Survival and behavior of radio-collared mule deer fawns during summers, 1978-1980, in the Missouri River Breaks, Montana
by Shawn James Riley

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Fish and Wildlife Management
Montana State University

Abstract:
A study to determine the causes and extent of mortality among mule deer fawns and to evaluate how behavior and habitat use affect early fawn survival was conducted in the Missouri River Breaks, north-central Montana, during the summers of 1978, 1979, and 1980. Forty-nine fawns were equipped with radio transmitters: 15 in 1978, 18 in 1979, and 16 in 1980. One-third of the total summer mortality (1 fawn each summer) was attributed to starvation due to abandonment. Known and/or suspected predation by coyotes resulted in fawn mortality rates of 16.7%, 11.8%, and 13.3% in 1978, 1979, and 1980, respectively. The low mortality occurred despite a stable to slightly increasing coyote population. Dense growth of yellow sweetclover during 1978 and 1979, an abundance of alternative prey for coyotes during all years, and changes in habitat use by fawns in 1980, apparently were important in reducing predation and increasing survival during the study period as compared with 1976 and 1977. Movements of fawns between relocations ranged from 0.00 to 3.85 kilometers, with an overall mean of 0.78 kilometers. Monitored fawns made greater movements in 1978 than in 1979 and 1980. Summer home ranges of fawns varied in size from 23 to 350 hectares and averaged 133 hectares through the study period. The average size decreased significantly from 211 hectares in 1978 to 100 hectares and 105 hectares in 1979 and 1980, respectively. Home ranges frequently overlapped, but complete overlap was observed only in 1980. The extent to which fawns utilized cover types differed significantly between early and late summer and between years. Decreased use of the open types occurred each year as summer progressed. Fawns utilized the Pinus-Juniperus and Psuedotsuga-Juniperus cover types earlier and to a greater extent in 1980 than in 1978 or 1979. Marked fawns selected bedsites that provided an average of 69% concealment cover from 3 sides. The amount of cover surrounding fawn bedsites did not differ significantly between years. Results indicated that predation patterns and rates within and between years were not a function of coyote numbers alone, but reflected complex interaction between coyotes, the availability and abundance of alternative prey, and environmental conditions that determine the vulnerability of fawns.

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by

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A thesis submitted in partial fulfillment
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ABSTRACT

A study to determine the causes and extent of mortality among mule deer fawns and to evaluate how behavior and habitat use affect early fawn survival was conducted in the Missouri River Breaks, north-central Montana, during the summers of 1978, 1979, and 1980. Forty-nine fawns were equipped with radio transmitters: 15 in 1978, 18 in 1979, and 16 in 1980. One-third of the total summer mortality (1 fawn each summer) was attributed to starvation due to abandonment. Known and/or suspected predation by coyotes resulted in fawn mortality rates of 16.7%, 11.8%, and 13.3% in 1978, 1979, and 1980, respectively. The low mortality occurred despite a stable to slightly increasing coyote population. Dense growth of yellow sweetclover during 1978 and 1979, an abundance of alternative prey for coyotes during all years, and changes in habitat use by fawns in 1980, apparently were important in reducing predation and increasing survival during the study period as compared with 1976 and 1977. Movements of fawns between relocations ranged from 0.00 to 3.85 kilometers, with an overall mean of 0.78 kilometers. Monitored fawns made greater movements in 1978 than in 1979 and 1980. Summer home ranges of fawns varied in size from 23 to 350 hectares and averaged 133 hectares through the study period. The average size decreased significantly from 211 hectares in 1978 to 100 hectares and 105 hectares in 1979 and 1980, respectively. Home ranges frequently overlapped, but complete overlap was observed only in 1980. The extent to which fawns utilized cover types differed significantly between early and late summer and between years. Decreased use of the open types occurred each year as summer progressed. Fawns utilized the *Pinus-Juniperus* and *Psuedotsuga-Juniperus* cover types earlier and to a greater extent in 1980 than in 1978 or 1979. Marked fawns selected bedsites that provided an average of 69% concealment cover from 3 sides. The amount of cover surrounding fawn bedsites did not differ significantly between years. Results indicated that predation patterns and rates within and between years were not a function of coyote numbers alone, but reflected complex interaction between coyotes, the availability and abundance of alternative prey, and environmental conditions that determine the vulnerability of fawns.

INTRODUCTION

The mule deer (*Odocoileus hemionus hemionus* Rafinesque) population in the Missouri River Breaks of Montana declined sharply during 1971-1973, apparently as a result of extensive overwinter mortality in 1971-1972 and low fawn production or survival (Mackie 1976). The population remained low through 1977 as a result of low fawn production/survival that persisted despite average to above normal spring-summer precipitation and mild, open winters (Hamlin 1978). A similar sharp decline in mule deer numbers occurred in the Breaks during 1964-1965, but was followed by a population recovery within 1-2 years (Mackie 1976, Hamlin 1978).

Although predation by coyotes (*Canis latrans latrans* Say) was suspected as a possible cause of low fawn:doe ratios observed during early fall and winter population surveys in the area (Knowles 1976, Hamlin 1977), quantitative data were lacking. Thus, in 1976, an intensive study was initiated to determine the extent and causes of summer mortality as a factor in low fawn recruitment. Results of the first 2 years of the investigation were reported by Dood (1978). I continued the studies during the summers of 1978, 1979, and 1980 to further evaluate the extent and causes of summer mortality of fawns as environmental conditions changed and the mule deer population increased and, determine how behavior and habitat use affect early fawn survival.

STUDY AREA

The 30,000 hectare (ha) study area, previously described by Mackie (1970) and Dood (1978), was located approximately 40 kilometers (km) northeast of Roy, in Fergus County, Montana (Fig. 1). Boundaries were the Missouri River on the north, the Musselshell Trail on the south, the Skyline Trail on the east, and U.S. Highway 191 on the west.

The area was a 6-to-11 km wide, dissected plateau along the Missouri River, described locally as "breaks" (Fig. 2). The Breaks consist largely of steep, easily erodable, shale ridges separated by deep, saline coulee bottoms. The coulees blended gradually into rolling prairie along the south edge of the study area. Elevations ranged from 685 meters (m) along the Missouri River to 915 m on the south boundary.

Gieseker (1938) and Gieseker et al. (1953) described the soils in the breaks as primarily Lismas and Pierre clay loams derived from the underlying Bearpaw formation and associated shales of the Cretaceous age. These soils, commonly called "gumbo", are relatively impermeable to water. Runoff is high and flash-flooding is common during heavy rainstorms.

The climate is semi-arid with wide year-to-year fluctuations in both temperature and precipitation. Climatological data were obtained from a United States Department of Commerce weather station (Roy 8NE), located approximately 20 km southwest of the study area. Average

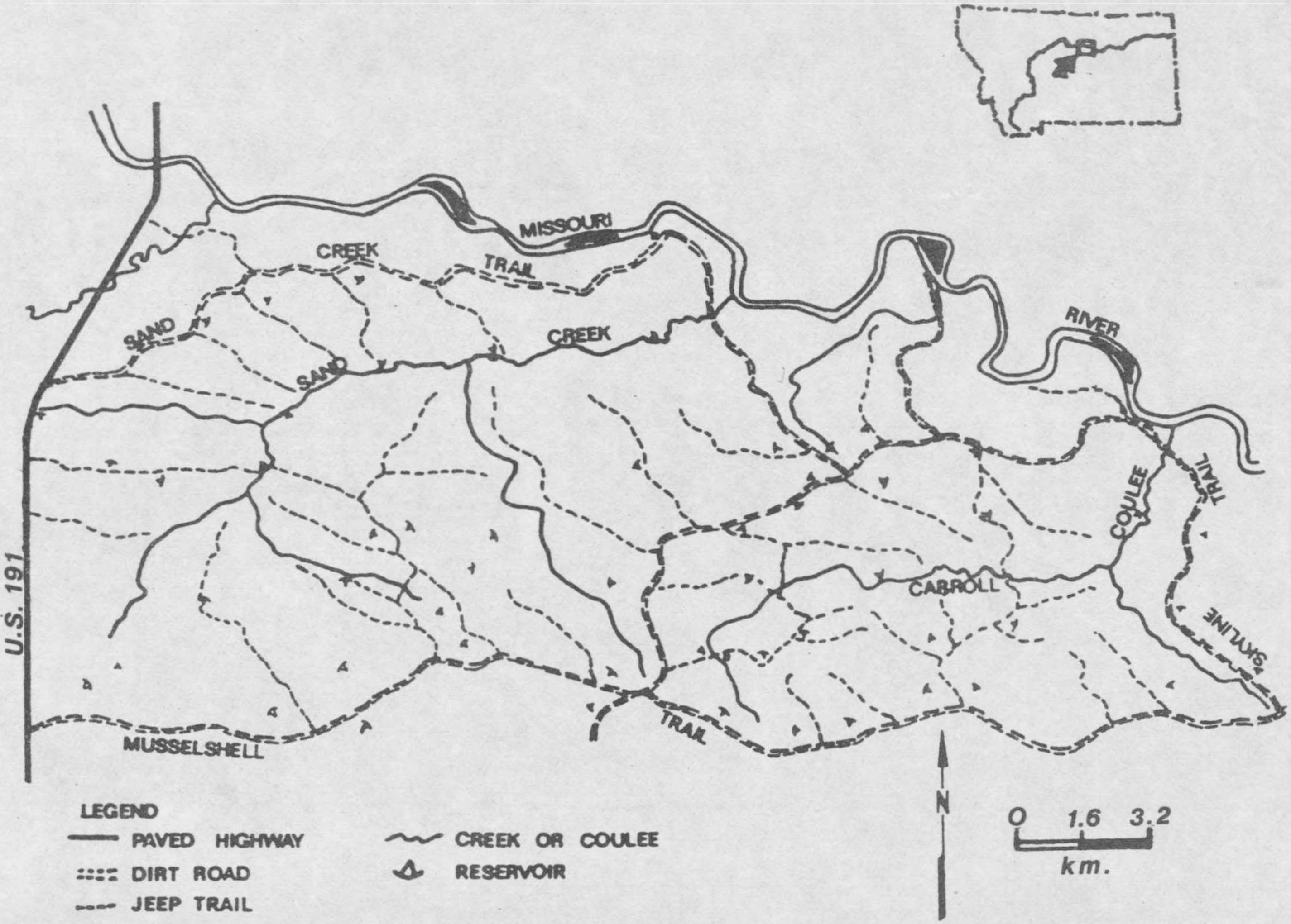

Figure 1. Map of the Missouri River Breaks Study Area.

