1979

Factors affecting pronghorn fawn mortality in central Idaho

Walter L. Bodie

The University of Montana

FACTORS AFFECTING PRONGHORN FAWN MORTALITY

IN CENTRAL IDAHO

By

Walter L. Bodie

B.A., Montana State University, 1966

Presented in partial fulfillment of the requirements for the degree of

Master of Science

UNIVERSITY OF MONTANA

1979

Approved by:

Chairman, Board of Examiners

Dean, Graduate School

June 13, 1979

Date

ABSTRACT

Bodie, Walter L., M.S., Spring 1979 Wildlife Biology

Factors Affecting Pronghorn Fawn Mortality in Central Idaho (90 pp.)

Director: Bart W. O'Gara

In a study, conducted from September 1975 through September 1978, I used radiotelemetry to determine neonatal histories of 42 pronghorn (Antilocapra americana Ord.) fawns in the upper Pahsimeroi River Drainage in central Idaho. Predation (36%) and starvation-disease (21%) were the major direct causes of mortality of marked fawns and most mortality (92%) occurred during the first 2 weeks of life.

The percentage of predator-killed fawns attributed to each predator species was: Golden Eagles (Aquila chrysaetos) 47, coyotes (Canis latrans) 27, bobcats (Lynx rufus) 13, and small raptors 13.

Fawn survival correlated with habitat selection. Fawns bedding in the tall sage-foothill community type had significantly ($p < 0.01$) higher predator-related mortality than fawns using the short sage-grass community type. Fawns selecting bedding sites in habitats least hunted by eagles and coyotes had the highest survival rate. Predators appeared to select the largest and most precocious fawns.

Pronghorn fawns were subject to losses from weak-fawn syndrome and symptoms were similar to those reported for neonatal cattle (Bos taurus) and domestic sheep (Ovis aries). Does were more likely to abandon fawns during some years than others.

Summer conditions of pronghorns varied depending upon plant moisture content and vegetative condition. Does raising fawns to late summer had lower fat reserves than other age and sex classes and were often emaciated in late September.

ACKNOWLEDGEMENTS

My sincerest appreciation to my major advisor, Dr. Bart W. O'Gara, for his encouragement, advice, and assistance during this study.

I would like to thank the other members of my committee, Drs. Les Pengelly and Lee Metzgar, for their suggestions and assistance in planning and evaluating my project.

A special thanks to my supervisors, Tom Reinecker and Robert Sherwood, of the Idaho Department of Fish and Game, for their support, encouragement, and assistance. Other members of the Department who materially contributed to the project were Lloyd Oldenburg, Roger Williams, and Robert Autenrieth, and especially Carol Prentice of the Department Laboratory for her extra efforts on the rumen analyses. Numerous other Region 6 employees contributed time and understanding and their assistance is gratefully acknowledged.

To my field assistants, Steve Wilkens, Sue Kozacek, and Bill Rudd, my profound gratitude for their hard work and intense interest in the project.

Drs. Winnie Kessler, Milena Stoszek, and Eric Stauber of the University of Idaho and Dr. William Foreyt of Washington State

University provided advice and laboratory analyses of various specimens and their assistance and interest are gratefully appreciated.

Funding was supplied by the Idaho Department of Fish and Game, University of Montana Cooperative Wildlife Research Unit, Idaho Federal Aid to Wildlife Restoration, Pittman-Robertson Project W-170-R-2, and the Young Adult Conservation Corps, United States Fish and Wildlife Service.

To secretary Charlotte Dunaway, a special thanks for her assistance in preparing this manuscript and for supplying the art illustrations.

Finally, I would like to thank my wife, Alice, for her understanding and field assistance during this project, and my parents for encouraging my interest in wildlife and the out-of-doors.

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The effect of predation on native ungulate populations has been the subject of long and often heated debates. Three widely held opinions exist on predator-ungulate relationships. Some environmentalists contend that predators live primarily on rodents and lagomorphs and improve game populations by culling the sick and the weak. Wildlife biologists and state game managers commonly maintain that predation is not a limiting factor for game populations on healthy habitats. Ranchers, farmers, and sportsmen often claim predation is the major cause of ungulate declines. Another view is slowly gaining supporters as ongoing predator-ungulate studies are completed. According to this view, under certain conditions, predation can seriously reduce the harvestable surplus or slow the recovery of a reduced population.

A literature review by Connolly (1979) indicated predation was the major decimating factor of big game populations in 31 of 58 studies. Habitat condition (6 studies) and disease (1 study) were other primary causes of mortality.

Past mortality studies concentrated on adult losses or documented levels of neonatal mortality through young/adult ratios taken during late summer. Few studies concentrated on the direct causes of neonatal mortality or its effect on net productivity. Techniques for monitoring newborn ungulates became available about 1970. The development of miniaturized radio transmitters made fawn monitoring possible.

Radio monitoring indicated that the following predators were the major mortality factors for the listed ungulates: bobcats for pronghorn fawns in Utah (Beale and Smith 1973); black bears (Ursus americanus) for elk (Cervus elaphus) calves on Coolwater Ridge in northern Idaho (Schlegel 1976); mountain lions (Felis concolor) (except for hunter caused mortality) in a southern Idaho mule deer (Odocoileus hemionus) herd (Nellis 1977); and coyotes for pronghorn fawns on the Charles Sheldon Game Range in Nevada (McNay pers. comm.) and in 2 separate studies on the National Bison Range in western Montana (Reichel 1976, Von Gunten 1978). Corneli (1979) found extensive predation by bobcats and Golden Eagles on the Range after limited spring control of coyotes.

Pronghorns on good range have a potential birth rate of 198 fawns/100 adult does (O'Gara 1968). However, Pittman-Robertson progress reports indicate that August ratios of less than 40 fawns/100 does are common. The factors causing such great disparity between observed and potential pronghorn productivity are seldom understood.

Working in the upper Pahsimeroi Valley of central Idaho, Fichter and Nielson (1964) found that most fawn losses occurred during the first 30 days after parturition. For 1957 through 1961, the August doe/fawn ratios ranged from 62 to 95 fawns/100 does. For the period 1973 through 1975, ratios dropped to an average of 43/100 (Autenrieth 1976).

In the early 1970's, the Idaho Department of Fish and Game funded 3 studies to monitor neonatal losses and determine the causes of mortality. The studies included 1 on elk in the Lochsa area of northern Idaho, another on mule deer in south central Idaho, and this study on pronghorns in the upper Pahsimeroi River Drainage of central Idaho.

The objectives of this study were to:

1) determine causes of fawn mortality;

2) relate condition of fawns at birth to fawn survival; and

3) relate fawn survival to range conditions, including

   a) habitat type and

   b) plant phenology and its relation to climatological conditions.

CHAPTER II

STUDY AREA

The Pahsimeroi River, a tributary of the Salmon River, is located in Custer County, Idaho. The 13,000 ha study area (Fig. 1) ranges in elevation from about 2000 to 2700 m and lies at the base of Idaho's highest mountain, Mount Borah, elevation 3857 m. Approximately 69% of the area is managed by the Bureau of Land Management, 24% by the United States Forest Service, 2% by the Idaho State Department of Lands, and 5% by private owners.

The Drainage is a high montane valley surrounded by steep high hills. The valley floor occurs as moraines, terraces, and open flats composed of glacial and alluvial deposits. Soils are shallow and gravelly except at the base of the foothills where they are black and deep. Three permanent streams, Burnt and Mahogany creeks and the Pahsimeroi River, dissect the study area. Water is also available in several stock tanks and at several natural springs.

The climate is semiarid and typical of that found in high montane valleys. Approximately 35% of the annual precipitation occurs during May and June, but the amount of precipitation is highly variable (Autenrieth and Fichter 1975). Near-blizzard conditions occurred

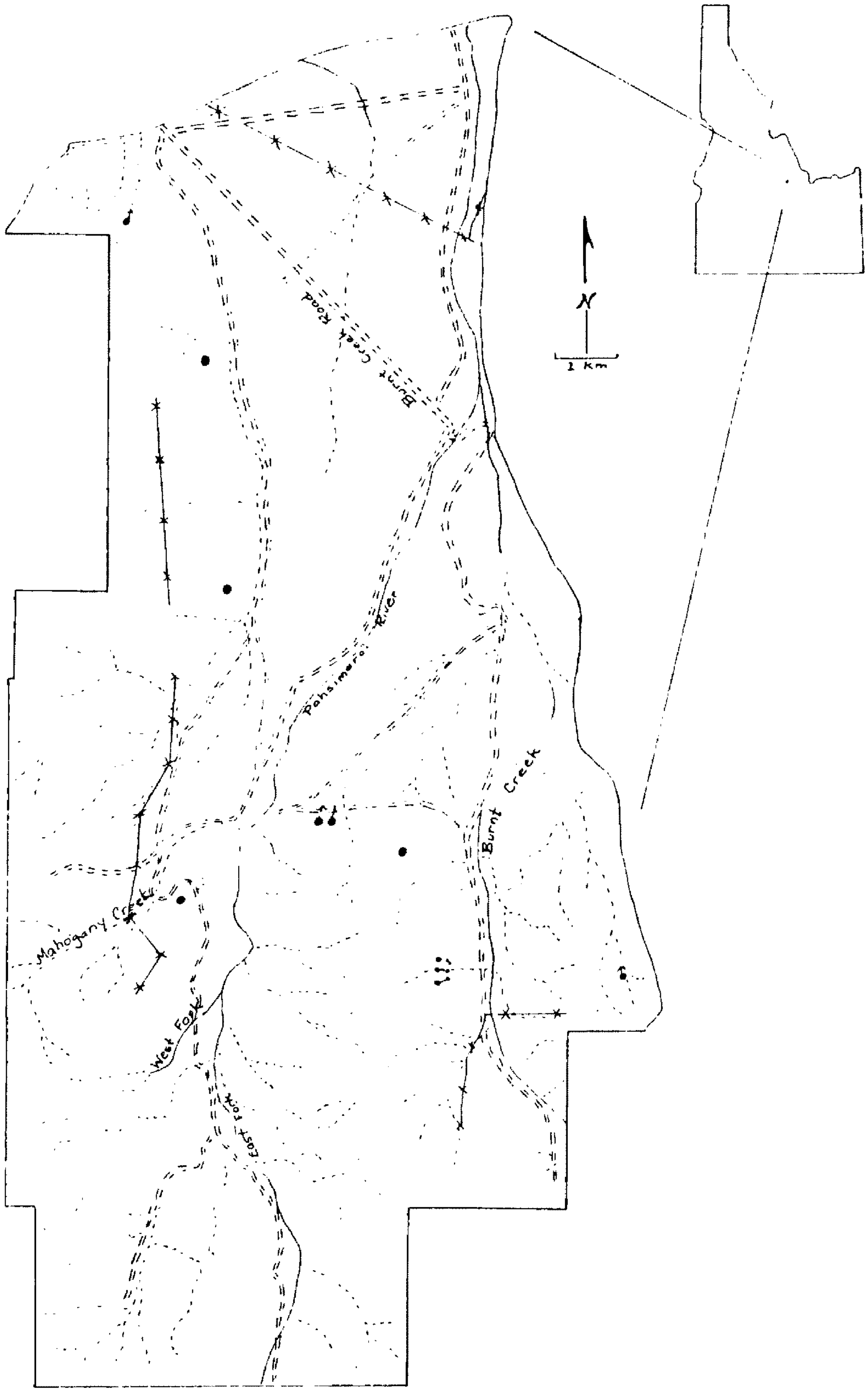


Fig. 1. Map of study area.

during the 1976 and 1977 fawning periods. Freezing temperatures were common during May and June and few days were windless during the study.

Vegetation is of the semidesert type (sagebrush-grass) described by Daubenmire (1952). Valley-floor vegetative types are an extension of the cool northern Great Basin desert communities and sagebrush (Artemisia spp.) is the most common overstory plant (Odum 1971).

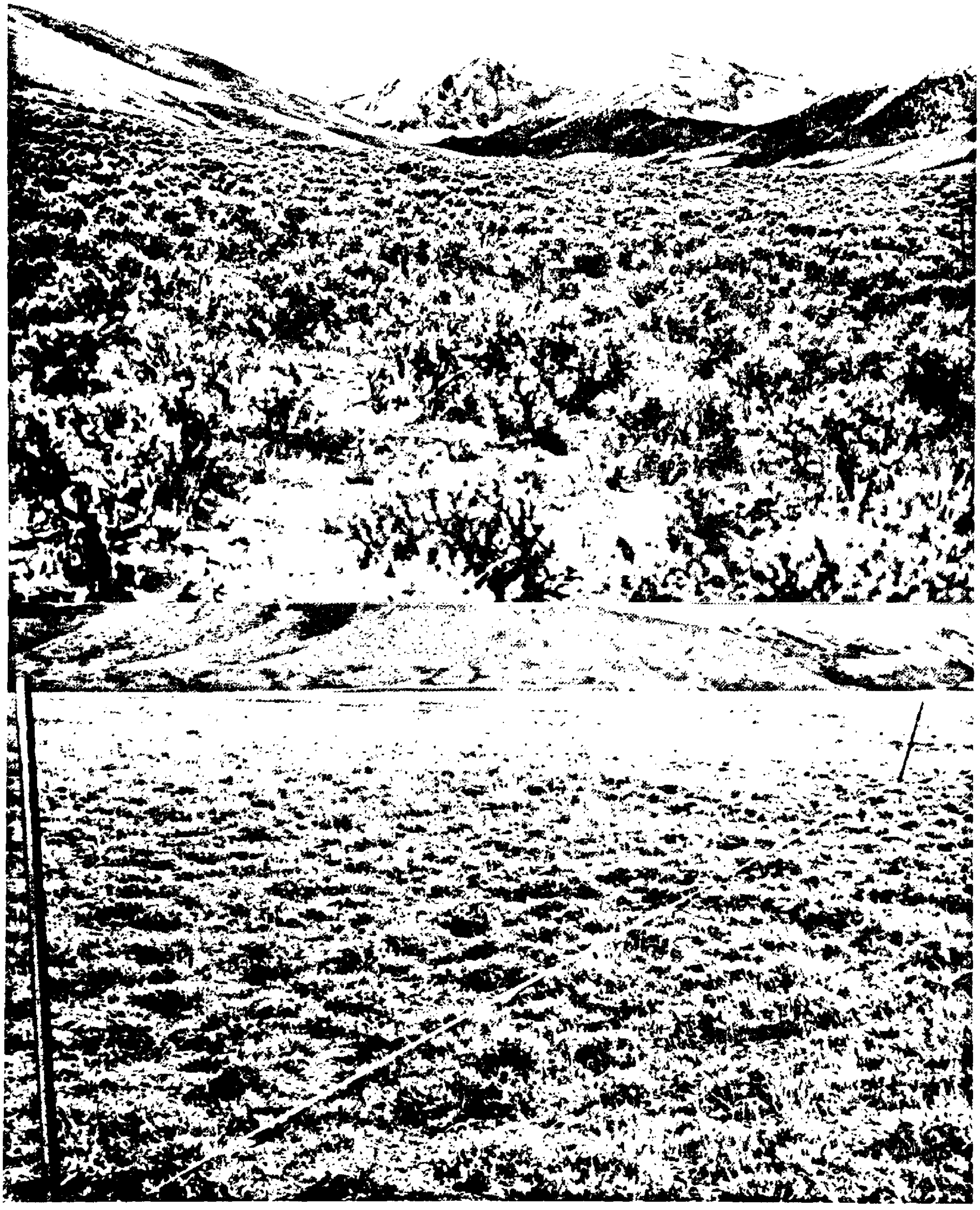
At least 5 species of sagebrush occur: Wyoming big sagebrush (A. tridentata wyomingensis), low sagebrush (A. arbuscula); fringed sagebrush (A. frigida); threetip sagebrush (A. tripartita); and mountain big sagebrush (A. vaseyana).

Wyoming big sagebrush is found in the valley floor bottoms and on the slopes of hills, ravines, and moraines. It is the major overstory species of the tall sage-foothill community type (Fig. 2). Low sagebrush is the dominant shrub species in the shallow soils of the short sage-flat community type (Fig. 3). Minor amounts of fringed and threetip sagebrush are present. Mountain big sagebrush is found in the upper elevations.

