Ecology of Mule Deer on The

Pinon Canyon Maneuver Site, Colorado.

by

Thomas P. Gerlach

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APPROVED:

Michael R. Vaughan, Chairman	W. Carter Johnson
Roy L. Kirkpatrick	Patrick F. Scanlon

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(ABSTRACT)

Mule deer (*Odocoileus hemionus*) population dynamics, movements, and habitat use were studied on the Pinon Canyon Maneuver Site in southeastern Colorado during January 1983- December 1984. Thirty-eight adults and 28 fawns were radio collared, and 35 adults were color collared or ear tagged. Population estimates were 365 and 370 deer for 1983 and 1984, respectively. The sex ratio (yearling and adult) was 60 males:100 females. Adult female pregnancy rate was 95%; the mean litter size for females over 1.5 years was 1.7 fawns. Annual fawn survival was 29% in 1983 and 22% in 1984. Coyote (*Canis latrans*) predation was responsible for 76% of fawn mortality. Adult survival was 88% in 1983 and 87% in 1984; coyote predation accounted for 67%, and hunting for 33% of the annual adult mortality. The calculated annual rate of increase (λ) was 1.01, indicating a stable population. Seasonal home range size differed ($p < 0.05$) between males and females only in the fall. Females preferred pinyon-juniper woodland in all seasons, and shrub grassland in winter, summer and fall; proportional use of woodland/ open grassland and shrub/ open grassland edge was greater than proportional availability. Males preferred pinyon-juniper woodland and avoided open grassland in all seasons. Fawns preferred shrub grassland and shrub/ open grassland edge; they avoided cholla/ open grassland edge. Fawns selected bed sites with greater ($P < 0.05$) concealment cover at all 0.5 m intervals up to 2 m in height, and greater ground cover of trees, shrubs, and grasses ($P < 0.01$) than random sites.

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GENERAL INTRODUCTION

The proposed acquistion of land in southeastern Colorado, by the Department of the Army for use as a remote military training area, resulted in the preparation of a Draft Environmental Impact Statement which required that studies be conducted to develop a comprehensive wildlife management program. Mule deer were among the six species to be studied. Existing information consisted largely of mule deer census flights (Colorado Division of Wildlife, unpublished files, 1977), and the environmental impact assessment. Specific population information on mule deer in this area was limited.

This study was conducted from January 1983 through December 1984. The objective was to provide information on mule deer population dynamics, including density estimates, adult and fawn survival, reproduction, movements and habitat use before military maneuvers. The rationale was that knowledge of baseline conditions was needed both to assess and mitigate possible impacts from Army maneuvers.

This thesis is presented in four chapters. The first and second chapters discuss the population dynamics, movements and habitat use of mule deer on the Pinon Canyon Maneuver Site, Colorado. The third chapter evaluates mule deer fawn bed site selection, and the final chapter discusses the use of two helicopter types for net-gunning mule deer.

STUDY AREA

The study was conducted on the 1,040 km^2 Pinon Canyon Maneuver Site (PCMS) along the Purgatoire River in Las Animas County, about 64 km northeast of Trinidad, Colorado (Fig. 1). The site has broad sloping uplands bordered by pinyon-juniper breaks to the north and northwest, and rocky canyons and breaks to the south and east. Elevation varies from 1,3ll m to 1,737 m. Annual precipitation is approximately 30 cm. The area had a history of dry-land cattle grazing. Cattle were present during the first year of the study.

The vegetation is primarily shortgrass prairie and pinyon-juniper woodland. The shortgrass prairie is dominated by blue grama (*Bouteloua gracilis*), in association with galleta (*Hilaria jamesii*), ring muhly (*Muhlenbergia torreyi*), western wheatgrass (*Agropyron smithii*), broom snakeweed (*Xanhocephalum sarothrae*) and sand dropseed (*Sporobolus cryptandrus*). The pinyon-juniper woodland is a tree, shrub, grass and forb mixture. Blue grama, sand dropseed, galleta, needle-and-thread (*Stipa comata*) and broom snakeweed dominate the understory beneath pinyon pine (*Pinus edulis*), one-seed juniper (*Juniperus monosperma*), mountain mahogany (*Cercocarpus montanus*), fourwing saltbush (*Atriplex canescens*) and skunkbush sumac (*Rhus trilobata*).