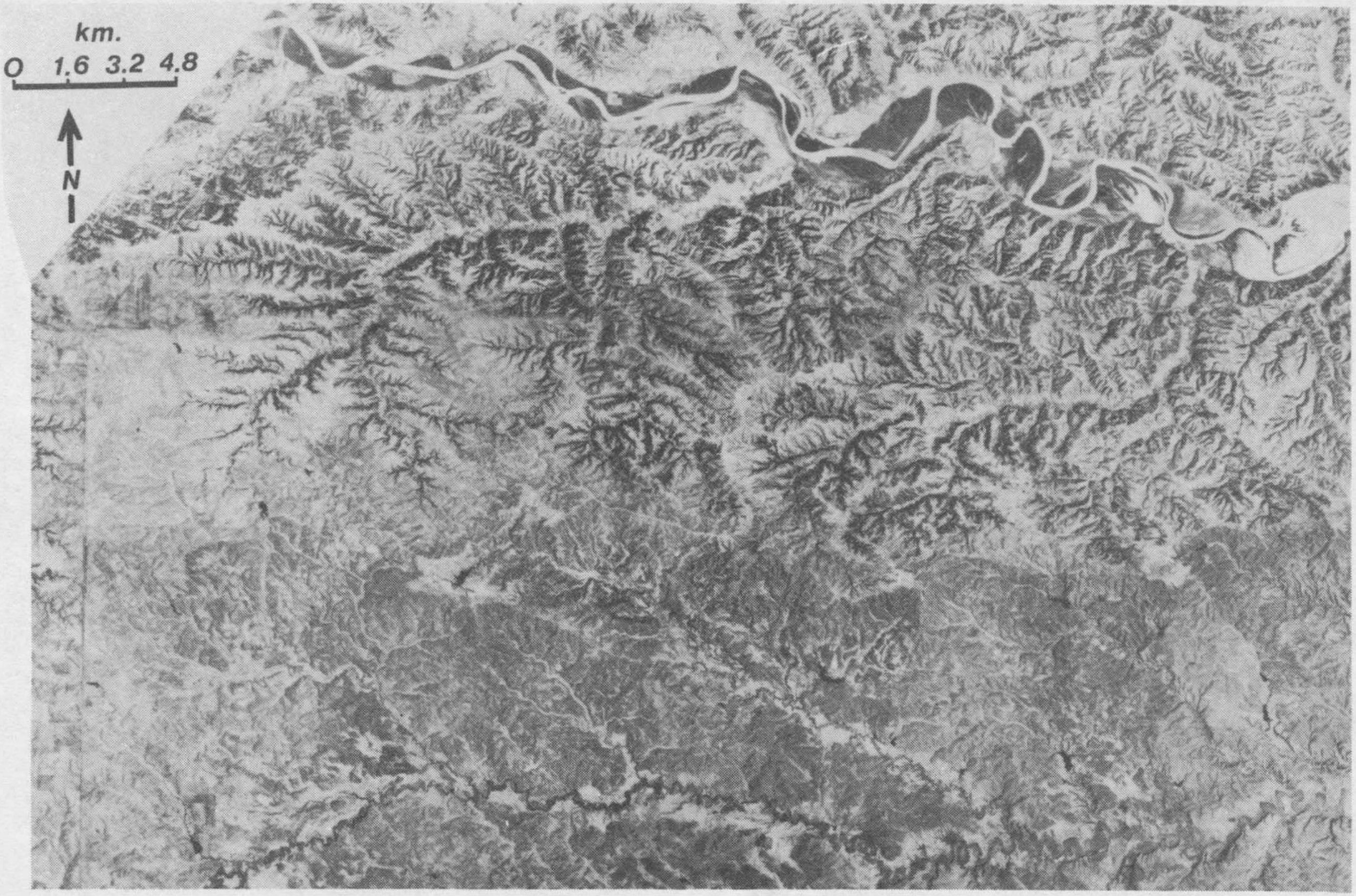

Figure 2. Aerial Mosaic of the Missouri Breaks Study Area.

monthly temperature and precipitation for the study period are compared with the 20-year (1960-1980) monthly means in Table 1.

Domestic livestock grazing was the principal commercial land use. Frequent droughts and heavy clay soils have greatly restricted successful agricultural cropping operations. Most previously cultivated tracts have reverted to grasslands. Nearly 45% of the study area was in the C. M. Russell Wildlife Refuge, while another 23% of the land was administered by other federal, state, and county agencies (Mackie 1970). Recreational uses of these lands included hunting, fishing, and camping.

In addition to mule deer, other wild ungulates on the study area included white-tailed deer (*Odocoileus virgininanus dacotensis* Goldman and Kellogg), elk (*Cervus elaphus nelsoni* Bailey), and pronghorn antelope (*Antilocapra americana americana* Ord). Possible predators of big game on the study area were coyotes, bobcats (*Lynx rufus floridanus* Rafinesque), and golden eagles (*Aquila chrysaetos canadensis* L.), but only coyotes existed in large numbers.

Vegetation cover types were varied and highly interspersed on the study area. Mackie (1970) provided a detailed description of the upland vegetation, while Allen (1968) described vegetation on the adjacent Missouri River bottom. Six general types were recognized as being important to mule deer fawns during this study.

Table 1. Monthly average temperature (°C) and monthly total precipitation (millimeters) during the study period compared to 20-year means for the Roy 8NE, Montana weather station (Climatological Data, 1977-1980).

Month	Monthly average temp.	Deviation from the mean	Monthly total precipitation	Deviation from the mean
8/77	16.7	-3.2	61	28
9/77	13.3	-0.5	54	25
10/77	8.8	0.4	16	- 3
11/77	- 1.9	-2.1	18	5
12/77	- 8.7	-3.7	49	39
1/78	-14.6	-6.3	33	21
2/78	-10.5	-6.1	23	13
3/78	- 0.6	0.8	13	1
4/78	6.7	0.4	35	8
5/78	11.6	-0.2	124	60
6/78	16.9	0.9	101	17
7/78	18.8	-2.1	97	58
8/78	18.4	-1.5	23	-10
9/78	14.6	0.8	132	103
10/78	8.5	0.1	8	11
11/78	- 4.9	-4.9	26	13
12/78	- 9.7	-4.7	24	15
1/79	-16.3	-8.0	19	7
2/79	-11.3	-6.6	20	10
3/79	0.1	1.5	16	2
4/79	3.8	-2.4	44	17
5/79	10.3	-1.6	38	-26
6/79	17.1	1.1	11	-74
7/79	20.9	0.1	22	-17
8/79	20.2	0.3	16	-17
9/79	16.9	3.2	4	-26
10/79	10.2	1.7	5	-14
11/79	- 0.3	-0.5	2	-10
12/79	- 0.4	4.5	2	- 7
1/80	- 9.3	-2.1	5	- 6
2/80	- 3.6	1.2	5	- 5
3/80	- 0.8	0.6	31	18
4/80	10.1	3.8	18	- 9

Table 1. Continued.

Month	Monthly average temp.	Deviation from the mean	Monthly total precipitation	Deviation from the mean
5/80	14.1	2.3	53	-11
6/80	17.7	1.8	39	-45
7/80	21.7	0.9	6	-33
8/80	17.4	-2.4	55	23
9/80	14.8	1.0	13	17

Artemisia-Agropyron cover type

This cover type occurred extensively along ridge tops and moderately sloped side ridges. It also occurred on steeper slopes with southerly exposure, and occupied nearly 31% of the study area. Big sagebrush (*Artemisia tridentata* Nutt.) was the dominant shrub species in this cover type. It was found in association with bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. and Smith) where soils were well developed and runoff was low (Fig. 3); these areas generally had northerly or easterly exposures. Big sagebrush was also found in association with western wheatgrass (*Agropyron smithii* Rydb.) on major ridge tops or similar dry, level sites (Fig. 4). Depending on local topoedaphic conditions, other prominent shrubs commonly found in this cover type were greasewood (*Sarcobatus vermiculatus* Hook.) and Rocky Mountain juniper (*Juniperus scopulorum* Sarg.).

Figure 3. *Artemisia tridentata-Agropyron spicatum* cover type.

Figure 4. *Artemisia tridentata-Agropyron smithii* cover type.

Artemisia longifolia cover type

This cover type occurred on loose shale slopes with southerly or westerly exposures (Fig. 5). Longleaf sage (*Artemisia longifolia* Nutt.) was the dominant plant. Grasses and forbs were generally sparse, however, yellow sweetclover (*Melilotus officinalis* (L.) Lam.) formed dense stands during some years.

Pinus-Juniperus cover type

A *Pinus-Juniperus* complex occurred on slopes and coulee heads, covering nearly 45% of the study area. It was most often found on steep south- and west-facing slopes, but also occurred to some degree on more gentle north- and east-facing aspects. Ponderosa pine (*Pinus ponderosa* Dougl.) was the dominant tree on all sites. The understory present depended largely on the degree and aspect of slope.

Dense stands of Rocky Mountain juniper grew on mesic sites (Fig. 6). These stands graded to more scattered pine and fewer juniper as the aspect became southerly or as the degree of slope decreased. A savannah, formed from an interspersion of ponderosa pine and big sagebrush-wheatgrass types occurred on slight southerly or westerly slopes, or as an ecotone between dense stands of *Pinus Juniperus* or *Psuedotsuga-Juniperus* and the *Artemesia-Agropyron* types (Fig. 7). On some steep shale slopes, ponderosa pine stands had little or no vegetative understory, and were denoted as a pine-shale type. Other shrubs found in association with the *Pinus-Juniperus* type

Figure 5. *Artemisia longifolia* cover type.

depending on local site conditions, included big sagebrush, skunkbrush sumac (*Rhus trilobata* Nutt.), western snowberry (*Symphoricarpos occidentalis* Hook.), rose (*Rosa* spp.), green rabbitbrush (*Chrysothamnus viscidiflorus* (Hook.) Nutt.) and rubber rabbitbrush (*Chrysothamnus nauseosus* (Pall.) Britt.).

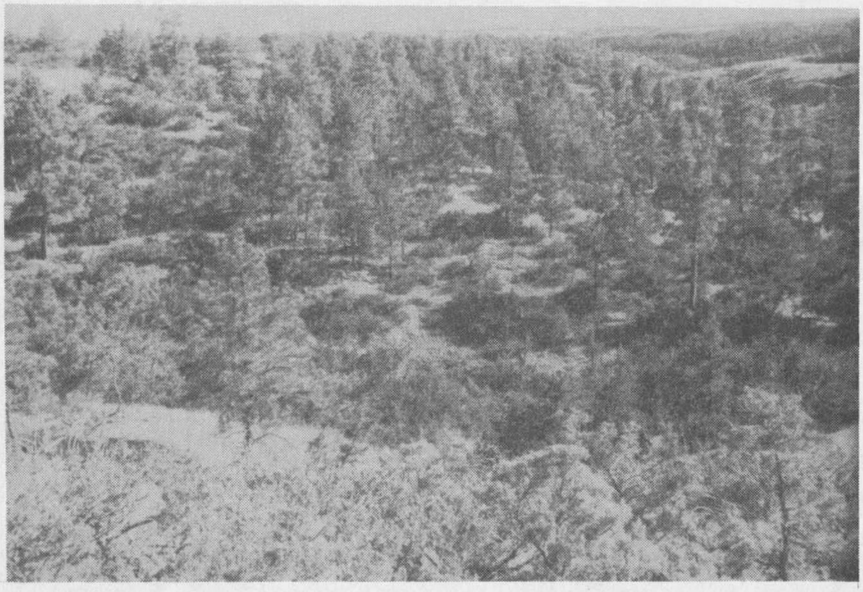

Figure 6. *Pinus-Juniperus* cover type with a dense understory of Rocky Mountain juniper.

