be causing unrealistic F ratios the analysis was not used.

The 0.05 confidence limits were used for all other tests of significance.

III

RESULTS

A. Range Use

Vegetation. Six vegetation types: (1) grassland, (2) dense timber, (3) open timber, (4) sagebrush, (5) riparian meadows, and (6) parkland, were used to make a habitat map of the Rock Creek winter range (Figure 1). The first five types correspond to types described by Berwick (1968). His cliff-and-talus type is included here in the open timber type. Parkland is a composite of types one through four. In some areas these four types are so interspersed that a composite classification was necessary in order to use the map for tallying animal locations. Table 18 shows the average abundance of plant species on each type during the summer. This table represents a synthesis of data from vegetative mapping and from range transects (Table 19).

Weather. The months of January through March, 1969 were characterized by temperatures below freezing (Table 2). In late December several snowstorms covered the winter range with approximately 2 feet of snow. In January, more snow fell, very little melted, and by February an average of 2 feet was still on the ground. February remained cold with only a few days with temperatures above 40F at the end of the month. On March 1, about 1.5 feet of snow remained on the ground and only on a few open, south-facing slopes was the snow thin enough to allow deer and sheep to utilize ground vegetation. The first part of March remained

Table 2. Temperature records from the Wyman Ranch, Rock Creek.

Month	Number of days of measurements	Number of days in which temperature was above 32F.	Number of days in which temperature was above 40F.
December 1968	23	7	4
January 1969	26	10	1
February 1969	24	18	5
March 1969	29	25	16

cold, but the second half was characterized by temperatures reaching 50F. During the latter period snow disappeared rapidly and by mid-April green forbs and grasses were present in all areas.

Range use. Sightings of deer and sheep, obtained while systematically checking the winter range during January and February, 1969, are tabulated by habitat type in Table 3. I spent less time in March checking the range in this manner and the values for this month were inadequate for tabulation.

Table 3. Sheep and deer sightings, by habitat types, during 32 periods of systematic observations on the Rock Creek winter range, January and February 1969.

Species	Number of observations	Percent of total observations of each species					
		Riparian meadow	Parkland	Sagebrush	Open timber	Dense timber	Grassland
Mule Deer	320	0	22	5	30	3	40
Bighorn Sheep	78	0	1	0	46	8	45

The distributions of sheep and deer sightings by habitat types for January and February combined (Table 3) are significantly different

($p < 0.05$, Table 4). If the number of animal sightings in a habitat is correlated with animal use of such habitat, then this difference indicates that (1) sheep and deer prefer different habitat types, or (2) sheep and deer prefer the same habitat types but utilization on certain types is higher by one species due to competitive interference. The most obvious difference is the higher percentage of sightings of mule deer in the parkland type. However, the percentage of sheep sightings in the open timber type is much higher than the percentage of deer sightings in that type.

Table 4. Test of significance of difference between sheep and deer sightings by habitat types during 32 periods of systematic observations during January and February, 1969.

Habitat Type	Mule Deer f 1/	Mule Deer f_c 2/	Bighorn Sheep f 1/	Bighorn Sheep f_c 2/	$\frac{(f-f_c)^2}{f_c}$
Parkland	69	56.3	1	13.7	14.6
Open timber	96	106.1	36	25.9	4.8
Sagebrush	15	12.1	0	2.9	3.6
Dense timber	10	12.8	6	3.2	2.8
Grassland	130	132.7	35	32.3	.3
Riparian meadows	0	0	0	0	0
					χ^2 = 26.1*

* significant at the 0.05 level.

1/ the observed number of sightings.

2/ the expected number of sightings assuming the null hypothesis that there is no difference in the distribution of sheep and deer sightings by habitat types.

The possibility that competition by interference was influencing sheep or deer distribution was investigated by testing the null hypothesis that the frequency of sightings of sheep and deer together on an area is equal to the frequency of sightings of sheep (either alone or with deer), times the frequency of sightings of deer (alone or with sheep).

During 20 days in January and February on two areas of about 80 acres each, deer were present 20 of the 38 times one area or the other was checked. Sheep were present 8 of the 38 times including 4 times during which both species were present. A chi-square value was calculated using the frequency of deer sightings (20/38) times the frequency of sheep sightings (8/38) as the expected value, and the frequency of sightings of sheep and deer together (4/38) as the observed value. The results indicated that the null hypothesis was sound ($\chi^2 < 0.02$, df = 1, $p > 0.99$).

B. Food Habits

Mule deer. Results of 47 analyses of rumen contents (Table 20) are summarized in Table 5. Variation among months for all three forage classes in rumens is significant ($p < 0.05$, Table 6). The mean percent of grass in rumens is quite low in mid-winter but increases significantly to 49 percent in April and May (Table 7). Forbs and browse comprise about 90 percent of the rumen contents from December to March; however, browse accounts for about 80 percent from January through March (Table 7).

The most abundant species in the rumens from the winter of 1968-1969 were big sagebrush (*Artemisia tridentata*), Douglas fir (*Pseudotsuga menziesii*), and rocky mountain juniper (*Juniperus scopulorum*). The mean percentage of these forages is 29, 17, and 9, respectively for all shot animals and 3, 12, and 9 for all animals found dead.

Table 5. Percentages of grass, forbs, and browse in rumens of mule deer on Rock Creek winter range, 1968-1969.

Month	No.	How obtained	Grass and grasslike plants Mean	SE 1/	Forbs Mean	SE 1/	Browse and lichens Mean	SE 1/
November-December 1968	6	Shot	12	7	43	11	45	14
January 1969	5	"	4	2	8	5	88	7
February 1969	5	"	4	3	15	5	81	5
March 1969	5	"	18	6	11	4	71	9
April-May 1969	6	"	49	10	29	7	22	4
February 1969	4	Carcass	3	2	30	14	67	12
Mid-winter 1969 2/	9	"	20	5	13	4	67	8
April 1969	5	"	55	13	31	14	14	6

1/ Some data are skewed due to presence of zeros; SE values calculated from these samples are only approximations of the variance.

2/ These represent carcasses found during January, February, and March for which the month of death could not be determined.

Table 6. Analyses of variance among months for percent of forage classes in rumens from 27 mule deer collected on Rock Creek winter range, 1968-1969. 1/

Forage class	Between Months df	Between Months Mean square	Within Months df	Within Months Mean square	Calculated F ratio 2/	$F_{.05}$
Grass and grass-like plants	4	1972.2	22	233.4	8.45*	2.82
Forbs	4	1189.9	22	302.0	3.94*	2.82
Browse and lichen	4	4188.1	22	440.6	9.50*	2.82

*significant at the 0.05 level.

1/ months compared and sample sizes are: November-December(6), January (5), February(5), March(5), and April-May(6).

2/ the F ratios obtained using a modified square root transformation ($x' = \sqrt{x + \frac{1}{2}}$, Steel and Torrie 1960:157) were 8.47, 3.91, and 8.48 for grass, forbs, and browse, respectively.

Table 7. Proportions of grass, forbs, and browse in rumens of mule deer collected on Rock Creek winter range, 1968-1969.

Period / Number / Forage	November-December (6)	January (5)	February (5)	March (5)	April-May (6)
Grass and Grasslike Mean Percentage of rumen contents 1/	12	4	4	18	49
Forbs Mean Percentage of rumen contents 1/	43	8	15	11	29
Browse Mean Percentage of rumen contents 1/	45	88	81	71	22

1/ Means connected by lines are not significantly different at the 0.05 level as determined by Duncan's new multiple range test (Duncan 1955).

An analysis of variance showed no significant difference ($p > 0.05$) among months in the amount of big sagebrush in the rumens of collected animals. However, the frequency of occurrence of sagebrush is significantly higher in collected animals than in those found dead ($\chi^2 > 13.1$, df = 1, $p < 0.05$).

Comparison of pellet analyses with rumen analyses. Analyses of plant species in rumen contents and epidermal remains of plants in fecal pellets from the same 24 deer provided an opportunity to compare the two methods for estimating food habits. There is a significant linear correlation ($r = 0.86$, df = 22) for monocots between percentage in the rumen and percentage of epidermal remains in pellets. The equation obtained ($Y = 0.76 + 1.02X$, where Y is the percentage in rumens and X is the percentage in fecal pellets) passes near the origin and has a slope close to one. The correlations for dicots and conifers were not significant, the correlation coefficients being .23 and .22, respectively.

Bighorn sheep. Table 8 shows the percentage of identifiable epidermal remains of monocots, dicots, and conifers in fecal pellets of sheep by months. Monocots comprise the largest percentage of epidermal remains for all months and vary only slightly among seasons.

Feeding site observations indicated that Idaho fescue and bluebunch wheatgrass made up the largest percentage of monocots eaten by sheep. I observed sheep eating small quantities of weathered great basin wildrye (Elymus cinereus) during February when snow was deep and very little other grass was available above the snow.

The only forb that I observed sheep eating in large amounts during winter was fringed sagebrush. Sheep would paw through the snow for this plant when weathered bluebunch wheatgrass was available in abundance without pawing. On two occasions feeding-site observations indicated sheep were taking at least 30 percent fringed sage, the remaining 70 percent consisting largely of bluebunch wheatgrass. During mid-winter sheep often ate fringed sagebrush down to the ground.

I observed sheep eating the following plants in small quantities during winter: Artemisia tridentata, Chrysothamnus nauseosus, Chrysothamnus viscidiflorus, Erigeron divergens, Juniperus scopulorum, and Leptodactylon pungens. Stems of the latter plant were often bitten off and then dropped.

Table 8. Percent of identifiable epidermal remains of plants in bighorn feces collected on Rock Creek winter range, 1968-1969.

Month	Number of Sheep	Monocotyledon			Dicotyledon			Conifer		
		$\bar{x}$	range	SE 1/	$\bar{x}$	range	SE 1/	$\bar{x}$	range	SE 1/
June, 1968	2	76	74-77		23	21-25		2	1-2	
September, 1968	3	76	67-83		22	13-31		2	1-4	
January, 1969	8	69	15-96	10	16	4-28	3	15	0-65	8
February, 1969	5	64	56-80	6	25	12-34	4	11	6-23	3
March, 1969	3	73	70-75	2	6	4-9	2	21	20-22	1

1/ Standard errors are calculated only when n>4. Some of the data are skewed due to presence of zeros; the SE values in these cases are only approximations of the variance.

Comparison of food habits of sheep and deer. Table 9 shows that fecal pellets of bighorn sheep contained a much higher percentage of monocot remains than those of deer. If the percentage of identifiable monocot remains in feces is directly correlated with percentage in their diet, then the greatest degree of overlap in use of this forage occurs in spring when deer utilization of grass increases.

Table 9. Percentages of identifiable remains of monocotyledons in feces of mule deer and bighorn sheep.

Period	Percentage of epidermal remains in mule deer feces	Percentage of epidermal remains in bighorn sheep feces
November-December 1/	11	72
January	6	69
February	6	64
March	17	73
April-May 1/	45	74

1/ Percentages for bighorn sheep for this period derived by interpolating values in Table 8.

C. Limiting Factors

Food and nutrition. The correlations among forage utilization figures derived by four techinques (Table 10) are generally poor. However, all techniques indicate that utilization on bluebunch wheatgrass and fringed sagebrush during winter of 1968-1969 was generally low.

Chemical analyses of forages (Table 23) indicate that the most pronounced seasonal change in bluebunch wheatgrass is a decrease in

Table 10. Production and utilization of three key forage species.

