



Range ecology and relations of mule deer, elk, and cattle in the Missouri River Breaks, Montana
by Richard John Mackie

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY in Fish and Wildlife Management

Montana State University

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Abstract:

A study was conducted during the four-year period 1960-64 to obtain quantitative data on food habits, range use, and relations of mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), and cattle on ponderosa pine-juniper (*Pinus ponderosa/Juniperus scopulorum*) and related vegetation types in the Missouri River "Breaks" in northcentral Montana. Eight vegetation types comprising 12 distinct communities were analyzed and described. Totals of 11,581 mule deer observations, 3,489 elk observations, and 25,125 cattle observations were recorded during morning and evening periods. Distributions, movements, and population trends during seasons and years were related to range use and forage conditions. Seasonal and yearly distributions of observations and animal activities were related to sunrise and sunset and environmental conditions, Group sizes during seasons and years were discussed in relation to social behavior and range use.

Seasonal, yearlong, and year-to-year trends in relative use and importance of vegetation types were evaluated with respect to animal activity, forage utilization, plant growth, and weather conditions. Relative frequencies of occurrence of each of the three animals on slopes of various degrees of steepness and exposure were discussed. Relations between distributions of mule deer, elk, and cattle use on the area and distributions of water sources were described. Instances of plant use at 263 mule deer, 178 elk, and 184 cattle feeding sites were related to animal use of the various vegetation types to ascertain seasonal food habits. Analyses of rumen samples from 37 mule deer, 12 elk, and 18 cattle supplemented feeding site data. Yearlong trends in relative use and importance of forage classes and individual plant taxa were described. Year-to-year trends in food habits were related to precipitation and its influence on plant growth. Relations between elk and mule deer, elk and cattle, and mule deer and cattle were evaluated with respect to degrees of overlap in distribution of use on the area in time and space in relation to food habits, range use, animal behavior, and condition of "key" forage plants. Conclusions and recommendations relating to mule deer, elk, and "multiple-use" management programs on the area were presented.

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194

by

RICHARD JOHN MACKIE

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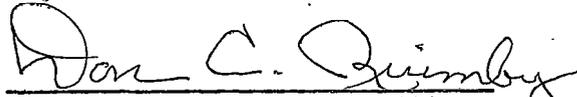
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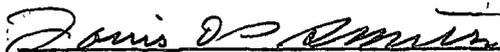
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ABSTRACT

A study was conducted during the four-year period 1960-64 to obtain quantitative data on food habits, range use, and relations of mule deer (Odocoileus hemionus), elk (Cervus canadensis), and cattle on ponderosa pine-juniper (Pinus ponderosa/Juniperus scopulorum) and related vegetation types in the Missouri River "Breaks" in northcentral Montana. Eight vegetation types comprising 12 distinct communities were analyzed and described. Totals of 11,581 mule deer observations, 3,489 elk observations, and 25,125 cattle observations were recorded during morning and evening periods. Distributions, movements, and population trends during seasons and years were related to range use and forage conditions. Seasonal and yearly distributions of observations and animal activities were related to sunrise and sunset and environmental conditions. Group sizes during seasons and years were discussed in relation to social behavior and range use. Seasonal, yearlong, and year-to-year trends in relative use and importance of vegetation types were evaluated with respect to animal activity, forage utilization, plant growth, and weather conditions. Relative frequencies of occurrence of each of the three animals on slopes of various degrees of steepness and exposure were discussed. Relations between distributions of mule deer, elk, and cattle use on the area and distributions of water sources were described. Instances of plant use at 263 mule deer, 178 elk, and 184 cattle feeding sites were related to animal use of the various vegetation types to ascertain seasonal food habits. Analyses of rumen samples from 37 mule deer, 12 elk, and 18 cattle supplemented feeding site data. Yearlong trends in relative use and importance of forage classes and individual plant taxa were described. Year-to-year trends in food habits were related to precipitation and its influence on plant growth. Relations between elk and mule deer, elk and cattle, and mule deer and cattle were evaluated with respect to degrees of overlap in distribution of use on the area in time and space in relation to food habits, range use, animal behavior, and condition of "key" forage plants. Conclusions and recommendations relating to mule deer, elk, and "multiple-use" management programs on the area were presented.

INTRODUCTION

Vegetation characterized by ponderosa pine (Pinus ponderosa) and rocky mountain juniper (Juniperus scopulorum) occurs extensively on rough uplands along the Missouri and Yellowstone River drainages and throughout central and eastern Montana. It represents the most important habitat type of mule deer (Odocoileus hemionus), is locally a superior habitat of elk (Cervus canadensis), and is heavily utilized in grazing by livestock. Much of this important game habitat type is publicly owned, mostly by the Federal Government, and administered by the Bureau of Land Management.

Paucity of quantitative data on big game and livestock food habits, range-use habits, and relations has hindered the establishment of sound effective management programs. A clarification of relationships is essential for development of cooperative multiple-use management programs. To aid in the formation of these, an intensive investigation was conducted on a representative 75,000 acre area in the Missouri River Breaks approximately 25 miles northeast of Roy, Montana. Full-time field work was conducted from June 1960 through September 1963. Additional data were obtained during several one-day to two-week periods from October 1963 to June 1964. The primary objectives were to obtain quantitative data on range-use and food habits of mule deer, elk, and cattle on the ponderosa pine-juniper and associated vegetational types and to develop methods and criteria for management. Habitat and population studies were conducted concomitantly to evaluate the effects of range condition, intraspecific and interspecific conflicts, and current game management practices on mule

deer and elk populations. These data also aided in interpretation of food and range-use relationships.

Seasonal and year-long food and/or range-use habits of mule deer and elk have been studied intensively on many parts of their ranges. Available data on range food and use habits of cattle on western rangelands appear largely observational or derived from forage utilization and condition studies. Some quantitative, seasonal and year-long data for cattle are available for a few areas where big game-livestock relations have been studied.

Few detailed studies of mule deer-cattle, elk-cattle, or mule deer-elk relationships have been made. Julander (1955) possibly presented the most comprehensive data on mule deer-cattle relationships in his report on the Oak Creek Unit of Fishlake National Forest, Utah. Detailed studies involving mule deer-cattle forage relations have been reported by Julander (1937) and Kimball and Watkins (1951) for the Kaibab deer range, Arizona and Dasmann (1949) for the interstate deer winter range, California. Elk-mule deer relationships have been considered previously in comparative winter food habit studies in northern Idaho and Montana (DeNio 1938), the Blue Mountains of Oregon (Cliff 1939), and Jasper Park, Alberta (Cowan 1947). Morris and Schwartz (1957) made a year-long study on food habits of these two species on the National Bison Range, Montana. Elk-cattle relationships were studied by Stevens (1964) in the Elkhorn Mountains, Montana. The only study of mule deer, elk, and cattle relationships known to the writer was reported by Julander and Jeffery (1964) on summer range relations in Utah.

DESCRIPTION OF THE STUDY AREA

Physiography

The study area (Figure 1) extended approximately 20 miles as a 4 to 7-mile wide belt adjacent to the Missouri River in northeast Fergus County, Montana. This area is part of a broad dissected plateau which slopes gently to the north and east. The terrain is characterized by "breaks" (Figure 2). Ridges, sharply cut coulees, and creek bottoms resulting from erosion of the plateau are closely interspersed. Elevations vary from about 3,100 feet along the southern boundary to approximately 2,250 feet along the Missouri River. Rolling plains extend, with slightly increasing elevation, to the south and southwest.

The soils, derived from the underlying Bearpaw Formation which consists largely of clay shale containing moderate amounts of alkali and other salts, are predominantly heavy clay loams of the Lismas and Pierre series (Gieseke 1938). Shallow layers of glacial lag may occur on higher level ridgetops. Shale outcrops are common. Alluvial soils of the Havre silt loam and Lohmiller clay loam series are predominant on Missouri River bottomlands. (Mr. E.K. Hogan, Pers. Comm., June 25, 1964). Several other soil types may be found locally on uplands, terraces, footslopes, fans, and bottomlands. As a group, these "gumbo" soils are relatively impermeable and runoff is high, especially from eroded and sparsely vegetated upland sites. They are considered too shallow, too heavy and plastic, and generally too steep for cultivation (Gieseke, op. cit.).

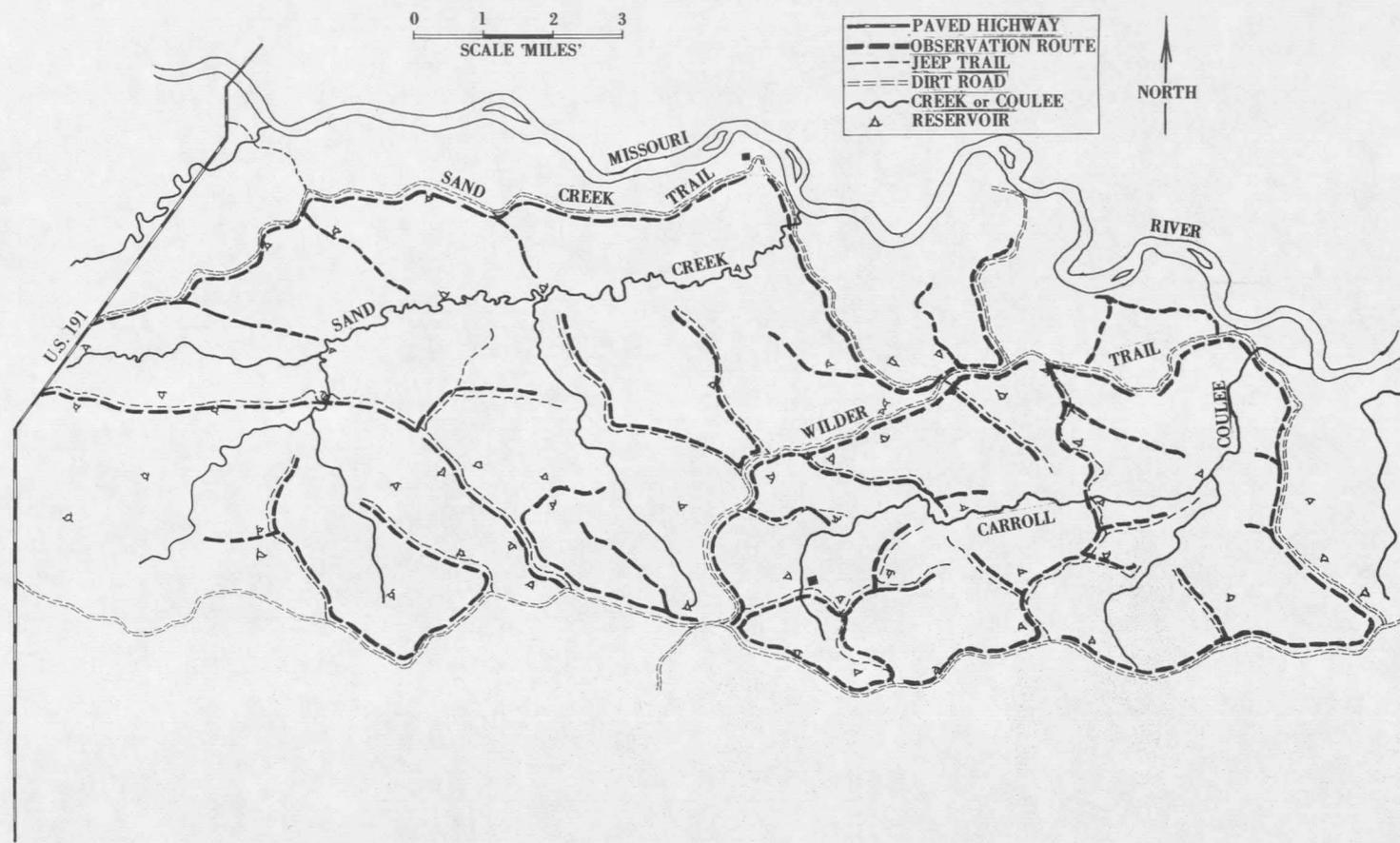


Figure 1. Map of the Missouri River Breaks Study Area.

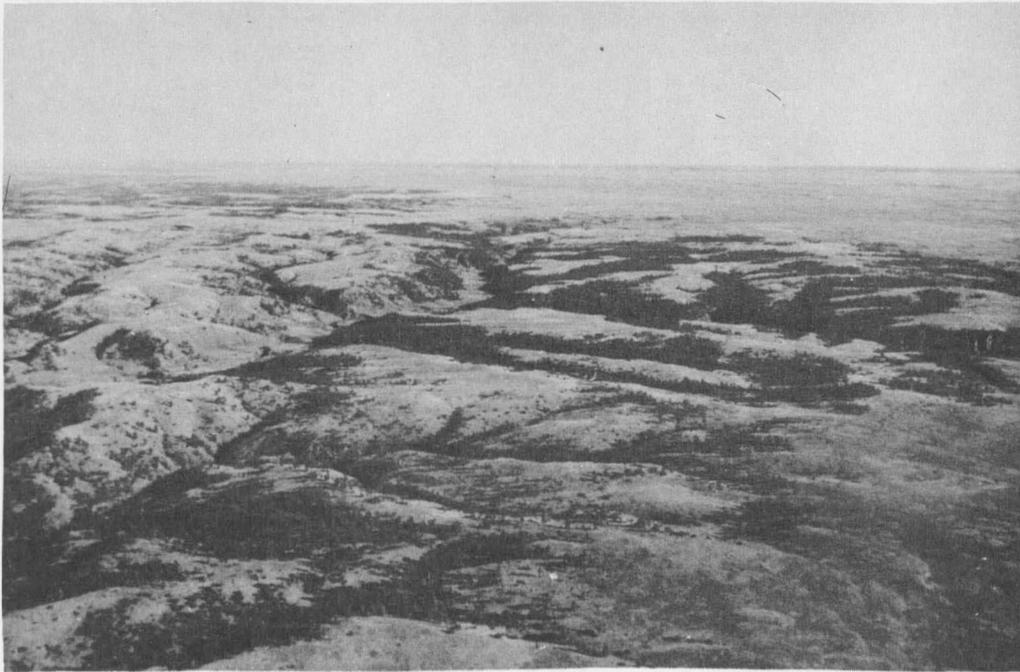


Figure 2. Typical "Breaks" of Uplands Adjacent to the Missouri River in Northcentral Montana. "Plains" Extend Southward in the Background.

In addition to intermittent streams of the Sand Creek Coulee and Carroll Coulee drainages which run water only during spring runoff or heavy rains, several natural springs or seeps, and one well, occur on the area. About 30 of the 55 stock-water reservoirs developed by stockmen and/or the Bureau of Land Management hold water throughout the summer. These are widely distributed except on the extreme southeast portion where no permanent stock-water sources exist. Most of these upland water sources dried up during the drought of 1960 and 1961.

Access is provided by three graded dirt roads leading from US Highway 191 which forms the western boundary, and by numerous jeep or truck trails which cover all parts of the area (Figure 1). As a rule, these roads and trails are impassable when wet.

Climate

The semi-arid climate is characterized by moderately low rainfall, comparatively low relative humidity, great extremes in summer and winter temperatures, and many sunny days. Records for the U.S. Department of Commerce weather station at Roy 8 NE, located approximately 15 miles southwest of the center of the area, show a 21-year (1943-1963) annual mean temperature of 44°F. January, with an average temperature of 16°F, is the coldest month and July, with an average of 71°F, is the warmest. Monthly and annual precipitation data for the January 1959-May 1964 period and 25-year (1939-1963) means are shown in Table I. Annual rainfall fluctuates widely between the lowest recorded value of 7.03 inches for 1952 and

TABLE I. PRECIPITATION DATA FOR MISSOURI RIVER BREAKS STUDY AREA, 1959-1964. U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU STATION, ROY 8 NE, MONTANA.

Month	25-Year Mean	Precipitation in Inches					
		1959	1960	1961	1962	1963	1964
January	0.39	0.52	0.87	0.26	0.47	0.85	0.23
February	0.40	0.72	0.43	0.20	0.48	0.92	0.08
March	0.54	0.26	0.28	0.16	0.33	T	1.00
April	0.88	1.01	1.78	0.15	0.30	1.18	1.53
May	2.26	2.84	1.54	1.25	7.58	2.65	-----
June	3.42	2.94	1.58	1.41	5.03	3.10	-----
July	1.50	1.21	0.23	2.77	2.08	1.25	-----
August	1.29	0.41	1.33	0.21	3.67	1.62	-----
September	1.14	2.46	0.34	1.77	0.37	1.41	-----
October	0.81	1.66	0.06	0.94	1.89	0.23	-----
November	0.47	1.13	0.12	0.38	0.78	0.37	-----
December	0.33	0.03	0.33	0.11	0.16	0.71	-----
Totals	13.49	15.19	8.89	10.61	23.14	14.29	-----
Deviation from mean		+1.70	-4.60	-2.88	+9.65	+0.80	

highest of 23.14 recorded during 1962. Eleven inches or less total precipitation was recorded for 7 of the 25 years. These years are notable in that rainfall during the critical growing season months of May, June, and July was also severely reduced. This suggests that drought conditions might be expected about every three to four years. Annual precipitation totals for the four-year study period represented nearly the complete range of expected conditions." The year prior to inception of the study, 1959, was quite "normal"; however, 1960 and 1961 were marked by drought conditions unmatched in the 25-year records. The total precipitation from January 1960 through April 1962 was only 21.08 inches. This includes only 8.42 inches during the most severe drought period which prevailed between June 1960 and July 1961. Exceptionally heavy rain fell during the late spring and summer of 1962, and near average amounts of precipitation were recorded for 1963. The mean annual precipitation recorded on a home rain gauge at the Iver Mathison ranch located on the south-central part of the area was 10.86 inches for the 1957-1962 period. This does not include water content of moderate snowfalls. A comparison with the 13.94-inch mean recorded for the same period at the Weather Station suggests slightly less annual rainfall on the study area.

Total snowfall amounts to about 25 inches annually. Snow cover seldom persists for more than a few days except during the coldest periods. Warm southwesterly "chinook" winds, characteristic of the region, temper the harshness of the winter and prevent accumulation of snow.

Land-Use Characteristics

Widespread grazing began on the study area and vicinity during the early 1880's (Gieseke 1938). According to Gieseke, et al (1953), large livestock companies grazed herds on range forage throughout the year until the early 1900's when many of these organizations failed or were dissolved and were succeeded by local stockmen and smaller herds. Much of the area was taken up under the Homestead Acts and settled between 1906 and 1915 when attempts were made to cultivate upland sites. Recurrent drought conditions, especially during the 1918-1921 and 1930-37 periods, and other factors led eventually to abandonment of most of these lands and a gradual depopulation of the area. At present, only three headquarter ranches persist. Formerly cultivated tracts have reverted to grasslands currently utilized for grazing or occasionally cut for hay. Publicly owned lands now comprise 51,210 acres or 68.3 per cent of the total area. Of this, 47,850 acres are owned by the Federal Government, 3,320 acres by the State, and 40 acres by Fergus County. Approximately 44 per cent of the area lies within the Charles M. Russell Wildlife Range established in 1936 and administered by the U.S. Fish and Wildlife Service. Most of the area is open range and grazed by domestic livestock--primarily cattle but a few horses are included. Occasionally domestic sheep are grazed into the "breaks" on the south-central portion. Livestock grazing is administered by the Bureau of Land Management and the Indian Buttes State Grazing District. The grazing season extends from April 1 through November 30.

Winter livestock use is restricted largely to Missouri River bottomlands and two privately owned upland pastures. Fourteen individual livestock operators hold permits to graze 1,646 cattle and 13 horses on the study area and/or adjacent prairie. Approximately 1,500 acres (2 per cent of the total) are cultivated. Except for one small dryland grain field on the western edge of the area, these lands are restricted to bottomlands along the Missouri River where alfalfa and a limited amount of barley are grown.

In addition to mule deer and elk which range throughout the area, white-tailed deer (Odocoileus virginianus) are common on the Missouri River bottomlands. Pronghorn antelope (Antilocapra americana) and an occasional bighorn sheep (Ovis canadensis) range onto the area from adjacent range-lands.

VEGETATION

Ecological studies of rangelands in eastern Montana are few. Wright and Wright (1948) studied grassland communities in southcentral Montana, and Jonas (1964) described plant communities in the Long Pines of southeastern Montana. Neither these, nor studies in the adjacent Great Plains of Canada (Coupland 1950, 1961) and western North Dakota (Hanson and Whitman 1938), seem entirely applicable to the vegetation of the study area. The present analyses were undertaken to ascertain the vegetal characteristics for determining intrinsic relationships between the animal species studied and their habitat.

Reconnaissance permitted tentative classification of "vegetation types." Refinements followed. Beginning during the winter of 1961-62, records were made of the presence and abundance of plant species at sites used for feeding by mule deer, elk, and/or cattle. Examination of 287 sites on eight vegetation types during all seasons of 1962 and 1963, aided in determining phenologies of the various taxa, recognition of unions, and delineation of communities. Statistical studies were conducted during July 1963 when taxa which characterized communities throughout most of the year had attained maximal development, and those of spring aspects had completed their annual cycles. For each of the 12 rangeland communities, three representative stands with one each in the eastern, central, and western portions of the study area were subjectively selected for analysis. The degree and direction of slope, soil type and condition, and major influent hoofed mammals for each stand were recorded. Sites which appeared

to have received recent significant prior animal use by grazing were avoided.

The primary method of vegetation analysis followed Daubenmire (1959). Forty 2 x 5 dm plots were systematically placed within a 20 x 50 ft sample unit located within a relatively homogeneous and undisturbed portion of each vegetation stand. The per cent canopy-cover of each taxon and percentages of bare ground and rock were estimated by class for each plot. Classes were: Class 1 = 0-5%; Class 2 = 5-25%; Class 3 = 25-50%; Class 4 = 50-75%; Class 5 = 75-95%; and Class 6 = 95-100%. The midpoint of each class was the value used in data tabulations. Taxa occurring within each stand but not in any of the plots were also recorded. Ground cover was further evaluated by recording whether each of the four, sharply pointed legs of the plot frame contacted bare ground, rock, litter, or living plant material.

Tree and taller shrub composition as well as canopy-coverage were studied in the four timbered communities by superimposing four (two in each of the three stands of the Pseudotsuga/Juniperus type) line transects at 50 ft intervals across the established sample unit. The 100 ft tape was suspended approximately 30 inches above the ground between two steel stakes. Crown intercept of each taxon was measured by using the densiometer (Lemon 1956) in a method described by Dealy (1960). While straddling the line, points of beginning and end of intercept were located with the densiometer. A plumb-line attached to the densiometer fell against the tape at the point of recorded measurement.

Phytosociologic terms used in describing the vegetation are as follows: "vegetation type" denotes the collective area occupied by a single association or a group of associations characterized by the same taxa, e.g., the Artemisia/Agropyron Type includes the Artemisia tridentata/Agropyron spicatum Association, the Artemisia tridentata/Agropyron smithii/Bouteloua gracilis Association, and the A. tridentata/A. smithii Associes. Seral stands are also included; i.e., the Pseudotsuga/Juniperus Type includes stands in which Pseudotsuga menziesii is sparse or absent but unions characteristic of the Pseudotsuga menziesii/Juniperus scopulorum Association are well represented. The terms "union" and "association" are used in the sense of Daubenmire (1952). The union represents the smallest structural unit of organization. It is comprised of a single species or of several species that are closely similar in ecology as indicated by similarity of local environmental amplitude and phenology. Association is applied only to what are believed to be climax (either climatic, edaphic, or topographic) communities, and indicates the distinctive combination of unions superimposed on the same area. "Associes" are developmental equivalents of associations (Weaver and Clements 1938). As used herein, the term denotes the unions or distinctive combination of unions which persist on the same area under disclimax conditions resulting from animal activity (including man's) and/or peculiar topoedaphic conditions which appear to be somewhat less than "permanent."

Artemisia/Agropyron Vegetation Type

This type occurs extensively on level to gently rolling ridgetops where it is largely restricted to less-than-15-degree slopes and clay subsoils more than 15 inches deep over shale. The type occupies approximately 23,000 acres or 31 per cent of the total area. Recognition is afforded by its physiographic location and prominence of the Artemisia tridentata union. The type includes three distinct communities, the distribution and organization of which seems related to livestock distribution, intensity of grazing, and edaphic (soil) conditions. Comparative statistical data for these communities and the type as a whole are presented in Table II. Ground-cover characteristics of these and the other rangeland communities are listed in Table III.

Artemisia tridentata/Agropyron spicatum Association.--This association (Figure 3) occurs where a "light," one-to-three inch layer, of "topsoil" persists and livestock use is much restricted as a result of inadequate water supplies or physiographic barriers. It attains widest distribution in areas greater than one mile from a permanent water source, though remnant stands or vestiges may be found at lesser distances. The association is most extensive on the very lightly grazed southeastern portion of the study area, but isolated stands occur throughout. The presence of "topsoil" seems important. Observations indicate that A. spicatum occasionally occurs in the A. tridentata/A. smithii associates; but on isolated or marginal areas of both communities where severe disturbance and

TABLE II. CONSTANCY, CANOPY COVERAGE, AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA ON THE ARTEMISIA/AGROPYRON TYPE. 1/

Community	<u>A. tridentata/</u> <u>A. spicatum</u> <u>Association</u>	<u>A. tridentata/</u> <u>A. smithii</u> <u>Associes</u>	<u>A. tridentata/</u> <u>A. smithii/</u> <u>B. gracilis</u> <u>Association</u>	Combined Type Totals
Union: Taxa 2/	Cy/Cv/Fr 3/	Cy/Cv/Fr	Cy/Cv/Fr	Cy/Cv/Fr
<u>Agropyron spicatum:</u>				
<u>Agropyron spicatum</u>	100/43/89	33/ +/ +		44/14/30
<u>Agropyron smithii:</u>				
<u>Agropyron smithii</u>	100/18/56	100/57/98	100/30/98	100/35/84
<u>Bouteloua gracilis</u>	33/ 2/10	67/ +/ 2	100/10/52	67/ 4/21
<u>Koleria cristata</u>	100/ 3/23	100/ 6/28	100/10/75	100/ 6/42
<u>Stipa comata</u>	33/ 2/13		33/ +/ 3	22/ +/ 6
<u>Stipa viridula</u>	100/ 5/26	100/ 5/27	67/ 1/ 5	89/ 4/19
<u>Carex spp.</u>	67/ 4/26	33/ +/ 4	33/ 3/19	44/ 3/16
<u>Artemisia tridentata:</u>				
<u>Artemisia tridentata</u>	100/15/50	100/15/52	100/19/67	100/16/56
<u>Chrysothamnus nauseosus</u>	33/ +/ 2	33/ +/ 5	67/ +/ 4	44/ +/ 4
<u>Gutierrezia sarothrae</u>	33/ +/ 2	33/ +/ +	100/ +/13	56/ +/ 5
<u>Artemisia frigida</u>	33/ 1/ 6		67/ 1/11	33/ +/ 6
<u>Hymenoxys richardsonii</u>			100/ +/ 3	33/ +/ 1
<u>Petalostemum purpureum</u>	33/ +		67/ +/ 8	33/ +/ 3
<u>Phlox hoodii</u>	33/ +/ +	33/ +/ 5	100/ 2/37	56/ +/14
<u>Tragopogon dubius:</u>				
<u>Comandra umbellatum</u>	100/ 1/20	100/ 1/28	67/ +/13	89/ +/20
<u>Melilotus officinalis</u>	33/ +/ 3	100/ 2/12	67/ +/ +	67/ 1/ 5
<u>Opuntia polyacantha</u>	100/ 1/10	100/ 1/10	100/ 1/10	100/ 2/13
<u>Selaginella densa</u>		33/ 1/ 5	67/ 1/13	33/ +/ 6
<u>Sphaeralcea coccinea</u>	100/ +/12	100/ +/19	67/ +/ 8	89/ +/13
<u>Tragopogon dubius</u>	100/ +/ 3	100/ +/ 3	33/ +/ +	78/ +/ 2
<u>Vicia americana</u>	67/ +/13	100/ +/ 3	100/ 4/14	89/ 2/14

TABLE II. Continued.

Community	<u>A. tridentata/</u>	<u>A. tridentata/</u>	<u>A. tridentata/</u>	Combined Type Totals
	<u>A. spicatum</u> Association-	<u>A. smithii</u> Associes	<u>A. smithii/</u> <u>B. gracilis</u> Association	
<u>Union:</u>				
Taxa <u>2/</u>	Cy/Cv/Fr <u>3/</u>	Cy/Cv/Fr	Cy/Cv/Fr	Cy/Cv/Fr
<u>Poa secunda:</u>				
<u>Poa secunda</u>	67/ +/ 5	100/15/58	100/10/67	89/ 9/43
<u>Descuriana pinnata</u>		67/ +/ 3		22/ +/ 1
<u>Oenothera caespitosa</u>		67/ +/ 3	33/ +/ +	33/ +/ 1
<u>Plantago spinulosa</u>		33/ +/ +	67/ +/ 8	33/ +/ 3
<u>Sarcobatus vermiculatus:</u>				
<u>Schedonardus paniculatus</u>		33/ +/ 8	67/ +/ 7	33/ +/ 5
Bare ground	100/46/98	100/54/100	100/50/100	100/50/100
Rock	33/ +/19	100/ 2/50	100/ 2/40	100/ 1/36

- 1/ Data are mean percentages for 120 two x five dm plots (40 in each of three stands) in each community.
- 2/ Includes only those species which occurred in at least two stands, i.e., constancy of 67 per cent or more, or had mean canopy-coverage of at least one per cent in any community. Other taxa are considered in Appendix Table XLI.
- 3/ Constancy/Canopy-coverage/Frequency. ++ indicates canopy-coverage or frequency values less than one per cent; a single + in place of these two values denotes occurrence in the stands but not in the plots.

TABLE III. GROUND-COVER CHARACTERISTICS FOR 12 RANGELAND COMMUNITIES. DATA ARE FREQUENCIES OF OCCURRENCE OF BARE GROUND, LITTER, AND LIVING PLANT MATERIAL AMONG 480 POINTS (160 IN EACH OF THREE STANDS) IN EACH COMMUNITY.

Community	Bare Ground Pct.	Litter Pct.	Live Plant Pct.
<u>Artemisia tridentata/Agropyron spicatum</u>	45.2	39.1	15.6
<u>Artemisia tridentata/Agropyron smithii</u>	54.0	34.6	11.2
<u>Artemisia tridentata/Agropyron smithii/ Bouteloua gracilis</u>	55.0	28.1	16.8
<u>Agropyron smithii/Poa secunda</u>	57.7	33.9	8.3
<u>Pinus ponderosa/Agropyron spicatum</u>	13.7	82.0	4.1
<u>Pinus ponderosa/Juniperus scopulorum</u>	19.3	71.8	8.7
<u>Pinus ponderosa/Artemisia longifolia</u>	77.0	22.5	0.4
<u>Pseudotsuga menziessii/Juniperus scopulorum</u>	0.2	61.4	38.3
<u>Sarcobatus vermiculatus/Artemisia tridentata</u>	47.7	38.5	13.7
<u>Agropyron smithii/Symphoricarpos occidentalis</u>	30.4	58.3	11.2
<u>Xanthium strumarium</u>	93.7	5.6	0.6
<u>Artemisia longifolia</u>	95.6	2.7	1.6



Figure 3. Artemisia/Agropyron Vegetation Type. Ridgetop Occupied by Artemisia tridentata/Agropyron spicatum Association.



Figure 4. Artemisia/Agropyron Vegetation Type. Ridgetop Occupied by Artemisia tridentata/Agropyron smithii Associates.

subsequent erosion partially or completely removed the topsoil leaving either a shallow, gravelly or clay-pan soil, A. spicatum is either absent or persists only on "pads" (small elevated mounds of soil) around the base of Artemisia.

The A. spicatum union is dominant (Table II). Artemisia tridentata and the A. smithii union, comprised of the principal grasses of the mixed prairie (Coupland 1950), are well represented but to a lesser degree than in the other two communities of the Artemisia/Agropyron type. The fact that the A. smithii union is relatively well developed here may indicate some disturbance in the stands. The Poa secunda union, which includes the earliest spring herbs, is scarcely represented; although Allium textile and Lomatium foeniculatum are common during the spring. The Tragopogon dubius union, comprised of species of relatively wide ecological amplitude and which attain maximum development in early summer, is best represented by Comandra umbellatum, Opuntia polyantha, Sphaeralcea coccinea, Tragopogon dubius, and Vicia americana.

This association appears to have somewhat greater total ground coverage than any of the other communities which occur on open ridgetops (Tables II and III). These data support general observations of less runoff during rainstorms and suggest greater soil stability on sites where it occurs.

In view of its distribution on deep, undulating, upland clay-loam soils throughout the relatively undisturbed portions of the area, this association may represent the climatic climax type in the central Missouri Breaks.

Artemisia tridentata/Agropyron smithii Associates.—On sites accessible to hoofed mammals throughout the study area where topoedaphic conditions seem similar to those supporting the A. tridentata/A. spicatum association, Agropyron spicatum appears to have been greatly reduced or eliminated and dominance assumed by the A. smithii union (Figure 4). The distribution of this community seems to correspond with areas where livestock use is periodic, fluctuates as a result of the lack of permanent water, or is otherwise restricted by man or grazing habits. Agropyron smithii is the usual dominant (Table II); however, either Koeleria cristata or Stipa viridula may dominate local stands. The A. tridentata union co-dominates with little change in importance from the Artemisia tridentata/Agropyron spicatum association. The Poa secunda union is well represented, especially by P. secunda and during the spring, by Allium textile, Lomatium foeniculatum, Microseris nutans, Musineon divaricatum, and Oenothera caespitosa. The Tragopogon dubius union is conspicuous in both the number and abundance of representative species.

The distribution of this community, the paucity of A. spicatum, the greatly increased importance of the A. smithii union, and the increased representation of forbs all suggest a disclimax condition resulting from disturbance of the Artemisia tridentata/Agropyron spicatum association.

Artemisia tridentata/Agropyron smithii/Bouteloua gracilis Association.—

This community (Figure 5) is especially prevalent on the western and central portions and along the southern boundary of the study area.



Figure 5. Artemisia/Agropyron Vegetation Type. Ridgetop Occupied by the Artemisia tridentata/Agropyron smithii/Bouteloua gracilis Association.



Figure 6. Agropyron/Poa Vegetation Type. Formerly Cultivated Ridgetop Now Occupied by the Agropyron smithii/Poa secunda Associates.

Its distribution seems to correspond with that of shallow, gravelly, or clay-pan surface soils and generally heavy grazing pressures. Normally, severe spot or sheet erosion is evident in that islands of higher-lying soil and vegetation continue to exist; A. tridentata frequently is elevated on small mounds of soil which are anchored by litter, Selaginella densa, and roots of both A. tridentata and herbs which grow through or beneath it. This suggests that degradation of sites normally supporting either of the other two communities has been at least partially responsible for its development. Vegetation cover is typically sparse and depauperate. Much of the total canopy-coverage is often concentrated on small islands where species and unions are superimposed.

The A. tridentata and A. smithii unions are dominant (Table II). Artemisia tridentata is somewhat more abundant than in either of the previously described communities and its associates are better represented. Chrysothamnus nauseosus and Gutierrezia sarothrae are conspicuous. Agropyron smithii, although less dense than in the Artemisia tridentata/Agropyron smithii associates, remains dominant; and Bouteloua gracilis and Koleria cristata become quite prominent. In contrast to the other communities of the Artemisia/Agropyron type, Stipa viridula is only poorly represented. The Poa secunda union is also prominent and on some sites may dominate the community. In local areas, particularly on the western part of the study area, the Sarcobatus vermiculatus union is frequently associated with this community.

Observations suggest that this association represents an edaphic climax on sites where it occurs.

Agropyron/Poa Vegetation Type

This type (Figure 6) occurs entirely on sites usually characterized by the Artemisia/Agropyron type. It is largely restricted to approximately 1,200 acres on ridgetops in the central and southwestern portions of the study area which were formerly cultivated and/or artificially reseeded with exotic grasses. Differences in times of abandonment or reseeding and past treatment have resulted in diverse vegetal characteristics. The three stands selected for analysis include an area grazed primarily during the winter and infrequently cut for hay, a stand grazed only during the grazing season and occasionally cut for hay, and a recently reseeded stand which is also grazed during the grazing season. All but the latter are now dominated by native species. Because of the minor extent of the type (1.5 per cent of area) and some indication that the successional trend on all reseeded areas is toward dominance by the same native grasses, these communities are recognized as a single associates in which the A. smithii and P. secunda unions dominate (Table IV). Although the Artemisia tridentata union appears to be regenerating slowly, it is only poorly represented by scattered young plants and a few depauperate older plants which persist despite occasional cutting, browsing, and trampling. Agropyron cristatum, an exotic, joins the A. smithii union in this community where deliberate or accidental seeding has occurred; however, it dominates only the recently reseeded stand. Bromus japonicus, another exotic, also joins the

TABLE IV. CONSTANCY, CANOPY-COVERAGE, AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA ON THE AGROPYRON SMITHII/POA SECUNDA ASSOCIES. 1/

<u>Union:</u> Taxa 2/	Cy/Cv/Fr 3/
<u>Agropyron smithii:</u>	
<u>Agropyron cristatum</u>	67/20/33
<u>Agropyron smithii</u>	100/46/82
<u>Bromus japonicus</u>	67/ 3/13
<u>Stipa viridula</u>	100/ 5/22
<u>Artemisia tridentata:</u>	
<u>Artemisia frigida</u>	33/ 2/21
<u>Aster occidentalis</u>	100/ +/ +
<u>Poa secunda:</u>	
<u>Poa secunda</u>	100/16/48
<u>Tragopogon dubius:</u>	
<u>Melilotus officinalis</u>	100/13/42
<u>Opuntia polyantha</u>	100/ +/ 3
<u>Polygonum erectum</u>	67/ +/19
<u>Sphaeralcea coccinea</u>	100/ +/ 9
<u>Vicia americana</u>	100/ +/ 7
Bare Ground	100/61/100
Rock	67/ +/ 6

1/ Data are mean percentages for 120 two x five dm plots distributed as 40 in each of three stands.

2/ Includes only those species which occurred in at least two stands, i.e., constancy of 67 per cent or greater or had mean canopy-coverage at least one per cent in the three stands. Other taxa are considered in in Appendix Table XIII.

3/ Constancy/canopy-coverage/frequency. +/+ indicates canopy-coverage or frequency values less than one per cent.

A. smithii union on local areas where disturbance seemingly has provided an avenue for invasion. At the time of analysis in late July, characteristic forbs were those of the Tragopogon dubius union. During the spring, however, observations indicate the P. secunda union is well represented by Allium textile, Lomatium foeniculatum, and Microseris nutans. The total ground cover provided by this type is somewhat less than that afforded by any community of the Artemisia/Agropyron type (c.f. Tables II, III, and IV).

Pinus/Juniperus Vegetation Type

This is a major type comprising approximately 45 per cent of the vegetation. It occurs extensively on slight to moderately steep slopes and soils which vary from clay-loam less than 15 inches deep over shale to raw shale. It is prevalent on south or west-facing slopes, but also occurs on northerly or easterly exposures where the degree of slope is slight. The type frequently acts as an ecotone between the Artemisia/Agropyron and Pseudotsuga/Juniperus types. Stands of pine are seldom dense. A near-complete overhead canopy may be found in only a few scattered stands on slight, north-facing slopes. Frequently, only a few scattered pines occur to give a savannah-like appearance, especially on old burn sites and along the upper limits of the type where it contacts the Artemisia/Agropyron type. The characteristically slow growth of P. ponderosa is attested by data obtained by the Bureau of Land Management for a "site" tree in each of 14 pine stands on and adjacent to the study area. These trees, which had a mean approximate age of 83.2 (51 to 141) years, averaged only 32.6 (22 to 46) feet in height and 8.5 (6.4 to 11.4) inches dbh (diameter 4.5

feet above the ground). The mean growth during the last 10 years was 0.29 inches for 36 trees. (Unpubl. Sample Plot Data, U.S. Bureau of Land Management, Lewistown, Montana, 1964). The type is comprised of three more or less distinct communities. The distribution and organization of these appears related to topographic and edaphic factors. Statistical data for the three communities and the type as a whole are presented in Tables V and VI.

Pinus ponderosa/Agropyron spicatum Association.--Wherever the Pinus/ Juniperus type abuts upon ridgetops dominated by the Artemisia/Agropyron type or the Agropyron/Poa-type, it is characteristically represented by the Pinus ponderosa/Agropyron spicatum association (Figure 7). At least a shallow layer of clay-loam soil seems essential to support the usually well developed grass understory. The more exposed, xeric upper slopes are also characteristic. On less exposed, more mesic footslopes and draws this community is replaced by the Pinus ponderosa/Juniperus scopulorum association.

Pinus ponderosa is dominant and better represented than in either of the other communities (Table V). Typical openness of stands is attested to by the 27 per cent coverage afforded by P. ponderosa and the total tree-shrub intercept of only 32 per cent. The principal undergrowth is herbaceous and usually dominated by the Agropyron spicatum union. Frequently, however, the Agropyron smithii union assumes this position. This may be correlated with the fact that the association characteristically occurs on gentle slopes susceptible to moderate or heavy use by hoofed

TABLE V. CONSTANCY, CANOPY-COVERAGE, AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA ON THE PINUS/JUNIPERUS TYPE. 1/

Association	Pinus ponderosa/ Agropyron spicatum	Pinus ponderosa/ J. scopulorum	Pinus ponderosa/ Artemisia longifolia	Combined Type total
	Association	Association	Association	
Union: Taxa 2/	Cy/Cv/Fr 3/	Cy/Cv/Fr	Cy/Cv/Fr	Cy/Cv/Fr
<u>Agropyron spicatum:</u>				
Agropyron spicatum	100/20/53	100/15/39	67/ +/ +	89/12/31
Muhlenbergia cuspidata	67/ +/ 5	67/ +/ 3	67/ +/ +	67/ +/ 3
<u>Agropyron smithii:</u>				
Agropyron smithii	100/17/62	67/ 5/19	100/ 4/29	89/ 9/37
Bouteloua gracilis	33/ +	67/ +/ 3		33/ +/ +
Koeleria cristata	67/ 3/13	67/ +/ 8		44/ 1/ 7
Stipa viridula	100/12/34	100/ 4/11	33/ +/ +	78/ 5/15
Carex spp.	67/ 9/48	67/10/40	33/ +/ 2	56/ 6/30
<u>Artemisia tridentata:</u>				
Artemisia tridentata	100/ +/ +	67/ +	33/ +/ +	67/ +/ +
Artemisia frigida	33/ +	67/ +/ 4	33/ +	44/ +/ 1
<u>Poa secunda:</u>				
Descuriana pinnata	33/ +	67/ +/ 3	67/ +/ 2	56/ +/ 2
Microseris nutans	67/ +/ 4			22/ +/ 1
<u>Juniperus scopulorum:</u>				
Juniperus scopulorum	100/ 3/ 4	100/19/38	100/ 2/ 3	100/ 8/15
Rhus trilobata	100/ 2/ 5	100/ 2/10	100/ +/ 2	100/ 1/ 6
Rosa arkansana	67/ +/ 6	100/ 2/ 9	33/ +/ 6	67/ 1/ 7
Symphoricarpos alba	100/ 3/22	33/ +/ +		44/ 1/ 7
Carex geyeri	33/ 9/18	33/ +/ +		22/ 3/ 6
Antennaria dimorpha	33/ +/ 2	67/ +/ 3		33/ +/ 2
<u>Tragopogon dubius:</u>				
Achillea millifolium	67/ 2/15	100/ 3/25		56/ 2/13
Artemisia ludoviciana	67/ +/ 3	67/ +/ 5		44/ +/ 3
Aster commutatus	67/ +/ 3	100/ +/ 8	67/ +/ 3	78/ +/ 6
Bahia oppositifolia	33/ 1/18	33/ +/ 2	33/ +/ 2	33/ +/ 7

TABLE V. Continued.

Association	<u>Pinus ponderosa/</u> <u>Agropyron spicatum</u> Association	<u>Pinus ponderosa/</u> <u>J. scopulorum</u> Association	<u>Pinus ponderosa/</u> <u>Artemisia longifolia</u> Association	Combined Type Total	
Union:	Taxa 2/	Cy/Cv/Fr 3/	Cy/Cv/Fr	Cy/Cv/Fr	Cy/Cv/Fr
	<u>Chenopodium album</u>	67/ +/ 2	67/ +/ 8	100/ +/ 5	78/ +/ 5
	<u>Comandra umbellatum</u>	67/ +/ 8			22/ +/ 3
	<u>Gaura coccinea</u>	67/ +/ 3		33/ +/ 4	33/ +/ 2
	<u>Grindelia squarrosa</u>	33/ +	67/ +/ +		33/ +/ +
	<u>Lactuca pulchella</u>	33/ +/ +	67/ +/ 6		33/ +/ 2
	<u>Melilotus officinalis</u>	33/ +/ +	67/ +/ 4	67/ +	55/ +/ 2
	<u>Opuntia polycantha</u>	67/ +/ +	67/ +/ 7	100/ +/ +	78/ +/ 2
	<u>Phacelia linearis</u>	67/ +/ 3	67/ +/ 10		44/ +/ 4
	<u>Selaginella densa</u>		67/ +/ 13		22/ +/ 4
	<u>Solidago missouriensis</u>	100/ +/ 8	100/ 2/ 17	67/ +/ 8	89/ 1/ 11
	<u>Stephanomeria runcinata</u>	67/ +/ 8	33/ +/ 3	100/ 2/ 17	67/ +/ 9
	<u>Thermopsis rhombifolia</u>	100/ 1/ 18		67/ +/ 4	56/ +/ 7
	<u>Tragopogon dubius</u>	100/ 2/ 12	67/ +/ 3	67/ +	78/ +/ 5
	<u>Vicia americana</u>	100/ 1/ 20	100/ 1/ 12		67/ +/ 11
	<u>Symphoricarpos occidentalis:</u>				
	<u>Symphoricarpos occidentalis</u>		67/ 6/ 24		22/ 2/ 15
	<u>Agropyron trachycaulum</u>		67/ 2/ 9		22/ +/ 3
	<u>Prunus virginiana:</u>				
	<u>Prunus virginiana</u>		33/ 1/ 6		11/ +/ 2
	<u>Ribes cereum</u>		67/ +/ +		22/ +/ +
	<u>Agrostis scabra</u>		100/ 19/ 43		33/ 6/ 14
	<u>Smilacina stellata</u>		33/ 1/ 3		11/ +/ +
	<u>Artemisia longifolia:</u>				
	<u>Artemisia longifolia</u>	33/ +	33/ +	100/ 2/ 7	56/ +/ 2
	<u>Calomovilfa longifolia</u>	33/ +		100/ 12/ 29	44/ 4/ 10
	<u>Oryzopsis hymenoides</u>			67/ +/ 3	22/ +/ +
	<u>Mentzelia laevicaulis</u>			67/ +/ 3	22/ +/ +
	<u>Mirabilis linearis</u>			67/ +/ 2	22/ +/ +

TABLE V. Continued.

Association	<u>Pinus ponderosa/</u> <u>Agropyron spicatum</u> Association	<u>Pinus ponderosa/</u> <u>J. scopulorum</u> Association	<u>Pinus ponderosa/</u> <u>Artemisia longifolia</u> Association	Combined Type Total
Union:				
Taxa <u>2/</u>	Cy/Cv/Fr/ <u>3/</u>	Cy/Cv/Fr	Cy/Cv/Fr	Cy/Cv/Fr
Xanthium strumarium:				
<u>Conringa orientalis</u>			67/ +/ +	22/ +/ +
Bare Ground	100/20/64	100/56/21	100/80/97	100/52/61
Rock	33/ +/ +	33/ +/ +	67/ +/ 3	44/ +/ +

- 1/ Data are mean percentages for 120 two x five dm plots (40 in each of three stands) in each association.
- 2/ Includes only those species which occurred in at least two stands, i.e., constancy of 67 per cent or more, or had mean canopy-coverage at least one per cent in any association. Other taxa are considered in Appendix Table XLIII.
- 3/ Constancy/canopy-coverage/frequency. +/+ indicates canopy-coverage or frequency values less than one per cent; a single + in place of these two values denotes occurrence in the stands but not in the plots.