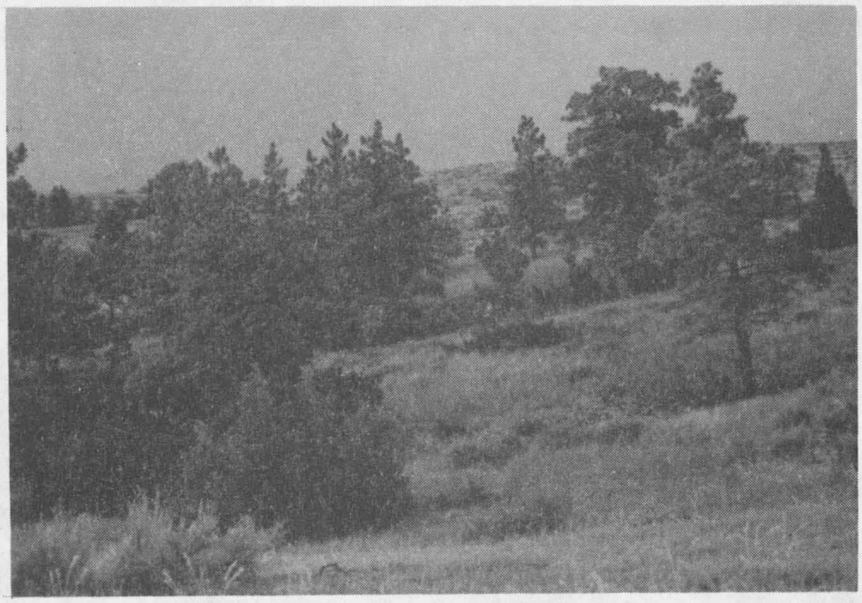

Figure 7. *Pinus-Juniperus* cover type, a pine savannah.

Psuedotsuga-Juniperus cover type

This cover type occurred almost exclusively on mesic, steep, north- and east-facing slopes or benches (Fig. 8). The dominant tree species was Douglas fir (*Psuedotsuga menziesii* (Mirbel) Franco), but ponderosa pine frequently occurred as a seral species. Shrubs commonly found included Rocky Mountain juniper, chokecherry (*Prunus virginiana* L.), skunkbrush sumac, western snowberry, rose, big sagebrush, and rabbitbrush. Deadfall from trees and shrubs was also densely concentrated at some sites. The *Psuedotsuga-Juniperus* type covered approximately 13% of the study area.

Sarcobatus-Agropyron cover type

This cover type was found primarily on saline slopes, benches, and bottoms along the Missouri River and major coulees (Fig. 9). Greasewood was the dominant shrub, but big sagebrush often shared dominance where soils were better developed and had a lower salt content. Western wheatgrass was the most common species in the typically sparse herbaceous layer.

Symphoricarpos-Agropyron cover type

This cover type (Fig. 10) was of limited occurrence, occupying sites along water courses where silty soils existed. Western snowberry was the dominant shrub and often formed dense patches. Western wheatgrass was the most abundant grass species, but also occurred with

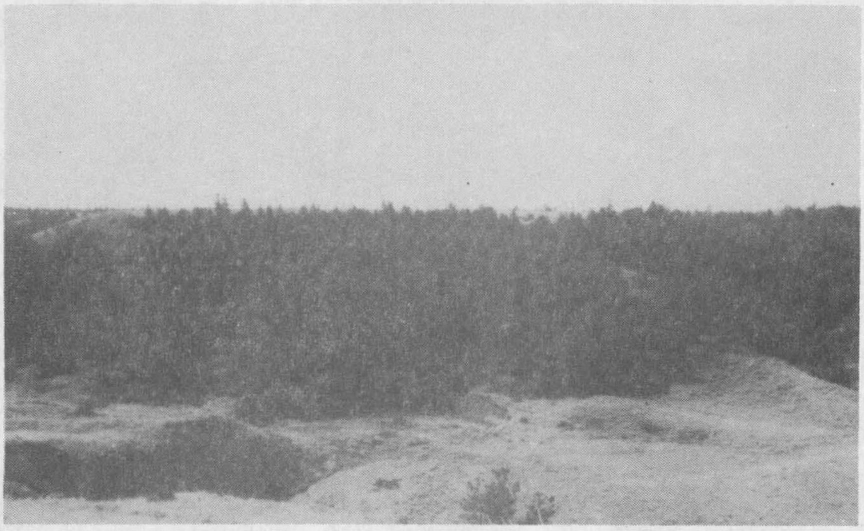

Figure 8. *Psuedotsuga-Juniperus* cover type.

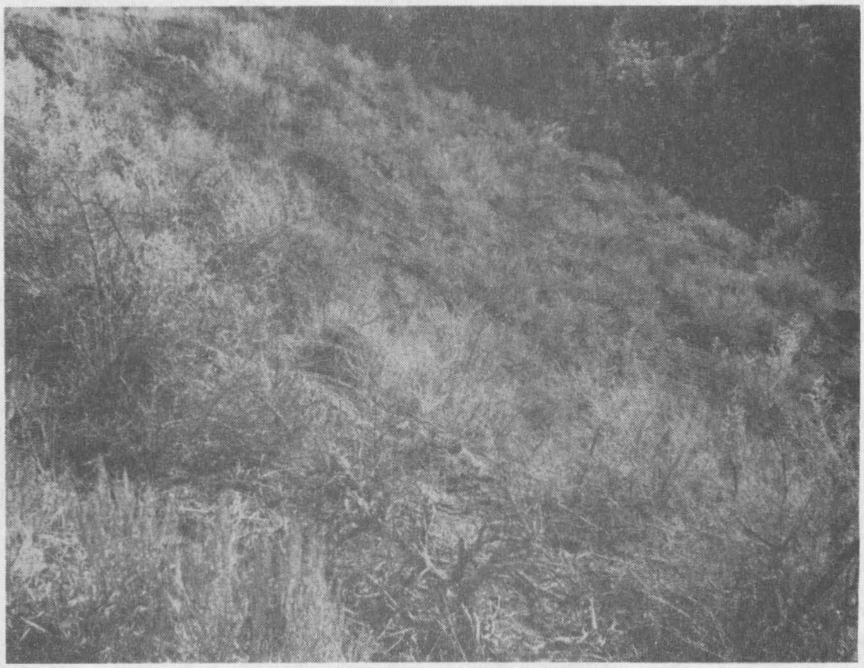

Figure 9. *Sarcobatus-Agropyron* cover type.

Figure 10. *Symphoricarpus-Agropyron* cover type.

bluegrasses (*Poa* spp.) or desert saltgrass (*Distichlis stricta* (Torr.) Rydb.) at some sites.

METHODS

Field studies were conducted from mid-June to mid-September in 1978, 1979, and 1980. Mule deer fawns, 1 day to 3-weeks of age, were captured during mid-June. Capture was effected by ground crews using long handled hoop nets. An observer, flying in a Piper Super Cub aircraft, located fawns and coordinated the capture operation with ground crews using 2-way transceivers.

Captured fawns were processed quickly and carefully to avoid the possible negative effects of handling (White et al. 1972). Each was sexed, weighed, examined for wounds or other irregularities, and the overall condition of the animal was noted. They were then fitted with a radio-transmitter collar and numbered metal ear-tags. The approximate age and birth date of each fawn was calculated later following Robinette and Jensen (1950).

Transmitters (Wildlife Materials Inc.) were in the 150-152 Megahertz range, and powered two 1,200-milliamp lithium batteries. Each had a decimeter (dm) external whip antenna and a motion sensitive switch. Transmitter and batteries were sealed in dental acrylic and attached to an expandable, elastic neckband. All neckbands had 5-6, 8 centimeter (cm) break-away flaps sewed with cotton thread. When the thread rotted or was stressed, the flaps broke open allowing expansion with growth of the fawn. The entire radio package weighed 80 grams.

Fawns were relocated from the ground using an LA12 portable receiver (AVM Instrument Co.) and a hand held Yagi antenna. Ground observations were supplemented with aerial observations during periods when roads were impassable. An attempt was made to visually locate each fawn at regular 2-3 day intervals from the time of capture until death or 15 September. Data recorded for each relocation included activity, cover type, aspect, degree of slope, and position on slope. The distance from the doe and the general overall condition of the fawn was also recorded. All relocations were plotted on an airphoto grid of the study area. Home ranges were determined using the modified minimum area method (Harvey and Barbour 1965). During this study, classification of vegetation cover types followed Mackie (1970).

Concealment cover surrounding fawn bedsites was measured using a 3 X 6 dm cover profile board (Nudds 1977). The board was divided from top to bottom into 1 dm bands of alternating red and yellow colors. Measurements were taken from a distance of 6 m, and from 3 directions at 120° intervals. The apex of a triangle formed from the 3 directions was always pointed to the north. Because the visual environment of a coyote is different from that of a human, readings were taken from a kneeling position (50 cm). The amount of cover was estimated to the nearest 5%.

When remains of a dead fawn were located, the surrounding area was extensively searched for evidence of the cause of death. Criteria used for determining the cause of death followed those described by White (1973), Dood (1978), and O'Gara (1978).

RESULTS

Forty-nine fawns were equipped with radio transmitters: 15 in 1978, 18 in 1979, and 16 in 1980 (Table 2). Two in the 1978 sample were not monitored due to transmitter failure. Two additional fawns were captured and marked only with ear streamers in 1980, but neither was subsequently reobserved. One fawn handled in 1978 and another caught in 1980 had been severely wounded by predators prior to capture. None of these were included in samples used to calculate mortality patterns and rates (Table 3).

Mortality

Total mortality rates were similar (X^2, $P>.05$) for the 3 summers (Table 3). The causes of death also were the same each year (Table 4). All mortality was attributed to either starvation following abandonment or predation. A complete description of each case of fawn mortality observed during the study is presented in Appendix Table 13.

One-third of the total mortality (1 fawn each summer) could be attributed to abandonment, though the proximal cause of death in each case was starvation. The rumens of 2 of those fawns (#12 and #23, Table 2) were empty. The rumen of the other (#41) was completely full of vegetation (primarily browse, Fig. 11) that retained a herbal fragrance indicating that digestion probably was not occurring. The bodies of all were emaciated, and none had been scavenged. Fawns 23 and 41 were offspring of the same marked doe, and each was a member

Table 2. Characteristics and fate of individual fawns captured during summer 1978, 1979, and 1980.