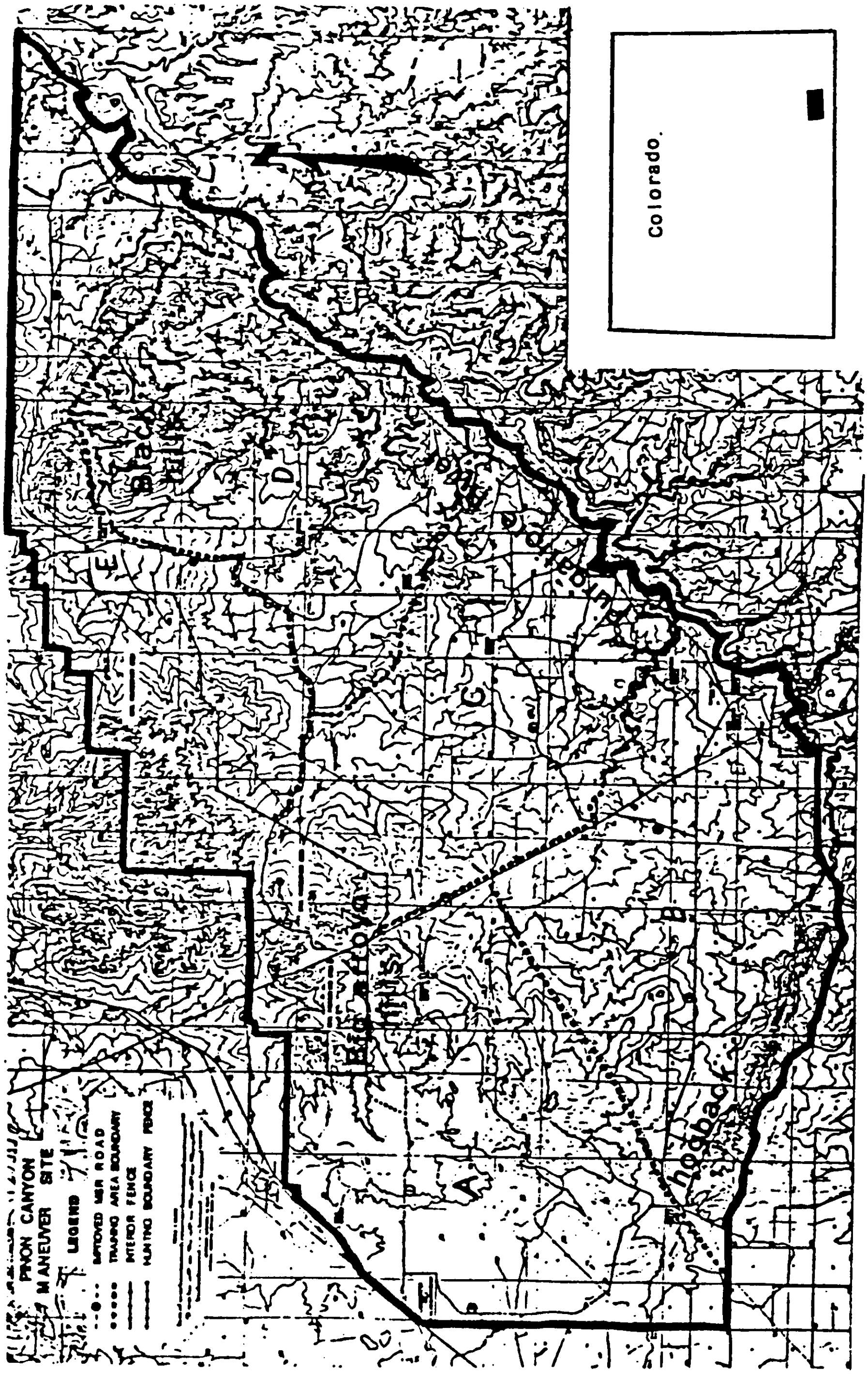

Fig. 1. The Pinon Canyon Maneuver Site, Colorado, 1983-1984.

CHAPTER ONE

POPULATION ECOLOGY OF MULE DEER ON THE PINON CANYON MANEUVER SITE, COLORADO

Abstract

Mule deer (*Odocoileus hemionus*) population dynamics were studied on the Pinon Canyon Maneuver Site in southeastern Colorado during January 1983- December 1984. Population estimates were 365 and 370 deer for 1983 and 1984, respectively. The sex ratio (yearling and adult) was 60 males :100 females. Late summer fawn: doe ratios in 1983 and 1984 were 30:100 and 29:100,

respectively. Adult female pregnancy rate was 95%; the mean litter size for females over 1.5 years was 1.7 fawns. The sex ratio of captured fawns was not different from 1:1. Annual fawn survival was 29% in 1983 and 22% in 1984. Coyote (*Canis latrans*) predation was responsible for 76% of fawn mortality. Adult survival was 88% in 1983 and 87% in 1984; coyote predation accounted for 67%, and hunting for 33% of the annual adult mortality. The annual rate of increase (λ) was 1.01, indicating a stable population. High adult survival and adequate reproduction were important in offsetting low fawn survival.

Introduction

The proposed acquistion of land in southeastern Colorado, by the Department of the Army for use as a remote military training area, resulted in the preparation of a Draft Environmental Impact Statement which required that studies be conducted to develop a comprehensive wildlife management program. Mule deer were among the six species to be studied. Existing information consisted largely of mule deer census flights (Colorado Division of Wildlife, unpublished files, 1977), and the environmental impact assessment. Specific population information on mule deer in this area was limited.

The objective was to provide information on mule deer population dynamics, including density estimates, adult and fawn survival and reproduction before military maneuvers. The rationale was that knowledge of baseline conditions was needed both to assess and mitigate possible impacts from Army maneuvers.

Methods

Adult Capture

Adult mule deer were captured by clover traps, drop-net, or Coda net-gun (Coda Enterprizes, Mesa, Arizona). Apple pulp, alfalfa, and salt blocks were used as bait for clover traps and drop-nets. Areas were prebaited 1-2 weeks before traps were set. The net-gun was shot from a UH-1 or an OH-58 military helicopter (Chapter 4). Deer selected for capture were hazed out of cover to bare slopes or water.

Captured deer received a numbered ear tag and either a radio collar or numbered color-coded collar. Collars placed on bucks were large enough to allow for neck swelling during the rut. Deer were assigned to age classes based on tooth wear and replacement (Robinette et al. 1957).

Fawn Capture

Fawns were located June-August by ground surveillance of radio-collared and unmarked does and then captured by hand or with throw nets. In 1983, captured fawns were equipped with solar (24g) or battery (32g) powered ear tag transmitters (Gerlach et al. 1985). Due to problems with ear tag transmitter weight and short signal range, expandable break-away radio collars (120g) (Trainer et al. 1981) were used in 1984. Sex and weight were noted for each fawn. Ages and birth dates were calculated following Robinette et al. (1973).

Fawns were located daily after capture up to 2 months and on a weekly basis thereafter. Adult mule deer were located at least once a week. Ground locations were supplemented by aerial locations from a helicopter or fixed-wing aircraft.

Census Flights

PCMS was stratified into low and high deer density areas based on a preliminary quadrat survey flown in March 1983 and density estimates from the Colorado Division of Wildlife (C. Wagner, unpubl. data 1982). In June, August, and December 1983, and May, August , and November 1984, thirty-five 2.6 km^2 quadrats were censused for deer following a stratified random sampling technique (Gill 1969). A UH-1 military helicopter with 2 pilots, 1 navigator, and 2 observers was used for all surveys. Surveys were flown at an altitude of 15-25 m above ground level and an airspeed of 20-40 knots. Population estimates from helicopter surveys were calculated from the total number of mule deer counted on random quadrats and the ratio of marked deer observed to total marked deer present using the Lincoln-Petersen estimate. The density estimate from the quadrat survey was extrapolated to all deer habitat on the study area.

Fecundity

Pregnancy rates were calculated two ways. The first was based on the pregnancy rate of radio-collared does, and the second rate was based on percent pregnant does to total does observed during a two week period during the middle of June each year (Caughley 1977:78). Does were considered pregnant if they had a distended udder. Average number of fawns produced was calculated from observed fawn production of radio and color-collared does and from reproductive tracts from road-killed does.