TABLE VI. CONSTANCY, COVERAGE, AND FREQUENCY OF TREES AND SHRUBS GREATER THAN 12 INCHES TALL ON THE PINUS/JUNIPERUS TYPE. 1/

Association	<u>Pinus ponderosa/</u> <u>Agropyron spicatum</u>	<u>Pinus ponderosa/</u> <u>Juniperus scopulorum</u>	<u>Pinus ponderosa/</u> <u>Artemisia longifolia</u>	Combined Type Total
Taxa	Cy/Cv/Fr 2/	Cy/Cv/Fr	Cy/Cv/Fr	Cy/Cv/Fr
<u>Pinus ponderosa</u>	100/27/100	100/14/75	100/18/73	100/20/83
<u>Juniperus scopulorum</u>	100/ 4/58	100/53/100	100/ 8/88	100/21/83
<u>Rhus trilobata</u>	100/ +/50	100/ 7/88	100/ +/36	100/ 3/54
<u>Artemisia tridentata</u>	33/ +/ 8	67/ 1/50	33/ 1/27	44/ +/26
<u>Chrysothamnus nauseosus</u>	67/ +/17			22/ +/ 6
<u>Prunus virginiana</u>		33/ 6/50		11/ 2/13
<u>Ribes cereum</u>	33/ +/ 8	67/ +/25		33/ +/10
<u>Artemisia cana</u>			33/ +/ 9	11/ +/ 3
<u>Artemisia longifolia</u>			67/ 3/73	22/ 1/26
<u>Sarcobatus vermiculatus</u>			33/ +/ 9	33/ +/ 3
Total Intercept (per cent)	32.2	80.9	30.7	44.3

1/ Data are mean percentages for twelve 100 ft line-intercept transects (four in each of three stands) in each association.

2/ Constancy/coverage/frequency. Frequency is the percentage occurrence among the twelve 100 ft lines. + indicates canopy-coverage values less than one per cent.



Figure 7. Pinus/Juniperus Vegetation Type. Slight South-facing Slope Occupied by Pinus ponderosa/Agropyron spicatum Association.



Figure 8. Pinus/Juniperus Vegetation Type. Moderate West-facing Slope Occupied by Pinus ponderosa/Juniperus scopulorum Association.

mammals. The A. smithii union seems almost identical in composition and abundance to its occurrence in the Artemisia tridentata/Agropyron spicatum association; however, the A. spicatum union appears less abundant but Muhlenbergia cuspidata is somewhat better represented here than in that association. Principal forbs are those of the Tragopogon dubius union which differs only in the relative abundance of member species from its occurrence on the Artemisia/Agropyron type. The Poa secunda union is very poorly represented, although Allium textile, Fritillaria pudica, Lomatium foeniculatum, and Microseris nutans are common during spring. The shrub layer is comprised mainly of a sparsely represented Juniperus scopulorum union (Tables V and VI) in which either J. scopulorum, Rhus trilobata, or Symphoricarpos alba may dominate in individual stands. Occasionally, shrubs of the Artemisia tridentata, Prunus virginiana, Sarcobatus vermiculatus and Symphoricarpos occidentalis unions occur as scattered individuals.

Pinus ponderosa/Juniperus scopulorum Association.—On less exposed, more mesic sites along shallow drainageways and south or west-facing slopes, the J. scopulorum union supplants the Agropyron unions in understory dominance (Table V) to give this association a distinctive physiognomy characterized by P. ponderosa and dense growths of J. scopulorum (Figure 8). Although P. ponderosa is usually prominent, it appears less abundant than in the Pinus ponderosa/Agropyron spicatum association (Table VI). This may be due to curtailed reproduction by the shade-intolerant pine under the dense canopy of J. scopulorum.

Symphoricarpos alba, which frequently is a very prominent member of the J. scopulorum union in open stands of the Pinus ponderosa/Agropyron spicatum association, is suppressed and the Prunus virginiana union, comprised of species typical of north-facing slopes, may develop under the shaded mesic conditions. Pseudotsuga menziesii may also occur. The herbaceous layer is usually dominated by A. spicatum (Table V); but on especially protected sites Agrostis scabra, a member of the P. virginiana union, may dominate. The Agropyron smithii union is of secondary importance, occurring primarily on alluvium along bottoms of smaller drainageways. The Symphoricarpos occidentalis union usually is associated with the A. smithii union on these sites. Forbs are largely those of the Tragopogon dubius union with only minor changes in species representation occurring as compared to the Pinus ponderosa/Agropyron spicatum association.

Distributional limitations suggest that this association represents a topographic climax on the sites where it occurs.

Pinus ponderosa/Artemisia longifolia Association.--This association (Figure 9) is restricted to shale outcroppings on steep slopes where it may represent a topoedaphic climax. These sites are generally unstable, and individual stands characterizing them exhibit considerable variation with local conditions. The community typically is characterized by a sparse pine overstory, a variable understory which usually is dominated by the A. longifolia union, comprised of species more or less restricted to shale outcrops, and a bare shale soil surface (Tables III, V, and VI).



Figure 9. Pinus/Juniperus Vegetation Type. Steep, South-facing Shale Slope Occupied by the Pinus ponderosa/Artemisia longifolia Association.

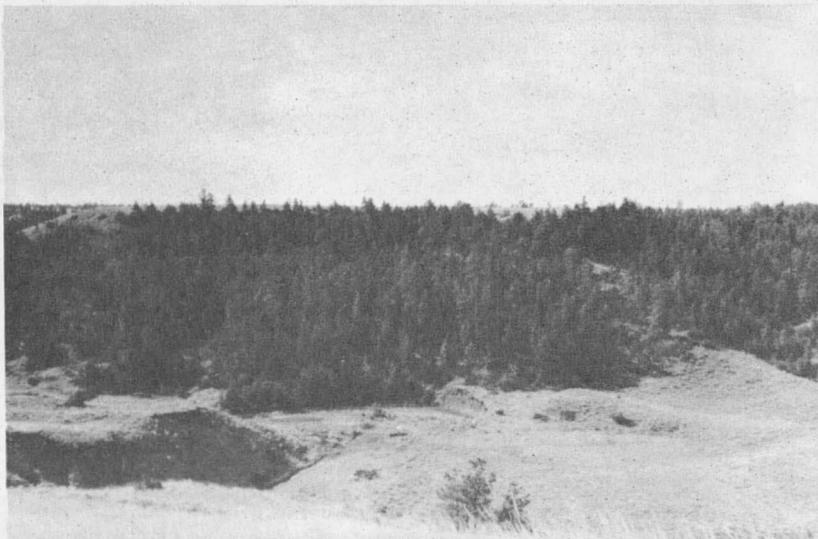


Figure 10. Pseudotsuga/Juniperus Vegetation Type. Steep North-facing Slope Occupied by the Pseudotsuga menziesii/Juniperus scopulorum Association.

The Juniperus scopulorum union is quite prominent and may dominate local stands. Although scarcely represented in the stands analyzed, the Sarcobatus vermiculatus union often occurs in this association; on steep, open slopes along deeply cut coulees in the northeastern part of the study area, it occasionally dominates the shrub layer. The poorly developed herbaceous layer is usually dominated by Calamovilfa longifolia; however, Agropyron spicatum and/or A. smithii may dominate on more stable sites. Forbs typically are poorly represented. Chenopodium album and Stephanomeria runcinata of the Tragopogon dubius union seem most common, but other species of the T. dubius, Artemisia longifolia, and Xanthium strumarium unions may be locally abundant.

Pseudotsuga/Juniperus Vegetation Type

This type predominates on approximately 10,000 acres (13 per cent of the total) of moderate to steep northerly exposures where cool mesic conditions prevail (Figure 10). Occasionally, where well-developed stands of the Pinus ponderosa/Agropyron spicatum association occur on slight north-facing slopes and provide protection, it extends upward onto more level sites. It seems to become slightly more extensive in the Missouri River Breaks west of the study area. To the east, it gradually becomes more restricted. Recognition is afforded by the dominance of Pseudotsuga menziesii or on seral or burned sites, the presence of conspicuous Prunus virginiana and Symphoricarpos occidentalis unions. Mature and undisturbed sites are characteristically occupied by the Pseudotsuga menziesii/Juniperus scopulorum association. Stands of this

association are usually characterized by a well-developed tree layer dominated by P. menziesii and dense shrub undergrowth dominated by the J. scopulorum and P. virginiana unions (Tables VII and VIII).

Pinus ponderosa typically is present but poorly represented in the overstory. Although this species may dominate open, seral or burned stands, tree reproduction in mature stands, except for open disturbed spots, is limited to P. menziesii. This suggests that pine is seral on these sites, as it is in the Pseudotsuga menziesii zone of the northern Rocky Mountains (Daubenmire 1952). The Symphoricarpos occidentalis union is best represented by S. occidentalis and Agropyron trachycaulum, but Artemisia cana and Chrysothamnus viscidiflorus frequently occur in more open or burned stands. Both P. virginiana and C. viscidiflorus are susceptible and sensitive to heavy browsing by mule deer and elk. Dead and depauperate remnant plants attest to greater abundance of these species in former years. The herbaceous layer typically is dominated by Agrostis scabra and/or Agropyron spicatum. The latter is predominant in more open, seral, or burned stands. As a group, forbs appear less abundant than on any of the other vegetation types; however, Selaginella densa often forms extensive mats on the organic matter which tends to accumulate on or near the ground surface and Achillea millifolium is common. Soil surface cover appears higher than in any of the other rangeland types (Tables III and VII).

Available evidence suggests that this association represents a topographic climax on the sites where it occurs.

TABLE VII. CONSTANCY, CANOPY-COVERAGE, AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA ON THE PSEUDOTSUGA MENZIESII/JUNIPERUS SCOPULORUM ASSOCIATION. 1/

<u>Union:</u> Taxa 2/	Cy/Cv/Fr 3/
<u>Pseudotsuga menziessii:</u> <u>Pseudotsuga menziessii</u>	100/ +/ 3
<u>Juniperus scopulorum:</u> <u>Juniperus scopulorum</u> <u>Rhus trilobata</u> <u>Carex geyeri</u> <u>Antennaria dimorpha</u>	100/19/38 100/ 1/ 3 100/ 2/25 67/ +/ 3
<u>Prunus virginiana:</u> <u>Prunus virginiana</u> <u>Ribes cereum</u> <u>Rosa nutkana</u> <u>Agrostis scabra</u> <u>Fragaria virginiana</u> <u>Galium aparine</u> <u>Geum triflorum</u> <u>Potentilla arguta</u>	100/ 2/ 5 67/ +/ 2 100/ 5/35 100/40/77 67/ 2/14 33/ 3/11 33/ 2/15 67/ +/ +
<u>Symphoricarpos occidentalis:</u> <u>Symphoricarpos occidentalis</u> <u>Agropyron trachycaulum</u>	100/10/53 100/ 2/13
<u>Agropyron spicatum:</u> <u>Agropyron spicatum</u>	100/16/50
<u>Agropyron smithii:</u> <u>Carex spp.</u>	67/ 2/ 9
<u>Tragopogon dubius:</u> <u>Achillea millifolium</u> <u>Aster commutatus</u> <u>Selaginella densa</u> <u>Solidago missouriensis</u>	100/ 3/26 67/ +/ 3 100/38/60 100/ 1/10

TABLE VII. Continued.

<u>Union:</u> <u>Taxa</u> ^{2/}	Cy/Cv/Fr ^{3/}
Bare Ground	67/ 1/ 8
Rock	0/ 0/ 0

^{1/} Data are mean percentages for 120 two x five dm plots distributed as 40 in each of three stands.

^{2/} Includes only those which occurred in at least two stands, i.e., constancy of 67 per cent or more, or had mean canopy-coverage at least one per cent in the three stands. Other taxa are considered in Appendix Table XLIV.

^{3/} Constancy/canopy-coverage/frequency. +/+ indicates canopy-coverage or frequency values less than one per cent.

TABLE VIII. CONSTANCY, COVERAGE, AND FREQUENCY OF TREES AND SHRUBS GREATER THAN 12 INCHES TALL IN THE PSEUDOTSUGA MENZIESII/JUNIPERUS SCOPULORUM ASSOCIATION. 1/

Plant Species	Cy/Cv/Fr 2/
<u>Pseudotsuga menziesii</u>	100/56/100
<u>Pinus ponderosa</u>	67/16/50
<u>Juniperus scopulorum</u>	100/30/100
<u>Rhus trilobata</u>	100/ +/67
<u>Prunus virginiana</u>	67/ 2/50
<u>Ribes aureum</u>	33/ +/17
<u>Ribes cereum</u>	33/ +/17
Total Intercept (per cent)	106.0

1/ Data are mean percentages for six 100 ft line-intercept transects distributed as two in each of three stands.

2/ Constancy/coverage/frequency. Frequency is the percentage occurrence among the six 100 ft lines. + indicates canopy-coverage values less than one per cent.

Sarcobatus/Artemisia Vegetation Type

Wherever dispersed clay soils containing considerable amounts of sodium occur, the vegetation characteristically is sparse and dominated by Sarcobatus vermiculatus. Foothills and low benches along larger coulees and Missouri River bottomlands are the usual site (Figure 11); however, the type extends upward along adjacent slopes on clay slides (formed by downslope movement of clay overlying unstable shale). Occasionally it may be found both on deep granular silty clay soils of higher outwashes or fans and in shallow upland basins. Despite some variation in community organization among the various sites, the usual prevalence of

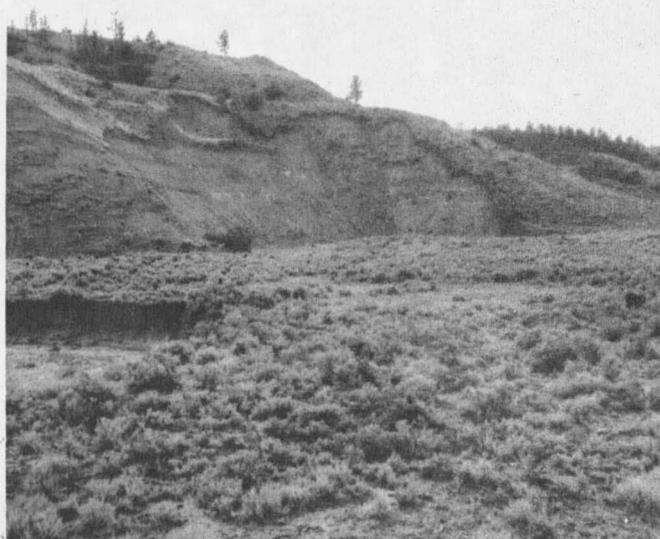


Figure 11. Sarcobatus/Artemisia Vegetation Type. Coulee-bottom Bench Occupied by the Sarcobatus vermiculatus/Artemisia tridentata Association.



Figure 12. Agropyron/Symphoricarpos Vegetation Type. Coulee-bottom Meadow Occupied by the Agropyron smithii/Symphoricarpos occidentalis Association.

S. vermiculatus and Artemisia tridentata unions seems to justify collective recognition of stands of this relatively minor type (approximately five per cent of the area) as the Sarcobatus vermiculatus/Artemisia tridentata association (Table IX). S. vermiculatus alone characterizes the shrub layer only on footslopes and benches along the Missouri River and on clay slides. The herbaceous layer typically is sparse, often extremely so; however, where the association occurs in small stands on higher outwashes, it may be well-developed. Although the Agropyron smithii union characteristically dominates, the Poa secunda union is conspicuous and may predominate in local stands. During spring, the latter is also well represented by Allium textile, Lomatium foeniculatum, Musineon divaricatum, Plantago spinulosa, and Thlaspi arvense. Summer forbs are typically of the Tragopogon dubius union. Those associated with A. tridentata or Xanthium strumarium unions are sparse or only locally common.

Agropyron/Symphoricarpos Vegetation Type

This type (Figure 12) is minor in extent, occurring only on silty clay soils of flats adjacent to water courses. Recognition is afforded by a wet meadow aspect dominated by Agropyron smithii; however, the Symphoricarpos occidentalis union is sufficiently represented to recognize the community as the Agropyron smithii/Symphoricarpos occidentalis association (Table IX). Symphoricarpos occidentalis is the most abundant shrub and frequently occurs in dense patches. Artemisia cana and Chrysothamnus viscidiflorus are characteristically present but both are most prominent on better drained, marginal sites. Agropyron smithii

TABLE IX. CONSTANCY, CANOPY-COVERAGE, AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA ON THE SARCOBATUS VERMICULATUS/ARTEMISIA TRIDENTATA ASSOCIATION, THE AGROPYRON SMITHII/SYMPHORICARPOS OCCIDENTALIS ASSOCIATION, AND THE XANTHIUM STRUMARIUM ASSOCIATION. 1/

Association	<u>Sarcobatus vermiculatus/</u> <u>Artemisia tridentata</u>	<u>Agropyron smithii/</u> <u>Symphoricarpos occidentalis</u>	<u>Xanthium</u> <u>strumarium</u>
Union:	Cy/Cv/Fr 3/	Cy/Cv/Fr	Cy/Cv/Fr
Taxa 2/			
<u>Artemisia tridentata:</u>			
<u>Artemisia tridentata</u>	100/19/42		
<u>Sarcobatus vermiculatus:</u>			
<u>Sarcobatus vermiculatus</u>	100/11/31		
<u>Agropyron smithii:</u>			
<u>Agropyron smithii</u>	100/42/91	100/88/100	100/ 3/15
<u>Koeleria cristata</u>	67/ 2/13		
<u>Stipa viridula</u>	100/ 5/26	67/ 4/19	67/ +/- 3
<u>Poa secunda:</u>			
<u>Poa secunda</u>	100/24/66		
<u>Plantago spinulosa</u>	67/ +/-13		
<u>Thlaspi arvense</u>		67/ +/- +	
<u>Tragopogon dubius:</u>			
<u>Aster commutatus</u>	67/ +/- 2	67/ +/- 5	
<u>Aster occidentalis</u>	67/ +/- 3		
<u>Chenopodium album</u>		67/ +/- 3	100/ 3/21
<u>Melilotus officinalis</u>	100/ 5/23	100/ 5/23	100/25/53
<u>Opuntia polyantha</u>	100/ 1/10	67/ +/- +	
<u>Tragopogon dubius</u>	100/ +/- 3	100/ +/-12	
<u>Vicia americana</u>	100/ +/- 4	67/ +/- 3	
<u>Symphoricarpos occidentalis:</u>			
<u>Artemisia cana</u>		67/ 3/ 5	67/ +/- 3
<u>Chrysothamnus viscidiflorus</u>		67/ 1/ 5	67/ 2/10
<u>Symphoricarpos occidentalis</u>		100/ 4/22	
<u>Agropyron trachycaulum</u>			67/ +/- 7
<u>Poa compressa</u>		100/16/58	
<u>Glycyrrhiza lepidota</u>		100/ 2/16	67/ 2/ 8

TABLE IX. Continued.

Association	<u>Sarcobatus vermiculatus/</u>	<u>Agropyron smithii/</u>	<u>Xanthium</u>
	<u>Artemisia tridentata</u>	<u>Symphoricarpos occidentalis</u>	<u>strumarium</u>
Union:	Cy/Cv/Fr 3/	Cy/Cv/Fr	Cy/Cv/Fr
Taxa 2/			
<u>Distichlis stricta:</u>			
<u>Distichlis stricta</u>		100/ 4/23	100/ 1/11
<u>Xanthium strumarium:</u>			
<u>Elymus canadensis</u>			67/ 2/ 7
<u>Hordeum jubatum</u>			100/ 2/ 8
<u>Spartina pectinata</u>			100/ 2/ 4
<u>Iva axillaris</u>	67/ +		67/ 2/11
<u>Lepidium densiflorum</u>	100/ +/11		
<u>Polygonum spp.</u>	67/ +/ 9		100/ +/ 9
<u>Rumex mexicanus</u>			100/ +/ 5
<u>Xanthium strumarium</u>			100/ 5/20
Bare Ground	100/52/98	100/37/95	100/90/100
Rock	33/ +/ +	0/0/0	100/ 1/11

- 1/ Data are mean percentages for 120 two x five dm plots (40 in each of three stands) in each association.
- 2/ Includes only those species which occurred in at least two stands, i.e., constancy of 67 per cent or more; or had mean canopy-coverage at least one per cent in any association. Other taxa are considered in Appendix Table XLV.
- 3/ Constancy/canopy-coverage/frequency. +/+ indicates canopy-coverage or frequency values less than one per cent.

appears to be more abundant in this association than in any other community; however, other members of its union are poorly represented. Poa compressa and Distichlis stricta typically occur. The latter attains abundance only in lower spots or along the edge of watercourses. Glycyrrhiza lepidota is the most characteristic forb, but members of the Tragopogon dubius union are usually common. Allium textile, Lomatium foeniculatum, and Thlaspi arvense are common spring forbs.

Although not analyzed in detail, Agropyron meadows on Missouri River bottomlands appear very similar in organization to this association.

Xanthium strumarium Vegetation Type

This type (Figure 13) refers to the vegetation characteristically associated with cuts or beds of intermittent watercourses where the shale, silty clay, or gravelly substrate is typically moist and alkaline. The Xanthium strumarium union, comprised of species which tolerate or thrive under these conditions, usually dominates the sparse vegetation growth (Tables III and IX). Xanthium strumarium is the most prominent and widely distributed species. Elymus canadensis, Spartina pectinata, Hordeum jubatum, and Rumex mexicanus are characteristic but usually restricted to marginal silty clay deposits. Where they occur, members of the Agropyron smithii and Symphoricarpos occidentalis unions and Distichlis stricta are also largely restricted to marginal deposits and clay banks. Melilotus officinalis, which consistently occurs with the X. strumarium union on these sites, often attains greater abundance than



Figure 13. Xanthium strumarium Vegetation Type. Coulee-bottom Cut Occupied by the Xanthium strumarium Association.



Figure 14. Artemisia longifolia Vegetation Type. Steep, Loose-Shale Slope Occupied by the Artemisia longifolia Associates.

any other species but again largely on marginal deposits and clay banks. Where standing water persists for extended periods, Eleocharis macrostachya and/or Scirpus paludosus may join the association.

Artemisia longifolia Vegetation Type

This type (Figure 14) is very limited and occurs only on the loose shale of steep cuts and slopes. Since these sites are generally similar to, but usually steeper than, those occupied by the Pinus ponderosa/Artemisia longifolia association, the latter might be expected to supplant the Artemisia longifolia associates in the absence of disturbance and/or as more stable conditions develop. This is also suggested by the vegetation composition of this community (Table X) which is similar in many respects to the understory vegetation of the Pinus ponderosa/Artemisia longifolia association. The Artemisia longifolia union characteristically dominates the typically sparse vegetation cover (Tables III and X). A. longifolia is usually the most conspicuous shrub; although Sarcobatus vermiculatus and members of the Juniperus scopulorum union frequently occur. S. vermiculatus is especially prominent and may predominate in local stands on south-facing slopes. The depauperate herbaceous layer is comprised largely of grasses and forbs of the Artemisia longifolia, Agropyron smithii, and Tragopogon dubius unions. Occasionally, some members of the Xanthium strumarium union attain abundance in local stands. Agropyron spicatum may be conspicuous, especially on more stable sites.

TABLE X. CONSTANCY, CANOPY-COVERAGE, AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA ON THE ARTEMISIA LONGIFOLIA ASSOCIES. 1/

<u>Union:</u> Taxa 2/	Cy/Cv/Fr 3/
<u>Artemisia longifolia:</u>	
<u>Artemisia longifolia</u>	100/ 8/35
<u>Calamovilfa longifolia</u>	67/ 3/ 7
<u>Chaenactis douglasii</u>	67/ +/ 5
<u>Mentzelia laevicaulis</u>	100/ +/ 8
<u>Lactuca seriola</u>	67/ +
<u>Salsola kali</u>	67/ +
<u>Juniperus scopulorum:</u>	
<u>Rosa arkansana</u>	67/ 3/13
<u>Sarcobatus vermiculatus:</u>	
<u>Sarcobatus vermiculatus</u>	67/ 4/10
<u>Agropyron smithii:</u>	
<u>Agropyron smithii</u>	100/ 4/26
<u>Agropyron spicatum:</u>	
<u>Agropyron spicatum</u>	33/ 2/ 8
<u>Poa secunda:</u>	
<u>Descuriana pinnata</u>	67/ +/ +
<u>Tragopogon dubius:</u>	
<u>Chenopodium album</u>	100/ +/ 8
<u>Melilotus officinalis</u>	67/ 6/13
<u>Tragopogon dubius</u>	100/ +/ 2
Bare Ground	100/94/99
Rock	100/ +/ 5

1/ Data are mean percentages for 120 two x five dm plots distributed as 40 in each stand.

2/ Includes only those which occurred in at least two stands, i.e., constancy of 67 per cent or more, or had mean canopy-coverage at least one per cent in the three stands. Other taxa are considered in Appendix Table XLVI.

3/ Constancy/canopy-coverage/frequency. +/+ indicates canopy-coverage or frequency values less than one per cent; a single + in place of these two values denotes occurrence in the stands but not in the plots.

Other Vegetation Types

The following vegetation types, characteristic of Missouri River bottomlands, occur on the study area but were not analyzed:

The Populus/Symphoricarpos type occurs on approximately 1,000 acres where Populus sargentii and Symphoricarpos occidentalis appear to be typical dominants of the tree and understory layers respectively; The Salix type comprises about 500 acres of dense thicket in which Salix interior, S. bebbiana, and S. mackenziana are common; The Agropyron/Symphoricarpos type covers about 250 acres and appears very similar to the Agropyron smithii/Symphoricarpos occidentalis association; The Sarcobatus type is restricted to footslopes and benches, and except for the paucity of Artemisia tridentata, appears similar to the Sarcobatus vermiculatus/Artemisia tridentata association. Approximately 1,400 acres of cultivated bottomland are variously dominated by alfalfa, barley, stubble, or weeds.

POPULATIONS

The distribution, seasonal movements, and behavioral habits of mule deer, elk, and cattle as well as population trends of mule deer and elk were determined primarily by observations during 521 morning and evening periods (233 for cattle) along 11 vehicle routes which encompassed all portions of the study area (Figure 1). Data were obtained from approximately 11,600 mule deer, 3,500 elk, and 25,000 cattle observations. Mule deer and elk were classified with respect to sex, age, young/female, and specific behavior when practicable. Locations were recorded to the nearest 0.05 mile from gridded aerial photographs and subsequently grouped into one and one-half square mile "blocks" to facilitate analyses. Supplementary data were obtained through aerial surveys, hunter harvest surveys, and collections of mule deer and elk. Relocations of individually recognizable mule deer and elk provided data on movements and home ranges.

Mule Deer

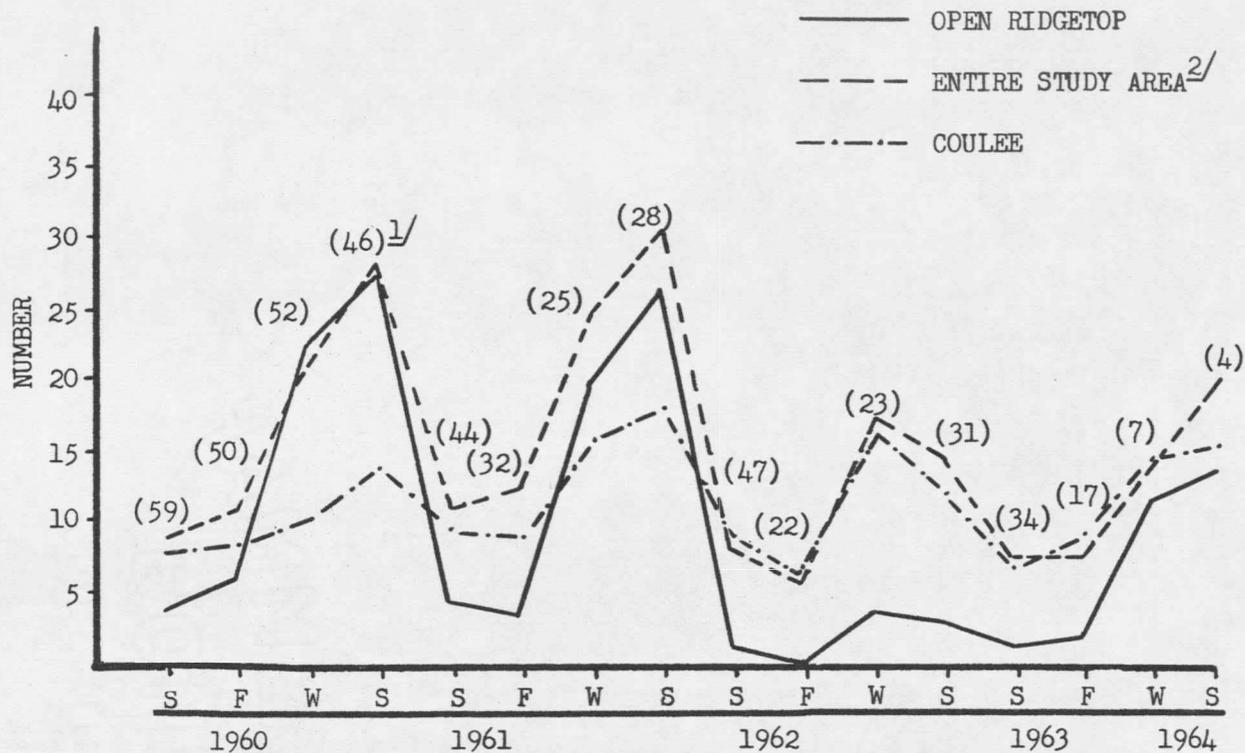
Distribution

The mule deer were non-migratory and widely dispersed over the entire study area, though local population densities varied. Maximal numbers occurred on the south-central portion where close interspersions of well-developed stands of Pinus/Juniperus and Pseudotsuga/Juniperus with other vegetation types provided a relatively high security-level. Lowest densities prevailed west and north of Sand Creek. Although differences related to topography and vegetation influenced observed numbers, averages of 15.0

and 11.0 mule deer respectively were recorded per observation trip along routes in these areas.

The only distinct seasonal shift in distribution consisted of movement onto Missouri River bottomlands during summer and fall as forage supplies on uplands became dessicated. It appeared to involve only animals from adjacent slopes and possibly uplands within about two miles of the river. Mule deer were rarely observed on bottomlands after early December. The increase in numbers of mule deer observed along extensive open ridgetops during winter and early spring (Figure 15) was probably a reflection of local movement and increased observability concomitant with seasonal changes in food and range-use habits. Numbers of mule deer recorded in predominantly coulee areas increased simultaneously.

Numbers of mule deer observed along the principal open ridgetops (Figure 15) and on Missouri River bottomlands declined significantly during 1962. These areas generally were associated with main access roads and sustained a substantial portion of the annual hunter harvest. Although this appeared to directly influence the number of animals observed, suggesting a general population decline, there was evidence that these "declines" were at least partially only "apparent." Mule deer food, range-use, and activity habits under extremely poor range conditions during 1960-62 rendered them exceptionally vulnerable to observation during the fall, winter, and spring. Availability of preferred forage on timbered sites into the fall and winter of 1962-63 had an opposite effect. Increasing alertness and wariness were also evident in mule deer and



^{1/} Number of observation trips.

^{2/} Includes only those mule deer observed within "route" boundaries where the potential for observing most of the animals present existed.

Figure 15. A Comparison of Mean Numbers of Mule Deer Recorded Per Observation Trip on Extensive Open Ridgetops (Roadside), Predominantly Coulee Areas (Away from Main Roads), and the Entire Study Area, 1960-64.

undoubtedly influenced observability. Average numbers of mule deer observed per trip in predominantly coulee areas remained about the same during 1962 as compared to earlier years (Figure 15). In view of decreased observability, this suggests that somewhat greater numbers actually used these areas during all seasons of 1962-63 than in the earlier period.

Males appeared less uniformly distributed than females, especially during summer and early fall when single males and/or groups of two to five (occasionally more) two-years-of-age and older animals appeared to congregate on the same non-descript local areas. At least 25 such "buck habitats" were known for the study area. During summer, an average of 1.66 males was observed per trip through "blocks" which partially or entirely encompassed male concentration areas. Only 0.24 males were observed per trip through blocks in other areas.

Movements and Home Range

Sixteen mule deer fawns were individually marked using various combinations of colored plastic tape and 2 x 3 inch flags of nylon impregnated fabric (Saflag Fabric, The Safety Flag Company of America, Pawtucket, R.I.) attached to an ear. Four were never relocated; three were last observed about one month after birth; and nine were individually relocated from 2 to 21 times over periods of 5 to 29 months after tagging. Five individually recognizable mule deer, one fawn and four adult males, were observed two to five times over periods of one day to four months.

A summary of movement data for recognizable animals other than fawns observed only when less than six months old is presented in Table XI.

TABLE XI. SUMMARY OF MOVEMENT DATA FOR MARKED AND RECOGNIZABLE MULE DEER.

Animal	Age at First Observation	Dates of Observation	Number of Observations	Distance (miles)			Estimated Home Range (Acres)
				Maximum Between Observ.	First to Last Observ.	From Center of Range 1/ Mean Maximum	
Female (D-1853)	1 day	6/61 - 11/63	21	1.59 ^{2/}	0.28	0.39 1.00 ^{3/}	300
Female (D-1851)	11 mos.	5/61 - 10/63	22	1.25	0.65	0.32 0.65	320
Male (D-1864)	4-5 day	6/62 - 3/64	10	1.09	0.93	0.38 0.62	400
Male (D-1859)	2-3 day	6/62 - 2/64	4	2.75 ^{4/}	2.75	-----	---
Male (D-1869)	8 mos.	2/63 - 10/63	5	0.90	0.59	0.43 0.53	300
Fawn (Recog.)	7 mos.	1/61 - 5/61	5	0.34	0.18	0.11 0.18	---
Male (Recog.)	19 mos.	1/62 - 3/62	3	1.00	1.00	0.45 0.59	---
Male (Recog.)	Adult	5/61 - 9/61	2	0.87	0.87	-----	---
Male (Recog.)	Adult	9/61	2	0.84	0.84	-----	---
Male (Recog.)	Adult	3/62 - 7/62	2	2.00	2.00	-----	---

^{1/} Approximate central point of the area within which the animal was observed.

^{2/} Maximum distance may have been influenced by hunters. Excluding this, distance was 1.12.

^{3/} Maximum distance may have been influenced by hunters. Excluding this, distance was 0.78.

^{4/} This animal had moved 0.43 mi. at 13 mos. A movement of 1.5 mi. occurred at about 17 mos. of age.

Movements of marked animals relocated over periods of one or more years are illustrated in Figures 16 and 17. Home ranges of females appeared to encompass approximately 300 acres. Males seemed somewhat more mobile and may have had larger home ranges but few quantitative data were obtained, especially for males older than two years. Relocations of three marked males to 16, 20, and 21 months of age indicated movements through the second summer were comparable to those of females, as reported by Dasmann and Taber (1956). Subsequently, movements became more extensive during the fall and/or winter resulting in enlargement of, or establishment of, new home ranges. Older males appeared to have greater mobility and larger home ranges.

Home ranges of marked females were established by the second summer and were partially superposed on those of parent females. Considerable variation was evident among males. One (D-1864) ranged over an increasingly larger area immediately adjacent to its home range as a fawn, at least until 21 months of age; another (D-1869) remained within the same general area on which it had been observed as a fawn until at least 16 months old; and the third (D-1859) was observed during the second summer on a male concentration area 0.4 mile from the tagging site and subsequently moved 1.5 mile during November to an entirely new area. These differences may have been influenced by social relationships during the second summer. The three associated with another young male, an adult female and fawns, and an older adult male respectively.

- = Male D-1864, June 1962-March 1964, Birth to 1 yr 9 mos.
- - - - = Male D-1869, Feb. 1963-Oct. 1963, 8 mos to 1 yr 5 mos.
- · - · - · = Male D-1859, June 1962-Feb. 1964, Birth to 1 yr 8 mos.

⊙ = winter-spring

• = summer

x = fall

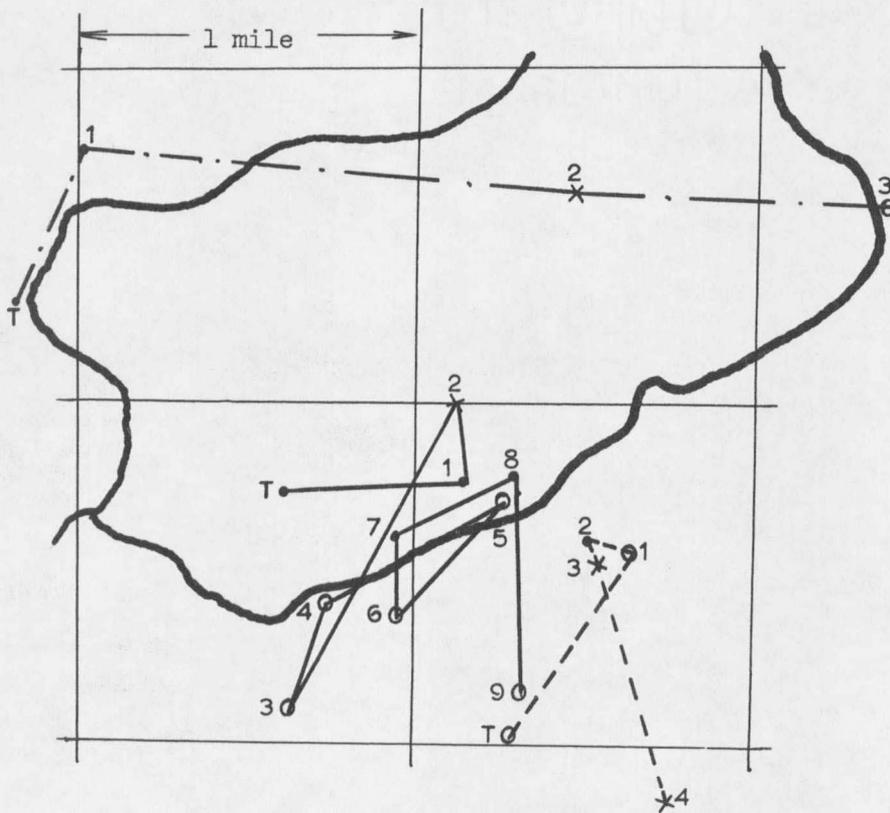


Figure 16. Movements of Three Marked "Yearling" Males on the Missouri River Breaks Study Area.

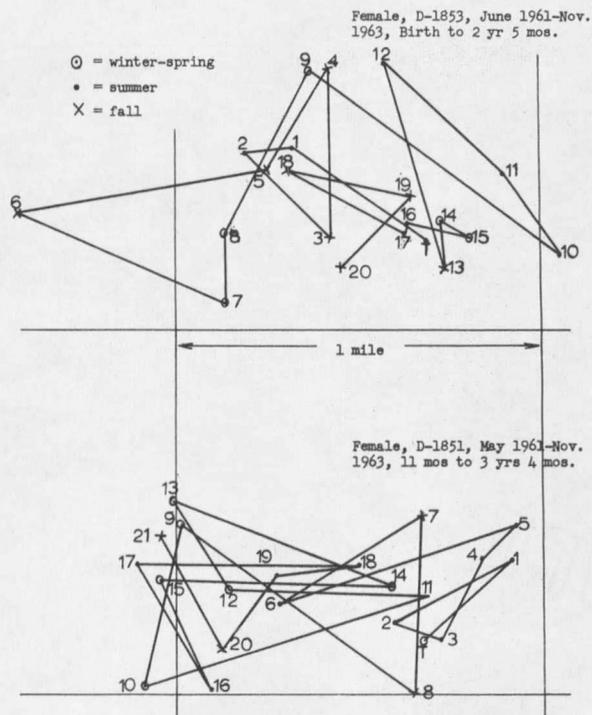


Figure 17. Movements of Two Marked Female Mule Deer on the Missouri River Breaks Study Area.

Differentially greater seasonal use of certain portions of home ranges was evident. Predominant use typically occurred on brushy or timbered portions on one side of the home range during the summer and on open ridgetop sites on the other side in winter. The extent of use of the different portions seemed to vary between years. One of the marked females (D-1853) ranged extensively on the open ridgetop portion of her home range during the fall and winter of 1961-62 but apparently remained in the vicinity of the more timbered portion during most of the winter of 1962-63. Both marked females appeared to return to the same portion of the home range where they were born to give birth to fawns. One was observed during the fawning periods of 1962 and 1963 in the same locality where tagged, and one of the twin fawns of the other was tagged when one day old within a few yards of where the female had been tagged as a day-old fawn.

Mule deer food preferences and the quantity and quality of available forage appeared to be primary factors influencing local and seasonal movements within home ranges. Observations suggested that movement was most restricted during the summer, then increasing to winter or early spring as food habits changed to include greater representation of species from the open Artemisia/Agropyron vegetation type. That is, greater effort became necessary to satisfy nutritional requirements as the quantity and quality of available forage declined. The importance of the latter was indicated by yearly contrasts in movement with variations in production and seasonal utilization of preferred species. In 1960 forage production was "sub-normal," summer-fall utilization of deciduous browse species was

heavy, and local movements increased appreciably to winter and early spring. During 1961, forage production was extremely low as a result of drought conditions, summer utilization of deciduous browse was extremely heavy, and seasonal changes in food habits occurred much earlier than in 1960. Also, fall rainfall resulted in a "green-up" of Sandberg bluegrass (Poa secunda) and junegrass (Koeleria cristata) which concomitantly became important forage sources on open vegetation types. The combined effects were reflected in more extensive movement during all seasons. During 1962-63, favorable growth conditions effected good forage production. Supplies of preferred forbs persisted into fall and winter, summer utilization of deciduous browse was light to moderate, and local movements appeared extremely restricted with only slight increase to winter and early spring.

The presence of fawns, whose maximum summer movements were limited to areas about 0.5 mile in diameter, may have influenced mobility of parent females (Table XII). However, general observations suggested that females usually foraged independently until mid-August, and females without fawns as well as males were equally restricted in movement during the summer period.

TABLE XII. MOVEMENTS OF FAWN MULE DEER DURING FIRST SUMMER AND FALL.

Period	Total Number of Fawns	Number of Observations	Mean, From Tag Site	Mean, First to Last Observation	Maximum Between Observations
June, July, Aug.	6	13	0.20	0.22	0.53
Sept., Oct., Nov.	4	8	0.57	0.72	0.72

Population Trends

No quantitative data are available for mule deer populations in the Missouri River Breaks prior to 1947. Information furnished by long-time area residents suggests that numbers declined during the early 1900's to extreme scarcity during the 1920's and early 1930's. The four-month hunting season with a bag limit of eight deer established in 1895 was successively reduced. By 1923 limits were one month and one male deer with antlers not less than four inches. From 1921 through 1930, an area encompassing the eastern one-half of the study area was closed to deer hunting. The entire area was closed during 1931-32. Hunting resumed in 1933 under regulations effected in 1923. Petroleum County, lying immediately adjacent to the east of the study area, remained closed to the hunting of mule deer until 1945. Hunting was prohibited within the Fort Peck Game Range (C.M. Russell Wildlife Range) from 1937 through 1947 and again during 1949.

Human depopulation, increasingly effective law enforcement, and predator control together with favorable deer range conditions which developed during the period of scarcity probably proved conducive to the subsequent development of the existing population. Increasing numbers of deer were noted during the late 1930's, throughout the 1940's, and into the early 1950's. Hollibaugh (1944) indicated that the "Breaks" herd was increasing at a tremendous rate under excellent range conditions. In 1947, from aerial surveys, Brown estimated the mule deer population as approximately five deer per square mile. That increases continued until at least 1951 was indicated by calculated post-hunting-season mule deer populations of

3,330 in 1949, 4,850 in 1950, and 5,230 for 1951 for the Missouri Breaks of Fergus, Petroleum, and Phillips Counties (Johnson 1952). The calculations of Brown and Brown (1950) suggest a minimal mule deer population of approximately seven per square mile during the winter of 1950-51. No data indicative of population size are available for the 1952-59 period.

Although mule deer numbers could not be determined precisely, the estimates presented in Table XIII are believed indicative of population trends on the study area during the 1960-64 period. Winter population estimates, believed to be conservative, were derived by plotting numbers of deer observed by location and/or from aerial surveys. Trends in local densities, population structure, mortality (including hunter harvests), and changes in observability were subjectively considered. Sex and age structures were determined from ratios observed in the field from late November through January. Summer adults were computed from winter data by adding yearlings (last year's fawns) in proportion to the sex ratios of fawns killed during the previous hunting season. Annual increments and late summer populations were calculated subsequently on the basis of September-October female:fawn classifications.

Year-to-year trends indicated decreasing mule deer numbers from 1960 through 1962 and recovery during 1963 and 1964. The decline in winter populations from 1960-61 to 1961-62 appeared to be effected by low production and/or survival of fawns, increased hunter harvest, and probable additional losses related to range conditions. The extremely poor range conditions which prevailed during 1961 were reflected in a substantially

TABLE XIII. SEASONAL AND ANNUAL TREND IN NUMBERS OF MULE DEER ON THE MISSOURI RIVER
BREAKS STUDY AREA, 1960-64.

Year	Summer Populations				Per Cent Increase from Winter	Winter Populations				Per Cent Decrease		Per Cent Change	
	Total	Male	Female	Fawn		Total	Male	Female	Fawn	Total Kill	Summer	Winter	
1960	1,500	225	660	615	--	1,100	110	550	440	27	20	--	--
1961	1,500	290	810	400	35	900	135	550	215	39	25	0	-18
1962	1,200	265	650	285	31	900	180	480	240	24	17	-20	0
1963	1,400	340	560	500	56	1,000	160	450	390	28	7	+17	+11
1964	1,500	420	580	500	50	1,100	250	525	325	27	10	+7	+10

reduced increment for 1962. The effects of improved range conditions after the spring of 1962, reduced mule deer numbers, and a female segment comprised largely of older animals were manifest during 1963 in a relatively large fawn crop and a substantially increased late summer population. Further increase apparently occurred during 1964 when, with continued good fawn production, the increment should have resulted in a summer population approximately equal to that of 1960. Although harvests decreased after 1961, total annual population losses seemingly were proportionately similar and the trend in winter numbers paralleled that of summer.

Numbers of mule deer recorded per observation trip (Figure 15), probably, were more indicative of the relative observability of animals than of population trends. For example, during 1961, "trend" counts indicated populations 10 to 20 per cent greater than 1960 whereas all other information indicated that 1961 summer numbers were subequal to those of the previous year and that 1961 winter-spring populations were 10 to 20 per cent lower. Average numbers observed per trip during the summer and fall of 1962 suggested declines of 25 per cent and 50 per cent respectively from 1961 populations compared with calculated decreases of approximately 20 per cent. Indicated numbers for winter and spring were 25 per cent and 50 per cent lower than 1961 despite evidence indicating quite similar population levels. Observations did not fully reflect the increase which occurred in 1963. The influence of observability was also evidenced by

variation in the magnitude and direction of seasonal changes in observed numbers (Figure 15) which indicated that similar proportions of male deer numbers were not seen in any given season of the different years. It should also be noted that average numbers observed per trip during 1960-61 and 1961-62 when the animals were relatively observable corresponded closely to numbers observed per trip on open ridgetop sites whereas data for the 1962-63 and 1963-64 periods were similar to numbers observed per trip into predominantly coulee areas (Figure 15).

Elk

Distribution

The study area comprised the principal range of the elk population south of the Missouri River. Adjacent "breaks," especially west of the area, received variable but increasing use during the four years. Some unexplained movement across the Missouri River occurred.

The elk were non-migratory, but differentially utilized various portions of the area during the year. Vegetational complexes and availability of preferred forage, as influenced by general range conditions, annual vegetal growth, and/or prior utilization, appeared to be the primary determinants of seasonal distributions and variations thereof. Physiographic and weather factors apparently were secondarily related. Variation in use of local areas within and between seasons and years corresponded closely to changes in distribution and intensity of grazing by domestic livestock.