Fawn No.	Sex	Weight (kg)	Estimated birth date	Time span monitored	Comments
1	M	3.6	15 June 1978	15 June 1978	Twin of fawn 2. Transmitter failed. Last observed alive on 15 June 1978.
2	F	3.9	15 June 1978	15 June - 24 June 1978	Twin of fawn 1. Transmitter failed. Last observed alive on 24 June 1978.
3	F	4.5	13 June 1978	17 June - 15 Sept 1978	A single fawn.
4	M	8.4	1 June 1978	18 June - 15 Sept 1978	Twin of fawn 5. Offspring of radio monitored doe.
5	M	8.6	1 June 1978	18 June - 8 Sept 1978	Twin of fawn 4. Fate unknown.
6	M	5.0	14 June 1978	18 June - 15 Sept 1978	Twin of fawn 7.
7	F	4.5	14 June 1978	18 June - 15 Sept 1978	Twin of fawn 6.
8	M	9.3	30 May 1978	18 June - 15 Sept 1978	One of a set of twins, other fawn eluded capture.
9	M	3.1	20 June 1978	20 June - 15 Sept 1978	One of a set of twins, other fawn killed by coyotes just prior to capture.
10	F	6.4	9 June 1978	20 June - 15 Sept 1978	Single fawn.
11	M	6.4	9 June 1978	20 June - 15 Sept 1978	Single fawn.
12	F	7.0	8 June 1978	21 June - 26 June 1978	Twin of fawn 13. Died 25 June - 26 June; death attributed to abandonment by the doe.
13	F	6.8	8 June 1978	21 June - 13 July 1978	Twin of fawn 12. Died 12 July - 13 July; death attributed to predation by coyotes.
14	M	7.3	9 June 1978	21 June - 15 Sept 1978	One of a set of twins. Other fawn eluded capture.

Table 2. Continued.

Fawn No.	Sex	Weight (kg)	Estimated birth date	Time span monitored	Comments
15	M	7.0	9 June 1978	21 June - 15 Sept 1978	One of a set of twins. Other fawn eluded capture.
16	F	5.0	7 June 1979	13 June - 15 Sept 1979	Twin of fawn 17.
17	F	5.2	7 June 1979	13 June - 15 Sept 1979	Twin of fawn 16.
18	M	5.4	8 June 1979	13 June - 15 Sept 1979	Single fawn.
19	F	7.4	29 May 1979	13 June - 15 Sept 1979	One of a set of twins. Other fawn eluded capture.
20	F	8.6	28 May 1979	17 June - 15 Sept 1979	Twin of fawn 21.
21	F	8.8	28 May 1979	17 June - 15 Sept 1979	Twin of fawn 20.
22	M	4.8	11 June 1979	14 June - 15 Sept 1979	One of a set of twins. Other fawn eluded capture. Offspring of radio monitored doe.
23	M	6.6	5 June 1979	14 June - 20 June 1979	One of a set of twins. Other fawn eluded capture. Offspring of radio monitored doe. This fawn died 18 June - 20 June; death attributed to abandonment by doe.
24	F	6.5	4 June 1979	14 June - 15 Sept 1979	Twin of fawn 25.
25	M	6.7	4 June 1979	14 June - 15 Sept 1979	Twin of fawn 24.
26	M	7.1	5 June 1979	16 June - 15 Sept 1979	Single fawn.
27	F	6.2	6 June 1979	16 June - 15 Sept 1979	One of a set of twins. Other fawn eluded capture.

Table 2. Continued.

Fawn No.	Sex	Weight (kg)	Estimated birth date	Time span monitored	Comments
28	F	8.3	28 May 1979	16 June - 4 Aug 1979	Single fawn. Died 2 August - 4 August; death attributed to predation by coyotes.
29	M	9.2	26 May 1979	18 June - 15 Sept 1979	One of a set of twins. Other fawn eluded capture.
30	F	4.0	15 June 1979	17 June - 8 Aug 1979	Single fawn. Died 3 August - 8 August; probable coyote involvement.
31	F	7.0	3 June 1979	17 June - 15 Sept 1979	Single fawn.
32	M	8.1	1 June 1979	17 June - 5 Sept 1979	Twin of fawn 33. Offspring of radio monitored doe. Lost radio collar but survived the study period.
33	M	8.6	1 June 1979	17 June - 15 Sept 1979	Twin of fawn 32. Offspring of radio monitored doe.
34	F	6.8	2 June 1980	16 June - 15 Sept 1980	Twin of fawn 35.
35	M	8.1	2 June 1980	16 June - 15 Sept 1980	Twin of fawn 34.
36	M	5.2	12 June 1980	16 June - 19 July 1980	Twin of fawn 52. This fawn died 17 July - 19 July; death attributed to predation by coyotes.
37	M	4.8	12 June 1980	16 June - 15 Sept 1980	Twin of fawn 38.
38	F	5.2	12 June 1980	16 June - 15 Sept 1980	Twin of fawn 37.
39	M	4.5	12 June 1980	16 June - 15 Sept 1980	Single fawn. At time of capture this fawn had scabs on the head and neck region; it is suspected that the fawn survived a predator attack.
40	M	4.3	16 June 1980	17 June - 15 Sept 1980	Single fawn.

Table 2. Continued.

Fawn No.	Sex	Weight (kg)	Estimated birth date	Time span monitored	Comments
41	F	6.8	4 June 1980	17 June - 22 June 1980	One of a set of twins. Other fawn eluded capture. Offspring of radio monitored doe. This fawn died 21 June - 22 June; death attributed to abandonment by doe.
42	F	4.5	13 June 1980	17 June - 15 Sept 1980	One of a set of twins. Other fawn eluded capture.
43	F	8.4	1 June 1980	17 June - 15 Sept 1980	Twin of fawn 44. Offspring of radio monitored doe.
44	M	7.9	1 June 1980	17 June - 15 Sept 1980	Twin of fawn 43. Offspring of radio monitored doe.
45	M	6.1	10 June 1980	17 June - 15 July 1980	Observed 10 days prior to capture with an apparent twin which was never observed again. Offspring of radio monitored doe. This fawn died 14 July - 15 July; death was attributed to a probable coyote kill.
46	F	4.1	17 June 1980	19 June - 15 Sept 1980	Sibling of fawns 47 and 48.
47	F	3.7	17 June 1980	19 June - 15 Sept 1980	Sibling of fawns 46 and 48.
48	M	5.0	17 June 1980	19 June - 15 Sept 1980	Sibling of fawns 46 and 47.
49	F	5.4	12 June 1980	19 June - 15 Sept 1980	Single fawn.
50	F	5.8	12 June 1980	19 June 1980	Twin of fawn 51. Marked with yellow, armotite streamers in each ear. Never observed again after capture.
51	F	6.1	12 June 1980	19 June 1980	Twin of fawn 50. Marked with yellow, armotite streamers in each ear. Never observed again after capture.
52	M	5.0	12 June 1980	16 June 1980	Twin of fawn 36. Fatally wounded prior to capture; coyote involvement.

Table 3. Number of mule deer fawns captured and monitored and the number and percentage dying from unnatural and natural causes during summers 1978-1980 in the Missouri River Breaks, Montana.

Year	Number marked	Number monitored[1]	Unnatural deaths[2]	Natural deaths[3]	Total deaths[2]
1978	16	13	1 (7.7%)	2 (16.7%)	3 (23.1%)
1979	18	18	1 (5.6%)	2 (11.8%)	3 (16.7%)
1980	19	16	1 (6.3%)	2 (13.3%)	3 (18.8%)
Totals	53	47	3 (6.4%)	6 (13.6%)	9 (18.8%)

[1] Excludes 2 fatally wounded fawns captured in 1978 and 1980, 2 fawns for which transmitters failed in 1978, and 2 fawns marked only with ear streamers in 1980.

[2] Percentages calculated from number monitored.

[3] Percentages calculated from number monitored - unnatural deaths.

Table 4. Time and cause of mortality of monitored fawns during summers 1978-1980 in the Missouri River Breaks, Montana.

Year	Fawn no.	Date of death	Cause of death
1978	12	25-26 June	Starvation
1978	13	12-13 July	Coyote predation
1978	5	8-14 Sept	Unknown
1979	23	18-20 June	Starvation
1979	28	4 August	Coyote predation
1979	30	3-8 August	Probable coyote predation
1980	41	21-22 June	Starvation
1980	36	17-19 July	Probable coyote predation
1980	45	14-15 July	Probable coyote predation

Figure 11. Rumen with undigested browse in fawn #41 that died of starvation due to abandonment.

of a set of twins produced in successive years. In both years the remaining unmarked twin was known to survive the summer study period. Abandonment thus appeared to be a reaction of individual does to the capture and/or marking of their offspring. Because of this, abandonment/starvation was considered unnatural mortality (Table 3).

Natural mortality rates were 16.7%, 11.8%, and 13.3% in 1978, 1979, and 1980, respectively. Coyote predation was the known or suspected cause of all natural mortality, though the fate of 1 fawn (#5) was not positively determined. All fawns killed were within the home ranges of denning coyote pairs (Pyrah 1980).

Five of the 8 fawns killed during the study were males, including all 3 that were killed in 1980. Both fawns dying from natural causes in 1979 were females.

In 1978, monitored fawns died both in early and late summer. All natural mortality in 1979 occurred during the first week of August, while the 2 fawns that were killed in 1980 died within 1 week during mid-July. During capture operations on 20 July, 1978, Hamlin and Schweitzer (1979) observed 2 coyotes kill the sibling of fawn number 9. In 1980, fawn number 52 was fatally wounded by predators prior to capture. Also, fawn number 45 was observed 10 days prior to capture with an apparent twin which subsequently disappeared.

Movements and Home Range

The minimum, maximum, and mean distances moved between relocations and home range sizes for all fawns monitored during the 3 summers are listed in Table 5. Movement between relocations ranged from 0.0 to 3.85 km. The overall mean was 0.78 km. Fawns monitored in 1978 made significantly greater movements between relocations than those monitored in 1979 and 1980 (Newman-Keul test, $P<.05$, $P = .06$, respectively). The greatest variation in movement between relocations occurred in 1980.

Although siblings were often relocated some distance apart, they generally moved together. There was no difference in the average

Table 5. Maximum, minimum, and average movements between relocations, and summer home range sizes for marked fawns during summers 1978-1980 in the Missouri River Breaks, Montana.