The tall sage-foothill and short sage-flat community types characterize the major portion of the study area (Fig. 4). Broom snakeweed (Gutierrezia sarothrae) grows in circular patches over most of the short sage-flat community type. Rubber rabbitbrush

Fig. 2. Transect 9 in the tall sage-foothill community type.

Fig. 3. Transect 8 in the short sage-flat community type.



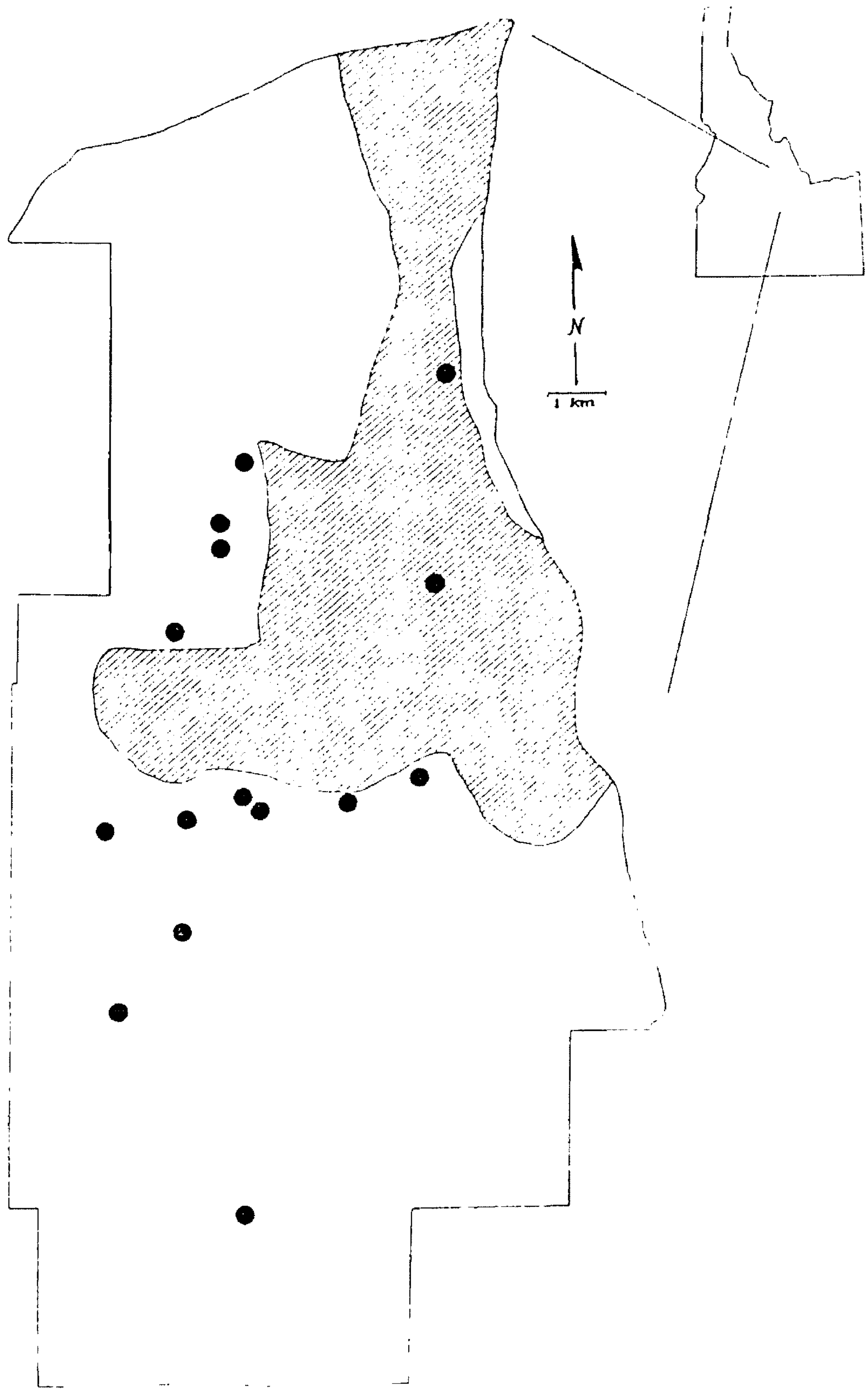


Fig. 4. Locations of short sage-flat (shaded), tall sage-foothill (clear) community types, and predator kills (black circles).

(Chrysothamnus nauseosus) and tall green rabbitbrush (C. viscidiflorus) commonly occur on disturbed sites.

Bluebunch wheatgrass (Agropyron spicatum) and Sandberg bluegrass (Poa sandbergii) are the most common grasses. Small amounts of western needlegrass (Stipa occidentalis), Indian ricegrass (Oryzopsis hymenoides), and bluestem wheatgrass (Agropyron smithii) are found in the short sage-flat community type. Antennaria, Arenaria Astragalus, Castilleja, Descurainia, Erigeron, Eriogonum, Lupinus, Penstemon, Phlox, Ranunculus, Senecio, and Zigadenus are the commonly observed genera of forbs.

During most winters, deep snow prevents pronghorns from using the study area. The normal winter range starts approximately 3 km north of the study area and extends down along both sides of the Pahsimeroi Valley, to its confluence with the main Salmon River.

Big game animals present include mule deer, elk, rocky mountain bighorn sheep (Ovis canadensis), and pronghorns. Common predators are bobcats, coyotes, badgers (Taxidea taxus), Golden Eagles, and various other raptors. Black bears and mountain lions are occasionally transients. The study area is included in Antelope Hunting Unit 437-1 and harvest is managed under a permit system.

CHAPTER III

METHODS AND MATERIALS

Fawns

Capture

Observation points overlooking the Ampitheater, Feralite Hill, the Carlson Ranch, and Poverty Flat (Fig. 1) were used to locate pronghorn fawns and pre-parturient does. Two observers, stationed at each observation point, used spotting scopes and binoculars to observe doe-fawn behavior and recorded predator-prey interactions. A pregnant doe signaled impending parturition by raising her tail, self-licking of belly and flank areas, humping her back, frequent alternations of standing and lying, and frequent defecation and urination. A doe nearing parturition usually stayed in a small area and showed swelling and contractions of the flanks immediately forward of the hind legs. Does observed giving birth were watched until they left the bedded fawns or a minimum of 2 to 6 hours had passed since birth. Occasionally, pre-parturient does were located in areas out of view of the observation points. An approach on foot or in a vehicle was made for closer observation in these situations.

The observation teams used portable radio transceivers to direct a marking crew to the fawns. One team member attracted a fawn's attention while the second member sneaked up behind it. An attempt was made to capture young less than 48 hours old. Fawns too wary to be captured by this technique were considered too old for study purposes. Surgical gloves were worn when handling fawns to minimize transmittal of human scent.

Blood samples were collected from 10 fawns during 1977 and 1978. Approximately 15 cc of blood was collected from each fawn, allowed to coagulate for 24 hours at room temperature, separated, and the serum frozen. Blood smears were collected from 13 fawns. Anal, nasal, and throat cultures were taken from 17 fawns in 1977 and 13 fawns in 1978.

Data were recorded on a datum sheet (Appendix A). Fawns were equipped with a miniature 151 MHZ radio transmitter and a 3 V. lithium battery with a 1,000 mA·h rating. The transmitters were equipped with a temperature sensing device. When a fawn died and its body temperature dropped below 28.5°C (78°F), the transmitter pulse rate was expected to change. Transmitters, batteries, and antennas were manufactured by Wildlife Materials, Inc. The transmitters, batteries, and antennas were assembled and set in acrylic compound manufactured by True Line, Inc., forming a transmitter package. During 1976 and 1977, 4 1.27-cm wide elastic straps were attached to each transmitter. Cattle tag cement held the transmitter package between the fawn's shoulder blades. The elastic bands were placed around the neck and behind the front legs and attached with staples (Fig. 5). This design kept the radio package in position but allowed it to fall off as the fawn grew and stretched the elastic, allowing recovery of the transmitter.

The back pack transmitter packages were converted to neck band collars for the 1978 fawning season, in an effort to reduce handling-caused abandonment. The transmitter, battery, and antenna were attached to a 2.5-cm wide piece of 7.5-cm diameter plastic pipe cut in half to form a semicircle. A 2.5-cm wide elastic band was attached to the plastic pipe and stapled behind the fawn's neck (Fig. 5). This system would allow recovery of the transmitter.

Fawns were returned to their bed sites in a curled position and their tails rubbed until the fawns relaxed and the technician could slowly move away without disturbing them.

Relocations

An attempt was made to visually locate fawns daily. An A. V. M. Instrument Co. LA12 receiver and 3-element Yagi antenna were used. The fawn's general location was determined by vehicle and the final approach was made on foot.

Data recorded for live fawns included date and time located, distance from previous bedding site, distance from twin, general

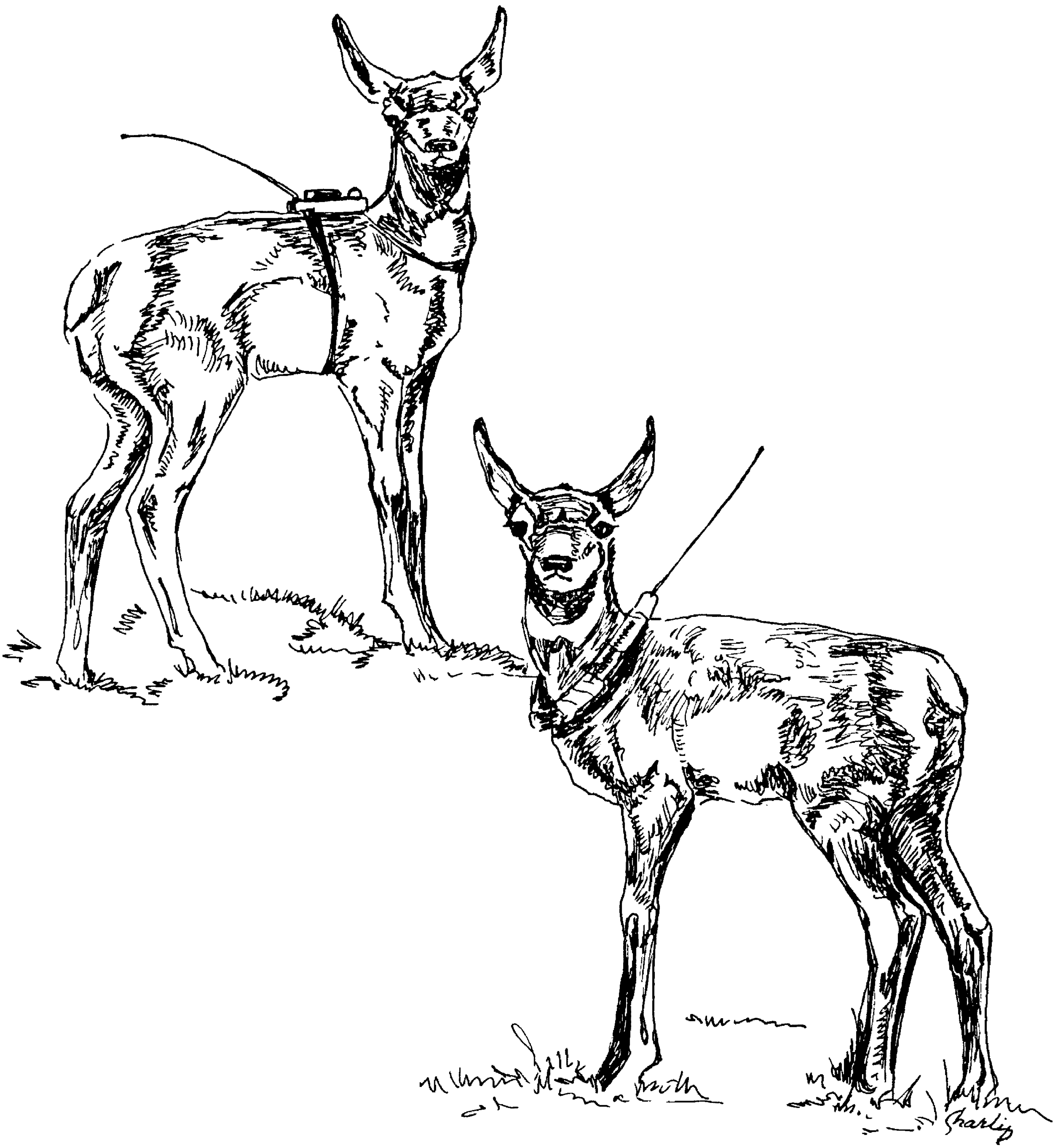


Fig. 5. Position of transmitter types on pronghorn fawns.

condition, and habitat type. Seven fawns were recaptured and weighed. Dead fawns were photographed, examined for external wounds, weighed and collected. Death sites were photographed, mapped, and marked for later vegetative analysis. The sites were searched and predator signs recorded. Fawns were monitored until they died, the transmitter fell off, or until 1 August.

Necropsy

Punctures, lacerations, and signs of feeding by predators were recorded and photographed. Indications of disease, starvation, general condition, and the stomach contents of fawns were noted.

Predators common to the study area leave characteristic feeding and wound patterns on prey species. Patterns described by Cowan and Karstad (1969) and Henne (1975) were used to determine the species involved in feeding on or killing a fawn.

Tissue samples were collected from 7 fawns for bacteriological, virological, histopathological, and trace mineral analyses. Samples for histopathological analyses were collected from the lungs, heart, thymus gland, liver, spleen, kidneys, small intestine, and mesenteric lymph nodes. Samples were preserved in 10% buffered formalin. Two tissue samples from the heart, lungs, thymus gland, mesenteric lymph nodes, kidneys, adrenal gland, small intestine, spleen, and liver were placed in individual plastic twirl bags and frozen for later bacterial and viral analyses. Samples for trace mineral analyses were collected and frozen from the heart, lungs, liver, kidneys, diaphragm, and brain.

Pronghorn Adults

Harvest

An Idaho Department of Fish and Game checking station was operated on the opening day of antelope season from 1975 through 1978. During 1975 and 1976, as many hunters as possible were contacted on their way into the study area. The purposes of the study were explained and they were asked to participate. Each hunter was requested to bring his animal to the checking station whole, if he could do so without the animal spoiling. Hunters were given a large heavy-duty plastic bag in case they were unable to return the whole animal. They were requested to place all viscera, hide, legs, etc. removed from the animal into the plastic bag and return it as soon as possible. During 1977 and 1978, all permit holders were sent a letter notifying them of the checking station location and asked to stop for instructions. Data from hunter kills were recorded on a datum sheet (Appendix A).

Tissue samples for trace mineral analyses from the heart, liver, lungs, muscle, and kidneys were collected in 1977 and 1978.

Food Habits

Weekly fecal collections were made during May and June of 1977 and 1978. Samples were stored in paper bags and air dried. Collections were made from 2 community types: tall sage-foothill and short sage-flat.

Rumen samples were collected from 54 hunter-killed pronghorns from 1975 through 1978.

Vegetative Analysis

Ten permanent 100-m transect lines were placed in known adult pronghorn feeding areas. Vegetation was sampled using the canopy coverage-frequency method described by Daubenmire (1959). A coverage value and frequency for each species were recorded on datum sheets (Appendix A). Plant phenology was noted and a clipped plot-ocular weight estimate of new growth (Tadmor et al. 1975), was recorded. An attempt was made to read each transect during the following time periods: early May, early June, and early July. Vegetation was also sampled in and immediately outside of a 2.5-ha Bureau of Land Management exclosure constructed in 1961.

Statistical Procedures

Statistical procedures described by Snedecor and Cochran (1967) were used throughout the results. The t-test of significance of a normal population was used to compare differences in weights and in measurements. The binomial distribution was used to test the significance of differences between the observed and expected results in sex-ratio data and between the expected and observed ratios of predator losses categorized by community types.

CHAPTER IV

RESULTS

Fawn Monitoring

Due to transmitter failures and the unusual wariness of pre-parturient does, the number of fawns marked was less than anticipated. Neonatal histories were gathered for 42 fawns (23 males and 19 females) during the 1976, 1977, and 1978 fawning seasons.

Fawning Period

The fawning periods extended from 24 May to 9 June. Field observations indicated this range was not greatly exceeded. The mean birth dates for all fawns marked were 29 May in 1976, 2 June in 1977, and 31 May in 1978.