The late-spring and summer distribution (Figure 18) coincided closely

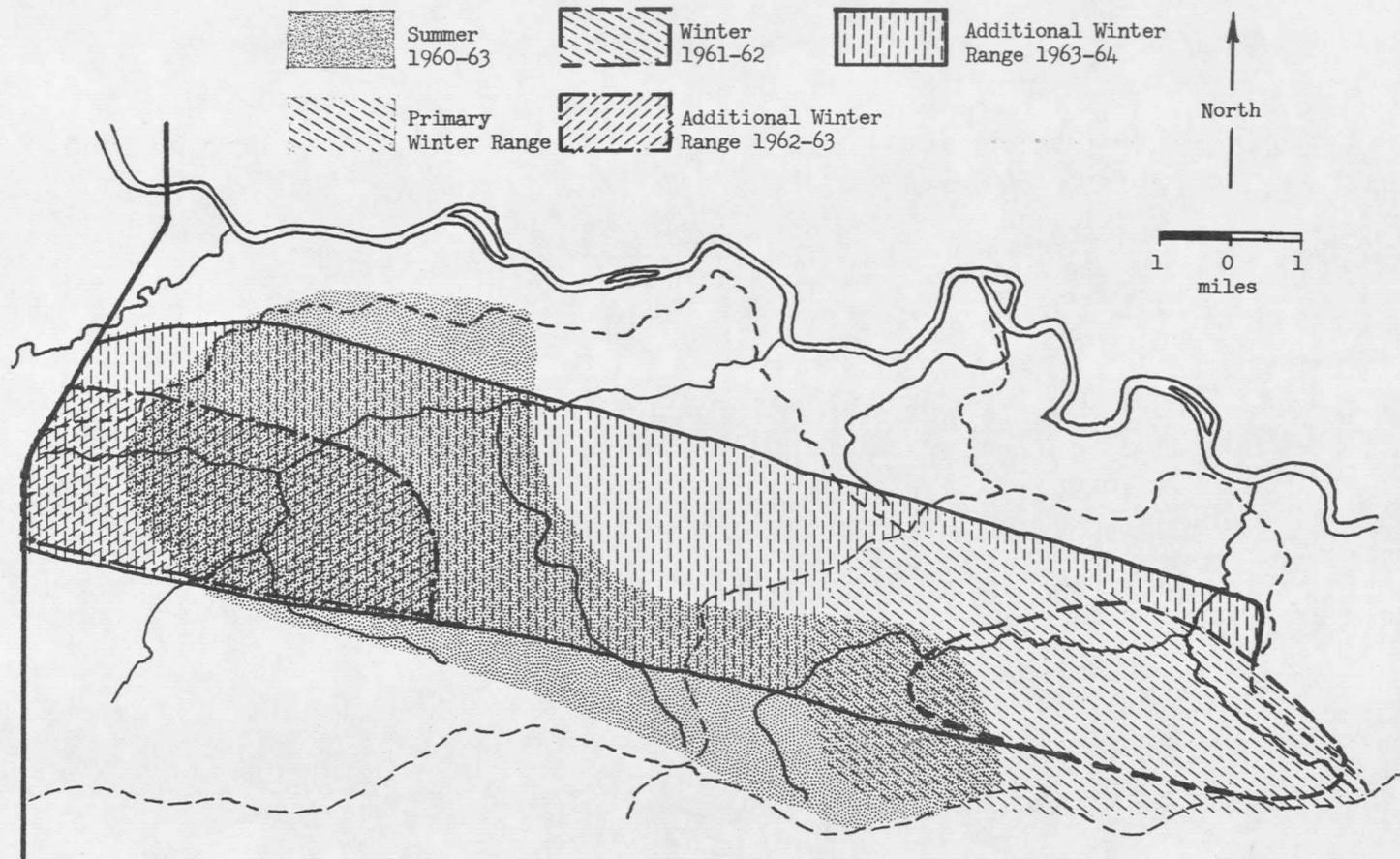


Figure 18. Summer and Winter Distributions of Elk on the Missouri River Breaks Study Area, 1960-64.

with the distribution of more extensive, well-developed stands of the Pseudotsuga/Juniperus vegetation type. Principal differences between years were those associated with use of local areas within the circumscribed area. Elk generally dispersed over all but the extreme eastern portion of the study area during early fall. Use of Missouri River bottomlands, which appeared to increase during the years of the study, occurred largely during this period. Concentration began in late October or early November. During 1960, 1961, and 1962, a majority of the animals congregated during this period in the vicinity of cattle winter pastures on the south-central portion of the study area. Significantly fewer elk utilized this area during 1963 when the population remained more dispersed and a segment congregated in the vicinity of previously ungrazed pastures along the western boundary of the study area. Use of the south-central area generally ceased during early December when cattle were turned onto and/or snow covered the grass-dominated pastures.

Winter elk distributions (Figure 18) encompassed portions of the area characterized by extensive stands of the more open vegetation types where grasses were prominently represented and little or no livestock use. The southeastern portion, much of which was only lightly grazed by cattle, was used almost exclusively during the winters of 1960-61 and 1961-62. During the latter, elk were observed largely on the central part where, with above-average range conditions, the extreme drought had minimal influence on the quantity of forage available. Elk were more dispersed during the winter of 1962-63, evidently in response to the increased availability of

forage on much of the area. Although most elk utilized the southeastern area in a distribution similar to the winter of 1960-61, some use occurred on the western portion of the study area which had little or no prior livestock use. Forage conditions were generally excellent throughout the area during the winter of 1963-64. The elk remained relatively widely dispersed with about one-third of the population wintering largely off the study area in the area lying west of Highway 191.

The rather abrupt dispersal from the winter range during late March coincided approximately with the onset of the spring "green-up." Most of the animals returned directly to the summer range. Use of local areas during early spring appeared inversely related to range conditions and directly related to the degree of prior livestock use. This undoubtedly reflected the seasonal elk preference for Poa secunda, Koeleria cristata, and early spring forbs which were commonly more abundant and/or more readily available on these sites.

Movements

Ten recognizable adults and three marked calves were individually relocated 2 to 19 times over periods of one day to four years. Movements of representative individuals, relocated at least 10 times during two or more seasons, are illustrated in Figures 19, 20, 21, and 22. Seasonal movements of these elk corresponded closely to and support distributional changes described above.

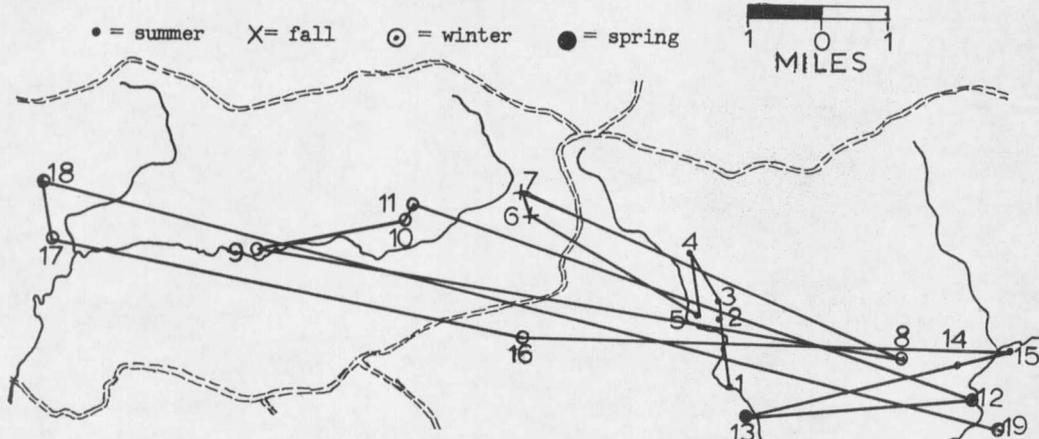


Figure 19. Movements of an Adult Female Elk from July 1962 to December 1964. The Animal Was Approximately Four and One-half Years Old When Killed at Last Relocation.

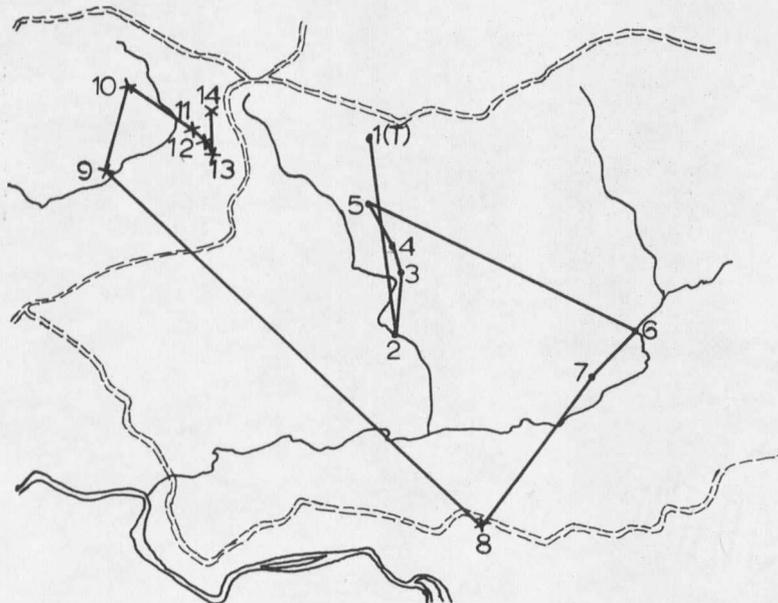


Figure 20. Movements of a Male Elk Calf from June to December 1962.

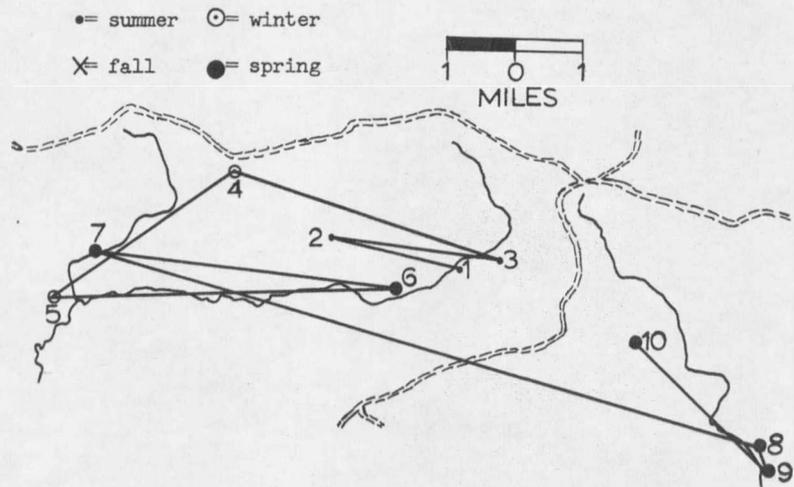


Figure 21. Movements of a "Yearling" Male Elk from July 1960 to April 1961.

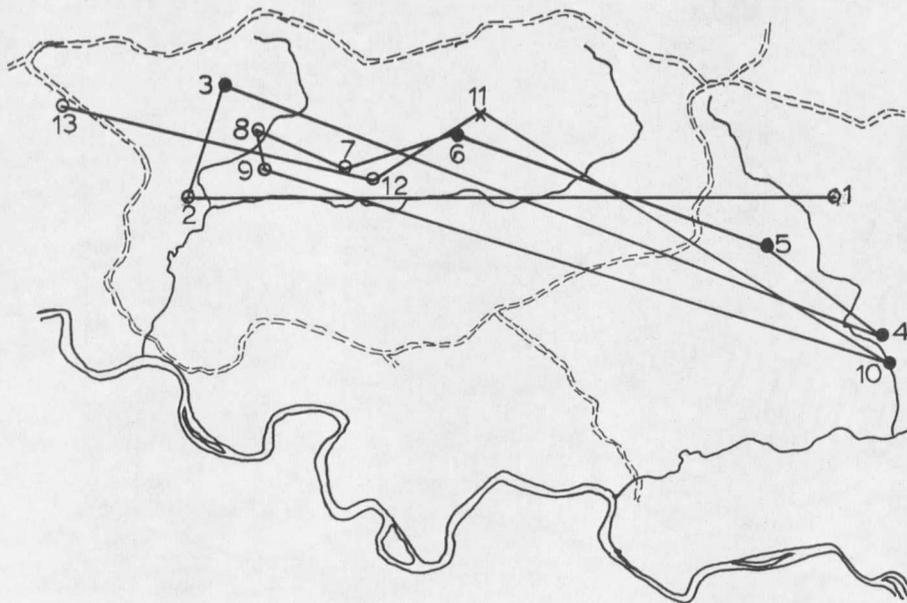


Figure 22. Movements of an Adult Male Elk from January 1961 to December 1964. The Animal Was Approximately Nine and One-half Years Old When Killed at Last Relocation.

The elk were highly mobile (Table XIV). During spring, summer, and fall, movement typically was erratic. There were variable periods of restricted movement on local areas broken by abrupt shifts involving more extensive movement. Constant "wandering" was characteristic of winter movement. In general, movement was most limited during summer and most extensive during late winter and early spring. Rapid, extensive movement occurred during all seasons. One cow-calf group moved more than five miles from morning to evening during summer; another traveled more than seven miles overnight during winter. Maximum distances between any two relocations of a given individual were: adult female, 14.5 mile; calf, 7.0 mile; adult male, 13.2 mile; and yearling male, 11.6 mile. The extreme mobility apparently enabled elk to adjust rapidly to environmental changes and constantly utilize the most favorable portions of the range.

Population Trends

The elk population developed following the release of 31 animals (22 adult females, 6 calves, and 3 adult males), transplanted from Yellowstone National Park, on the south-central portion of the present study area during February 1951. No data on growth of the population were obtained prior to 1959 when Janson (Pers. Comm.) estimated a minimum of 80 elk on the area prior to a special hunting season to alleviate damage on private lands.

TABLE XIV. SEASONAL AND ANNUAL MOVEMENT OF RECOGNIZABLE ELK ON THE MISSOURI RIVER BREAKS STUDY AREA.

Group Class	Sample Size	Mean Distance Between Relocations (Air Miles)				
		Spring	Summer	Fall ^{1/}	Winter	Year
Adult	4	4.3 (3) ^{2/}	2.0 (10)	1.8 (2)	6.1 (8)	3.7 (23)
Calf	4	3.3 (1)	2.2 (9)	1.8 (7)	6.4 (1)	2.4 (18)
Adult	2	6.7 (4)	1.6 (1)	7.3 (1)	3.0 (7)	3.3 (13)
Yearling	3	3.8 (4)	2.2 (2)	---	3.4 (8)	4.2 (14)
-Calf combined	8	4.0 (4)	2.1 (19)	1.8 (9)	6.1 (9)	3.1 (41)
Total	13	4.9 (12)	2.1 (22)	2.4 (10)	4.3 (24)	3.4 (68)

^{1/} Fall data largely from October-November period during which elk congregated on south-central portion of the area.

^{2/} Number of relocations in parenthesis.

The elk on the study area during the 1960-64 period (Table XV) did not comprise a discrete population. Undetermined numbers occurred on adjacent areas during all years. Year-to-year relationships of numbers in the various sex and age classes on the study area indicated interchange of individuals and/or groups between the study and adjacent areas. On the basis of data from Table XV and known losses, minimum contributing summer populations of 90 elk in 1959, 110 in 1960, and 135 during 1961 were necessary to produce the sex-age structures observed on the study area during the 1960-62 period. For example, the total of 13 yearling males for the winter of 1961-62 is not compatible with the 20 calves for 1960-61 when

sex ratios are considered. Further calculations suggest total summer populations in excess of 160 and 200 respectively during 1962 and 1963.

TABLE XV. WINTER ELK POPULATIONS ON THE MISSOURI RIVER BREAKS STUDY AREA, 1960-64.

Year	Total	Males		Females	Calves	Calves: 100	Males: 100
		Adult	Yearling				
1960-61	70	8	10	32	20	62	56
1961-62	80	9	13	41	17	42	54
1962-63	108	12	13	54	29	54	46
1963-64	108	13	9	51	35	69	43

The mean net recruitment to the population, based on observed population structures, calf production (Table XV), and losses, was approximately 35 per cent during the four years. Assuming a similar rate of increase in years prior to the study, a much larger population could exist. It seemed unlikely, however, that actual numbers were greatly in excess of those calculated above. Either mortality was of greater than observed proportions or emigration from the area has provided effective control over population growth.

Trends in numbers of elk on the study area during other seasons appeared similar to that of winter. Spring populations generally appeared to be somewhat lower than those of previous winters. Summer numbers apparently were subequal to those of subsequent fall and winter periods when some movement onto the study area seemed to occur. Known losses

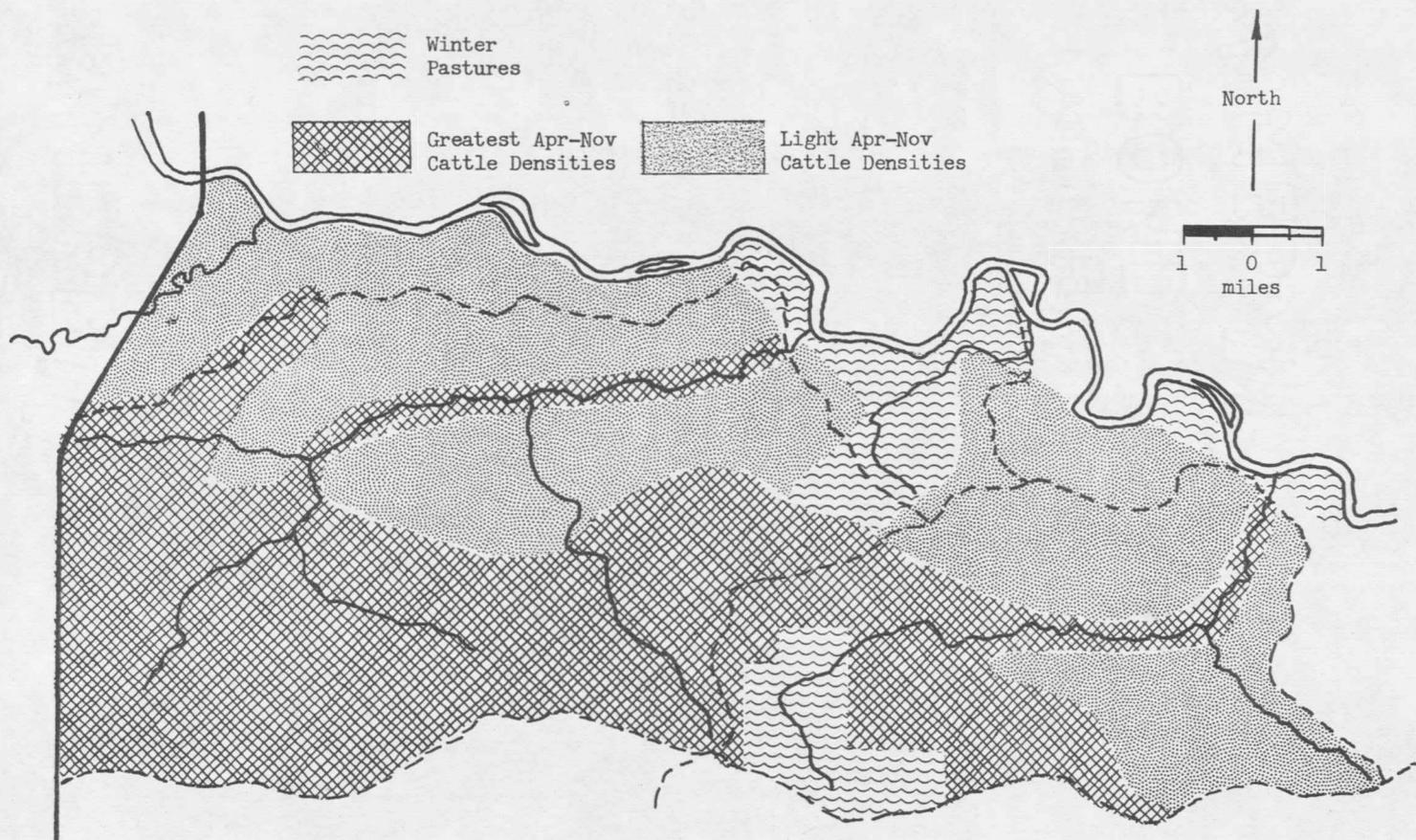
during the fall varied from two in 1962 to eleven during 1961. No legal hunting of elk occurred during the study.

Cattle

Distribution

The entire area, except portions on some Missouri River bottomlands, was subject to use by cattle. During the April 1-November 30 grazing season, greatest cattle densities typically occurred on the southern one-half of the study area; light or occasional use prevailed on the northern and extreme eastern portions (Figure 23). The only important exception occurred during 1962 when the area of greatest cattle density extended further north along the Wilder Trail and light use prevailed over most of the southwestern portion. Use of local areas varied considerably during all years, reflecting changes in forage availability, water supplies, and weather conditions.

The areas of greatest cattle densities were major coulee bottoms and uplands characterized by dominance of the Artemisia/Agropyron and Agropyron/Poa vegetation types associated with ridgetops, slight to moderate slopes, and well-distributed water sources. Areas of light or occasional use were those with inadequate water supplies and/or broken topography with steep slopes and limited ridgetop areas. Access to the extreme eastern portion was also limited by fences. It appeared that grazing pressures were substantially greater where cattle could disperse from water over extensive areas of primary range types. Use of distal



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Figure 23. Distribution of Cattle Densities, "Generalized," for the April-November Grazing Season and Livestock Wintering Areas on the Missouri River Breaks Study Area.

portions of ridges where the dispersal area was limited was generally low despite sufficient water.

Cattle were observed on "light use" areas most frequently during fall, following heavy utilization of forage on preferred sites, when rains provided additional water sources and/or cooler temperatures enabled more extensive movement. Some use also occurred during spring, especially in drought years, when standing runoff water was available and/or forage was relatively more abundant. These areas were most heavily used during 1961 when reduced production and heavy use of forage on more intensively grazed areas forced cattle to range more widely.

Most cattle were turned onto winter pastures and/or removed from the area by the end of the grazing season. Winter pastures on the south-central portion of the area were not grazed by cattle during the winter of 1961-62. The upland part of the north-central winter pasture was usually grazed only during the early winter period.

Population Trends

Fourteen operators held permits to graze 1,646 cattle (plus calves) on or adjacent to the study area (Pers. Comm., BLM, Lewistown, Montana). Of these, 11 permittees with 1,205 permits ran their stock largely on the area; 2 with 166 permits partially used the area; and 1 with 175 permits usually did not use the area. Actual numbers of cattle on the study area varied considerably within and between years, some proportion of the total always ranging onto immediately adjacent areas. This number appeared to increase from spring to summer, then decreased slightly to fall. Greatest

numbers of cattle occurred on the study area during the spring and summer periods of 1961 when most operators turned their cattle into the "breaks" where forage and water conditions were somewhat better than on adjacent areas. Lowest numbers occurred during the fall of 1961, when most cattle were removed long before the end of the grazing season, and during the spring of 1962, when most operators delayed turning their cattle onto the open range until early May.

RANGE USE

Mule deer, elk, and cattle observed along established routes (see previous discussion, page 49) were recorded with respect to time of day, type of activity occurrence on the various vegetation types, slopes, and exposures, and distance from known water sources. Environmental conditions (temperature, precipitation, wind direction and velocity, cloud cover, ground condition, and moon phase), times of sunrise or sunset, as well as duration and distance of travel were recorded for each observation period. Observations of mule deer and elk were recorded during all periods. Observations of cattle were recorded at weekly intervals after August 1960, except during the December-March period when observations were irregularly recorded whenever cattle were encountered on upland winter pastures. All portions of the study area were usually visited at intervals of one month or less from June 1960 through September 1963, during November and December 1963, and during January and March 1964.

All observational data were transferred to standard 80-column punch cards and subsequently tabulated and statistically analyzed using IBM unit records equipment and computers.

Mule Deer

A total of 11,581 mule deer observations, used in evaluating range-use habits, was recorded as follows: 1960-61, 5,577; 1961-62, 3,431; 1962-63, 1,797; and 1963-64, 776.

Activity Habits

The time of day of each observation was recorded to the nearest quarter-hour, then converted to the nearest hour relative to sunrise or sunset to provide a basis for comparisons of data within and between time periods. All animals were classified as feeding, bedding, alert, or traveling on the basis of their behavior when first observed.

Mule deer typically were active and observable mostly within three-to-four-hour periods in early morning and late afternoon. They appeared more active during mornings when an average of 26 animals was recorded per observation trip, compared to 19 per trip during evening, and "activity periods" were slightly longer. Greatest numbers were observed during the first and last hours of daylight, with 75 per cent or more of all observations usually occurring within two and one-half hours after sunrise and before sunset and more than 90 per cent within three and one-half hours. Percentage distributions for morning, evening, seasonal, and yearly periods (Figures 24 and 25) were similar despite differences in numbers of animals observed, range-forage conditions, weather conditions, as well as mule deer densities, food and range-use habits, and behavior. These factors generally effected variation only within the normal "activity periods."

The "prolonged" activity periods of late winter and early spring reflected more nearly equal distribution of observations through normal activity periods and some extended feeding later in the day. These

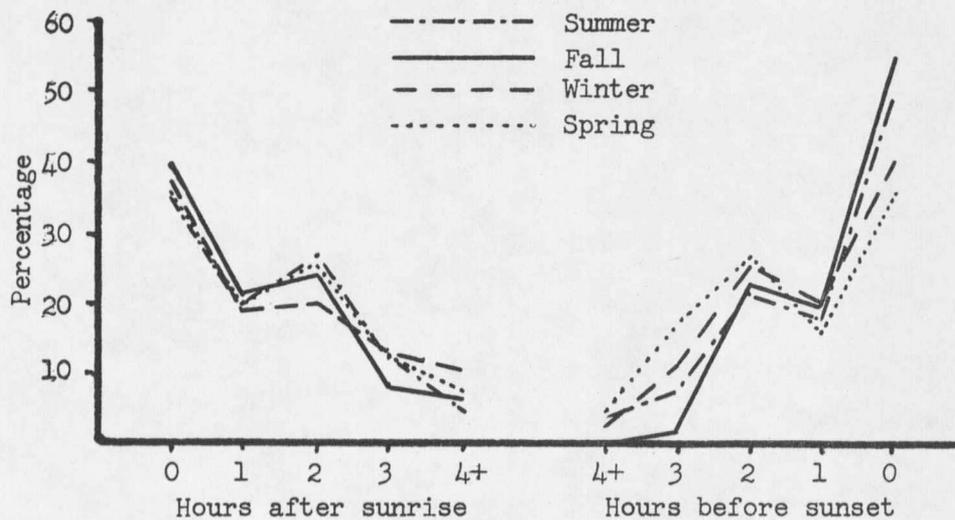


Figure 24. Percentages of Total Mule Deer Observed by Hour Relative to Sunrise and Sunset During Seasons.

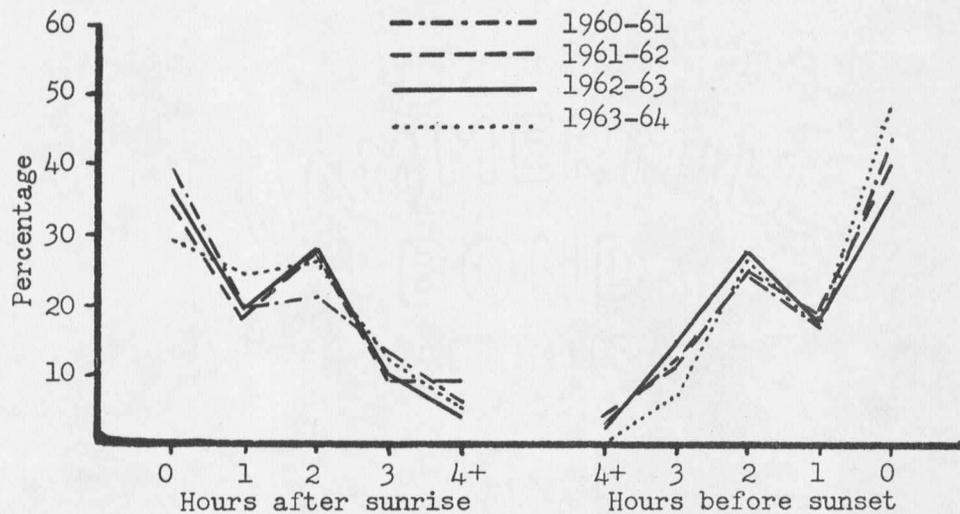


Figure 25. Percentages of Total Mule Deer Observed by Hour Relative to Sunrise and Sunset During Years.

phenomena were most pronounced under the extremely poor range-forage conditions which prevailed during 1961-62. The "short" periods of fall were characterized by concentration of activity in the first and last hours of daylight and sharply decreased activity later in the day, except during the fall of 1961 when activity was "prolonged" in a distribution similar to that of winter. A trend toward a fall-like distribution during all seasons occurred after the spring of 1962 as range-forage conditions improved and mule deer became increasingly wary.

The distribution of activity during normal activity periods varied with temperature. The proportions of the total mule deer observed during the first and last hours of daylight increased as temperature increased (Figure 26). The most significant differences were associated with sub-zero temperatures, when only 25 per cent of the animals were observed during the first and last hours of daylight and approximately 30 per cent of all observations were recorded more than two and one-half hours after sunrise and before sunset and with temperatures above 80 degrees, when nearly 60 per cent and less than 10 per cent respectively of all observations occurred during those periods. Other weather factors undoubtedly influenced variation but significant effects were obscured by interactions.

Feeding was the predominant activity recorded for mule deer observed during all hours of activity periods (Figure 27), seasons, and years (Figure 28). The hour of most intensive feeding was between one-half and one and one-half hours after sunrise and before sunset (Figure 27). Decreased movement associated with this may have influenced the

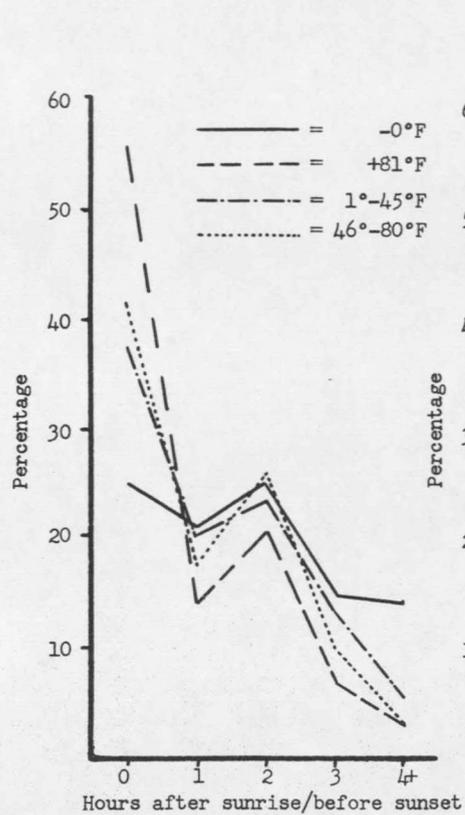


Figure 26. Percentages of Total Mule Deer Observed by Hour Relative to Sunrise/Sunset in Relation to Temperature.

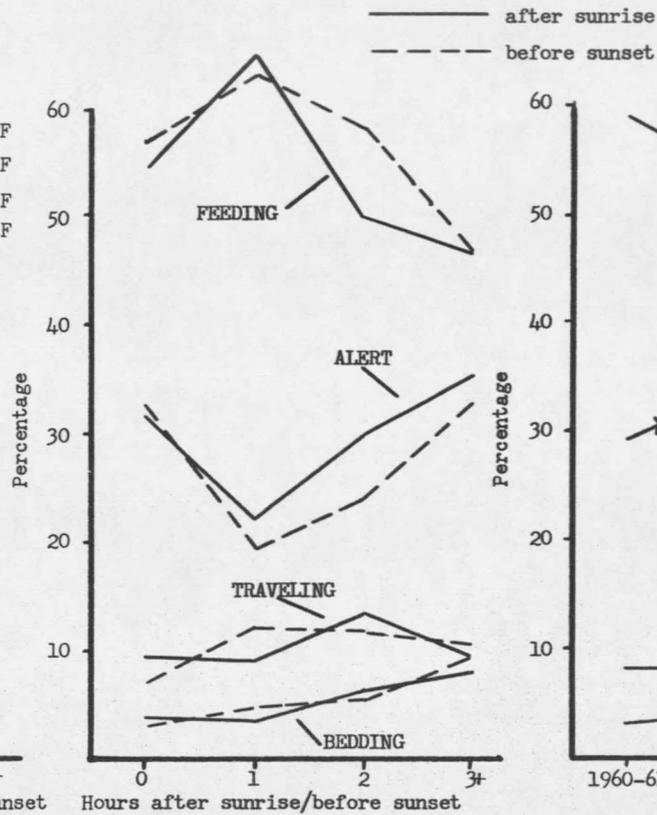


Figure 27. Percentages of Total Mule Deer Observed by Activity Class by Hour Relative to Sunrise/Sunset.

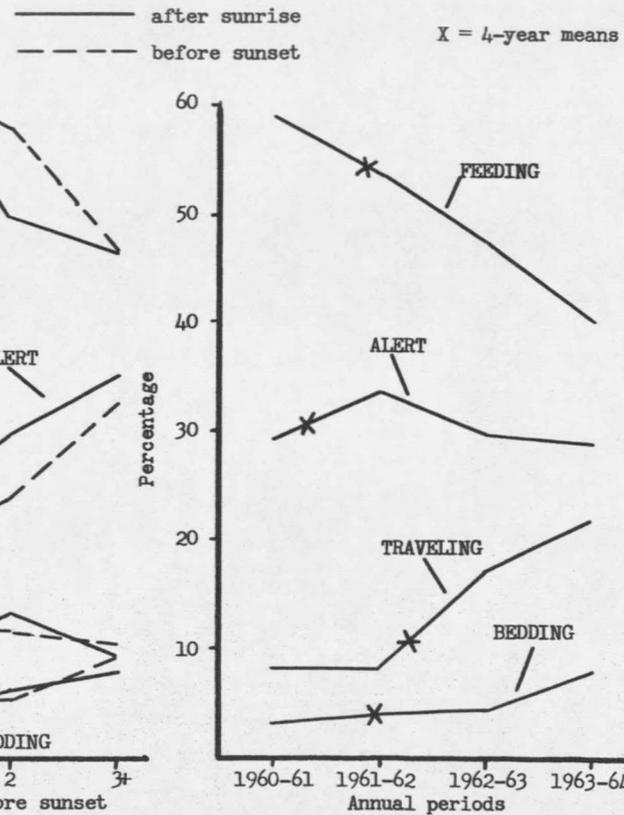


Figure 28. Percentages of Total Mule Deer Observed by Activity Class by Years.

characteristic decrease in numbers of animals observed during that time (Figures 24 and 25). That type of activity influenced observability was further illustrated by the small differences in proportions observed bedding through activity periods. Numbers observed differed greatly.

The decrease in proportions of mule deer observed feeding and the complementary increase in traveling during the four years (Figure 28) can be interpreted as an increase in wariness. This was particularly apparent along roads on major ridges. These changes appeared correlated with hunting pressures during the 1960-62 period, suggesting selective removal of less wary animals from the previously lightly hunted population and/or that mule deer became increasingly responsive to disturbance.

A summary of observed mule deer activities by seasons and years is given in Appendix Table XLVII. A complete summary of weather factors as related to mule deer activity is presented in Appendix Table XLVIII.

Group Size

Mule deer were recorded collectively when observed within about 100 yards of each other and/or their behavior was indicative of a "group" relationship. Groups ranged in size from 1 to 25 animals, but the most common numbers were near seasonal means (Table XVI).

Groups typically were smallest in summer when mule deer were relatively dispersed and using a variety of range types. Those of more than four or five animals were almost invariably comprised of males. Aggregation occurred slowly through fall and winter, concomitant with increasing

use of "open" vegetation types and/or concentration on certain sites. The largest groups generally were observed in late winter and early spring. This increase in seasonal group size apparently reflected more strongly a greater incidence of association on mutually used areas than changes in social relationships. Support for this statement was provided by observations that the composition of "groups" associated with recognizable animals changed frequently. The number of mule deer in a group reflected the locations within home ranges of individuals on overlapping home ranges.

Group sizes were somewhat larger in 1961-62 than in other years. Possibly, this was related to more concentrated use of certain vegetation types. Group sizes in general decreased in subsequent years as the animals remained more widely dispersed.

TABLE XVI. AVERAGE SIZE OF GROUPS FOR MULE DEER OBSERVED DURING SEASONS AND YEARS, 1960-64.

Year	Summer	Fall	Winter	Spring	Year
1960-61	1.5 (731) ^{1/}	2.5 (734)	3.7 (1,441)	4.4 (2,671)	3.1
1961-62	1.5 (669)	2.8 (587)	5.2 (845)	5.0 (1,330)	3.2
1962-63	1.5 (483)	2.4 (163)	4.0 (526)	3.8 (626)	2.6
1963-64	1.6 (376)	2.5 (160)	3.5 (120)	5.7 (120)	2.2
1960-64	1.5	2.6	4.1	4.5	3.0

^{1/} Number of mule deer in sample.

Use of Vegetation Types

Mule deer relations to vegetation types were evaluated by recording the type on which individuals were first observed. To consider bias resulting from greater observability on "open" types, "observability indices" were determined by comparing average numbers recorded per observation trip with calculated "expected values"; i.e., average numbers which could have been recorded, based on data for the spring of 1961 when maximum numbers of mule deer were observable and yearly population trends. For example, about 78 mule deer were "expected" per observation trip during the summer of 1960 in contrast to 12.4 (16 per cent = "observability index") actually recorded. The 84 per cent not observed evidently were using "timbered" types and/or were inactive.

Frequencies of mule deer occurrence on vegetation types receiving more than 10 per cent of the total use during monthly periods are plotted in Figure 29. The complete results for seasons, years, and the four-year period are presented in Appendix Table XLIX.

Summer (June, July, August).—The Pinus/Juniperus type was used most intensively in summer when it was the most important vegetation type for all mule deer activities. The Pinus ponderosa/Agropyron spicatum association appeared to be the most important community, especially for feeding. Greatest use on the P. ponderosa/Juniperus scopulorum and P. ponderosa/Artemisia longifolia associations occurred in early summer, though the former remained important for bedding and escape throughout the period.

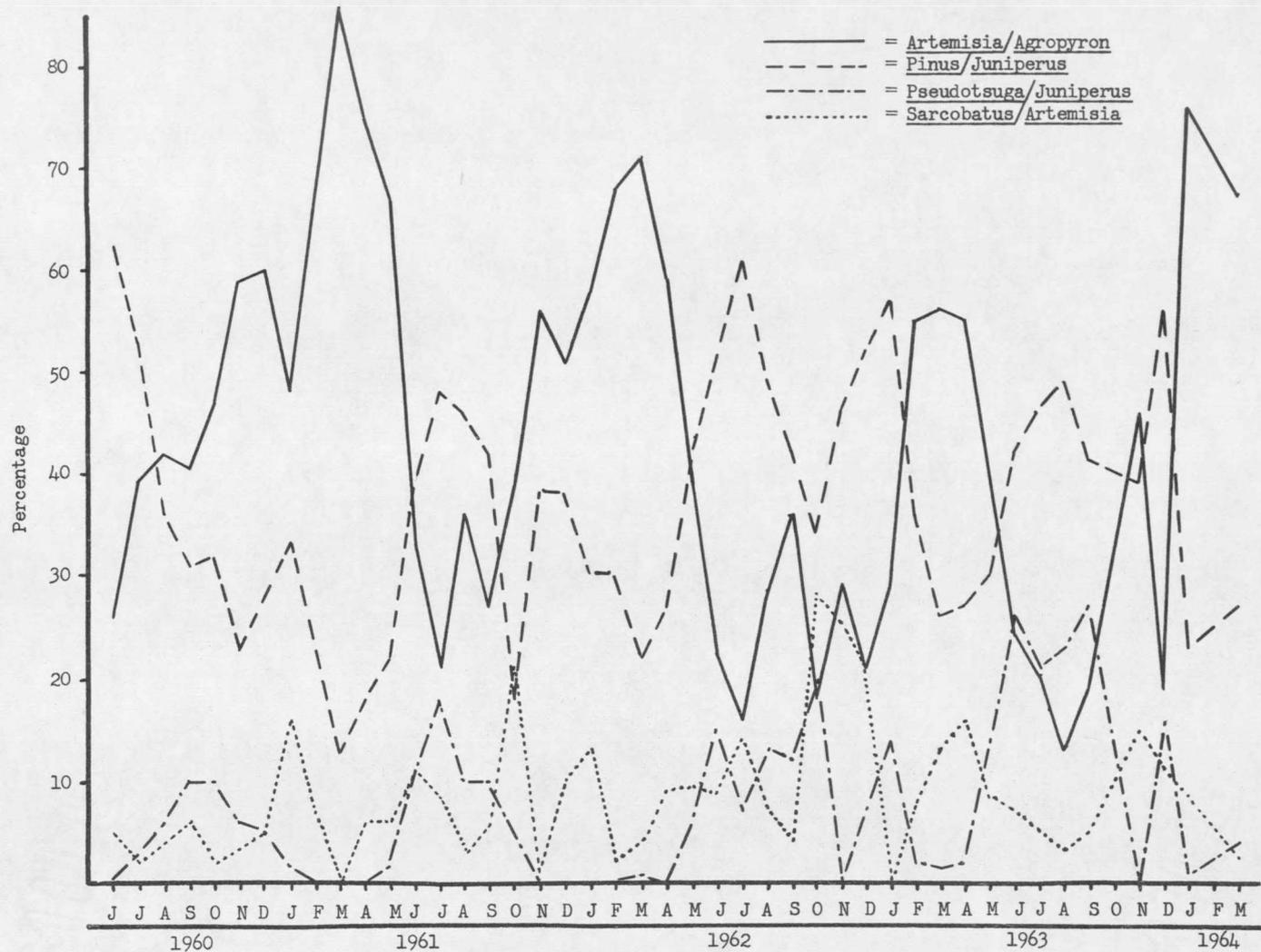


Figure 29. Monthly Frequencies of Mule Deer Occurrence on Vegetation Types Receiving More Than Ten Per Cent of the Total Use During at Least One Month.

Use of the Artemisia/Agropyron type ranked second during three of the four summers. Use was predominantly on the Artemisia tridentata/Agropyron smithii associates and the A. tridentata/A. spicatum association on smaller ridgetops and benches and/or along the edge of "timbered" types. Many forbs preferred for food were members of the Tragopogon dubius union which was best developed in these communities.

Observed use of the Pseudotsuga/Juniperus type was moderate over-all, but varied from minor during the summer of 1960 to relatively heavy in 1963. Most intensive use typically occurred in June during the fawning period.

Over-all use of the Sarcobatus/Artemisia type was minor but reached significant proportions during some months.

Other vegetation types received relatively little use because of restricted distribution and/or small total acreages. Occasionally, as in 1960, abundance of preferred forbs on the Agropyron/Symphoricarpos and Xanthium types attracted intensive use.

The low observability index (average 16.6 per cent) for the period suggested that use of the Pinus/Juniperus and Pseudotsuga/Juniperus types was much more intensive than observations indicated, and that the relative use of the Artemisia/Agropyron type was minor.

Fall (September, October, November).--Relative intensities of use on the two most heavily used vegetation types during this period varied. The Artemisia/Agropyron type, which received the highest percentage of over-all use for the four years, was the most heavily used type during 1960 when it

received its greatest fall usage. Utilization of the Pinus/Juniperus type approached that of Artemisia/Agropyron in 1961 and exceeded it during 1962 and 1963.

Use of individual communities in fall differed from summer, especially on the Artemisia/Agropyron type where activity became more intensified on the Artemisia tridentata/Agropyron smithii associates and on the A. tridentata/A. smithii/Bouteloua gracilis association which received the greatest usage. This appeared related to utilization of Chrysothamnus nauseosus and occasionally, Poa secunda during fall "green-up." The Pinus ponderosa/Agropyron spicatum association remained most important on the Pinus/Juniperus type. The P. ponderosa/Artemisia longifolia association was used rather extensively during mid-September when A. longifolia was briefly important as a food source, but later received only very minor use as did the P. Ponderosa/Juniperus scopulorum association.

Use of the remaining vegetation types was minor, although for some, over-all use in fall was greater than in summer. Differences in intensity of use for the different years was largely related to precipitation and its influence on certain food plants.

The observability index of 19.3 for all suggested continued use of the Pinus/Juniperus and Pseudotsuga/Juniperus types substantially in excess of observed intensities.

Winter (December, January, February).--The Artemisia/Agropyron type received substantially greater use than any other type for the entire period except for 1962-63 when use of the Pinus/Juniperus type was closely comparable. The Artemisia/Agropyron type was especially prominent for feeding, receiving about two-thirds of the total. Lightest and most variable intensities of use were indicated for early winter, especially in 1962-63 when the type was of secondary importance through January. This apparently was related to the availability of preferred and/or "variety" forage on other vegetation types. Percentages observed on the Artemisia/Agropyron type increased monthly, reflecting increasing mule deer dependence on Artemisia tridentata and associated taxa. The A. tridentata/Agropyron smithii associates and the A. tridentata/A. smithii/Bouteloua gracilis association remained the most important communities. The increased importance of the latter through the winter may have been influenced by greater abundance of A. tridentata, but Chrysothamnus nauseosus and Phlox hoodii, which received appreciable use when available, were also more abundant here. The heavily grazed, extensive open ridgetops characteristic of this association held less snow.

The Pinus/Juniperus type ranked second in importance. The intensity of use for feeding varied in relation to amounts of forage available, generally decreasing throughout the winter but generally increasing during the years of study. A large percentage of the feeding, especially during the first two winters and in late winter of all years, was associated with

movement to and from bedding sites as well as with utilization of Juniperus scopulorum which mule deer used deliberately when feeding on Artemisia tridentata. The most intensive use on the type occurred during and for a few days after winter storms. The Pinus ponderosa/Agropyron spicatum association was the most important community. The P. ponderosa/Juniperus scopulorum association occasionally received heavy use during and immediately after snowstorms.

Sarcobatus/Artemisia, the only other type of any importance during winter, received minor use. This occurred mostly during December and January and was predominantly on steeper slopes locally dominated by the type in contrast to earlier use largely on coulee-bottom sites.

The Pseudotsuga/Juniperus type, restricted to windswept, snow-retaining, northerly exposures, received only very minor use. Most was along upper margins of the type, transitory, or during mild, open periods.

Little or no use was observed on other vegetation types during winter.

Observability was much increased over summer and fall. Although greater than indicated percentages probably used the Pinus/Juniperus type, it seems extremely unlikely that the difference was significant enough to alter conclusions as to the relative importance of the various types.

Spring (March, April, May).--The Artemisia/Agropyron type received the greatest use throughout the period. It was used most intensively during late March and/or early April concomitant with the appearance of green plants. Early spring activity was centered upon the Artemisia tridentata/

Agropyron smithii/Bouteloua gracilis association. This appeared related to the prominent Poa secunda union which was an important source of mule deer forage during the period. The relative use and importance of the Artemisia/Agropyron type declined sharply after mid-April as forage became increasingly available on other types.

Use of the Pinus/Juniperus type was relatively minor until about mid-April, then increased rapidly until late May when observed use was comparable to summer. The Pinus ponderosa/Agropyron spicatum association received the greatest use, though numbers of mule deer observed on the P. ponderosa/Juniperus scopulorum association increased considerably after new growth appeared on shrubs.

Sarcobatus/Artemisia was the only other vegetation type which received appreciable spring use. Most of this appeared related to utilization of Poa secunda and associated forbs which were well-represented on coulee-bottom sites.

Mule deer typically were highly observable during early spring. Observations, particularly for 1961 and 1962, probably reflect relative intensities of use on the various vegetation types more closely than for other periods of the year.