Fawn no.	Number of relocations	Maximum movement (km)	Minimum movement (km)	Average movement (km)	Homerange[1/] (ha)
			1978		
1	1	--	--	--	--
2	3	1.41	0.40	0.91	--
3	17	2.92	0.10	0.93	111
4	19	2.41	0.10	0.95	229
5	18	2.41	0.10	0.98	229
6	23	2.01	0.10	1.01	248
7	23	2.01	0.10	1.01	248
8	20	1.81	0.50	0.70	157
9	21	1.29	0.10	0.56	105
10	21	2.21	0.20	1.03	275
11	20	3.32	0.10	0.93	226
12	3	1.21	0.08	0.64	--
13	6	2.21	1.21	1.63	--
14	20	2.21	0.10	1.31	350
15	20	2.31	0.10	0.91	196
Mean	16	2.28	0.11	0.93	211
CV[2/]	--	28	131	19	33
			1979		
16	25	1.22	0.03	0.57	189
17	25	1.22	0.03	0.57	189
18	25	1.82	0.09	0.49	90
19	25	1.72	0.03	0.68	44
20	24	3.04	0.09	0.99	80
21	24	3.04	0.09	0.99	80
22	24	1.93	0.09	0.72	101
23	2	0.41	0.03	0.22	--
24	24	1.72	0.09	0.76	107
25	24	1.72	0.09	0.76	107
26	23	1.52	0.09	0.57	77
27	24	2.53	0.09	0.77	113
28	15	1.01	0.05	0.42	55

Table 5. Continued.

Fawn no.	Number of relocations	Maximum movement (km)	Minimum movement (km)	Average movement (km)	Homerange[1] (ha)
29	25	2.13	0.09	0.94	203
30	14	1.12	0.30	0.72	115
31	22	1.93	0.02	0.68	68
32	23	1.12	0.20	0.68	62
33	23	1.12	0.20	0.68	62
Mean	22	1.76	0.10	0.69	100
CV	--	36	77	22	47
1980					
34	29	0.91	0.00	0.52	76
35	29	0.91	0.00	0.52	76
36	11	2.03	0.08	0.71	72
37	29	1.52	0.10	0.38	125
38	29	1.52	0.10	0.38	125
39	28	0.71	0.03	0.52	96
40	27	2.03	0.08	0.71	201
41	2	0.81	0.81	0.81	--
42	29	2.64	0.01	1.54	194
43	30	3.85	0.20	1.07	112
44	30	3.85	0.20	1.07	112
45	10	1.01	0.20	1.46	23
46	29	0.51	0.01	0.31	47
47	29	0.51	0.01	0.31	47
48	29	0.51	0.01	0.31	47
49	29	1.32	0.02	0.99	110
Mean	23	1.65	0.07	0.73	106
CV	--	71	171	53	54
Overall Mean	21	1.78	0.14	1.04	164.28
Overall CV	--	44	148	168	115

[1] Homeranges not calculated for those fawns with less than 10 relocations.

[2] $CV = \frac{St.\ Dev.}{Mean} X\ 100.$

distances moved by single fawns as compared with twins (t-test, P>.05).

There was not a significant correlation between the age of individual fawns and distance moved between relocations. However, the average distance moved by all fawns during 2-week periods increased in a positive linear relationship (r = .8447, P<.05) with time. This indicated that fawns, while highly variable in their movements, could be expected to make larger movements as summer progressed. Fawns were capable of extensive movement at any age, and nearly all made at least 1 movement greater than 1 km at some time during the summer.

Fourteen sets (41%) of fawns made greater than average movements immediately after capture, and 11 sets (32%) never returned to the area in which they were captured. Of the 6 marked fawns that died "natural" deaths during the study, 4 belonged to this apparently displaced group.

Summer home ranges varied in size from 23 to 350 ha (Table 5). The overall mean was 133 ha. The mean for 1978 (211 ha) was approximately twice as large as the means for 1979 (100 ha) and 1980 (106 ha). Within years, home range sizes were similar for single fawns and twin/triplets (t-test, P>.05).

Home ranges of monitored fawns frequently overlapped (Figures 12a-c), but complete overlap (Figure 12b) was observed only during 1980. Figure 12c illustrates the spatial relationship and minimal overlap

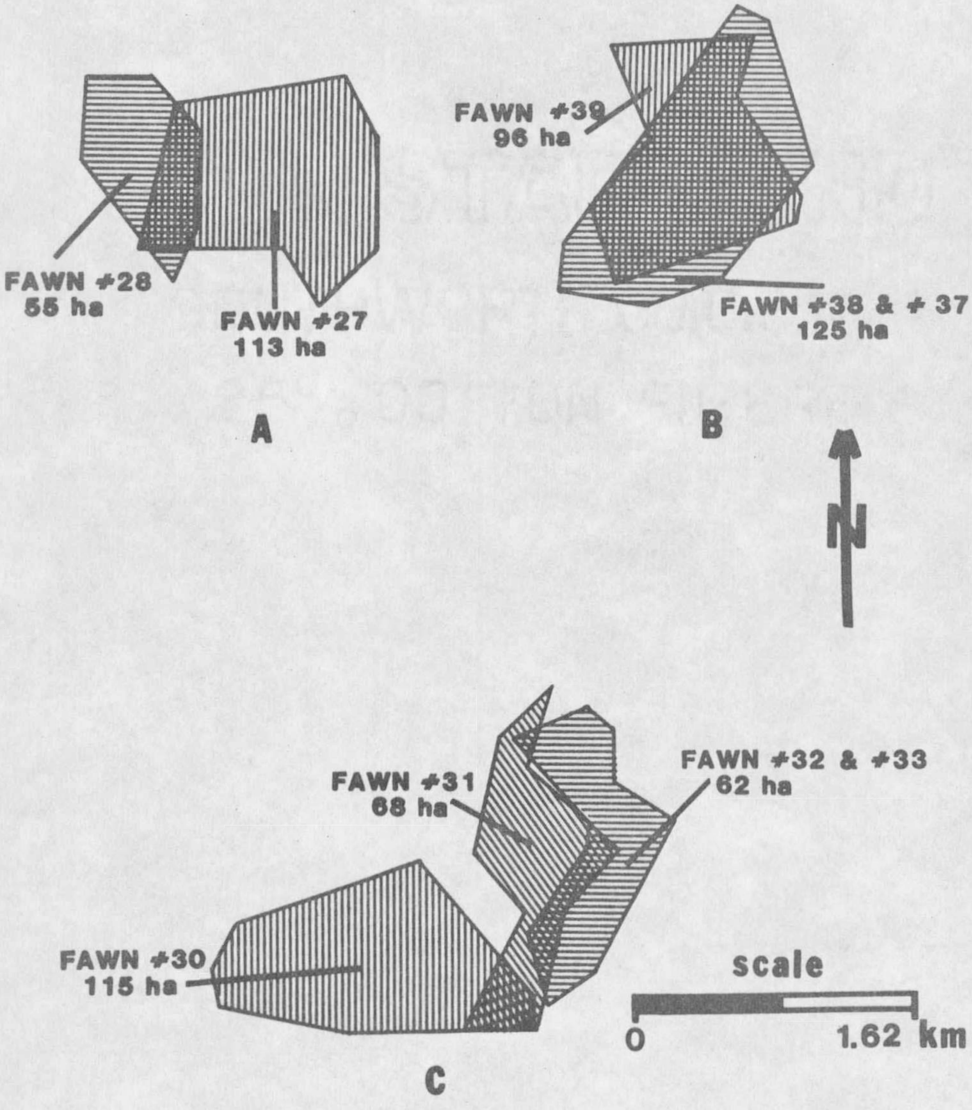

Figure 12. Plots of summer home ranges of marked fawns, illustrating various degrees of home range overlap. Figure 12a, partial overlap. Figure 12b, complete overlap. Figure 12c, adjacent home ranges with a minimum of overlap.

between 3 sets of marked fawns with adjacent home ranges. During consecutive years, fawns of the same marked does occupied different though partially overlapping home ranges (Figures 13a-b).

Habitat Use

The extent to which fawns utilized each cover type differed significantly (X^2, $P<.05$) between early and late summer and between years (Table 6). Open types (Pine savannah, *Artemesia-Agropyron,* and *Sarcobatus-Agropyron*) received the greatest use in early summer. Fawns used dense cover types (*Pinus-Juniperus* and *Psuedotsuga-Juniperus*) more as summer progressed. Fawns utilized the dense cover types more in 1980 than in 1978 or 1979.

Northerly aspects received the greatest use by fawns, while southerly exposures were used the least (Table 7). Increased use of north slopes occurred through each summer.

Fawns typically utilized small, pawed-out spots on moderately steep (11-35°) slopes for bedsites and avoided both level areas and extremely steep (36°+) slopes (Table 8). They tended to utilize steeper slopes later in the season, especially during 1980. Gradual slopes (0-10°) were used more during 1978 than in 1979 or 1980.

The middle and lower third of the slopes were preferred bedding areas (Table 9). Although fawns were rarely observed on ridge tops or coulee bottoms, most use of these areas occurred during early summer.

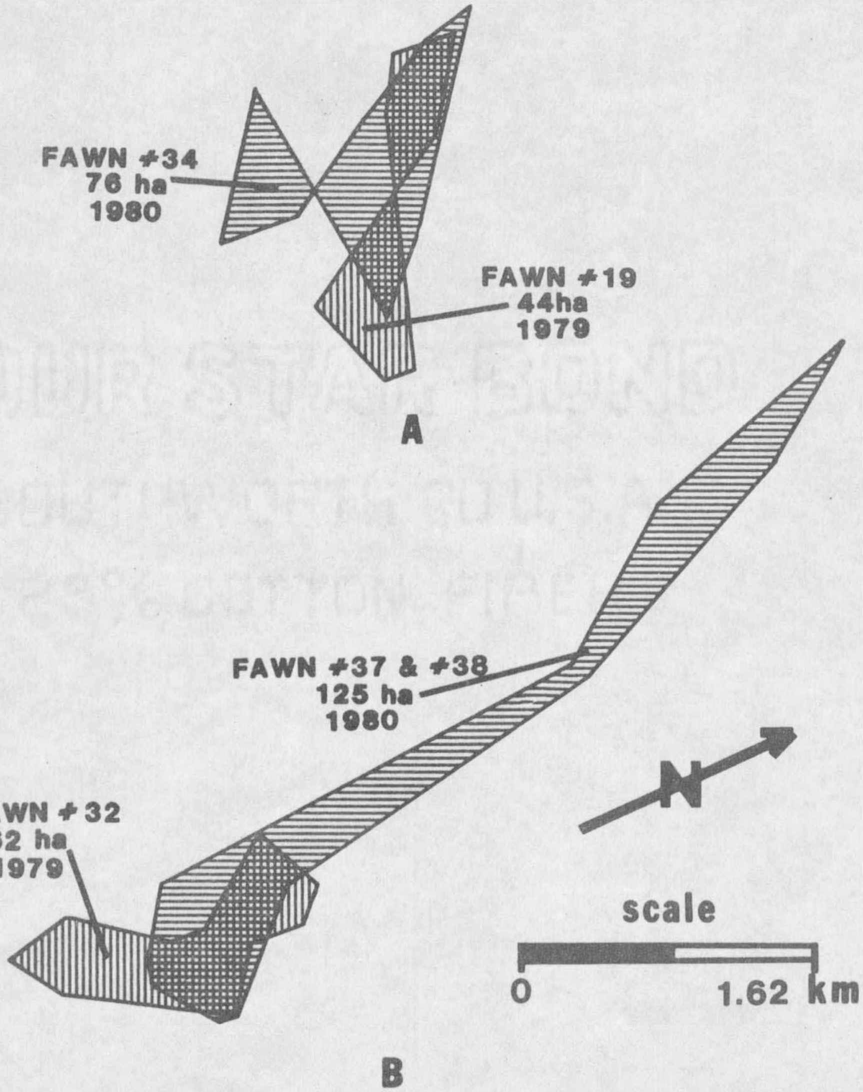

Figure 13. Summer home ranges of fawns from the same marked does during 1979 and 1980.