Survival

Adult and fawn survival was estimated from survival of radio-equipped deer using the computer program "MICROMORT" (Heisey and Fuller 1985). MICROMORT calculates survival rates from the number of transmitter-days, the number of mortalities, and the number of days in the time interval. Two separate estimates were made: the first included only those deer whose fates were known, and the second included those whose fate was known and individuals with which radio contact was lost. In the second instance we took the average of 2 rates: the first assumed that all the missing individuals were dead, and the second assumed that all were alive (Trent and Rongstad 1974). Survival rates were calculated bimonthly for adults and monthly for the first 4 months (summer) of life for fawns. Annual fawn survival rates were determined by multiplying summer survival rates from radio-marked fawns with survival rates for the remaining 8 months based on changes in estimated fawn: doe ratios (Paulik and Robson 1969). Age classifications were obtained in October and March of each year from composition data.

Results

Population Estimates

During January 1983-November 1984, 6 aerial surveys were flown to estimate population levels of mule deer on PCMS (Table 1). Estimates were based on data from stratified random quadrat surveys and Lincoln-Petersen estimates from marked deer observed during quadrat surveys. The quadrat survey and Lincoln-Petersen estimates did not differ over seasons ($P > 0.05$).

Table 1. Population estimates and 95% confidence intervals using 2 estimation techniques for mule deer on the Pinon Canyon Maneuver Site, Colorado, 1983-1984.

Date	Quadrat survey	Lincoln-Petersen *	Buck: Doe: Fawn
June 1983	422(277-567)	312(102-1086)	40:100
August 1983	350(259-441)	322(90-1528)	63:100:30
December 1983	324(237-411)	425(88-1476)	60:100:27
May 1984	337(250-424)	456(185-1195)	36:100
August 1984	320(205-435)	502(176-2962)	123:100:29
November 1984	452(409-495)	469(198-1280)	50:100:39

(*) Poisson correction factor applied to Confidence Interval.

However, we eliminated Lincoln-Petersen estimates from our population calculations because of the large variances caused by low reobservation rates. We also eliminated 2 quadrat surveys from analyses because of poor weather conditions and inconsistency in pilots and observers. We thus obtained our estimate of population levels from quadrat surveys. These estimates were 365 for 1983 and 370 for 1984. Population estimates did not differ ($P > 0.05$) within or between years.

Herd Structure

The age structure did not differ ($P > 0.05$) between years (Fig. 2); therefore, capture data were combined to yield a 2-year estimate of 61% adults, 12% yearlings and 27% fawns. Composition counts from aerial surveys yielded late-summer fawn: doe ratios of 30:100 in 1983 and 29:100 in 1984 and buck: doe ratios ranging from 36:100 to 123:100. Fawn: doe ratios did not differ ($P > 0.05$) between the August and November and December quadrat surveys. Buck: doe ratios were higher ($P < 0.05$) in August than in June or December. Structure determined from composition counts during March of each year yielded fawn: doe and buck: doe ratios of 35:100 and 58:100 for 1983 and 39:100 and 67:100 for 1984.

Reproduction

Based on the estimated birth dates of captured fawns, fawning occurred from early June to early August and peaked during the last week of June and the first week in July. Sex ratios of captured fawns in 1983 (4 males, 3 females) and 1984 (10 males, 11 females) did not differ ($P > 0.05$) from 1:1.

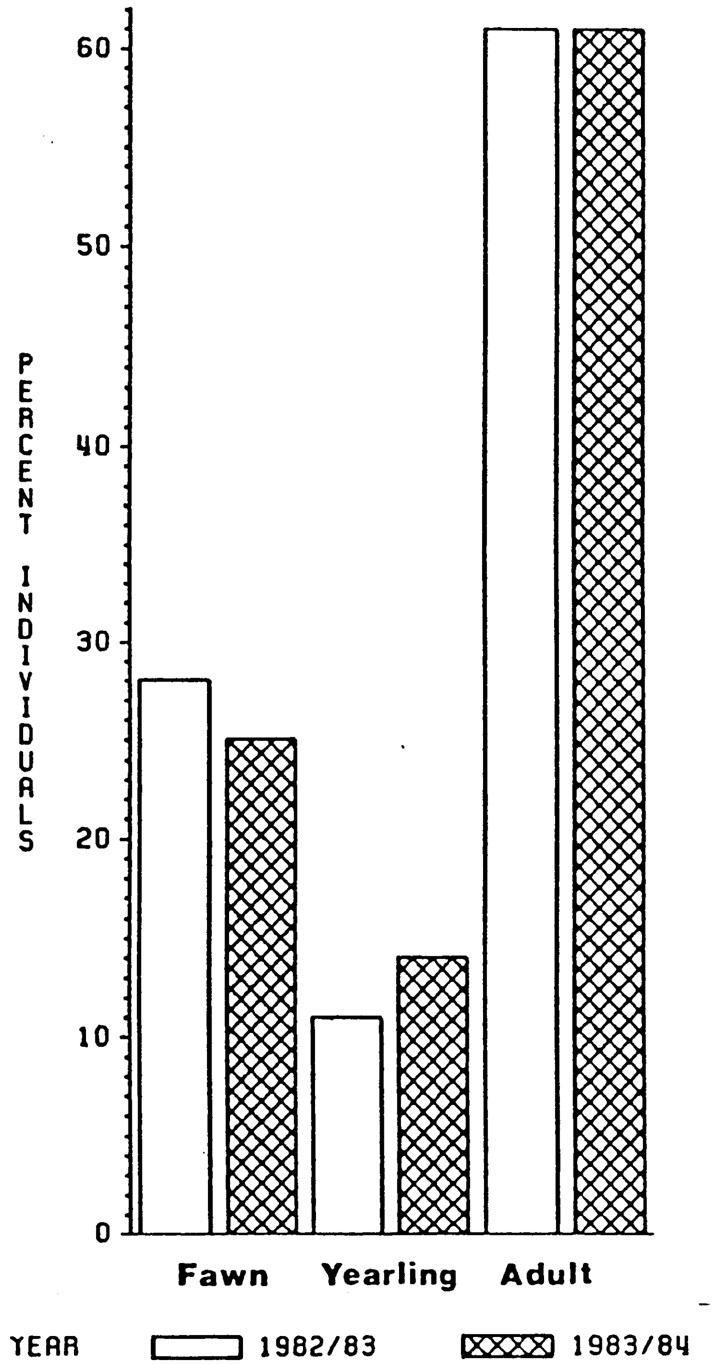

Fig. 2. Age structure of captured mule deer on the Pinon Canyon Maneuver Site, Colorado, 1983-1984.