Yearlong and Year-to-Year Trends.—The results indicated significant trends in mule deer relations to vegetation types. Pinus/Juniperus, a major type, received maximum use and was the single, most important type during summer. The moderately extensive Pseudotsuga/Juniperus type appeared to rank second. Relative use of both declined slowly through

fall, the latter becoming relatively unimportant except as escape cover by early winter. Though generally declining in use, the Pinus/Juniperus type remained moderately important for feeding and most important for bedding and escape until early spring. Use of both types increased rapidly to summer levels during late spring. Relative use and importance of Artemisia/Agropyron, the other major type, was lowest during summer. Use generally increased through fall, becoming of major importance during early winter. Most extensive use occurred in early spring when it was by far the most important habitat type for feeding. The moderately extensive Sarcobatus/Artemisia type received minor use during all seasons. The minor Agropyron/Symphoricarpos type was of some importance during summer and fall and little used during other periods. Other vegetation types were very minor in both area size and mule deer use.

Differences between years were important. The consistent decline in relative seasonal use and importance of the Artemisia/Agropyron type from 1960 to early fall of 1963 was complemented by commensurate increases in use of other types, particularly Pinus/Juniperus and Pseudotsuga/Juniperus. The prominence of the Artemisia/Agropyron type during 1960 and 1961 appeared related to over-utilization of preferred deciduous browse on "timbered" types under drought conditions and/or high mule deer populations resulting in some shifting to the former. The most significant differences, occurring after the spring of 1962, were related to increased growth of forbs, especially Melilotus officinalis. Use of these plants by mule deer decreased utilization of preferred browse during summer resulting

in persistent availability of forage on all vegetation types through fall and winter.

Weather conditions also influenced use on the various types. Greater percentages of total animals observed were in "timbered" types at temperatures below 0° and above 80° than with more moderate temperatures for summer and winter respectively. Use of the Artemisia/Agropyron and Agropyron/Poa types decreased progressively with wind velocities above 10 mph. During winters, the Pinus/Juniperus type was used most intensively during periods of complete snow cover. A summary of use of vegetation types in relation to weather conditions is presented in Appendix Table L.

Use of Slopes

Steepness of the slope on which each mule deer occurred was estimated and recorded by class as follows: Class 1 = 0°-10°; Class 2 = 11°-25°; Class 3 = 26°-35°; and Class 4 = 36°+. The results for seasonal and yearly periods are presented in Table XVII.

TABLE XVII. PERCENTAGES OF TOTAL MULE DEER OBSERVED ON SLOPE CLASSES, BY SEASON AND YEARS, 1960-64.

Season	Sample Size	Degrees of Slope			
		0-10	11-25	26-35	36+
Summer	2,256	41.4	24.4	22.5	11.7
Fall	1,647	49.2	23.8	16.9	10.0
Winter	2,932	49.6	21.8	17.9	10.7
Spring	4,746	64.4	19.9	11.8	3.8
1960-61	5,577	59.1	20.6	13.3	7.1
1961-62	3,431	50.8	23.3	16.2	9.6
1962-63	1,797	45.7	22.3	23.2	8.8
1963-64	776	50.5	23.0	20.8	5.6
1960-64	11,581	54.0	21.8	16.2	7.9

Approximately 50 per cent of the mule deer were observed on slopes of 11° or more but few animals were observed on slopes steeper than 45°. Seasonally, steeper slopes were used during summer. This reflected the predominant use of timbered vegetation types. The animals were concentrated on level to gently sloping sites during late winter and early spring when primarily using the Artemisia/Agropyron type. The variation between years was related to differences in use of vegetational types.

Use of Exposures

The direction of exposure was recorded for all mule deer observed on slopes. The results, summarized by season and year in Table XVIII, appeared more indicative of relative mule deer use and observability on the Pinus/Juniperus and Pseudotsuga/Juniperus vegetation types and/or the relative amount of area with each exposure than distinct seasonal preferences. South, southwest, north, and northeast-facing slopes were generally most extensive on the area. Southerly-facing slopes seemed to receive more use during all seasons, especially winter. Increase use of northerly exposures during fall may have been related to use of thicker cover. The subsequent decrease in winter and spring was influenced by snow and wind.

Relations to Water

Distances to the nearest stock water reservoir, well, spring-seep, or to the Missouri River were determined from gridded aerial photographs and recorded by quarter-mile distance classes for all observed mule deer. Temporary water, including snow, was not considered quantitatively.

TABLE XVIII. PERCENTAGES OF TOTAL MULE DEER OBSERVED ON VARIOUS EXPOSURES, BY SEASON AND YEARS, 1960-64.

Season	Sample Size	% 0°-10° Slope	Exposure <u>1/</u>							
			N	NE	E	SE	S	SW	W	NW
Summer	2,256	41.4	16.4	13.5	9.3	10.3	20.3	15.3	9.0	5.7
Fall	1,647	49.2	20.6	14.5	9.8	4.4	20.4	13.7	4.7	7.8
Winter	2,932	49.6	18.7	8.0	7.3	12.9	29.1	14.3	6.2	3.0
Spring	4,746	64.4	11.4	13.6	12.9	15.6	17.3	14.2	9.1	5.9
1960-61	5,577	59.1	19.3	12.9	9.7	14.4	18.7	13.3	6.4	5.1
1961-62	3,431	50.8	14.8	10.8	8.9	9.8	27.2	16.2	6.9	5.6
1962-63	1,797	45.7	9.3	11.7	12.2	11.4	26.3	14.0	10.1	4.8
1963-64	776	50.5	19.8	15.8	11.5	5.1	13.9	14.7	12.0	7.2
1960-64	11,581	54.0	16.1	12.2	10.0	11.7	22.4	14.4	7.6	5.4

1/ Percentages of total observed on slopes steeper than 10 degrees.

When all reservoirs held water, most parts of the study area were within about one mile of a water source. The extent of areas greater distances from water increased through the summer as less "permanent" reservoirs dried.

The relative percentages of observations at various distances from water (Table XIX) indicated that use of range by mule deer decreased sharply at distances of one mile or more. Most observations, especially during summer and fall when "permanent" water sources would be most important, were within three-fourths mile of a water source. The number of observations at greater distances decreased as distance increased with negligible use at two miles or more. These relationships reflected the distribution of water sources in relation to areas used by mule deer

TABLE XIX. PERCENTAGES OF TOTAL MULE DEER OBSERVED AT ONE-FOURTH MILE DISTANCE INTERVALS FROM KNOWN WATER SOURCES, BY SEASON AND YEARS, 1960-64.

Season Year	Sample Size	Distance Class ^{1/}								
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Summer 1960	731	37.3	38.2	17.6	4.8	1.1	T ^{2/}	T		
1961	669	22.1	22.9	20.2	10.9	8.5	9.0	4.3	2.1	
1962	483	8.7	21.3	28.8	18.0	8.1	9.5	5.4	T	
1963	373	17.0	19.1	24.5	17.8	8.2	9.0	4.3		
Total 1960-63	2,256	23.3	26.9	21.9	11.6	6.0	6.4	3.2	T	
Fall 1960	734	33.0	29.6	16.5	9.8	7.4	3.0	T		
1961	587	31.3	33.6	14.5	10.2	4.1	2.7	3.6		
1962	163	7.4	18.4	36.8	16.0	8.6	5.5	3.1	4.3	
1963	163	4.3	20.2	33.1	18.4	5.5	10.4	2.5	4.3	1.2
Total 1960-63	1,647	27.0	29.0	19.4	11.4	6.1	3.9	2.2	T	T
Winter 1961	1,441	11.0	22.1	30.1	20.6	8.5	3.5	2.0	2.2	
1962	845	37.5	21.3	17.5	16.0	3.2	1.9	2.1	T	
1963	526	9.3	28.5	23.4	15.8	10.5	7.6	4.4	T	
1964	120	22.5	23.0	23.3	35.0	T	8.3	9.2	T	
Total 1961-64	2,932	18.8	22.1	25.0	19.0	7.0	4.0	2.8	1.3	
Spring 1961	2,671	15.4	25.9	31.3	15.8	5.8	3.6	1.8	T	
1962	1,330	14.7	21.7	29.6	18.9	7.8	4.4	2.0	T	
1963	625	10.4	23.6	32.3	21.2	6.5	4.3	1.6		
1964	120	22.5	15.8	30.0	10.0	8.3	13.3			
Total 1961-64	4,746	14.7	24.2	30.9	17.3	6.6	4.2	1.7	T	
1960-61	5,577	19.4	27.0	27.3	14.8	6.1	3.1	1.5	T	
1961-62	3,431	24.6	23.8	22.2	15.2	6.2	4.4	2.7	T	
1962-63	1,797	9.3	24.0	29.1	18.3	8.3	6.8	3.6	T	
1963-64	776	16.0	15.9	27.0	19.4	6.5	9.9	4.0	1.0	T
1960-64	11,581	19.2	24.9	26.0	15.8	6.5	4.5	2.4	T	T

^{1/} Distance Class: (1) = 0-1/4 mile, (2) = 1/4-1/2 mile, (3) = 1/2-3/4 mile, (4) = 3/4-1 mile, (5) = 1-1 1/4 mile, (6) = 1 1/4-1 1/2 mile, (7) = 1 1/2-1 3/4 mile, (8) = 1 3/4-2 mile, (9) = 2+ mile.

^{2/} T = less than one per cent.

during different seasons and years. In 1961, when water sources were at a minimum, the percentage of mule deer observations within one-half mile of water decreased and the number at greater distances increased as compared to 1960. Most reservoirs were along the periphery of larger ridgetops. Relative intensities of use of the Artemisia/Agropyron type during seasons and years largely determined the relationship between locations of mule deer observations and water supplies. The distribution of water on the study area even during the most arid years was not a significant factor in determining mule deer distribution.

Elk

Elk activity habits, use of vegetation types, slopes, and exposures as well as relations to water were evaluated using methods described for mule deer. The small number, irregular distribution, and gregarious behavior of elk was reflected in observations for only 280 observation trips (54 per cent of the total) at the low frequency of 1.8 groups (12.4 individuals) per trip. A total of 3,489 elk observations, used in evaluating range-use habits, was recorded as follows: 1960-61, 1,307; 1961-62, 1,111; 1962-63, 815; and 1963-64, 256.

Activity Habits

Like mule deer, elk were active mostly within three-to-four-hour periods in early morning and late afternoon. Slightly greater numbers (58 per cent of the total) were observed during mornings when an average of 15 elk was recorded per observation trip, compared to 10 per trip

during evening, and "activity periods" were slightly longer. During the four-year period, greatest numbers were observed during the first and last hours of daylight. Approximately 78 per cent of all observations occurred within two and one-half hours after sunrise and before sunset, and 94 per cent within three and one-half hours. Variation in the distribution of observations during normal activity periods for feeding elk is shown in Figures 30 and 31. The slopes of curves are exaggerated in some instances because of the concentrated nature of observations due to the gregarious habits and the distribution of elk. The consistency of "peaks" for the two-hour category suggested a true relationship and that elk feeding was at a high level through/at that time during some seasons.

Activity periods were "shortest" in fall when feeding was concentrated in the first and last hours of daylight and "longest" in late winter when most elk were observed between one and one-half and two and one-half hours after sunrise and before sunset.

Feeding was the predominant activity for elk observed within three and one-half hours after sunrise and before sunset (Figure 32). Higher percentages were observed feeding in spring than during other seasons. The indicated decrease in proportions feeding and increased percentages alert and traveling during 1962-63 and 1963-64, as compared to earlier years, were related to changes in range use and further, in 1963-64, to undue influence of concentration of observations in summer.

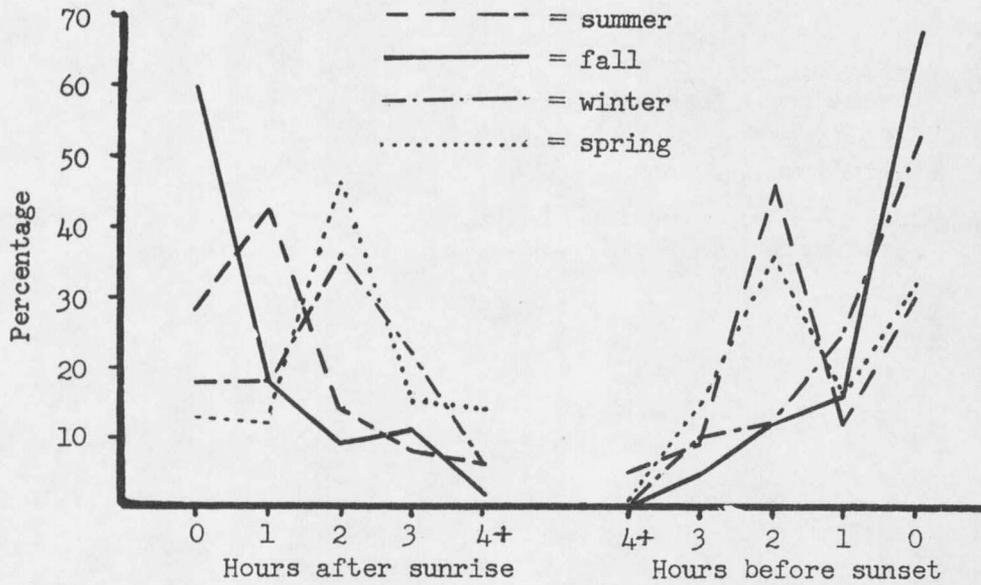


Figure 30. Percentages of Total Feeding Elk Observed by Hour Relative to Sunrise and Sunset During Seasons.

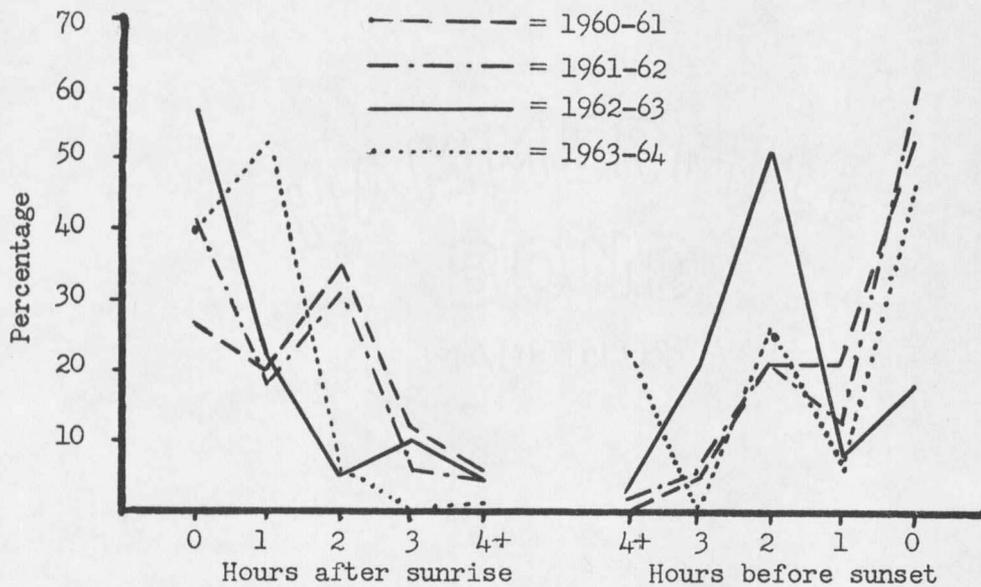


Figure 31. Percentages of Total Feeding Elk Observed by Hour Relative to Sunrise and Sunset During Seasons.

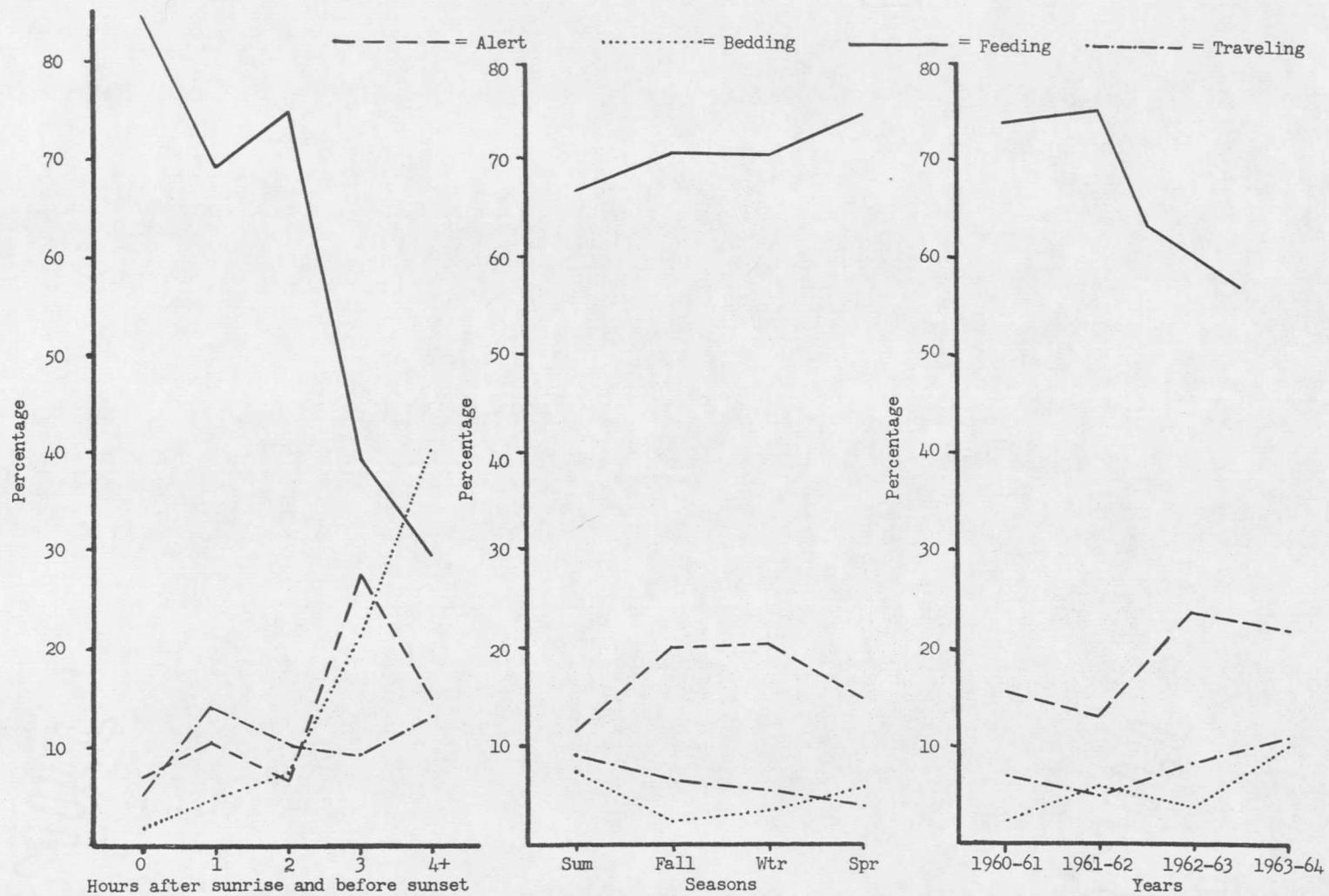


Figure 32. Percentages of Total Elk Observed by Activity Class, During Normal Activity Periods, Seasons, and Years.

Elk food and range-use habits, range-forage conditions, and weather, doubtless influenced elk activities, but these relationships were largely obscured by interactions. A complete summary of elk activities as recorded by seasons and years is presented in Appendix Table LI. Elk activity relations to various environmental conditions are summarized in Appendix Table LII.

Group Size

Observed groups ranged in size from 1 to 66 animals. Seasonal and yearly averages (Table XX) varied in relation to social relationships and distributions of elk use on the area. The high average during the winter of 1961-62 was associated with extreme concentration on the southeastern portion of the study area. That of the fall of 1962 was related to aggregation on winter pastures on the south-central portion during November. Single individuals and small groups were most common in late May and early June. "Average" groups were common only in mid-summer and spring prior to the calving period. The largest and most variable group numbers occurred during fall and winter. Groups including more than 30 elk were rare aggregations associated with feeding and/or flight. The composition of groups associated with recognizable elk changed frequently during all seasons.

TABLE XX. AVERAGE SIZE OF GROUPS FOR ELK OBSERVED DURING SEASONS AND YEARS, 1960-64.

Year	Summer	Fall	Winter	Spring	Year
1960-61	4.0 (194) ^{1/}	7.5 (378)	7.9 (397)	6.1 (338)	6.4
1961-62	3.7 (145)	6.7 (263)	14.6 (484)	7.5 (219)	7.9
1962-63	4.2 (189)	12.6 (278)	10.8 (173)	4.7 (175)	6.8
1963-64	5.9 (136)	6.4 (32)	8.2 (74)	4.6 (14)	6.4
1960-64	4.3	8.1	10.4	6.0	6.9

^{1/} Number of elk in sample.

Use of Vegetation Types

Frequencies of elk occurrence on vegetation types receiving more than 10 per cent of the total use during monthly periods are plotted in Figures 33 and 34. The variation in these data reflected both small monthly samples in which single observations often influenced results and actual trends in use of the various types. A complete summary of results for seasons, years, and the four-year period is presented in Appendix Table LIII.

Elk population and distributional phenomena on the study area precluded the use of observability indices as a measure of undetected use of timbered vegetation types.

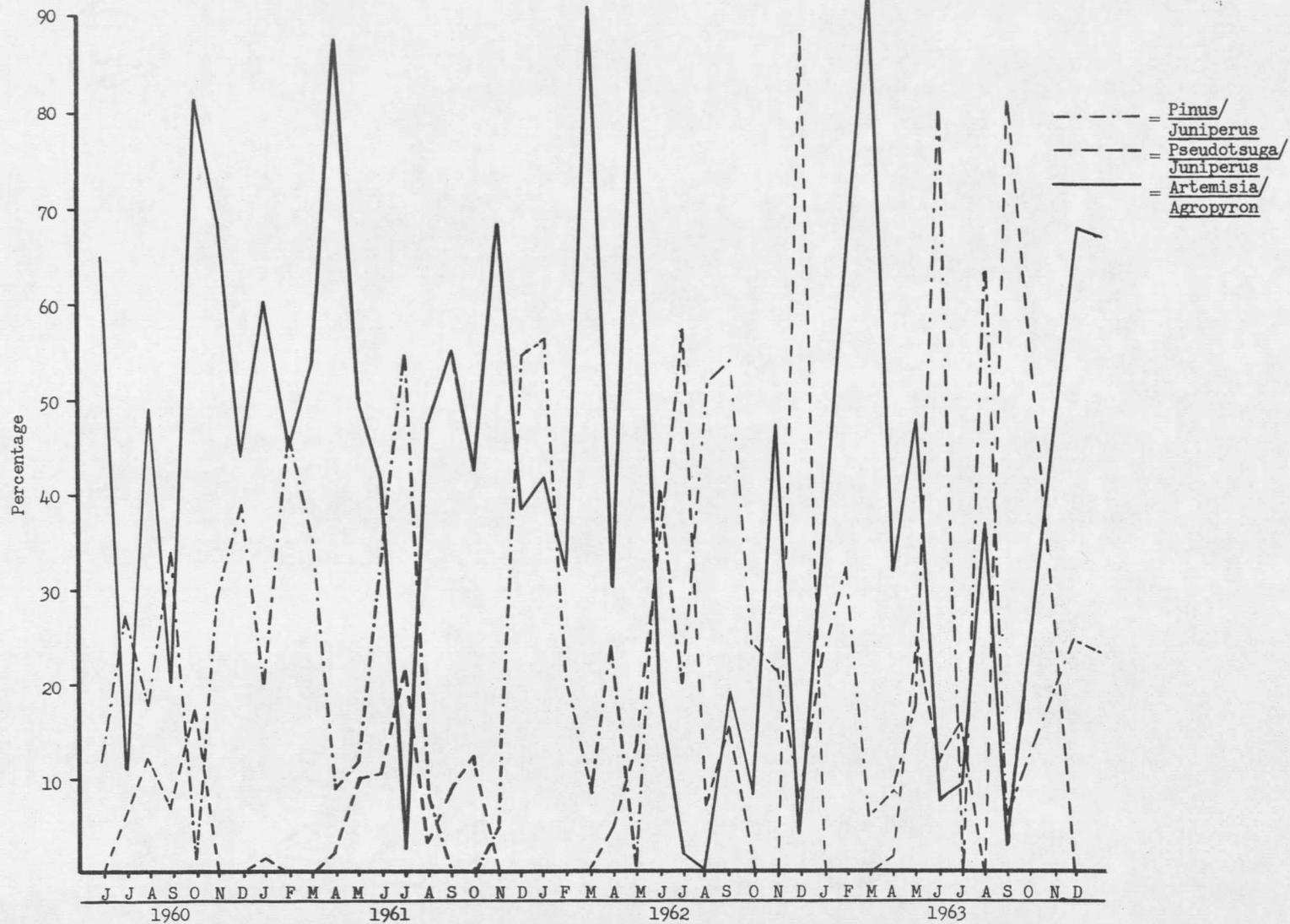


Figure 33. Monthly Frequencies of Elk Occurrence on Vegetation Types Receiving More Than Ten Per Cent of the Total Use During at Least One Month. (see Fig. 34 also)

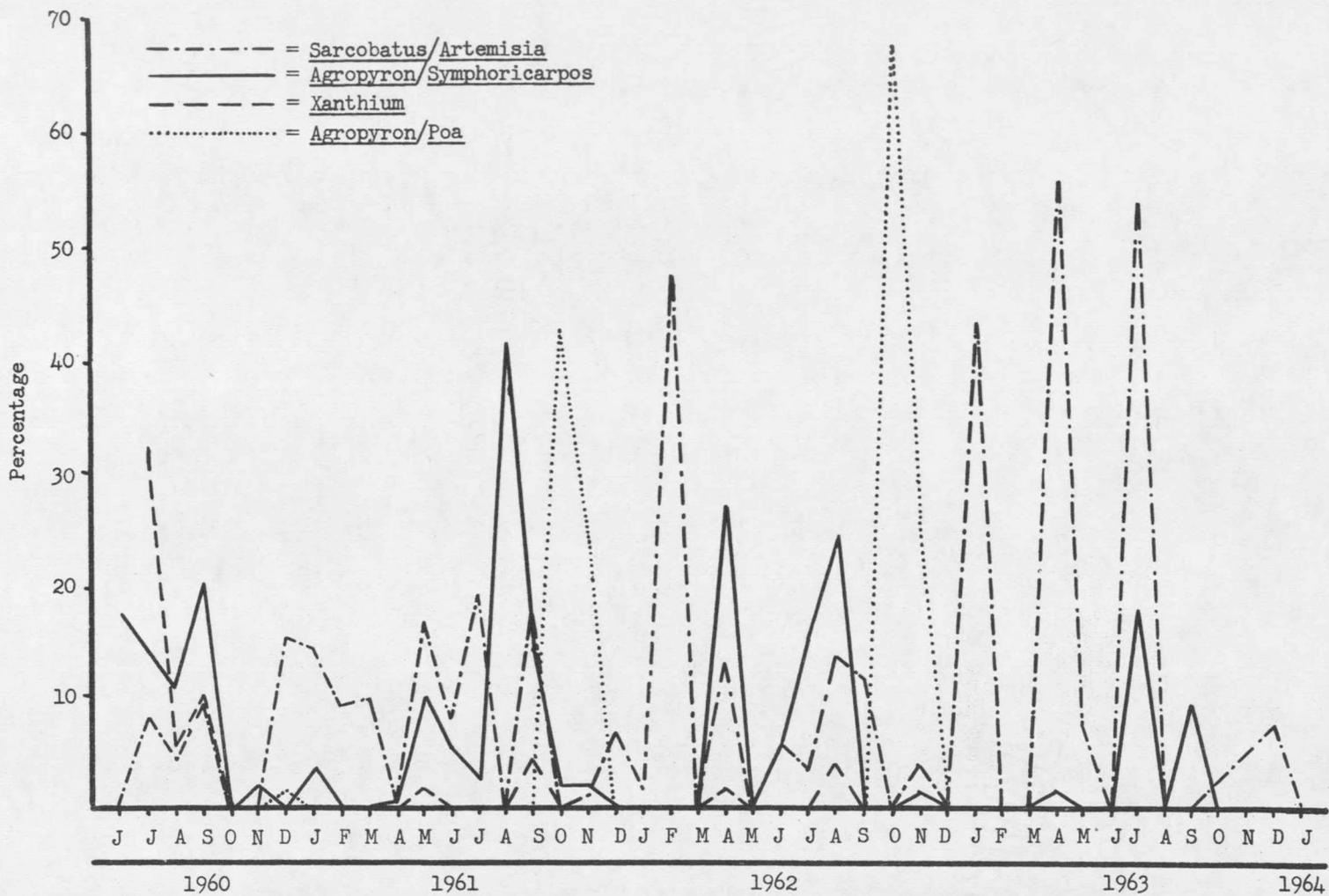


Figure 34. Monthly Frequencies of Elk Occurrence on Vegetation Types Receiving More Than Ten Per Cent of the Total Use During at Least One Month. (see Fig. 33 also)

Summer (June, July, August).--Use and importance of vegetation types varied widely during summers. Use of the Sarcobatus/Artemisia type for all activities varied from minor to heavy during the four summers. As a feeding area, the type ranked first in over-all summer usage for the four years and in 1962 and 1963 but ranked fifth in 1960 and 1961. It was used in association with the Agropyron/Symphoricarpos type, which received moderate to heavy use in all years, and the Xanthium type, which occasionally received heavy use when abundant growth of forbs occurred. These "coulee-bottom" types collectively comprised the major feeding areas in summer, particularly in July and August.

The Artemisia/Agropyron type ranked second in average summer usage for total elk activities and for feeding, but use varied significantly between years in relation to the abundance of preferred food plants on other types. It was the most important type for feeding in 1960 and 1961 but its importance in 1962 and 1963 was minor or moderate. The Artemisia tridentata/Agropyron smithii associates and the A. tridentata/A. spicatum association were the most important communities, reflecting distributions on smaller ridges, benches, and along the edge of timbered types and development of the Tragopogon dubius union.

Greatest summer usage occurred on timbered types. The Pinus/Juniperus and Pseudotsuga/Juniperus types were moderately important for feeding and more important than other types for bedding. The former typically was used most intensively during June. The Pinus ponderosa/Agropyron spicatum association appeared to be the most important community.

The Pseudotsuga/Juniperus type was used in June for calving. Late July and early August use seemed related to increased utilization of browse and persistence of forbs.

Other vegetation types were of little importance during the summer.

Fall (September, October, November).--The Artemisia/Agropyron type was the most heavily used vegetation type during this period when grasses became increasingly important in the diet of elk. Use generally increased as the season progressed, but varied in relation to the availability of various grass species and the abundance of forbs on other types.

The Artemisia tridentata/Agropyron smithii associates was the most important community on the Artemisia/Agropyron type during 1960, whereas the A. tridentata/A. smithii/Bouteloua gracilis association appeared to be used more intensively during years of "green-up."

The Agropyron/Poa type was heavily used in October and November of 1961 and 1962, following "green-ups" of Poa secunda and Koeleria cristata on winter pastures in the south-central portion of the area.

The more intensive use in 1962 reflected increased elk numbers on the area and possibly, greater availability of Poa secunda and Koeleria cristata after the pastures were cut for hay.

Over-all use of the Pinus/Juniperus type was moderate. For feeding it was very minor in 1961 but prominent in 1962 and 1963 when forbs, especially Melilotus officinalis, were abundant. The Pinus ponderosa/Agropyron spicatum association was most important, but the P. ponderosa/Juniperus scopulorum association received intensive use in 1962.

The P. ponderosa/Artemisia longifolia association received only minor use, largely in September.

Other types generally received only minor use during fall. Moderate feeding on the Agropyron/Symphoricarpos type in 1961 reflected utilization of Chrysothamnus viscidiflorus and grass, primarily during September.

Data for the fall of 1963 were obtained only during September.

Winter (December, January, February).--The Artemisia/Agropyron type was most important three of the four winters and for all winters combined. The Artemisia tridentata/Agropyron smithii associes was generally used most intensively. The A. tridentata/A. spicatum association ranked second. It was especially important during 1961 when elk use was concentrated on areas with better range conditions. Use on the A. tridentata/A. smithii/ Bouteloua gracilis association varied in relation to availability of grasses. Use was influenced by prior grazing and snow cover.

The Pinus/Juniperus type ranked second. The intensive use in the winter of 1961-62 reflected attraction to the Pinus ponderosa/ Agropyron spicatum association on steeper, semi-open slopes where grasses persisted in relative abundance. Other communities received only occasional use.

Sarcobatus/Artemisia was the only other type of importance, receiving moderate use during all winters except 1963. Use was largely on steeper slopes, in contrast to predominant use of this type on coulee-bottom sites during other seasons, where grasses were relatively abundant.

Spring (March, April, May).--The Artemisia/Agropyron type received the greatest use throughout the period. The most intensive use, occurring during late March and early April, coincided approximately with the onset of the spring "green-up." The Artemisia tridentata/Agropyron smithii/Bouteloua gracilis association was the most important community, reflecting seasonal elk preferences for grasses and early developing forbs of the Poa secunda union. The A. tridentata/A. smithii associates received increasing use throughout spring. Relative use on the Artemisia/Agropyron type declined sharply during the last week of May as most adult females dispersed prior to calving.

Over-all use of all other vegetation types was minor or negligible, though use of some types was significant in some months; e.g., the Sarcobatus/Artemisia type in late March and/or early April and the Pseudotsuga/Juniperus type in late May by adult females.

Yearlong and Year-to-Year Trends.--Yearlong elk relations to vegetation types were characterized by significant trends. The Sarcobatus/Artemisia, Agropyron/Symphoricarpos, and Xanthium types, which individually received variable use by elk, collectively comprised the most important area for feeding during summer. Use of these "coulee-bottom" types was minor after early fall. Relative use of the Artemisia/Agropyron types, which received the most intensive use over-all, generally increased from very minor in mid-summer, through fall and winter. It was by far the most important habitat type for feeding throughout winter and spring, with

the most intensive use occurring in early spring. The Pinus/Juniperus type was of moderate importance through summer and fall and of major importance during winter when lightly or ungrazed stands of grass on semi-open, steeper slopes were important forage sources. It received only minor use during spring. Stands of Pseudotsuga/Juniperus received important use by female and calf elk during late May and early June, and were relatively important for feeding in late summer. This type was especially important for bedding during summer and early fall. The Agropyron/Poa type was important only during October and November in years of fall "green-up." Use of the Artemisia longifolia type was minor at all times.

The important differences in use of vegetation types between years were largely related to precipitation and its influence on forage supplies and feeding habits of elk. The prominent use on the Artemisia/Agropyron type from 1960 through the spring of 1962 was associated with drought conditions. The decreased use and importance of this type and increased or markedly different use of other vegetation types after the spring of 1962 reflected increased growth of forbs, especially Melilotus officinalis.

Weather conditions generally did not appear to influence relative use of the various vegetation types, except during winter when complete snow cover seemed to effect significantly greater use on the Pinus/Juniperus type and/or decreased use of the Artemisia/Agropyron type. A complete summary of use of vegetation types in relation to weather conditions is presented in Appendix Table LIV.

Use of Slopes

The distribution of elk observations on slopes of varying steepness is presented in Table XXI. Approximately 42 per cent of all elk occurred on slopes steeper than 10 degrees. Less than one per cent were observed on slopes of 45 degrees or more.

TABLE XXI. PERCENTAGES OF TOTAL ELK OBSERVED ON SLOPE CLASSES, BY SEASON AND YEARS, 1960-64.

Season	Sample Size	Degrees of Slope			
		0-10	11-25	26-35	35+
Summer	664	49.5	18.4	17.6	14.5
Fall	951	70.7	11.5	8.7	10.0
Winter	1,128	45.0	25.0	20.9	9.0
Spring	746	67.8	15.5	16.0	8.6
1960-61	1,307	57.8	15.8	17.0	9.5
1961-62	1,111	56.2	21.8	12.2	9.9
1962-63	815	62.2	18.4	14.5	4.9
1963-64	256	50.8	12.1	28.1	9.0
1960-64	3,489	57.8	18.0	15.7	8.6

Use of slopes varied during seasons and years in relation to relative frequencies of use on the various vegetation types. Seasonally greater use of steeper slopes largely reflected use on the Pinus/Juniperus and Pseudotsuga/Juniperus types in summer and the Pinus/Juniperus and Sarcobatus/Artemisia types in winter. The high percentages observed on level to gently sloping sites in fall and spring correspond to intensive use on the Artemisia/Agropyron type.

Use of Exposures

The distribution of elk observed on slopes of various exposures during seasons and years is presented in Table XXII. Although the results partly reflect relative amounts of area with each exposure, northerly exposures appeared to receive especially intensive use in summer when most elk ranged in proximity to the Pseudotsuga/Juniperus type. Greater use of west and northerly exposures was evident during winter when upper portions of slopes dominated by the Pinus ponderosa/Agropyron spicatum were important feeding areas. Cold winds and/or snow depths which prevailed in winter did not appear to influence use of northerly exposures by elk. Exceptionally intense use appeared on south, southeast, and east-facing slopes in spring.

TABLE XXII. PERCENTAGES OF TOTAL ELK OBSERVED ON VARIOUS EXPOSURES, BY SEASON AND YEARS, 1960-64.

Season	Sample Size	% 0°-10° Slope	Exposure <u>1/</u>							
			N	NE	E	SE	S	SW	W	NW
Summer	664	49.5	26.0	19.1	3.3	4.4	14.6	12.4	5.0	11.3
Fall	951	70.7	16.9	20.9	0.7	3.2	24.5	21.2	4.7	6.7
Winter	1,128	45.0	22.1	21.1	7.9	4.0	7.9	13.1	12.9	10.7
Spring	746	67.8	19.2	12.4	14.5	26.9	16.2	4.3	4.7	1.7
1960-61	1,307	57.8	13.8	19.7	5.6	10.2	24.6	14.2	4.8	7.1
1961-62	1,111	56.2	32.2	16.1	7.2	8.9	2.5	7.4	15.1	10.5
1962-63	815	62.2	19.6	25.2	3.7	4.7	11.0	17.6	5.3	11.3
1963-64	256	50.8	19.5	14.8	12.8	0.0	19.5	18.1	2.7	2.0
1960-64	3,489	57.8	21.6	19.2	6.5	7.6	14.0	13.1	8.1	8.6

1/ Percentages of total observed on slopes steeper than 10 degrees.

Relations to Water

Relative percentages of elk observed at various distances from water are presented in Table XXIII. Most observations during summer and fall were within three-fourths mile of a water source, though greatest numbers typically occurred between one-fourth and three-fourths mile. Use at distances of one mile or more was only minor at all times, and considerably lower than was recorded for mule deer.

Year-to-year relationships reflected the distribution of water in relation to areas used by elk in the same manner as described for mule deer. The percentages of elk observations within one-half mile of water decreased and the number at greater distances increased in the summer of 1961, as compared to 1960, when water sources were at a minimum. Use at greater distances was also higher in 1962 and 1963 when elk used "timbered" and "coulee-bottom" vegetation types more intensively than in prior years when intensive use occurred on the Artemisia/Agropyron type in proximity of reservoirs.

Use on areas more distant from "permanent" water sources was greatest during winter and early spring when elk were distributed on the southeastern portion of the study area where few reservoirs existed. Yearly differences were related to the degree and/or location of elk concentration.

TABLE XXIII. PERCENTAGES OF TOTAL ELK OBSERVED AT ONE-FOURTH MILE DISTANCE INTERVALS FROM KNOWN WATER SOURCES, BY SEASON AND YEARS, 1960-64.

Season Year	Sample Size	Distance Class ^{1/}								
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Summer 1960	194	25.3	51.5	21.1	2.1					
1961	145	20.0	46.2	15.2	6.9	3.4	3.4	4.8		
1962	189	7.4	34.9	20.6	21.7	4.8	8.5	2.1		
1963	136	13.2	50.7	32.4	2.9		T ^{2/}			
Total 1960-63	664	16.6	45.5	22.0	8.9	2.1	3.3	1.7		
Fall 1960	378	15.6	15.1	38.4	16.9	9.8	4.2			
1961	263	35.0	36.1	12.9	9.9	6.1				
1962	278	15.5	40.3	38.1	2.9	3.2				
1963	32		3.1	53.1	18.6			6.3		18.8
Total 1960-63	951	20.4	27.9	31.8	10.9	6.5	1.7	T		T
Winter 1961	397		1.5	9.1	41.6	25.4	4.3	12.6	5.5	
1962	484	19.0	19.2	38.6	10.7	2.3	4.3	4.1	1.7	
1963	173	8.7	40.5	23.1	27.7					
1964	74	58.1		14.9	24.3		2.7			
Total 1961-64	1,128	13.3	15.0	24.3	25.1	9.9	3.5	6.2	2.7	
Spring 1961	338	1.5	4.7	11.2	32.0	39.6	6.5	4.4		
1962	219	18.3	22.4	39.7	11.0		8.7			
1963	175	21.7	29.7	28.6	10.9	6.3	2.9			
1964	14			50.0				35.7	14.3	
Total 1961-64	746	11.1	15.7	24.4	20.2	19.4	6.2	2.7	T	
1960-61	1,307	8.6	13.7	19.9	26.1	20.8	4.2	5.0	1.7	
1961-62	1,111	22.8	27.4	29.7	10.1	2.9	4.1	2.4	T	
1962-63	815	13.5	36.8	28.8	14.2	3.6	2.6	T		
1963-64	256	23.8	27.3	30.9	10.9		1.2	2.7	T	2.3
1960-64	3,489	15.4	24.4	25.9	17.1	9.5	3.6	3.0	T	T

^{1/} Distance Class: (1) = 0-1/4 mile, (2) = 1/4-1/2 mile, (3) = 1/2-3/4 mile, (4) = 3/4-1 mile, (5) = 1-1 1/4 mile, (6) = 1 1/4-1 1/2 mile, (7) = 1 1/2-1 3/4 mile, (8) = 1 3/4-2 mile, (9) = 2+ mile.

^{2/} T = less than one per cent.

Cattle

Range-use characteristics of cattle were evaluated in the same manner as those of mule deer and elk. The total of 233 observation trips typically included one morning and one afternoon each week during the grazing season, except during July and August, 1960 and after September 1963. A total of 25,125 cattle observations, used in evaluating range-use habits, was recorded as follows: 1960-61, 6,562; 1961-62, 7,466; 1962-63, 6,291; and 1963-64, 4,788.

Activity Habits

Cattle activity habits resembled those of mule deer and elk in that feeding was most intensive during three-to-four-hour periods in early morning and late afternoon, but most cattle also fed sporadically between these two periods. For the four-year period, greatest numbers were observed during the first and last hours of daylight. Approximately 67 per cent of all cattle and 76 per cent of feeding cattle observed during observation periods were recorded within two and one-half hours after sunrise and before sunset, with 84 per cent and 89 per cent respectively observed within three and one-half hours. These percentages were "high" for total daily activities because observations usually were not continuous through mid-day during late spring, summer, and early fall.

Percentages of the total that were feeding among cattle observed during morning, evening, seasonal, and yearly periods are shown in

Figures 35, 36, and 37. Periods of intensive activity were shortest during summer and longest in winter.

The duration of intensive activity as well as the extent of feeding later in the day varied in relation to range-forage conditions. Intensive activity was most prolonged during drought years, 1960-61 and 1961-62, when cattle were relatively active throughout the day as compared with 1962-63 and 1963-64 when decreased proportions observed feeding more than two and one-half hours after sunrise and before sunset reflected improved forage conditions.

Feeding predominated the recorded activity for cattle within three and one-half hours after sunrise and before sunset. Feeding was more intensive in early morning than late evening. Proportions observed bedded increased sharply between two and one-half hours after sunrise and one and one-half hours before sunset. Traveling was a minor activity at all times. Proportions traveling were highest between two and one-half and three and one-half hours after sunrise and between one-half hour before and after sunset when greatest numbers of cattle moved toward reservoirs and evening feeding areas, respectively. Greater numbers were observed traveling during 1961-62 when extensive movement occurred between feeding and bedding (reservoir) areas. Complete summaries of cattle activities as recorded by seasons and years and in relation to recorded environmental conditions are presented in Appendix Tables LV and LVI.

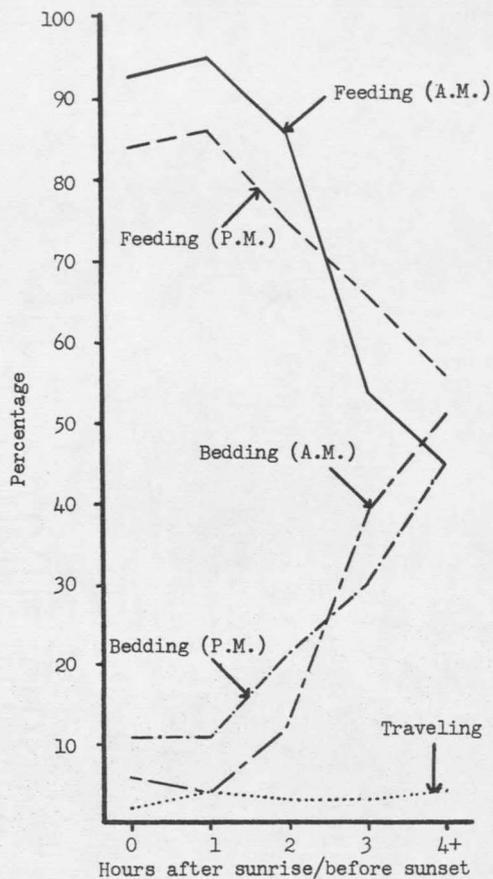


Figure 35. Percentages of Cattle Feeding, Bedding, and Traveling by Hour Relative to Sunrise/Sunset.

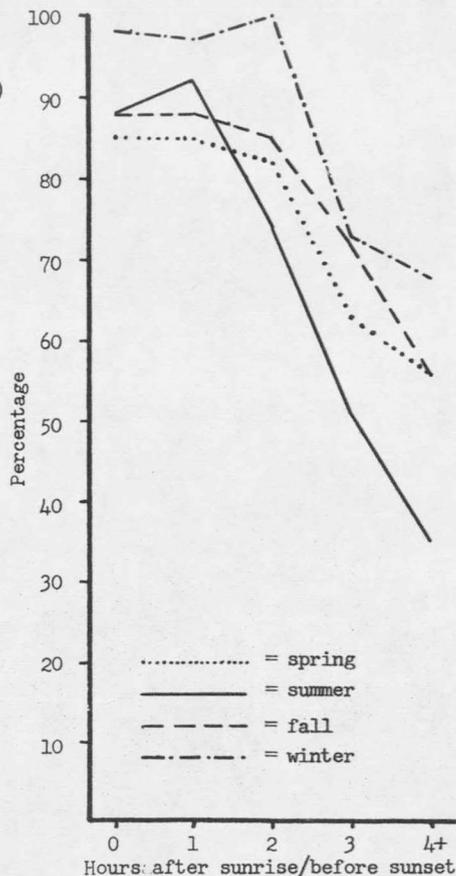


Figure 36. Percentages of Cattle Feeding by Hour Relative to Sunrise/Sunset During Seasons.

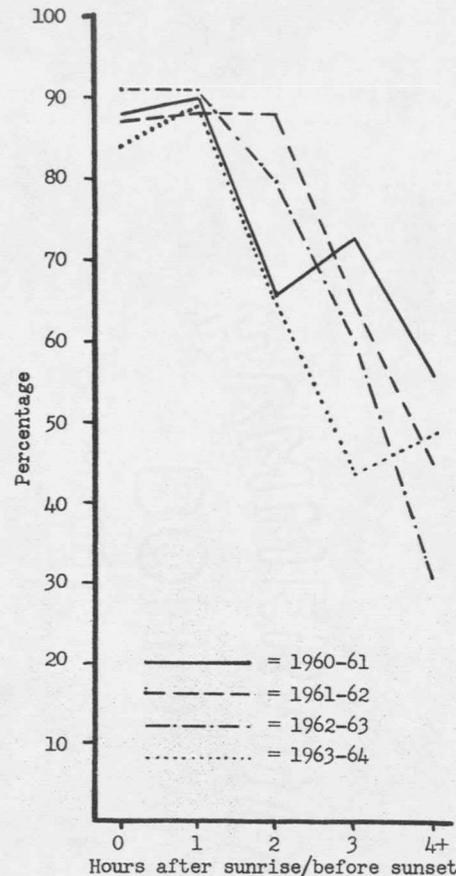


Figure 37. Percentages of Cattle Feeding by Hour Relative to Sunrise/Sunset During Years.