Sex Ratio

The secondary sex-ratio of M-121/F-100 for marked fawns was probably representative of that in the population, since only 1 of 4 fawns for which sibling sex data were missing was a male. The sex ratio for this study is compared with ratios from other studies in Table 1.

Table 1. A comparison of reported pronghorn secondary sex ratios.

	Male	Female	Total	M/100F	
	4	9	13	44	Autenrieth (pers. comm.)
	117	119	236	98	Autenrieth & Fichter (1975)
	23	19	42	121	Bodie (this study)
	8	6	14	133	Bromley (1977)
	16	19	35	84	Chattin & Lassen (1950)
	25	11	36	227	Corneli (pers. comm.)
	44	36	80	122	Edwards (1958)
	27	25	52	108	Hoover & Ogilvie (1954)
	64	53	117	121	Kitchen & Bromley (1974)
	34	31	65	110	O'Gara (1968)
	15	15	30	100	Von Gunten (1978)
Total	377	343	720	110	

Weights and Measurements

Mean weights and measurements of fawns at time of capture are given in Table 2. Differences between sexes were not significant ($p > 0.05$). Average weights and hind-foot lengths were significantly higher ($p < 0.5$) during 1977 than during 1976 or 1978. Differences in total lengths were not significant ($p > 0.5$)

Habitat Selection

From late May to 1 August, 743 fawn relocations were categorized by community types. Approximately 75% of the birth sites and 69% of the bedding sites were located in the short sage-flat type.

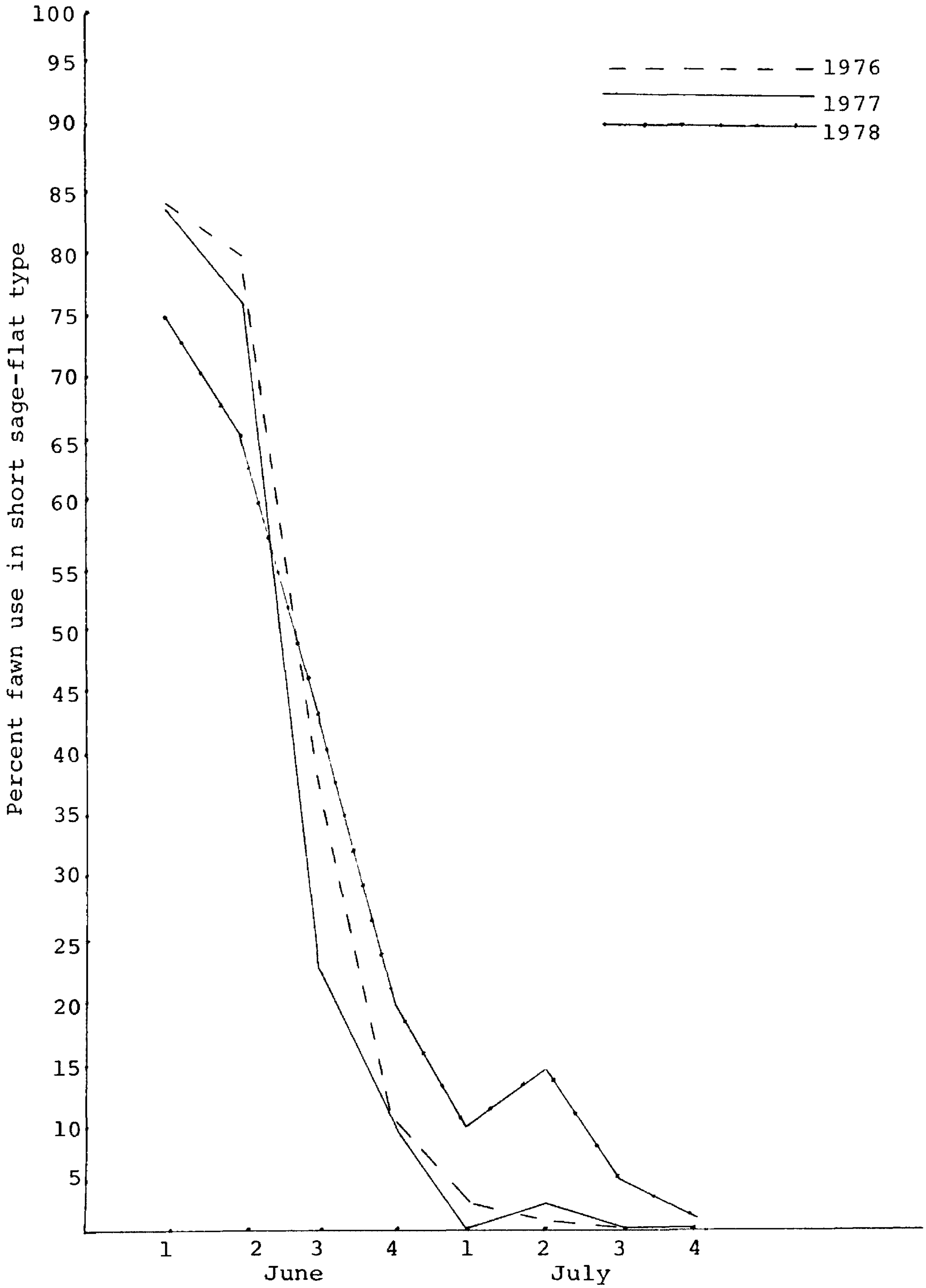
Table 2. Means and standard deviations of weights (kg) and measurements (mm) for transmittered fawns by year.

		Weight		Total Length		Hind-foot Length	
Year	N	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1976	12	3.46	0.58	630	44	241	10
1977	17	3.90	0.51	651	33	250	10
1978	13	3.50	0.54	630	26	233	11
Totals	42	3.62	0.54	637	34	241	10

In several cases, does gave birth to fawns in the tall sage-foothill type but moved the fawns into the short sage-flat type within 24 hours of birth.

Short sage-flat was the type most used during the first 2 weeks of life. Use in this type decreased during June and by 1 July most relocations occurred in the tall sage type, and by 1 August fawns were rarely located in the short sage-flat type (Fig. 6). Observations made during the late summer (August) herd composition flights indicated that the short sage-flats were nearly abandoned by all age and sex classes. At that time, most pronghorns were located on or near wet meadows associated with natural springs in the foothill areas.

Birth and subsequent bedding sites in the short sage-flat community type were usually located in vegetation higher than the average for that type. However, some birth and bedding sites were observed in vegetation lower than the average. Birth and bedding sites



of fawn bedding sites located in short sage-flat
.ity type by week and year.

in the tall sage-foothill type did not appear different than the average for that type. The tall sage-foothill type had a fairly uniform cover height so difference would not be readily apparent. If available, fawns tended to select bedding sites similar in plant composition and height to those on or immediately adjacent to their birth sites.

The movement patterns and use areas of does were apparently related to moisture content of the forage. On several occasions, does moved fawns up-valley toward or into the tall sage-foothill type as forage dried, and reversed their movements after a soaking rain. Birth and bedding site selection did not relate to the level of dry-weight or green-weight production or to the percent moisture in the vegetation (Table 3).

Table 3. A comparison of fawn use* and vegetative moisture content by community type, time period, and year.

		Tall Sage-foothill		Short Sage-flat	
Date	Time Period	% Moisture	% Use	% Moisture	% Use
1977	early June	65	20	60	80
	early July	60	90	50	10
1978	early June	68	25	63	75
	early July	53	85	43	15

*Based on percent of fawn locations in each community type. Transects 9 and 10 were used for the tall sage-foothill community type.

Checking Station Data

Numbers of pronghorns checked increased by 80% for 1977 and 1978 over 1975 and 1976. The increase in hunter participation is credited to contacting permit holders by letter before the opening date and asking them to participate.

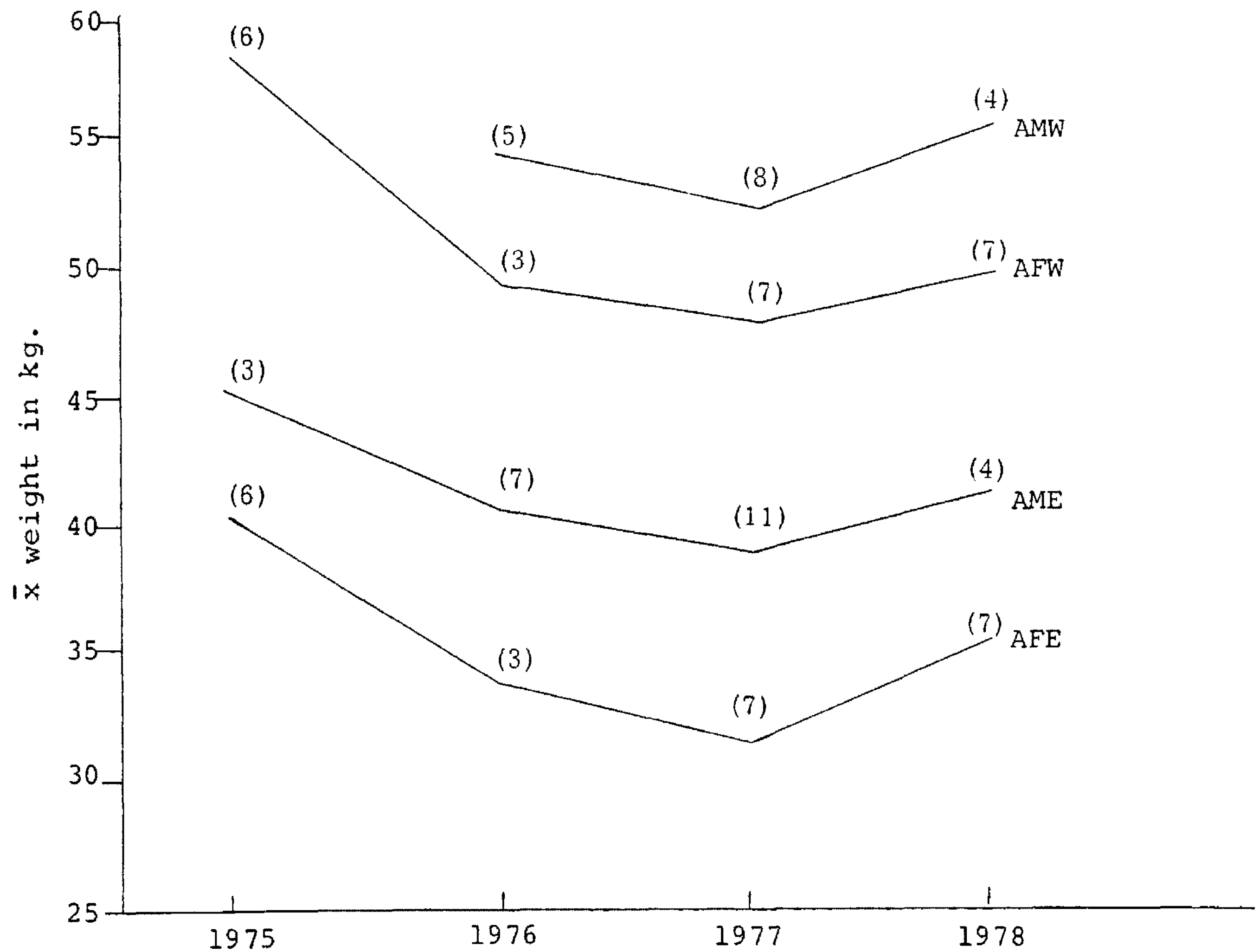
Checking station data were gathered from 101 pronghorns, including 25 adult males, 23 adult females, 39 yearlings, and 14 fawns. Because of hunter selectivity, the data are not proportional to population data. Yearlings and fawns made up 53% of all harvested animals. The ratios of bucks, yearlings, and fawns per 100 does in the kill were 109, 170, and 61, respectively.

Mean whole and eviscerated weights (Fig. 7) were highest in 1975, dropped in 1976 and 1977, and increased in 1978. Kidney fat weights followed a similar pattern. Weights and measurements by sex and age class are listed in Appendix B (Tables I-III).

Food Habits

Table 4 presents data from 54 hunter-killed pronghorns analyzed by the Idaho Fish and Game Laboratory by the macrofragment analysis technique.

Eighty-five pellet samples collected during the 1977 and 1978 spring-summer periods were analyzed by the University of Idaho Range Laboratory using the microhistological analysis technique



AMW = Adult male whole weight
AFW = Adult female whole weight
AME = Adult male eviscerated weight
AFE = Adult female eviscerated weight

Fig. 7. A comparison of mean whole and eviscerated weights for adult pronghorn by year and sex with sample sizes in parenthesis.

described by Dusi (1949), Storr (1961), Sparks (1968), and Todd and Hansen (1973). Browse accounted for approximately 70%, forbs 20%, and grasses 10%. No significant difference ($p > 0.05$) was observed between 1977 and 1978 data. Data by species and year for microhistological analyses are given in Appendix C.

Table 4. Percent composition of identifiable rumen material by forage class and year.

Year	N	Browse	Forbs	Grasses	Miscellaneous
1975	16	63	27	6	3
1976	18	69	15	11	4
1977	20	77	16	2	5
1978	18	86	4	8	T
Mean	18	74	15	7	3

Vegetation

Except for a small amount of riparian vegetation, the study area was classified as a sagebrush-grass habitat type. Tall sage-foothill (75%) and short sage-flat (25%) were the major components.

Canopy coverage and frequency of individual plant species were similar during 1977 and 1978 (Appendix D, Tables I-V). Differences were largely due to observer error and difficulty in identifying grass species during early growth stages. Approximately 25% of the area had a vegetative cover with the remainder as bare ground (50%) and litter (25%).

Production during Period III (early July) was similar during both years but was lower for both community types during early June (Period II) in 1978.

The mean total forage production of dry vegetation was higher for the tall sage-foothill transects (1 and 2) than for the short sage-flat transects. This difference remained true for all 3 time periods and for both years (Table 5). Production appeared to drop slightly for the tall sage type and increase slightly for the short sage type during 1978. The percent moisture (Table 5) was highest during Period II for both community types and years and appeared to be at least partially responsible for the high total green weight production observed for Period II in 1977.

Table 5. Mean totals of green and dry weights in kg/ha and percent moisture content by time period, year, and community type.