Area	Year	Principal Use	Species	Method	Pounds Per Acre 1/ Summer Mean	Fall Mean	Fall SE	Spring Mean	Spring SE	Percent Utilization Mean 2/	SE 3/	Source
Exclosure 1	1967-1968	Bighorn Sheep, Mule Deer	Agropyron spicatum	Clipping 50 4.8 ft plots	336			174		48		Berwick (1968)
			Festuca idahoensis		0			0		0		
			Artemisia frigida		74			62		21		
Exclosure 2		Bighorn Sheep, Mule Deer	A. spicatum		476			362		24		
			F. idahoensis		0			0		0		
			A. frigida		114			66		57		
Exclosure 3		Cattle, Bighorn Sheep, Mule Deer	A. spicatum		558			201		82		
			F. idahoensis		174			41		24		
			A. frigida		148			6		96		
Exclosure 4		Cattle, Mule Deer, Bighorn Sheep	A. spicatum		626			2		99		
			F. idahoensis		3			0		76		
			A. frigida		45			11		100		
Exclosure 5		Bighorn Sheep, Mule Deer	A. spicatum		82			108		Negative 4/		
			F. idahoensis		118			71		39		
			A. frigida		2			24		Negative 4/		
Exclosure 1	1968-1969	Bighorn Sheep, Mule Deer	A. spicatum	Grazed stem counts (GSC)						11		Present study
				Gauge method						<1		
				Clipping 20 milacre plots		154	24	133	17	14*	3	
			A. frigida			11	3	7	1	36	42	
Neal Ranch, open s. facing grassland		Cattle, Mule Deer	A. spicatum	GSC						21		
				Gauge						2		
Exclosure 3		Bighorn Sheep, Mule Deer 5/	A. spicatum	GSC						6		
				Gauge						<1		
				Clipping		426	31	222	29	45*	14	
			F. idahoensis			37	4					
			A. frigida			42	8	14	6	66*	28	
Windlass Gulch Wedge, s.w. face		Cattle, Mule Deer, Elk	A. spicatum			144	16					
			F. idahoensis			97	13					
			A. frigida			14	3					
Exclosure 5		Bighorn Sheep, Mule Deer	A. spicatum	GSC						<1		
				Gauge						1		
				Clipping		100	12	81	11	20	22	
			F. idahoensis			29	5					
			A. frigida			5	2	15	3	Negative 4/		

* significantly different at the 0.05 level as determined by testing the null hypothesis that the paired differences are equal to zero.

1/ Oven dry weight.

2/ For clipping methods, this figure represents the difference between summer or fall weight and spring weight, expressed as a percentage of the former.

3/ The standard error of the paired differences (Snedicor and Cochran 1967:94), expressed as a percentage of the fall weight, treating adjacent plots as pairs.

4/ More weight present in spring than in previous fall or summer.

5/ This area was fenced during the summer of 1968 by the Forest Service to exclude cattle. All utilization on this area during 1968-1969 was by game.

protein and phosphorus content in winter. In contrast to wheatgrass, the browse species, big sagebrush, Douglas fir, and rocky mountain juniper, all contained more than 7 percent protein in mid-winter. Analyses of green grasses and forbs in April (Table 23) indicate that nutritious forage was available by the second week of April.

Comparisons of chemical analyses of bluebunch wheatgrass, fringed sagebrush, Idaho fescue, and big sagebrush from Rock Creek with published analyses of the same species from other areas (Dietz et al. 1962, Van Dyne et al. 1965, Demarchi 1968) revealed few consistent differences that could not be accounted for by variation in collection techniques or in plant phenology. The great variation among ether extract levels in big sagebrush from three areas (Table 11) could not be explained by either of the above factors.

The percentage of ether extract in rumen contents of collected deer is the only component of the proximate analysis that varied significantly among months (Table 12). The increase of ether extract in rumen contents during winter is significantly correlated with the increased content of rocky mountain juniper ($t = 3.63$, $df = 22$) and Douglas fir ($t = 2.40$, $df = 22$), but not big sagebrush ($t = 1.11$, $df = 22$). Application of a stepwise multiple linear regression program to the data on percent of ether extract and percent of sagebrush, Douglas fir, and juniper in rumen contents indicated that the best correlation ($r = .69$) between ether extract and percentage of these three species is obtained by using only the percentage of juniper. The single chemical analysis of rocky mountain juniper showed it to have 22.3 percent ether extract which is more than twice as high as the values for Douglas fir and big sagebrush (Table 23).

Table 11. Percentages of ether extract in leaves and twigs of big sagebrush from three areas.1/

Area	Miles City, Mont.2/			Rock Creek, Montana			Colorado3/		
Season	No. Samples	Mean	Range	No. Samples	Mean	Range	No. Samples	Mean	Range
Summer (July-August)				2	6.9	5.8-7.9	3	12.8	11.8-13.6
Fall (September-November)				1	7.2		3	14.4	13.7-14.9
Winter (December-February)	6	5.8	2.8-7.8	1	9.8		3	12.9	12.4-13.2
Spring (April-May)				1	9.7		3	12.2	10.5-14.4

1/ All data are expressed as percentage of oven dry weight.

2/ Van Dyne *et al*. (1965).

3/ Dietz *et al*. (1962).

Table 12. Analyses of variance among months for nutrients in rumens of collected mule deer.1/

Nutrient	Among Months		Within Months		Calculated F ratio	$F_{.05}$
	df	Mean Square	df	Mean Square		
Nitrogen-free extract	4	10.42	22	5.12	2.03	2.82
Crude protein2/	4	2.54	22	2.10	1.22	2.82
Ether extract	4	16.53	22	1.03	16.06*	2.82
Ash	4	9.63	22	3.59	2.68	2.82
Crude fiber	4	38.57	22	16.54	2.33	2.82
Phosphorus	4	.16	22	.05	3.12*	2.82
Calcium	4	.16	22	.09	1.78	2.82

* significant at the 0.05 level.

1/months compared and sample sizes are November-December(6), January(5), February(5), March(5), and April-May(6).

2/the F ratio for this analysis is questionable since the variances were heterogeneous ($F_{max} > 100$, $p < 0.99$) as determined by the F_{max} test of Hartley (1950).

Crude protein, ether extract, and calcium in fecal pellets from both mule deer and bighorn sheep vary significantly among months (Table 13). Furthermore the percentage of these same three nutrients in deer rumens is significantly correlated with the percentage in pellets from the same animals (Table 14).

Condition. The kidney fat indices of collected deer generally decrease from November to May (Table 26). However, variation among indices from individuals of the same sex and age class is high even within months. No significant difference was found among kidney fat

Table 13. Analyses of variance among months for nutrients in fecal pellets of bighorn sheep and mule deer.

Nutrient	Among Months df	Among Months Mean Square	Within Months df	Within Months Mean Square	Calculated F ratio	$F_{.05}$
Mule Deer 1/						
Crude protein	4	21.87	19	6.53	3.35*	2.90
Ether extract	4	12.11	19	1.32	9.13*	2.90
Ash	4	104.09	19	22.57	4.61*	2.90
Crude fiber	4	96.35	19	13.71	7.03*	2.90
Phosphorus	4	.05	19	.06	.85	2.90
Calcium	4	1.36	19	.23	5.81*	2.90
Bighorn Sheep 2/						
Crude protein	2	7.24	9	.29	25.01*	4.26
Ether extract	2	32.89	9	.28	116.44*	4.26
Ash	2	5.49	9	17.19	.32	4.26
Crude fiber	2	2.01	9	3.29	.61	4.26
Phosphorus	2	.07	9	.01	5.09*	4.26
Calcium	2	.01	9	.06	16.78*	4.26

* significant at the 0.05 level.

1/ Months compared and sample sizes are November-December(4), January(4), February(5), March(5), and April-May(6); the samples were all from collected deer.

2/ Months compared and sample sizes are September(3), January(5), and February-March(4).

Table 14. Correlation between chemical analyses of nutrients in rumens and fecal pellets of 24 collected mule deer.

Nutrient	Equation1/	df	r
Crude protein	Y = 4.98 + .83X	22	.63*
Ether extract	Y = 3.19 + .62X	22	.77*
Ash	Y = 4.88 + .12X	22	.38
Crude fiber	Y = 35.96 + .04X	22	.07
Phosphorus	Y = .52 + .16X	22	.15
Calcium	Y = .59 + .31X	22	.67*

* significant at the 0.05 level.

1/ the correlation between percentage of the nutrient in the rumen(Y) and percentage of the nutrient in fecal pellets(X).

indices of adult female deer from Rock Creek, the National Bison Range, or Rattlesnake Creek from animals collected during the same season (Table 15).

The percentage of ether extract in femur marrow from collected deer was much higher than in marrow from carcasses (Table 27). The marrow from carcasses that was analyzed was typical of marrow from carcasses found in the field.

Parasites and disease. Baermann examinations of sheep fecal pellets indicated that 12 of 34 samples contained *Protostrongylus* larvae and one contained larvae of *Nematodirus*. One of two fecal samples collected from mule deer in mid-summer contained numerous *Protostrongylus* larvae.

Table 15. Analysis of variance among kidney fat indices of adult female mule deer from three areas and three seasons.1/

Source	df	Mean Square	Calculated F ratio	$F_{.05}$
Area2/	2	17.57	.14	3.35
Season3/	2	2553.35	19.69*	3.35
Area X Season	4	96.15	.74	2.73
Residual	27	129.65		

* significant at the 0.05 level.

1/ Kidney fat indices (Riney 1955) of four adult female mule deer (over 2 years old) from each area taken during each season were used; when more than four indices from a given season and area were available, the data from the four youngest animals were used.

2/ Areas compared were Rock Creek, Rattlesnake Creek (Knoche 1968), and the National Bison Range (Nellis 1964).

3/ Seasons compared were fall (November-December), winter (January-March), and spring (April-May).

All mule deer blood samples tested were negative for brucellosis and leptospirosis. However, seven out of ten mule deer were positive for anaplasmosis.

Botfly larvae were the only parasites found in mule deer that appeared to be sufficiently numerous to be harmful to the hosts. Larvae were first noticed when autopsying mule deer number 59 on February 27, 1969. All deer collected and all fresh carcasses checked after this date carried botfly larvae. The most larvae found in a deer was 52 from deer number 79 which died on April 11. Mr. Robert Neal, a local rancher, saw this animal run out of Cornish Gulch, across an open field and into a fence near his house where it dropped dead. The deer, a male fawn, weighed 55 pounds and had a kidney fat index of 11 when autopsied the next day. The most larvae found in a collected deer was 38 taken from number 93. Individual botfly larvae were not identified to species, however, Dr. Albert Canaris, Department of Zoology, University of Montana, Missoula, examined samples and tentatively identified them as *Oestrus ovis*.

Reproduction. Corpora lutea and fetus counts from Rock Creek deer were similar to reported counts from other areas in Montana (Table 16).

Table 16. Comparison of corpora lutea and fetus counts from adult does from three Montana deer herds.1/

Area	Number of animals	Corpora lutea per doe	Number of animals	Fetus per doe
Rock Creek2/	15	1.87	20	1.70
Rattlesnake3/	11	1.91	11	1.73
National Bison Range4/	13	1.92	12	1.75

1/ Only data on does over two years old are tabulated here.

2/ The fetus per doe ratio includes data from five animals collected by Berwick during the winter of 1967-1968 (Table 29).

3/ Knoche (1968).

4/ Nellis (1964).

The fetuses collected from mule deer number 93 were noteworthy in that they were quite different in size. The left foetus weighed 810 grams and had a crown-rump length of 295 mm and a hind-foot length of 130 mm. The right foetus weighed 2130 grams, had a crown-rump length of 400 mm and a hind-foot length of 185 mm (Table 28). Two corpora lutea were counted in the right ovary and none in the left. Both fetuses appeared normal and healthy.

Mortality. The high number of carcasses of old animals that were found suggests that the population contains a high proportion of old animals (Table 17). The age structure of collected animals is not significantly different ($p > 0.05$) than the age structure predicted from carcass data (Table 17).

Table 17. Comparison of the age distribution of collected deer with the age distribution predicted from a life table based on ages of deer carcasses found in the field.1/

Age Class	Number of Carcasses	d_x	l_x	f 2/	f_c 3/	$\frac{(f-f_c)^2}{f_c}$
0 - 1	21	234	766			
1 - 2	16	178	588			
2 - 3	5	56	532	7	5.1	.6
3 - 4	3	33	499	7	4.9	.9
4 - 5	2	24	475	6	4.6	.4
5 - 6	3	33	442	2	4.3	1.2
6 - 7	1	11	431	2	4.2	1.2
7 - 8	4	44	387	1	3.7	.8
8 - 9	15	165	222	4	2.2	1.5
9 - 10	20	222				
						$\chi^2 = 6.6$
						df = 6
						p = .6

1/ The life table is derived by the method of Quick (1963).

2/ The number of collected deer in each adult age class.

3/ The number of collected deer in each adult age class predicted from the life table.

IV

DISCUSSION

The small size of the Rock Creek bighorn sheep herd plus the desirability of minimizing disturbance of the animals made collection of adequate quantitative data difficult. Most of the data are from only one year of field work, sample sizes are small, and confidence limits are wide. However, the importance of the sheep herd made it desirable to present tentative conclusions as a basis for management decisions. Thus where available data appeared to represent actual trends, I have drawn conclusions, even though the trends were not always statistically significant. The major value of such inference is to serve as a basis for management decisions until more adequate data are available.