Based on our sample of marked does, pregnancy rates were 90% (n = 10) and 20% (n = 5) for adults and yearlings, respectively in 1983, and 96% (n = 27) and 17% (n = 6) for adults and yearlings, respectively in 1984. Pregnancy rate, calculated from observed does in 1983 (total classified = 38) and 1984 (total classified = 45) during the first 2 weeks of June did not differ ($P > 0.05$) between years, thus a two year mean of 94% was calculated for adult females. Fawn production, based on our sample of marked does was 1.6 fawns / doe (n = 10) and 0.2 fawns / yearling doe (n = 5) in 1983 and 1.7 fawns / doe (n = 27) and 0.17 fawns / yearling doe (n = 6) in 1984. Three road killed adult does collected in late gestation all carried 2 fetuses.

Survival

Fawns

Fawn survival was lowest during the first month after birth and remained at relatively low levels throughout the summer (Table 2). Summer survival rates were 0.31 for 1983 (n = 7) and 0.22 for 1984 (n = 18). Annual fawn survival rates, calculated by changes in estimated fawn: doe ratios and by relocation of radio-marked fawns were 0.29 in 1983 and 0.22 in 1984. Survival rates of 15 male and 13 female fawns did not differ ($P > 0.05$). Coyote predation was responsible for 13 of 17 (76%) known fawn mortalities whereas starvation was responsible for the remaining 4 (24%). Three of the 4 mortalities due to starvation were probably due to fawn abandonment. These 3 mortalities were excluded from fawn survival calculations because investigator interference was believed to be the cause of the abandonment.

Table 2. Monthly survival rates of radio-marked mule deer fawns from June-September 1983-84, on the Pinon Canyon Maneuver Site, Colorado.

	Month	Radio days	Mortality	Monthly Survival
1983	June	9	0	1.0
	July	136	2	.59
	August	135	0(2)*	.79
	September	79	1	.63
			1983 Rate	.31
1984	June	69	0	1.0
	July	314	5	.59
	August	271	4	.61
	September	213	3	.63
			1984 Rate	.22

(*) Numbers in parentheses are lost signals. The estimate given is a mean from calculations assuming first that lost signals represent dead animals, then assuming they represent living animals.

Adult

Bimonthly survival rates for adult females were lowest during May-June in 1983 and during May-June and July-August in 1984, whereas adult male survival rates were lowest during November-December 1983 and during January-February and March-April 1984 (Table 3). Annual survival rates of males and females were 0.83 and 0.94, respectively in 1983 and 0.87 and 0.88 in 1984. Male and female survival rates did not differ ($P > 0.05$) within or between years. Coyote predation was responsible for 2 doe mortalities that occurred during the fawning season, whereas the only buck mortality occurred during the 1983 hunting season.

Rate of Increase

The rate of increase and stable age distribution for the PCMS deer population was calculated from estimates of age-specific survival and fecundity in our radio-marked sample, using the iterative technique described by Caughley (1977:110). Annual survival rates for fawns and adults were 0.29 and 0.88 in 1983 and 0.22 and 0.88 in 1984. Adult pregnancy rate was 95% with a birth rate of 0.8 female fawns per breeding female. The resulting finite rates of increase (λ) were 1.035 and 0.999 for 1983 and 1984, respectively.

Calculating a mean annual survival rate based on combined data yielded a finite rate of increase of 1.01, assuming a stable age distribution of 35% fawns, 9% yearlings and 56% adults. The observed age structure from our capture data was not different from the calculated stable age distribution.

Table 3. Bimonthly survival rates of radio-marked adult mule deer on the Pinon Canyon Maneuver Site, Colorado, January 1983-December 1984.

	Bimonthly period	Radio days Male/Female	Mortality Males	Survival Males	Mortality Females	Survival Females
1983	Jan.,Feb.	31/40	0	1.0	0	1.0
	Mar.,Apr.	196/255	0	1.0	0	1.0
	May,June	366/488	0	1.0	0(1)*	0.94
	July,Aug.	372/434	0	1.0	0	1.0
	Sept.,Oct.	366/427	0	1.0	0	1.0
	Nov.,Dec.	344/427	1	0.82	0	1.0
			Annual Rate	**0.83**		**0.94**
1984	Jan.,Feb.	409/822	0(1)*	0.92	0	1.0
	Mar.,Apr.	427/1769	0(1)*	0.93	0	1.0
	May, June	366/1704	0	1.0	2(1)*	0.92
	July, Aug.	372/1575	0	1.0	1	0.96
	Sept.,Oct.	366/1525	0	1.0	0	1.0
	Nov.,Dec.	366/1525	0	1.0	0	1.0
			Annual Rate	**0.87**		**0.88**

(*) Signals were lost on 4 transmitters, a mean survival estimate is presented for that time interval from calculations considering them all dead and then all still alive.

Discussion

Population Estimate

Population estimates varied among seasons, years and estimators but not significantly ($P > 0.05$), probably due to the large variances associated with each estimate. Variances on the Lincoln-Petersen estimates were extremely large due to low reobservation rates. Quadrat survey variances also were large due to the large number of empty quadrats, which may reflect the patchy distribution of deer in this habitat, the size of our quadrat, habituation to helicopters by deer, or differences in pilot and observer efficiency among surveys. Low and variable resightability of mule deer in pinyon-juniper vegetation on PCMS precluded making accurate population estimates from mark-recapture data; thus were excluded from population calculations.

Sex ratios from quadrat surveys varied among surveys with low ratios in late spring and high ratios in fall and winter. The low ratios in spring tend to under represent males, which could be related to misclassification of bucks because of antler casting and the fact that doe family groups had not broken up and were more observable than small groups or solitary bucks. The over representation of bucks in August 1984 could be explained by greater observability of bachelor groups over solitary does with fawns. However, this is not consistent with results from the August 1983 survey.

A sightability index was not calculated for each survey as recommended by Floyd et al. (1979); however I estimated our sightability to be approximately 25%, based on observation of marked deer from quadrat surveys. Biggins and Jackson (1983) reported an overall sightability rate for mule deer in shrub/ pinyon-juniper vegetation of 32%. Floyd et al. (1979) observed white-tailed deer at a 53% rate, while Rice and Harder (1977) and Gilbert and Grieb (1957) reported observation rates of 34-58% for white-tailed and mule deer, respectively.