		Green Weight		Dry Weight		% Moisture of Green Weight	
Date	Time Period*	Tall Sage	Short Sage	Tall Sage	Short Sage	Tall Sage	Short Sage
1977	I	390	210	198	111	49	47
	II	942	559	393	226	58	59
	III	887	437	403	217	55	50
1978	II	552	404	214	148	61	63
	III	658	464	314	245	52	47

$$\% \text{ Moisture} = \frac{\text{Green Weight} - \text{Dry Weight}}{\text{Green Weight}}$$

*I = early May
II = early June
III = early July

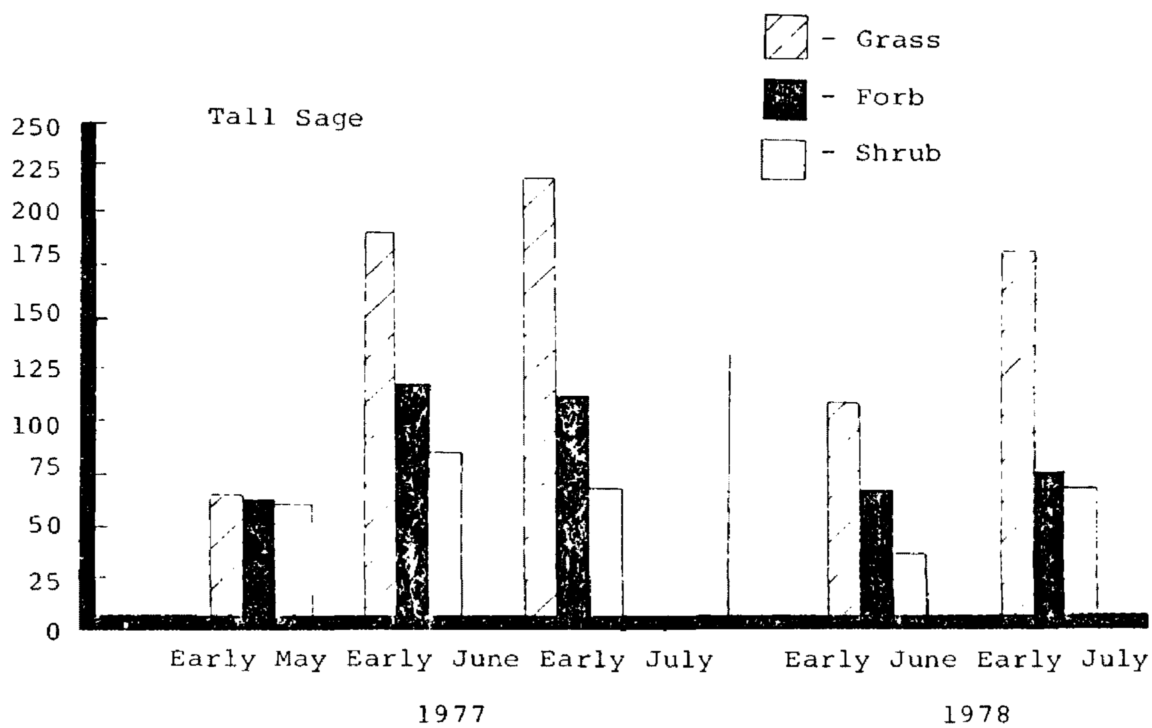
(Transects 1, 2, 9, 10 were used for tall sage)

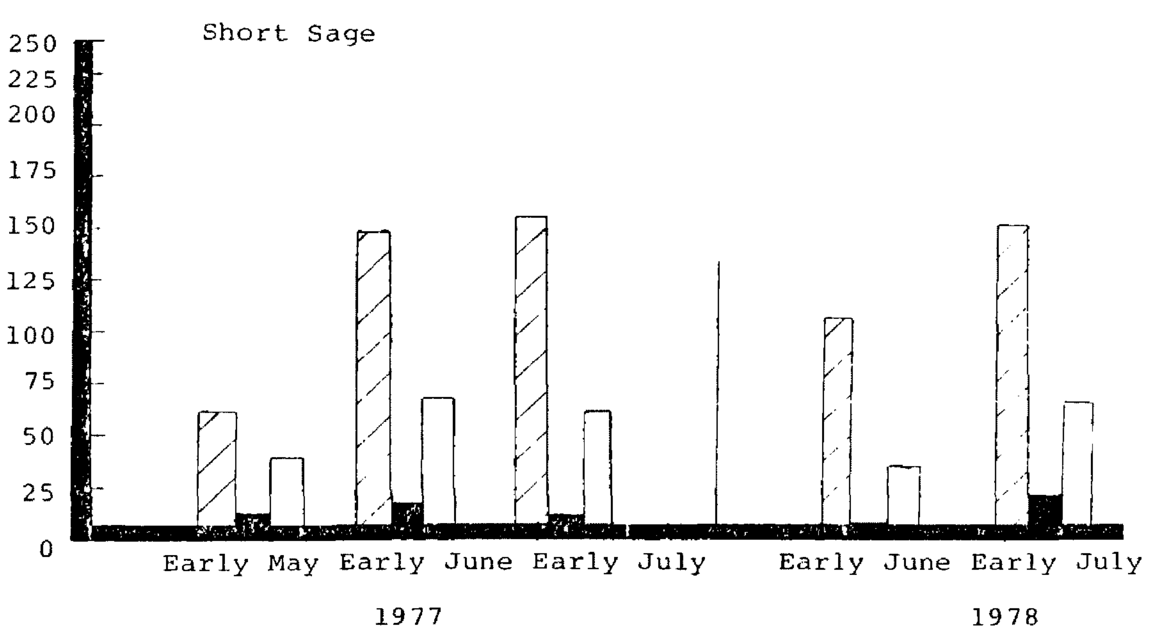
Figs. 8 and 9 depict dry weight production by time period, year, and forage class. Total sage production was similar for tall and short sage community types. Production of grasses was somewhat higher for tall sage but forb production was significantly higher ($p < 0.1$) for all time periods in the tall sage type.

Significant changes in plant composition and production were observed after 16 years of protection from grazing. Total production (Fig. 10) of all forage classes was higher outside than inside of the livestock exclosure. Forbs were almost absent on the ungrazed portion. Canopy coverage of bluebunch wheatgrass was significantly higher ($p < 0.05$) inside the exclosure than outside and the opposite was true for Sandberg's bluegrass.

Mortality

Losses by category and year are given in Table 6. Predation accounted for 35.7% of all marked fawns, starvation-disease 21.4%, and other causes 4.8%. Sixty-two percent of all fawns marked did not survive to 1 September and 92% of all mortality occurred during the first 2 weeks after birth. Six carcasses of unmarked fawns were found but not included in the mortality rates. Cause of death could not be determined for 2 of those 6 fawns. Differences in mean weights (Table 7) by mortality category were significantly higher ($p < 0.05$) for predator kills than for the mean weight of all fawns marked. The mean





Figs. 8 and 9. A comparison of dry weight production in kg/ha, for short sage-flat and tall sage-foothill community types by forage class, time period, and year.

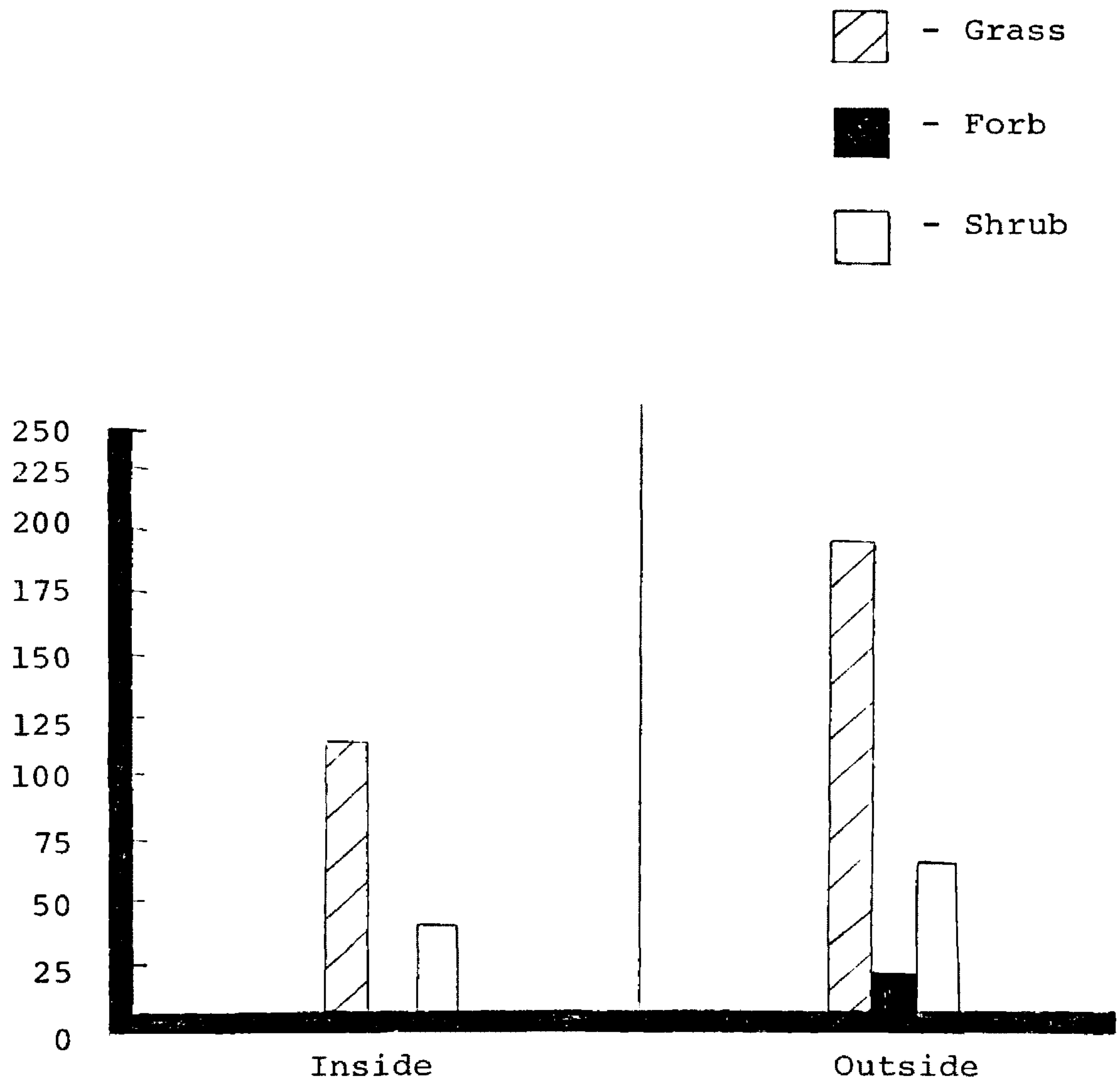


Fig. 10. A comparison of dry weight production, in kg/ha, for transects inside of and immediately outside of a 2.5-ha exclosure by forage class, time period, and year.

Table 6. Fates of transmitter-equipped fawns by year.

Year	N	Predation: Coyote	Predation: Eagle	Predation: Bobcat	Predation: Small Raptor	Disease-Starv.	Other	Survived
1976	12	2	2	1	2	3	0	2
1977	17	0	2	0	0	5	1	9
1978	13	2	3	1	0	1	1	5
Total	42	4	7	2	2	9	2	16
Percent	100	9.5	16.7	4.8	4.8	21.4	4.8	38.1
		35.7						

Table 7. Mean birth weights in kg by loss category and year.

Year	Predation	Starvation	Disease	Survived	Mean
1976	3.20 (3.62)*	3.32	3.68	3.26	3.46
1977	4.14	3.80	4.04	3.85	3.90
1978	3.99	...	2.49	3.32	3.52
Total	3.78 (3.91)*	3.56	3.41	3.48	3.66

*With 2 small raptor kills excluded.

weight of starvation-disease losses or for fawns that survived were not significantly different ($p > 0.05$) than the mean of all fawns marked.

Data for 3 fawns were lost due to transmitter problems. Two transmitter losses occurred after 2 weeks of the fawns life, but because most mortality occurred during this period, the fawns probably survived.

Predation

Daily visual location of all fawns allowed retrieval of most carcasses before they had been devoured. This technique aided in determining the species of predator involved.

Community types of 419 bedding sites, selected before 1 July, were categorized. Fawns selected sites at the following percentages: short sage-flat 69; foothill-tall sage 30; and riparian 1%. The percentages of marked fawns killed by predators in habitat types were short sage-flat 14, tall sage-foothill 86, and riparian 0.

Fawns selecting the tall sage-foothill community type (1 kill/ 10 bed days) had significantly higher ($p < 0.01$) predator-caused mortality than those bedding in the short sage-flat community type (1 kill/145 bed days). During the first 2 weeks of life, 93% of all predator kills occurred.

Eagles. Golden Eagles were the single most important mortality factor accounting for 7 (27%) of 26 losses and 47% of the predator-caused mortalities. An additional 4 eagle-killed fawns were found and 6 unsuccessful attacks recorded. On 27 May 1976, an eagle was observed carrying an instrumented fawn from a ridgetop. The fawn weighed 3.3 kg (7.2 lbs).

Eagles hunted approximately 50 to 100 m above the ground. After sighting a fawn they would glide down to the target, flutter over the prey, extend their talons, hook the fawn with their hallux and grab with the talons. Head wounds were found in 5 of the 11 eagle-killed fawns. The remainder were struck over or immediately behind the shoulders, and usually the shoulder blades were punctured. Death resulted from massive hemorrhaging of the lungs, liver, and dorsal aorta. In 1 case, the spinal cord was also severed.

Eagles were seldom observed hunting on hot, windless days or during rain or snow storms. Eagles hunted throughout the day but were most often seen during the early morning or late afternoon.

Three eagle eyries were located on or immediately adjacent to the study area. Eight eagles were known to hunt the study area, including 3 nesting pairs and 2 immature birds.

Coyotes. Coyotes were responsible for 4 (27%) of 15 predator-caused mortalities. Three of the 4 coyote-killed fawns were initially grabbed in the abdominal region. No wounds were observed forward of a line drawn immediately behind the front shoulders. I was unable to locate the initial grab marks on 1 fawn that was mostly devoured, although sufficient subcutaneous hemorrhaging was observed to indicate a coyote kill.

Coyote kills and observed activity occurred before 0800 and 2 coyote dens were located on the study area. At least 12 coyotes were killed by hunters and ranchers on or immediately adjacent to the study area during 1976, 1977, and 1978, including a female and 5 pups.

Other predators. Two bobcat and 2 small-raptor kills were recorded. A pair of twins, F-76-11 and F-76-12, were killed 9 days apart.

F-76-12 was abandoned at the birth site and attacked by a small raptor 2 days later. A small talon hole, found on the top of the head, penetrated into the cerebral tissue. Three talon wounds were also observed under the left eye. Although the fawn was alive when picked up, it was sufficiently affected by the wound to negate any chances of survival and is listed as a predator kill.

F-76-11 was observed on 20 June 1976 in a weakened condition and barely able to walk. It was found dead the next day. On necropsy, indications of disease and small-raptor-caused wounds were found. The age of the fawn at death (11 days), presence of milk in the stomach, and the presence of the doe indicated that the fawn had not been abandoned. These were the only fawns known to have been in a weakened condition before being attacked by a predator. Which mortality category the fawns should be placed into is questionable.

I suspect a Prairie Falcon (Falco mexicanus) was the predator involved. A Prairie Falcon nest was located within 400 m of the F-76-11 kill site and 700 m of that of F-76-12. Size and spread of the talon wound pattern were consistent with that of a Prairie Falcon.

Starvation

The high rate of starvation-disease losses, 25% in 1976, and 30% in 1977, were the result of a combination of factors, disease, starvation, and abandonment. Determining the direct cause of mortality was difficult, as fawns affected by disease often showed evidence of starvation and the reverse may have also been true. The number of fawns lost to starvation-disease in 1976 may have been higher than recorded if fawns taken by predators during the first 5 days of life had survived.

No significant symptoms of disease were found in 3 of 9 starvation-disease losses. Handling disturbance was probably a contributing factor in at least 2 of the 3 cases. In the other case, the carcass of a 7-day-old fawn was found 2 days after its sibling was killed by an eagle. Length of time from marking, the presence or absence of the doe, the presence of milk in the stomach, and the presence of serous atrophy of fat were indicators used to determine handling-caused abandonment losses.

Fawns handled at a minimum of 5 to 6 hours after birth appeared to be accepted by the doe more readily than those instrumented 3 hours after birth. Normal fawns typically squealed and tried to escape when captured. Two fawns (F-76-1 and F-78-11), marked a minimum of 6 hours after birth, exhibited aberrant behavior. Fawn F-78-11 showed no fear of me or the marking crew. It tried to suck my finger and followed me when released. Its twin, F-78-10, acted normally. F-78-11 was observed bedding with a yearling doe while its sibling was born.

Fawn F-76-1 jumped up and ran toward an approaching marker, stopped within 3 m, squealed, approached the marker, and nuzzled his hands and clothes apparently trying to find a nipple. Although the birth was not observed, a yearling doe was seen following the doe immediately before and after birth.

Disease

At least 6 of the 9 starvation-disease losses showed sufficient evidence to indicate disease as a contributing factor to death. Typically, these animals showed signs of enteritis, swollen livers and spleens, edema in hock joints, swollen lymph nodes, a rough dry coat, and empty rumens. One fawn with a systemic infection caused by an infected umbilical cord was probably a disease loss and is listed in the starvation-disease category.

Table 8 presents data on anal and nasal cultures. Data are lacking on basic flora and fauna of newborn pronghorn fawns and these data are presented in the hope they will be useful to subsequent researchers.

Histopathology provided little conclusive data on disease losses. Anomalies were found in several liver and kidney samples but were not severe enough to have caused death. Two thymus glands collected during 1976 from weak-acting fawns were analyzed by histopathological techniques and showed indications of poor development. The sample size was too small to draw a reliable conclusion, but did indicate a potential problem in fetal development during some years (Leathers pers. comm.).

Fifteen thymus glands were collected from fawn carcasses and mean weights for the thoracic portion increased during the 3 years of the study from 0.582, to 0.799, to 2.31 g. The cervical lobe was separate from the thoracic lobe and was found along the ventral surface of the trachea. Weight data collected from the cervical lobes were minimal because the lobe was absent in some animals and dispersed into small sections in others.