A. Range Use

Vegetation. The distribution of plant species (Table 18) indicates that very few are limited to any particular habitat type. Most species are only abundant in one or two habitat types. Relatively few species make up most of the recorded herbage (Table 18). A large number of the plants recorded during the summer are annual forbs that dry up and decompose before winter. Thus four species, Douglas fir, rocky mountain juniper, big sagebrush, and bluebunch wheatgrass, comprise more than 90 percent of the available winter forage. Three of these species are found interspersed throughout the winter range. The fourth, big sagebrush, is found primarily on the western half of the range and rarely east of Flat Gulch.

Weather. Data on winter temperatures (Table 2) give only a rough idea of the severity of the winter. However, the measurements are correlated with snow melt. Significant melting occurs only when the temperature is above 40F. Thus when temperatures are consistently above 40F vegetation is being uncovered and a continuously expanding food supply is available. Deer and sheep move into and feed in these areas where vegetation is being uncovered. During the winter of 1968-1969 temperatures remained above 40F after mid-March.

Range use. Although the data on habitat use by sheep and deer (Table 3) are based on a small number of sightings, I believe they represent a typical pattern. However, the use of two habitat types appears to be underestimated.

Utilization of the sagebrush type is probably underestimated because these areas are not very visible from the road where the sightings recorded in Table 3 were made. I spent many days on foot in these areas and it was my impression that from December to early March deer populations were as dense on these areas as anywhere on the sheep range. Berwick (1968) estimated that sagebrush areas make up only 2 percent of the winter range. However, I often counted 50 deer on one of these areas (Figure 1) in a single day.

Utilization of the dense timber type is undoubtedly underestimated due to the difficulty of sighting animals in these areas. Observations of tracks and beds indicate that deer use dense timber types a great deal during winter.

The relatively large number of sheep sightings in the open timber type reflects their preference for rocks since virtually all the open timber areas border the cliffs and talus slopes rising above Rock Creek. This preference for rocks appears to be the major factor affecting the distribution of bighorn sheep on the winter range.

The high percentage of deer observations in the parkland type is partly due to the relatively high percentage of the range that consists of this type. It is also due to the good interspersion of habitats in the parkland type. This interspersion allows a deer to meet his daily needs for food and cover in a relatively small area, an obvious advantage in mid-winter when snow is deep and travel is difficult.

The comparison of expected and observed frequencies of sighting of sheep and deer together is based on inadequate data for any general conclusion. However, the high correlation between the observed and expected frequencies ($p > 0.99$) suggests that competition by interference, if present, does not result in any obvious change in patterns of distribution on areas as large as 80 acres. Thus the difference in distribution of sheep and deer observations (Table 4) can be attributed to differential habitat preferences of the two species and not to competitive interference.

Clearly differential distribution tends to reduce exploitative competition. Thus the data indicate that exploitative competition between bighorn sheep and mule deer, if present, is reduced by their preference for different habitat types.

B. Food Habits

Mule deer. Data on winter food habits of Rock Creek mule deer (Tables 5, 7, 9, 20, 21) indicate that the deer rely heavily on browse during mid-winter and eat large amounts of grass only during early spring. This pattern of forage utilization is typical of northern deer herds (Hill 1956). The increased use of browse and decreased use of forbs during mid-winter probably results from the comparatively high nutrimental content of browse at this time in addition to the reduced availability of forbs due to deep snow. The increased intake of grass in spring coincides with the early growth of grasses.

Food habits data from the winter of 1968-1969 are comparable to the data from the previous winter. The high percentage of forbs in the diet of deer collected in February 1968 compared to those collected in February 1969 was due to the early snow melt which left most of the south facing slopes bare by the end of February 1968 when the former collections were made.

Data from this study indicate that Berwick's (1968) estimate, that grasses constitute 40 percent of the mule deer's diet during a normal winter, is too high and does not take into account the significant seasonal changes in the utilization of grass by deer. During the winter of 1967-1968 the only rumens with more than 5 percent grass were taken either before November 19 or after March 26 (Berwick op. cit.). Data from rumen samples from both winters (Table 20) indicate that consumption of grass by mule deer on Rock Creek from January to mid-March averages no more than 10 percent.

Big sagebrush comprised the largest volume of any single plant species in deer rumens from November 1968 to May 1969. The greater utilization of sagebrush by deer that were collected than by deer whose carcasses were found can be partly explained by the location of the carcasses and of the collections. Fourteen of the eighteen carcasses were found in riparian meadows and in areas south of Flat Gulch where sagebrush is not present. About 80 percent of my time in the field was spent in areas where sagebrush was common. Deer congregated in these areas so one would expect to find more carcasses in areas with sagebrush. The fact that I found just the opposite suggests that winter mortality of deer on Rock Creek is greater in areas without sagebrush.

All but one of the deer collected during the winter of 1968-1969 were shot in or adjacent to areas containing sagebrush. About half of the deer collected during the winter of 1967-1968 were taken south of Flat Gulch where sagebrush is scarce. Thus, geographic location can also explain the lower percentage of sagebrush in the rumens from deer collected by Berwick (op. cit.).

Rocky mountain juniper appears to be the least palatable of the three principal browse species. During the winter of 1968-1969 it was found only in rumens from mid-January to mid-March when the availability of other forage was limited due to browsing and deep snow. During this period some browse species, such as sagebrush, are less available to deer because of deep snow which hinders their movement. The fact that Douglas fir is almost uniformly high-lined on the winter range whereas many juniper plants are only lightly browsed suggests that juniper is the less palatable of the two.

Bighorn sheep. The high percentage of epidermal remains of monocotyledons in feces during mid-winter indicates that sheep utilize large amounts of grass and grasslike plants (Families Graminae, Cyperaceae, and Juncaceae). These plants are the only monocots which are available during this period and the only ones which Berwick (1968) or I have observed sheep eating during winter. If a direct correlation exists between percentage of monocot remains in the feces and percentage of monocots in the diet, then the mid-winter diet consists of 68 percent grass with a standard error of 5 percent. This is significantly less than Berwick's (op. cit.) estimate of 90 percent grass in the bighorn sheep's diet during mid-winter.

Comparison of sheep and deer food habits. The reliability of a comparison between the diets of sheep and deer is dependent on the accuracy and precision of the method used for measuring food habits of each animal. The good correlation between percent of identifiable epidermal remains of monocots in feces and the percent of monocots in rumens of mule deer indicates that this is a reliable method for this forage class.

The data on epidermal remains of monocots for both species indicates that the only time during winter when both mule deer and bighorn sheep utilize large amounts of monocots (grass) is in late winter (April and May) when green grass is available in abundance.

C. Limiting Factors

Food and nutrition. Estimates of utilization derived by clipping techniques (Table 10) are questionable since they do not take into account gain in weight during fall regrowth and loss in weight due to weathering. However, fall growth after the areas were clipped appeared to be slight. Weathering probably accounts for the higher utilization figures on bluebunch wheatgrass obtained by clipping than those obtained by other techniques. Weathering could also account for the high utilization figures obtained by Berwick (op. cit.) and presented in Table 10 since his first clippings were taken much earlier than mine, thus allowing more time for weathering.

The generally low utilization on bluebunch wheatgrass, Idaho fescue, and fringed sagebrush as indicated by my data (Table 10) supports the conclusion that overgrazing is not a limiting factor at present on these sites and is probably not limiting in other areas of low livestock use and heavy game use.

Field observations indicate that only a small percentage of the total grass produced is available to animals in mid-winter due to deep snow. Thus, the amount of available grass and other ground vegetation as determined by snow cover is of much greater importance as a limiting factor than total production and utilization. Since distribution of snow and forage are both uneven in mountainous areas such as Rock Creek, more sophisticated range techniques than are now available will be required to obtain meaningful estimates of available ground forage in winter.

Proximate analyses of forages are of limited value in determining the adequacy of the winter diet of sheep or deer because the nutritional requirements of these animals are not known. The practice of comparing nutritional requirements for domestic sheep with chemical analyses of plant species to evaluate forages for bighorns (Demarchi 1968) is questionable. Domestic sheep have become highly specialized through thousands of years of domestication. Most nutritional requirements are based on maintenance or gain in weight. Wild bighorn sheep lose weight in winter even on good range and nutritional requirements for an animal losing weight are probably substantially lower than for maintenance. Nutritional requirements in terms of proximate analyses do not take into account the high variability in both palatability and digestibility in plants which show similar chemical analyses.

The fact that analyses of Rock Creek forages do not differ greatly from analyses of the same forages from other sheep and deer ranges (Dietz et al. 1962, Demarchi 1968) suggests that nutritional quality of the forages is of no greater importance as a limiting factor on Rock Creek than on other areas.

Proximate analyses of washed rumen samples from mule deer (Table 24) indicate nutritional variations by months of collection in forages eaten. The ruminal microorganisms and their byproducts are removed by washing. The washed rumen sample supposedly represents the forages eaten although some digestion has undoubtedly taken place. Klein (1964) found significantly higher ($p < 0.001$) levels of nitrogen and significantly lower ($p < 0.001$) levels of fiber in washed rumen samples which were taken during summer from black-tailed deer from high-quality range than in rumens from animals on poorer range.

The high protein content of the mule deer rumens from Rock Creek (Table 24) suggests that dietary protein is adequate. The protein content of rumens from all collected deer is higher than the estimated

7 to 8 percent necessary for maintenance (Hill 1956). Some of the nitrogen may be of endogenous origin since washing the rumen does not completely remove all nonplant material. However, the high level of protein in plants such as big sagebrush and Douglas fir (Table 23), which deer rely upon heavily in mid-winter, supports the contention that dietary crude protein is not an important factor limiting mule deer on Rock Creek.

Maynard and Loosli (1962:64-74) describe the components of the ether extract. The correlation between percentages of ether extract and percentages of Douglas fir and rocky mountain juniper in rumens suggests that the increase in ether extract in mule deer rumens during mid-winter is due to their increased intake of these species. The correlation between percentage ether extract in fecal pellets and in rumens (r = .77, Table 14) suggests that a significant amount of ether extract is undigested. Douglas fir is known to contain substantial levels of essential oils, many of which inhibit rumen microbes and thus retard digestion (Oh et al, 1967). Longhurst et al. (1968) have suggested that plants evolved essential oils for protection from browsing and grazing animals and that these oils both inhibit rumen microbial activity and reduce palatability. Since these oils are a component of the ether extract, the high level of ether extract in rocky mountain juniper suggests that this species contains a high percentage of essential oils. This assertion is supported by the comparatively low palatability for deer of juniper on Rock Creek. High intake of essential oils from juniper and Douglas fir could slow down digestion and cause nutritional stress in mid-winter.

The data on food habits and chemical analyses suggest that nutritional stress in Rock Creek deer during mid-winter results from increased intake of essential oils, which inhibit rumen microbes and retard digestion, rather than from shortage of crude protein in the diet. More data would be required to fully substantiate the above hypothesis but it is consistent with all the available data. Obtaining maintenance levels of protein and avoiding excessive levels of essential oils are not independent since the plants with the highest levels of protein appear to be those with the highest levels of essential oils.

The lack of correlation between percentages of ether extract and of big sagebrush in the rumen is surprising. This species is known to contain substantial amounts of essential oils which inhibit rumen microbial activity (Nagy 1964). However, the level of ether extract in big sagebrush from Rock Creek is substantially lower than the values of ether extract from sagebrush from Sevenmile Creek, Colorado (Table 11), the area where Nagy (_op_. _cit_.) obtained sagebrush for digestion trials. It is possible that the lower levels of ether extract in sagebrush from Rock Creek reflect lower levels of essential oils and that this accounts for the high intake and apparent high palatability of sagebrush there. The evidence for this assertion is weak, however, since not all essential oils of plants inhibit rumen microbial activity and some even enhance it (Ch _et_ _al_. 1968).

Condition. The similarity in physical condition of adult female deer (as measured by kidney fat indices) from Rock Creek, Rattlesnake Creek, and the National Bison Range either indicates that differences are not present or that sample sizes are inadequate to detect such differences. The high variability in kidney fat indices in deer of the same sex and age class from the same area taken during the same season suggests that the small sample size is responsible for the lack of detectable differences among herds. The lack of published standards against which condition indices of mule deer from specific areas can be compared makes such indices of questionable value in measuring condition. The decrease in kidney fat indices of Rock Creek deer during winter (Table 26) is typical of other herds (Nellis 1964, Knoche 1968).