Group Size

Average numbers of cattle observed per group (Table XXIV) varied in relation to the degree of dispersal and/or use of certain vegetation types as well as the type and duration of activity. Group sizes generally were smallest during drought years, especially 1961-62, when cattle were relatively dispersed, seeking forage on normally less-used areas and timbered vegetation types, and fed more intensively during much of the day. Larger groups prevailed during the last two years when cattle were relatively concentrated during most periods with abundant forage in proximity to water sources, heavier seasonal use on ridgetops, and less intensive feeding.

TABLE XXIV. AVERAGE SIZE OF GROUPS FOR CATTLE OBSERVED DURING SEASONS AND YEARS, 1960-64.

Year	Summer	Fall	Winter	Spring	Year
1960-61	7.5 (548) ^{1/}	5.7 (2,879)	8.3 (411)	7.4 (2,724)	6.6
1961-62	4.9 (3,519)	4.5 (2,340)	6.1 (154)	7.4 (1,435)	5.1
1962-63	7.1 (3,379)	5.2 (1,298)	4.7 (71)	11.2 (1,543)	7.2
1963-64	13.6 (3,254)	8.5 (1,388)	11.7 (82)	64.0 (64)	11.6
1960-64	7.1	5.5	7.4	8.2	6.7

^{1/} Number of cattle in sample.

Use of Vegetation Types

Relative intensities of cattle use on vegetation types which received more than 10 per cent of the total use during months are illustrated in Figure 38. A complete summary of cattle use on vegetation types for feeding and all activities during seasons and years is in Appendix Table LVII.

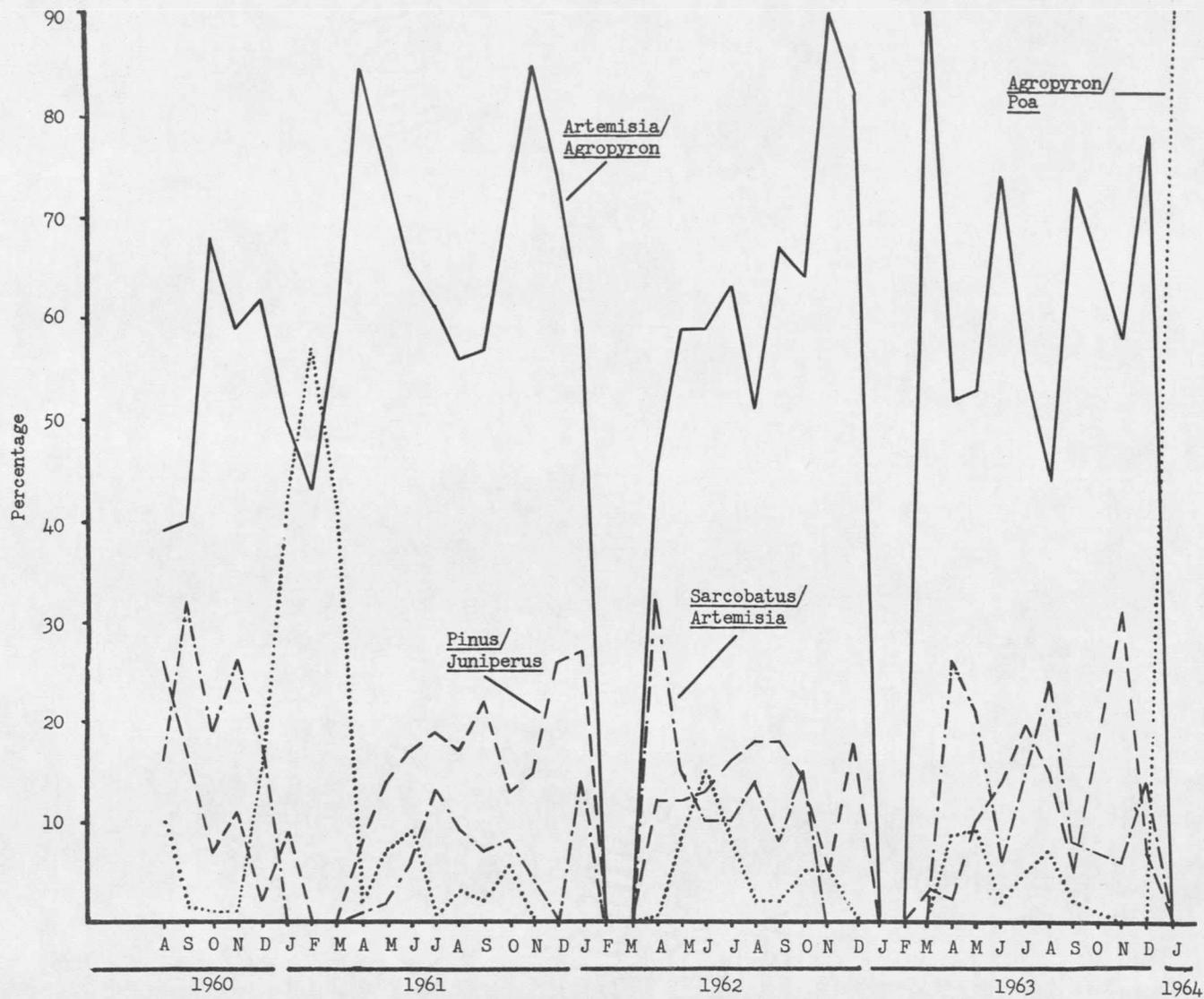


Figure 38. Monthly Frequencies of Cattle Occurrence on Vegetation Types Receiving More Than Ten Per Cent of the Total Use During at Least One Month.

Summer (June, July, August).--The Artemisia/Agropyron type was most important in summer during all years. Relative intensities of use generally decreased through the period, being lowest in August. Use was predominantly on the Artemisia tridentata/Agropyron smithii/Bouteloua gracilis association. Use of the A. tridentata/A. smithii associates varied in relation to the distribution of water on the area. It was used more intensively during 1961 when cattle ranged further to obtain forage. The A. tridentata/A. spicatum association received only very light use.

The Pinus/Juniperus type ranked second, receiving moderate use for feeding and some additional use for bedding and loafing. It typically was used most intensively during mid and/or late summer. The Pinus ponderosa/Agropyron spicatum association on slopes of less than about 25 degrees was the most important community. The P. ponderosa/Juniperus scopulorum association received some use for both feeding and bedding. The P. ponderosa/Artemisia longifolia type was only rarely used by cattle.

The Sarcobatus/Artemisia type ranked third for feeding during three of the four summers and for all years combined. Over all, it was of moderate importance, but use reached significant proportions during August of some years.

Use on the Agropyron/Symphoricarpos and Agropyron/Poa types was minor during all years. The former received its greatest use during August when green forage persisted.

Other vegetation types received very minor use at all times.

Fall (September, October, November).--The Artemisia/Agropyron type was by far the most important vegetation type during fall, for feeding as well as all activities. The Artemisia tridentata/Agropyron smithii/Bouteloua gracilis association remained the most important community, but use on the A. tridentata/A. smithii associates increased as precipitation provided additional water sources and/or cattle movement became more extensive with cooler temperatures. The A. tridentata/A. spicatum association received only very minor use.

The Pinus/Juniperus type was moderately important, ranking second in three of the four years. Use of individual communities was similar to summer, though slightly increased use on the Pinus ponderosa/Juniperus scopulorum association occurred late in the period.

Over-all use on the Sarcobatus/Artemisia type was about equal to that on the Pinus/Juniperus type, largely because of relatively intense use during 1960. The type ranked third and was of minor importance during other years.

The Agropyron/Symphoricarpos and Agropyron/Poa types received minor and very minor use respectively in all years.

Use of other types was negligible.

Winter (December, January, February).--Cattle use of upland vegetation types during this period was largely confined to winter pastures on the north and south-central portions of the area. Winter use on the former area was predominantly on the Artemisia/Agropyron type. Use varied

through the winter on the south-central area, but both the Artemisia/Agropyron type and the Agropyron/Poa type were important.

The Pinus/Juniperus type was of minor importance, but use occasionally reached significant proportions on the north-central pasture in early winter. This use was almost entirely on the Pinus ponderosa/Agropyron spicatum association.

The Sarcobatus/Artemisia type also received minor use, primarily in December and/or January.

Use on other vegetation types was negligible during winter.

Spring (March, April, May).--Cattle use during March was entirely on winter pastures on the south-central portion of the area. Less than one per cent of the total recorded use in spring occurred during the month.

The Artemisia/Agropyron type received the most intensive use during April and May. The Artemisia tridentata/Agropyron smithii/Bouteloua gracilis association was the most important community, especially during April. The A. tridentata/A. smithii association received important use during some years, particularly during May.

The Sarcobatus/Artemisia type was of only minor importance for the entire period, but received significant use during April in 1962 and 1963.

Over all, the Pinus/Juniperus type was also of relatively minor importance, though moderate intensities of use were observed during April and May of 1962.

The Agropyron/Symphoricarpos and Agropyron/Poa types received only very minor use during spring. Other vegetation types were used only occasionally.

Yearlong and Year-to-Year Trends.--Cattle relations to vegetation types were significant in that a single type, Artemisia/Agropyron, was used most intensively throughout the spring, summer, fall, grazing season and relatively few types received important use. Seasonally, cattle use on the Artemisia/Agropyron type varied only slightly. Monthly usage was more varied evidently in relation to the distribution of water and the relative availability of forage on other types. Use on this type was lowest in August, then generally increased through November. The Sarcobatus/Artemisia and Agropyron/Symphoricarpos type, which received moderate and minor use respectively, collectively comprised the second, most important area for feeding. Use on these types was most intensive during early spring and late summer. The Pinus/Juniperus type was of moderate importance over-all. Relative intensities of use generally increased from spring through early fall, then decreased to the end of the grazing season. The Agropyron/Poa type received very minor use throughout the period. Only occasional or transient use occurred on other vegetation types.

Relative intensities of cattle use on the various vegetation types on winter pastures were similar to that during the grazing season, except on the south-central portion of the area where the Agropyron/Poa type received important use during some winters.

Differences in use of Artemisia/Agropyron between years were minor. Some differences, largely related to precipitation and its influence on plant growth and water supplies occurred on certain other types. The most important of these occurred in the spring of 1962, when relatively high

intensities of use occurred on the Pinus/Juniperus and Sarcobatus/Artemisia types during April, when cattle numbers were low and forage conditions somewhat better on these types, and during early fall of 1960 when the Sarcobatus/Artemisia type received greater use than in other years.

Weather conditions generally did not appear to influence relative use on the various vegetation types by cattle. A summary of use of vegetation types in relation to weather conditions is presented in Appendix Table LVIII.

Use of Slopes

Percentages of total cattle observed during seasons and years on slopes of varying steepness are presented in Table XXV. Use was predominantly on level to gently sloping sites and decreased sharply on steeper slopes during all periods. Slopes steeper than 25 degrees received only very minor use by cattle. This plus the increased use on steeper slopes in winter, when cattle were confined to pastures, and during 1961-62, when forage supplies on normally grazed sites were minimal, suggested that steepness of slope exerted important influence on the distribution of cattle use on the area.

Use of Exposures

The distribution of observed cattle use on slopes by direction of exposure (Table XXVI) appeared largely related to relative amounts of area with each exposure. Over-all use was only slightly greater on northerly than on southerly exposures. Increased use on upper portions of

north-facing slopes, where grasses typically were abundant, occurred in fall and during 1961-62.

TABLE XXV. PERCENTAGES OF TOTAL CATTLE OBSERVED ON SLOPE CLASSES, BY SEASON AND YEARS, 1960-64.

Season	Sample Size	Degree of Slope			
		0-10	11-25	26-35	35+
Summer	10,700	82.2	13.2	4.2	T ^{1/}
Fall	7,923	82.0	12.7	4.3	1.0
Winter	718	80.4	9.4	10.1	T
Spring	5,766	81.4	14.6	3.6	0.3
1960-61	6,562	83.1	11.7	4.6	T
1961-62	7,466	75.5	17.8	5.8	1.0
1962-63	6,291	83.3	12.9	3.5	T
1963-64	4,788	88.5	8.9	2.3	T
1960-64	25,125	81.9	13.3	4.2	T

^{1/} T = less than one per cent.

TABLE XXVI. PERCENTAGES OF TOTAL CATTLE OBSERVED ON VARIOUS EXPOSURES, BY SEASON AND YEARS, 1960-64.

Season	Sample Size	% 0°-10° Slope	Exposure ^{1/}							
			N	NE	E	SE	S	SW	W	NW
Summer	10,700	82.2	19.9	17.0	5.9	6.8	22.3	14.4	7.1	5.7
Fall	7,923	82.0	29.7	11.4	5.9	5.0	19.9	14.0	4.5	9.5
Winter	718	80.4	13.1	19.0	8.0	12.4	21.2	16.1	0.0	10.2
Spring	5,766	81.4	13.8	23.9	9.1	10.3	15.0	15.0	2.7	10.3
1960-61	6,562	83.1	17.2	19.2	7.6	6.6	18.0	15.7	3.5	12.1
1961-62	7,466	75.5	26.0	13.8	5.5	10.3	19.8	11.3	5.8	6.5
1962-63	6,291	83.3	19.1	19.9	8.4	4.9	16.1	19.1	5.1	7.4
1963-64	4,788	88.5	19.2	16.3	5.7	1.8	30.3	14.0	5.5	6.5
1960-64	25,125	81.9	21.4	16.8	6.7	7.2	19.8	14.4	5.0	8.1

^{1/} Percentages of total observed on slopes steeper than 10 degrees.

Relations to Water

Relative percentages of cattle observed during seasons and years at various distances from known water sources are presented in Table XXVII. Most observations occurred within three-fourths mile of a water source. Greatest numbers typically were observed within one-fourth mile of water, and only minor use was recorded at distances greater than one mile. During summer, when permanent water sources were most important, use was predominantly on sites less than one-half mile from water. More than two-thirds of all observations were within this distance during 1961 when the number of water sources was minimal. This was in contrast to observations for mule deer and elk suggesting that the distribution of cattle use on the area was more closely related to the distribution of water. Cattle use at greater distances from water increased during fall as water supplies and/or cattle movement increased.

The concentration of cattle use near water sources in spring reflected increased availability of water as well as the predominant use on more intensively grazed sites early in the period. In 1962 when most cattle were turned onto the area during May, distributions with respect to water were similar to summer.

TABLE XXVII. PERCENTAGES OF TOTAL CATTLE OBSERVED AT ONE-FOURTH MILE DISTANCE INTERVALS FROM KNOWN WATER SOURCES, BY SEASON AND YEARS, 1960-64.

Season	Year	Sample Size	Distance Class ^{1/}									
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
Summer	1960 ^{2/}	548	26.6	17.2	18.4	25.7	9.1	1.6	1.3			
	1961	3,519	46.2	24.3	13.2	8.1	3.6	1.4	2.3	T	^{3/}	
	1962	3,379	31.8	22.1	22.8	15.1	4.9	2.3	T			T
	1963	3,254	37.8	25.8	26.6	8.8	1.0					
Total	1960-63	10,700	38.1	23.7	20.6	11.4	3.5	1.3	1.0	T		T
Fall	1960	2,879	29.8	9.0	19.6	12.7	15.4	6.5	6.3	T		T
	1961	2,340	35.4	26.9	15.1	10.0	4.4	4.1	3.6	T		
	1962	1,298	19.3	14.6	33.4	14.3	10.0	2.0	2.9	3.5		
	1963	1,388	39.8	7.5	30.5	8.1	9.1	3.2		T		1.2
Total	1960-63	7,923	31.5	15.0	22.4	11.4	10.1	4.5	3.8	1.1		T
Winter	1961	411	59.9	20.7	13.1	3.6	1.7			1.0		
	1962	154	56.5			38.3	3.9	1.3				
	1963	71	42.3	42.3	2.6	9.0	3.8					
	1964	82	86.6		1.2	8.5		2.4				1.2
Total	1961-64	718	60.3	16.3	7.9	12.1	2.2	T	T			T
Spring	1961	2,724	38.8	37.8	11.1	6.4	3.3	T	1.7			
	1962	1,435	34.6	17.4	24.7	19.8	2.0	1.6				
	1963	1,543	47.2	29.4	13.5	8.1	1.2	T				
	1964	64	100.0									
Total	1961-64	5,766	40.7	30.1	15.0	10.1	2.4	T	T	T		
	1960-61	6,562	35.2	22.4	15.6	10.6	9.0	3.3	3.6	T		T
	1961-62	7,466	40.8	23.3	15.7	11.6	3.6	2.3	2.2	T		
	1962-63	6,291	47.2	29.4	13.5	8.1	1.2	T				
	1963-64	4,788	40.1	19.7	26.9	8.5	3.3	1.0		T		T
	1960-64	25,125	37.3	22.2	19.5	11.1	5.3	2.2	1.8	T		T

^{1/} Distance Class: (1) = 0-1/4 mile, (2) = 1/4-1/2 mile, (3) = 1/2-3/4 mile, (4) = 3/4-1 mile, (5) = 1-1 1/4 mile, (6) = 1 1/4-1 1/2 mile, (7) = 1 1/2-1 3/4 mile, (8) = 1 3/4-2 mile, (9) = 2+ mile.

^{2/} August only.

^{3/} T = less than one per cent.

FOOD HABITS

Food habits of mule deer, elk, and cattle were determined primarily by recording frequencies of plant use by taxon at feeding sites as described by Cole (1956) and others. The requisite minima during my study for recording data were 50 instances of recent plant use on one vegetation type by one of the animals studied. Use of a rooted stem for grass and grass-like plants, an individual leaf or twig for trees and shrubs, and individual leaves or stems for forbs each constituted one instance of use. Data generally were obtained for each of the three animals on "major" vegetation types at intervals of one month or less and on other types as opportunity afforded. Use of a taxon was computed as a percentage of the total instances of use on each site. Percentages for various sites were aggregated and averaged within vegetation types and/or time periods.

Data from feeding site examinations were supplemented by analyses of one quart rumen samples from each of 37 mule deer, 12 elk, and 18 cattle. Rumen samples for mule deer were from animals killed by hunters or collected specifically for this study. All cattle samples were from animals found dead. The deaths of most of those from which rumen samples were collected during spring and early summer of 1963 were attributed to sweetclover (Melilotus officinalis) bloat. Elk samples were represented by animals found dead as well as intentionally collected. Separations and measurements of items in the rumen samples were performed by personnel of the Montana Fish and Game Department Wildlife Laboratory using standard techniques. I assisted in identification of plant materials. Relative volumes of plant taxa in each rumen sample were expressed as percentages.

Percentages were aggregated and averaged for seasons by year.

Mule Deer

A total of 40,982 instances of plant use was recorded at 263 mule deer feeding sites between June 1960 and March 1964. The number of instances of use at each site varied from 50 to 500 but typically was between 100 and 200 (average 156). Smaller samples were characteristic of "minor" vegetation types and early summer when mule deer group sizes were small.

Data for use of taxa which individually received at least ten per cent of the total instances of plant use for at least one vegetation type during at least one season are presented in Table XXVIII. Those taxa which did not meet these requirements are considered in Appendix Table LIX.

Summer (June, July, August).--A total of 87 mule deer feeding sites was examined during the four summers; 27, 27, 23, and 10 for 1960, 1961, 1962, and 1963 respectively. Use was recorded on 62 taxa, including 44 forbs, 12 shrubs, and 6 grasses or sedges. Nine taxa, five forbs and four shrubs, received an average of more than one per cent of the total instances of use during summers. Forbs predominated the use on all but timbered vegetation types. Melilotus officinalis was by far the single most important taxon, accounting for 44.5 per cent of the total combined summer use. It occurred on 87 per cent and was used on 70 per cent of all mule deer feeding sites. Other forbs individually were of only minor importance. Those taxa which received the greatest use were Comandra umbellatum, Glycyrrhiza lepidota, and Tragopogon dubius.

TABLE XXVIII. MULE DEER USE OF TAXA WHICH INDIVIDUALLY RECEIVED AT LEAST TEN PER CENT OF THE TOTAL INSTANCES OF PLANT USE FOR AT LEAST ONE VEGETATION TYPE DURING AT LEAST ONE SEASON, 1960-64 COMBINED.

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Artemisia/Agropyron:</u>	(18-14) <u>1/</u>	(11-15)	(27-27)	(27-38)
<u>Poa secunda</u>	6/T <u>2/</u>	27/17	15/1	59/12
Grass Total	6/T	36/18	37/2	85/16
<u>Artemisia tridentata</u>		27/10	85/56	70/32
<u>Chrysothamnus nauseosus</u>	11/T	54/26	41/22	4/T
Browse Total	17/6	73/37	96/88	79/35
<u>Comandra umbellatum</u>	33/6	27/T		30/10
<u>Lomatium foeniculatum</u>				52/10
<u>Melilotus officinalis</u>	94/85	54/36	15/T	22/3
Forb Total	94/94	73/45	44/10	89/49
<u>Agropyron/Poa:</u>	(1-1)	(1-4)		(1-7)
<u>Poa secunda</u>				100/79
Grass Total		100/1		100/83
<u>Chrysothamnus nauseosus</u>		100/81		
Browse Total		100/81		
<u>Fritillaria pudica</u>				100/12
<u>Melilotus officinalis</u>	100/100			
<u>Tragopogon dubius</u>		100/17		
Forb Total	100/100	100/18		100/17
<u>Pinus/Juniperus:</u>	(38-42)	(17-37)	(20-25)	(22-45)
Grass Total	13/T	28/2	20/T	50/T
<u>Artemisia cana</u>		6/5	15/10	23/3
<u>Artemisia longifolia</u>	3/T	22/11	25/6	14/T
<u>Artemisia tridentata</u>		11/7	40/8	50/13
<u>Chrysothamnus viscidiflorus</u>		22/20	35/5	9/1
<u>Juniperus scopulorum</u>		33/7	80/18	50/20
<u>Rhus trilobata</u>	84/44	83/33	85/14	50/10
<u>Symphoricarpos spp.</u>	60/10	56/11	70/18	41/6
Browse Total	92/64	100/83	100/86	100/66
<u>Melilotus officinalis</u>	58/24	22/2	20/7	9/2
Forb Total	79/36	67/15	55/14	68/26

TABLE XXVIII. Continued.

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Pseudotsuga/Juniperus:</u>	(10-24)	(6-14)	(6-17)	(4-23)
Grass Total	20/T	20/T	17/T	25/T
<u>Artemisia tridentata</u>			68/15	25/T
<u>Chrysothamnus viscidiflorus</u>	10/T	20/18	68/29	25/T
<u>Juniperus scopulorum</u>	10/T	40/1	100/30	50/23
<u>Prunus virginiana</u>	80/14	40/5	68/4	
<u>Pseudotsuga menziesii</u>			17/7	50/24
<u>Rhus trilobata</u>	90/44	80/21	100/4	50/7
<u>Rosa spp.</u>	80/6	40/4	50/T	75/10
<u>Symphoricarpos spp.</u>	80/11	100/32	68/5	50/11
Browse Total	100/82	100/86	100/98	100/81
<u>Melilotus officinalis</u>	50/11	40/8	17/1	25/10
Forb Total	79/36	67/15	55/14	68/26
<u>Sarcobatus/Artemisia:</u>	(6-11)	(4-17)	(8-18)	(9-21)
<u>Poa secunda</u>		25/19	12/10	56/16
Grass Total		25/19	12/10	56/16
<u>Artemisia tridentata</u>			50/30	89/47
<u>Chrysothamnus viscidiflorus</u>		25/25	12/12	11/T
<u>Sarcobatus vermiculatus</u>		25/T	75/25	44/T
Browse Total	50/2	50/25	100/80	89/53
<u>Melilotus officinalis</u>	83/71	50/26	25/5	
<u>Musineon divaricatum</u>				56/11
<u>Sphaeralcea coccinea</u>		25/19		
<u>Tragopogon dubius</u>	50/17	50/T	12/T	22/T
Forb Total	100/98	100/56	50/8	89/28
<u>Agropyron/Symphoricarpos:</u>	(5-9)	(6-7)	(1-2)	(2-9)
Grass Total	40/1			50/1
<u>Artemisia cana</u>		33/4	100/26	
<u>Chrysothamnus viscidiflorus</u>		33/30	100/74	100/48
<u>Symphoricarpos spp.</u>	60/36	50/46		50/41
Browse Total	60/37	83/81	100/100	100/95
<u>Glycyrrhiza lepidota</u>	80/3	33/16		50/1
<u>Melilotus officinalis</u>	80/56	33/2		
Forb Total	100/62	50/19		50/4
<u>Xanthium:</u>	(6-9)	(1-3)		
<u>Symphoricarpos spp.</u>	50/24			
Browse Total	50/29			
<u>Glycyrrhiza lepidota</u>	68/3	100/19		
<u>Melilotus officinalis</u>	50/24	100/74		
Forb Total	100/71	100/93		

TABLE XXVIII. Continued.

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Artemisia longifolia:</u>	(3-10)	(3-8)		
<u>Artemisia longifolia</u>		100/89		
<u>Rosa spp.</u>	33/10	33/2		
Browse Total	67/13	100/93		
<u>Glycyrrhiza lepidota</u>	68/24			
<u>Melilotus officinalis</u>	68/50	33/T		
Forb Total	100/87	100/7		

1/ In parenthesis: The number of feeding sites on this vegetation--The total number of taxa used on the type.

2/ Per cent frequency of use among all feeding sites on this vegetation type/aggregate mean percentage of the total instances of use for this vegetation type. T = less than one per cent.

Browse ranked second in total use on feeding sites during summer. It was the most important forage class used on the Pinus/Juniperus and Pseudotsuga/Juniperus vegetation types. Rhus trilobata was the most intensively used taxon on the latter and ranked second over-all. Symphoricarpos spp. (S. alba and S. occidentalis) which received about 10 per cent of the total summer use, Rosa spp. (R. arkansana and R. nutkana), and Prunus virginiana ranked third, fourth, and fifth respectively for all vegetation types combined. The latter was important only on the Pseudotsuga/Juniperus type where it was the second, most intensively used taxon. Symphoricarpos spp. and Rosa spp. received prominent use on both timbered types. Symphoricarpos occidentalis, which was used intensively on Agropyron/Symphoricarpos, was the only shrub receiving significant use by mule deer on a non-timbered vegetation type during summer.

Use on grass and grass-like plants was negligible at all times during summer.

Analyses of six mule deer rumen samples from the summer of 1963 (Table XXIX) showed similarly used taxa but greater use of browse than feeding site data. The predominance of browse, including the slightly greater volume of Rhus trilobata as compared to Melilotus officinalis, in the rumen samples may represent a truer relationship between forbs and browse in the mule deer diet than feeding site examinations. Numbers of feeding site examinations corresponded generally to relative intensities of observed mule deer use of timbered types. This, together with the observed predominant use of browse on timbered types, was circumstantial

TABLE XXIX. FREQUENCY OF OCCURRENCE AND VOLUME PERCENTAGES OF PLANT TAXA AND FORAGE CLASSES AMONG 37 MULE DEER RUMEN SAMPLES.

Taxa 1/ Forage Class	Summer	Fall (Oct-Nov)				Winter			Spring
	1963	1960	1961	1962	Total	1961-62	1962-63	Total	1963
	(6) 2/	(1)	(6)	(10)	(17)	(4)	(4)	(8)	(6)
Gramineae Family	33/T 3/		100/43	70/23	77/29	100/3	100/19	100/11	67/25
Grass & Grass-like	33/T		100/43	70/23	77/29	100/3	100/19	100/11	83/25
<u>Artemisia cana</u>				30/5	1/3	50/T		25/T	
<u>Artemisia tridentata</u>			100/15	10/T	41/5	100/63	100/21	100/42	83/5
<u>Chrysothamnus spp.</u>		100/95	83/25	70/7	77/19	75/2	75/16	75/9	33/8
<u>Juniperus scopulorum</u>			100/9	60/3	71/5	100/16	75/9	87/13	33/5
<u>Prunus virginiana</u>	83/14			10/T	5/T				17/T
<u>Pseudotsuga menziesii</u>			17/T	10/T	11/T	50/2		25/T	17/T
<u>Rhus trilobata</u>	100/26		33/T	20/T	23/T	25/T	25/T	25/T	17/T
<u>Rosa spp.</u>	100/13	100/T	17/T	40/1	47/T	50/T		25/T	67/15
<u>Symphoricarpos spp.</u>	83/2		33/T	50/3	41/1	25/T		13/T	33/2
Unidentified browse	17/T	100/1	67/4	60/1	65/2	50/T	25/7	37/3	67/1
Browse Total	100/59	100/99	100/57	100/21	100/39	100/95	100/53	100/73	100/54
<u>Allium textile</u>									33/5
<u>Aster spp.</u>							25/5	13/3	
<u>Cirsium spp.</u>				20/1	11/T				
<u>Comandra umbellatum</u>	33/2								
<u>Compositae family</u>			17/T		5/T		75/1	37/T	17/T
<u>Leguminosae family</u>				10/9	5/5				
<u>Medicago spp.</u>				20/5	11/3		25/T	13/T	
<u>Melilotus officinalis</u>	100/25			30/16	17/9				67/3
<u>Tragopogon dubius</u>	49/7						25/5	13/3	33/4
Unidentified forbs	67/1	100/T	67/T	100/21	88/13	50/2	75/15	63/9	83/2
Forb Total	100/36	100/T	67/1	100/54	88/32	50/2	100/28	75/27	100/30

TABLE XXIX, Continued.

- 1/ Taxa having volume percentages of one per cent or more of the total during any seasonal period. Others occurring during seasons included: Carex spp. (S), Artemisia frigida (W), Artemisia ludoviciana (F), Antennaria spp. (F), Conringia orientalis (S), Crepis occidentalis (S), Descuriana pinnata (S), Gaura coccinea (S), Geum triflorum (S), Glycyrrhiza lepidota (FW), Lactuca pulchella (Su), Linium rigidum (Su), Lomatium foeniculatum (S), Microseris nutans (S), Potentilla arguta (Su), Senecio canus (Su), Thlaspi arvensis (S), Vicia americana (S Su), Yucca glauca (F), Petalostemum (F), and Ericaceae family (F).
- 2/ Number of rumen samples in parenthesis.
- 3/ Per cent frequency/per cent of total volume. T = less than one per cent.

evidence for greater than observed importance of shrubs. This suggested that Rhus trilobata was the most intensively used individual taxon and that use of other shrubs was also relatively greater in summer.

Fall (September, October, November).--Data were obtained at 48 mule deer feeding sites; 22, 18, 4, and 5 for 1960, 1961, 1962, and 1963 respectively. Mule deer use was recorded on 53 taxa; 33 forbs, 12 shrubs, and 8 grasses. Fifteen of these, five forbs, nine shrubs, and one grass, received more than one per cent of the total combined use.

Use of browse increased from summer and predominated use for all types combined as well as on Agropyron/Symphoricarpos, Agropyron/Poa, Artemisia longifolia, and both timbered types. Over-all, use on Rhus trilobata, Chrysothamnus viscidiflorus, Symphoricarpos spp., and Melilotus officinalis, a forb, was about equal. Rhus trilobata was used at intensities similar to summer during September and early October. Considering the observed and/or inferred importance of the Pinus/Juniperus and Pseudotsuga/Juniperus vegetation types for use by mule deer, it probably was the single, most important taxon, at least in September. Although Chrysothamnus viscidiflorus received rather intensive use on both of the timbered vegetation types as well as on Sarcobatus/Artemisia and Agropyron/Symphoricarpos, this taxon was abundant and/or widely distributed only on the latter. Chrysothamnus nauseosus, which was abundant, widely distributed, and intensively used on the Artemisia/Agropyron type, appeared much more important and may have been the single, most important taxon during October and November. Symphoricarpos spp. received intensive

use on the Agropyron/Symphoricarpos type during September and early October as well as on both timbered types throughout the period. Other shrubs individually received only minor use, occurred largely on minor vegetation types, and/or were used intensively during only part of the period. Those which appeared of some importance included: Rosa spp. in September; Artemisia longifolia which was used intensively during September, largely on the minor Artemisia longifolia type and Pinus ponderosa/Artemisia longifolia association; Artemisia cana in October and November; and Artemisia tridentata as well as Juniperus scopulorum in November.

Melilotus officinalis, the most intensively used forb, was one of the more important forage sources during fall, especially in September. Use of other forbs generally was very minor but varied in relation to availability of Melilotus. Aster commutatus and Tragopogon dubius were most consistently and widely used. Glycyrrhiza lepidota received intensive use in early fall, largely on the Agropyron/Symphoricarpos vegetation type. Other taxa receiving somewhat greater use included Artemisia ludoviciana and Eriogonum multiceps during October and Phlox hoodii in November.

Use of grass by mule deer during the fall varied considerably. Intensive use was restricted to Poa secunda and was related to fall "green-up." It occurred only during October and November.

The greater discrepancy between rumen samples and feeding site data during fall was related to collection of most samples during late October and November in years of intensive fall grass use.

Winter (December, January, February).--Sixty-two mule deer feeding sites were examined during the four winters as follows: 1961, 32; 1962, 16; 1963, 9; and 1964, 5. Use was recorded on 39 taxa; 14 forbs, 16 shrubs, and 9 grasses. Of these, 15--including 4 forbs, 10 shrubs, and 1 grass--received more than one per cent of the total instances of use for all years. Browse was by far the most important forage class.

Artemisia tridentata, the single, most important taxon, received about 33 per cent of the four-year total winter use. It was used most intensively during mid-winter and periods of snow cover. Use of

Chrysothamnus nauseosus, which ranked second, was most intensive in early winter and declined to minor levels late in the period.

Juniperus scopulorum ranked third. It appeared to receive some use in association with feeding on Artemisia tridentata, but was also used intensively when mule deer used the Pinus/Juniperus vegetation type during periods of heavy snow and cold temperatures. Symphoricarpos spp. and

Rhus trilobata received frequent, though minor, use on the Pinus/Juniperus type throughout the winter. Use on other shrubs usually was very minor and/or restricted to minor or moderately used vegetation types.

Chrysothamnus viscidiflorus was used mostly on the Pseudotsuga/Juniperus and Sarcobatus/Artemisia types which received only minor winter use by mule deer.

Forbs collectively were of only minor importance during most winters. Taxa used most consistently included Melilotus officinalis, Tragopogon dubius, Artemisia frigida, and Phlox hoodii. The latter was

used relatively intensively during snow-free periods and during February. None of these received more than three per cent of the total winter use.

Winter use of grasses was very minor over-all but varied in relation to "green-up" and snow cover. Intensive use occurred only on "green" Poa secunda, mostly during December. Other species received only incidental and/or use of seedheads.

Volumetric percentages for winter rumen samples indicated forage class and individual taxon usage similar to that recorded at feeding sites. The slightly greater use of grasses reflected collections only during "green-up" years.

Spring (March, April, May).--A total of 65 feeding site examinations was made during spring; including 34 in 1961, 20 in 1962, 10 in 1963, and 1 during March 1964. The use of 65 taxa, comprised of 44 forbs, 16 shrubs, and 7 grass and grass-like plants, reflected the flux in availability as well as mule deer forage preferences throughout the period. Twenty-one taxa, 9 forbs, 10 shrubs, and 2 grasses, received more than one per cent of the total instances of use recorded during spring.

Browse was the most important forage class for all years combined. Artemisia tridentata was the most important taxon over-all, largely because of intensive use during March. Its use and importance generally declined sharply during April to very minor by early May. Juniperus scopulorum ranked second in importance among shrubs and third among all plants. Trends in use of this as well as other winter browse plants which received only minor use in early spring, paralleled that of Artemisia tridentata.

This was reflected in a 56 per cent decrease in recorded use on shrubs from March through May. Rhus trilobata, Ribes cereum, Rosa spp., and Symphoricarpos spp. were of only very minor importance for the entire period, but received increasing use monthly. Ribes cereum received some intensive use during April.

Forbs, which ranked second in combined data, typically received only minor use during March but were about equally used as compared to browse during April and predominated recorded use in May. Phlox hoodii, which received minor use, was the only forb with significant use during March. Although no taxon received more than six per cent of the total instances of use for the entire period, several members of the Poa secunda union received intensive use during April and early May. The more important, and most consistently used taxa included Allium textile, Lomatium foeniculatum, Microseris nutans, and Fritillaria pudica. Use of this group declined by mid-May and was supplanted by increasing use of taxa from the Tragopogon dubius union, especially Comandra umbellatum, Tragopogon dubius, and Melilotus officinalis, but including Arnica sororia, Crepis occidentalis, Gaura coccinea, and Vicia americana.

Grasses were used more intensively by mule deer during spring than other seasons but typically received only moderate use, largely during April. Poa secunda was the only taxon receiving intensive use. The very minor use of Agropyron smithii and occasional use of Koleria cristata appeared largely incidental to use of Poa.

Rumen samples for the spring period generally reflected trends in use of forage classes and individual taxa similar to those indicated by feeding site data. The undue prominence of Rosa spp. in the rumen data reflected influence of a sample comprised largely of that item.

Yearlong Trends.--The results indicated significant yearlong changes in mule deer use of various forage classes and individual taxa for food. Shrubs (browse) comprised the most important forage source averaging approximately 62 per cent of mean monthly instances of use during the four-year period. The mean seasonal percentage of browse in rumen samples was 56 per cent. Use of browse was lowest in May, increased gradually through summer and sharply through fall to a maximum in January, then decreased through March and April to the minimum by late April and/or early May. Trends in use of forbs, collectively, complemented changes in use of browse. This forage class comprised approximately 32 per cent of the total instances of plant use averaged over months and 31 per cent of rumen samples averaged over seasons. Most intensive use occurred in early May, the lowest in January. Over-all, grasses and grass-like plants were of minor importance. Yearlong averages were about six per cent of mean monthly total instances of plant use and fourteen per cent of mean seasonal rumen sample volume percentages. The discrepancy between rumens and feeding site data was related to concentration of rumen collections in periods of more intensive grass use. Use of grass was negligible during summer and early fall, increased in late fall in years of "green-up," declined to a minimum during mid-winter, increased sharply during

late March and/or early April to maximum yearly intensities of use in early April, then decreased to minimal summer levels by mid-May.

Melilotus officinalis was the single, most important taxon in relative use on feeding sites on all vegetation types from mid-June through September. Subsequent yearly use was generally minor but varied in relation to late summer-early fall growth and persistence of first-year stems and/or the abundance of dry seed stalks. It was used most intensively after flowering commenced. Rhus trilobata ranked second in use on all feeding sites from early June through late September or early October, but was by far the single, most important taxon on the intensively used Pinus/Juniperus and Pseudotsuga/Juniperus vegetation types and may have been most important over-all. Subsequent fall, winter, and spring use was generally minor, but varied in relation to prior summer-early fall use and/or relative intensities of mule deer use on the Pinus/Juniperus type during these periods. Symphoricarpos alba, S. occidentalis, Rosa arkansana, R. nutkana, and Prunus virginiana were other shrubs receiving relatively important use by mule deer throughout the summer and early fall. Trends in use of these deciduous shrubs generally paralleled use on Rhus trilobata, except that Symphoricarpos spp. remained important throughout fall and into early winter and Prunus virginiana was only rarely used in winter and early spring. Early summer use on each consisted largely of leaves. Use of twigs increased progressively and predominated late summer and subsequent periods.

One of four major seasonal changes in the yearlong food habits of mule deer occurred during early fall when use on Chrysothamnus nauseosus and C. viscidiflorus increased sharply concomitant to decreased availability and use on deciduous shrubs and forbs. The former appeared most important. The abundance of C. viscidiflorus only on the minor Agropyron/Symphoricarpos type precluded important use. There was some evidence to suggest that this taxon had been more abundant and probably of greater importance in previous years. Both Chrysothamnus nauseosus and C. viscidiflorus were used intensively only after flowering. "Leaders" which had previously been "clipped" appeared more preferred than those which held seedheads. Artemisia cana and Artemisia longifolia received some use though never significant because of limited abundance and/or distribution. Poa secunda was moderately important in late fall of some years. Use of "fall" browse taxa, especially C. nauseosus, remained important into early winter, then declined to only minor levels in late winter and early spring. The second major seasonal change in mule deer food habits occurred concomitant to decreased availability of Chrysothamnus nauseosus and the onset of winter conditions in late fall. It was characterized by sharply increased use of Artemisia tridentata and Juniperus scopulorum. The former prevailed as the single, most important taxon on feeding sites on the intensively used Artemisia/Agropyron vegetation type as well as all types combined through March. Use on Juniperus scopulorum was consistently of minor or moderate importance.

Although relatively unimportant over-all. Atriplex nuttallii, Sarcobatus vermiculatus, Pseudotsuga menziesii, and Pinus ponderosa received intensive use on some feeding sites during some winters. The third and most marked seasonal change in mule deer food habits occurred in late March and/or early April. This coincided with the onset of spring "green-up" when the sudden, significant decline in mule deer use of Artemisia tridentata was complemented by a marked increase in use of grass, largely Poa secunda, on feeding sites. Use of this taxon declined after mid-April in most years with increasingly intensive mule deer use of early forbs of the Poa secunda union. These, collectively, were most important during late April and early May but decreased as increasingly important use of forbs of the Tragopogon dubius union and deciduous shrubs resulted in the last major seasonal change to food habits characteristic of summer.

Trueblood (1960) reported generally similar trends in food habits of mule deer in the Missouri River Breaks of Valley County, Montana. Janson and Picton (1959) found Pseudotsuga menziesii and Chrysothamnus spp. to be the principal items in 14 rumen samples from mule deer collected during February 1958 from the Missouri River Breaks of Fergus County, west of the present study area.

Year-to-Year Trends.--Relative intensities of mule deer use of forage classes (Table XXX) and individual taxa (Table XXXI) varied significantly between and within years. This was largely related to extensive differences in precipitation and its influence on vegetal growth. Conditions ranged from severe drought and extremely poor plant growth during 1961 to

TABLE XXX. A COMPARISON OF PERCENTAGES OF MULE DEER USE OF GRASS, BROWSE, AND FORBS AT FEEDING SITES ON VARIOUS VEGETATION TYPES DURING SEASONS AND YEARS, 1960-64.

Forage Class	ARTEM/ AGROP 1/				PINUS/ JUNIP 1/				PSEUD/ JUNIP 1/				SARCO/ ARTEM 1/				ALL TYPES COMBINED			
	Su	Fa	Wr	Sp	Su	Fa	Wr	Sp	Su	Fa	Wr	Sp	Su	Fa	Wr	Sp	Su	Fa	Wr	Sp
					2/															
Grass and Grass-like																				
1960-61	0	0	T ^{3/}	9	T	0	0	2	0	0	0	1	--	--	T	7	T	0	T	6
1961-62	T	65	5	16	T	5	3	2	0	--	0	0	0	26	T	18	T	17	3	14
1962-63	0	2	3	39	T	T	T	30	0	2	--	0	0	0	45	87	T	1	12	36
1963-64	0	0	1	--	T	T	0	--	T	0	T	--	0	--	--	--	T	T	T	--
1960-64	T	18	2	16	T	2	T	7	T	T	T	T	0	19	12	19	T	5	2	13
Browse																				
1960-61	0	57	92	40	77	92	100	68	72	100	100	90	--	--	100	52	46	81	96	56
1961-62	14	22	94	33	84	79	80	75	99	---	100	100	1	34	96	78	54	90	91	54
1962-63	2	0	64	21	41	36	53	43	49	64	---	43	2	0	28	9	25	25	52	31
1963-64	0	2	95	--	46	86	79	--	76	63	93	---	5	--	--	--	45	65	88	--
1960-64	6	37	88	35	64	83	86	66	82	86	98	81	2	25	80	53	43	72	88	52
Forbs																				
1960-61	100	43	8	50	23	8	T	29	4	0	0	9	--	--	0	40	51	19	4	38
1961-62	85	14	2	52	16	16	17	23	1	--	0	0	99	41	4	4	45	13	6	32
1962-63	98	98	32	40	59	63	47	27	51	34	--	57	98	100	27	4	75	74	36	33
1963-64	100	98	4	--	54	14	21	--	23	37	6	--	95	--	--	--	54	35	12	--
1960-64	94	45	10	49	36	15	14	26	18	14	2	19	98	56	8	28	56	23	10	35

1/ Vegetation types receiving 10 per cent or more of the total observed mule deer use during at least one season: Artemisia/Agropyron; Pinus/Juniperus; Pseudotsuga/Juniperus; and Sarcobatus/Artemisia.

2/ Summer, fall, winter, and spring respectively.

3/ T = less than one per cent.

well above "normal" rainfall and exceptionally good plant growth during 1962. They were "below normal" in 1960, and "above normal" in 1963. All classes of plants were affected but changes in composition and abundance of forbs, especially Melilotus officinalis (Table XXXII) were most significant.

TABLE XXXI. A COMPARISON OF RELATIVE INTENSITIES OF MULE DEER USE OF SOME IMPORTANT FOOD PLANTS DURING SEASONS AND YEARS, 1960-64. 1/

Taxon	1960-61		1961-62		1962-63		1963-64	
	Su	Fl/Wr/Sp	Su	Fl/Wr/Sp	Su	Fl/Wr/Sp	Su	Fl/Wr/Sp
<u>Melilotus officinalis</u>	45/13/	0/ T	36/ 1/	0/ T	58/62/19/14	37/24/	7/---	
<u>Rhus trilobata</u>	29/20/	6/ 6	36/ 6/	7/ 2	10/ 9/	T/ 4	22/23/	3/---
<u>Symphoricarpos</u> spp.	10/15/10/	6	10/13/	2/ 1	8/ 9/	1/ 3	14/ 8/11/	---
<u>Chrysothamnus</u> spp.	0/27/19/	1	0/30/	9/ 5	0/ 0/28/	4	0/ 5/34/	---
<u>Artemisia tridentata</u>	0/ 4/33/27		0/ 3/49/24		0/ 0/13/16		0/ 0/18/	---
<u>Juniperus scopulorum</u>	0/ T/	9/ 6	T/ 7/16/18		0/ 0/	3/ 4	0/ T/	2/---
Number of taxa used	21/20/20/45		30/37/24/50		34/15/31/41		26/21/19/10	

1/. Percentages of total instances of use on all vegetation types combined.

TABLE XXXII. PERCENTAGES OF MULE DEER FEEDING SITES EXAMINED DURING SUMMER AND FALL SEASONS ON WHICH MELILOTUS OFFICINALIS WAS ABUNDANT, SCATTERED, AND ABSENT, 1960-63.

Relative Abundance	1960		1961		1962		1963	
	Summer	Fall	Summer	Fall	Summer	Fall	Summer	Fall
Abundant	59	23	30	0	61	100	90	60
Scattered	19	4	16	40	30	0	10	40
Absent	22	73	54	60	9	0	0	0

Decreased availability of forbs during 1960 and 1961 was reflected in increased use of browse as well as unseasonable use of certain taxa as compared with other years. These phenomena were most pronounced during 1961 when summer-fall use of M. officinalis and other forbs was lowest and browse, especially Rhus trilobata, was most intensively used in summer. As a result of sharply decreased availability, fall use of "summer" browse taxa was relatively minor and was supplanted by "early," intensive use on "fall" browse, especially Chrysothamnus spp.. Subsequently, with decreasing availability and use of these taxa, Artemisia tridentata and Juniperus scopulorum received unseasonable, intensive use in October. Although feeding sites showed minor use of A. tridentata during both 1960 and 1961, this taxon comprised an average of 12 per cent for three rumen samples from October 1961 while absent from the one sample for 1960. Winter use of both the latter and J. scopulorum was relatively high, as compared to 1960, and use of most other "preferred" browse was low. These taxa were also used exceptionally late into spring, early May, in 1961.