Kidney fat and serous atrophy of fat were almost absent in fawns during 1976; apparently the fawns were born with little fat reserve. During 1977 and 1978, fawn kidneys had approximately 30% of their surfaces covered with fat. Fawns were easier to catch, more

Table 8. Results of nasal and rectal cultures for 1977.

Fawn No.	Date	Nasal	Rectal	Fate
1	5/31/77 6/1/77*	Bacillus subtilis Bacillus subtilis Pseudomonas spp.	Negative Pseudomonas spp.	Trauma
2	5/31/77	Pseudomonas spp.	Pseudomonas spp. Staph. epidermitis	Predation
3	6/1/77 6/1/77*	Pseudomonas spp. Pseudomonas spp. Bacillus subtilis	Pseudomonas spp. Pseudomonas spp.	Disease
4	6/1/77	Pseudomonas spp.	Staph. epidermitis	Survived
5	6/1/77	Negative	No sample	Survived
6	6/1/77	Negative	Negative	Survived
7	6/1/77 6/3/77*	Pseudomonas spp. Pseudomonas spp.	Staph. epidermitis Staph. epidermitis	Starvation-Disease
8	6/1/77	Pseudomonas spp. Staph. epidermitis Bacillus subtilis	Negative	Survived
9	6/1/77	Negative	Negative	Survived
10	6/6/77	Bacillus spp.	Bacillus subtilis	Starvation-Disease
11	6/6/77	Bacillus subtilis	Negative	Predation
12	6/6/77	Bacillus subtilis	Staph. epidermitis	Survived
13	6/6/77	Bacillus subtilis	Pseudomonas spp.	Survived
14	6/6/77 6/10/77*	Bacillus subtilis Pseudomonas spp.	Negative Pseudomonas spp.	Disease
15	6/6/77	Pseudomonas spp.	Negative	Survived
16	6/10/77 6/20/77*	Negative Not done	Negative Not done	Disease
17	6/10/77	Bacillus spp.	Negative	Survived

*Post mortem.

docile when handled, and appeared less precocious in 1976 than during 1977 and 1978. No indication of birth anomalies were observed.

Four of 5 blood samples taken from newborn fawns had positive detectable antibody titers for para-influenza type 3 (PI_3), indicating a possible high rate of exposure in adult Pahsimeroi pronghorns. One fawn showed respiratory problems at marking. It was coughing and wheezing when handled and was not seen again. Necropsy data did not indicate a respiratory problem in other fawns or adults. The 5 samples had no detectable antibodies for infectious bovine rhinotracheitis, blue tongue, or bovine virus diarrhea.

Other Causes

The carcass of a 6-day-old fawn (F-78-10) was located in the Pahsimeroi River. Large volumes of water were found in the lungs and rumen. No wounds or symptoms of disease were evident and death was attributed to drowning. The River in this section was approximately 20 m wide and the depth varied from 1 to 2 m. On the following day, the still wet sibling (F-78-11) was located across the Pahsimeroi River from where it was located the previous day.

Fawn F-76-7 died of unknown causes at approximately 38 days of age. It was found lying in a relaxed position without external wounds. The fawn had been dead for about 5 days and a necropsy was not done because of the advanced state of autolysis.

Fawn F-77-1 died of massive internal injuries and no external signs of predation were evident. Eight instances of aggressive behavior toward fawns by yearling pronghorns were observed. Commonly, nursing does were accompanied by a yearling. Yearlings were seen butting fawns with sufficient force to knock them down. In 2 cases, yearlings were observed insinuating themselves between a doe and fawn and preventing nursing. Does with young fawns did not show aggressive behavior toward yearlings, although agonistic behavior was observed between lactating does and other adult does.

CHAPTER V

DISCUSSION

Fawn Monitoring

Fawning Period

The mean capture date for marked Pahsimeroi fawns (31 May) was later than those reported by Von Gunten (1978--25 May) and Corneli (1979--26 May) for the National Bison Range (NBR). O'Gara (1968) gave ovulation data for NBR and Yellowstone National Park does collected during 1965. He reported that most does ovulated between 8 and 20 September with the latest recent ovulation observed on 20 September and the mean fawn capture date for 1966 was 24 May. Ovaries from 5 of 15 hunter-killed Pahsimeroi does checked on 24 September 1977 and 25 September 1978 had corpora hemorrhagica indicating recent ovulation. Pahsimeroi does apparently ovulated later than those on the NBR. Late fawning in the Pahsimeroi could be a function of selection. Severe spring weather may make late fawning advantageous to pronghorns on high-altitude ranges.

Sex Ratio

The secondary sex-ratio for all fawns reported was not significantly higher ($p > 0.05$) for males than females, and was not significantly different than the ratio of 110/100 revealed by a review of the literature.

Verme (1962) and Robinette et al. (1973) indicated a relationship between the nutritional condition of the dam and the sex-ratio at birth for deer. White-tail deer does under nutritional stress produced more female fawns than dams on a high nutritional plane. A separation of the pronghorn data (Table 1) by nutritional condition may show a similar difference in the secondary sex-ratio for pronghorns.

Condition

The mean total weight of 3.62 kg for all fawns in my study was comparable to those reported by Bromley (1977) 3.64 kg, Von Gunten (1978) 3.68 kg, Corneli (1979) 3.54 kg for the NBR, and lower than the 4.14 kg reported by Autenrieth (pers. comm.) for central Idaho fawns. The difference of 0.45 kg in mean fawn weights between 1976 and 1977 indicated a higher yearly variation for Pahsimeroi fawns than for NBR fawns.

The high mean weight of fawns in the Pahsimeroi Drainage during 1977 was probably related to the extremely mild winter of 1976-1977. A lack of winter precipitation caused the drought experienced throughout the West during the summer of 1977, and wintering pronghorns were able to use all seasonal ranges.

Ungulate birth weights may be a function of the general body condition of the dams during pregnancy, especially the last 60 days before parturition (Verme 1962, Thorne et al. 1976). However, the literature is not consistent on this subject. Robinette et al. (1973) reported that mule deer birth weights did not increase when nutritional levels of dams were improved, and Murphy and Coates (1966) reported similar results in feeding trials using white-tailed does.

Verme (1962) and Thorne et al. (1976) found an inverse relationship between ungulate birth weights and early non-predator fawn mortality. However, Murphy and Coates (1966) and Robinette et al. (1973) reported that early fawn mortality and birth weights were not related; similarly, early, non-predator-caused fawn losses in the Pahsimeroi did not appear to be related to fawn birth weights. Fawn survival and behavior indicated better condition in 1978 than in 1977, although mean weights were approximately 0.45 kg higher in 1977.

Robinette et al. (1973), working with mule deer, reported that fawn weights were usually proportional to litter size, first-birth fawns appeared to weigh less than later fawns, and female twins weighed less than male twins. Preobrazhenskii (1961) found that birth weights of reindeer fawns increased from 5.75 kg for 2-year-old mothers to 7.27 kg for 7-year-old dams.

Data on the relationship between does' ages and fawns' birth weights were not gathered during this study. Male fawns in the Pahsimeroi were not significantly different in weight from female fawns. In fact, during 1976 and 1977, female fawns weighed slightly, but not significantly, more than male fawns. Single fawns averaged more than twins but the sample size of singles was too small to draw a reliable conclusion.

Ozaga and Verme (1978) reported that thymus weights in white-tailed deer were related to nutritional plane on a seasonal and regional basis and an evident relationship existed between young fawns' general vitality and the thymus sizes. As the average size of thymus glands increased over the 3 years of this study, from 0.582 g to 2.31 g, fawn losses to starvation-disease decreased from 25 to 8%. The amount of thymic material in neonatal pronghorn fawns appeared related to condition and may be a better indication of fawn vitality than birth weights. These data are presented as base line data, since sample size was not large enough to develop reliable conclusions.

Bromley (1977) described a technique for determining the age of young fawns using behavior, pelage, and the condition of the umbilical cord. I did not find behavior a reliable age criterion. Fawn condition affected behavior, which was highly variable between fawns of the same age. In several cases, fawns less than 10 hours old attempted to run when approached by a marker. In other cases, fawns known to be at least 3 days of age were easily caught and made only feeble attempts to escape.

Reproduction

The mean ovulation rates (Appendix B, Table IV) for all age classes of Pahsimeroi does were similar to those reported by O'Gara (1968) and appeared sufficiently high for normal reproductive success.

Recurrent estrus can extend the breeding season, causing a later mean fawning date. Einarsen (1948) postulated that pronghorns did not have recurrent estrus, but O'Gara's (1968) data indicated that more than 1 estrus occurred. He observed a doe with well developed corpora lutea (solid) and corpora hemorrhagica, indicating 2 distinct ovulation periods. Three does collected from the Pahsimeroi each had solid corpora lutea, hollow corpora lutea, and corpora hemorrhagica, indicating that 3 ovulation periods had occurred. The does involved were all over 4 years of age. They had total kidney fat weights of less than 14 gm each, eviscerated weights lower than the average for adult does, and large udders indicating lactation until late summer. The 3 does may have bred but at least the early matings were unsuccessful. Also, the does could have experienced quiet heats (Nalbandov 1958); the histological and physiological phenomena, including ovulations, occurred, but the mating response (psychological heat) did not. Quiet heat apparently occurs when the ovaries do not secrete sufficient estrogen to trigger a mating response. Although the above data indicate, but do not prove, recurrent estrus in pronghorns, they suggest a problem with conception in some Pahsimeroi does.

The apparent problem with conception could be related to several factors. Poor condition of lactating does during fall can affect breeding success and time of ovulation in ungulates (Preobrazhenskii 1961, Verme 1965, Robinette et al. 1973). The low number of mature bucks and the apparent lack of buck territoriality could cause a decrease in breeding success. Kitchen and Bromley (1974) reported that most of the breeding was done by territorial pronghorn bucks, and Geist (1971) found that large mountain sheep rams did most of the breeding and were preferred by females. A mature territorial buck may be more successful in eliciting a mating response from a doe than a young, nonterritorial buck, especially if a variation in intensity of the psychological response by the female occurs.

Habitat Selection

The migration from wintering to fawning grounds began around 1 May and usually occurred before greenup had started on the upper portions of the study area. Deep snow can delay the migration or cause a shift in fawning areas.

Bucks were seldom observed in the short sage-flat community type and most observations of buck and doe herds were in the tall sage-foothill type. As fawning time approached, small groups of adult does (less than 10) and yearlings began using the short sage-flat community type. Pre-parturient does left these groups and selected birth sites.

Does selected general bedding areas by leading their fawns to them, as reported by Autenrieth (1976). Several times, does teased reluctant fawns into moving by refusing to let them nurse. Once the general area was selected, fawns searched out and chose the actual bedding sites. Autenrieth (1976) reported on bed selection in the upper Pahsimeroi for 3 years prior to 1976; 87% of the birth sites and 73% of the bedding sites occurred in big sage. The remaining birth and bedding sites were located in low sage. During my study in the same area, 75% of the birth sites and 69% of the bedding sites were located in low sage with the remainder in big sage. The tall sage-foothill type had higher green weight and dry weight production of all forage classes than the short sage-flat type did. Moisture content of new-growth vegetation was also consistently higher in the tall sage-foothill type. The observed preference of buck and doe herds for the tall sage type appeared to be related to better forage conditions in the tall sage-foothill type. The high incidence of birth and bedding site locations in the short sage-flat community type indicated that forage conditions were not the determining factors for habitat selection by pregnant or lactating does, if forage moisture content did not drop much below 60% (Table 3). The observed movements of does with young fawns from the short sage-flat type to the tall sage-foothill type as forage dried and reverse movements after a spring rain provided further evidence of this relationship. Apparently, does selected birth and bedding areas because of reduced chances of predator encounters rather than forage quality and quantity or the presence of hiding cover.

The amount of big sage on the study area has been reduced during the past 5 years. A sagebrush spray project was completed in 1974 on a portion of the study area and a significant amount of sagebrush was winter-killed during the 1976-1977 winter. The reduction of big sage on those 2 historical fawning areas may have caused some of the additional use observed on the short sage-flat type by pregnant and lactating does, but does not explain the continued use of the tall sage-foothill type by bucks and non-lactating does. Autenrieth and Fichter (1975) and Barrett (1973) reported that fawns tended to select bedding sites similar in plant composition and height to those of their birth sites. In this study, Pahsimeroi fawns normally selected several bedding sites within 50 m of their birth sites during the first 6 hours after birth and before the doe left the fawns for the first time. Subsequent bedding sites more closely resembled those first bedding sites than the actual birth sites. Quantitative vegetation analysis is needed to verify this observation.

Mortality

The mortality rate of 62% for Pahsimeroi fawns was higher than the 42% reported by Beale and Smith (1973) for a western Utah study area and lower than the 90% (Von Gunten 1978) and 67% (Corneli

1979) reported for 2 years on the NBR. The 4000-ha western Utah study area of Beale and Smith was enclosed by a fence and the NBR is a relatively large (7506 ha) area surrounded by a game-proof woven wire fence and is not native pronghorn range. Consequently, data from those areas may not be directly comparable to open pronghorn ranges where predator control is practiced and pronghorns are hunted.

High mortality rates for pronghorn fawns are commonly reported and are usually based on late-summer fawn/doe ratios. The literature does not indicate that pronghorns on poor ranges produce fewer fawns than those on good ranges. Most reported mortality has occurred between parturition and late-summer herd-composition surveys. However, the possible conception problem, observed in emaciated Pahsimeroi does, indicated that the nutrition of the dam could affect productivity.

The estimated fawn/doe ratio based on marked animals was not directly comparable to the August aerial herd composition counts (Table 9) provided by Autenrieth (1978). My data were based on adult does, but yearling does were included in the aerial data. Based on ground classification of 173 female pronghorns during the springs of 1977 and 1978, there were approximately 40 yearling females per 100 adult does. The total August fawn/doe ratio (46.3) corrected for the yearling component was 77.2 fawns per 100 adult does and was comparable to the 80.2 fawns per 100 adult does estimated from all marked animals.

Table 9. A comparison of estimated and August aerial doe/fawn ratios for 1976-1978.

Year	Total	Bucks	Does	Fawns	*F/100 Does (August)	**Est. F/100 Does (Adult)
1976	257	34	161	62	39	64
1977	321	39	188	94	50	102
1978	305	71	156	78	50	74
Total	883	144	505	234	46	80

*August aerial data.

**Est. fawn/adult doe ratio from marked fawns.

Adult Pronghorns

Harvest Rates

Either sex permits, 175 per year, were issued for the Upper Pahsimeroi Drainage. An estimated 100 animals were harvested each year during the study. Based on an estimated population of 400 animals, a 25% rate of harvest is high for pronghorns on semidesert ranges. Pre-season population numbers and winter population levels have remained relatively constant. The few adult does harvested and immigration from bordering areas during September probably allowed a stable population with a relatively high harvest rate.

Autenrieth (1966) observed territorial bucks in the Upper Pahsimeroi. During the 3 years of this study, only 1 buck showed territorial behavior. Hunter selectivity has apparently reduced the number of mature bucks on the study area. Data are not available on the effects of reduced numbers of mature bucks or the elimination of territorial behavior (Fichter and Autenrieth 1978).

Condition

Eviscerated weights gave a better indication of fall condition than whole weights, and hunters were more likely to return eviscerated animals, increasing sample size. Eviscerated weights were less variable than whole weights. Pronghorn bucks had only small amounts of rumen contents, probably accounting for the observed variation.

Yearling and adult males had higher kidney fat weights than adult does. Lactating or recently lactating does had the lowest kidney fat levels. Several had less than 5 g. Lactating does expend a large portion of their nutrient intake in the production of milk. Pronghorns continue to store fat until November (O'Gara 1968) and should be in better condition going into the winter than their September condition would indicate.

Average measurements of Pahsimeroi animals were somewhat less than those reported by Mason (1952), Evans (1965), Bear (1966), and Mitchell (1978). Certain year and age classes approximated the above data; the differences between Pahsimeroi animals and those from other areas were apparently due to high yearly variations in growth conditions in the Pahsimeroi.

O'Gara (1968) compared his weight data with that of Edwards (1958) for Wyoming pronghorns. He observed the same whole weights for does, but Wyoming data showed smaller weights for bucks. O'Gara theorized that the difference in mean buck weights may have been due to a younger age class of bucks because of hunter preference for males. Pahsimeroi data indicated similar results to that reported for Wyoming. Although this difference was noted for whole weights, eviscerated weights were comparable. Weight loss for all my animals was 27% and compared with the 31% reported by Edwards and 28% noted by O'Gara, although Pahsimeroi adult males lost an average of 21%. The difference was attributed to reduced rumen content of adult males during the September rutting period.