The poor nutritional state of the deer which died during midwinter on Rock Creek (as indicated by fat content of femur marrow) suggests that the deer population is too large for the winter range. However, this conclusion must be tentative without further knowledge concerning the proportion of animals that are dying due to the indirect or direct effects of malnutrition.

Parasites and disease. Evidence was not found for unnaturally high levels of parasites or disease in deer or sheep. Lungworm larvae were previously reported in Rock Creek sheep (Forrester and Senger 1964) and there is no reason to believe that lungworm is more prevalent at present than before. The *Protostrongylus* larvae found in one mule deer are probably *P. macrotis*. Anaplasmosis has been reported in mule deer (Howe and Hepworth 1965) but there is no evidence that it is debilitating in this species. Botfly larvae are probably a drain on the vigor of deer but the deer seem to be able to carry relatively large numbers of them. Disease and parasites themselves apparently do not limit either sheep or deer numbers on Rock Creek.

Reproduction. Reproductive rates from Rock Creek deer as measured by counts of corpora lutea and fetuses are comparable to those of other mule deer herds and there is no evidence that reproduction during early and middle pregnancy is hindered by range condition. A thorough evaluation of the degree to which reproduction might be hindered would require data on fawn production and survival.

Mortality. The age structure, indicated by the life table (Table 17), is indicative of underharvest or the beginning of habitat deterioration providing this is a stable population (Alexander 1958). Berwick (1968) has reported habitat deterioration, and my field observationsindicate that hunting pressure on the herd is light. It is not known if the deer population is stable; however, an age structure of this nature can be attributed to the same factors in increasing or decreasing populations. With a decreasing population, habitat deterioration is most important while in increasing populations underharvest is the likely cause (Alexander *op. cit.*).

The life table is of limited value since the method of deriving it is questionable (Caughley 1966) and aging by tooth replacement and wear gives only approximate ages. However, I believe that the high proportion of old animals indicated by the life table reflects a real situation. This assertion is supported by the fact that the age structure of collected deer is consistent with the age structure of the life table derived from jaws of carcasses (Table 17).

D. Competition

Berwick (1968) discussed competition between livestock and bighorn sheep on Rock Creek. This discussion is limited to competition between mule deer and bighorn sheep. Without a more thorough knowledge of factors limiting the deer or sheep herds only a partial evaluation of the degree of competition between them can be made. The available evidence indicates that competition for grass between deer and sheep on Rock Creek is not an important factor limiting the sheep. Evidence from both rumen and pellet analyses indicates that utilization of grass by deer during mid-winter, when grass is in shortest supply, is minimal. The two species have different habitat preferences in mid-winter which would tend to reduce competition for forage. The high intake of grass by sheep, as indicated by fall and spring rumen analyses (Berwick 1968) and mid-winter pellet analyses, suggests that grass is not in limited supply.

Grass appears to be of negligible importance in the mid-winter diet of deer but the intake of small amounts of green grass may be important to both sheep and deer. Green grass is much more nutritous than weathered grass (Table 23). Both sheep and deer actively seek green grass by pawing through the snow. The presence of green grass and forbs in mid-winter results from fall regrowth being covered with snow before weathering can take place. When snow melts, these plants are uncovered and provide small quantities of highly nutritious food. Both sheep and deer seek out areas where snow melt is making green vegetation available and this forage may be very important for maintaining their physical condition through winter. If forage competition between bighorn sheep and mule deer exists, I would expect it to be for green forage on small areas of ridge tops and south facing slopes where snow melts early.

Sheep and deer could also be competing for browse. Although sheep do not normally eat large amounts of browse (Capp 1968), the small quantity they eat might be quite important in their nutrition. Berwick (1968) stated that the mid-winter diet of Rock Creek sheep was inadequate because of the absence of palatable browse species. The low protein content of weathered grasses and the generally high protein content of preferred browse species, such as chokecherry (*Prunus virginiana*) (Table 10), suggests that sheep may eat small quantities of browse to obtain protein. Other things being equal, one would expect that competition for a forage such as browse would be most deleterious to the species that relied on it most heavily. Thus in the case of competition for browse, deer would be expected to be more severly affected than sheep. However, on Rock Creek the most abundant browse species, big sagebrush, Douglas fir, and rocky mountain juniper, are apparently so unpalatable to sheep that they make only slight use of them. Thus, deer have an advantage in any competition for browse since they have a large alternate supply which is unpalatable to sheep. Furthermore deer outnumber sheep by a ratio of roughly 80 to 1 on the Rock Creek winter range and can put heavy browsing pressure on the few browse species that are palatable to sheep.

There are substantial numbers of chokecherry plants among the cliffs and open timber areas along Rock Creek. These plants are heavily browsed by deer and many are dead or dying. Chokecherry may have once provided an important source of protein for sheep in mid-winter.

E. Historical Changes

Data on range use, food habits, nutrition, and mortality provide evidence that big sagebrush is an extremely important mid-winter forage species for deer. Berwick's (1968) assertion that sagebrush has increased in abundance in the last 45 years is thus of some interest since he also indicates that deer have increased in numbers from about 150 in 1930 to an estimated 800 in 1968. If deer were limited by quantity of browse then an increase in sagebrush might increase the number of deer that the winter range could support. Leopold (1950) suggested that the increased numbers of deer in many western areas was due to the invasion of xerophytic shrubs, including big sagebrush, into former grassland.

Increased numbers of deer on Rock Creek would put more pressure on highly palatable browse species such as chokecherry. Increased pressure on these species could in turn seriously reduce an important source of protein and other nutrients for bighorn sheep. No general conclusions can be drawn, but the available evidence indicates that the correlation between sagebrush invasion, increased numbers of deer, decrease in palatable browse species and decreased numbers of bighorn sheep, is more than coincidental.

F. Management Considerations

Data on habitat preference indicate that the distribution of bighorn sheep in mid-winter is determined largely by their preference for rocky terrain. Management of habitat for the benefit of sheep should concentrate on those areas which include or are adjacent to rocks. One area has been fenced by the Forest Service to exclude cattle and reserve the forage for game animals, especially sheep (Figure 2). My data on habitat preference indicate that the area, which consists of open timber and adjacent grassland, was a good choice. More fencing for this purpose is both desirable and feasible. Such management should concentrate on open timber areas and the adjoining grassland (Figure 1). Since much of this land is privately owned the Montana Fish and Game Department should consider purchasing or leasing these portions of winter range.

The available data suggest that the deer herd is underharvested and that the deer habitat is declining. The high mid-winter intake of relatively unpalatable browse (such as juniper), the malnutrition in deer whose carcasses are found during winter, and the age structure of the population are indicative of habitat deterioration. The low numbers of deer harvested in comparison with the estimated numbers present and the age structure of the population indicate that the herd is lightly harvested.

The lack of good evidence for competition between sheep and deer suggests that any reduction in deer would be unlikely to allow an increase in the sheep population. However, competition for forage, especially for browse and green forbs and grass, could be important. Even without evidence of competition a reduction in the number of deer is desirable. Any increase in sheep numbers and vigor after a deer reduction would provide circumstantial evidence for competition.

Although a deer reduction is desirable for several reasons it may not be feasible at the present time. The general abundance of deer in western Montana and the difficulty of hunting much of the Rock Creek winter range makes it difficult to attract enough hunters to the area to cause a substantial reduction in the deer herd. A slight increase in hunting pressure might merely increase the proportion of females in the herd and thus increase the productivity of the herd. This could compound the problems of habitat deterioration.

A heavier harvest should not be encouraged unless (1) such a harvest will substantially reduce the deer herd, and (2) enough hunting pressure can be maintained to keep the deer population at the reduced level. At present it is unlikely that both of the above conditions can be met.

Since sagebrush is probably an invader species on the winter range (Berwick 1968), sagebrush control to increase forage production for livestock may be both desirable and feasible. Most of the areas with sagebrush are privately owned although some are public land. The heavy use of sagebrush by deer indicates that the immediate effect of sagebrush control would be to decrease the number of deer that the range could support. A sudden removal of sagebrush would undoubtedly cause heavy browsing pressure by deer on the remaining stands of palatable browse species. A substantial reduction in the deer herd prior to sagebrush control would (1) alleviate damage to these stands of browse and circumvent the possibility of increased competition with sheep, and (2) reduce the possibility of a massive die-off of deer.

V

SUMMARY

This study is the third in a series on factors relating to the decline of bighorn sheep on the Rock Creek winter range in western Montana. The objectives were: (1) to investigate the competition for food between bighorn sheep and mule deer, (2) to evaluate the effect of increased numbers of deer on the sheep decline at Rock Creek, and (3) to predict the effect of mule deer on any recovery of the sheep population.

Range use was analyzed by tabulating and comparing sheep and deer sightings in habitat types. The distribution of sheep and deer sightings by habitat types was found to differ significantly, and the difference was attributed to different habitat preferences.

Food habits were determined by analyses of mule deer rumens and by analyses of epidermal remains of plant species in fecal pellets. Rumen analyses indicated that the most important plants in the winter diet of mule deer were big sagebrush, Douglas fir and rocky mountain juniper, in that order. Deer ate a substantial amount of grass in April and May but relied upon browse during mid-winter; whereas pellet analyses indicated that sheep relied upon grass at all times of year.

Factors possibly limiting the sheep and deer herds were investigated by analyzing aspects of their food and nutrition, incidence of parasites and disease, physical condition, reproduction and mortality.

Neither production and utilization of grass nor nutrient content of forages limited sheep or deer populations. Proximate analyses of rumens suggested that nutritional stress of mule deer in mid-winter is caused more by high levels of rumen-inhibiting essential oils than by low levels of crude protein. Evidence was not found for unnaturally high levels of parasites or disease in sheep or deer. Physical condition of deer collected in mid-winter (as measured by kidney fat indices) was similar to condition of deer from other Montana herds. Low fat content of femur marrow from deer carcasses found in mid-winter indicated they were dying of indirect or direct effects of malnutrition. Reproductive rates from Rock Creek deer (as measured by counts of corpora lutea and fetuses) were comparable to those of other Montana deer herds. The age structure of collected deer plus a life table constructed from ages of carcasses found in the field indicated that the deer herd had a large number of old animals.

The major conclusions of the study are:

(1) Competition for grass between mule deer and bighorn sheep during mid-winter, when forage is most limited, is minimal and is reduced by different habitat preferences.

(2) The mule deer rely heavily on big sagebrush during winter and invasion of sagebrush into grassland areas has increased the carrying capacity of the winter range for deer. This resulted in increased numbers of deer which have put heavy pressure on browse species such as chokecherry; small quantities of these desirable browse species may be important in the winter diet of sheep.

(3) The deer herd is underharvested and a reduction in the number of deer is desirable both to keep the deer population in balance with the winter food supply and to reduce any possible competition with sheep. Such a reduction may not be feasible now.

VI

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APPENDIX

Figure 1. Habitat types on Rock Creek winter range.