Survival

Fawn mortality was highest during the first month after birth, which is similar to reports by Cook et al. (1971) for white-tailed deer in Texas, Salwasser et al. (1978) for black-tailed deer in California and Trainer et al. (1981) for mule deer in Oregon. We also found mule deer fawns to be vulnerable to coyote predation throughout the summer, as did Hamlin et al. (1984) in Montana. Coyotes were the major cause of fawn mortalities in both years on PCMS. Studies in Texas, Washington, Oregon and Montana also determined that coyote predation was the major proximal cause of summer fawn mortality for mule deer and white-tailed deer (Cook et al. 1971, Steigers and Flinders 1980, Trainer et al. 1981, Hamlin et al. 1984).

Adult survival was high in both years of the study on PCMS. Death of two lactating does was attributed to coyote predation. Energy expenditure is great during lactation and this is often the most critical period for does in semi-arid areas (Mackie et al. 1982). The protective nature of the does during the fawning season and the added stress of lactation may have made them more vulnerable to predation.

Rate of Increase

The rate of increase calculated from 1983-1984 quadrat surveys ($\lambda = 1.01$) and from age specific survival and fecundity data ($\lambda = 1.01$) suggested a stationary population. Also, the calculated stable age distribution was not different from the observed age distribution from capture data.

Our data on reproduction and survival supports the theory postulated by Short (1979) for mule deer populations in the southwest. In simulations of southwestern mule deer herds, Short (1979) found that stable populations occurred when adult survival was high (90%) and the survival rate of fawns and yearlings varied from low to high in several combinations. High adult doe survival on PCMS seems to be the most important variable offsetting the low recruitment rate. Any environmental pressure that significantly increases adult doe mortality rate may cause a decrease in deer numbers. The most promising way of increasing the rate of increase and hence harvestable surplus would be to reduce the early fawn mortality rate through coyote control.

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CHAPTER TWO

MOVEMENTS AND HABITAT USE OF MULE DEER IN SOUTHEASTERN COLORADO

Abstract

Movements and habitat use of mule deer were studied on the 1040 km^2 Pinon Canyon Maneuver Site, in southeastern Colorado during 1983-1984. Thirty-eight adults and 28 fawns were radio collared, and 35 adults were color-collared or ear-tagged. Intensity of use of home ranges was not uniform and physical features within the home range, such as canyons and pinyon-juniper breaks, influenced deer movements. Seasonal home range size differed ($p < 0.05$) between males and females only in the fall. There was no difference between sexes in distance moved between seasonal core areas. Males made long distance (14-21 km) temporary movements during the rut. All other movements for both males and females were confined to seasonal home ranges. Habitat

use was similar for both males and females from season to season. Females preferred pinyon-juniper woodland in all seasons, and shrub grassland in winter, summer and fall; proportional use of woodland/ open grassland and shrub/ open grassland edge was greater than proportional availability. Males preferred pinyon-juniper woodland and avoided open grassland in all seasons. Males preferred woodland/ open grassland edge in all seasons except winter when they preferred woodland/ shrub edge. Fawns preferred shrub grassland and shrub/ open grassland edge; they avoided cholla/ open grassland edge.

Introduction

The proposed acquistion of land in southeastern Colorado, by the Department of the Army for use as a remote military training area, resulted in the preparation of a Draft Environmental Impact Statement which required that studies be conducted to develop a comprehensive wildlife management program. Mule deer were among the six species to be studied. Existing information consisted largely of mule deer census flights (Colorado Division of Wildlife, unpublished files, 1977), and the environmental impact assessment. Specific information on movements and habitat use of mule deer in this area was limited.

The objective of this study was to provide information on mule deer movements and habitat use before military maneuvers. The rationale was that knowledge of baseline conditions was needed both to assess and mitigate possible impacts from Army maneuvers.

Vegetation Types

High altitude infrared photographs were used to map vegetation types on PCMS. The map was digitized and transformed into cellular format for computer analysis by the Western Energy Land Use Team. Cell sizes were 50.8 x 50.8 m. Proportional availability of a vegetation type was defined as the number of cells of that type as a proportion of the total number of cells for the study area. Eight vegetation types were delineated on PCMS based on vegetative communities and substrate.

Pinyon juniper woodland vegetation types comprised 20% of the study area whereas open grassland, cholla grassland and shrub grassland comprised approximately 55% of the study area; Open grassland comprised 45% of all grassland. Twenty-four percent of the study area was classified as edge.

Pinyon-juniper woodland-Sandstone.--A vegetation type characterized by evergreen woodlands exceeding 15% tree cover in and along canyons. Pinyon pine (*Pinus edulis*), and one-seed juniper (*Juniperus monosperma*) are the dominant species. Shrub species include mountain mahoghany (*Cercocarpus montanus*), skunkbush (*Rhus trilobata*), and walkingstick cholla (*Cholla imbricata*). Substrate is exposed sandstone.

Pinyon-juniper woodland-Limestone--A vegetation type characterized by evergreen woodlands exceeding 15% tree cover in upland areas. Pinyon pine and one-seed juniper dominate the overstory. Greasebush (*Forsellesia spinescens*), bigelow sage (*Artemesia bigelowii*), cholla, Colorado four-o-clocks (*Mirabilis multiflora*), and various grasses form the understory.

Open grassland.--A vegetation type characterized by blue grama (*Bouteloua gracilis*), in association with galleta (*Hilaria jamesii*) and western wheatgrass (*Agropyron smithii*). Broom snakeweed (*Guterrezia sarothrae*), needle-and-thread grass (*Stipa neomexicana*), Indian rice grass (*Oryzopsis hymenoides*), ring muhly (*Muhlenbergia torreyi*), winterfat (*Eurotia lanata*), and sunflower (*Helianthus annuus*) are common.

Cholla grassland.--A vegetation type characterized by walkingstick cholla exceeding 15% cover in grassland areas. Dominant grass species include blue grama, galleta and western wheatgrass.

Shrub grassland.-- A vegetation type characterized by shrub cover exceeding 15% and usually found in and along drainages and arroyos. Dominant shrub species include fourwing saltbush (*Atriplex canescens*), wolfberry (*Lycium palidum*), greasewood (*Sarcobatus vermiculatis*), and small soapweed (*Yucca glauca*).

Canyon shrub.--A vegetation type characterized by shrubby vegetation within canyons; dominant species include skunkbush, rabbitbrush (*Chrysothamnus nauseosus*), mountain mahagony, and gooseberries (*Ribes sp.*), with numerous sandstone outcroppings.