The literature on ruminant physiology provides some data on the effects of season of year but little about the effects of mean yearly precipitation or habitat conditions on kidney weights. Differences in pronghorn kidney weights could be caused by seasonal changes in forage quality or winter inanition with reduced metabolism (Batcheler and Clark 1970), proteinuria (Gans 1970), heat stress (McDonald and McFarlane 1958), or body water kinetics (Cameron and Luick 1972).

Total kidney weights for Pahsimeroi pronghorns were 18% larger than those reported by O'Gara (1968). The larger mean kidney weights underestimated the kidney fat index (KFI) (Appendix B, Table

III) by approximately 17% when compared with O'Gara's data. Variations in kidney weights by populations were probably related to water availability.

Dauphiné (1975) reported that KFI was not reliable if used to display seasonal changes in body condition due to pronounced seasonal fluctuations of caribou (Rangifer tarandus) kidney weights. He stated "there is little justification for using the KFI in place of perirenal fat if the approximate ages of specimens can be determined."

Perirenal fat weights appeared to be a better indicator of condition than the kidney fat index, if animals were separated by age and sex, when comparing population condition or seasonal variations in condition.

Food Habits

A comparison of food habits measured by 2 techniques, microhistological fecal (Appendix C) and macrofragment rumen (Table 4), indicated a similar pattern of forage use. The diet composition averaged 70% browse, 20% forbs, and 10% grasses. The percentage of various forage classes in the diet was comparable to data reported by Brown (1946), Scarvie and Arney (1957), Yoakum (1958), and Terwilliger (1946) for populations on sagebrush-grassland ranges.

Data for all years and forage classes were similar except for 1975. Browse use was lower and forb use higher during 1975, when the observed condition of all age and sex classes during autumn was the highest. Unfortunately, forage production and plant moisture were not measured during 1975.

Fawn Mortality Factors

Predation

Fawn condition. Two fawns (F-76-11 and F-76-12) were obviously in a weakened condition when attacked by a small raptor. Raptors the size of a Prairie Falcon may find it difficult to kill 3 to 4 kg fawns unless the fawns are in a weakened condition. Larger predators such as coyotes, eagles, and bobcats kill prey species much larger than newborn pronghorn fawns. If the 2 small raptor-killed fawns are removed from the weight data, the average weight of predator-killed fawns increases to 3.92 kg and is higher than the mean of 3.67 kg for all fawns marked. Beale and Smith (1973) reported that predators may select larger fawns. No indication of starvation or disease was observed in any of the predator-killed fawns except for the 2 small-raptor kills. The contention that predators take the weak and sick probably is not true for pronghorn fawns. Pronghorn fawns were easily caught and killed and predation rates appeared to depend upon the predator's ability to locate fawns. Weak fawns moved their bedding sites less often and remained more motionless when bedded than healthier and more precocious fawns. The increased movement of healthy fawns may increase a predator's ability to locate them.

I found no indication that predators fed on fawns that had died of other causes. The remains of 6 fawns were placed in a shallow draw on the short sage-flat. No sign of scavenger activity was observed during the following 2-week period.

Bedding site selection. The significantly higher rate of predator-caused fawn mortality in the tall sage-foothill community type was caused by several factors. In areas open to hunting, predators become more nocturnal and use cover to a greater extent than in non-hunted areas. The short sage-flat provides little cover for a hunting bobcat or coyote. Beale and Smith (1973) found that 63% of the fawn losses occurred in or near washes and theorized that bobcats hunted the draws making fawns bedded near them more vulnerable. Reichel (1976) and Von Gunten (1978) correlated high coyote-caused mortality with the close proximity of coyote dens. A similar situation appeared to occur in the Pahsimeroi. All coyote and most eagle observations were in the tall sage type and the 2 coyote dens and 3 eagle eyries were also located in the tall sage-foothill community type. Observations of alternate prey species indicated a higher use of the tall sage type than short sage type by rodents, lagomorphs, and Sage Grouse (*Centrocercus urophasianus*). Air currents in or near the foothills were probably more conducive to raptor flight than on the flats. Fawn bedding sites were visible to does at greater distances in the short sage-flat type than in the tall sage-foothill type. This increased visibility may have assisted in the doe's observation of approaching predators and subsequent defense of fawns.

Alternate prey species. Although quantitative data were not gathered on alternate prey populations, a gradual increase in lagomorphs and sage grouse was noted. Whitetailed and blacktailed jack rabbit (*Lepus townsendii* and *L. californicus*) populations in the upper Pahsimeroi were relatively low when compared with populations in the lower Pahsimeroi. Ground squirrel (*Citellus richardsonii*) populations were high during all 3 years of the study. The emergence of young from dens during late May and early June provided a high number of easily caught prey. Ground squirrels appeared to be more common along the riparian zone and where the ground was rocky. During 1976, fawn predation abruptly stopped when young ground squirrels emerged from their dens, but fawn predation did not start in 1978 until well after the emergence of ground squirrels. August doe/fawn ratios have been consistently higher in the lower Pahsimeroi where jack rabbits are numerous than in the upper Pahsimeroi where rabbit populations are low.

Predation on pronghorn fawns is probably related to alternate prey populations but a direct relationship could not be proven.

Doe defensive behavior. Eighteen eagle and 11 coyote interactions with pronghorns were recorded when fawns were known to be present. One fawn was killed and 2 wounded by eagles during these 27 interactions. In all cases, a doe or a group of does showed defensive behavior. Does were highly aggressive and usually successful in defending fawns from predators. Only 3 of 9 eagle-killed fawns showed any significant amount of feeding. Adult pronghorn tracks in the vicinity of eagle and coyote kills indicated that does actively defended the fawns after death and were often successful in preventing feeding.

In most cases, does ran toward eagles and coyotes and chased them until they were out of the area. In 1 case, a coyote was chased over 1.6 km from the area of a bedded fawn. A group of does was observed running past a coyote several times in an apparent effort to draw the coyote away from the vicinity of a fawn. When that failed and the coyote approached within 50 m of the bedded fawn, the doe attacked the coyote and chased it from the area.

Starvation

Starvation losses reduced the marked fawn population by 7%. Symptoms of starvation were also observed in 5 of 6 disease losses. The presence of serous atrophy of fat appeared to be a reliable indicator of starvation during some years. Its presence indicated that fawns were born with fat reserves but were forced to use them due to nutritional stress. During 1976, serous atrophy of fat was not observed and fawns were apparently born without fat reserves.

Abandonment caused by handling was probably responsible for 2 of 3 starvation losses and may have been a contributing factor in others. Does appeared to vary by year and individual in their reaction to newly marked fawns. An avoidance reaction to newly marked fawns was commonly observed during 1976 and 1977. In some cases, the fawn was not accepted until 24 hours after marking. In no case were both fawns of a set of twins abandoned and birth weights did not appear to correlate with rejection or starvation (Table 7). Twice, the larger of a set of twins died of starvation disease while the smaller twin survived. The minimum time from birth to marking was increased from 3 hours (Autenrieth and Fichter 1975) to 6 hours (Prenzlow 1964) and the change appeared to ease acceptance problems.

The smell of the hip tag cement, used to hold the backpack transmitter in place, appeared to be responsible for some of the rejection problems. A similar technique used on the NBR did not appear to cause problems (Reichel 1976, Von Gunten 1978, Corneli 1979).

Signs of rejection behavior were not observed during 1978. The change from backpack to neck collar may be partially responsible although Beale and Smith (1973) observed acceptance problems while using a neck collar in Utah.

Thomson and Thomson (1949, 1953) found that nutritionally stressed domestic ewes provided little milk to their offspring and their maternal instincts were poor. Langenou and Lerg (1976) reported that a majority of white-tailed deer fawn mortality within a few days after birth occurred because of a maternal rejection syndrome, and fawns born to nutritionally stressed does evoked a fear and aggression response rather than a normal licking and grooming response. The rejection behavior described by Langenou and Lerg was similar to that observed in the Pahsimeroi for both marked and unmarked fawns.

Fawns were apparently more susceptible to abandonment and starvation during some years than others, and some populations may be more susceptible than others. During years when fawns were susceptible to abandonment and starvation, human harassment, presence of livestock, predator attacks, disease, and severe weather conditions appeared to increase abandonment and consequently starvation losses.

Few, if any, fawns actually died of starvation or malnutrition. Two abandoned fawns picked up 48 hours after marking had rectal temperatures of less than 29.4°C (85°F). They were too weak to stand and their ability to nurse was impaired. Actual death was probably caused by hypothermia. The chance of survival of fawns with such low temperatures is slight.

The effects of yearlings butting fawns, interfering with nursing, or the mere presence of a yearling doe at the birth site causing imprint confusion appeared to place stresses on the mother-young bond.

Disease

Few data are available in the literature concerning disease in pronghorn fawns. Hoover and Ogilvie (1954) suspected a loss of newborn fawns in Wyoming to disease after finding fawn carcasses lying in a relaxed position without external signs of predation. Pahsimeroi fawns that died of starvation, as well as of disease, were found lying in a similar relaxed position.

Fawns in western Utah were lost to pneumonia and salmonellosis (Beale 1978). Barrett (1978) reported a loss of 30% of his marked fawns in Alberta to starvation/unknown but could find no indication that infectious agents contributed directly or indirectly to the death of any marked fawns. Reichel (1976) attributed the death of 2 fawns on the NBR to weak calf syndrome. He based his conclusion primarily on atrophic thymus glands (O'Gara pers. comm.).

Ward (pers. comm.) and Card et al. (1973) recognized and described symptoms of weak calf syndrome in cattle. Affected animals showed one or more of the following symptoms: hemorrhages, edema or fibrous material in the leg joints; an atrophic thymus gland;

enlarged and edematous suprascapular and prefemoral lymph nodes; and susceptibility to secondary bacterial enteritis leading to diarrhea. Calves sometimes died of hypothermia in rather mild winter weather (4.4°C). Calves and lambs were born in a weakened condition and many died within a few days after birth. Domestic lambs suffering from the weak calf syndrome often have minor infections and swollen spleens and livers. In most cases, the abnormalities are not severe enough to have been the direct cause of mortality (O'Gara pers. comm.).

Causes of the weak calf problem are not well known. Bull et al.(1974) found a relationship between the nutritional state of pregnant cattle in Lemhi and Custer counties, Idaho, and subsequent calf survival. Januszewski (1972) reported a causal relationship between weak calf-lamb syndrome and a virus in Montana. Epidemiology also suggests that the syndrome is caused by an infectious organism. In Montana, the syndrome appeared to be restricted to the first calves of infected cows, and the problem was first noted in a herd of cattle brought in from out of state. Bull et al. (1978) was able to produce symptoms of weak calf syndrome in domestic cattle by subjecting newborn calves to cold stress.

The relationship of trace mineral deficiencies to pronghorn fawn survival is largely unknown. Stoszek et al. (1978) compared selenium, zinc, and cobalt levels for Pahsimeroi pronghorns with those of a central Montana population. She considered the selenium levels deficient and the zinc and cobalt levels reduced when compared with levels found in Montana pronghorns and thought they could be responsible for poor health and the observed low survival rate. Individual pronghorns had liver selenium levels as low as those of selenium-deficient farm livestock suffering from clinical signs of white muscle disease (Underwood 1977).

All of the symptoms described for weak calf-lamb syndrome were observed in Pahsimeroi fawns classified as starvation-disease losses. The symptoms were not observed in 2 suspected handling-caused abandonment losses or in any of the predator kills. The presence of edema, hemorrhaging, and fibrin in leg joints; yearly variation in amount of thymic material; susceptibility to cold stress; weakness; lack of suckling response; and early mortality in Pahsimeroi fawns indicated the presence of a condition similar to weak calf syndrome.

Pronghorn neonates suffering from "weak fawn syndrome" may be predisposed to death since there was no indication of symptoms in fawns that died from predation or other causes. A newborn fawn's survival is tenuous due to its complete dependence on maternal care and a natural weakness. Additional stress, such as secondary enteritis or diminished milk supply, may not be serious to an older animal but could jeopardize the survival of a newborn. Fawns born with low fat reserves probably succumb quicker than normal fawns. Low milk intake appears to cause a low body temperature and consequently a weak animal, which in turn results in a still lower milk intake. This condition apparently builds momentum and may be very difficult to reverse.

CHAPTER VI

SUMMARY

I conducted a study to determine the factors affecting fawn mortality of a native, unrestricted pronghorn population in the upper Pahsimeroi River Drainage of central Idaho. During the fawning seasons of 1976, 1977, and 1978, neonatal histories were gathered for 42 fawns through the use of radiotelemetry. Adult summer condition trends were monitored using data gathered from 101 pronghorns killed by hunters from 1975 through 1978. Range condition, trend, and spring-summer food habits were determined.

By 1 September, 62% of all marked fawns were dead, and 92% of all mortality occurred during the first 2 weeks after birth. Mortality rates, determined from marked fawns, ranged from 47 to 83% and were representative of that observed for the rest of the population. The failure to remove nonproducing yearling does from late summer herd composition information affects the accuracy of these data. The greater the number of yearling does in the population, the greater the underestimate of fawn survival. Total mortality was high during those years when heavy losses to predation and disease occurred concurrently.

Predation was the most important mortality factor accounting for 35.7% of all marked fawns and ranged from 12 to 58%. Eagles were the most successful predators and accounted for approximately 50% of all predator-caused mortality. Larger, more active fawns were more susceptible to predation than smaller, less precocious fawns. Does actively defended fawns from coyote and eagle attacks and were usually successful. Fawns bedding in the tall sage-foothill community type were more susceptible to predator-caused mortality than fawns bedding in the short sage-flat type. Most predator sightings, kills, and all coyote dens and eagle eyries were located in the tall sage type.

Does preferred the short sage-flat community type for birth sites and most fawn bedding sites were located in this type during late May and early June. Fawns were moved toward the tall sage type during June and by late June-early July most fawns were bedding in the tall sage type. The short sage flats were nearly abandoned by all age and sex classes by 1 August.

Pahsimeroi does were more likely to abandon fawns during some years than others. Stress on the mother-young bond from human harassment, adverse weather conditions, predator kills of siblings, disease, livestock, and imprint confusion from the presence of yearlings at birth sites was observed.

During some years, Pahsimeroi fawns were subject to losses from weak fawn syndrome. Observed symptoms were: (1) general weakness; (2) susceptibility to hypothermia; (3) early mortality; (4) secondary enteritis; (5) swollen livers and spleens; (6) edema, fibrin, and hemorrhaging in hock joints; (7) enlarged and edematous suprascapular and prefemoral lymph nodes; (8) rough and dry coat; and (9) atrophic thymus glands.

Shrubs had a consistently higher moisture content than forbs and forbs had consistently higher moisture content than grasses. During September, adult pronghorns used forage at the following percentages: shrubs 68, forbs 23, and grass 4. Food habits for the spring period were similar to that of September; thus, pronghorns selected the most succulent forage.

Pronghorns were of normal size for this latitude. Eviscerated and total kidney fat weights indicated a high yearly variation in fall condition. Rutting bucks had only small quantities of food in their rumens. Lactating does had minimal fat reserves and often appeared emaciated. Three instances of multiple ovulation periods were observed in emaciated does. The effect of the possible problem in conception on net productivity is unknown.

The upper Pahsimeroi River Drainage is marginal pronghorn range. The high altitude and low spring-summer precipitation adversely affect forage production and, subsequently, fall pronghorn condition. Yearly total forage production and phenological development was highly variable. The tall sage community was more productive and had more succulent vegetation during all periods and for all forage classes than the short sage-flat type.

Livestock use has increased grass, forb, and shrub production and diversity in the short sage type. Forbs were largely absent in an ungrazed portion of this type. Grazing has reduced the amount of bluebunch wheatgrass and increased the production of Sandberg bluegrass. The amount of grazing pressure needed to produce the optimum ratio of grass, forbs, and shrubs for pronghorns is unknown.

REFERENCES CITED

Autenrieth, R. E. 1966. Behavior and socialization of pronghorn fawns. M.S. Thesis. Idaho State Univ., Pocatello. 82 pp.