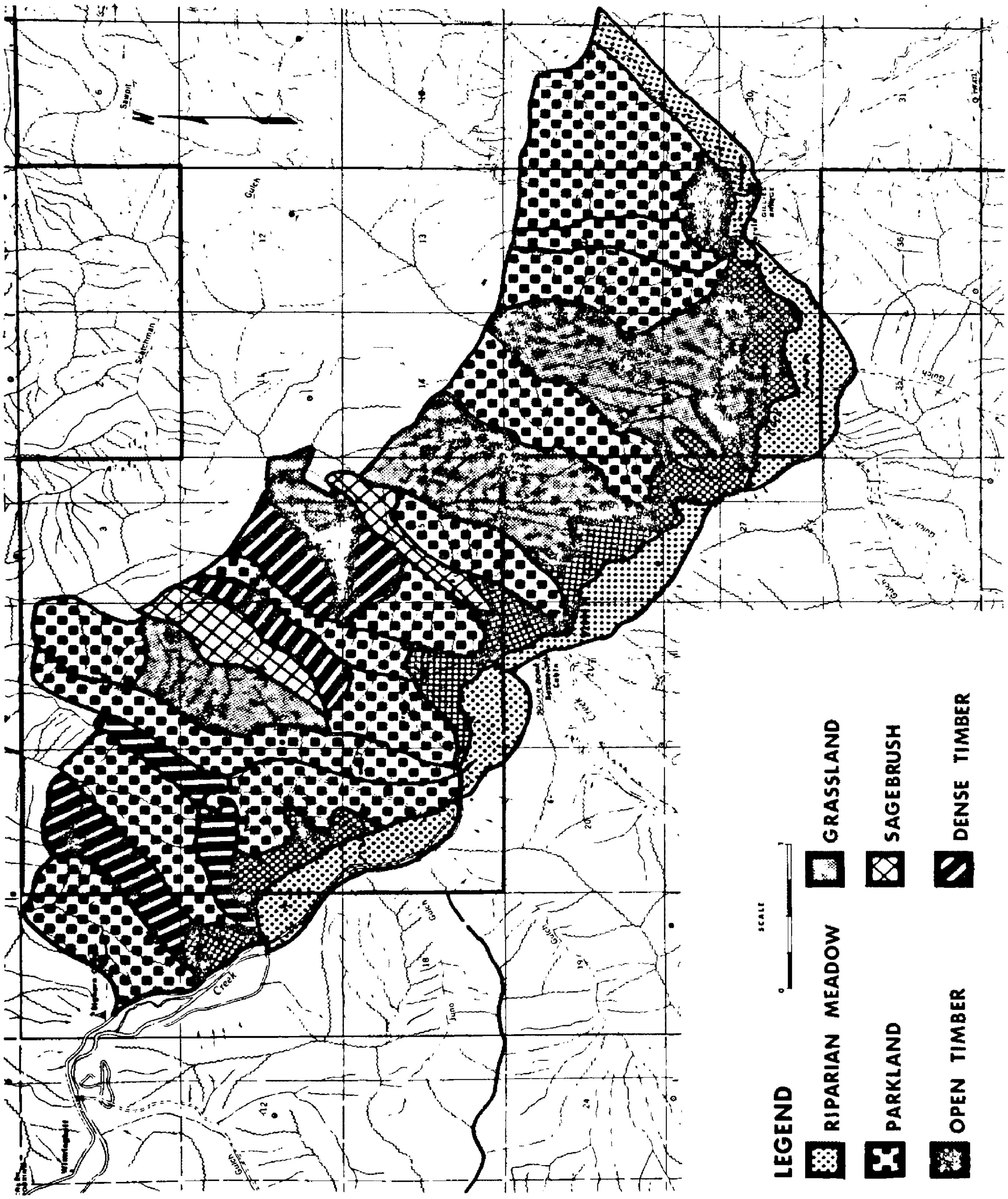
LEGEND
RIPARIAN MEADOW
PARKLAND
OPEN TIMBER
GRASSLAND
SAGEBRUSH
DENSE TIMBER
SCALE
Creek
Gulch

Figure 2. Map of Rock Creek winter range showing Forest Service fence built in 1968 to exclude cattle from a portion of key winter game range.

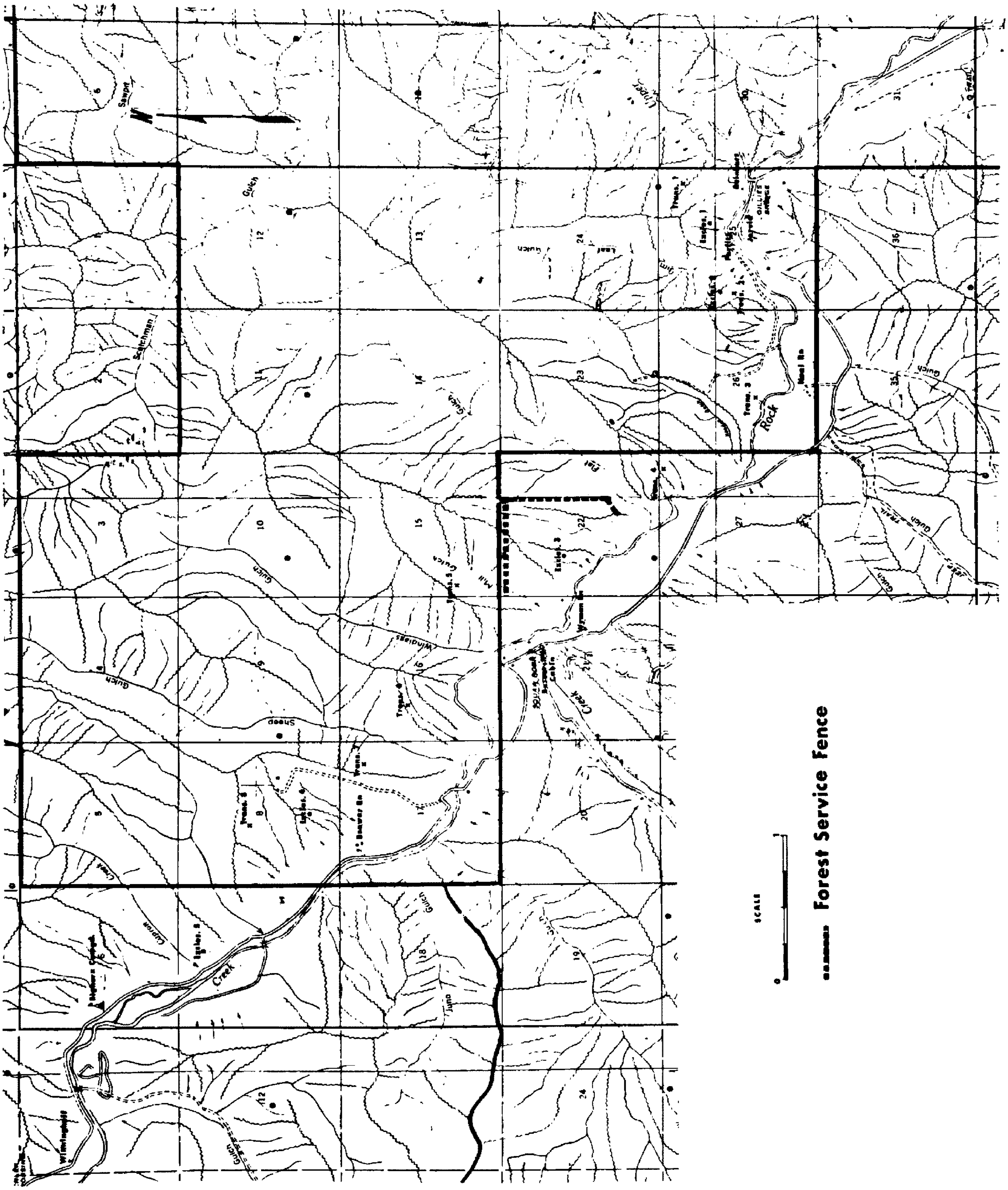
SCALE
Forest Service Fence

Table 18. Coverage of plant species by habitat types on Rock Creek winter range.1/

Habitat Type / Family / Species3/	Coverage2/ Riparian meadow	Grass-land	Sage-brush	Dense timber	Open timber	Parkland
Aceraceae						
Acer glabrum	tr			tr		tr
Boraginaceae						
Amsinskia menziesii						
Cryptantha bradburiana		tr			tr	
Lappula redowski		tr				
Lithospermum arvense						
Lithospermum ruderale		tr	tr	tr		1
Mertensia oblongifolia		tr	tr	1	tr	tr
Mertensia paniculata						tr
Berberidaceae						
Berberis repens		tr		tr		tr
Betulaceae						
Alnus incana	tr					
Betula occidentalis	tr					
Cactaceae						
Opuntia spp.		tr				
Caprifoliaceae						
Lonicera involcrata						
Symphoricarpus albus	1	tr		1	tr	1
Caryophyllaceae						
Arenaria congesta		tr	tr		tr	1
Cerastium arvense			tr	1		tr
Chenopodiaceae						
Monolepis nuttalliana						

1/ Coverage determined by method of Küchler (1955).

2/ Symbols used are:
tr = very sparsely present; cover very small.
1 = plentiful but less than 1/20 of the area.
2 = covering 1/20 to 1/4 of the area.
3 = covering 1/4 to 1/2 of the area.
4 = covering 1/2 to 3/4 of the area.
5 = covering more than 3/4 of the area.

3/ Species listed but not recorded in any habitat type represent species which were found on the winter range by Berwick (1968) or myself which were not found when mapping vegetation.

Table 18 (continued)

Habitat Type / Family / Species	Coverage					
	Riparian meadow	Grass-land	Sage-brush	Dense timber	Open timber	Parkland
Compositae						
Achillea millefolium	1	1	1	tr	1	1
Agoscris aurantica						
Agoseris hererophylla						
Antennaria spp.		1	tr	1	1	1
Antennaria rosea		1			1	tr
Arnica cordifolia				1		
Arnica sororia		tr	tr	1		1
Artemisia dranunculus		tr	tr			tr
Artemisia frigida	1	1			1	1
Artemisia ludoviciana		tr			tr	tr
Artemisia tridentata		1	2		tr	tr
Aster canescens						
Balsamorhiza sagittata		1	1	tr	tr	1
Chrysopsis villosa		tr			tr	tr
Chrysothamnus nauseosus		1	1		tr	tr
Chrysothamnus viscidiflorus	tr	tr				tr
Cirsium undulatum		tr				
Cirsium vulgare						
Crepis acuminata		1	1		tr	tr
Erigeron compositus	1	1	1	1	1	1
Erigeron divergens	tr	tr				tr
Erigeron speciosus		tr	tr		tr	tr
Gaillardia aristata						
Haplopappus acaulis						
Hieracium albiflorum		tr				tr
Hieracium cynoglossoides						
Senecio spp.		tr				
Senecio canus						
Senecio integerrimus						
Senecio lugens						
Solidago nemoralis						
Taraxacum spp.	tr	tr	tr	tr	tr	tr
Tetradymia canescens	tr	tr			tr	
Townsendia parryi		tr				
Trapogon dubius		1			tr	tr
Trapogon pratensis		1	tr		tr	tr
Cornaceae						
Cornus stolonifera	1					tr
Crassulaceae						
Sedum spp.			tr			
Sedum stenopetalum		tr	tr	tr	tr	1

Table 18 (continued)

Habitat Type / Family / Species	Coverage: Riparian meadow	Grass-land	Sage-brush	Dense timber	Open timber	Parkland
Cruciferae						
Arabis spp.		tr			tr	
Arabis holboellii						
Arabis microphylla						
Braya richardsonii						
Camelina microcarpa						
Capsella spp.		tr				
Capsella bursa-pastoris						
Conringia orientalis						
Descurainia pinnata						
Descurainia richardsonii						
Draba spp.						
Draba numerosa						
Erysimum inconspicuum						
Erysimum repandum						
Isatis tinctoria						
Lepidium spp.		tr				
Physaria didymocarpa						
Sisymbrium altissimum						
Sophia spp.						
Thlaspi spp.						tr
Thlaspi arvense					tr	
Thlaspi fondleri						tr
Cyperaceae						
Carex spp.		tr	tr	tr	tr	tr
Carex platylepis						
Elaeagmaceae						
Shepherdia canadensis	tr					
Equisetaceae						
Equisetum spp.	tr					
Ericaceae						
Arcotostaphylos uva-ursi	tr					
Vaccinium membranaceum						
Vaccinium scoparium						
Geraniaceae						
Geranium viscosissimum	tr	tr	tr			tr
Graminae						
Agropyron repens						
Agropyron smithii						
Agropyron spicatum		1	1	1	2	1
Bromus inermis	tr					
Bromus marginatus						
Bromus tectorum		1	1	tr	1	1

Table 18 (continued)

Family / Species (Habitat Type →)	Coverage					
	Riparian meadow	Grass-land	Sage-brush	Dense timber	Open timber	Parkland
Graminae (continued)						
Calamagrostis rubescens		tr		2		
Danthonia spicata		tr			tr	
Danthonia unispicata						
Elymus cinereus		tr	tr		tr	tr
Festuca idahoensis		1	1	tr	1	1
Festuca scabrella		tr	tr	tr	tr	tr
Koeleria cristata		1	tr		tr	1
Melica bulbosa						
Phleum alpinum	1	tr				
Phleum pratense	1					
Poa pratensis		tr	tr	tr	tr	tr
Poa secunda		tr	tr		1	1
Stipa comata						
Hydrophyllaceae						
Hydrophyllum capitatum		tr				
Phacelia franklinii		tr				
Phacelia glandulosa		tr	tr		tr	tr
Phacelia heterophylla		tr				
Phacelia linearis	tr	1	1		1	1
Juncaceae						
Juncus balticus		tr				tr
Labiatae						
Agastache urticifolia						
Leguminosae						
Astragalus drummondii		tr			tr	
Astragalus microcystis						
Astragalus missouriensis						
Lupinus spp.		tr	tr			
Lupinus caudatus						
Lupinus sericeus		1	1		tr	
Lupinus wyethii		1	1	tr	tr	1
Oxytropis spp.		tr	tr	tr	tr	tr
Oxytropis lagopus						
Trifolium spp.	tr	tr				tr
Trifolium pratense	1					tr
Liliaceae						
Allium spp.	tr					tr
Allium cernuum		tr				
Calochortus spp.			tr			
Camassia quamash						
Fritillaria atropurpurea				tr		
Fritillaria pudica						
Smilacina stellata						tr