Table 6. Frequency of use of various cover types by mule deer fawns for bedsites during early (15 June - 31 July) and late (1 August - 15 September) summer 1978-1980 in the Missouri River Breaks, Montana.

Cover type	Season	1978 n=113	1979 n=194	1980 n=229	$\overline{X}$
Psuedotsuga -	Early	23	18	44	28.3
Juniperus	Late	54	41	66	53.6
Pinus -	Early	50	64	45	53.0
Juniperus	Late	44	55	34	44.3
Pine	Early	27	11	19	19.0
Juniper	Late	22	29	20	23.7
Pine	Early	21	53	25	33.0
Savannah	Late	16	16	14	15.3
Pine	Early	2	0	1	1.0
Shale	Late	6	10	0	5.3
Artemisia -	Early	17	11	4	10.7
Agropyron	Late	1	3	0	1.3
Sarcobatus -	Early	8	6	5	6.3
Agropyron	Late	0	1	0	0.3
Symphoricarpos -	Early	2	0	0	0.7
Agropyron	Late	0	0	0	0.0
Artemisia	Early	0	1	0	0.3
longifolia	Late	0	0	0	0.0

Table 7. Frequency of use of slopes of various exposure for bedsites by mule deer fawns during early (15 June - 31 July) and late (1 August - 15 September) summer 1978-1980, in the Missouri River Breaks, Montana.

Year	Season	Aspect N	NE	E	SE	S	SW	W	NW
1978	Early	19	17	15	2	11	6	20	10
n=192	Late	14	26	7	5	8	11	17	12
1979	Early	18	13	12	10	10	9	10	18
n=360	Late	26	14	14	4	2	8	12	20
1980	Early	11	10	8	11	10	10	17	23
n=245	Late	30	14	9	13	2	2	9	21
$\bar{X}$	Early	16.0	13.3	11.3	7.7	10.3	8.3	15.7	17.0
n=792	Late	23.3	28.0	10.0	7.3	4.0	7.0	12.7	17.7

Table 8. Frequency of use of slopes of various steepness used by mule deer fawns during early (15 June - 31 July) and late (1 August - 15 September) summer 1978-1980, in the Missouri River Breaks, Montana.

Year	Season	Degree of slope 0-10	11-25	25-35	36+
1978	Early	50	48	2	0
n=106	Late	30	48	20	2
1979	Early	28	52	20	0
n=346	Late	18	47	35	0
1980	Early	22	42	35	1
n=224	Late	15	32	36	17
$\bar{X}$	Early	33	47	19	0.3
n=672	Late	21	42	30	6

Table 9. Frequency of use of various positions on slopes for bedsites by mule deer fawns during early (15 June - 31 July) and late (1 August - 15 September) summer 1978-1980, in the Missouri River Breaks, Montana.

Year	Season	Ridge tops	Upper 1/3	Middle 1/3	Lower 1/3	Coulee bottoms
1979	Early	6	18	42	31	3
n=159	Late	0	7	39	54	0
1980	Early	8	11	44	32	5
n=177	Late	0	31	21	35	13
$\overline{X}$	Early	7	15	43	32	4
n=336	Late	0	19	30	45	7

Bedsites were generally among shrubs or deadfall. Juniper occurred with substantially greater frequency than any other shrub species at fawn bedsites (Table 10).

Marked fawns selected bedsites that provided an average of 69% concealment cover from 3 sides (Table 11). There was no significant difference (ANOVA, P>.10) between years in the amount of cover surrounding fawn bedsites; thus, the data were pooled to increase the sample size. Over 80% concealment cover was observed at 57% of the bedsites sampled. Means, however, do not indicate how cover was spatially distributed. Individual decimeter height bands were typically either densely (80-100%) or sparsely (0-20%) covered (Fig. 14).

Table 10. Frequency of occurrence of various shrub species and deadfall at fawn bedsites during summers 1978-1980, in the Missouri River Breaks, Montana.

Species	1978 n=94	1979 n=181	1980 n=137	$\overline{X}$
Juniper	46	55	53	51
Sagebrush	17	9	3	10
Greasewood	8	7	7	7
Young ponderosa pine	9	11	2	7
Young Douglass fir	2	3	6	4
Chokecherry	0	1	4	2
Skunkbrush	1	5	7	4
Rose	6	2	3	4
Snowberry	0	0	3	1
Miscellaneous	10	1	4	5
Deadfall	1	6	8	5

Behavior

When active with the doe, single fawns generally appeared more sedate than twins. Twins often played together, running back and forth across slopes. The triplets behaved much like twins, though typically only 2 of the 3 fawns were active at once.

Fawns increased their activity as summer progressed. They also became increasingly more difficult to approach. Early in the summer, fawns were generally bedded except when flushed, but by 1 August, most were observed moving in the absence of the doe. Foraging by fawns was

Table 11. Range, means and coefficients of variation of visual concealment provided by cover surrounding fawn bedsites during summers 1978-1980, in the Missouri River Breaks, Montana.[1]

Height class (dm)	Percent coverage Range	Mean	CV[2]
0-1	0-100	81	40
0-2	0-100	78	44
0-3	0-100	77	45
0-4	0-100	74	49
0-5	0-100	72	52
0-6	0-100	69	54

[1] n = 84.

[2] $CV = \frac{\text{St. Dev.}}{\text{Mean}} \times 100.$

first observed on 17 July, 14 July, and 8 July during 1978, 1979, and 1980, respectively.

Early in the summer, does appeared to attend fawns solely for the purposes of feeding and protection. The length of time fawns spent with their dams increased through the summer period. Marked does were observed 10 m- to- 1.84 km from their bedded fawns; however, most were typically less than 250 m away and in line of sight.

The general area where a fawn bedded was determined by the dam, but the fawn selected the actual bedsite. Twins typically bedded apart at an early age, but the distance decreased through the summer ($r = -0.8561$, $P<.05$, Fig. 15).

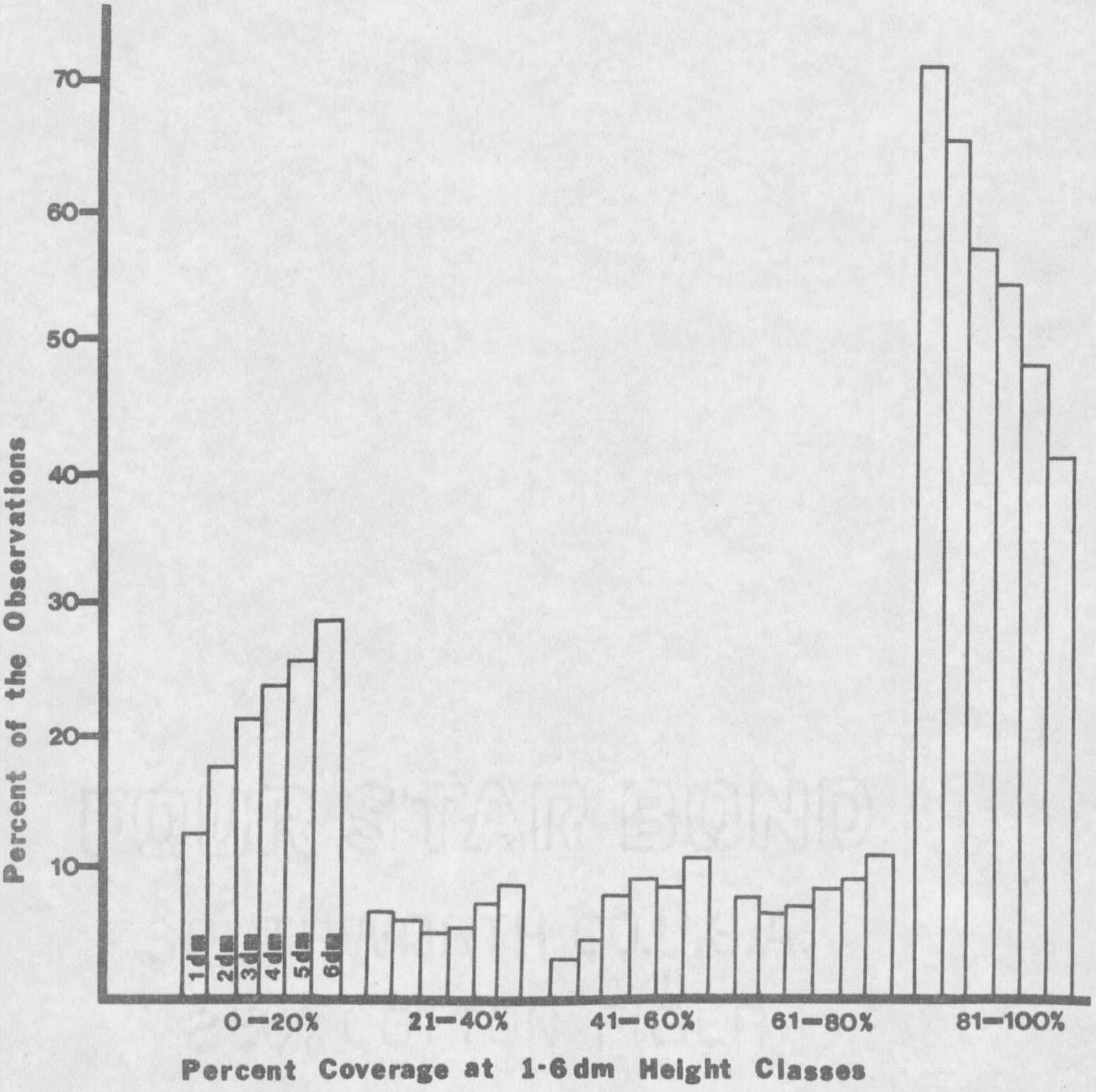

Figure 14. Percentage of the total observations made up by different classes of concealment cover at 1-6 dm heights surrounding fawn bedsites in the Missouri River Breaks, Montana.