________. 1976. A study of birth sites selected by pronghorn does and the bed sites of fawns. Proc. Antelope States Workshop 7:127-134.

________. 1978. Antelope ecology. Job Completion Rept. W-160-R-5. Idaho Fish and Game Dept., Boise. 11 pp.

________, and E. Fichter. 1975. On the behavior and socialization of pronghorn fawns. Wildl. Monogr. 42. 111 pp.

Barrett, M. W. 1973. Investigations related to pronghorn antelope kid tagging in Alberta. Prairie Habitat Conf. Brooks, Alberta. Mimeo. rept. 46 pp.

________. 1978. Pronghorn fawn mortality in Alberta. Proc. Antelope States Workshop 8:429-444.

Batcheler, C. L., and C. M. H. Clarke. 1970. Note on kidney weights and the kidney fat index. N.Z.J. Sci. 13(4):665-668.

Beale, D. M. 1978. Birth rate and fawn mortality among pronghorn antelope in western Utah. Proc. Antelope States Workshop 8: 445-448.

________, and A. D. Smith. 1973. Mortality of pronghorn antelope fawns in western Utah. J. Wildl. Manage. 37(3):343-352.

Bear, G. D. 1966. Antelope investigations. Job Completion Rept. W-40-R-6. Colorado Fish and Game Dept., Denver. 83 pp.

Bromley, P. T. 1977. Aspects of the behavioral ecology and sociobiology of the pronghorn. Ph.D. Thesis. Univ. of Calgary, Alberta. 363 pp.

Brown, R. O. 1946. Antelope surveys and investigations. Quarterly Rept. 4-R. Colorado Fish and Game Dept., Denver. 4 pp.

Bull, R. C., R. R. Loucks, F. L. Edmiston, J. N. Hawkins, and E. H. Stauber. 1974. Nutrition and weak calf syndrome in beef cattle. Univ. of Idaho. Current Info. Series No. 246. 27 pp.

________, D. P. Olson, M. J. Stoszek, and R. H. Ross. 1978. Maternal protein restriction and cold stress during rearing on blood composition and pathological lesions in neonatal calves. Proc. Western Section Amer. Soc. Anim. Sci. 19 pp.

Cameron, R. D., and J. R. Luick. 1972. Seasonal changes in total body water, extracellular fluid, and blood volume in grazing reindeer. Can. J. Zool. 50(1):107-116.

Card, C. S., G. R. Spencer, E. H. Stauber, F. W. Frank, R. F. Hall, and A. C. S. Ward. 1973. Weak calf syndrome--epidemiology, pathology, and microorganisms recovered in proc. 77th Ann. Mtg. U.S. Health Assoc. pp. 67-72.

Chattin, S. E., and R. Lassen. 1950. California antelope reproductive potential. California Fish and Game, Sacramento. 36(3):328-329.

Connolly, G. E. 1979. Predators and predator control. Pages 369-394 in J. L. Schmidt and D. L. Gilbert, eds. Big game of North America. The Stackpole Co., Harrisburg, PA. 494 pp.

Cowan, I. McT., and L. Karstad. 1969. Post-mortem examinations. Pages 251-258 in R. H. Giles, Jr., ed. Wildlife management techniques. 3rd ed. The Wildlife Society, Washington, D.C. 623 pp.

Daubenmire, R. F. 1952. Plant geography of Idaho. Pages 1-17 in R. J. Davis, ed. Flora of Idaho. Brigham Young Univ. Press, Provo. 836 pp.

________. 1959. A canopy coverage method of vegetational analysis. Northwest Sci. 33:43-66.

Dauphiné, T. C. Jr. 1975. Kidney weight fluctuations affecting the kidney fat index in caribou. J. Wildl. Manage. 39(2):379-386.

Dusi, J. L. 1949. Methods for the determination of food habits by plant microtechniques and histology and their application to cottontail rabbit food habits. J. Wildl. Manage. 13(3):295-298.

Edwards, W. C. 1958. Reproductive potential of big game animals. Pages 33-57 in Job Completion Rept. FW-3-R-5. Wyoming Game and Fish Dept., Laramie.

Einarsen, A. S. 1948. The pronghorn antelope and its management. The Stackpole Co., Harrisburg, PA. 256 pp.

Evans, D. 1965. Big pleasure in big country. South Dakota Conservation Digest 32(4):2-6.

Fichter, E., and A. E. Nielson. 1964. Pronghorn antelope study. Job Completion Rept. W-85-R-14. Idaho Fish and Game Dept., Boise. 16 pp.

________, and R. E. Autenrieth. 1978. Is trophy hunting fostering "unnatural" selection for smaller, less vigorous and nonterritorial pronghorn bucks. Proc. Antelope States Workshop 8:52-69.

Gans, J. H. 1970. The kidneys. Pages 767-812 in M. J. Swenson, ed. Dukes' physiology of domestic animals. 8th ed. Cornell Univ. Press, Ithaca, NY.

Geist, V. 1971. Mountain sheep, a study in behavior and evolution. Univ. of Chicago Press. 383 pp.

Henne, D. R. 1975. Domestic sheep mortality on a western Montana ranch. M.S. Thesis. Univ. of Montana, Missoula. 53 pp.

Hoover, R. L., and S. Olgilvie. 1954. Fed. Aid Qtrly. Rept. April:33-38. Colorado Game and Fish Dept., Denver.

Januszewski, T. C. 1972. Isolation and characterization of a virus associated with the weak calf-lamb syndrome. M.S. Thesis. Univ. of Montana, Missoula. 72 pp.

Kitchen, D. W., and P. T. Bromley. 1974. Agonistic behavior of territorial pronghorn bucks. In the behavior of ungulates and its relation to management. 2 Vols. IUCN New Ser. Publ. 24, Morges, Switzerland. 940 pp.

Langenou, E. E. Jr., and J. M. Lerg. 1976. The effects of winter nutritional stress on maternal and neonatal behavior in penned whitetailed deer. Appl. Anim. Ethol. 2:207-223.

Mason, E. 1952. Food habits and measurements of Hart mountain antelope. J. Wildl. Manage. 16(3):387-389.

McDonald, J., and W. V. MacFarlane. 1958. Renal function of sheep in hot environments. Aust. J. Agric. Res. 9(5):680-692.

Mitchell, G. J. 1971. Measurements, weights, and carcass yields of pronghorns in Alberta. J. Wildl. Manage. 35(1):76-85.

Murphy, D. A., and J. A. Coates. 1966. Effects of dietary protein on deer. Trans. N. Amer. Wildl. Nat. Resour. Conf. 31:129-138.

Nalbandov, A. V. 1958. Reproductive physiology. W. H. Freeman and Co., San Francisco. 271 pp.

Nellis, C. H. 1977. Mule deer ecology. Job Completion Rept. W-160-R-4. Idaho Fish and Game Dept., Boise. 15 pp.

Odum, E. P. 1971. Fundamentals of ecology. W. B. Sanders Co., Philadelphia. 574 pp.

O'Gara, B. W. 1968. A study of the reproductive cycle of the female pronghorn (Antilocapra americana Ord.). Ph.D. Thesis. Univ. of Montana, Missoula. 161 pp.

Ozaga, J. J., and L. J. Verme. 1978. The thymus gland as a nutritional status indicator in deer. J. Wildl. Manage. 42(4): 791-798.

Prenzlow, E. J. 1964. Doe-kid behavior of pronghorns in north central Colorado. Colorado Coop. Wildl. Res. Unit, Colorado State Univ., Fort Collins. 7 pp.

Preobrazhenskii, B. V. 1961. Management and breeding of reindeer. Pages 78-128 in P. S. Zhigunov, ed. Reindeer husbandry. [Transl. from Russian from Israel program for Sci., U.S. Dept. of Commerce, 1968.]

Reichel, J. D. 1976. Coyote-prey relationships on the National Bison Range. M.S. Thesis. Univ. of Montana, Missoula. 93 pp.

Robinette, W. L., C. H. Baer, R. E. Pillmore, and C. E. Knittle. 1973. Effects of nutritional change on captive mule deer. J. Wildl. Manage. 37(3):312-326.

Scarvie, O., and J. A. Arney. 1957. Food habits of pronghorn antelope (Antilocapra americana), in October in northern Colorado. Colorado State Univ., Fort Collins. 7 pp.

Schlegel, M. 1976. Factors affecting calf elk survival in north central Idaho. Proc. Western Assn. Game and Fish Comm. 56:342-355.

Snedecor, G. W., and W. G. Cochran. 1967. Statistical methods. 6th ed. Iowa State Univ., Ames. 593 pp.

Sparks, D. R., and J. C. Malechek. 1968. Estimating percentage dry weight in diets using a microscopic technique. J. Range Manage. 21(4):264-265.

Storr, G. M. 1961. Microscopic analysis of faeces, a technique for ascertaining the diet of herbivorous mammals. Aust. J. Biol. Sci. 14(1):157-164.

Stoszek, M. J., W. B. Kessler, and H. Willmes. 1978. Trace mineral content of antelope tissues. Proc. Antelope States Workshop 8:156-161.

Tadmor, N. H., A. Breighet, I. Noy-meir, R. W. Benjamin, and E. Eyal. 1975. An evaluation of the calibrated weight-estimate method for measuring production in annual vegetation. J. Range Manage. 28(1):65-69.

Terwilliger, C. 1946. Food habits of antelope. Game Manage. Problem. Colorado State Univ., Fort Collins. 15 pp.

Thomson, A. M., and W. Thomson. 1949. Lambing in relation to the diet of the pregnant ewe. Br. J. Nutr. 2(4):290-305.

Thomson, W., and A. M. Thomson. 1953. Effect of diet on milk yield of the ewe and growth of her lamb. Br. J. Nutr. 7(3):263-274.

Thorne, E. T., R. E. Dean, and W. G. Hepworth. 1976. Nutrition during gestation in relation to successful reproduction in elk. J. Wildl. Manage. 40(2):330-335.

Todd, J. W., and R. M. Hansen. 1973. Plant fragments in the feces of bighorns as indicators of food habits. J. Wildl. Manage. 37(3): 363-366.

Underwood, E. J. 1977. Trace elements in human and animal nutrition. 4th ed. Academic Press, New York. 527 pp.

Verme, L. J. 1962. Mortality of whitetailed deer fawns in relation to nutrition. Proc. Nat. Deer Dis. Symp. 1:15-38.

________. 1965. Reproductive studies on penned whitetailed deer. J. Wildl. Manage. 29(1):74-79.

________. 1969. Reproductive patterns of whitetail deer related to nutritional plane. J. Wildl. Manage. 33(4):881-887.

Von Gunten, B. L. 1978. Pronghorn fawn mortality on the National Bison Range. Proc. Antelope States Workshop 8:394-416.

Yoakum, J. 1958. Seasonal food habits of the Oregon pronghorn antelope (Antilocapra americana oregona Bailey). Trans. Inter-Antelope Confer., 9:47-59.

APPENDIX A

DATUM SHEETS USED IN THE STUDY

PRONGHORN FAWN FORM

Fawn No. ____________________ Date ____________ Time ________

Map Location ____________________ Approx. age ____________________

No. Fawns/Doe ____________________ Handling Behavior ____________________

Twin Fawn No. ____________________ ____________________

Sex ________ Wt. ________ Body Temp. ________ Behavior of Doe ____________________

H. Ft. L. ____________ T. L. ____________ ____________________

Tooth Length ____________________ Fawn Accepted ________ Rejected ________

Placenta ____________________ Time Accepted ____________

Boots: ____________________ ____________________

Birth Observed ____________________ (Blood sample, external parasites, abnormal-

Radio Collar No. ____________________ ities, etc.)

Radio Frequency ____________________ Fawn Loc. Marker # ______ Photo # ______

Radio Collar Ch. ____________________ Observer: ____________________

F.T., etc. ____________________

RADIO LOCATIONS

Date	Time	B.P.M.	Visual	Date	Time	B.P.M.	Visual

Datum Sheet for Recording Vegetational Information

DATE	FORM #	OB FORM #	HABITS FORM #	VEG. HABITAT TYPE	TYPE OF USE	DIRECTION	LOCATION·GRID	LOCATION-TWP	
	C.	A.	B.						
1	7	12	17	22	31	32	33	39	49

Sheet ____ of 4
51 52

2 X 5 DECIMETER PLOTS

Area ________________

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Sub. T.	Sub. F.
B.A.R.E.																											
L.I.T.T.E.R																											
R.O.C.K.																											

Coverage Class Codes

	Range	Midpoint
1.	0-5	2.5
2.	5-25	15.0
3.	25-50	37.5
4.	50-75	62.5
5.	75-95	85.0
6.	95-100	97.5

Tallest Shrub Height

1. ______ 2. ______
53 54

Recorder ____________________

FIELD DATUM COLLECTION SHEET

Data gathered from hunter-killed pronghorns

Place____ Age__________ Date______________

Collection Number______________ Time Shot________________ Sex________________________

Circumstances of Death____

MEASUREMENTS (Millimeters)

Total Length______________________________ Hind Foot______________________________

Tail Length______________________________ Ear Length______________________________

Chest Girth______________________________ Shoulder Height______________________________

Neck Girth:
Greatest______________ Least____________

Nipple Length and Appearance:
____

Horn Length:
L__________________ R__________________

Horn Girth:
L__________________ R__________________

WEIGHTS

Whole (lbs)______________________________ Eviscerated______________________________

Ovaries (gms):
L__________________ R__________________

Udder______________________________

Heart with Pericardium:
____

Heart without Pericardium:
____

Kidneys with Fat:
L__________________ R__________________

Kidneys without Fat:
L__________________ R__________________

OTHER

Rumen Weight______________________________ Rumen Sample 1__________ 2__________

Jaw______________________________ Fecal Pellets______________________________

Milk Present______________________________

REMARKS:

APPENDIX B

MEANS AND STANDARD DEVIATIONS OF WEIGHTS AND MEASUREMENTS, AND OVULATION RATES OF HUNTER-KILLED PRONGHORNS

Table I

	Sample Size	Mean	Std.Dev.	Sample Size	Mean	Std.Dev.
	Total Length in mm			Hind Foot Length in mm		
FEMALES						
Fawns	3	1136	19	3	371	38
Yrlgs.	11	1385	54	12	410	22
Adults	13	1356	94	13	418	35
2+	1	1462	0	1	395	0
3+	1	1442	0	1	416	0
4+	11	1341	93	11	420	38
MALES						
Fawns	6	1205	73	6	397	40
Yrlgs.	15	1361	38	16	405	32
Adults	18	1402	57	18	421	34
2+	5	1446	46	5	426	31
3+	7	1373	61	7	420	45
4+	6	1399	36	6	420	25
	Tail Length in mm			Ear Length in mm		
FEMALES						
Fawns	1	100	0	3	130	21
Yrlgs.	5	115	6	9	149	14
Adults	5	127	18	13	145	9
2+	1	123	0	1	150	0
3+	-	-	-	1	141	0
4+	4	128	21	11	145	10
MALES						
Fawns	4	109	33	6	137	19
Yrlgs.	7	125	23	16	145	13
Adults	5	111	22	18	150	13
2+	2	109	41	5	147	18
3+	1	122	0	7	153	13
4+	2	107	7	6	150	13
	Shoulder Height in mm			Chest Girth in mm		
FEMALES						
Fawns	3	757	51	3	802	110
Yrlgs.	12	914	25	8	931	24
Adults	13	873	53	10	975	31
2+	1	917	0	1	950	0
3+	1	905	0	1	1010	0
4+	11	866	55	8	973	31
MALES						
Fawns	6	780	88	6	793	49
Yrlgs.	15	895	62	6	958	24
Adults	18	895	61	12	1004	60
2+	5	910	44	4	962	39
3+	7	886	77	4	1046	73
4+	6	895	60	4	1003	41