Table 18 (continued)

Family / Species \ Habitat Type	Coverage					
	Riparian meadow	Grass-land	Sage-brush	Dense timber	Open timber	Parkland
Liliaceae (continued)						
Zygadenus elegans			tr			
Zygadenus gramineus		tr	tr	tr	tr	tr
Zygadenus paniculatus						
Linaceae						
Linum lewisii						
Onagraceae						
Epilobium minutum						
Pinaceae						
Juniperus communis	tr	tr		tr	tr	tr
Juniperus scopulorum	1	tr	tr	2	2	1
Pinus contorta	tr	tr		tr		tr
Pinus ponderosa	1	tr			tr	1
Pseudotsuga menziesii	1	tr	tr	5	3	3
Plantaginaceae						
Plantago purshii						
Polemoniaceae						
Collomia linearis		tr	tr		tr	
Leptodactylon pungens		tr			tr	
Phlox hoodii		tr				
Phlox longifolia		tr	tr	tr		tr
Polemonium occidentale					tr	tr
Polygonaceae						
Eriogonum spp.						
Eriogonum flavum	tr	1				tr
Polygonum spp.						tr
Polygonum douglasii						
Portulacaceae						
Lewisia rediviva		tr	tr			tr
Primulaceae						
Dodecatheon conjugens		tr		tr		tr
Douglasia montana						
Ranunculaceae						
Anemone cylindrica						
Anemone patens						
Berberis repens	tr					
Clematis columbiana						
Delphinium bicolor		1	1	tr		tr
Ranunculus acris						
Ranunculus glaberrimus						
Thalictrum occidentale						tr
Rosaceae						
Amelanchier alnifolia						
Frageria vesca			tr	1	tr	tr

Table 18 (continued)

Habitat Type / Family Species	Coverage					
	Riparian meadow	Grass-land	Sage-brush	Dense timber	Open timber	Parkland
Rosaceae (continued)						
Frageria virginiana				tr		tr
Geum triflorum		tr	tr	tr	tr	tr
Physocarpus malvaceus				1		
Potentilla arguta		tr	tr			tr
Potentilla fruticosa						tr
Potentilla glandulosa						
Potentilla gracilis						
Potentilla pensylvanica						
Prunus virginiana		tr			1	tr
Rosa woodsii	1	tr			tr	tr
Rubus spp.	tr					
Rubus idaeus						
Salicaceae						
Populus tremuloides	2	tr			tr	tr
Populus trichocarpa	tr					
Salix spp.	2					
Saxifragacaceae						
Heuchera cylindrica	tr			1	tr	tr
Lithophragma bulbifera		tr				
Philadelphus lewisii						
Ribes hudsonianum	tr			tr	tr	tr
Scrophulariaceae						
Castilleja spp.			tr		tr	
Castilleja agustifolia						
Castilleja lutescens						
Castilleja minata			tr			
Collinsia parviflora		tr	1	tr	tr	tr
Mimulus gattatus						
Orthocarpus luteus		tr	tr			
Orthocarpus tenuifolius		tr	tr			
Penstemon albertinus				tr	tr	tr
Penstemon eriantherus		tr			tr	
Penstemon nitidus					tr	
Penstemon procerus				tr	tr	tr
Verbascum spp.		tr				
Verbascum thapsus						
Solonaceae						
Hyoscyamus niger						
Umbelliferae						
Lomatium spp.		tr			tr	
Lomatium simplex		tr				tr
Lomatium triternatum		tr			tr	

Table 18 (continued)

Habitat Type / Family Species	Coverage					
	Riparian meadow	Grass-land	Sage-brush	Dense timber	Open timber	Parkland
Violaceae						
Viola spp.					tr	
Viola adunca						
Viola nuttallii		tr		tr		
Viola praemorsa						
Viola septentrionalis						

Table 19. Percent foliar coverage of nonarboreal plant species at 14 sites on the Rock Creek winter range.

Type 1/	G	OT	G	OT	S	G	G	G	OT	DT	G	G	S	S
Transect 2/ / Family / Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Boraginaceae														
Cryptantha bradburiana	tr	tr		tr		2		tr						
Lappula redowskii						2	tr	tr						
Lithospermum ruderale					4		6				tr			tr
Caprifoliaccae														
Symphoricarpus albus										tr				
Caryophyllaccae														
Arenaria congesta		tr		2	tr	5	4					tr		
Cerastium arvense						tr	tr							
Compositae														
Achillea millefolium	1	3	3	2	17	6	39	44	1	tr	1	tr		tr
Antennaria spp.											tr			tr
Antennaria rosea	tr	3	tr	tr			2							
Arnica cordifolia										1				
Arnica sororia					19		8	7						
Artemisia frigida	15	11	33	10			tr	2	tr					
Artemisia tridentata					49								9	11
Balsamorhiza sagittata							21	34			tr			3
Chrysopsis villosa				17										
Chrysothamnus nauscosus	2	2		13				4						
Chrysothamnus viscidiflorus							tr							
Cirsium undulatum	1	1				1								
Crepis acuminata	2	tr		2	5	6	12	2						
Erigeron compositus	tr	3		3	tr	8	tr						tr	
Erigeron speciosus				tr	6	tr								
Hieracium albiflorum		tr	tr				tr							
Senecio spp.			tr											
Taraxacum spp.										tr		tr		tr
Trapogon dubius	1													
Trapogon pratensis		1		3	tr	1	tr	tr						
Crassulaceae														
Sedum spp.														tr

1/ Symbols used are: grassland(G), open timber(OT), sagebrush(S), dense timber(DT); tr indicates the species was present but consisted of less than .5 percent foliar coverage.

2/ Transects 1 through 8, run during June and July, 1967 are from Berwick (1968); the rest were done in July 1968 by me with the aid of a work study student.

Table 19. (continued)

Type	G	OT	G	OT	S	G	G	G	OT	DT	G	G	S	S
Transects / Family, Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cruciferae														
Arabis spp.	tr	tr		tr		12	tr	tr						
Capsella spp.							tr							
Draba spp.					2		tr	1						
Lepidium spp.							tr							
Sophia spp.						tr	tr	tr						
Cyperaceae														
Carex spp.					tr					tr	tr			tr
Geraniaceae														
Geranium viscosissimum							tr							
Gramineae														
Agropyron spicatum	32	43	20	10	4	11	13	18			2	1	3	1
Bromus tectorum	tr	tr	4	6	2	16	4	5	tr		tr	tr	tr	
Calamagrostis rubescens	tr	3		tr	3	tr		tr		7				
Festuca idahoensis	tr	3									2	1	tr	3
Festuca scabrella										tr	tr	tr		
Koeleria cristata	14	15		6	2	7	3	3	4	tr		tr		
Poa secunda	6	4		2	2	4	7	3	tr		tr	tr		tr
Hydrophyllaceae														
Hydrophyllum capitatum							tr							
Phacelia glandulosa												tr		
Phacelia heterophylla	tr													
Phacelia linearis	3	tr	1	5	1	8	tr	9			tr			tr
Leguninosae														
Astragulus drummondii	12			2		tr								
Lupinus spp.											1			2
Lupinus sericous	2	1		2	36	12	39	50						
Liliaceae														
Allium spp.														tr
Allium cernuum							tr							
Calochortus spp.														tr
Zygadenus elegans					tr									
Linaceae														
Linum lewisii	tr	tr		tr										
Polemoniaceae														
Collomin linearis	4	3	3	2	4	5	3	2						
Leptodactylon pungens	8	13							1					
Phlox hoodii				8		1	1							
Phlox longifolia											tr			tr
Polemonium occidentale										tr				
Polygonaceae														
Eriogonum spp.		1												
Eriogonum flavum											tr			tr

Table 19. (continued)

Type / Transects / Family Species	G 1	OT 2	G 3	OT 4	S 5	G 6	G 7	G 8	OT 9	DT 10	G 11	G 12	S 13	S 14
Primulaceae														
Dodecatheon conjugens												tr		
Rosaceae														
Amelanchier alnifolia			3											
Frageria vesca										1		tr		
Frageria virginiana							tr							
Geum triflorum					tr		tr							
Potentilla arguta											tr			
Potentilla glandulosa							tr							
Prunus virginiana			6											
Rosa woodsii			3											
Rubus spp.										tr		tr		
Saxifragaceae														
Heuchera cylindrica										tr		tr		
Scrophulariaceae														
Castilleja spp.														tr
Collinsia spp.										tr	tr			
Collinsia parviflora		tr	tr		tr		tr	2						
Orthocarpus luteus								tr			tr			1
Orthocarpus tenuifolius					1	tr		tr						
Penstemon nitidus									tr					
Umbelliferae														
Lomatium spp.		4	1											
Lomatium triternatum	tr			tr			tr							
Violaceae														
Viola spp.						5								

Table 20. Percent by volume of plant species in Rock Creek mule deer rumens.

Source						Berwick (1968)																									Present Study																										
Year		1967									1968																			1969																											
Month		November			Jan.		February			Mar	Apr		November				December				January				February						March				April				May			February						Mid-winter							April		
How obtained		Hunter				Collection							Hunter																	Collection																		Carcass									
Collection number													35	36	37	38	40	41	42	43	44	45	47	50	53	55	58	59	62	64	65	66	68	70	71	72	73	93	95	48	52	54	80	60	63	67	69	74	84	88	89	91	79	83	85	86	87
Grasses and grasslike plants	0	8	39	59	2	0	5	tr	1	55	94	67	44	10	2	2	7	9	2	1	1	12	4	0	0	0	16	2	8	26	21	31	1	40	68	54	43	79	9	0	0	8	3	tr	48	11	4	29	31	11	11	36	10	45	70	82	70
Forbs																																																									
Achillea millefolium	tr	1									tr	tr							1		tr	tr											tr					tr	tr				tr														
Anemone spp.																																																									
Antennaria spp.																																		5	2		5												1						4		1
Antennaria rosea				40	6	48	9																																																		
Arctostaphylos uva-ursi	tr	1	tr	1						1	tr	tr																						tr		2	3										3	1	tr					3	2	1	2
Arnica sororia												1																																													
Arenaria congesta							12						tr																																												
Artemisia dranunculus																																																									
Artemisia frigida	3	tr	3				1		8						3	2	tr				tr														tr						1				1	3			2			tr	2		tr		
Balsamorhiza sagittata													tr	20			27	7	2					2												1			16																		
Berberis repens																																																				5	8			
Family Cruciferae	1																																																								
Erigeron spp.											tr	tr				tr																																									
Erigeron compositus		2							2	tr	tr	1		tr			1													tr		2				1	1								13		1					tr	1			4	
Eriogonum spp.					1						tr																																														
Frageria spp.													tr																																												
Frageria virginiana	8	13			13																																																				
Geum triflorum					1	1																												2	5	3	1		1															3			tr
Family Leguminosae													2		2	tr	1	tr																																							
Lewisia rediviva																																		tr	2		tr		tr																		
Lupinus spp.															1		tr																						tr																		tr
Lupinus caudatus	2										1	1																																													
Lupinus sericeus	8	13	1						4			1																																													
Oxytropis spp.								tr	3																																																
Penstemon cyaneus	tr																																																								
Phacelia linearis	2	1																																																							
Phlox hoodii																																		tr			1																tr			4	tr
Potentilla gracilis													1																																												
Potentilla glandulosa	tr																																																								
Sedum spp.																																																					2				
Taraxacum officinale											2	tr																																													
Tragopogon pratensis					tr																																																				
Family Umbelliferae																																							3																		
Unidentified forbs	60	33	32	5			40	20	22	29	1	14	42	62	22	1	34	29	4	tr	3	26	2	6	28	23	14	3	94	6	19	19	1	22	2	17	16	19	42	60	47	12	2		14	4	27	10	2	7	5	22	68	7	9	11	11
Total Forbs	84	64	36	6	14	0	93	28	88	0	5	19	45	83	28	3	63	37	7	tr	3	26	2	8	28	23	14	3	94	6	19	21	1	30	11	24	27	19	62	60	48	12	2	0	28	7	31	11	5	7	5	23	86	21	19	16	14
Browse																																																									
Acer glabrum					1																																							tr							2						
Amelanchier alnifolia					tr																																		6																		
Artemisia tridentata			10	6				6	2		tr	12	tr	5	44	49	28	54	87	1	92	21	12	1	1		29	52	38	43	13	48	59	22	16	19	27	1					33	tr			tr	tr									
Chrysothamnus nauseosus																	1		3	1	tr	1		tr										tr															tr				2		1		
Cornus stolinifera	11					37																			3																4	1	tr														
Juniperus communis																																																1			2						
Juniperus scopularum		5	41	1			3														tr	32		40	17	5	13	43	43	8	15									1	20	10	23	tr	20	72	6	tr	27	2	2	tr					
Physocarpus malvaceus																																										tr										tr					
Pinus ponderosa				1				32	tr																8																						4		2								
Prunus virginiana																									3		1				3										5	2	17				12		19						1		
Pseudotsuga menziesii	3	28	4	14	30	4	tr	9		tr		1	tr	2	26	24	1		1	97	4	2	82	49	7	68	17			4	3		39	1	3	2	1		1	4	11	22	3	9	4	6	38	18	1	67	44	34	2	27	tr	tr	4
Ribes spp.												tr																							tr				2																		
Rosa woodsii	1	tr																																																							
Salix spp.																																								1																	
Spirea betulifolia					4																																																				
Symphocarpos albus			5			7						tr																																													
Unidentified browse	1		4	14	18	11	1	25	9	2	1		11			22		tr	tr			3		tr	27	4	10				26			7	2	1	1	1	20	34	12	45	19	91		3	5	41	14	13	34	7		7	9	2	12
Total Browse	16	28	25	75	59	100	2	72	11	6	1	14	11	7	70	95	30	54	91	99	96	60	94	91	67	77	70	95	81	54	60	48	98	30	21	22	30	2	29	40	52	80	95	100	24	82	65	60	64	82	84	41	4	34	11	2	16
Other																																																									
Lichen					25															tr		2		1	5	tr			2	14																											
Total					25															tr		2		1	5	tr			2	14																											