Edge.--Edge types occurred when 2 vegetation types fell within the same mapping cell. The five edge categories were: woodland/shrubs, shrubs/shrubs, woodland/open grassland, cholla/open grassland, and shrubs/open grassland. "Shrubs" included shrub grassland, and canyon shrub vegetation types. "Woodlands" included both pinyon-juniper woodland vegetation types.

METHODS

Adult Capture

Three techniques were used to capture adult mule deer: (1) clover traps, (2) drop-net, and (3) Coda net-gun (Coda Enterprizes, Mesa, Arizona). Apple pulp, alfalfa, and salt blocks were used as bait for clover traps and drop-nets. Areas were prebaited 1-2 weeks before traps were set. The net-gun was fired from a UH-1 or an OH-58 military helicopter (Chapter 4). Deer selected for capture were hazed out of cover to bare slopes or water.

Captured adult deer received a numbered ear tag and either a radio collar or numbered color-coded collar. Collars placed on bucks were large enough to allow for neck swelling during the rut. Deer were assigned to age classes based on tooth wear and replacement (Robinette et al. 1957).

Fawn Capture

Mule deer fawns were marked during June-August 1983 and 1984. Fawns were located by ground surveillance of radio-collared and unmarked does and then captured by hand or with throw nets. In 1983, captured fawns were equipped with solar (24g) or battery (32g) powered ear tag transmitters (Gerlach et al. 1985). Due to problems with ear tag transmitter weight and short signal range, expandable break-away radio collars (120g) (Trainer et al. 1981) were used in 1984. Sex and weight were noted for each fawn. Ages and birth dates were calculated following Robinette et al. (1973).

Radio marked deer were visually located using a receiver and hand-held "H" antenna. An attempt was made to relocate yearling and adult deer at least once a week and fawns every 2-3 days. Ground locations were supplemented by locations from a helicopter or fixed-wing aircraft with the same tracking equipment. All locations were plotted on USGS 1:24,000 topographic maps and later converted to UTM grid coordinates to facilitate computer analysis.

Statistical Analysis

Seasonal home ranges and activity centers were calculated using the minimum convex polygon method, 95% ellipse and the harmonic mean tranformation method (Dixon and Chapman

1980). Annual home ranges also were calculated for comparison with other studies. A minimum of 15 locations per season was used for each home range calculation based on the distribution of our location data (Smith et al. 1981). Activity centers were calculated for each sex and season combination; movement between seasonal activity centers for males and females also was calculated. Only radio-marked animals were used in the analysis of movements and home range, but all marked animals were included in the habitat use analysis.

Seasons were defined by mule deer behavior. Winter (1 January to 15 March) began post-rut and continued through antler shedding and formation and break-up of winter groups. Spring (16 March until 31 May) was the prefawning period following break up of family groups. Summer (1 June through 15 September) was the fawn rearing period, and fall (16 September until 31 December) encompassed the rut. Chi-square analysis was used to compare the distribution of male, female, and fawn mule deer among vegetation types for each of the seasons.

A Bonferroni Z statistic was used to estimate proportional use of vegetation types within each season-sex combination (Neu et al. 1974). Pianka's similarity index (SI) (Pianka 1974) was used to compare similarity of habitat use between sexes within each season, within sex between seasons, and for fawns June - August.

Results and Discussion

Seasonal Home Range

The size of home ranges varied with season, sex, and method of calculation (Table 4). Home range estimates obtained by the minimum convex polygon (MCP), and 95% harmonic mean transformation (HMT) were on average 70% smaller than the 95% ellipse method in all cases.

Table 4. Mean (SE) home range size of radio-collared adult mule deer on the Pinon Canyon Maneuver Site, Colorado, January 1983-December 1984.

	N	Convex Polygon (km^2)	NMC*	95% Ellipse (km^2)	NMC*	50% HMT (km^2)	NMC*	95% HMT (km^2)	NMC*
FEMALES									
Winter	5	3.72 (1.28)		12.99 (3.64)		0.95 (0.09)		6.48 (0.06)	
Spring	13	4.88 (1.04)		18.72 (3.54)		1.53 (0.31)		7.39 (1.55)	
Summer	32	7.19 (1.32)		21.25 (4.43)		2.03 (0.27)		12.64 (2.48)	
Fall	16	4.22 (0.33)		15.05 (1.40)		1.44 (0.14)		6.46 (0.67)	
MALES									
Winter	8	8.87 (1.92)		33.67 (10.29)		1.50 (0.60)		15.24 (4.72)	
Spring	4	5.43 (3.19)		25.01 (10.29)		1.93 (1.47)		12.74 (7.87)	
Summer	7	9.18 (2.78)		34.19 (7.62)		2.61 (1.06)		14.78 (2.74)	
Fall	5	17.36 (8.79)		64.78 (34.84)		2.22 (0.80)		74.09 (42.88)	
FAWNS									
Summer	14	4.25 (0.40)		9.02 (0.85)		1.38 (0.12)		5.75 (0.47)	

(*) NMC = Nonparametric multiple comparison. Vertical lines connect means that are not different ($P > 0.05$).

Seasonal home ranges of males and females differed ($P < 0.05$) only during the fall period; winter home ranges of females were smaller ($P < 0.05$) than summer home ranges by the MCP method. Winter home ranges of males were smaller ($P < 0.05$) then fall home ranges with the 95% ellipse and 95% HMT methods. Spring home ranges for females were larger ($P < 0.05$) than fall home ranges but similar ($P > 0.05$) to summer and winter home ranges with the MCP method. Fifty percent HMT "core areas" (Dixon and Chapman 1980) did not differ ($P > 0.05$) between sexes or seasons (Table 4).

In addition to seasonal home ranges, annual ranges were calculated for comparison with other studies. Annual home ranges (12.2 km^2) were similar to those reported (10.6 km^2) for mule deer on semidesert range (Rogers et al. 1978), but larger than those reported (7 km^2) for timbered, prairie breaks habitat (Hamlin 1978). Severson and Carter (1978) reported that movements and home ranges of mule deer in open prairie habitats were larger than those in timbered badlands, which were larger than those in mountain foothills. The variation in home range sizes probably reflects differences in individuals and in the habitats they exploit.

Mean summer home range of fawns was approximately 60% of mean summer home range of does using MCP and 95% HMT methods. Summer home ranges of mule deer fawns on PCMS (425 ha) were larger than the summer home ranges of fawns in northern Colorado (130 ha-Geduldig 1981), Washington (257 ha- Steigers and Flinders 1980) and Montana (185 ha-Riley and Dood 1984).