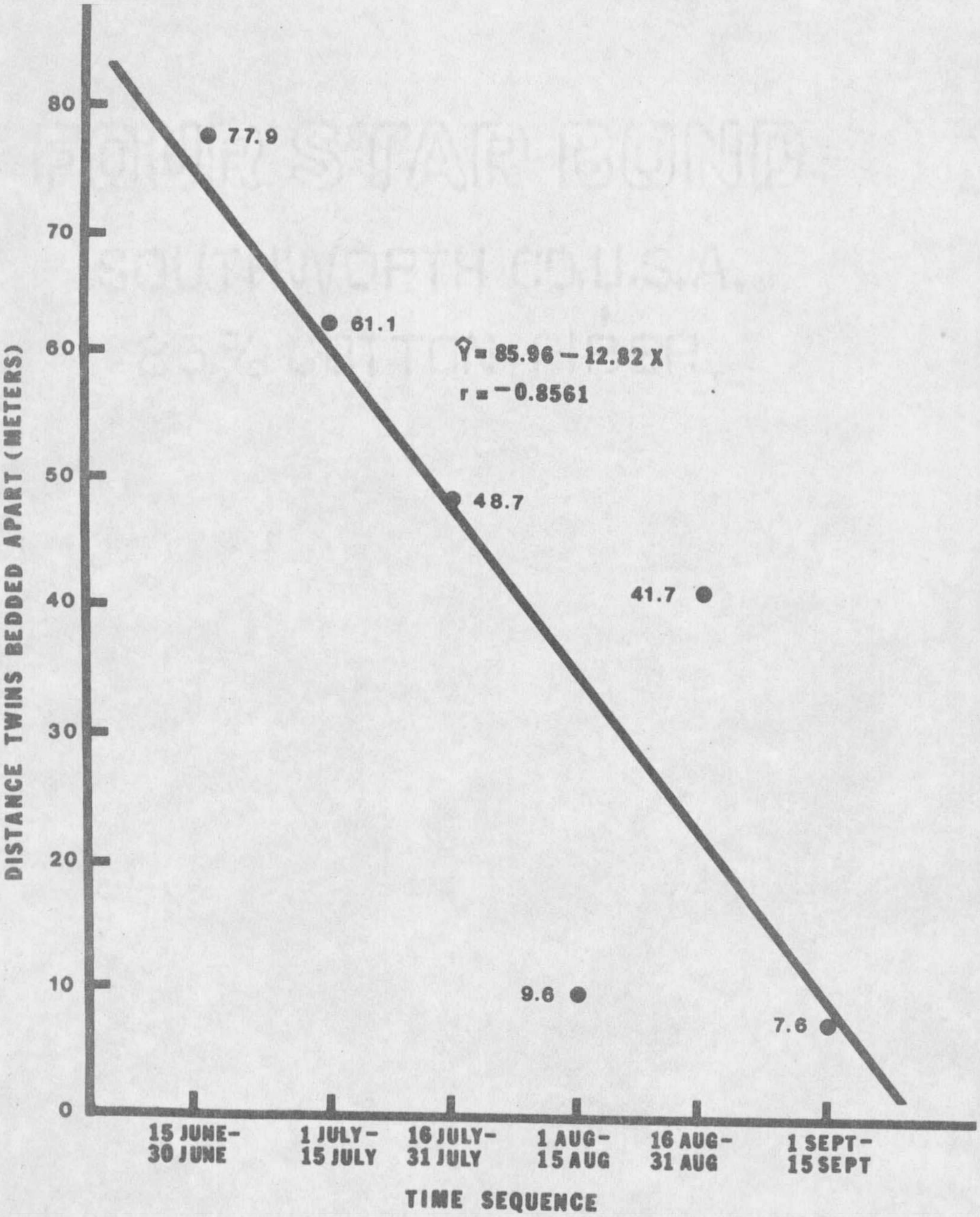

Figure 15. A plot of the average distance (meters) twin fawns were bedded apart during 2-week periods throughout summers 1978-1980 in the Missouri River Breaks, Montana.

The tolerance of does with marked fawns towards other mule deer varied. Typically, does were aggressive toward yearling mule deer, often striking them with a front leg. No encounters between fawns or adult does from different families were observed in 1978. During 1979, one observation was made of a doe showing aggression towards another doe with a fawn. Seven different sets of unrelated fawns were observed bedded or mingling together on 18 different occasions in 1980, and aggression by the dams was not apparent at any time.

Response of the dams to the presence of other ungulate species was vigilant, but generally passive. Only 2 cases of aggression were observed during the study. In 1 instance, a doe (marked doe of fawns #32 and #33) was observed bounding and snorting towards a group of 7 elk, causing them to flee. In another case, a doe (dam of fawns #46, #47, and #48) charged and drove 2 female white-tailed deer from the area occupied by her fawns. Cattle were rarely observed within the home ranges of marked fawns during 1978 and were never observed closer than 250 m from fawns. Livestock spent considerable time within the home ranges of marked fawns during both 1979 and 1980, but fawns and cattle seldom occupied the same site at the same time.

DISCUSSION AND CONCLUSIONS

Published data have indicated considerable variation in summer mortality of fawns between populations and between years (Table 12). The summer mortality rates observed in the Missouri River Breaks since 1976 have varied from moderate to low compared to other studies. Those reported were for 1978, 1979, and 1980 (16.7%, 11.8%, and 13.3%, respectively) were among the lowest ever documented for free-ranging deer populations. This occurred despite a stable to slightly increasing coyote population that ranged in density from minima of 0.28 to 0.41 coyotes/km^2 and averaged a minimum of 0.36/km^2 during 1976-1980 (Pyrah 1980). Other studies of free-ranging deer populations subject to predation generally have reported summer fawn mortality rates greater than 25%, while relatively low rates have been reported in the absence of predators (McGinnes and Downing 1969, Kie et al. 1979).

Fawn mortality rates may be influenced by factors other than the abundance of predators, such as poor range condition (Carrol and Brown 1977) and inadequate nutrition for the doe (Verme 1962, Salwasser et al. 1978). The high survival rates for fawns on the Missouri Breaks study area during the summers 1978-1980 may have been influenced by: (1) exceptionally heavy production of yellow sweetclover on the area during 1978 and 1979, (2) an abundance of alternative prey species for coyotes throughout the study period, and (3) a change in habitat use by fawns during the summer of 1980.

Table 12. Estimates of early mortality among mule deer (MD) and white-tailed deer (WTD) fawns from various studies in North America.

Location (source)	Species	Estimated mortality rates (percent)	Comments
New York (O'Pezio 1978)	WTD	24	Population within an enclosure.
Texas (Teer et al. 1965)	WTD	13,11	Both prenatal and neonatal losses calculated.
Texas (Cook et al. 1971)	WTD	72	
Texas (Carrol and Brown 1977)	WTD	10-90	3-year study.
Texas (Kie et al. 1979)	WTD	80 47	Outside enclosure. Inside enclosure.
Oklahoma (Logan 1972)	WTD	18-64	3-year study.
Oklahoma (Garner et al. 1976)	WTD	88	
Virginia (McGinnes and Downing 1969)	WTD	11	A confined deer herd.
Montana (Dood 1978)	MD	36,32	Missouri River Breaks, 1976 and 1977.
Utah (Swenson 1972)	MD	49	
Nevada (Stivers 1978)	MD	6-44	
Oregon (Trainer 1975)	MD	27	
California (Salwasser et al. 1978)	MD	up to 70	Determined by scat analysis.

Table 12. Continued.

Location (source)	Species	Estimated mortality rates (percent)	Comments
Texas (Dickenson et al. 1980)	MD	75	
Washington (Steigers and Flinders 1980)	MD	54	

Above normal precipitation during fall 1977 and spring 1978 produced a dense growth of first year yellow sweetclover in the summer of 1978. Favorable precipitation sustained the clover and produced a dense second year growth in 1979. The sweetclover provided excellent concealment cover for bedded or moving fawns. In addition, it provided an abundant and highly nutritional food source for does in the last trimester of pregnancy and through the lactation period.

Small mammal populations, the most likely alternative prey source for coyotes, were low on the study area during 1976 and 1977 (Trout 1978). In 1978 and 1979, however, an abundance of microtine rodents (*Microtus ochrogaster*, *M. pennsylvanicus*, and *Lagurus curtatus*) coincided with the sweetclover production (Hamlin and Riley unpubl. data). General observations indicated that cottontail rabbit (*Sylvilagus* spp.)

numbers also increased in 1978. Although the vole populations declined after 1979, cottontail rabbits appeared to maintain their numbers through the summer of 1980.

Leopold (1933) noted the importance of buffer species in satisfying predator food requirements, thus diverting their attention or drawing them away from areas occupied by "desirable" species such as deer. Analysis of coyote scats from the study area (Schladweiler 1980, Hamlin pers. comm.) indicated that rodents and lagomorphs constituted 40.1, 78.2, and 23.1% of the coyote diet during the summers of 1978, 1979, and 1980, respectively. During these same periods, mule deer made up less than 1% of the coyote diets. The abundance of rodents and lagomorphs may have diverted the attention of coyotes from deer fawns. In 1979, a coyote, apparently hunting voles in a typical "head down" posture, came within 100 m of a set of marked twin fawns, briefly looked at them, and returned to hunting with no sign of further interest in the fawns. The abundance of alternative prey may have also drawn coyotes away from those areas normally occupied by fawns. Vole numbers were generally greatest on grassy ridgetops and coulee bottoms, sites least frequented by fawns.

High survival of fawns during summer 1980, despite low rodent populations, may have been due to fawns making significantly greater use of steep slopes and the dense *Psuedotsuga-Juniperus* and *Pinus-Juniperus* cover types. Below average precipitation from May 1979 to

July 1980 inhibited the growth of herbaceous cover during the spring of 1980. Dood (1978) also reported that fawns tended to select dense cover types during temporary droughts, and thus suffer decreased predation losses.

Although some mortality was known to have occurred immediately after birth, all marked fawns killed during the study were over 1 month of age. At that time, the increasing food requirements of maturing pups may have forced adult coyotes to search for larger prey such as deer fawns. In addition, the desiccation of vegetative cover and the increased activity of fawns through the summer may have predisposed fawns to predation. Cook et al. (1971), Swenson (1972), and Trainer (1975) have suggested that most mortality occurs during the first month of a fawn's life, while others (Dood 1978, Dickenson et al. 1980, and Steigers and Flinders 1980) presented evidence indicating that major mortality periods can occur anytime through the summer.

Because of the small number of marked fawns which perished, differential mortality among sexes was not clearly evident during this study. It has been suggested that the greater activity, curiosity and independence of males (Jackson et al. 1972) may account for the greater mortality commonly reported for male fawns (Taber and Dasmann 1954, Kie et al. 1979, Steigers and Flinders 1980).