Table II

	Sample Size	Mean	Std. Dev.	Sample Size	Mean	Std. Dev.
	Whole Weight in kg			Eviscerated Weight in kg		
FEMALES						
Fawns	2	30.7	6.8	5	19.4	3.0
Yrlgs.	9	45.8	5.7	14	32.8	4.2
Adults	12	49.7	5.8	20	34.8	4.3
2+	2	44.7	0.3	4	33.3	0.6
3+	2	55.1	9.3	3	33.1	3.9
4+	8	49.8	5.1	13	35.6	4.8
MALES						
Fawns	7	29.6	4.7	12	19.8	3.3
Yrlgs.	7	44.7	3.0	22	34.4	2.6
Adults	11	51.9	3.6	36	40.0	4.3
2+	3	52.6	2.0	11	38.1	3.8
3+	5	51.6	3.7	16	41.3	4.7
4+	3	51.7	3.8	9	39.7	3.4
	Left Kidney wt. in g			Right Kidney wt. in g		
FEMALES						
Fawns	2	66.0	12.7	3	67.3	14.3
Yrlgs.	12	100.8	18.3	12	100.8	17.5
Adults	18	115.5	16.3	17	117.9	17.2
2+	3	105.3	8.5	3	115.6	7.8
3+	3	100.7	9.5	4	100.0	14.4
4+	8	128.5	13.7	7	132.6	9.4
MALES						
Fawns	3	74.0	8.9	3	72.3	11.0
Yrlgs.	12	117.6	14.1	11	113.4	11.1
Adults	11	138.6	18.8	13	141.5	31.8
2+	3	134.3	26.4	4	156.2	48.4
3+	3	150.3	24.0	3	146.0	30.0
4+	3	130.7	12.5	3	134.0	17.3
	Total Kidneys wt. in g			Total Kidneys fat in g		
FEMALES						
Fawns	3	132.7	23.3	2	21.5	2.1
Yrlgs.	12	201.1	35.0	11	116.4	40.4
Adults	17	236.4	28.6	16	103.3	119.5
2+	3	221.0	15.5	3	58.3	63.3
3+	3	211.3	12.7	3	225.0	249.0
4+	8	257.4	24.4	7	62.7	44.3
MALES						
Fawns	3	146.3	19.8	3	28.7	18.0
Yrlgs.	14	238.7	31.0	14	75.1	68.1
Adults	13	283.9	62.8	13	102.5	75.9
2+	4	313.0	98.0	4	104.5	130.6
3+	3	296.3	51.8	3	146.7	37.6
4+	3	264.7	29.7	3	87.0	43.6

Table III

	Kidney Fat Index		
	Sample Size	Mean	Std. Dev.
		Female	
Fawns	2	22.9	11.7
Yrlgs.	11	60.4	20.6
Adults	16	48.2	53.6
2+	3	26.2	28.8
3+	3	102.8	108.9
4+	7	31.1	24.3
		Male	
Fawns	3	19.4	11.9
Yrlgs.	14	36.3	29.4
Adults	13	42.0	34.7
2+	4	45.3	62.7
3+	3	51.3	20.5
4+	3	32.2	13.5

Table IV

	No. of Corpora Lutea		
	Left	Right	Total
		6 Months	
Sample Size	4	4	4
Mean	2.0	0	0.5
Std. Dev.		0	
		1+	
Sample Size	7	6	6
Mean	2.1	1.8	3.9
Std. Dev.	.9	1.7	2.1
		2+	
Sample Size	1	1	1
Mean	3	3	6
Std. Dev.	0	0	0
		3+	
Sample Size	1	1	1
Mean	3	2	5
Std. Dev.	0	0	0
		4+	
Sample Size	8	8	8
Mean	2.5	3.5	6.0
Std. Dev.	1.1	1.6	1.8

APPENDIX C

FOOD HABITS DETERMINED BY MICROHISTOLOGICAL FECAL ANALYSIS TECHNIQUES

Table I

1977 (N = 13)

Species	% Frequency	Density	% Diet 95% C.I.	Std.Dev.
AGROP	2.8	.028	0.8 + OR - 0.3	1.13
BRTE	2.8	.028	0.8 + OR - 0.3	1.34
CAREX	1.1	.011	0.3 + OR - 0.2	0.68
FEID	0.6	.006	0.2 + OR - 0.1	0.46
KOCR	0.2	.002	0.0 + OR - 0.1	0.24
POA	5.3	.055	1.6 + OR - 0.5	1.92
STIPA	0.4	.004	0.1 + OR - 0.1	0.39
UNK GRS	16.6	.182	5.3 + OR - 0.7	2.76
ACMI	4.7	.048	1.4 + OR - 0.5	1.95
ASTER	1.1	.012	0.3 + OR - 0.2	0.84
ASTRA	18.2	.201	5.9 + OR - 2.0	7.95
BORAGE	3.3	.033	1.0 + OR - 0.5	1.89
DESCU	1.9	.019	0.6 + OR - 0.3	1.15
ERIGE	4.3	.044	1.3 + OR - 0.8	3.26
ERIOG	0.1	.001	0.0 + OR - 0.0	0.16
GETR	1.7	.017	0.5 + OR - 0.3	1.18
LESQU	2.5	.026	0.8 + OR - 0.5	1.99
LOMAT	0.5	.005	0.1 + OR - 0.2	0.71
LUPIN	0.7	.007	0.2 + OR - 0.1	0.58
ROOT	2.0	.020	0.6 + OR - 0.5	1.83
SEST	0.1	.001	0.0 + OR - 0.0	0.19
SENEC	0.4	.004	0.1 + OR - 0.1	0.53
TRIFO	0.6	.006	0.2 + OR - 0.3	1.14
UNK FRB	14.5	.157	4.6 + OR - 0.7	2.68
ARTEM2	51.9	.732	21.4 + OR - 1.4	5.54
ARAR-TR2	21.7	.245	7.1 + OR - 1.1	4.28
ARFR2	0.4	.004	0.1 + OR - 0.2	0.80
ARNO2	4.0	.041	1.2 + OR - 0.6	2.21
ARTR	50.7	.708	20.7 + OR - 1.4	5.55
CELE	0.3	.003	0.1 + OR - 0.1	0.50
CHNA	5.3	.055	1.6 + OR - 0.6	2.49
CHV12	12.0	.128	3.7 + OR - 1.0	3.94
GUSA	0.5	.005	0.1 + OR - 0.2	0.92
PHLOX2	21.7	.245	7.1 + OR - 1.1	4.25
UNK BRS	28.9	.340	9.9 + OR - 0.9	3.40
CONIFER	0.4	.004	0.1 + OR - 0.2	0.66

Table II

1978 (N = 17)

Species	% Frequency	Density	% Diet 95% C.I.	Std.Dev.
AGROP	3.9	.040	1.1 + OR - 0.8	1.46
BRTE	2.9	.029	0.8 + OR - 0.6	1.10
CAREX	2.1	.022	0.6 + OR - 0.5	0.94
FEID	0.7	.007	0.2 + OR - 0.4	0.71
KOCR	0.4	.004	0.1 + OR - 0.2	0.41
POA	3.6	.036	1.0 + OR - 0.6	1.12
STIPA	1.1	.011	0.3 + OR - 0.5	0.91
UNK GRS	18.2	.201	5.7 + OR - 1.2	2.07
ACMI	5.7	.059	1.7 + OR - 1.9	3.23
ASTER	2.1	.022	0.6 + OR - 0.6	1.03
ASTRA	22.1	.250	7.2 + OR - 3.3	5.68
BORAGE	3.6	.036	1.0 + OR - 0.8	1.41
DESCU	0.4	.004	0.1 + OR - 0.2	0.40
ERIGE	3.9	.040	1.1 + OR - 1.6	2.79
ERIOG	0.7	.007	0.2 + OR - 0.3	0.54
GETR	3.2	.033	0.9 + OR - 1.4	2.47
LESQU	0.4	.004	0.1 + OR - 0.2	0.36
LOMAT	1.1	.011	0.3 + OR - 0.5	0.88
LUPIN	0.7	.007	0.2 + OR - 0.3	0.50
SENEC	0.4	.004	0.1 + OR - 0.2	0.40
UNK FRB	19.6	.219	6.3 + OR - 1.4	2.49
ARTEM2	43.2	.566	16.2 + OR - 3.1	5.37
ARAR-TR2	20.7	.232	6.6 + OR - 2.5	4.28
ARFR2	0.4	.004	0.1 + OR - 0.2	0.41
ARNO2	1.8	.018	0.5 + OR - 0.5	0.94
ARTR	45.4	.604	17.3 + OR - 2.5	4.30
CHNA	12.9	.138	3.9 + OR - 2.1	3.67
CHV12	15.7	.171	4.9 + OR - 2.6	4.57
GUSA	0.7	.007	0.2 + OR - 0.4	0.77
PHLOX2	29.6	.352	10.1 + OR - 3.1	5.36
UNK BRS	30.4	.362	10.3 + OR - 1.5	2.59

APPENDIX D

CANOPY COVERAGE, FREQUENCY, AND PRODUCTION

IN kg/ha BY YEAR AND TRANSECT

Table I

Percent canopy coverage to left of slash and frequency to right of slash.

Species	Tall Sage 1977	Tall Sage 1978	Short Sage 1977	Short Sage 1978
AGSP	6.7/74	5.18/ 64	4.46/66	4.71/56
BROMU	.06/1	.46/ 27	.24/7	1.35/22
ORHY	---	.01/1	---	---
POSA	4.32/ 94	6.4/ 95	3.65/85	5.63/92
SIHY	---	.06/3	---	---
STCO	.33/12	.67/16	3.31/44	4.25/43
AGOSE	.07/3	.01/1	---	---
ALCE	.16/7	.28/11	---	---
ANTEN	.79/14	1.41/17	---	+/T
ARLE	.06/2	.33/13	.04/2	---
ASSC	.36/9	.63/11	---	---
ASTRA	.02/1	.02/1	---	---
CACH	.06/T	.17/3	---	---
COPA	---	.09/4	---	---
CRAT	---	.46/8	---	---
CREPI	.28/7	---	---	---
DEPI	---	.19/8	---	---
ERCO	.09/4	.17/4	.01/T	.03/1
ERIGE	.03/1	---	---	---
ERIOG	.88/1	.46/7	.04/1	.03/1
ERIT	.01/T	---	---	---
EULA	.24/5	.06/2	.21/6	.21/4
GUSO	.08/1	---	.13/4	.18/4
HAPLO	1.18/20	1.5/18	.04/1	.07/1
LEPU	.04/2	---	+/T	---
LOMAT	---	.03/1	.03/1	.05/2
MELO	.03/1	---	.03/1	.07/2
PENST	.01/T	---	---	---
PHHO	1.64/38	2.19/39	.13/5	.13/4
PHLO	.36/14	.49/17	.06/2	.09/4
TARAX	.09/4	.21/7	.01/1	.01/T
ARTEM	10.34/55	11.01/58	14.00/92	14.37/93
ATNU	---	.24/5	---	---
CHVI	.04/2	.08/2	---	---
ZIGAD	.01/T	---	---	---
UNK	.18/7	.02/1	.01/T	---
BARE	54.56/100	45.53/95	54.82/1.0	52.37/100
LITTER	31.02/100	22.11/1.0	28.54/1.0	4.74/100
ROCK	.47/5	1.64/16	.10/1	+/T

\+ = Less than .01 percent

T = Less than 1.0 percent

Table II

Mean coverage and frequency, and production (in kg/ha) inside of and immediately outside of a 2.5-ha Bureau of Land Management Exclosure located in the short sage-flat community type.

		Inside		Outside	
		1977	1978	1977	1978
AGSP		10.0/100	5.1/87	2.6/81	2.5/51
POSA		4.5/99	2.3/74	12.5/99	3.9/98
SIHY		---	---	.5/17	.5/10
STCO		11.0/85	6.0/85	4.4/76	6.3/97
ANDI		---	.2/2	---	---
ARHO		T/1	T/3	T/2	---
ASPU		---	T/1	---	2.1/35
ASSC		.9/10	---	.1/4	T/3
EULA		T/2	.3/4	T/1	T/2
HAPLO		.2/3	---	---	---
PHHO		---	.8/13	.2/7	1.6/34
PHLO		---	---	.1/4	9.7/79
ARAR		14.4/88	14.7/79	14.3/93	9.7/79
ATNU		---	.2/2	---	.4/15
UNK		.3/14	---	---	---
BARE		42.7/94	45.0/100	57.3/99	47.7/100
LITTER		24.2/99	35.2/100	16.9/98	27.4/100
ROCK		.3/4	1.0/11	T/3	T/2
Green Wt.	Grass	---	214	---	311
	Forb	---	---	---	28
	Shrub	---	112	---	137
Dry Wt.	Grass	---	117	---	194
	Forb	---	---	---	23
	Shrub	---	40	---	68

Table III

Green and dry weight production (kg/ha) of forage classes by time period (I through III). Transects 1 and 2 were in the tall sage-foothill type in the upper end of the study area and 9 and 10 were in the lower end.

Year	Period	Transect / Class	Dry Wt.	Dry Wt. Total	Green Wt.	Green Wt. Total
1977	I	1 & 2				
		Grass	54	249	95	371
		Forb	82		112	
		Shrub	113		163	
		9 & 10				
		Grass	82	147	194	410
		Forb	50		147	
		Shrub	14		69	
	II	1 & 2				
		Grass	123	338	199	610
		Forb	126		225	
		Shrub	90		186	
		9 & 10				
		Grass	261	448	670	1274
		Forb	110		353	
		Shrub	77		252	
	III	1 & 2				
		Grass	107	251	119	514
		Forb	96		202	
		Shrub	47		113	
		9 & 10				
		Grass	334	508	659	1260
		Forb	127		318	
		Shrub	95		284	
1978	I	NO DATA				
	II	1 & 2				
		Grass	124	220	212	459
		Forb	57		163	
		Shrub	39		84	
		9 & 10				
		Grass	91	207	276	644
		Forb	80		244	
		Shrub	36		124	
	III	1 & 2				
		Grass	141	263	276	515
		Forb	60		141	
		Shrub	62		97	
		9 & 10				
		Grass	222	392	412	827
		Forb	94		197	
		Shrub	76		218	

TABLE IV

Green and dry weight production (kg/ha) of forage classes by time period (I through III) for transects located in the short sage-flat community type.

			Dry Wt.		Green Wt.	
				Total		Total
1977	I	Grass	59	111	106	210
		Forb	7		11	
		Shrub	44		93	
	II	Grass	149	226	328	559
		Forb	10		27	
		Shrub	67		204	
	III	Grass	153	217	284	438
		Forb	5		13	
		Shrub	59		124	
1978	I	NO DATA				
	II	Grass	112	148	252	404
		Forb	T		13	
		Shrub	36		139	
	III	Grass	157	245	276	464
		Forb	17		30	
		Shrub	71		151	

T = less than 1.0 percent.

Table V

Mean canopy coverage and frequency of plant species for all transects by year.

Species	1977 $\bar{X}$ Canopy Coverage	1977 $\bar{X}$ Frequency	1978 $\bar{X}$ Canopy Coverage	1978 $\bar{X}$ Frequency
AGSM	.0322	.07	---	---
AGSP	4.27	.65	4.68	.58
BROMU	.143	.096	.92	.15
FEID	.007	.003	---	---
ORHY	----	----	T	T
POSA	4.69	.896	5.76	.94
SIHY	.05	.015	.07	.02
STCO	2.32	.352	3.14	.42
AGOSE	.03	.01	T	T
ALCE	.05	.02	.1	.04
ANTEN	.13	.05	.51	.06
ARLE	.043	.017	.21	.08
ASSC	----	----	T	T
ASTRA	.04	.02	.23	.05
CACH	.023	.01	.06	.01
COPA	----	----	.03	.01
CRAT	----	----	T	T
CREPI	.1	.02	---	---
DEPI	----	----	.45	.17
ERCO	.036	.014	.08	.02
ERIGE	.011	.004	---	---
ERIOG	.175	.05	.22	.04
ERIT	T	T	---	---
EULA	.2	.05	.14	.03
GUSO	.1	.02	.1	.02
HAPLO	.04	.08	.58	.07
LEPU	T	T	---	---
LOMAT	.15	.01	.03	.01
MELO	.03	.01	.04	.01
PENST	T	T	---	---
PHHO	.68	.17	1.73	.2
PHLO	.08	.03	.1	.03
SEDUM	T	T	---	---
TANAC	.02	T	---	---
TARAX	.45	.02	.03	.03
ZIGAD	T	T	---	---
ARTEM	12.7	.78	12.73	.79
ARFR	----	----	.1	T
ATNU	.03	.01	.05	.03
CHVI	.016	.006	.03	.01
UNKNOWNS	.08	.03	.06	.02
BARE	54.95	1.0	50.91	.99
LITTER	28.39	1.0	12.89	1.0
ROCK	.23	.02	.58	.06