Seasonal Movements

The PCMS mule deer herd was nonmigratory and movements were restricted to those associated with the rut in males and short movements by both sexes between seasonal core areas. Mackie et al. (1982) found that most deer populations in prairie habitats and timbered badlands were not migratory. During all seasons except fall, both sexes on PCMS had similar home range sizes and did not exhibit any extensive movements. Adult males and females exhibited similar movement distances between core areas. Movement during any season never exceeded 2 km. Fidelity to seasonal core areas was high for both sexes and possibly could explain apparent unused habitat on PCMS. The mean distance between summer activity centers for 1983 and 1984 was 1.5 and 2.0 km for males and females, respectively.

Dasmann and Taber (1956) stated that a nonmigratory population of *O.h.columbianus* exhibited three types of movement outside the home range; breeding season travels, wanderings, and dispersal. In this study, the only extensive movements were for males during the rut and then for only a short duration. Five adult male mule deer exhibited temporary long distance movements during the rut. Average one way distance was 16 km. Two of the males made the same trip in both years of the study. The average length of the rut-associated movements was estimated to be 25 days.

Habitat Use

Pinyon-juniper woodland is an important vegetation type year round for adult mule deer on PCMS. Proportional use of woodland habitats by adult females was greater than proportional availability year round (Table 5), whereas proportional use of Pinyon juniper woodland-sandstone type by adult males was greater than proportional availability year round, and Pinyon juniper woodland- limestone type in proportion to availability (Table 6). The difference in woodland vegetation types for males might be an actual preference for that type or a reflection of our small sample size for males and poor distribution of marked animals. Mackie (1970) found that pinyon-juniper woodland received the greatest use by mule deer in the summer and concluded that it was the most important habitat for that season. Severson and Carter (1978) found juniper woodland to be important for mule deer in South Dakota during the summer.

Table 5. Frequency of female mule deer locations in 6 vegetation and 5 edge types during all seasons on the Pinon Canyon Maneuver Site, Colorado, 1983-1984.

Vegetation Type	Proportional Availability	Proportional Use			
		Winter	Spring	Summer	Fall
Pinyon Juniper Sandstone	.154	.342*	.256*	.200*	.309*
Pinyon Juniper Limestone	.045	.126*	.155*	.177*	.251*
Open Grassland	.448	.247*	.289*	.250*	.146*
Cholla Grassland	.086	.000	.000	.000	.004*
Shrub Grassland	.020	.105*	.037	.073*	.076*
Canyon Shrubland	.006	.000	.000	.000	.000
EDGE	.240	.179	.263	.297*	.215
N		190	297	673	275
X^2 [a]		201.8*	151.1*	532.4*	442.3*
Woodland/shrubs	.058	.000	.136	.099	.040
Woodland/open grassland	.451	.655	.546	.580*	.720*
Shrubs/shrubs [b]	.008	.000	.000	.012	.000
Cholla/open grassland	.377	.000	.000	.000	.000
Shrubs/open grassland	.105	.345*	.318*	.309*	.240
N		29	66	162	50
X^2 [a]		31.4*	62.1*	136.3*	36.2*

(*) indicates values significantly ($P < 0.05$) greater or less than expected, indicating avoidance or preference of a particular habitat.

(a) X^2 tested the hypothesis that proportional use = availability.

(b) "Shrubs" include shrub grassland, and canyon shrub habitats.

Table 6. Frequency of male mule deer locations in 6 vegetation and 5 edge types during all seasons on the Pinon Canyon Maneuver Site, Colorado, 1983-1984.

Vegetation Type	Proportional Availability	Proportional Use			
		Winter	Spring	Summer	Fall
Pinyon Juniper Sandstone	.154	.527*	.500*	.663*	.737*
Pinyon Juniper Limestone	.045	.164	.138	.069	.026
Open Grassland	.448	.055*	.017*	.047*	.000
Cholla Grassland	.086	.000	.000	.000	.000
Shrub Grassland	.020	.000	.000	.000	.000
Canyon Shrub	.006	.018	.000	.023	.000
EDGE	.240	.236	.345	.198	.237
N		55	58	86	76
X^2 [a]		87.3*	83.3*	181.4*	202.9*
Woodland/shrubs	.058	.308*	.200*	.118	.222
Woodland/open grassland	.451	.462	.700*	.706*	.778*
Shrubs/shrubs [b]	.008	.000	.000	.000	.000
Cholla/open grassland	.377	.000	.000	.000	.000
Shrubs/open grassland	.105	.231	.100	.177	.000
N		32	41	31	29
X^2 [a]		39.3*	22.8*	7.92*	16.9*

(*) Indicates values significantly ($P < 0.05$) greater or less than expected, indicating avoidance or preference of a particular habitat.

(a) X^2 tested the hypothesis that proportional use = availability.

(b) Shrubs include shrub grassland, and shrub canyon habitats.

Woodland/ open grassland and woodland/ shrub edge types also were important to adults of both sexes. Females used woodland/ shrub edge in proportion to availability year round, while proportional use of woodland/ open grassland edge was greater than proportional availability in summer and fall seasons (Table 5). Proportional use of woodland/ shrub edge by males was greater than proportional availability in winter, whereas proportional use of woodland/ open grassland edge was greater than proportional availability in the spring, summer and fall (Table 6). Both Mackie (1970) and Severson and Carter (1978) found grassland sites within juniper woodland to be important to mule deer because of good forage production close to cover.

Shrub vegetation types and shrub/ open grassland edges were more important types for females and fawns than males on PCMS. Proportional use of shrub grassland types by females was greater than proportional availability in all seasons except spring, while proportional use of shrub/ open grassland edge was greater than proportional availability in all seasons except fall (Table 5). Shrub grassland type was the most important vegetation type for fawns and proportional use was greater than proportional availability all summer long (Table 7). Fawns also preferred shrub/ open grassland edge during all summer months except June. Males used shrub canyon type in proportion to availability in summer and winter and shrub/ open grassland edge in proportion to availability year round. Shrub grasslands are generally found along drainages or stock ponds and provide water, cover and forage. The use of shrub grassland vegetation type by fawns and does during the summer may reflect selection for concealment cover by fawns and possibly the greater need for water for does. Heugel et al. (1986) found that fawns responded to a cover stimulus and selected bed sites on a structural basis irrespective of individual plant species. Concealment cover at the 0-0.5 m layer was the most important variable measured at fawn bed sites on PCMS (Chapter 3).