Table 21. Percentages of identifiable remains of forage classes in mule deer fecal pellets.

		Percent of Epidermal Remains					
		Monocotyledon		Dicotyledon		Conifer	
Number	Month	Mean 1/	SE 2/	Mean 1/	SE 2/	Mean 1/	SE 2/
36	November	0	--	42	8	58	8
38	December	10	2	36	4	54	3
40	"	31	4	45	2	24	3
41	"	2	1	55	6	43	5
42	January	1	1	55	2	44	2
44	"	4	2	18	3	78	3
45	"	16	3	30	6	54	7
47	"	2	1	72	6	26	6
50	February	3	1	49	10	48	9
53	"	10	4	69	10	21	9
55	"	5	2	62	8	33	8
58	"	8	1	55	6	37	5
59	"	3	1	77	4	20	4
62	March	19	4	56	5	25	4
64	"	15	5	48	8	37	4
65	"	10	3	55	7	35	4
66	"	29	4	22	8	49	4
68	"	11	3	51	7	38	5
70	April	40	4	31	6	29	4
71	"	59	3	15	2	26	1
72	"	45	6	18	6	37	2
73	"	28	4	22	3	50	3
93	"	69	4	24	5	7	3
95	May	32	3	58	3	10	3

1/ This represents the mean percentage for five slides prepared from pellets of one animal.

2/ Some of the data is skewed due to the presence of low numbers and zeros; standard error values in these cases represent only approximations of the sample variance.

Table 22. Percentages of identifiable epidermal remains of forage classes in bighorn sheep feces.

Date 1/	Percent of Epidermal Remains					
	Monocotyledon		Dicotyledon		Conifer	
	Mean 2/	SE 3/	Mean 2/	SE 3/	Mean 2/	SE 3/
6-17-68	74	6	25	6	1	1
"	77	3	21	4	2	1
9-23-68	83	4	13	4	4	2
"	67	5	31	5	2	2
"	77	4	22	4	1	1
1-13-69	69	4	13	5	18	4
"	91	4	9	4	0	-
"	79	4	21	4	0	-
"	15	1	20	6	65	7
"	96	1	4	1	0	-
1-20-69	80	4	12	2	8	3
"	68	3	26	3	6	3
"	57	3	34	7	9	6
2-8-69	80	4	12	2	8	3
"	68	3	26	3	6	3
"	57	3	34	7	9	6
2-13-69	56	5	21	5	23	1
2-26-69	58	4	31	4	11	3
3-12-69	75	4	5	2	20	3
"	70	3	9	2	21	3
"	74	7	4	2	22	7

1/ Pellets collected on the same day were from the same area.

2/ This represents the mean percentage for five slides prepared from pellets of one animal.

3/ Some of the data is skewed due to the presence of low numbers and zeros; standard error values in these cases represent only approximations of the variance.

Table 23. Chemical analyses of forage plants from the Rock Creek winter range.1/

Species	Month	Plant Part	Stage	NFE2/	CP3/	EE4/	Ash	CF5/	P	Ca
Artemisia tridentata	July	Upper four	Mature	50.1	13.0	5.8	6.3	24.5	.44	.43
" "	"	inches stem and leaves	"	48.7	12.0	7.9	6.0	25.2	.45	.40
" "	September	"	"	54.7	9.8	7.2	3.5	24.6	.29	.31
" "	January	"	Dormant	51.4	9.4	9.8	2.8	26.4	.16	.35
" "	April	"	Mature	54.0	10.2	9.7	3.5	22.4	.19	.34
Agropyron spicatum	July	"	"	45.2	9.7	3.7	5.7	35.4	.22	.24
" "	"		"	47.3	9.5	3.8	5.3	33.8	.14	.28
" "	September	"	"	47.2	8.2	4.6	6.9	32.7	.11	.81
" "	"	"	"	43.9	6.8	4.8	7.1	37.0	.09	.24
" "	"	"	"	45.2	7.2	4.1	7.4	35.9	.11	.46
" "	October	"	"	48.4	3.4	4.8	8.2	35.0	.06	.40
" "	January	"	Weathered	44.7	2.8	5.2	8.8	38.2	.03	.35
" "	"	"	"	48.3	2.1	2.0	4.3	43.1	.03	.10

1/ All analyses expressed as a percentage of oven-dry weight.

2/ Nitrogen-free extract.

3/ Crude protein.

4/ Ether extract.

5/ Crude fiber.

Table 23. (continued)

Species	Month	Plant Part	Stage	NFE	CP	EE	Ash	CF	P	Ca
Agropyron spicatum (continued)	March	Upper four inches stem and leaves	Weathered	44.7	3.0	2.9	7.2	41.9	.04	.22
" "	April	"	"	43.6	3.0	2.7	8.8	41.7	.05	.14
" "	"	"	"	47.4	2.7	3.0	6.3	40.3	.04	.15
" "	"	Upper two inches leaves	Immature	39.8	14.8	2.3	9.4	33.5	.24	.21
Artemisia frigida	July	Upper four inches leaves and stem		46.2	9.1	4.7	5.5	34.3	.16	.52
" "	September		Mature	50.2	8.3	4.9	4.0	32.4	.17	.47
" "	"	"	"	48.2	10.7	5.0	4.6	31.2	.22	.51
" "	"	"	"	51.1	10.2	5.3	4.3	28.8	.19	.50
" "	October	"	"	51.2	8.9	5.5	4.9	29.2	.15	.60
" "	January	"	"	48.5	6.4	4.1	4.2	36.5	.11	.65
" "	"	"	"	53.0	7.3	4.5	3.7	31.3	.11	.71
" "	March	"	Weathered	41.2	4.8	2.2	4.8	46.7	.07	.32
" "	April	"	"	42.4	6.0	2.6	4.4	44.3	.10	.39
" "	"	"	Immature	46.7	9.3	3.8	5.3	34.6	.14	.55
Festuca idahoensis	July	Upper two inches leaves	Mature	46.4	9.1	5.4	7.8	31.1	.15	.21
" "	"	"	"	45.6	8.4	4.9	8.5	32.4	.16	.27
" "	September	"	"	46.6	6.7	4.3	8.6	33.5	.16	.16
" "	"	"	"	44.0	7.8	4.7	7.7	35.6	.14	.17
" "	"	"	"	45.5	6.6	4.2	8.9	34.5	.14	.23
" "	April	"	Immature	43.9	9.8	3.7	10.2	32.1	.18	.21

Table 23. (continued)

Species	Month	Plant Part	Stage	NFE	CP	EE	Ash	CF	P	Ca
Balsamorhiza sagittata	July	Leaf	Mature	49.7	15.2	3.6	15.6	15.6	.48	1.51
" "	"	Upper petiole	"	43.6	4.7	.8	18.6	32.0	.42	1.17
" "	"	Lower petiole	"	38.6	4.8	.9	18.8	36.6	.57	1.05
Chrysothamnus nauseosus	January	Upper four inches stem	Dormant	43.2	8.0	9.3	3.5	35.9	.11	.50
Pseudotsuga menziesii	"	Terminal twig and needles	"	58.7	7.0	7.7	3.6	22.8	.11	.57
Juniperus scopularum	"	"	"	42.8	7.6	22.3	4.3	22.8	.12	.93
Prunus virginiana	"	Terminal four inches stem	"	57.5	11.3	2.5	4.1	24.3	.20	1.17
Cornus stolonifera	"	"	"	54.5	5.6	6.1	3.1	30.5	.15	.71
Populus tremuloides	"	"	"	44.5	5.9	20.5	2.1	26.8	.13	.48
Ranunculus glaberrimus	April	Whole plant	Immature	54.6	14.9	2.6	9.0	18.6	.46	.42

Table 24. Nutrients in mule deer rumens.1/

Number	Age	Sex	Percent Composition of Rumen1/ NFE2/	Crude protein	Ether extract	Ash	Crude fiber	P	Ca
Collected Animals-									
November 1968									
35	8½	Male	36.0	15.5	3.2	2.4	42.6	.39	.65
36	4½	Female	38.2	17.5	3.8	9.0	31.2	.70	1.16
37	1½	Female	32.0	14.7	4.6	6.3	42.0	.66	.60
December 1968									
38	4½	Female	35.2	14.9	4.4	11.9	33.2	1.38	1.49
40	2½	Male	35.8	14.9	4.6	11.2	33.2	1.21	1.89
41	4½	Female	37.3	14.2	5.3	8.6	34.3	.83	1.33
January 1969									
42	2½	Male	35.4	12.6	5.8	6.1	39.8	.72	1.01
43	0½	Male	36.6	8.2	5.3	2.9	46.8	.18	.60
44	1½	Male	37.2	10.6	6.7	4.3	41.0	.48	.64
45	4½	Female	34.4	10.9	8.4	6.3	39.8	.71	.94
47	2½	Male	36.6	10.9	9.1	5.3	37.9	.63	.76
February 1969									
50	3½	Male	35.4	9.8	8.6	4.0	41.9	.37	1.07
53	2½	Female	34.8	11.7	7.5	5.7	40.1	.55	.84
55	2½	Female	30.8	24.6	7.0	5.4	31.9	.55	.77
58	3½	Female	35.2	11.7	8.5	6.1	38.2	.53	1.14
59	4½	Female	32.7	11.0	9.3	4.7	42.1	.50	.83
March 1969									
62	1½	Female	34.0	12.3	7.9	5.3	40.3	.44	.84
65	2½	Female	35.0	12.7	8.8	6.3	36.9	.44	1.04
66	1½	Female	36.1	11.2	6.8	7.4	38.3	.39	.69
68	3½	Female	37.3	11.0	9.2	4.6	37.7	.38	.73
April 1969									
70	3½	Female	38.4	11.8	6.3	7.3	36.0	.59	.99
71	8½	Female	38.7	13.1	5.6	7.6	34.8	.59	.91
72	3½	Female	42.3	9.8	6.0	6.1	35.6	.35	.72
73	7½	Male	39.3	9.1	5.6	5.6	40.1	.40	.70
93	3½	Female	32.4	23.0	5.4	6.0	32.9	.36	.43
May 1969									
95	6	Female	34.7	27.5	6.0	6.3	25.4	.89	1.26
Carcasses-February 1969									
48	1½	Male	34.5	13.1	8.4	3.6	40.2	.75	.85
52	0½	Male	36.4	7.7	8.1	5.9	41.6	.56	.98
54	0½	Female	35.2	12.4	7.7	5.5	39.0	.63	1.18

1/ Expressed as percentage of oven-dry weight.