The most significant differences appear in comparisons of data for 1960-61 and 1961-62 with that for subsequent years. Forbs were moderately abundant during early summer of 1962, but greatly increased in late summer and fall following growth of first-year stems of Melilotus officinalis. This taxon, in particular, was intensively used during summer and fall and received moderate use in winter on the timbered vegetation types where it persisted in relative abundance. Relative intensities of use on deciduous browse, especially Rhus trilobata,

decreased significantly during summer as compared to previous years. Use of the latter may have been influenced by severe defoliation by a larval Lepidoptera during that summer and/or undue sampling bias favoring "open" vegetation types. Moderate to high levels of use occurred on feeding sites on both of the timbered vegetation types. Fall use was at intensities similar to summer. Significantly, fall use was not detected on Chrysothamnus spp., Artemisia tridentata, and Juniperus scopulorum at feeding sites. Minor percentages of Chrysothamnus spp. and J. scopulorum and only a trace percentage of A. tridentata occurred in 10 rumen samples collected during the period (Table XXIX), though Chrysothamnus spp. was prominent in several samples collected prior to intensive use of grass in late October. The substantial decrease in use of A. tridentata and J. scopulorum and the greatly increased use on Chrysothamnus spp. during winter, as compared with previous years, was more significant than changes in use during fall. The repeated occurrence of the same phenomena under somewhat similar conditions during the winter of 1963-64 suggested that both A. tridentata and J. scopulorum were only secondarily preferred winter forage species. Their importance during 1960-61 and 1961-62 may have been unduly exaggerated due to excessive and/or unseasonal utilization of Chrysothamnus spp. and other more preferred shrubs; e.g., Symphoricarpos spp.. Forbs, especially Melilotus officinalis, were exceptionally abundant again during 1963 and received intensive use during summer and fall. The relatively intensive use of Rhus trilobata at feeding sites, despite the abundance of M. officinalis, was further evidence that this taxon was

equally or more important as a summer-fall forage source. This further suggested that the decreased use of R. trilobata on feeding sites during 1962 was exaggerated by some factor other than preference for M. officinalis.

Some yearly variation in mule deer food habits was also influenced during fall, winter, and spring by the relative availability of "green" grass, especially Poa secunda. The increased occurrence of grass in both the feeding site data and rumen samples for the fall and winter periods of 1961-62 and 1962-63 reflected "green-ups" in early October and late October respectively. This certainly influenced intensities of use on Chrysothamnus spp. and may also have influenced use of other forage taxa. The relatively high use of grass for the spring of 1963 reflected early growth and greater abundance of Poa secunda and its intensive use during March as well as April. The relatively light use of grass during the spring of 1961 was related to the generally reduced herbaceous growth of that year.

In addition to changes in intensities of use of important taxa, variation in forage conditions influenced differences in the number of taxa used during seasons and years (Table XXXI). This was most significant during spring and fall of driest years when supplies of seasonally preferred taxa were minimal.

The significance of seasonal and yearly differences on observability of mule deer as well as population trends was discussed earlier.

Elk

A total of 28,030 instances of plant use by elk was recorded at 178 feeding sites between June 1960 and January 1964. The number of instances of use at each site varied from 50 to 750 but usually was between 100 and 200. The average number was 157. The smallest samples occurred in late spring and early summer when single individuals and small groups of elk were common.

Data for elk use of taxa which received at least 10 per cent of the total instances of plant use for at least one vegetation type during at least one season are presented in Table XXXIII. Taxa which received lesser intensities of use are considered in Appendix Table LX.

Summer (June, July, August).--A total of 64 elk feeding sites was examined during the four summers; 23, 14, 19, and 8 respectively for 1960, 1961, 1962, and 1963. Use was recorded on 71 taxa, including 49 forbs, 10 shrubs, and 12 grass and grass-like plants. Eleven taxa, six forbs, three shrubs, and two grasses received an average of more than one per cent of the total instances of use during summer.

Forbs were the most important forage source on all but the Pseudotsuga/Juniperus vegetation type and comprised 75 per cent of the total combined summer use. Melilotus officinalis, the predominant taxon, accounted for more than two-thirds of the use on forbs and received approximately 53 per cent of the total instances of use for the period. It was used on 88 per cent of all elk feeding sites. Glycyrrhiza lepidota, which

TABLE XXXIII. ELK USE OF TAXA RECEIVING AT LEAST TEN PER CENT OF THE TOTAL INSTANCES OF PLANT USE AT FEEDING SITES ON AT LEAST ONE VEGETATION TYPE DURING AT LEAST ONE SEASON, 1960-64 COMBINED.

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Artemisia/Agropyron:</u>	(29-26) 1/	(17-27)	(17-19)	(19-29)
<u>Agropyron smithii</u>	42/13 2/	88/43	100/70	100/54
<u>Koeleria cristata</u>	33/6	82/17	71/8	53/4
<u>Poa secunda</u>	17/T	76/10	76/5	90/20
Grass Total	67/23	100/81	100/86	100/81
<u>Melilotus officinalis</u>	92/59	18/7	12/T	21/2
Forb Total	100/77	53/13	35/2	90/13
<u>Artemisia tridentata</u>		18/2	41/10	58/8
Browse Total	8/T	29/6	47/11	58/8
<u>Pinus/Juniperus:</u>	(15-35)	(9-19)	(11-22)	(5-16)
<u>Agropyron smithii</u>	33/13	44/24	91/64	100/49
<u>Muhlenbergia cuspidata</u>	13/T	56/11	18/1	
<u>Stipa viridula</u>	20/T	22/T	36/2	60/14
Grass Total	47/18	89/45	91/78	100/77
<u>Arnica sororia</u>				20/11
<u>Melilotus officinalis</u>	87/62	22/20	9/T	
Forb Total	100/74	44/22	46/6	40/13
<u>Juniperus scopulorum</u>		11/11	36/3	20/5
<u>Symphoricarpos spp.</u>	33/3	44/10	27/5	
<u>Artemisia longifolia</u>	7/T	11/11	9/1	20/T
Browse Total	47/8	56/32	73/17	40/10
<u>Pseudotsuga/Juniperus</u>	(10-24)	(3-12)	(1-16)	
<u>Agropyron smithii</u>	10/T	67/22	100/3	
Grass Total	40/T	67/31	100/5	
<u>Artemisia ludoviciana</u>		33/16		
<u>Melilotus officinalis</u>	60/26		100/2	
Forb Total	70/32	67/18	100/6	
<u>Chrysothamnus viscidiflorus</u>			100/13	
<u>Juniperus scopulorum</u>			100/12	
<u>Prunus virginiana</u>	80/37	33/2		
<u>Pseudotsuga menziesii</u>			100/19	
<u>Symphoricarpos spp.</u>	100/21	33/14	100/T	
<u>Artemisia tridentata</u>		33/33	100/42	
Browse Total	100/67	68/51	100/90	

TABLE XXXIII. Continued.

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Sarcobatus/Artemisia:</u>	(4-13)	(3-7)	(8-16)	(3-16)
<u>Agropyron smithii</u>	25/20	33/30	75/57	100/61
<u>Poa secunda</u>		100/40	62/16	68/25
Grass Total	50/25	100/73	88/77	100/86
<u>Melilotus officinalis</u>	100/69	33/2		
Forb Total	100/73	33/2	25/1	100/11
<u>Chrysothamnus viscidiflorus</u>		33/17		
<u>Artemisia cana</u>			12/12	
Browse Total	50/2	67/25	62/22	67/2
<u>Agropyron/Symphoricarpos:</u>	(13-25)	(5-14)		(4-18)
<u>Agropyron smithii</u>	36/2	60/20		100/62
<u>Poa compressa</u>		20/7		75/15
Grass Total	43/3	100/36		100/84
<u>Aster commutatus</u>	14/T	40/12		
<u>Glycyrrhiza lepidota</u>	100/34	60/12		
<u>Helianthus maxamilliana</u>	7/T	20/10		
<u>Melilotus officinalis</u>	93/53	40/15		50/T
Forb Total	100/94	80/59		75/16
<u>Xanthium:</u>	(7-18)	(1-2)	(1-4)	(2-10)
<u>Agropyron smithii</u>	33/4			100/59
<u>Distichlis stricta</u>			100/12	
Grass Total	33.6		100/12	100/93
<u>Glycyrrhiza lepidota</u>	83/37	100/60	100/12	50/1
<u>Melilotus officinalis</u>	100/46	100/33		50/4
<u>Xanthium strumarium</u>	33/T		100/60	
Forb Total	100/92	100/100	100/71	50/7
<u>Artemisia longifolia</u>	17/T		100/17	
Browse Total	67/3		100/17	
<u>Artemisia longifolia:</u>	(3-10)			
<u>Lactuca serriola</u>	67/24			
<u>Melilotus officinalis</u>	100/57			
Forb Total	100/100			

TABLE XXXIII. Continued.

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Agropyron/Poa:</u>		(5-13)		
<u>Agropyron smithii</u>		100/13		
<u>Poa secunda</u>		100/57		
Grass Total		100/74		
<u>Melilotus officinalis</u>		60/22		
Forb Total		100/24		

1/ In parenthesis: The number of feeding sites on this vegetation-The total number of taxa used on the type.

2/ Per cent frequency of use among all feeding sites on this vegetation type/aggregate mean percentage of the total instances of use for this vegetation type. T = less than one per cent.

received moderate use, was the only other forb of importance. It was especially important on the Agropyron/Symphoricarpos type which was used intensively by elk during July and August. Aster commutatus, Lactuca serriola, Microseris nutans, and Tragopogon dubius received minor use, largely during June. Comandra umbellatum, Helianthus maximilliana, and Petalostemum purpureum also received minor use later in the period.

Browse, which received about 15 per cent of the total summer use, was used most intensively on the Pseudotsuga/Juniperus vegetation type during July and especially, August. The most important taxon was Prunus virginiana. Symphoricarpos spp. ranked second. Rhus trilobata received only minor use throughout the period, but was used on both of the timbered vegetation types. Rosa spp. and Ribes spp. also received minor use, largely on the Pseudotsuga/Juniperus type.

Grass and grass-like plants generally constituted only a minor percentage of the total use for elk during the summer. Agropyron smithii was the most intensively used taxon. It ranked third in importance over all, mostly because of exceptionally intensive use during one summer. Koleria cristata received minor use, primarily on the Artemisia/Agropyron and Pinus/Juniperus vegetation types. Other grasses received only very minor use at all times.

The slightly decreased use on forbs through the summer was complemented by increased use of browse. Grass use was consistently low throughout.

The contents of one elk rumen, collected during July 1963, was comprised almost entirely of Melilotus officinalis (Table XXXIV). Prunus virginiana, Rosa spp., and Symphoricarpos spp. were present but only in minor or trace amounts.

Fall (September, October, November).---Forty-three elk feeding sites were examined as follows: 1960, 23; 1961, 12; 1962, 7; and 1963, 1. Use was recorded on 35 taxa, including 18 forbs, 11 shrubs, and 16 grass and grass-like plants. Sixteen of these, 5 forbs, 5 shrubs, and 6 grasses, received more than one per cent of the total combined fall use.

Use of grass increased significantly from summer, constituting about 62 per cent of the total fall use. It was intensively used on all but the minor Xanthium vegetation type. Agropyron smithii, the single, most important taxon, received approximately 30 per cent of the total fall use.

TABLE XXXIV. FREQUENCY OF OCCURRENCE AND VOLUME PERCENTAGES OF PLANT TAXA AND FORAGE CLASSES AMONG 12 ELK RUMEN SAMPLES.

Taxa Forage class 1/	Summer	Fall			Winter 1963	Spring 1963	
	1963	1961	1962	1963			Total
	(1) 2/	(5)	(1)	(3)	(9)	(1)	(1)
Gramineae (Total)		100/87 ^{3/}	98	100/24	100/68	97	82
<u>Artemisia frigida</u>				33/6	11/2	T	
<u>Melilotus officinalis</u>	96			100/15	33/5		10
<u>Solidago</u> sp.				33/3	11/T		
<u>Yucca glauca</u>				67/2	22/T		
Unidentified forbs	T	60/T	T		44/T	2	1
Forb Total	97	60/1	T	100/26	66/8	2	12
<u>Artemisia cana</u>		20/T		33/11	22/6		
<u>Artemisia longifolia</u>				33/4	11/1		
<u>Artemisia tridentata</u>		80/6	T		55/3	T	
<u>Chrysothamnus</u> spp.		40/1		67/17	44/6		
<u>Prunus virginiana</u>	1			33/13	11/4		T
<u>Rosa</u> spp.	1	40/T		33/T	33/T		T
<u>Symphoricarpos</u> spp.	T			100/2	33/T		1
Unidentified browse	T	60/4	T	67/T	66/2	T	4
Browse Total	3	100/12	1	100/48	100/24	1	6

1/ Only those taxa which comprised at least one per cent of the total volume percentage for at least one season for one year. Others occurring, with season of use in parenthesis, were: Aster sp. (SuF), Cirsium sp. (F), Glycyrrhiza lepidota (SuF), Labiatae family (Su), Lomatium foeniculatum (S), Menzelia laevicaulis (F), Microseris nutans (S), Tragopogon dubius (SuF), Compositae family (W), Juniperus scopulorum (FW), Pinus ponderosa (F), Rhus trilobata (F), and Ribes sp. (S).

2/ Number of rumen samples in parenthesis.

3/ Per cent frequency of occurrence among rumen samples/average percentage of total volume each sample.

This occurred primarily during October and November. A. smithii received only minor use during September. Poa secunda ranked second among grasses for the entire period but was used intensively only when "green." Its greatest use occurred on the Agropyron/Poa vegetation type in late fall. Koeleria cristata, the only other grass to receive important use throughout fall, was also used most intensively when "green" and in late fall. Muhlenbergia cuspidata received only minor use over-all, but was the most intensively used grass during September. Other grasses received only very minor use.

Forbs ranked second. Melilotus officinalis was the most intensively used taxon for the entire period. Glycyrrhiza lepidota and Aster commutatus were equally important during September, when forbs were the most important forage source, but received only minor use later. Other forbs individually received only minor use and/or were used mostly on minor vegetation types.

Use on shrubs comprised about 15 per cent of the combined fall total. The most intensive use of browse occurred during September. Symphoricarpos spp. and Chrysothamnus viscidiflorus received consistent, though generally minor, use throughout fall. Use of other taxa was usually very minor. Artemisia longifolia was of some importance in September and both Artemisia tridentata and Juniperus scopulorum received minor use in late fall of some years.

Rumen samples indicated similar high levels of grass use during fall, but suggested that browse may be used to a greater extent than indicated by feeding site data, at least during some years.

Winter (December, January, February).---Data were obtained at 38 elk feeding sites; 22 in 1961, 9 in 1962, 3 in 1963, and 4 in 1964. Elk use was recorded on 39 taxa, including 14 forbs, 13 shrubs, and 12 grass and grass-like plants. Ten, consisting of one forb, five shrubs, and four grasses, received more than one per cent of the total combined winter use.

Grass was by far the most important forage class. Agropyron smithii, the single, most important taxon, received about 62 per cent of the total use. Poa secunda and Koleria cristata, which ranked second and third respectively, were used most intensively during early and late winter in years of fall "green-up." Agropyron spicatum was used relatively frequently but in only minor amounts. All other grasses received only occasional use during the period.

Shrubs constituted about 17 per cent of the total combined instances of use for winter. Nearly one-half of this was on Artemisia tridentata. Artemisia cana, Juniperus scopulorum, and Symphoricarpos spp. received minor use, mostly during January. This reflected sharply increased use of browse by elk during periods of snow cover. Rouse (1957) reported important use of browse by elk in winter only during periods of severe cold and snow cover. Other shrubs were used only occasionally, primarily in December and/or January.

The contents of the single rumen sample collected in late winter was comprised almost entirely of grass.

Spring (March, April, May).---A total of 33 elk feeding sites was examined during spring; 19 in 1960, 9 in 1962, and 5 in 1963. Elk use was recorded on 50 taxa, including 34 forbs, 5 shrubs, and 11 grass and grass-like plants. Eleven, five forbs, one shrub, and five grasses, received one per cent or more of the total spring use.

Grass continued from winter as the predominant forage for elk, constituting approximately 82 per cent of the total combined spring use.

Agropyron smithii, which remained the most important taxon, received about 50 per cent of the total use. Poa secunda received moderate use and was the second, most important source of forage throughout the period. Other grasses received only minor use. Those used more intensively included Agropyron spicatum in March, Stipa viridula in March and April, Poa compressa in April but only on the Agropyron/Symphoricarpos vegetation type, and Koeleria cristata throughout the period. Use of grasses generally decreased monthly throughout spring.

Forbs, which ranked second in the combined data, received only minor use during March, increased in relative use and importance during April, and were used rather intensively during May. Although no taxon individually received more than two per cent of the total combined spring use, several members of the Poa secunda union, Allium textile, Lomatium foeniculatum, and Microseris nutans, received relatively intensive use during April and May. Decreased use of this group after mid-May was complemented by relatively intensive elk use of several members of the

Tragopogon dubius union, especially Arnica sororia, Comandra umbellatum, Lactuca pulchella, Melilotus officinalis, Taraxacum officinale, Tragopogon dubius, and Vicia americana.

Spring use of shrubs was only minor, about five per cent of the total, and consisted largely of use of Artemisia tridentata during March and early April. Juniperus scopulorum also received some use during March. Use of browse was negligible during May.

The single rumen sample collected during early May showed similar taxa used and about the same percentages of grasses, forbs, and browse as feeding site data.

Yearlong Trends.--Yearlong elk preferences for forage classes and individual taxa for food were characterized by significant trends. Grass comprised the most important forage, averaging 58 per cent of mean monthly instances of use during the four-year period. The mean seasonal percentage of grass in elk rumen samples was 62 per cent. Use of grass was lowest during summer, increased sharply through September to October when grass became the predominant forage, then gradually through late fall and early winter. Grass use typically decreased during January in relation to increased use of other forage during periods of complete snow cover, but subsequently increased to the yearly maximum in February. Use was intensive through mid-April, then decreased sharply through late April and May to relatively low levels by early June. Trends in use of forbs, which ranked second over-all, generally complemented changes in use of grass.

Yearlong averages for use of forbs were 29 per cent of mean monthly instances of plant use and 30 per cent of mean seasonal rumen sample volume percentages. Use of forbs was most intensive during summer, when this forage class was by far the most important source of forage for elk. Use declined sharply throughout fall and early winter, increased slightly in January, then decreased to minimal in February. Use of forbs increased slightly through March and sharply through April and May to maximal summer levels during June. Over-all use of browse was only moderate. This forage class comprised approximately 13 per cent of the total instances of plant use averaged over months and 8 per cent of rumen samples averaged over seasons. Seasonal differences in intensities of use on shrubs, collectively, were not extensive. Use of browse was lowest during late April and May, when only occasional use occurred, then increased to near maximum during August and September. Use decreased slightly through November but increased during December to the yearly maximum during January. Subsequently, elk use of browse again declined slightly through March, then sharply to the minimum in late spring.

Melilotus officinalis was the single, most important taxon in relative use on feeding sites on all but the Pseudotsuga/Juniperus vegetation type from early June through early September. It persisted as the most important forb, receiving moderate use, throughout the fall when dry stems and/or abundant growth of first-year stems were available. Subsequent winter and spring use was always very minor or negligible.

Glycyrrhiza lepidota was the second-ranking forb and forage source during

summer and early fall. It received important use during July, August, and September on intensively used "coulee-bottom" sites, but was used only rarely during other periods. Prunus virginiana ranked third and was the most important browse plant for summer use, especially during July and August. Its use and importance declined after September when only occasional use occurred. Symphoricarpos sp. (mostly S. occidentalis) was the second, most important browse plant for seasonal use. It received consistent, though generally minor, use throughout summer as well as during fall and early winter. Rhus trilobata consistently received very minor use through summer and only occasionally during the remainder of the year. Summer elk use on shrubs consisted largely of leaves. Use of twigs increased and predominated after late summer.

A major change in the yearlong food habits of elk occurred during late September when increased use on Muhlenbergia cuspidata, Koeleria cristata, Poa secunda, and other grasses complemented decreased use of forbs and deciduous browse. M. cuspidata was used intensively and was the most important forage source only during late September. Use of Agropyron smithii, which received only minor use during summer and early fall, increased very sharply during October when this taxon became the single, most important food source for elk. Extremely intensive use of A. smithii prevailed throughout late fall, winter, and early spring. Its relative use and importance declined gradually through April and early May then very sharply during mid and late May to near minimum by early June. Poa secunda ranked as the second, most important source of elk forage

during the entire period of intensive use on A. smithii. Moderate intensities of use occurred during late fall and early winter, primarily following "green-ups," as well as throughout spring. Mid and late winter use varied in relation to the availability of "green" blades and/or snow cover.

Koeleria cristata, which received minor use throughout most of the year, was the only other grass receiving prominent use during the fall-winter-spring period. Its greatest importance occurred after "green-up" in late fall. Poa compressa received intensive use only on coulee-bottom sites during September and April. Stipa viridula received minor use throughout fall as well as in March and April, and Agropyron spicatum received very minor use throughout winter and spring. Among shrubs,

Chrysothamnus viscidiflorus received considerable use during September and relatively minor use later in the period. This taxon was used only occasionally after early winter. Artemisia longifolia received some intensive use during September but was used only rarely in other periods. Use of Artemisia tridentata increased during October and/or November and persisted at moderately low levels throughout winter and early spring. The most intensive use on this taxon occurred during periods of complete snow cover. Use declined sharply and was negligible by early April.

The second major change in the yearlong diet of elk occurred during late April and May. It coincided with increased availability of forbs and resulted in this forage class supplanting grass as the most important elk forage. The change was marked by increasingly intensive use of early forbs of the Poa secunda union through April and early May and subsequently,

by increasingly important use of forbs of the Tragopogon dubius union in late May and early June as food habits became characteristic of summer.

Yearlong trends in elk food habits reported for other studies vary between areas in relation to vegetational characteristics and/or seasonal availability of the various forage classes. Generally, as reported here, the results have indicated preference and intensive use of forbs and leaves of deciduous shrubs during summer. Extreme differences have been reported for winter; e.g., differences in relative use of grass and browse which range from more than 99 per cent grass (Morris and Schwartz, 1957) to 90 per cent browse (Young, 1938). Lovaas (1963) presented data showing relative use of forage classes by elk ranging from 69 per cent grass and 23 per cent browse during an "open" winter to 9 per cent grass and 91 per cent browse during a "severe" winter as evidence of elk preference for grass when available. The intensive use of grass by elk in early fall, when "summer" browse remained available, as well as during winter indicated that the importance of grass in the fall-winter-spring diet of elk in the Missouri River Breaks resulted from seasonal preference for this class of forage.

Year-to-Year Trends.---Intensities of elk use of forage classes (Table XXXV) and individual taxa (Table XXXVI) varied significantly between years. These differences were largely related to precipitation and its influence on plant growth (see discussion, page 141, and Table XXXII).

TABLE XXXV. A COMPARISON OF PERCENTAGES OF ELK USE OF GRASS, BROWSE, AND FORBS AT FEEDING SITES ON VARIOUS VEGETATION TYPES DURING SEASONS AND YEARS, 1960-64.

Forage Class	ARTEM/AGROP 1/				PINUS/JUNIP 2/				PSEUD/JUNIP 1/				SARCO/ARTEM 1/				All Types Combined			
	Su	Fa	Wr	Sp	Su	Fa	Wr	Sp												
Grass and Grass-like																				
1960-61	9	92	97	85	0	61	76	80	1	31	--	--	7	63	75	85	2	64	82	82
1961-62	71	81	69	71	65	31	82	74	0	--	--	--	88	--	75	88	44	67	75	79
1962-63	4	41	64	83	T	8	--	--	T	--	5	--	0	93	--	--	T	44	44	86
1963-64	5	69	82	--	13	--	79	--	2	--	--	--	--	--	90	--	4	69	83	--
1960-64	23	81	86	81	18	45	78	77	T	31	5	--	25	73	77	86	11	62	78	82
Browse																				
1960-61	0	3	T	4	9	19	16	0	92	51	--	--	2	37	25	4	20	16	11	3
1961-62	0	11	31	12	T	66	18	25	100	--	--	--	4	--	22	T	16	22	24	11
1962-63	0	0	34	4	15	0	--	--	31	--	89	--	0	T	--	--	9	T	53	3
1963-64	T	22	16	--	0	--	16	--	12	--	--	--	--	--	10	--	3	22	14	--
1960-64	T	6	11	6	8	33	17	10	67	51	90	--	2	25	22	2	14	15	17	5
Forbs																				
1960-61	97	5	3	11	91	20	8	20	7	18	--	--	91	0	0	11	78	20	7	15
1961-62	29	8	T	17	35	3	T	1	T	--	--	--	8	--	3	11	40	12	1	10
1962-63	96	59	2	13	84	92	--	--	69	--	6	--	100	7	--	--	90	56	3	10
1963-64	95	9	2	--	87	--	5	--	86	--	--	--	--	--	0	--	93	9	3	--
1960-64	77	13	2	13	74	22	6	13	32	18	6	--	73	2	1	11	75	23	5	13

1/ Vegetation Types: Artemisia/Agropyron; Pinus/Juniperus; Pseudotsuga/Juniperus; and Sarcobatus/Artemisia.

2/ Summer, fall, winter, and spring respectively.

3/ T = less than one per cent.

TABLE XXXVI. A COMPARISON OF RELATIVE INTENSITIES OF ELK USE OF SOME IMPORTANT FOOD PLANTS DURING SEASONS AND YEARS, 1960-64. 1/

Taxa	1960-61	1961-62	1962-63	1963-64
	Su/Fa/Wr/Sp <u>2/</u>	Su/Fa/Wr/Sp	Su/Fa/Wr/Sp	Su/Fa/Wr/Sp
<u>Melilotus officinalis</u>	65/ 6/ 0/ T	9/ T/ 0/ T	56/56/ T/ 5	85/ 8/ 1/--
<u>Prunus virginiana</u>	10/ T/ 2/ 0	7/ 0/ 0/ 0	3/ 0/ 0/ 0	0/ 0/ 0/--
<u>Symphoricarpos</u> spp.	5/ 6/ 2/ 0	6/ T/ 0/ 0	3/ 0/ 0/ 0	T/ 0/ 0/--
<u>Agropyron smithii</u>	T/40/65/68	32/24/58/41	T/ 1/26/32	T/67/77/--
<u>Poa secunda</u>	4/ 6/ 9/12	T/24/ 2/11	T/33/ 4/33	T/ 1/ 1/--
<u>Artemisia tridentata</u>	0/ 4/ T/ 2	0/ 2/17/ 8	0/ 0/34/ T	0/22/ 8/--
Number of taxa used	31/32/21/39	36/25/17/19	39/14/15/ 8	33/ 7/20/--

1/ Percentages of total instances of use on all vegetation types combined.

2/ Summer, fall, winter, and spring respectively.

The decreased availability of forbs during 1960 and 1961 was reflected in increased use of grasses and/or browse by elk. The most important difference occurred during the summer of 1961 when use of Melilotus officinalis and other forbs was lowest. Grass, especially Agropyron smithii, received intensive use and was the principal source of elk forage. Shrubs appeared to be used more intensively during summer in 1960 and 1961 as compared to 1962 and 1963. Greater use of browse occurred during the summer of 1960 when decreased use of forbs was complemented by increased use on shrubs rather than grass. During the summer of 1961, elk browsed intensively in June but only rarely in late summer when the most intensive use of shrubs occurred in other years.

The extreme abundance of forbs during the summer and fall of 1962 as well as the spring and summer of 1963 was reflected in increased use of this forage class, especially Melilotus officinalis, and decreased use of browse as compared to earlier years. Use of grass, as well as browse, declined during the fall of 1962 coincident to intensive use of M. officinalis.

Some yearly variation in fall food habits of elk was also influenced by the availability of "green" grass, especially Poa secunda. Use of this taxon increased sharply and use on Agropyron smithii declined following "green-ups" during October in 1961 and 1962.

The decreased use of grass, especially A. smithii, and intensive use of browse, particularly Artemisia tridentata, during the winter of 1962-63

was influenced by persistent snow cover and cold temperatures during January and early February.

Cattle

A total of 184 cattle feeding sites was examined between April 1961 and January 1964, mostly during the April-November grazing season. During winter, feeding sites were examined only when cattle were ranging freely on upland pastures and using only range forage. The number of instances of plant use recorded at each site varied from 60 to 780 but typically was between 200 and 300 (mean 237). The total number for all sites was 43,655.

Data for use of taxa which individually received at least ten per cent of the total instances of plant use for at least one vegetation type during at least one season are presented in Table XXXVII. Taxa which received less intensive use are considered in Appendix Table LXI.

Spring (April, May).—Thirty-seven cattle feeding sites were examined during spring after cattle were turned onto open range. This total included 10 in 1961, 12 in 1962, and 15 in 1963. Use was recorded on 48 taxa; 28 forbs, 6 shrubs, and 14 grass and grass-like plants. Ten of these, five forbs and five grasses, received an average of more than one per cent of the total instances of use during spring.

Grass was the most important source of forage on all vegetation types, comprising 82 per cent of the total combined spring use. Agropyron smithii, the predominant taxon, accounted for approximately two-thirds of the use on grasses. It was used on all sites examined. Poa secunda, which ranked

TABLE XXXVII. CATTLE USE OF TAXA WHICH INDIVIDUALLY RECEIVED AT LEAST TEN PER CENT OF THE TOTAL INSTANCES OF PLANT USE FOR AT LEAST ONE VEGETATION TYPE DURING AT LEAST ONE SEASON, 1961-63 COMBINED.

Vegetation Type: Plant Taxa	Spring	Summer	Fall	Winter
<u>Artemisia/Agropyron:</u>	(17-32) ^{1/}	(35-60)	(22-31)	(6-20)
<u>Agropyron smithii</u>	100/53 ^{2/}	100/35	100/47	100/55
<u>Muhlenbergia cuspidata</u>	5/2	65/15	61/5	17/T
<u>Poa secunda</u>	100/15	57/1	65/8	100/10
Grass Total	100/79	100/65	100/78	100/83
Browse Total	24/T	46/3	56/6	100/14
<u>Melilotus officinalis</u>	47/10	65/23	65/14	33/1
Forb Total	94/20	94/31	95/15	67/3
<u>Pinus/Juniperus:</u>	(9-24)	(22-45)	(8-24)	(4-19)
<u>Agropyron smithii</u>	100/45	100/37	100/57	100/32
<u>Agropyron spicatum</u>	44/1	45/3	75/3	75/33
<u>Poa secunda</u>	77/17	23/T	38/T	50/15
<u>Stipa viridula</u>	89/9	95/14	87/13	75/5
Grass Total	100/79	100/63	100/83	100/94
Browse Total	11/T	54/2	75/4	100/5
<u>Melilotus officinalis</u>	33/9	73/31	62/9	25/T
<u>Pseudotsuga/Juniperus:</u>		(4-19)		
<u>Agropyron spicatum</u>		100/19		
<u>Stipa viridula</u>		75/13		
Grass Total		100/49		
Browse Total		50/4		
<u>Melilotus officinalis</u>		75/43		
Forb Total		100/46		
<u>Sarcobatus/Artemisia:</u>		(7-20)	(7-25)	(4-12)
<u>Agropyron smithii</u>		100/49	85/38	100/47
<u>Poa secunda</u>		43/3	71/13	100/34
Grass Total		100/55	85/55	100/83
<u>Sarcobatus vermiculatus</u>		100/11	85/19	25/T
Browse Total		100/11	85/22	25/T
<u>Melilotus officinalis</u>		71/31	71/19	75/8
Forb Total		85/33	100/23	100/17

TABLE XXXVII. Continued.

Vegetation Type: Plant Taxa	Spring	Summer	Fall	Winter
<u>Agropyron/Symphoricarpos:</u>	(5-22)	(11-35)	(4-20)	
<u>Agropyron smithii</u>	100/83	100/72	100/81	
Grass Total	100/88	100/75	100/89	
Browse Total	40/1	73/2	75/2	
<u>Melilotus officinalis</u>	60/7	72/15	100/5	
Forb Total	80/11	100/22	100/9	
<u>Xanthium:</u>		(6-26)	(2-16)	
<u>Agropyron smithii</u>		100/33	100/35	
<u>Spartina pectinata</u>		50/10	50/2	
Grass Total		100/51	100/46	
Browse Total		50/T	50/T	
<u>Chenopodium album</u>		33/3	100/15	
<u>Melilotus officinalis</u>		100/38	100/31	
Forb Total		100/49	100/53	
<u>Artemisia longifolia:</u>		(1-3)		
<u>Agropyron smithii</u>		100/10		
<u>Calamovilfa longifolia</u>		100/82		
Grass		100/91		
Browse Total		100/8		
<u>Agropyron/Poa:</u>	(2-7)	(5-21)	(1-5)	(1-10)
<u>Agropyron smithii</u>	100/57	100/51	100/33	100/63
<u>Hordeum jubatum</u>	50/11			
<u>Poa secunda</u>	100/13	80/T	100/63	100/6
<u>Stipa viridula</u>	100/13	80/10	100/T	
<u>Bouteloua gracilis</u>		40/3		100/11
Grass Total	100/95	100/67	100/99	100/86
Browse Total		40/1		
<u>Melilotus officinalis</u>	100/2	100/24		100/10
Forb Total	100/4	100/31	100/T	100/13

1/ In parenthesis: The number of feeding sites on this vegetation-The total number of taxa used on the type.

2/ Per cent frequency of use among all feeding sites on this vegetation type/aggregate mean percentage of the total instances of use for this vegetation type. T = less than one per cent.

second, was used at moderate intensities and on about 85 per cent of the sites. Other grasses received only minor use though some, especially Koeleria cristata and Stipa viridula, were used relatively frequently.

Forbs received about 18 per cent of the total spring use but increased in importance throughout the period. Melilotus officinalis was the most intensively used forb, largely because of exceptional use during one year. All other taxa received only very minor use. Allium textile, Lomatium foeniculatum, and Microseris nutans were the most important individual taxa during April and early May. Tragopogon dubius and Vicia americana, in addition to Melilotus officinalis, were more intensively used in mid and late May.

Shrubs were only rarely used by cattle during spring.

Analyses of six cattle rumen samples (Table XXXVIII), collected during the spring of 1963, showed similar taxa but slightly greater use of grass than feeding site data.

Summer (June, July, August).--A total of 91 feeding sites was examined during the three summers; 23, 30, and 38 respectively for 1961, 1962, and 1963. Cattle use was recorded on 95 taxa, including 62 forbs, 10 shrubs, and 23 grass and grass-like plants. Eleven taxa, three forbs, one shrub, and seven grasses, received an average of one per cent or more of the total combined summer use.

TABLE XXXVIII. FREQUENCY OF OCCURRENCE AND VOLUME PERCENTAGES OF PLANT TAXA AND FORAGE CLASSES AMONG CATTLE RUMEN SAMPLES.

Taxa Forage Class	Spring	Summer		Total
	1963	1962	1963	
	(6) 1/	(4)	(8)	(12)
Cyperaceae family	17/T 2/		38/T	25/T
Gramineae family	100/90	100/92	100/71	100/78
Grass and Grass-like Total	100/90	100/92	100/71	100/78
<u>Camelina microcarpa</u>		25/T		8/T
<u>Comandra umbellatum</u>	17/T		62/T	42/T
Compositae family			12/T	8/T
Leguminosae family		25/T		8/T
<u>Melilotus officinalis</u>	83/10	25/T	100/26	75/18
<u>Thlaspi arvense</u>			12/T	8/T
<u>Vicia americana</u>	33/T		12/T	8/T
Unidentified forbs	33/T	75/6	38/T	50/2
Forb Total	100/10	75/6	100/27	92/20
<u>Artemisia tridentata</u>	50/T		62/T	42/T
<u>Chrysothamnus viscidiflorus</u>			12/T	8/T
<u>Prunus virginiana</u>			12/T	8/T
<u>Pinus ponderosa</u>	33/T		50/T	33/T
<u>Rhus trilobata</u>	33/T	25/T	62/T	50/T
<u>Ribes cereum</u>			12/T	8/T
<u>Rosa spp.</u>	33/T	25/T	38/T	25/T
<u>Symphoricarpos spp.</u>	17/T	25/T	38/T	25/T
Unidentified browse	100/T	75/1	100/T	92/T
Browse Total	100/T	75/1	100/2	92/2

1/ Number of rumen samples in parenthesis.

2/ Per cent frequency of occurrence among rumen samples/average percentage of total volume for each sample.

Use of grass decreased from spring, constituting about 64 per cent of the total summer use. Agropyron smithii remained the most important taxon, predominating in use for vegetation types that were used most intensively by cattle. It received about 40 per cent of the total use for all types combined and was used on 99 per cent of all feeding sites. Use of Muhlenbergia cuspidata, which ranked second among grasses and third over-all, was moderate on the Artemisia/Agropyron type and only minor on the Pinus/Juniperus type. It was used on less than one-half of all cattle feeding sites. Stipa viridula received only minor use particularly on the intensively used Artemisia/Agropyron vegetation type, but was used on about two-thirds of the sites examined. Use was most intensive in late summer and on the Pinus/Juniperus type. Other grasses, individually, received only very minor use. Of these, Bouteloua gracilis, which received minor use during early summer and moderate use in August on the Artemisia/Agropyron vegetation type, was of greatest importance.

Although grass was the most important forage throughout the period, forbs received moderate to relatively intensive use at feeding sites, especially during June and July. Melilotus officinalis was the most important forb and ranked second over-all for the three summers. It accounted for approximately 26 per cent of the total combined summer use. Use on other forbs was generally minor, but varied in relation to their abundance as well as the relative abundance and use of M. officinalis. Comandra umbellatum and Vicia americana were used most consistently and of some importance, especially in early summer. Tragopogon dubius was

used frequently at feeding sites but constituted only a small percentage of the total use.

Shrubs, collectively as well as individually, were of only minor importance. Sarcobatus vermiculatus, the most consistently used browse plant, received only one per cent of the total summer use. It was used largely on the Sarcobatus/Artemisia vegetation type. Rhus trilobata and Symphoricarpos sp. received relatively frequent, though very minor, use on the Pinus/Juniperus vegetation type.

The contents of 12 cattle rumen samples, collected during the summers of 1962 and 1963 (Table XXXVIII) were comprised of similar taxa but greater percentages of grass as compared to feeding site data.

Fall (September, October, November).--Data were obtained at 45 cattle feeding sites; 14 in 1961, 14 in 1962, and 17 in 1963. Use was recorded on 60 taxa, including 31 forbs, 10 shrubs, and 19 grass and grass-like plants. Ten of these, one forb, two shrubs, and seven grasses, individually received one per cent or more of the total instances of plant use during fall.

Grass was by far the most important forage class. Use increased from summer, constituting approximately 76 per cent of the combined, fall total. Agropyron smithii, the single, most important taxon, comprised about two-thirds of the total use on grasses. It was used on 98 per cent of all feeding sites. Use on Poa secunda was minor over-all but was relatively intensive and important, especially in October, during years of fall "green-up." Muhlenbergia cuspidata, Bouteloua gracilis, Koeleria cristata,

and Stipa viridula received relatively minor, though frequent, use at feeding sites. M. cuspidata and S. viridula were used most intensively during September; B. gracilis was more important in November. Other grasses were of only minor importance throughout the period.

Forbs ranked second throughout fall, largely because of intensive use of Melilotus officinalis, the only important taxon, during 1962 and September 1963. Other taxa were used only occasionally or on minor vegetation types.

Cattle use of shrubs increased from summer but remained of only minor importance. Browse constituted approximately 8 per cent of the total combined fall use and was used on 64 per cent of the feeding sites. Sarcobatus vermiculatus and Chrysothamnus nauseosus were the only taxa receiving intensive use. The latter was used most intensively during September. S. vermiculatus received minor use throughout the period. Symphoricarpos spp. received minor use on the Pinus/Juniperus and Agropyron/Symphoricarpos vegetation types.

Winter (December, January).--Eleven cattle feeding sites were examined during early winter; six in 1961-62, three in 1962-63, and two in 1963-64. Use was recorded on 27 taxa, including 9 forbs, 9 shrubs, and 9 grass and grass-like plants. Twelve of these, 1 forb, 3 shrubs, and 8 grasses, received one per cent or more of the total instances of use.

Grass, the predominant forage, constituted about 87 per cent of the total winter use. Agropyron smithii, the most intensively used taxon,

received nearly 50 per cent of the combined total use. Agropyron spicatum ranked second, but was used intensively only on the Pinus/Juniperus vegetation type. Its greatest use occurred during periods of complete snow cover in January. Poa secunda received moderate use, mostly during early winter in years marked by fall "green-up." Bouteloua gracilis, Koleria cristata, and Stipa viridula received minor, but frequent, use throughout the period.

Shrubs ranked second, receiving about 10 per cent of the total winter use. Artemisia tridentata, which was used on 46 per cent of all sites, Chrysothamnus nauseosus, and Sarcobatus vermiculatus were the most important browse plants, but individually received only very minor use.

Use of forbs was very minor during winter. Most of that recorded was on Melilotus officinalis.

Yearlong Trends.--Grass comprised the most important forage for cattle throughout the year, constituting approximately 76 per cent of the total instances of plant use averaged over months for the three-year period. Use of grass was most intensive during April, decreased gradually to the yearly minimum during June, then increased consistently to near maximum levels by November. Intensities of grass use on winter pastures were similar to those of November and/or April. Trends in use of forbs by cattle complemented changes in use of grass. This forage class comprised about 18 per cent of the total instances of use on feeding sites averaged for months. Maximum use of forbs occurred during June; the minimum in

December. Browse was of only minor importance at all times. Use on shrubs constituted approximately five per cent of the mean monthly instances of plant use. Relative intensities of use of this forage class were lowest in April and increased gradually through summer and early fall to a maximum of ten per cent of the total instances of use for October. Browse use on winter pastures was similar to that in October.

Agropyron smithii was the single, most important taxon in relative use on cattle feeding sites throughout the year. Trends in use of A. smithii, which comprised between one-half and two-thirds of the use on grass and grass-like plants during all periods, paralleled those described for the forage class. Poa secunda ranked second in use on feeding sites during spring. Subsequently, it received only occasional use during summer and early fall. Fall use varied from very minor to intensive in relation to fall precipitation and "green-up." Other grasses were of only minor importance during most periods. Those which were frequently used on feeding sites included: Stipa viridula which received more intensive use in late spring as well as late summer and early fall; Muhlenbergia cuspidata which was of some importance only during summer and early fall; Bouteloua gracilis which received minor use throughout but was of greater importance in late summer; and Koleria cristata which received minor use during most periods. Agropyron spicatum received important use only on winter pastures. Use of all other grasses was always very minor and/or occurred largely on minor vegetation types.

The decline in relative use of grasses in late April was complemented by increased use of early forbs, especially Allium textile, Lomatium foeniculatum, and Microseris nutans of the Poa secunda union in late April and early May and Comandra umbellatum, Vicia americana, and Melilotus officinalis of the Tragopogon dubius union in late May and early June. M. officinalis was the single, most important forb used by cattle from June through September as well as later in the fall and winter when first-year growth and/or dry stems persisted. Use of other forbs in summer, fall, and winter was only very minor and/or occurred only on minor vegetation types.

Sarcobatus vermiculatus, the most important shrub, received only minor use throughout most of the year. Rhus trilobata, occasionally received minor use on the Pinus/Juniperus vegetation type during summer.

Symphoricarpos spp. was frequently used at feeding sites on the Pinus/Juniperus and Agropyron/Symphoricarpos types during summer and fall but constituted only a minor percentage of the total use. Use on Chrysothamnus nauseosus occurred after flowering in August, increased to some importance during early fall, then generally declined. Minor use of this taxon also occurred on winter pastures. Artemisia tridentata received minor use on winter pastures, mostly during periods of complete snow cover.

Year-to-Year Trends.--Cattle food habits were less affected by yearly differences in precipitation and vegetal growth than those of mule deer

or elk but some important variation in use of forage classes (Table XXXIX) and individual taxa (Table XL) was evident.

Grass use was consistently high at cattle feeding sites throughout 1961 and the spring of 1962 when plant growth was minimal. Subsequent increased growth and availability of forbs, especially Melilotus officinalis, during the summer of 1962 was directly reflected in greater representation of this forage class as well as M. officinalis in recorded use for the summer and fall of that year. Further increases in abundance during 1963 influenced more intensive use of forbs during spring, and especially, summer when forbs comprised the most important forage class and M. officinalis was the single, most important taxon at cattle feeding sites. Comparisons of mean percentages of total forbs and M. officinalis in rumen samples for 1962 and 1963 (Table XXXVIII) show increased use of these items during 1963. The greater percentages for grass than for forbs in the samples for the summer of 1963 was in contrast to feeding site data. The maximum percentage of forbs in a single sample was 82 per cent but the percentage in most was between 10 and 15 per cent. This suggested that the relative use and importance of forbs may have been unduly exaggerated at feeding sites.

Although differences were not extreme, higher percentages of use of browse at feeding sites during 1961 as compared with 1962 and 1963 suggested slightly greater use of browse by cattle during periods of poor range-forage conditions.

TABLE XXXIX. A COMPARISON OF PERCENTAGES OF CATTLE USE OF GRASS, BROWSE, AND FORBS AT FEEDING SITES ON VARIOUS VEGETATION TYPES DURING SEASONS AND YEARS, 1960-63.

Forage Class	ARTEM/AGROP 1/			PINUS/JUNIP 1/			SARCO/ARTEM 1/			All Types Combined			
	Sp	Su	Fa 2/	Sp	Su	Fa	Sp	Su	Fa	Sp	Su	Fa	Wi
Grass													
1961	90	86	97	88	92	93	--	70	35	89	87	81	90
1962	85	70	65	86	65	70	77	61	80	86	69	70	78
1963	64	45	85	62	42	89	88	38	62	73	46	80	90
1961-63	79	66	78	79	62	84	82	55	56	82	64	76	87
Browse													
1961	T ^{3/}	5	T	0	5	5	--	30	39	6	6	11	9
1962	1	3	4	0	1	2	0	10	T	T	4	2	16
1963	0	T	4	T	2	7	1	5	18	T	1	6	2
1961-63	T	3	6	T	3	4	T	12	22	T	3	7	10
Forbs													
1961	10	9	2	12	3	2	--	0	26	10	8	8	T
1962	14	26	31	14	34	28	23	29	20	13	27	28	6
1963	36	54	11	38	56	4	11	57	20	26	52	14	8
1961-63	20	31	16	21	35	12	17	33	22	18	33	17	3

1/ Vegetation Types: Artemisia/Agropyron; Pinus/Juniperus; and Sarcobatus/Artemisia.

2/ Spring, summer, and fall respectively.

3/ T = less than one per cent.

TABLE XL. A COMPARISON OF RELATIVE INTENSITIES OF CATTLE USE OF SOME IMPORTANT FOOD PLANTS DURING SEASONS AND YEARS, 1961-63. 1/

Taxa	<u>1961</u> Sp/Su/Fa	<u>1962</u> Sp/Su/Fa	<u>1963</u> Sp/Su/Fa
<u>Melilotus officinalis</u>	T/ T/ 5	2/19/25	19/48/11
<u>Agropyron smithii</u>	58/47/45	62/48/41	48/30/61
<u>Poa secunda</u>	16/ T/10	14/ 2/14	18/ T/ 1
Number of taxa used	23/44/30	32/59/33	37/69/45

1/ Percentages of total instances of use on all vegetation types combined.

The influence of fall precipitation and "green-up" on cattle use of individual grasses was indicated by relatively intensive use of Poa secunda when "green" during fall periods in 1961 and 1962 as compared to only very minor use of this taxon plus increased use of Agropyron smithii during the fall of 1963 when "green-up" did not occur.

RANGE RELATIONS

Interspecific relations between grazing animals may connote "competition" in which the welfare of one or more of the animals is adversely affected. The extent to which two species graze the same area and prefer the same forage was considered by Julander (1958) as the main factor controlling interspecific competition. Cole (1958a) listed similar criteria, but included requirements that forage plants be in limited supply or deteriorating as a result of combined use. Smith and Julander (1953) differentiated the latter as "forage" competition as opposed to "land use" competition which they associated with common use of a forage species which was adequately abundant to meet the requirements of both animals, but where removal of one would permit increased numbers of the other. Cole (op.cit.) recognized circumstances under which certain big game species may benefit from heavy livestock grazing.

Data from the present study were evaluated with respect to these considerations which require comparisons of the distributions of animal use on the area in time and space in relation to vegetation types, topography, and water sources, as well as forage preferences and the composition, abundance, and intensity of use of forage plants.