Although abandonment of fawns by their dams accounted for one-third of the total fawn mortality recorded during the 3 summers, abandonment of fawns did not appear to be a general or widespread population phenomenon. Rather, it appeared to occur as a reaction of individual does to the handling and/or marking of their offspring. Similar cases of abandonment have been reported for nearly every study in which neonates have been handled (Trainer 1975, Stiver 1978, Dickenson et al. 1980, Steigers and Flinders 1980).

White et al. (1972) indicated that abandonment of fawns as a result of disturbance is a potential problem in marking neonates. The amount of natural abandonment that occurs in deer populations is not well known, but Langenau and Lerg (1976) found that it was more common when does were nutritionally stressed.

All 3 abandoned fawns were less than 3-weeks-old at the time of death. All died of starvation, and only one had made any attempt to consume vegetation. Although digestion had not occurred, the plant materials consumed approximated the early summer diet of adult deer on the area (Mackie 1970). Deer fawns probably cannot become fully dependent on normal ruminant processes until at least 5 weeks of age (Short 1964, Sadleir 1980); and, if orphaned prior to 6 weeks of age, they have a poor chance of survival (Swenson 1972).

Fawns appeared to have been born earlier (or at least weighed more at capture) in 1979 than in 1978 or 1980. This apparent advance in parturition dates may have been a response to above normal precipitation during 1978, a relationship described by Knowlton (1976).

Average weights of fawns at the time of capture during 1978, 1979, and 1980 were all greater than those found by Dood (1978) during 1976 and 1977. However, weights from 1980 were only slightly greater than those from 1976 and 1977. This similarity in weights probably reflected similar precipitation patterns and vegetation growth for those years.

Average movements between relocations and home range sizes for the summer of 1978 were similar to those reported for the same area during 1976 and 1977 (Dood 1978). The decreased average movement and home range sizes in 1979 and 1980, were coincident with, and possibly influenced by, a substantial increase in the mule deer population on the study area. Total numbers of deer increased from approximately 500 in 1976 and 1977 to more than 700 in 1978 and about 1,100 in 1979 and 1980 (Hamlin 1981). The home range sizes recorded during this study were greater than those reported for white-tailed deer fawns in Texas (Carrol and Brown 1977) and Oklahoma (Garner 1976), but smaller than those reported for mule deer fawns in Washington (Steigers and Flinders 1980).

The increased use of dense cover types, steep slopes, and northerly exposures by fawns during early summer was closely linked to the desiccation of herbaceous cover. Short herbaceous species and/or sparse cover have been found to deter fawns from using an area (Garner et al. 1979). Evidently, the earlier use of the *Psuedotsuga-Juniperus* and *Pinus-Juniperus* cover types in 1980 was a response to the paucity of herbaceous vegetation produced that year. Greater use of the open types such as *Artemisia-Agropyron* and *Sarcobatus-Agropyron* was possible in 1978 and 1979 because of the dense sweetclover that occurred during those summers.

Use of steep and "middle" slopes by fawns may also minimize encounters with coyotes. Although regular hunting circuits have rarely been noted, coyotes apparently follow favorite travel lanes (Young and Jackson 1951, Ozoga and Harger 1966). If these travel lanes were primarily on ridge tops and coulee bottoms, the use of the middle and lower thirds of slopes by fawns would have obvious survival advantages.

The use of steeper slopes by fawns may operate to minimize encounters with livestock. During normal years, cattle in the Missouri Breaks are distributed primarily on ridgetops, coulee bottoms, and gradual slopes (Mackie 1970), whereas fawns tend to utilize steeper slopes and avoid ridgetops and coulee bottoms. Cattle distribution, however, can be extremely variable and, during dry years, livestock often utilize steeper slopes and move into the more mesic, timbered habitats preferred by fawns. During these times, conflicts between cattle and fawns (Michael 1967) may arise due to grazing and/or trampling of cover. Dood (1978) suggested that changes in cattle distribution may affect use of vegetation types by fawns.

The presence of at least 70% cover at bedsites appears to be important to mule deer fawns in the Missouri Breaks. Other studies (Kjos and Montgomery 1969, Sheehy 1978, Dood 1978) also found that dense bedsite cover was critical to deer fawn survival. It was also apparently important for fawns to have clear visibility out of a bed, as well as be adequately concealed. This may have enabled them to detect the approach of predators or their dams. Shrubs, especially Rocky Mountain juniper, seemed to be essential in providing concealment cover for fawns in the Missouri River Breaks. Factors which negatively affect shrub growth lower the suitability of an area as fawn-rearing habitat (Sheehy 1978).

The frequent mingling of unrelated fawns, and the decreased aggression by does in 1980 may have been a response to the relatively high deer densities occurring on the study area at that time. Geist (1981) suggested that resource defense by mule deer is faculative. Given the high deer densities during 1980, it may not have been efficient or even possible for does to defend fawn-rearing areas. The social groups observed probably resulted from deer which were familiar with or related to each other (Miller 1974). With an increase in deer densities, deer-cattle social interactions also increased. Information on deer-cattle social interaction is varied and often contradictory (Mackie 1981). Data from this study, however, tended to support Krämer

(1973) in that mule deer does and fawns tended to ignore cattle as long as a distance was kept between them.

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APPENDIX

Table 13. Case histories of known fawn mortalities during summers 1978-1980, in the Missouri River Breaks, Montana.

Case 1. Unmarked fawn, sibling of fawn 9.

Date of capture: 20 June 1978

Date of death: 20 June 1978

Attacked by a pair of coyotes (Hamlin and Schweitzer 1979), the fawn died shortly after the arrival of a tagging crew. The skull had been punctured in 4 spots, and there were bit marks on the neck and shoulder region. After seizing the fawn, the coyote carried it into a sprawling juniper bush. Its sibling dropped to the ground, froze immediately, and was not harmed.

Case 2. Fawn 12.

Date of capture: 21 June 1978

Date of death: 25-26 June 1978

On the evening of 24 June, this fawn was separated from its doe and marked twin by 1.3 km. It was found on the morning of 27 June, bloated and wet. Rainshowers had occurred during the previous day, thus the fawn probably died sometime prior to 26 June. Despite being wet, the fawn had lost 0.91 kg. (13% of its original body weight) since its capture. A necropsy revealed that the proximal cause of death was starvation.

Case 3. Fawn 13, sibling of fawn 12.

Date of capture: 21 June 1978

Date of death: 12-13 July 1978

The head and neck were found buried in a hole and covered with soil and litter. These remains were in a dense patch of sprawling juniper, 1.2 km. from where the fawn was last observed alive. The skull had several puncture holes, and there was subcutaneous hemorrhaging in the head, neck, and nose regions. No sign of struggling was evident in the immediate area, although numerous coyote tracks were found. A doe stood, reluctant to leave, several hundred meters away from the fawn remains.

Table 13. Continued.

Case 4. Fawn 5, sibling of fawn 4, offspring of a marked doe.

Date of capture: 18 June 1978

Date of death: 8-14 September 1978

This fawn was last observed alive on 8 September. Its radio transmitter failed, and it was never observed again with either its marked twin or its marked doe. Unsuccessful attempts were made to locate it from the air. There was no evidence to suggest a fawn of this age would disperse from the area by itself. Although the ultimate fate of this fawn is uncertain, it probably died a violent death.

Case 5. Fawn 23, offspring of a marked doe.

Date of capture: 14 June 1979

Date of death: 18-20 June 1979

The emaciated carcass was recovered 350 m from the capture site. Although the doe remained in the area, this fawn's rumen was void of milk curds, indicating that recent feeding had not taken place. There was no sign of struggling in the immediate area, and a necropsy indicated that the proximal cause of death was starvation. This fawn's twin was known to have survived the study period. (Also see case 9, relating to 1980 offspring of this doe.)

Case 6. Fawn 28

Date of capture: 16 June 1979

Date of death: 4 August 1979

The blood-stained radio collar was found lying on the ground. Thirty meters upslope, numerous fawn, adult deer, and coyote tracks were hardened to clay; a struggle was evident. Drag marks through the grass led to bits of skull, bone, and blood soaked fawn hair. Because of the tracks left behind in the dried clay, it is assumed the time of death was shortly after a rainstorm on 4 August 1979. Site evidence clearly indicated coyote predation was the cause of death.

Table 13. Continued.

Case 7. Fawn 30.

Date of capture: 17 June 1979

Date of death: 3-8 August 1979

The radio collar was found lying on the ground, near the head of an open coulee. The elastic neck band was partially torn, and was stained by several spots of dried blood. Site evidence (coyote tracks and scats, 2 half eaten cottontail rabbits, and numerous miscellaneous bones) indicated the area was heavily used by coyotes. A coyote den was known to be in the area, and this particular coulee was used as a lounging area by the denning pair. Although the ultimate fate of fawn 30 is unknown, evidence indicates that it was a probable coyote kill.

Case 8. Fawn 36, twin of fawn 52.

Date of capture: 16 June 1980

Date of death: 17-19 July 1980

The radio collar was found partially buried in the ground under a sprawling juniper bush. A patch of fawn hair was near the depression. This site was 0.71 km from where the fawn was last observed alive. Numerous coyote tracks and scats were found in the immediate area. Bite marks were imprinted in the plastic covering of the radio, and blood stains covered both the elastic collar and radio package. The ultimate fate of fawn 36 is unknown, however site evidence, and the similarities of this case to that of case #2, suggest that it was a probable coyote kill.

Case 9. Fawn 41, offspring of a marked doe.

Date captured: 17 June 1980

Date of death: 21-22 June 1980

The carcass was recovered intact 0.81 km from the capture site, and in the same location that it was observed alive 2 days earlier. The rumen was full (Fig. 11 of text), but void of milk curds. Rumen contents

Table 13. Continued.

Case 9 (Continued)

included rose, snowberry, and skunkbrush sumac in nearly equal proportions, and a small amount of grass and sage. Digestion had not occurred. The unmarked twin of this fawn was known to have survived the study period. This same doe abandoned fawn #23 (case 5) in 1979, and exhibited similar behavior in both cases.

Case 10. Fawn 45, offspring of a marked doe.

Date of capture: 17 June 1980

Date of death: 14-15 July 1980

The radio collar was found completely buried in a hole under a sprawling juniper bush. This site was 2.7 km from where the fawn was last observed alive. Both the radio package and collar were covered with bite marks and blood. Coyote tracks were found in the scrappings surrounding the hole in which the collar was buried. Evidence indicated probable coyote predation as the cause of death.

Case 11. Fawn 52, sibling of fawn 36.

Date captured: 16 June 1980

Date of death: 16 June 1980

This fawn was fatally wounded at the time of capture. Evidence indicated it had narrowly escaped a traumatic episode with a predator. The fawn was in shock, and nonrespondent to touch. Bite marks were evident on the skull, neck, shoulder, and anal regions. The femur was cleanly broken and protruding through the skin. Due to the nature of the bite marks, especially in the head region, the predator was probably a coyote.