2/ Nitrogen-free extract.

Table 24. (continued)

Number	Age	Sex	Percent Composition of Rumen NFE	Crude protein	Ether extract	Ash	Crude fiber	P	Ca
Carcasses-February 1969 (continued)									
80	0½	Female	35.5	12.7	7.8	5.3	38.4	.34	1.03
92	-	-	32.6	7.9	3.8	5.1	50.4	.36	.66
Mid-winter 1969									
64	2½	Female	34.6	12.4	9.7	5.6	37.4	.50	.64
60	7½	-	30.3	7.1	2.4	2.8	57.2	.26	.53
63	-	-	33.3	10.2	9.7	8.0	38.5	.72	1.38
67	-	-	35.8	9.7	9.5	6.4	38.4	.36	1.28
69	0½	Female	37.3	12.9	7.2	6.6	35.8	.64	1.54
74	0½	Female	35.7	12.0	5.6	6.8	39.6	.35	.82
84	1½	Female	26.4	19.0	8.1	11.0	35.2	.50	.95
88	4½	-	33.2	12.9	6.5	5.5	41.6	.87	1.09
89	9½	Female	32.0	11.2	7.6	4.7	44.4	.49	1.15
91	0½	Male	32.4	18.1	5.6	8.2	35.5	.86	1.51
April 1969									
79	0½	Male	30.5	14.0	7.9	9.6	37.7	.47	.78
85	9½	Female	34.9	19.9	5.0	8.1	31.8	.41	.61
86	9½	Female	41.0	11.0	6.8	13.3	27.6	1.08	.69
87	0½	Male	31.2	12.0	6.3	20.0	30.3	.77	.63

Table 25. Chemical analyses of mule deer and bighorn sheep fecal pellets.1/

Collection number	Sex	Age	Crude protein	Ether extract	Ash	Crude fiber	P	Ca
Mule Deer1/								
November								
36	Female	4½	5.1	4.8	13.7	23.6	.33	2.7
December								
38	Female	4½	11.9	4.6	11.1	29.6	.30	2.1
40	Male	2½	12.7	5.1	12.2	26.0	.43	1.96
41	Female	4½	11.4	5.1	15.5	25.0	.32	1.7
January								
42	Male	2½	10.7	5.3	9.1	34.5	.51	1.1
44	Male	1½	9.5	4.8	7.3	36.2	.42	1.29
45	Female	4½	8.8	5.6	7.0	36.3	.30	1.26
47	Male	2½	8.7	8.8	7.7	34.9	.54	0.97
February								
50	Male	3½	8.7	8.7	6.6	37.0	.45	1.34
53	Female	2½	9.2	8.1	6.9	35.4	.27	0.72
55	Female	2½	10.2	7.4	11.0	32.7	.23	0.91
58	Female	3½	10.0	8.9	10.6	28.4	.40	1.34
59	Female	4½	8.9	8.9	5.0	38.2	.37	0.62
March								
62	Female	1½	8.7	6.5	16.5	26.7	.40	0.37
64	Female	2½	9.8	9.3	10.2	33.8	.54	0.76
65	Female	2½	9.5	6.8	18.0	27.4	.29	0.60
66	Female	1½	8.2	4.7	33.5	22.0	.33	0.35
68	Female	3½	10.3	7.8	12.1	30.9	.41	0.87
April								
70	Female	3½	12.5	4.7	18.5	25.0	.28	0.79
71	Female	8½	11.2	4.7	16.9	26.3	.28	0.48
72	Female	3½	11.4	4.9	11.4	30.6	.35	0.94
73	Male	7½	10.8	4.8	13.8	30.0	.26	0.92
93	Female	3½	16.9	5.4	15.6	26.7	1.05	1.04
May								
95	Female	6½	20.7	3.5	20.0	18.0	1.20	2.72
Bighorn Sheep2/								
September			10.1	9.5	20.7	26.1	.25	1.73
September			10.6	9.8	20.5	23.3	.71	1.78

1/ Only feces from collected deer were analyzed; all analyses are expressed as percent of oven-dry weight.

2/ Most samples analyzed were from several sheep.

Table 25. (continued)

Collection number	Sex	Age	Crude protein	Ether extract	Ash	Crude fiber	P	Ca
Bighorn Sheep (continued)								
September			9.7	8.5	21.8	25.1	.52	1.34
January			7.1	5.2	17.5	25.6	.21	0.57
January			7.9	5.8	19.3	23.6	.28	0.67
January			8.0	5.9	15.2	29.2	.31	0.71
January			7.7	5.3	18.7	24.7	.25	0.73
January			6.5	5.7	25.6	24.0	.18	0.83
February			7.9	3.6	19.2	26.1	.25	1.03
February			7.9	3.6	17.3	26.8	.22	.75
February			8.4	2.8	19.2	27.8	.19	.27
March			7.3	2.3	29.6	24.6	.30	.27

Table 26. Weights, measurements, and condition indices from Rock Creek mule deer.

No.	Sex	Age	Whole wt(lbs)	Heart girth (inches)	Hind foot (inches)	Body length (inches) 1/	Kidney fat index 2/	Adrenal wt(gm)	Liver wt(gm)
November 1967 3/									
	F	½					24.1		1244
2772	F	5½			18.0		54.3		
2773	F	1½			16.5		48.3		
2774	F	5½					39.0		
2775	F	1½					38.5		
January 1968									
2776	M	1½	135	36.5	19.3	56.5	12.4		1297
2777	M	1½	115	36.0	18.8	53.3	21.0		1081
February 1968									
2867	F	9½	146		20.0	58.0	17.0		871
2868	F	4½	125	36.0	18.5		1.8		1055
2869	F	3½	134	37.5	19.0		33.3		870
March 1968									
2864	M	6½	150	36.0	21.0	55.7	7.4		1065
April 1968									
2865	F	2½	133	35.0	19.0	50.2	15.4		1110
2866	F	9½	143	36.5	19.5	60.0	16.3		1411
November 1968									
35	M	8½		48.5	19.8	63.8	47.4	4.76	2250
36	F	4½	155	38.0	18.6	60.4	37.5	2.88	1300
December 1968									
38	F	4½	175	38.5	20.5	64.5	47.5	3.86	1450
40	M	2½	150	38.3	19.3	59.0	20.0	2.29	1320
41	F	4½	156	38.0	19.0	59.9	50.1	1.99	1225
January 1969									
42	M	2½	181	39.5	19.8	64.4	9.0	2.60	1350
43	M	½	70	29.8	16.4	49.2	28.8	2.02	710

1/ Tip of nose to base of tail along curvature of spine.

2/ Calculated by method of Riney (1954).

3/ Data on deer from November 1967 to April 1968 are from deer collected by Berwick under permit from the Montana Fish and Game Department.

Table 26. (continued)

No.	Sex	Age	Whole wt(lbs)	Heart girth (inches)	Hind foot (inches)	Body length (inches)	Kidney fat index	Adrenal wt(gm)	Liver wt(gm)
January 1969 (Continued)									
44	M	1½	115	33.1	17.5	53.3	12.1	2.44	1000
45	F	4½	142	37.3	18.8	55.5	33.8	2.32	1100
47	M	2½	136	36.8	19.6	58.2	9.9	3.11	1300
February 1969									
50	M	3½	135	36.5	19.0	59.9	8.8	3.28	1150
53	F	2½	115	33.5	18.0	59.5	50.9	2.34	1000
55	F	2½	128	35.5	18.5	58.5	23.0	2.66	850
58	F	3½	124	37.0	19.5	60.5	12.9	2.67	950
59	F	4½	121	36.0	19.0	61.0	19.8	3.63	1100
March 1969									
62	F	1½	91	31.0	18.0	57.8	15.2	1.79	825
64	F	2½	125	35.5	19.5	59.7	10.0	2.24	1250
65	F	2½	117	33.5	19.0	58.0	23.6	2.50	950
66	F	1½	91	29.5	18.0	53.0	11.7	1.56	825
68	F	3½	126	35.0	20.0	58.5	9.8	2.77	1150
April 1969									
70	F	3½	110	35.5	19.3	57.2	6.6	2.30	900
71	F	8½	141	38.8	20.0	57.8	14.7	3.22	1000
72	F	3½	119	35.0	19.8	55.5	7.4	2.61	900
73	M	7½	150	40.3	20.3	57.7	6.2	3.49	1250
93	F	3½	140	36.0	19.0	60.0	18.4		
May 1969									
95	F	6½	140	37.8	19.5	57.9	12.2	1.90	1650

Table 27. Chemical analyses of femur marrow from mule deer.

Number	Sex	Age	Month	How obtained	Ether extract 1/	Percent compression 2/	Percent moisture
59	Female	4½	February	Shot	81.1	0.1	16.0
62	Female	1½	March	Shot	59.0	4.0	36.2
64	Female	2½	March	Shot	62.4	3.0	34.7
65	Female	2½	March	Shot	68.1	5.0	29.3
66	Female	1½	March	Shot	46.0	6.0	48.1
68	Female	3½	March	Shot	64.7	3.0	31.5
83	Female	9½	April	Carcass	0.4	27.0	82.9
85	Female	9½	April	Carcass	1.0	30.0	84.6
86	Female	9½	April	Carcass	1.1	22.0	82.7
70	Female	3½	April	Shot	30.8	16.0	64.8
71	Female	8½	April	Shot	57.3	5.0	37.3
93	Female	3½	April	Shot	84.6	0.1	12.1
95	Female	6½	May	Shot	48.9	16.0	46.7

1/ Reported as percent of whole sample (including moisture).

2/ Greer (1968).

Table 28. Weights and measurements of embryos and fetuses from mule deer collected on Rock Creek.

Number	Date	Left			Right		
		Weight (gm)	Crown-rump length (mm)	Hind-foot length (mm)	Weight (gm)	Crown-rump length (mm)	Hind-foot length (mm)
45	1-16-69	117	73	18	15	72	17
53	2-17-69	200	170	65	204	167	65
55	2-20-69	152	159	54	143	154	54
58	2-23-69	155	159	55	160	159	54
59	2-27-69	230	177	65	260	183	67
62	3-6-69	246	175	63			
64	3-10-69				452	198	84
65	3-12-69	715	243	105			
66	3-22-69	499	222	89			
68	3-24-69	620	245	101	600	233	102
70	4-5-69	600	255	113	455	230	100
71	4-5-69	1000	289	127	1000	291	133
72	4-5-69	620	256	110	550	235	109
93	4-26-69	810	295	130	2130	400	185
95	5-10-69	2300	415	203	2300	440	205

Table 29. Counts of corpora lutea and fetuses from female mule deer collected on Rock Creek.

Number	Age of Doe	Date	Corpora lutea		Fetuses			
			Right	Left	Right		Left	
					No.	Sex	No.	Sex
2867	9½	2-25-68	No data	No data	1	ND1/	1	ND
2868	4½	"	"	"	0	"	0	"
2869	3½	"	"	"		2/		2/
2865	3½	4-27-68	"	"	1	ND	1	ND
2866	10½	"	"	"	1	"	1	"
33	4½	12-11-68	2	0	1	ND	1	ND
41	4½	12-26-68	2	0	1	"	0	
45	4½	1-16-69	1	1	1	♂	1	♂
53	2½	2-17-69	1	1	1	♀	1	♀
55	2½	2-20-69	0	2	1	♀	1	♀
58	3½	2-23-69	0	2	1	♂	1	♀
59	4½	2-27-69	1	1	1	ND	1	♂
62	1½	3-6-69	1	0	0		1	♂
64	2½	3-10-69	0	1	0		1	ND
65	2½	3-12-69	0	1	1	♂	0	
66	1½	3-22-69	1	0	0		1	♂
68	3½	3-24-69	2	0	1	♂	1	♂
70	3½	4-5-69	2	0	1	♀	1	♂
71	8½	"	1	1	1	♀	1	♀
72	3½	"	1	1	1	♀	1	♂
93	3½	4-26-69	2	0	1	♂	1	♂
95	6½	5-10-69	1	1	1	ND	1	ND

1/ No data.

2/ One embryo recorded but not the side in which it was found.