Elk and Mule Deer Relations

Mule deer and elk were most similar in habits between April and September. The distribution of elk during this period overlapped the distribution of greatest mule deer densities. Both animals used the Artemisia/Agropyron vegetation type, especially the Artemisia tridentata/

Agropyron smithii/Bouteloua gracilis association, intensively during early spring. After mid-May, mule deer use became concentrated on timbered vegetation types as did some significant summer elk use. Some forbs and Poa secunda were used by both animals during April and May, but grass, primarily Agropyron smithii, was the most important elk forage. Forbs became important for elk as well as mule deer in late spring and summer when similar taxa were used by both. Melilotus officinalis was one of the most important mule deer forage sources and the single, most important elk forage from June through early September. Browse, a very important summer forage for mule deer, was of only moderate importance in the summer diet of elk. Rhus trilobata, the most important mule deer summer browse plant, received only minor use by elk. Prunus virginiana, the most important summer browse for elk, received relatively minor use by mule deer. Browse became more important for mule deer during September when grass was used increasingly by elk. Chrysothamnus nauseosus, used intensively by mule deer, was of little importance to elk.

Dissimilarities in range use and food habits of mule deer and elk during late fall and winter afforded less opportunity for association and conflict. Grass, the most important elk forage after September, received little use by mule deer. During winter, the Artemisia/Agropyron vegetation type was used intensively and the Pinus/Juniperus and Sarcobatus/Artemisia types received moderate use by both animals, but food habits differed. Grass was the major item in the elk diet and browse was the most important food for mule deer. Artemisia tridentata, the most important winter deer

browse under prevailing conditions, received only minor use by elk as did Juniperus scopulorum and Symphoricarpos spp. which received moderate or minor use by mule deer.

Although these results indicate probable conflicts between mule deer and elk, complete evaluation of the interaction requires consideration of forage conditions as well as other range use factors.

Numbers of elk on the study area apparently were not excessive with respect to forage, as indicated by the average ratio of 57 calves per 100 females for the four-year period.

Mule deer probably contended with forage deficiencies and intra-specific competition during most years as a result of excessive utilization of forage. Measurements of nine utilization and condition trend sample units using methods described by Cole (1958b) showed that an average of 58 per cent (40 per cent to 81 per cent yearly) of the available "leaders" on Rhus trilobata was used annually during the four-year period. Relatively low levels of "leader use" during 1962-63 and 1963-64, 40 per cent and 53 per cent respectively, reflected "buffering" by the unusual abundance and use of forbs during those years. Despite this, more than 80 per cent of all plants of R. trilobata were "severely hedged." More than 95 per cent of the plants were "decadent" and/or reduced to "resprouts." The annual average percentage of leader use on Chrysothamnus nauseosus for six sample units was 85 per cent (77 per cent to 89 per cent yearly). More than 95 per cent of the plants were "decadent" by the spring of 1964. Leader use on Chrysothamnus viscidiflorus

averaged more than 80 per cent for the four years on one upland site. The average percentage of leaders used on Artemisia tridentata on five sample units was 24 per cent (8 per cent to 32 per cent yearly) for the four-year period, but utilization of this extremely abundant plant varied in relation to the availability of other forage. Prunus virginiana was reduced to clumps of resprouts and plants taller than six feet on which browse was largely unavailable to mule deer. The extreme utilization and deteriorated condition of important summer-fall forage plants indicated that summer and fall range condition was equally as important as winter range to the welfare of mule deer. The condition of the winter range was directly related to the intensity of summer-fall use of certain "key" species. Additional utilization of any of the more important summer and fall browse plants by other animals would have adverse effect on the mule deer forage supply and population.

The home range behavior and restricted movement of mule deer may also have affected interspecific relations. In contrast to mule deer, elk moved extensively in response to changes in availability of forage during all seasons and thus were capable of substantial impact on forage supplies of individual deer.

It seems apparent that direct competition of elk with mule deer must have occurred during the April-September period, especially early spring, of most years. In comparison with the April-September period, conflict between elk and mule deer during late fall and winter would be of minor

importance related to occasional elk use of mule deer browse plants, other than Artemisia tridentata, on local areas.

The evidence indicated that elk were more "efficient" competitors than mule deer. Elk intensively used most vegetation types, topographic sites, as well as all classes of forage during the year and/or as necessary under the various conditions which prevailed during the four-year period. Mule deer consistently used a limited number of vegetation types and were strongly restricted in their diet of browse and forbs, except for use of a single grass species when "green" and when other forage was limited.

Elk and Cattle Relations

The distributions of intensive elk and cattle use overlapped throughout the April-November grazing season. The two animals were extremely similar in habits during spring and fall but generally dissimilar through summer. Elk habits during winter were alike those of cattle but the distribution of elk was restricted to the southeastern and/or other portions of the study area where only occasional cattle use had occurred previously. Both animals used grass intensively and in about the same proportion during spring. Use on Agropyron smithii, the most important forage source for both, was also very similar. The Artemisia/Agropyron vegetation type was used most intensively by elk as well as cattle. Habits diverged after late May when forbs generally became the most important source of elk forage and the timbered vegetation types received significant elk use. Although some forbs were commonly used by both

animals, elk typically utilized only minor amounts of grass which continued as the most important cattle forage. Habits of the two species became increasingly similar during September and were closely comparable during October and November.

These data indicated opportunity for direct and intensive interaction between elk and cattle during early spring and fall, especially on the Artemisia tridentata/Agropyron smithii/Bouteloua gracilis association in early spring. Conflict of a less direct nature could result because of intensive use of Agropyron smithii, the favored winter food of both animals, by cattle during the grazing season, and by elk in fall on livestock wintering areas. Intensive use of Muhlenbergia cuspidata, Poa secunda, and Koeleria cristata by elk under various conditions somewhat lessened the conflict on cattle pastures. Actual competition was also limited by the low numbers, distribution, and movements of elk. Elk preferred areas which had received little, if any, prior use by cattle during the same year and moved extensively in response to changes in forage availability and/or the distribution of domestic livestock grazing. They readily used steeper and the timbered vegetation types in deference to a ridgetops and bottomlands which had received recent use by livestock.

The opportunity for elk-cattle interaction increased significantly during periods of severely reduced forb growth when elk intensively utilized grass, especially Agropyron smithii, during summer as well as other seasons.

Mule Deer and Cattle Relations

The overlap between areas of intensive cattle grazing and greater mule deer densities indicated opportunity for interaction, but food and range-use habits differed substantially. Grass comprised the major portion of the cattle diet, whereas browse and/or forbs were the most important foods of mule deer. More extensive, level or gently rolling ridgetop and coulee-bottom areas were used most intensively by cattle. Mule deer range use was largely on the timbered vegetation types on steeper slopes. The greatest overlap was in April and early May on the Artemisia/Agropyron vegetation type, especially on the Artemisia tridentata/Agropyron smithii/Bouteloua gracilis association. Poa secunda and several forbs, the occurrence of which was probably related to heavy grazing by cattle in previous years, were commonly used by both animals, but Agropyron smithii, the most important source of cattle forage was used only occasionally by mule deer. Forbs received moderate use by cattle. Little overlap in food habits occurred in summer. The degree of overlap increased after late summer when cattle use on the Pinus/Juniperus type increased slightly, possibly because of intensive grass utilization on primary range sites during spring and summer. Mule deer use on the Artemisia/Agropyron type became increasingly intensive during fall. Common use occurred on Chrysothamnus nauseosus, an important browse plant for mule deer. Moderate use of this plant by cattle may have increased its palatability for mule deer because of the latter's preference for clipped stems.

The opportunity for association and conflict between mule deer and cattle during winter was limited by restriction of cattle to pastures where only minor use of browse occurred.

CONCLUSIONS AND RECOMMENDATIONS FOR MANAGEMENT

Rhus trilobata and Chrysothamnus nauseosus were "key" mule deer forage species. Agropyron smithii was a "key" species for both elk and cattle. The abundance, intensity of use, and condition of these plants on "key" range sites should serve as bases for evaluating range conditions. Melilotus officinalis was extremely important to mule deer and elk. Its heavy use during years of abundance relieved the drain on key species. This "exotic" apparently has become established as a part of the vegetation of the Missouri River Breaks but because of extreme fluctuations in abundance should not be considered as a basic forage source for management.

"Key" range areas for mule deer were the Pinus/Juniperus vegetation type on moderate to steep slopes and the Artemisia/Agropyron type on smaller ridgetops and along margins of more extensive ridges. Small to moderately extensive ridgetops dominated by Artemisia/Agropyron in areas of "light" cattle use appeared to be "key" areas for elk. "Primary" range areas for cattle were extensive, unbroken ridgetops as well as coulee-bottoms within about one mile of a dependable water source.

Mule deer should be more rigidly controlled by adequate hunter harvests and maintained at levels which will permit improvement and replacement of deteriorated browse plants as well as sustain deer populations.

Greater than existing numbers of elk will not be compatible with management to sustain mule deer range and populations. Whether existing numbers are compatible is not clear. The relative importance of elk with respect to mule deer as well as other game species and land uses must be

evaluated and established as a basis for management. If mule deer are deemed the most important species, elk should not be permitted to increase beyond existing numbers or be reduced in number from existing population levels.

The potential impact of elk range use on the biota of the Missouri River Breaks should be recognized and given foremost consideration in the management of existing game populations, in introduction of new animal species to the area, and in relation to introduction of elk into other areas along the Missouri River or similar habitat in eastern Montana where "multiple-use" is the object of management.

In multiple-use management programs, livestock numbers and management should be considered on the basis of the forage available, with "proper" utilization of Agropyron smithii, on "primary" range areas rather than by "type" or the entire area. Winter grazing should be restricted from areas where smaller ridges and timbered coulees are closely interspersed.

Big game-livestock interactions were most intensive during April and early May. Consideration should be given to changing the date of onset of livestock grazing to mid-May when plant growth is more advanced. This would eliminate conflict during early spring and reduce possible competition during subsequent periods.

The development and control of water sources in association with "primary" cattle range areas could effect better cattle distribution and lessen opportunities for overlapping range use and conflict with game. Water development should not be considered for terminal portions of larger

ridges or on smaller ridges where the area available for cattle dispersal on "primary" range types is limited.

Allowable utilization with respect to forage production and reproduction of "key" browse and grass species should be evaluated experimentally. Experiments should also be designed and conducted to ascertain the time and conditions required to restore "range condition," especially browse in areas where existing plants are in deteriorated condition, reproduction is lacking, and/or previously existing plants have been removed by excessive use. Until such time as more quantitative criteria are established, usually accepted criteria for "proper" use should be rigidly enforced.

SUMMARY

A study of the food habits, range use and relations of mule deer, elk, and cattle was conducted during 1960-64 on a 75,000 acres area in the Missouri River Breaks in northcentral Montana to provide criteria for management on ponderosa pine/juniper and related vegetation types.

Physiographic, climatic, and land-use characteristics of the area were described.

Canopy-coverage analyses of three stands of each of 12 rangeland communities provided data on vegetal characteristics of the Artemisia/Agropyron vegetation type, including the A. tridentata/A. spicatum association, the A. tridentata/A. smithii associates, and the A. tridentata/A. smithii/Bouteloua gracilis association; the Agropyron/Poa type (A. smithii/P. secunda associates); the Pinus/Juniperus type, including the P. ponderosa/A. spicatum association, the P. ponderosa/J. scopulorum association, and the P. ponderosa/Artemisia longifolia association; the Pseudotsuga/Juniperus type (P. menziesii/J. scopulorum association); the Sarcobatus/Artemisia type (S. vermiculatus/A. tridentata association); the Agropyron/Symphoricarpos type (A. smithii/S. occidentalis association); the Xanthium strumarium type (association); and the Artemisia longifolia type (associates).

Observations totaling approximately 11,600 for mule deer, 3,500 for elk, and 25,000 for cattle provided information on distributions, movements, population trends, and range use.

Mule deer were distributed over the entire area. Variation in seasonal distribution reflected differences in food and range-use habits in relation to availability of preferred forage. Seventy-six relocations of 10 recognizable mule deer over periods of 1 day to 29 months indicated that mule deer movement was largely restricted to relatively small home ranges. Relocations of two marked females over periods of 29 months indicated movement within approximately 300 acres. Relocations of three males to 16, 20, and 21 months of age suggested that males moved more extensively after their second summer. Mule deer population estimates indicated a decline in numbers during 1960-62 and recovery during 1963-64, and suggested a mean winter density of about 10 mule deer per square mile for the 1960-64 period. Comparisons of trends in estimated mule deer numbers with trends in numbers of mule deer observed per trip along vehicle routes indicated that the latter reflected changes in "observability" rather than numbers of animals on the area.

Elk were generally distributed on the south and west-central portion of the area during summer and the southeast portion during winter. Local distributions varied in relation to forage conditions. Sixty-eight relocations of 13 recognizable elk within periods of 1 day to 4 years showed average movement of 3.4 miles between relocations; the maximum was 14.5 miles. The extreme mobility enabled elk to adjust rapidly to environmental conditions and utilize the most favorable portions of the range. Minimum counts of elk on the study area during winters were 70 in 1960-61, 80 in 1961-62, 108 in 1962-63, and 108 in 1963-64.

Greatest cattle densities occurred on the southern one-half of the area during the April-November grazing season. Use of local areas varied in relation to forage availability, water supplies, and weather conditions. Winter grazing was restricted to pastures on the northern and southcentral portions of the area. Numbers of cattle on the area varied considerably within and between years.

Approximately 90 per cent of the total numbers of mule deer, elk, and cattle observed were recorded within three and one-half hours after sunrise and before sunset. Intensive activity was concentrated in the first and last hours of daylight. The "prolonged" activity periods of late winter and early spring were characterized by persistence of activity through two and one-half or three and one-half hours after sunrise and before sunset and some activity in mid-day.

Approximately 54, 70, and 87 per cent respectively of all observed mule deer, elk, and cattle were feeding. Feeding was the predominant activity among mule deer observed during all hours as well as among elk and cattle observed within three and one-half hours after sunrise and before sunset. Decreased proportions of mule deer observed feeding through the four years were indicative of increased wariness.

Mean numbers of animals observed per group were 3.0 mule deer, 6.9 elk, and 6.7 cattle. Average group sizes varied in relation to intensities of use of the Artemisia/Agropyron vegetation type and/or certain range sites. Variation in numbers of mule deer in groups also reflected the

locations within home ranges of individuals on overlapping home ranges.

More than 47 per cent of the mule deer observed during summer were on the Pinus/Juniperus vegetation type. Use on this as well as the Pseudotsuga/Juniperus type, which was indicated as second in importance, declined after early fall concomitant with increased use on Artemisia/Agropyron. The latter was shown to be the most important type for mule deer use from early December through mid-May, receiving about 67 and 76 per cent respectively of total use for winter and spring. The low "observability" of mule deer during summer and fall indicated greater than observed use of timbered vegetation types during those periods. Intensities of mule deer use on the various vegetation types were shown to vary between years in relation to influences of precipitation and/or mule deer populations on abundance of certain forage plants.

During summer, elk use was predominantly on coulee-bottom and timbered vegetation types with more than 50 per cent of the total feeding elk observed on the Sarcobatus/Artemisia, Agropyron/Symphoricarpos, and Xanthium types collectively. The Pseudotsuga/Juniperus type was especially important for calving during June and for bedding throughout summer. After September, use on these types declined concomitant to increased use on the Artemisia/Agropyron type. The latter, which predominated elk use from October through May, received nearly 50 per cent of elk use for feeding during fall and winter and 81 per cent of that for spring. The Pinus/Juniperus type was indicated as moderately important in fall and received more than one-third of the total use for winter when open and semi-open

slopes were used intensively. The Sarcobatus/Artemisia type received some important use on slopes in winter and on coulee bottoms in early spring. The Agropyron/Poa type received important elk usage during October and November in years of fall "green-up." The Artemisia/Agropyron type received intensive elk use during all seasons under drought conditions which prevailed from 1960 through the spring of 1962.

Approximately 60 to 70 per cent of the total cattle observed during all seasons were on the Artemisia/Agropyron type. The Sarcobatus/Artemisia and Agropyron/Symphoricarpos types in coulee bottoms collectively received moderate cattle usage and comprised the second, most important area for cattle use during the grazing season. The Pinus/Juniperus type was shown to receive minor use by cattle during winter and spring and moderate usage in summer and fall. Some yearly differences in seasonal use of vegetation types occurred in relation to differences in precipitation and its influence on plant growth and water supplies.

Use of slopes of various degrees of steepness closely reflected animal use of vegetation types. Approximately 50, 42, and 18 per cent respectively of the total mule deer, elk, and cattle were observed on slopes steeper than 11 degrees.

Percentages of total mule deer, elk, and cattle observed on slopes of various exposures appeared to reflect relative amounts of area with each exposure more strongly than animal preferences.

Distances at which mule deer and elk were observed from water were largely related to the distribution of water sources with respect to areas

used by the animals during different seasons and years. The distribution of water sources, even during the most arid years, was not a significant factor in determining either mule deer distributions or the distribution of elk within seasonal ranges. Consistent observations of most cattle within one-half mile of water indicated that the distribution of cattle use on the area was closely related to the distribution of water.

Data from 263 mule deer feeding site examinations showed that forbs were the most important forage during summer. Use of forbs constituted 56 per cent of the total combined instances of plant use in summer, 23 per cent during fall, 10 per cent during winter, and 35 per cent during spring. Browse constituted 43 per cent of the total use for summer, and 72, 88, and 52 per cent respectively of the total use for fall, winter, and spring when shrubs were the most important forage source. Use of grass was minor, amounting to a trace, 5, 2, and 13 per cent of respective seasonal use. Melilotus officinalis was the principal summer forb. Rhus trilobata, Chrysothamnus nauseosus, and Artemisia tridentata respectively were indicated as the most important browse plants for summer-early fall, late fall-early winter, and late winter-early spring. Poa secunda, when green, was the only grass to receive significant use by mule deer during any season. Significant changes in the diet of mule deer occurred during September, late November or early December, late March or early April, and late May. Use of forage classes and individual taxa varied significantly between years in relation to precipitation and its influence on plant growth. Intensive and unseasonally early use of browse during

1960 and 1961 was associated with decreased availability of forbs. Intensive use of Melilotus officinalis in years of abundance "buffered" use on important browse species.

Examination of 178 elk feeding sites showed that forbs were the most important forage during summer. This forage class constituted 75 per cent of the total combined instances of plant use in summer, 23 per cent in fall, 5 per cent in winter, and 13 per cent in spring. Grass use was minor during summer, comprising 11 per cent of the total, but was most important during fall, winter and spring when it comprised 62, 78, and 82 per cent respectively of the total seasonal use. Browse amounted to 14, 15, 17, and 5 per cent of the summer, fall, winter, and spring use respectively.

Melilotus officinalis was the most important summer forage.

Agropyron smithii was the single, most important taxon in use from October through May. Significant yearlong changes in the diet of elk occurred during September and late May or early June. Agropyron smithii was used intensively throughout the summer of 1961 and browse received increased summer use during 1960 as well as 1961 when forb growth was minimal.

Examination of 184 cattle feeding sites showed that grass was the predominant forage throughout the year, constituting 82, 64, 76, and 87 per cent of the total instances of plant use for spring, summer, fall, and winter respectively. Forbs comprised 18, 33, 17, and 3 per cent respectively of total use during these seasons. Browse was a minor item in the

diet of cattle at all times, amounting to a trace, 3, 7, and 10 per cent of the total use for respective seasons. Agropyron smithii was the predominantly used taxon throughout the year.

Comparisons of food and range-use habits and behavior of mule deer and elk indicated conflict between April and September, especially during April and early May. Heavy utilization and deteriorated condition of important mule deer browse plants aggravated conflict occurring after mid-May. The evidence indicated that elk were more efficient competitors than mule deer.

Considerable overlap in habits of elk and cattle afforded opportunity for direct conflict during early spring and fall as well as less direct conflict resulting from use of elk wintering areas in summer by cattle and use of cattle wintering areas by elk in fall. Competition was lessened by low numbers, distribution, and movements of elk.

The potential for competition between mule deer and cattle was limited by broad differences in food and range-use habits. The greatest opportunities for conflict occurred on the Artemisia/Agropyron vegetation type in April and early May and during late summer and fall. Overlap in range use increased during the latter period and common use on Chrysothamnus nauseosus occurred on the Artemisia/Agropyron type.

Abundance, intensity of use, and condition of "key" species Rhus trilobata, Chrysothamnus nauseosus, and Agropyron smithii on "key" range sites should serve as criteria for evaluating range conditions as

well as regulating animal numbers in mule deer, elk, and "multiple-use" management programs.

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APPENDIX

TABLE XLI. CONSTANCY, CANOPY-COVERAGE, AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA HAVING CONSTANCY OF LESS THAN 67 PER CENT OR MEAN CANOPY-COVERAGE OF LESS THAN ONE PER CENT IN ANY COMMUNITY ON THE ARTEMISIA/AGROPYRON TYPE. 1/

Community	<u>A. tridentata/</u> <u>A. spicatum</u> Association	<u>A. tridentata/</u> <u>A. smithii</u> Associes	<u>A. tridentata/</u> <u>A. smithii/</u> <u>B. gracilis</u> Association	Combined Type Totals
Union: Taxa	Cy/Cv/Fr 2/	Cy/Cv/Fr	Cy/Cv/Fr	Cy/Cv/Fr
<u>Agropyron spicatum:</u>				
<u>Carex filifolia</u>	33/ +/ +			11/ +/ +
<u>Muhlenbergia cuspidata</u>		33/ +/ 3	33/ +/ 5	22/ +/ 3
<u>Artemisia tridentata:</u>				
<u>Aster canescens</u>			33/ +/ +	11/ +/ +
<u>Aster occidentalis</u>			33/ +/ +	11/ +/ +
<u>Astragalus bisulcatus</u>			33/ +/ 4	11/ +/ 1
<u>Linum rigidum</u>			33/ +/ 6	11/ +/ 2
<u>Orobanché ludoviciana</u>			33/ +/ 2	11/ +/ +
<u>Psoralea argophylla</u>			33/ +/ 2	11/ +/ +
<u>Tragopogon dubius:</u>				
<u>Bahia oppositifolia</u>	33/ +/ 9			11/ +/ 3
<u>Collomia linearis</u>		33/ +/ +		11/ +/ +
<u>Gaura coccinea</u>	33/ +/ 6			11/ +/ 2
<u>Grindelia squarrosa</u>			33/ +/ +	11/ +/ +
<u>Lactuca pulchella</u>		33/ +/ +		11/ +/ +
<u>Phacelia linearis</u>	33/ +/ 6	33/ +/ 8	33/ +/ 2	33/ +/ 5
<u>Poa secunda:</u>				
<u>Astragalus agrestis</u>			33/ +/ 2	11/ +/ +
<u>Astragalus missouriensis</u>			33/ +/ 2	11/ +/ +
<u>Lepidium densiflorum</u>		33/ +/ +		11/ +/ +
<u>Lomatium foeniculatum</u>		33/ +/ 2		11/ +/ +

TABLE XLI. Continued.

Community	<u>A. tridentata/</u> <u>A. spicatum</u> Association	<u>A. tridentata/</u> <u>A. smithii</u> Associates	<u>A. tridentata/</u> <u>A. smithii/</u> <u>B. gracilis</u> Association	Combined Type Totals
Union: Taxa	Cy/Cv/Fr <u>2/</u>	Cy/Cv/Fr	Cy/Cv/Fr	Cy/Cv/Fr
<u>Sarcobatus vermiculatus:</u> <u>Sarcobatus vermiculatus</u>		33/ +/ 4		11/ +/ 1
<u>Xanthium strumarium:</u> <u>Lactuca serriola</u>	33/ +/ 2			11/ +/ +
<u>Polygonum erectum</u>	33/ +/ +	33/ +/ 2	33/ +/ +	33/ +/ +
<u>Iva axillaris</u>		33/ +/ 2		11/ +/ +

1/ Data are mean percentages for 120 two x five dm plots (40 in each of three stands) in each community.

2/ Constancy/canopy-coverage/frequency. +/+ indicates canopy-coverage or frequency values less than one per cent.

TABLE XLII. CONSTANCY, CANOPY-COVERAGE, AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA HAVING CONSTANCY OF LESS THAN 67 PER CENT OR MEAN CANOPY-COVERAGE OF LESS THAN ONE PER CENT ON THE AGROPYRON SMITHII/POA SECUNDA ASSOCIATION. 1/

<u>Union:</u> Taxa	Cy/Cv/Fr 2/
<u>Agropyron smithii:</u>	
<u>Bouteloua gracilis</u>	33/ +/ +
<u>Koeleria cristata</u>	33/ +/ 2
<u>Schedonnardus paniculatus</u>	33/ +/ +
<u>Artemisia tridentata:</u>	
<u>Artemisia tridentata</u>	33/ +/ +
<u>Gutierrezia sarothrae</u>	33/ +/ 5
<u>Aster occidentalis</u>	33/ +/ +
<u>Plantago spinulosa</u>	33/ +/ 3
<u>Poa secunda:</u>	
<u>Mertensia lanceolata</u>	33/ +/ 2
<u>Tragopogon dubius:</u>	
<u>Cirsium undulatum</u>	33/ +/ +
<u>Tragopogon dubius</u>	33/ +/ +
<u>Xanthium strumarium:</u>	
<u>Conringia orientalis</u>	33/ +/ 3

1/ Data are mean percentages for 120 two x five dm plots distributed as 40 in each of three stands.

2/ Constancy/canopy-coverage/frequency. +/+ indicates canopy-coverage or frequency values less than one per cent.

TABLE XLIII. CONSTANCY, CANOPY-COVERAGE AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA HAVING CONSTANCY OF LESS THAN 67 PER CENT OR MEAN CANOPY-COVERAGE OF LESS THAN ONE PER CENT ON THE PINUS/JUNIPERUS TYPE. 1/

Association	<u>Pinus ponderosa/</u> <u>Agropyron spicatum</u> Association	<u>Pinus ponderosa/</u> <u>J. scopulorum</u> Association	<u>Pinus ponderosa/</u> <u>Artemisia longifolia</u> Association	Combined Type Total
Union:				
Taxa	Cy/Cv/Fr 2/	Cy/Cv/Fr	Cy/Cv/Fr	Cy/Cv/Fr
<u>Artemisia tridentata:</u>				
<u>Psoralea argophylla</u>	33/ +/ 2			33/ +/ +
<u>Poa secunda:</u>				
<u>Astragalus agrestis</u>		33/ +/ 3		33/ +/ 1
<u>Poa secunda</u>	33/ +/ 3	33/ +/ +		22/ +/ 1
<u>Juniperus scopulorum:</u>				
<u>Danthonia unispicatum</u>	33/ +/ 1			11/ +/ +
<u>Poa compressa</u>	33/ +/ 2			11/ +/ +
<u>Tragopogon dubius:</u>				
<u>Collomia linearis</u>	33/ +/ +	33/ +/ +		22/ +/ +
<u>Helianthus petiolaris</u>			3/ +/ +	11/ +/ +
<u>Senecio canus</u>		33/ +/ +		11/ +/ +
<u>Sphaeralcea coccinea</u>	33/ +/ 3		33/ +/ +	22/ +/ 1
<u>Prunus virginiana:</u>				
<u>Ribes setosum</u>		33/ +/ +		11/ +/ +
<u>Galium aparine</u>		33/ +/ 5		11/ +/ 2
<u>Artemisia longifolia:</u>				
<u>Convulvulus sepium</u>			33/ +/ +	11/ +/ +
<u>Yucca glauca</u>			33/ +/ +	11/ +/ +
<u>Xanthium strumarium:</u>				
<u>Cirsium arvense</u>	33/ +/ 2			11/ +/ +
<u>Polygonum sp.</u>			33/ +/ 2	11/ +/ +
<u>Salsola kali</u>			33/ +/ 2	11/ +/ +

1/ Data are mean percentages for 120 two x five dm plots (40 in each of three stands) in each association.

2/ Constancy/canopy-coverage/frequency, + = canopy-coverage or frequency less than one per cent.

TABLE XLIV. CONSTANCY, CANOPY-COVERAGE, AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA HAVING CONSTANCY OF LESS THAN 67 PER CENT OR MEAN CANOPY-COVERAGE OF LESS THAN ONE PER CENT ON THE PSEUDOTSUGA/JUNIPERUS TYPE. 1/

<u>Union:</u> <u>Taxa</u>	<u>Cy/Cv/Fr</u> <u>2/</u>
<u>Symphoricarpos occidentalis:</u>	
<u>Poa compressa</u>	33/ +/ +
<u>Agropyron smithii:</u>	
<u>Stipa viridula</u>	33/ +/ 2
<u>Poa secunda:</u>	
<u>Descuriana pinnata</u>	33/ +/ 5
<u>Tragopogon dubius:</u>	
<u>Artemisia ludoviciana</u>	33/ +/ +
<u>Cirsium undulatum</u>	33/ +/ +
<u>Lactuca pulchella</u>	33/ +/ +
<u>Melilotus officinalis</u>	33/ +/ 3
<u>Senecio canus</u>	33/ +/ +
<u>Taraxacum officinale</u>	33/ +/ +
<u>Tragopogon dubius</u>	33/ +/ +
<u>Vicia americana</u>	33/ +/ 4

1/ Data are mean percentages for 120 two x five dm plots distributed as 40 in each of three stands.

2/ Constancy/canopy-coverage/frequency. +/+ indicates canopy-coverage or frequency values less than one per cent.

TABLE XLV. CONSTANCY, CANOPY-COVERAGE AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA HAVING CONSTANCY OF LESS THAN 67 PER CENT OR MEAN CANOPY-COVERAGE OF LESS THAN ONE PER CENT ON THE SARCOBATUS VERMICULATUS/ARTEMISIA TRIDENTATA ASSOCIATION, THE AGROPYRON SMITHII/SYMPHORICARPOS OCCIDENTALIS ASSOCIATION, OR THE XANTHIUM STRUMARIUM ASSOCIATION. 1/

Association	<u>Sarcobatus vermiculatus/</u> <u>Artemisia tridentata</u>	<u>Agropyron smithii/</u> <u>Symphoricarpos occidentalis</u>	<u>Xanthium</u> <u>strumarium</u>
Union:			
Taxa	Cy/Cv/Fr 2/	Cy/Cv/Fr	Cy/Cv/Fr
<u>Artemisia tridentata:</u>			
<u>Gutierrezia sarothrae</u>	33/ +/ 6		
<u>Sarcobatus vermiculatus:</u>			
<u>Atriplex nuttallii</u>	33/ +/ 1		
<u>Agropyron smithii:</u>			
<u>Bromus japonicus</u>	33/ +/ 2		
<u>Tragopogon dubius:</u>			
<u>Artemisia ludoviciana</u>		33/ +/ 9	
<u>Grindelia squarrosa</u>		33/ +/ +	
<u>Symphoricarpos occidentalis:</u>			
<u>Rosa arkansana</u>		33/ +/15	
<u>Xanthium strumarium:</u>			
<u>Atriplex dioica</u>			33/ +/ +

1/ Data are mean percentages for 120 two x five dm plots (40 in each of three stands) in each association.

2/ Constancy/canopy-coverage/frequency. +/+ indicates canopy-coverage or frequency values less than one per cent.

TABLE XLVI. CONSTANCY, CANOPY-COVERAGE, AND FREQUENCY AND DISTRIBUTION BY UNIONS OF TAXA HAVING CONSTANCY OF LESS THAN 67 PER CENT OR CANOPY-COVERAGE OF LESS THAN ONE PER CENT ON THE ARTEMISIA LONGIFOLIA ASSOCIES. 1/

<u>Union:</u> Taxa	Cy/Cv/Fr 2/
<u>Artemisia longifolia:</u>	
<u>Mirabilis linearis</u>	33/ +/ +
<u>Yucca glauca</u>	33/ +/ +
<u>Agropyron smithii:</u>	
<u>Stipa viridula</u>	33/ +/ +
<u>Poa secunda:</u>	
<u>Poa secunda</u>	33/ +/ 3
<u>Tragopogon dubius:</u>	
<u>Artemisia ludoviciana</u>	33/ +/ +
<u>Campanula rotundifolia</u>	33/ +/ +
<u>Solidago missouriensis</u>	33/ +/ 4
<u>Thermopsis rombifolia</u>	33/ +/ 3
<u>Gaura coccinea</u>	33/ +/ 7
<u>Xanthium strumarium:</u>	
<u>Conringia orientalis</u>	33/ +/ 2
<u>Polygonum spp.</u>	33/ +/ 2
<u>Iva axillaris</u>	33/ +/ 7

1/ Data are mean percentages for 120 two x five dm plots distributed as 40 in each of three stands.

2/ Constancy/canopy-coverage/frequency. +/+ indicates canopy-coverage or frequency values less than one per cent.

TABLE XLVII. PERCENTAGES OF TOTAL MULE DEER OBSERVED BY ACTIVITY CLASS DURING SEASONS AND YEARS, 1960-64.

Activity	Year	Summer	Fall	Winter	Spring	Yearly Averages
Feeding	1960-61	55 (400) ^{1/}	48 (353)	54 (739)	66 (1,727)	56 ^{2/}
	1961-62	48 (312)	57 (318)	46 (363)	61 (758)	53
	1962-63	42 (195)	44 (70)	50 (244)	51 (311)	47
	1963-64	39 (139)	49 (77)	42 (44)	31 (36)	40
	1960-64 Comb.	47	51	50	62	54
Alert	1960-61	30 (220)	38 (273)	33 (452)	25 (644)	31
	1961-62	34 (223)	29 (161)	48 (386)	27 (334)	34
	1962-63	31 (143)	29 (45)	33 (163)	28 (170)	30
	1963-64	29 (104)	32 (51)	28 (30)	27 (32)	30
	1960-64 Comb.	31	33	37	26	31
Traveling	1960-61	11 (79)	12 (90)	6 (90)	8 (198)	9
	1961-62	11 (71)	10 (56)	2 (17)	10 (123)	8
	1962-63	19 (87)	24 (38)	13 (66)	18 (108)	18
	1963-64	23 (83)	17 (27)	10 (10)	37 (43)	22
	1960-64 Comb.	14	13	7	10	11
Bedding	1960-61	4 (29)	2 (12)	6 (87)	2 (48)	3
	1961-62	7 (49)	4 (24)	4 (31)	2 (30)	4
	1962-63	9 (42)	2 (4)	3 (16)	3 (20)	5
	1963-64	9 (32)	2 (3)	20 (21)	5 (6)	8
	1960-64 Comb.	7	3	6	2	4

^{1/} Number of mule deer in parenthesis.

^{2/} Mean of seasonal percentages.

TABLE XLVII. AVERAGE NUMBERS OF MULE DEER OBSERVED BY ACTIVITY CLASS PER TRIP UNDER VARIOUS ENVIRONMENTAL CONDITIONS.

Condition	Number of Trips	Feeding	Bedding	Alert and Traveling	Total
Temperature					
-0°	20	18.4 (57) ^{1/}	2.1 (6)	12.1 (37)	32.6
1-32°	76	17.4 (51)	1.9 (6)	14.5 (43)	33.9
33-45°	91	17.9 (57)	1.1 (4)	12.0 (39)	31.0
46-60°	175	8.9 (56)	1.1 (5)	7.6 (39)	19.5
61-80°	96	8.6 (51)	T (4) ^{2/}	7.6 (45)	16.9
81°+	63	3.4 (45)	T (6)	3.6 (49)	7.4
Precipitation					
None	455	11.7 (54)	1.1 (5)	8.9 (41)	21.8
Light Rain	30	12.7 (60)	1.2 (6)	7.2 (34)	21.2
Rain	24	2.5 (52)	T (4)	2.7 (44)	5.7
Light Snow	6	19.2 (44)	1.6 (9)	15.0 (47)	36.8
Snow	6	10.0 (60)	1.0 (6)	5.7 (34)	16.7
Wind Velocity					
Calm	185	14.4 (54)	1.1 (4)	11.4 (42)	26.9
-10 mph	208	11.8 (57)	1.0 (5)	8.1 (38)	21.0
11-20 mph	67	9.2 (49)	1.6 (8)	8.1 (43)	18.8
21-30 mph	31	10.1 (56)	T (4)	7.2 (40)	18.0
31+ mph	30	6.5 (51)	T (6)	5.5 (43)	12.8
Cloud Cover					
Clear	186	11.1 (51)	1.1 (5)	9.6 (44)	21.8
Partly	201	12.2 (55)	1.2 (5)	8.8 (40)	21.0
Mostly	61	8.7 (52)	1.1 (7)	6.8 (41)	16.6
Overcast	73	16.7 (61)	T (3)	10.0 (36)	27.6
Ground Condition					
Dry	345	11.1 (55)	T (4)	8.3 (41)	20.2
Damp	64	15.0 (58)	1.5 (6)	9.3 (36)	25.9
Muddy	24	12.2 (62)	T (4)	6.6 (34)	19.6
Scat. Snow	41	13.8 (45)	2.7 (9)	13.2 (46)	30.9
Snow Cover	46	13.2 (51)	1.2 (5)	11.4 (44)	26.1
Moon Phase					
New	135	11.8 (53)	1.2 (5)	9.2 (41)	22.2
First $\frac{1}{4}$	114	12.0 (56)	1.0 (5)	8.5 (39)	21.4
Full	139	12.3 (54)	1.0 (4)	9.4 (42)	22.7
Last $\frac{1}{4}$	131	12.1 (54)	1.2 (5)	9.1 (41)	22.5

^{1/} Percentage of total mule deer observed under each set of conditions in parenthesis.

^{2/} T = less than one per cent.

TABLE XLIX. PERCENTAGES OF TOTAL MULE DEER OBSERVED ON VEGETATION TYPES BY ACTIVITY, SEASONS, AND YEARS, 1960-64.

Season Year	Sample Size	Average Number Observed Per Trip	Observability Index 1/	Percentage Feeding 2/	ARTEM/ AGROP		AGROP/ POA		PINUS/ JUNIP		PSEUD/ JUNIP		SARCO/ ARTEM		AGROP/ SYMPH		XANTH		ARLO 3/	
					4/	5/	4/	5/	4/	5/	4/	5/	4/	5/	4/	5/	4/	5/	4/	5/
Summer 1960	731	12.4	16.0	54.9	36.3	37.2	T	0.5	39.7	47.2	5.3	3.8	5.0	3.7	6.3	3.8	4.8	3.2	2.4	1.5
1961	669	15.2	19.5	47.6	33.6	30.0	T	0.6	34.2	44.2	13.5	13.0	9.3	7.0	6.0	4.3	1.5	T	T	T
1962	483	10.3	16.3	41.7	22.9	22.2	1.0	T	52.9	53.8	9.5	12.0	11.0	9.5	2.4	1.7	T	T	0	0
1963	373	11.1	14.6	38.8	20.9	20.4	0	T	44.6	45.6	24.5	22.8	5.0	5.6	3.6	2.7	T	T	T	T
1960-63	2,256	12.3	16.6	47.3	31.0	29.1	T	T	41.2	47.5	11.0	11.4	7.5	6.3	5.1	3.3	2.4	1.0	1.3	T
Fall 1960	734	14.7	21.6	48.4	47.5	47.7	5.5	3.0	22.7	29.2	8.2	8.7	2.5	4.0	9.8	5.6	1.4	T	2.5	1.4
1961	587	18.3	28.0	56.8	34.7	35.1	5.5	3.6	31.1	33.9	3.8	7.2	11.5	10.1	5.5	3.9	1.4	1.0	3.0	3.1
1962	163	7.4	13.2	44.5	22.4	28.8	0	1.2	39.5	40.5	11.8	11.7	26.3	16.0	0	1.8	0	0	0	0
1963	163	9.4	14.5	48.7	11.9	21.5	0	0	35.7	41.1	34.5	25.2	4.8	5.5	6.0	3.1	0	0	7.1	3.7
1960-63	1,647	13.6	19.3	51.0	37.3	38.7	4.6	2.7	29.2	33.2	9.3	10.1	8.5	7.5	6.7	4.4	1.1	T	3.0	2.1
Winter 1961	1,441	27.7	39.1	54.0	63.5	57.7	1.5	T	21.5	28.3	2.1	1.9	9.5	10.0	0	T	T	T	T	T
1962	845	33.8	70.4	45.6	73.8	59.8	T	T	22.2	32.4	0	T	4.0	7.6	0	0	0	0	0	0
1963	526	22.9	47.7	49.8	59.9	43.0	0	0	33.3	42.4	5.2	44.6	1.5	10.1	0	0	0	0	0	0
1964	120	17.1	31.7	41.9	79.2	63.3	0	0	11.3	30.0	3.8	4.2	5.7	2.5	0	0	0	0	0	0
1961-64	2,932	27.6	47.2	50.3	66.8	55.9	T	T	23.6	32.1	2.1	2.0	8.1	9.0	0	T	T	T	T	T
Spring 1961	2,671	58.1	100.0	65.9	82.0	77.5	0	0	11.6	16.7	T	T	4.8	4.0	1.4	1.3	0	0	0	0
1962	1,330	47.5	100.0	60.8	72.0	62.3	T	1.5	18.6	26.5	1.3	1.1	5.4	6.7	T	1.0	T	T	T	T
1963	625	20.2	42.1	51.0	51.5	51.8	T	T	21.1	27.0	2.1	4.2	10.0	12.5	1.8	T	T	T	3.6	3.0
1964	120	30.0	55.5	30.7	100.0	66.7	0	0	0	26.7	0	4.2	0	2.5	0	0	0	0	0	0
1961-64	4,746	43.6	74.4	61.7	76.2	69.6	T	T	14.4	21.0	T	1.3	6.5	5.8	1.3	1.1	T	T	T	T
1960-61	5,577	27.0	44.2	59.1	68.3	63.2	T	T	18.5	25.3	2.2	2.4	5.6	5.5	2.6	1.9	T	T	T	T
1961-62	3,431	26.6	54.2	53.7	58.9	50.7	1.4	1.3	24.4	32.7	3.6	4.3	6.9	7.5	2.4	1.9	T	T	T	T
1962-63	1,797	14.7	29.8	47.6	44.8	39.2	0	T	33.9	40.0	5.6	7.1	12.5	11.3	1.2	T	T	T	1.3	1.1
1963-64	776	12.5	29.1	40.1	38.1	34.4	0	T	31.1	39.3	20.6	17.5	4.4	4.6	3.2	1.9	T	T	2.2	1.7
1960-64	11,581	22.3	39.4	54.5	61.1	53.8	T	T	23.1	30.7	4.0	4.7	6.8	6.9	2.4	1.8	T	T	T	T

1/ Percentage of total mule deer expected to be observed per trip.

2/ Percentage of total mule deer observed feeding.

3/ Vegetation types: Artemisia/Agropyron; Agropyron/Poa; Pinus/Juniperus; Pseudotsuga/Juniperus; Sarcobatus/Artemisia; Agropyron/Symphoricarpos; Xanthium; and Artemisia longifolia, respectively.

4/ Feeding = the percentage of feeding mule deer observed on this type.

5/ Total = the percentage of total mule deer observed on this type, T = less than one per cent.

TABLE I. PERCENTAGES OF TOTAL MULE DEER OBSERVED ON VARIOUS VEGETATION TYPES IN RELATION TO WEATHER CONDITIONS.

Condition	Sample Size	ARTEM/AGROP, AGROP/POA <u>1/</u>	PINUS/ JUNIP	PSEUD/ JUNIP	SARCO/ARTEM, AGROP/SYMPH, XANTH.
Temperature					
-0°	654	50.2	39.8	1.5	8.6
1-32°	2,575	62.4	27.3	2.2	8.1
33-45°	2,825	64.2	27.1	3.2	5.5
46-60°	3,425	46.2	34.9	7.4	11.5
61-80°	1,623	50.5	32.2	5.4	11.8
81°+	468	35.9	4.2	9.0	13.0
Precipitation					
None	9,914	53.4	32.3	4.9	9.3
Light Rain	636	53.3	30.7	5.2	10.8
Rain	34	41.2	38.2	5.9	14.7
Light Snow	886	70/3	22.2	1.6	5.9
Snow	100	45.0	29.0	8.0	18.0
Wind Velocity					
Calm	4,984	56.5	31.2	4.8	8.6
-10 mph	4,382	56.9	29.8	4.4	8.9
11-20 mph	1,262	49.7	29.3	6.2	14.8
21-30 mph	559	42.4	45.2	8.9	11.4
31+ mph	383	37.6	42.3	6.5	13.6
Cloud Cover					
Clear	4,048	47.0	36.1	6.0	10.8
Partly	4,494	59.8	28.6	3.7	7.9
Mostly	1,012	44.8	35.8	7.0	12.4
Overcast	2,016	63.2	26.5	3.0	7.3
Ground Condition					
Dry	6,970	52.0	32.2	5.6	10.2
Damp	1,659	65.1	26.9	2.8	5.2
Muddy	471	47.1	28.9	10.6	13.4
Scat. Snow	1,268	59.3	32.2	1.0	7.5
Snow Cover	1,202	53.3	33.8	3.5	9.4

1/ Vegetation types: Artemisia/Agropyron and Agropyron/Poa combined; Pinus/Juniperus; Pseudotsuga/Juniperus; and Sarcobatus/Artemisia, Agropyron/Symphoricarpos, and Xanthium combined.

TABLE LI. PERCENTAGES OF TOTAL ELK OBSERVED BY ACTIVITY CLASS DURING SEASONS AND YEARS, 1960-64.

Year	Summer	Fall	Winter	Spring	Yearly Averages
Feeding 1960-61	78 (151) ^{1/}	74 (267)	67 (253)	79 (253)	74 ^{2/}
1961-62	54 (72)	85 (203)	76 (342)	75 (144)	72
1962-63	70 (114)	58 (140)	56 (79)	70 (110)	63
1963-64	60 (81)	4 (1)	78 (48)	14 (2)	39
1960-64 Comb.	66	70	70	74	70
Alert 1960-61	6 (13)	20 (76)	20 (75)	12 (41)	15
1961-62	16 (21)	2 (5)	22 (99)	4 (9)	11
1962-63	12 (21)	30 (71)	26 (37)	26 (42)	24
1963-64	12 (16)	96 (23)	0 (0)	86 (12)	48
1960-64 Comb.	11	20	20	15	16
Traveling 1960-61	10 (21)	4 (15)	8 (33)	6 (22)	8
1961-62	20 (26)	10 (24)	0 (0)	2 (5)	8
1962-63	10 (18)	8 (19)	16 (22)	0 (0)	8
1963-64	18 (24)	0 (0)	3 (2)	9 (0)	5
1960-64 Comb.	14	6	6	4	8
Bedding 1960-61	4 (9)	1 (5)	4 (14)	1 (4)	2
1961-62	10 (14)	2 (6)	2 (8)	17 (33)	8
1962-63	6 (11)	4 (10)	2 (3)	3 (5)	4
1963-64	9 (12)	0 (0)	18 (11)	0 (0)	6
1960-64 Comb.	7	2	4	6	4

^{1/} Number of elk in parenthesis.

^{2/} Mean of seasonal percentages.

TABLE LIII. AVERAGE NUMBERS OF ELK OBSERVED BY ACTIVITY CLASS PER TRIP UNDER VARIOUS ENVIRONMENTAL CONDITIONS.

Condition	Number of Trips	Feeding	Bedding	Alert and Traveling	Total
Temperature					
-0°	20	8.2 (76) ^{1/}	2.0 (18)	T. (5) ^{2/}	10.7
1-32°	76	6.7 (66)	T. (8)	2.6 (26)	10.0
33-45°	91	7.3 (68)	1.1 (10)	2.4 (22)	10.9
46-60°	175	3.1 (65)	T (5)	1.4 (29)	4.8
61-80°	96	3.1 (72)	T (8)	T (20)	4.3
81°+	63	3.0 (72)	T (6)	T (21)	4.2
Precipitation					
None	455	4.6 (67)	T (7)	1.7 (25)	6.8
Light Rain	30	2.2 (52)	1.0 (26)	1.0 (23)	4.3
Rain	24	7.3 (84)	T (5)	1.0 (11)	8.8
Light Snow	6	3.5 (88)	T (12)	0.0 (0)	4.0
Snow	6	3.0 (90)	0.0 (0)	T (10)	3.3
Wind Velocity					
Calm	185	5.1 (63)	T (7)	2.3 (29)	8.0
-10 mph	208	4.0 (71)	T (10)	1.0 (18)	5.5
11-20 mph	67	4.4 (66)	T (12)	1.4 (21)	6.6
21-30 mph	31	6.3 (79)	T (8)	1.0 (12)	8.0
31+ mph	30	3.4 (62)	T (2)	2.0 (36)	5.6
Cloud Cover					
Clear	186	4.4 (65)	T (4)	2.1 (31)	6.7
Partly	201	4.5 (75)	T (11)	T (15)	6.0
Mostly	61	2.2 (46)	T (17)	1.8 (37)	4.9
Overcast	73	7.1 (72)	T (9)	1.9 (19)	9.9
Ground Condition					
Dry	345	3.7 (70)	T (8)	1.2 (23)	5.3
Damp	64	4.9 (64)	1.1 (15)	1.6 (21)	7.6
Muddy	24	3.9 (64)	T (9)	1.7 (28)	6.3
Scat. Snow	41	6.5 (64)	T (6)	3.1 (30)	10.3
Snow Cover	46	8.9 (71)	1.0 (8)	2.6 (21)	12.6
Moon Phase					
New	135	5.9 (71)	T (7)	1.8 (22)	8.4
First $\frac{1}{4}$	114	4.1 (66)	T (10)	1.5 (24)	6.2
Full	139	3.9 (59)	T (10)	2.0 (31)	6.5
Last $\frac{1}{4}$	131	4.3 (76)	T (7)	T (16)	5.6

^{1/} Percentage of total elk observed under each set of conditions in parenthesis.

^{2/} T = less than one per cent.

TABLE LIII. PERCENTAGES OF TOTAL ELK OBSERVED ON VEGETATION TYPES BY ACTIVITY, SEASONS, AND YEARS, 1960-64.

Season	Year	Sample Size	Average Number Observed Per Trip	Percent- age Feeding 1/	ARTEM/ AGROP		AGROP/ POA		PINUS/ JUNIP		PSEUD/ JUNIP		SARGO/ ARTEM		AGROP/ SYMPH		XANTH		ARLO 2/	
					Feed 3/	Totl 4/	Feed	Totl	Feed	Totl	Feed	Totl	Feed	Totl	Feed	Totl	Feed	Totl	Feed	Totl
Summer	1960	194	3.3	77.8	30.4	30.7	0.0	0.0	18.3	22.2	0.0	7.9	12.0	5.8	13.6	13.2	24.6	19.0	1.0	1.1
	1961	145	3.3	54.1	32.9	33.1	0.0	0.0	17.1	28.3	13.3	10.3	5.1	7.6	31.6	20.7	0.0	0.0	0.0	0.0
	1962	189	4.0	69.5	3.3	4.9	0.0	0.0	22.3	29.3	22.3	44.0	39.1	5.4	12.6	14.7	T	T	0.0	1.1
	1963	136	4.0	60.9	13.6	14.7	0.0	0.0	0.0	27.2	9.9	11.8	55.6	33.1	17.3	11.0	0.0	0.0	3.7	2.2
	1960-63	664	3.6	66.9	19.8	20.6	0.0	0.0	17.0	26.6	11.9	19.4	24.8	11.8	18.1	14.8	7.4	5.7	T	1.1
Fall	1960	378	9.6	73.5	64.7	57.9	0.0	0.0	17.9	25.9	4.5	4.8	4.5	2.4	5.9	6.3	2.3	2.6	T	0.0
	1961	263	8.2	85.2	41.8	56.3	34.2	24.0	1.6	1.9	2.5	6.5	5.6	4.9	13.5	5.3	T	1.1	0.0	0.0
	1962	278	12.6	58.3	10.1	39.6	51.3	29.1	31.6	24.8	0.0	1.4	5.1	4.0	1.9	1.1	0.0	0.0	0.0	0.0
	1963	32	1.9	4.1	0.0	3.1	0.0	0.0	25.0	6.3	50.0	81.3	0.0	0.0	25.0	9.4	0.0	0.0	0.0	0.0
	1960-63	951	7.8	70.6	46.2	50.3	22.0	15.1	13.2	18.3	3.5	6.8	5.0	3.5	8.7	4.6	1.3	1.4	T	0.0
Winter	1961	397	7.6	67.4	50.2	49.4	0.0	T	34.3	36.0	T	T	13.3	12.6	T	1.0	1.3	0.0	0.0	0.0
	1962	484	19.4	76.1	34.5	38.6	0.0	0.0	48.2	47.1	0.0	0.0	17.3	14.3	0.0	0.0	0.0	0.0	0.0	0.0
	1963	173	7.5	56.0	75.0	52.6	0.0	0.0	12.0	27.2	0.0	12.7	13.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0
	1964	74	10.6	78.6	69.6	67.5	0.0	0.0	23.2	24.3	3.6	2.7	3.6	5.4	0.0	0.0	0.0	0.0	0.0	0.0
	1961-64	1,128	10.5	70.3	47.6	46.5	0.0	T	36.8	38.7	T	2.3	14.2	12.1	T	T	T	0.0	0.0	0.0
Spring	1961	338	7.3	79.0	86.5	68.6	0.0	T	4.1	19.5	2.1	2.7	3.9	6.8	3.0	2.1	T	T	0.0	0.0
	1962	219	7.8	75.3	74.6	73.1	0.0	0.0	10.7	11.4	2.8	3.7	5.6	3.7	5.1	7.8	1.1	T	0.0	0.0
	1963	175	5.6	70.0	57.3	59.4	0.0	0.0	8.9	10.3	7.3	8.0	25.8	21.1	0.0	T	0.0	0.0	T	T
	1964	14	3.5	14.2	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1961-64	746	6.8	74.6	81.0	66.5	0.0	0.0	5.9	16.5	2.8	4.2	6.7	9.1	3.0	3.4	T	T	T	T
1960-61	1,307	6.3	73.8	63.7	54.1	0.0	T	19.5	26.8	1.6	3.4	8.3	7.1	3.6	4.6	3.1	3.6	T	T	
1961-62	1,111	8.6	75.2	42.5	48.9	12.1	5.7	22.4	26.9	3.0	3.6	10.0	9.1	9.5	5.5	T	T	0.0	0.0	
1962-63	815	6.6	63.1	28.3	38.8	13.6	10.0	20.3	23.2	9.5	14.9	22.9	8.8	5.0	3.8	T	T	T	T	
1963-64	256	4.1	56.8	33.1	27.7	0.0	0.0	11.9	27.7	10.6	17.2	31.1	19.1	11.3	7.0	0.0	0.0	2.0	1.2	
1960-64	3,489	6.7	70.6	51.5	46.9	5.4	4.2	20.2	26.1	3.4	7.2	11.6	9.0	5.8	4.9	1.8	1.5	T	T	

1/ The percentage of total elk observed that were feeding.

2/ Vegetation types: Artemisia/Agropyron; Agropyron/Poa; Pinus/Juniperus; Pseudotsuga/Juniperus; Sarcobatus/Artemisia; Agropyron/Symphoricarpos; Xanthium; and Artemisia longifolia, respectively.

3/ Feeding = the percentage of feeding elk observed on this type.

4/ Total = the percentage of all elk observed on this type, T = less than one per cent.

TABLE LIV. PERCENTAGES OF TOTAL ELK OBSERVED ON VARIOUS VEGETATION TYPES IN RELATION TO WEATHER CONDITIONS.

Condition	Sample Size	ARTEM/AGROP, AGROP/POA ^{1/}	PINUS/ JUNIP	PSEUD/ JUNIP	SARCO/ARTEM, AGROP/SYPH, XANTH.
Temperature					
-0°	214	37.8	29.0		33.2
1-32°	759	58.9	29.4	3.4	8.3
33-45°	989	64.4	24.7	3.7	7.2
46-60°	834	47.4	26.4	11.4	14.9
61-80°	415	40.0	18.6	17.6	23.9
81°+	261	18.8	34.1	6.9	40.0
Precipitation					
None	3,093	53.2	26.5	6.7	13.7
Light Rain	125	16.0	28.8	33.6	21.6
Rain	24	33.0	4.2		62.5
Light Snow	210	48.1	19.5		32.4
Snow	20	10.0	90.0		
Wind Velocity					
Calm	1,468	56.1	20.1	10.2	12.9
-10 mph	1,153	53.0	29.0	5.5	12.5
11-20 mph	442	45.7	26.8	6.8	19.7
21-30 mph	242	33.5	42.1	T ^{2/}	24.0
31+ mph	167	34.7	29.9	3.0	32.3
Cloud Cover					
Clear	1,252	57.8	25.1	7.2	9.9
Partly	1,212	50.8	25.7	5.3	18.2
Mostly	293	42.4	31.1	19.1	7.4
Overcast	715	43.5	27.8	5.1	23.2
Ground Condition					
Dry	1,838	47.8	25.3	9.8	17.1
Damp	486	68.7	10.9	9.5	10.9
Muddy	147	31.3	34.0	4.8	29.9
Scat. Snow	422	74.9	18.7	3.1	3.3
Snow Cover	579	34.7	46.3	T	18.6

^{1/} Vegetation types: Artemisia/Agropyron and Agropyron/Poa combined; Pinus/Juniperus; Pseudotsuga/Juniperus; and Sarcobatus/Artemisia, Agropyron/Symphoricarpos, and Xanthium combined.

^{2/} T = less than one per cent.

TABLE LV. PERCENTAGES OF TOTAL CATTLE OBSERVED BY ACTIVITY CLASS DURING SEASONS AND YEARS, 1960-64.

	Year	Summer	Fall	Winter	Spring	Yearly <u>1/</u> Averages
Feeding	1960-61	88 (439) ^{2/}	84 (2,183)	88 (301)	86 (1,731)	87
	1961-62	76 (2,171)	89 (1,792)	84 (117)	78 (708)	82
	1962-63	83 (2,000)	90 (1,022)	98 (67)	93 (1,064)	91
	1963-64	86 (2,037)	92 (1,026)	100 (53)	100 (38)	94
	1960-64 Comb.	82	88	90	86	86
Traveling	1960-61	2 (8)	6 (156)	T (2) ^{3/}	2 (51)	2
	1961-62	6 (158)	2 (55)	0 (0)	6 (53)	3
	1962-63	4 (110)	2 (20)	0 (0)	2 (20)	2
	1963-64	2 (40)	4 (51)	0 (0)	0 (0)	2
	1960-64 Comb.	4	4	T	2	2
Bedding	1960-61	10 (48)	9 (245)	10 (36)	11 (226)	10
	1961-62	18 (502)	7 (158)	15 (21)	16 (149)	14
	1962-63	12 (287)	7 (86)	1 (1)	4 (56)	6
	1963-64	12 (280)	3 (37)	0 (0)	0 (0)	4
	1960-64 Comb.	14	8	10	10	10

1/ Mean of seasonal percentages.

2/ Number of cattle in parenthesis.

3/ T = less than one per cent.

TABLE LVI. AVERAGE NUMBERS OF CATTLE OBSERVED BY ACTIVITY CLASS PER TRIP UNDER VARIOUS ENVIRONMENTAL CONDITIONS.

Condition	Number of Trips	Feeding	Bedding	Traveling	Total
Temperature					
-0°	1	57.0 (97) ^{1/}	2.0 (3)	0.0 (0)	59.0
1-32°	19	46.8 (77)	11.9 (19)	1.3 (2)	59.5
33-45°	35	85.7 (82)	16.3 (15)	2.4 (2)	104.4
46-60°	90	76.0 (70)	26.0 (24)	3.7 (5)	106.0
61-80°	53	86.1 (75)	22.6 (19)	5.2 (5)	113.3
81°+	35	101.7 (75)	28.4 (21)	4.2 (2)	134.1
Precipitation					
None	204	83.2 (75)	24.2 (21)	4.1 (3)	111.4
Light Rain	18	75.8 (81)	16.4 (17)	1.9 (2)	95.1
Rain	8	35.5 (83)	7.0 (16)	T (1) ^{2/}	41.6
Light Snow	3	93.7 (89)	11.7 (11)	0.0 (0)	105.3
Snow	0	0.0 (0)	0.0 (0)	0.0 (0)	0.0
Wind Velocity					
Calm	70	84.1 (75)	24.1 (21)	4.2 (3)	112.4
-10 mph	101	87.6 (75)	23.9 (21)	3.9 (3)	115.3
11-20 mph	35	78.8 (71)	28.4 (25)	3.5 (3)	110.3
21-30 mph	14	51.4 (85)	8.1 (13)	1.2 (2)	60.8
31+ mph	13	53.3 (81)	9.6 (15)	2.8 (4)	65.8
Cloud Cover					
Clear	87	84.3 (75)	24.6 (21)	3.9 (3)	112.7
Partly	83	85.7 (73)	26.7 (23)	4.2 (3)	116.5
Mostly	31	70.7 (76)	17.6 (19)	4.5 (5)	92.9
Overcast	32	71.1 (83)	13.4 (15)	11.9 (1)	85.3
Ground Condition					
Dry	176	86.6 (75)	24.5 (21)	4.2 (3)	115.3
Damp	31	72.0 (74)	22.1 (23)	3.1 (3)	97.0
Muddy	14	70.1 (81)	15.0 (17)	1.4 (2)	86.4
Scat. Snow	7	44.3 (73)	15.4 (25)	T (1)	59.1
Snow Cover	5	28.0 (86)	4.4 (13)	0.0 (0)	32.4
Moon Phase					
New	59	81.3 (76)	20.4 (19)	5.0 (5)	106.6
First $\frac{1}{4}$	46	65.6 (71)	21.6 (23)	4.4 (5)	91.6
Full	60	80.6 (75)	23.2 (21)	2.4 (2)	106.1
Last $\frac{1}{4}$	68	92.0 (76)	25.6 (21)	3.3 (3)	120.8

^{1/} Percentage of total cattle observed under each set of conditions in parenthesis.

^{2/} T = less than one per cent.

TABLE LVII. PERCENTAGES OF TOTAL CATTLE OBSERVED ON VEGETATION TYPES BY ACTIVITY, SEASONS, AND YEARS, 1960-64.

Season Year	Sample Size	Average Number Observ. Per Trip	Percent-Feeding <u>1/</u>	ARTEM/AGROP		AGROP/POA		PINUS/JUNIP		PSEUD/JUNIP		SARCO/ARTEM		AGROP/SYMPH		XANTH		ARIO <u>2/</u>	
				Feed	Totl	Feed	Totl	Feed	Totl	Feed	Totl	Feed	Totl	Feed	Totl	Feed	Totl	Feed	Totl
Summer 1960 ^{5/}	548	60.9	88.6	37.2	39.1	11.3	10.4	28.2	26.1	T	T	16.2	15.7	4.0	6.0	2.9	2.6	0.0	0.0
1961	3,519	140.8	76.6	61.3	60.3	3.8	4.4	13.3	17.5	T	T	11.8	9.2	8.3	6.9	1.1	T	0.0	0.0
1962	3,379	130.0	83.4	57.8	58.3	9.1	9.3	17.2	15.0	T	T	8.7	11.1	5.6	4.9	T	T	T	T
1963	3,254	141.5	86.4	66.1	63.3	3.7	3.7	14.7	16.5	1.7	1.5	8.6	10.8	5.0	3.9	T	T	0.0	0.0
1960-63	10,700	127.9	82.2	59.4	59.5	5.7	6.0	15.5	16.9	T	1.0	11.2	10.6	6.5	5.3	T	T	T	T
Fall 1960	2,879	82.3	84.4	55.7	55.4	1.6	1.3	10.5	11.5	T	T	25.5	25.5	5.9	5.7	0.0	0.0	T	T
1961	2,340	137.6	89.3	65.7	64.9	3.1	3.5	17.6	17.4	T	T	6.9	7.3	5.5	5.7	T	T	T	T
1962	1,298	92.7	90.6	66.9	67.1	3.4	2.9	16.4	16.7	T	T	9.5	9.6	3.4	3.2	T	T	0.0	0.0
1963	1,388	106.8	92.1	72.2	69.9	1.9	1.7	8.7	10.5	4.7	4.2	6.1	7.6	5.0	5.0	T	T	0.0	0.0
1960-63	7,923	100.3	88.1	64.3	62.7	2.4	2.3	13.5	13.9	T	1.1	13.7	14.3	5.2	5.2	T	T	T	T
Winter 1961	411	31.6	88.7	62.3	53.3	26.8	35.0	3.1	5.1	0.0	0.0	7.5	6.3	T	T	0.0	0.0	0.0	0.0
1962	154	51.3	84.7	62.6	66.9	0.0	0.0	12.8	26.6	0.0	0.0	4.6	6.5	0.0	0.0	0.0	0.0	0.0	0.0
1963	71	35.5	98.5	87.7	82.1	0.0	0.0	12.3	17.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	82	27.3	100.0	13.4	13.4	82.9	82.9	1.2	1.2	0.0	0.0	2.4	2.4	0.0	0.0	0.0	0.0	0.0	0.0
1961-64	718	34.2	89.9	65.6	54.8	22.2	29.2	6.9	10.6	0.0	0.0	5.2	5.2	T	T	0.0	0.0	0.0	0.0
Spring 1961	2,724	133.8	86.2	80.2	77.0	7.4	7.2	8.3	11.7	T	T	1.7	1.5	2.0	1.8	T	T	0.0	0.0
1962	1,435	130.4	77.8	54.7	55.1	3.2	6.3	15.3	12.3	0.0	0.0	20.6	19.7	5.7	5.9	T	T	0.0	0.0
1963	1,543	96.4	93.3	64.0	57.4	7.9	8.0	6.4	7.6	T	T	14.8	20.9	5.5	4.9	1.0	T	T	T
1964	64	64.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1961-64	5,766	115.3	86.4	70.2	66.6	6.5	7.1	9.3	10.6	T	T	9.6	11.2	3.4	3.6	T	T	T	T
1960-61	6,562	83.1	85.7	64.7	62.9	6.4	6.6	10.7	12.4	T	T	13.7	13.5	3.8	3.7	T	T	T	T
1961-62	7,466	133.3	81.3	62.5	60.9	3.3	4.4	15.1	16.7	T	T	11.3	10.6	6.6	6.2	T	T	T	T
1962-63	6,291	108.5	87.7	61.7	60.2	7.4	7.6	14.3	13.6	T	T	10.3	13.0	5.0	4.5	T	T	T	T
1963-64	4,788	129.4	88.5	67.4	64.8	4.7	4.4	12.4	14.3	2.5	2.2	7.6	9.6	4.8	4.1	T	T	0.0	0.0
1960-64	25,125	109.2	85.4	63.6	62.0	5.4	5.8	13.2	14.3	T	T	11.4	11.8	5.3	4.7	T	T	T	T

1/ The percentage of the total cattle observed that were feeding.

2/ Vegetation types: Artemisia/Agropyron; Agropyron/Poa; Pinus/Juniperus; Pseudotsuga/Juniperus; Sarcobatus/Artemisia; Agropyron/Symphoricarpos; Xanthium; and Artemisia longifolia, respectively.

3/ Feeding = the percentage of feeding cattle observed on this type.

4/ Total = the percentage of all cattle observed on this type, T = less than one per cent.

5/ August only.

TABLE LVIII. PERCENTAGES OF TOTAL CATTLE OBSERVED ON VARIOUS VEGETATION TYPES IN RELATION TO WEATHER CONDITIONS.

Condition	Sample Size	ARTEM/AGROP, AGROP/POA ^{1/}	PINUS/ JUNIP	PSEUD/ JUNIP	SARCO/ARTEM, AGROP/SYMPH, XANTH.
Temperature					
-0°	59	69.5	22.0		8.5
1-32°	1,132	74.4	14.1		11.5
33-45°	3,654	70.7	16.8	6.6	11.8
46-60°	9,507	67.6	15.2	T ^{2/}	16.3
61-80°	6,088	67.2	10.6	1.6	20.6
81°+	4,716	64.7	15.9	T	19.1
Precipitation					
None	22,730	68.1	14.7	T	16.6
Light Rain	1,714	59.5	13.8	3.4	23.3
Rain	379	68.1	7.7		24.2
Light Snow	333	89.7	4.5		5.7
Snow					
Wind Velocity					
Calm	7,829	69.0	15.3	T	15.3
-10 mph	11,682	69.3	13.8	T	18.2
11-20 mph	3,937	71.6	11.4	2.3	14.6
21-30 mph	852	55.4	19.9	T	24.4
31+ mph	856	57.2	22.0	T	20.3
Cloud Cover					
Clear	9,788	66.2	16.0	T	17.2
Partly	9,691	69.7	13.3	T	16.2
Mostly	2,944	67.8	12.6	T	18.3
Overcast	2,733	66.0	14.3	2.2	17.5
Ground Condition					
Dry	20,294	67.5	14.1	T	17.5
Damp	3,074	69.6	16.5	T	13.7
Muddy	1,212	62.1	13.6	1.5	22.8
Scat. Snow	414	81.6	13.0		5.4
Snow Cover	162	67.9	25.9		6.2

^{1/} Vegetation types: Artemisia/Agropyron and Agropyron/Poa combined; Pinus/Juniperus; Pseudotsuga/Juniperus; and Sarcobatus/Artemisia, Agropyron/Symphoricarpos, and Xanthium combined.

^{2/} T = less than one per cent.

TABLE LIX. MULE DEER USE OF TAXA WHICH INDIVIDUALLY RECEIVED AT LEAST ONE PER CENT BUT LESS THAN TEN PER CENT OF THE TOTAL INSTANCES OF PLANT USE FOR AT LEAST ONE VEGETATION TYPE DURING AT LEAST ONE SEASON, 1960-64 COMBINED. 1/

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Artemisia/Agropyron:</u>				
<u>Agropyron smithii</u>		18/T2/	15/T	56/3
<u>Allium textile</u>				56/8
<u>Aster spp.</u>	6/T	36/5	7/2	4/T
<u>Fritillaria pudica</u>				7/2
<u>Microseris nutans</u>				44/6
<u>Phlox hoodii</u>			30/5	30/6
<u>Sphaeralcea coccinea</u>	6/2			4/T
<u>Tragopogon dubius</u>	11/T	9/T	11/2	37/T
<u>Yucca glauca</u>				4/2
<u>Artemisia cana</u>			4/2	
<u>Chrysothamnus viscidiflorus</u>			7 2	
<u>Juniperus scopulorum</u>			26/2	7/2
<u>Symphoricarpos spp.</u>	6/T		7/2	
<u>Pinus/Juniperus:</u>				
<u>Agropyron smithii</u>	5/T	6/T	10/T	27/1
<u>Poa secunda</u>		6/T	10/T	23/5
<u>Allium textile</u>				36/4
<u>Arnica sororia</u>				9/1
<u>Artemisia frigida</u>		6/T	20/4	
<u>Aster commutatus</u>	11/T	39/4	5/T	9/T
<u>Comandra umbellatum</u>	5/T	6/T		18/1
<u>Fritillaria pudica</u>				27/6
<u>Microseris nutans</u>	3/T	6/T		41/4
<u>Phacelia linearis</u>	5/1			9/T
<u>Phlox hoodii</u>		6/T		9/1
<u>Tragopogon dubius</u>	34/2	28/T	35/2	50/3
<u>Vicia americana</u>	21/1	6/T		14/1
<u>Yucca glauca</u>	5/3		5/T	
<u>Chrysothamnus nauseosus</u>	3/T	17/3	10/3	18/2
<u>Pinus ponderosa</u>			15/T	18/2
<u>Prunus virginiana</u>	10/1	11/T	10/T	18/1
<u>Ribes spp.</u>	13/1		5/T	14/3
<u>Rosa spp.</u>	63/8	39/4	45/2	45/3

TABLE LIX. Continued.

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Pseudotsuga/Juniperus:</u>				
<u>Allium textile</u>				25/1
<u>Aster commutatus</u>	10/T	40/2		
<u>Glycyrrhiza lepidota</u>	10/1			
<u>Lactuca pulchella</u>				50/2
<u>Lactuca serriola</u>				25/2
<u>Tragopogon dubius</u>	50/1	40/4	33/T	
<u>Vicia americana</u>	10/1			25/T
<u>Artemisia longifolia</u>		20/2	17/T	25/2
<u>Ribes cereum</u>	20/T	20/T	17/T	25/4
<u>Sarcobatus/Artemisia:</u>				
<u>Agropyron smithii</u>			25/T	33/2
<u>Allium textile</u>				67/7
<u>Aster canescens</u>		50/1		
<u>Chenopodium album</u>		25/1	12/T	11/T
<u>Cirsium undulatum</u>	16/2			
<u>Comandra umbellatum</u>	33/2			
<u>Eriogonum multiceps</u>			12/1	
<u>Helianthus petiolaris</u>		25/2	12/T	11/T
<u>Lomatium foeniculatum</u>				33/6
<u>Microseris nutans</u>				33/2
<u>Monolepis nutalliana</u>	17/T	25/1		
<u>Vicia americana</u>	50/3	50/2		11/T
<u>Hymenoxys richardsonii</u>		25/2		
<u>Artemisia longifolia</u>			12/6	
<u>Atriplex nutallii</u>	17/T		25/7	11/3
<u>Rosa spp.</u>	17/1			
<u>Agropyron/Symphoricarpos:</u>				
<u>Aster commutatus</u>				50/2
<u>Chenopodium album</u>	20/2			50/T
<u>Lactuca pulchella</u>	40/1	33/2		
<u>Rosa spp.</u>	40/2			50/T
<u>Sarcobatus vermiculatus</u>				50/6
<u>Xanthium:</u>				
<u>Chenopodium album</u>	17/1			
<u>Chrysothamnus viscidiflorus</u>	17/2	100/7		
<u>Rosa spp.</u>	50/4			

TABLE LIX. Continued.

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Artemisia longifolia:</u>				
<u>Chenopodium album</u>	33/3	33/5		
<u>Collomia linearis</u>	33/4			
<u>Eriogonum multiceps</u>		33/2		
<u>Polygonum spp.</u>	33/2			
<u>Chrysothamnus viscidiflorus</u>		33/1		
<u>Symphoricarpos spp.</u>	33/1	33/1		
<u>Agropyron/Poa:</u>				
<u>Agropyron smithii</u>		100/1		100/4
<u>Conringia orientalis</u>				100/3
<u>Lomatium foeniculatum</u>				100/1
<u>Taraxacum officinalis</u>	100/1	100/1		

1/ Other taxa used by mule deer but comprising less than one per cent of the mean seasonal use on any vegetation type with seasons of recorded use in parenthesis were: Grasses; Agropyron spicatum (FWS), Agropyron trachycaulum (Su), Hordeum jubatum (WS), Koeleria cristata (FWS), Muhlenbergia cuspidata (FW), Stipa viridula (SuFWS), Bouteloua gracilis (FW), Calamovilfa longifolia (SuW), and Carex (SuFS). Forbs; Achillea millefolium (FS), Astragalus bisulcatus (SuFW), Astragalus gilviflorus (Su), Astragalus missouriensis (FS), Atriplex rosea (Su), Atriplex argentea (Su), Atriplex dioica (F), Calchortus nuttallii (S Su), Camalina microcarps (S Su), Convulvulus arvensis (Su), Crepis occidentalia (S Su), Descurainia pinnata (S), Euphorbia helioscopia (Su), Gaura coccinea (S SuF), Grindelia squarrosa (FWS), Lappula redowski (S), Liastris punctata (SF), Lomatium orientale (S), Mirabilis linearis (Su), Melilotus alba (F), Mertensia longiflora (S), Oenothera caespitosa (S), Opuntia polyantha (Su), Penstemon nitidis (S Su), Petalostemum candidum (Su), Polygonum erectum (Su), Polygonum lapathifolium (Su), Salsola kali (S), Solidago missouriensis (FW), Solidago gigantea (SuF), Stephanomeria runcinata (S SuF), Thermopsis rombifolia (S), Thlaspi arvense (S Su), and Viola nuttallii (S).
Browse; Gutierrezia sarothrae (Su), Ribes setosum (SuWS), Ribes aureum (S Su), and Juniperus horizontalis (WS).

2/ Per cent frequency of use among all feeding sites on this vegetation type/aggregate mean percentage of total recorded instances of use for this type. T = less than one per cent.

TABLE LX. ELK USE OF TAXA WHICH INDIVIDUALLY RECEIVED AT LEAST ONE PER CENT BUT LESS THAN TEN PER CENT OF THE TOTAL INSTANCES OF PLANT USE FOR AT LEAST ONE VEGETATION TYPE DURING AT LEAST ONE SEASON, 1960-64 COMBINED. 1/

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Artemisia/Agropyron:</u>				
<u>Agropyron spicatum</u>	8/T 2/	12/T	47/1	10/T
<u>Stipa viridula</u>	42/2	35/4	6/T	32/2
<u>Bouteloua gracilis</u>	17/T	53/4	29/1	5/T
<u>Allium textile</u>				68/3
<u>Aster commutatus</u>	8/T	18/3	12/T	5/T
<u>Comandra umbellatum</u>	25/4	18/1		11/T
<u>Lomatium foeniculatum</u>	8/T			42/2
<u>Microseris nutans</u>	25/5			42/1
<u>Oenothera caespitosa</u>	8/2			5/T
<u>Petalostemum purpureum</u>	8/2			
<u>Tragopogon dubius</u>	25/2	12/T	12/T	26/T
<u>Vicia americana</u>	25/1		6/T	5/1
<u>Chrysothamnus viscidiflorus</u>		6/1	6/T	
<u>Juniperus scopulorum</u>		12/2		
<u>Pinus/Juniperus:</u>				
<u>Agropyron spicatum</u>	13/T	11/T	36/1	60/8
<u>Koeleria cristata</u>	33/2	56/4	36/7	40/T
<u>Poa secunda</u>	20/T	44/2	64/3	60/5
<u>Calamovilfa longifolia</u>		22/1	9/T	
<u>Carex spp.</u>	7/1	11/T	9/T	20/2
<u>Artemisia ludoviciana</u>			18/3	
<u>Aster commutatus</u>	33/2	22/T	27/1	
<u>Microseris nutans</u>	33/3			
<u>Gaura coccinea</u>	13/1			
<u>Prunus virginiana</u>	7/1		9/3	
<u>Rhus trilobata</u>	20/3		27/2	20/T
<u>Rosa spp.</u>	20/T	11/1		
<u>Artemisia tridentata</u>			27/2	40/5
<u>Pseudotsuga/Juniperus:</u>				
<u>Agropyron spicatum</u>	10/T	33/1	100/T	
<u>Agropyron trachycaulum</u>	20/T	67/5		
<u>Muhlenbergia cuspidata</u>			100/1	
<u>Stipa viridula</u>		33/3		
<u>Artemisia frigida</u>		33/T	100/1	
<u>Aster commutatus</u>	60/2	33/2	100/T	
<u>Glycyrrhiza lepidota</u>	20/1			

TABLE LX. Continued.

Vegetation Type: Plant	Summer	Fall	Winter	Spring
<u>Pseudotsuga/Juniperus: cont.</u>				
<u>Taraxacum officinale</u>	10/1			
<u>Tragopogon dubius</u>	10/T		100/3	
<u>Rhus trilobata</u>	60/4	33/2	100/T	
<u>Ribes spp.</u>	40/2			
<u>Rosa spp.</u>	80/3			
<u>Artemisia cana</u>			100/1	
<u>Sarcobatus/Artemisia:</u>				
<u>Agropyron spicatum</u>	25/2		12/2	
<u>Distichlis stricta</u>		33/2		
<u>Muhlenbergia cuspidata</u>	25/2		12/T	
<u>Carex spp.</u>	25/2			
<u>Allium textile</u>				67/3
<u>Camalina microcarpa</u>				53/2
<u>Microseris nutans</u>				33/1
<u>Tragopogon dubius</u>	50/T			33/1
<u>Vicia americana</u>	50/1			33/T
<u>Sarcobatus vermiculatus</u>	50/2	67/8	50/3	
<u>Artemisia tridentata</u>			38/7	33/T
<u>Atriplex nuttallii</u>				33/2
<u>Agropyron/Symphoricarpos:</u>				
<u>Distichlis stricta</u>		20/1		
<u>Poa secunda</u>		40/7		50/4
<u>Stipa viridula</u>				50/3
<u>Allium textile</u>				25/1
<u>Artemisia biennis</u>	14/2			
<u>Chenopodium album</u>	14/1			
<u>Helianthus petiolaris</u>	7/T	20/7		25/T
<u>Lactuca pulchella</u>	38/T			50/4
<u>Polygonum lapathifolium</u>				25/2
<u>Solidago gigantea</u>		20/3		
<u>Taraxacum officinale</u>	7/T			50/3
<u>Thlaspi arvense</u>				50/3
<u>Tragopogon dubius</u>	50/3			50/T
<u>Chrysothamnus viscidiflorus</u>		40/5		
<u>Symphoricarpos spp.</u>	36/1			
<u>Xanthium:</u>				
<u>Agropyron trachycaulum</u>				50/8
<u>Poa compressa</u>	17/2			50/8
<u>Poa secunda</u>				50/2

TABLE LX. Continued.

Vegetation Type: Plant Taxa	Summer	Fall	Winter	Spring
<u>Xanthium: cont.</u>				
<u>Spartina pectinata</u>				50/6
<u>Stipa viridula</u>				50/9
<u>Helianthus maxamilliana</u>	17/3			
<u>Rumex spp.</u>	33/1			50/2
<u>Symphoricarpos spp.</u>	33/1			
<u>Artemisia longifolia:</u>				
<u>Chenopodium album</u>	33/8			
<u>Helianthus petiolaris</u>	33/8			
<u>Vicia americana</u>	33/2			
<u>Agropyron/Poa:</u>				
<u>Koeleria cristata</u>		100/2		
<u>Bouteloua gracilis</u>		60/1		
<u>Artemisia frigida</u>		60/2		

1/ Other taxa used by elk but comprised less than one per cent of the total use of any vegetation type were, with season of use in parenthesis:

Grasses; Bromus japonicus (Su), B. tectorum (F), Panicum capillare (FW), Sporobolus cryptandrus (FW), Carex filifolia (FWS), Carex geyeri (Su).
 Forbs; Achillea millefolium (SuFS), Astragalus bisulcatus (Su), Astragalus missouriensis (F), Calochortus nuttallii (S Su), Chaenactis douglasii (S), Chenopodium gigantospermum (Su), C. glaucum (Su), Collomia linearis (Su), Conringia orientalis (S Su), Crepis occidentalis (S Su), Fritillaria pudica (S), Geum triflorum (Su), Grindelia squarrosa (W), Lepidium densiflorum (S), Mentzelia albicaulis (Su), M. laevicaulis (Su), Mirabilis linearis (Su), Monalepis nuttalliana (S), Opuntia polycantha (WS), Penstemon nitidis (S), Phlox hoodii (FWS), Polygonum douglasii (Su), P. erectum (Su), Ranunculus cymbalaria (S), Rumex crispus (F), R. mexicanus (Su), Salsola kali (Su), Senecio integerrimus (Su), Solidago missouriensis (Su), Sphaeralcea coccinea (S SuF), Thermopsis rombifolia (Su), Viola nuttallii (Su), Bahia oppositifolia (Su), Hymenoxys richardsonii (S Su), Iva axillaris (Su), Liatris punctata (Su), Yucca glauca (SuW).
 Browse; Chrysothamnus nauseosus (FW), Gutierrezia sarothrae (W), Pinus ponderosa (W), Ribes aureum (Su), Ribes cereum (SuF), Ribes setosum (Su).

2/ Per cent frequency of use among all feeding sites on this vegetation type/aggregate mean percentage of the total instances of use for this vegetation type. T = less than one per cent.

TABLE LXI. CATTLE USE OF TAXA WHICH INDIVIDUALLY RECEIVED AT LEAST ONE PER CENT BUT LESS THAN TEN PER CENT OF THE TOTAL INSTANCES OF PLANT USE FOR AT LEAST ONE VEGETATION TYPE DURING AT LEAST ONE SEASON, 1960-64 COMBINED. 1/

Vegetation Type: Plant Taxa	Spring	Summer	Fall	Winter
<u>Artemisia/Agropyron:</u>				
<u>Koeleria cristata</u>	59/1 ^{2/}	49/1	87/5	67/6
<u>Stipa viridula</u>	71/3	74/3	83.5	50/3
<u>Bouteloua gracilis</u>	23/2	57/7	73/5	100/7
<u>Carex spp.</u>	6/T	25/1	30/1	17/T
<u>Chrysothamnus nauseosus</u>	12/T	3/T	43/5	17/3
<u>Gutierrezia sarothrae</u>	6/T	9/T	4/T	50/1
<u>Sarcobatus vermiculatus</u>		12/1	13/1	50/4
<u>Artemisia tridentata</u>				67/4
<u>Atriplex nuttallii</u>	6/T	29/1	9/T	17/T
<u>Allium textile</u>	65/4	6/T		
<u>Comandra umbellatum</u>	18/T	43/2	4/T	
<u>Lomatium foeniculatum</u>	53/3	6/T		
<u>Vicia americana</u>	59/1	45/3	4/T	
<u>Pinus/Juniperus:</u>				
<u>Bromus tectorum</u>				25/1
<u>Koeleria cristata</u>	67/3	45/1	87/4	50/2
<u>Muhlenbergia cuspidata</u>	33/T	59/5	50/T	50/1
<u>Poa compressa</u>	11/1	4/T		
<u>Carex spp.</u>	22/1	27/1	37/4	25/3
<u>Chrysothamnus nauseosus</u>			12/T	50/3
<u>Rhus trilobata</u>		36/1	T/T	25/T
<u>Symphoricarpos spp.</u>		31/3	63/3	50/T
<u>Allium textile</u>	55/1			
<u>Microseris nutans</u>	67/3	9/T		
<u>Pseudotsuga/Juniperus:</u>				
<u>Agropyron smithii</u>		75/5		
<u>Koeleria cristata</u>		100/1		
<u>Muhlenbergia cuspidata</u>		75/5		
<u>Carex spp.</u>		25/4		
<u>Prunus virginiana</u>		25/3		
<u>Aster commutatus</u>		50/1		
<u>Sarcobatus/Artemisia:</u>				
<u>Koeleria cristata</u>	25/1	29/T	29/1	
<u>Carex spp.</u>		29/1	14/T	
<u>Atriplex nuttallii</u>			29/2	

TABLE LXI. Continued.

Vegetation Type: Plant Taxa	Spring	Summer	Fall	Winter
<u>Sarcobatus/Artemisia:</u> cont.				
<u>Allium textile</u>	100/5			
<u>Atriplex dioica</u>			14/1	
<u>Lomatium foeniculatum</u>	75/1			
<u>Thlaspi arvense</u>	50/1	14/T		
<u>Agropyron/Symphoricarpos:</u>				
<u>Distichlis stricta</u>	20/T	55/1	75/3	
<u>Poa compressa</u>	60/3	18/T	75/1	
<u>Poa secunda</u>	20/1	18/T		
<u>Stipa viridula</u>	20/T	18/T	75/3	
<u>Symphoricarpos</u> spp.	20/T	45/1	75/1	
<u>Chenopodium album</u>		18/1	75/1	
<u>Glycyrrhiza lepidota</u>		54/1	75/1	
<u>Thlaspi arvense</u>	80/1	18/T		
<u>Tragopogon dubius</u>	40/T	45/1	25/T	
<u>Xanthium:</u>				
<u>Distichlis stricta</u>		83/3	100/5	
<u>Hordeum jubatum</u>		33/T	50/1	
<u>Scirpus paludosus</u>		17/2	100/1	
<u>Glycyrrhiza lepidota</u>		83/2	50/T	
<u>Helianthus marimilliana</u>		17/1		
<u>Lactuca pulchella</u>		67/1		
<u>Rumex mexicanus</u>		17/T	50/3	
<u>Tragopogon dubius</u>		33/T	50/2	
<u>Artemisia longifolia:</u>				
<u>Artemisia longifolia</u>		100/8		
<u>Agropyron/Poa:</u>				
<u>Koeleria cristata</u>	50/T	40/T	100/1	100/5
<u>Muhlenbergia cuspidata</u>		20/3		
<u>Artemisia frigida</u>				100/1
<u>Lomatium foeniculatum</u>	50/1			
<u>Polygonum</u> spp.		20/1		
<u>Tragopogon dubius</u>		40/1		100/1
<u>Vicia americana</u>	50/T	60/1		100/T

TABLE LXI. Continued.

- 1/ Other taxa used by cattle but comprising less than one per cent of the mean seasonal use on any vegetation type, with seasons of recorded use in parenthesis, were: Grass and grass-like; Agropyron cristatum (Su), Agropyron trachycaulum (S SuF), Bromus japonicus (Su), Puccinella nuttalliana (Su), Schedonnardus paniculatus (SuF), Carex filifolia (SuF).
Forbs; Amaranthus graecizans (Su), Artemisia ludoviciana (SF), Aster canescens (SF), Aster occidentalis (Su), Astragalus agrestis (Su), Astragalus bisulcatus (S SuF), Astragalus missouriensis (Su), Calochortus nuttallii (S), Camalina microcarpa (Su), Chenopodium gigantospermum (SuF), Cirsium spp. (Su), Conringia orientalis (Su), Convulvulus sepium (Su), Crepis occidentalis (S Su), Descuriana pinnata (S), Erysimum inconspicuum (S Su), Fritillaria pudica (S), Geum triflorum (Su), Grindelia squarrosa (S SuF), Haplopappus nuttallii (W), Helianthus petiolaris (SuF), Lactuca serriola (Su), Lappula redowski (S), Linum rigidum (Su), Mertensia longifolia (S Su), Oenothera caespitosa (Su), Penstemon nitidis (Su), Petalostemum candidum (Su), Petalostemum purpureum (SuF), Phacelia linearis (Su), Phlox hoodii (S SuFW), Plantago spinulosa (S Su), Polygonum erectum (Su), Polygonum lapathifolium (Su), Psoralea argophylla (Su), Psoralea esculenta (Su), Rumex crispus (F), Salsola kali (SuFW), Solidago missouriensis (SuF), Solidago gigantea (Su), Spaeralcea coccinea (S SuF), Stephanomeria runcinata (Su), Taraxacum officinale (S Su), Thermopsis rombifolia (SuF), Xanthium strumarium (Su), Bahia oppositifolia (SuF), Musineon divaricatum (S), Gaura coccinea (Su), Hymenoxys richardsonii (Su), Iva axillaris (SuF).
Shrubs; Chrysothamnus viscidiflorus (SF), Eurotia lanata (Su), Artemisia cana (F).

- 2/ Per cent frequency of use among all feeding sites on this vegetation type/aggregate mean percentage of total recorded instances of use for this type. T = less than one per cent.

LITERATURE CITED

- Brown, D.L. and L.E. Brown. 1950. Mid-winter deer survey, Fort Peck Game Range. Mont. Fish and Game P-R. Qtr. 10(1).
- Cliff, E.P. 1939. Relationships between elk and mule deer in the Blue Mountains of Oregon. Trans N. Am. Wildl. Conf., 4:560-569.
- Cole, G.F. 1956. The pronghorn antelope - Its range use and food habits in central Montana with special reference to alfalfa. Mont. Fish and Game Dept. and Mont. Agr. Expt. Sta. Tech. Bull. 516. 63 pp.
- _____. 1958a. Big game-livestock competition on Montana's mountain rangelands. Mont. Wildl., April:24-30.
- _____. 1958b. Range survey guide. Montana Fish and Game Dept. Multilith. 18pp.
- Cowan, I. McT. 1947. Range competition between mule deer, bighorn sheep, and elk in Jasper Park, Alberta. Trans. N. Am. Wildl. Conf., 12:223-227.
- Coupland, R.T. 1950. Ecology of mixed prairie in Canada. Ecol. Monog., 20:271-315.
- _____. 1961. A reconsideration of grassland classification in the northern Great Plains of North America. J. Ecol., 49:135-167.
- Dasmann, W. 1949. Deer-livestock forage studies on the interstate winter deer range in California. J. Range Mgmt., 2(4):206-212.
- Dasmann, R.F. and R.D. Taber. 1956. Behavior of Columbian black-tailed deer with reference to population ecology. J. Mamm., 37(2):143-164.
- Daubenmire, R. 1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing upon concepts of vegetation classification. Ecol. Monog., 22(4):301-330.
- _____. 1959. A canopy-coverage method of vegetational analysis. Northwest Sci., 33:43-64.
- Dealy, J.E. 1960. The densiometer for measurement of crown intercept above a line transect. U.S. Dept. of Agr., Pacific N.W. For. and Range Expt. Sta., Res. Note 199. 5 pp.
- DeNio, R.M. 1938. Elk and deer food and feeding habits. Trans. N. Am. Wildl. Conf., 3:421-427.

- Giesecker, L.F. 1938. Soils of Fergus County. Mont. Agr. Expt. Sta. Bull. 355. 82 pp.
- _____, C.B. Manifold, A.T. Strahorn, and O.F. Bartholemew. 1953. Soil survey, central Montana. U.S. Dept. of Agr. and Mont. Agr. Expt. Sta. Series 1940, No. 9. 133 pp.
- Hanson, H.C. and W. Whitman. 1938. Characteristics of major grassland types in western North Dakota. Ecol. Monog., 8:57-114.
- Hollibaugh, G. 1944. Fergus Unit Quarterly Report for the 2nd quarter. Montana Fish and Game Dept. Typewritten. 8 pp.
- Janson, R.G. and H.D. Picton. 1959. Big game surveys and investigations, deer surveys phase. P-R Completion Report, Project W-74-R-4. Montana Fish and Game Dept. Multilith. 30 pp.
- Johnson, D.E. 1952. Population studies of deer - Fort Peck Game Range and vicinity. P-R Completion Report, Project 1-R. Montana Fish and Game Dept. Multilith. 8 pp.
- Jonas, R.J. 1964. Ecology and management of Merriam's turkey in the Long Pines, southeastern Montana. Unpubl. thesis (PhD), Montana State College. 118 pp.
- Julander, O. 1937. Utilization of browse by wildlife. Trans. N. Am. Wildl. Conf., 2:276-287.
- _____. 1955. Deer and cattle range relations in Utah. For. Sci., 1(2):130-139.
- _____. 1958. Techniques in studying competition between big game and livestock. J. Range Mgmt., 11:18-21.
- _____ and D.E. Jeffery. 1964. Deer, elk, and cattle range relations on summer range in Utah. Trans. N. Am. Wildl. Conf., 29:404-417.
- Kimball, T.L. and A.G. Watkins. 1951. The Kaibab North cooperative deer-livestock forage relationships study. Ariz. Game and Fish Comm. 77 pp.
- Lovaas, A.L. 1963. Gallatin big game studies. P-R Completion Report, Project W-98-R-4. Montana Fish and Game Dept. Multilith. 37 pp.
- Lemon, P.E. 1956. A spherical densiometer for estimating forest over-story density. For. Sci., 2(4):314-320.

- Morris, M.S. and J.E. Schwartz. 1957. Mule deer and elk food habits on the National Bison Range. *J. Wildl. Mgmt.*, 21(2):189-193.
- Rouse, R.A. 1957. Elk food habits, range use, and movements, Gravelly Mountains, Montana. Unpubl. thesis (M.S.), Montana State College. 29 pp.
- Smith, J.G. and O. Julander. 1953. Deer and sheep competition in Utah. *J. Wildl. Mgmt.*, 17(2):101-112.
- Stevens, D.R. 1964. Elk and livestock relationships in the Crow Creek Drainage, Elkhorn Mountains, Montana. Unpubl. thesis (M.S.), Montana State College. 68 pp.
- Trueblood, R. 1960. Big game surveys and investigations. P-R Completion Report, Project W-76-R-5. Montana Fish and Game Dept. Multilith. 30 pp.
- U.S. Department of Commerce Weather Bureau. 1943-64. Climatological data. Montana Monthly Summary. U.S. Government Printing Office, Washington, D. C.
- Weaver, J.E. and F.E. Clements. 1938. Plant ecology. 2d ed. McGraw-Hill Book Co. New York.
- Wright, J.C. and E.A. Wright. 1948. Grassland types of south central Montana. *Ecol.*, 29(4):449-460.
- Young, V.A. 1938. The carrying capacity of big game range. *J. Wildl. Mgmt.*, 2(2):131-134.