Open habitat types were not used or proportional use was less than proportional availability year round. Females did not use cholla grassland, except for the fall season when proportional use was less than proportional availability. Proportional use of open grassland was less than proportional availability year round by both sexes. Open habitat types were not used or proportional use was less than proportional availability by fawns all summer long (Table 7).

Table 7. Frequency of fawn mule deer locations in 6 vegetation and 5 edge types during all seasons on the Pinon Canyon Maneuver Site, Colorado, 1983-1984.

Vegetation Type	Proportional Availability	Proportional Use			
		June	July	August	September
Pinyon Juniper Sandstone	.154	.197	.093*	.105	.045*
Pinyon Juniper Limestone	.045	.013	.064	.046	.077
Open Grassland	.448	.329	.377	.382	.453
Cholla Grassland	.086	.000	.000	.000	.005*
Shrub Grassland	.020	.171*	.171*	.214*	.149*
Canyon Shrub	.006	.000	.000	.000	.000
EDGE	.240	.289	.295	.255	.272
N		76	281	220	221
X^2 [a]		126.5*	461.9*	563.8*	284.3*
Woodland/shrubs	.058	.118	.017	.075	.000
Woodland/open grassland	.451	.647	.400	.375	.314
Shrubs/shrubs [b]	.008	.000	.000	.000	.000
Cholla/open grassland	.377	.000	.067*	.025*	.057*
Shrubs/open grassland	.105	.235	.517*	.525*	.629*
N		17	60	40	35
X^2 [a]		11.6	114.4*	81.1*	104.5*

(*) indicates values significantly ($P < 0.05$) greater or less than expected, indicating avoidance or preference of a particular habitat.

(a) X^2 tested the hypothesis that proportional use = availability.

(b) "Shrubs" include shrub grassland, and shrub canyon habitats.

Adult and fawn mule deer of both sexes use similar habitats from season to season. The mean similarity index (Pianka 1974) for habitat use by female mule deer from season to season was 0.95 (SE = 0.014) for pure habitats and 0.99 (SE = 0.004) for edge habitats. The mean similarity index for habitat use among seasons for male mule deer was 0.97 (SE = 0.011) for pure habitats and 0.94 (SE = 0.024) for edge habitats. The mean similarity index of habitat use between sexes within each season was 0.77 (SE = 0.047) for pure habitats and 0.92 (SE = 0.02) for edge habitats. The lower similarity index between sexes was due to a high dissimilarity in summer. Males were primarily in woodland types while females had moved to shrub grassland types for the fawning season. Bowyer (1984) reported sexual segregation and niche differentiation in southern mule deer during the summer and attributed this to the greater water needs of lactating does. The mean similarity index for mule deer fawns was 0.97 (SE = 0.01) between the 4 summer months.

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CHAPTER THREE

MULE DEER FAWN BED SITE SELECTION IN SOUTHEASTERN COLORADO

Abstract

Vegetative and topographic characteristics of one-hundred-fifty bed sites of 28 mule deer fawns and 600 random sites were surveyed on the Pinon Canyon Maneuver Site, during summers of 1983 and 1984. Fawns commonly bedded on midslope benches and in shrubby drainages and small depressions. Bed sites selected by fawns were typified by 70% concealment cover at the 0-1 m interval and 30% concealment cover at the 1-2 m interval. Older fawns selected bed sites with lower ($P < 0.05$) percent ground cover of forbs and greater ($P < 0.05$) percent bare ground than younger fawns. Slope and aspect of bed sites differed ($P < 0.05$) between years, but not with fawn age. Fawns selected sites with greater ($P < 0.05$) concealment cover at all 0.5 m intervals up to 2

m in height, and greater ground cover of trees, shrubs, and grasses ($P < 0.01$) than random sites. Concealment cover up to 0.5 m in height was most important of all variables considered.

Introduction

Predation is an important cause of mortality for mule deer fawns (Smith and LeCount 1979, Steiger and Flinders 1980, Hamlin et al. 1984), and fawn survival is believed to be related to characteristics of fawn bedding sites (Smith and LeCount 1979, Riley 1982, Huegel et al. 1986). Vegetation, through its influence on doe nutritional condition and fawn concealment cover, may be an ultimate factor in fawn mortality (Knowlton 1976, Robinette et al. 1977). Coyotes (*Canis latrans*) generally rely on visual cues to locate prey (Wells and Lehner 1978) and increased vegetative cover could reduce their ability to locate and kill fawns, especially during the first few weeks when fawns spend approximately 90% of their time bedded (Jackson et al. 1972). Thus, the bed site chosen is important in determining the fawn's vulnerability to coyotes.

This study described mule deer fawn bedding sites in a pinyon (*Pinus edulis*)-juniper (*Juniperus monosperma*)/ shortgrass prairie habitat and tested 2 null hypotheses: (a) characteristics of fawn bed sites do not differ between years or with fawn age; (b) mule deer fawns choose bedding sites at random.

Methods

Fawn Capture

Mule deer fawns were marked during June-August 1983 and 1984. Fawns were located by ground surveillance of radio-collared and unmarked does and then captured by hand or with throw nets. Radio-marked (Advanced Telemetry Systems, Inc., Bethel, Minn. 55005) fawns were located using a receiver and hand-held "H" antenna (Telonics, Inc., Mesa, Ariz. 85204). Ground locations were supplemented by locations from a helicopter or fixed-wing aircraft with the same tracking equipment. Fawns were visually located at 2-3 day intervals from capture until 12 weeks of age, or death, and on a weekly basis thereafter. Activity, time of day, group association, habitat, and fawn condition were noted for each relocation. Location points were plotted on USGS 1:24,000 topographic maps. Bed sites were marked for later vegetative and structural analysis. All bed sites were measured within two weeks.

Bed Site Analysis

Concealment cover was measured at fawn bed sites with a 0.3 by 2 m cover board marked-off in 0.25 m intervals. The board was placed at each bed site and read from each of the 4 cardinal directions from a distance of 15 m. The proportion of each 0.25 m interval obstructed by vegetation was recorded as a single-digit density score (Nudds 1977).

Percent ground cover of grasses, forbs, and shrubs was measured at each bed site by the grid technique of ocular estimation (Hays et al. 1981). A 0.2 by 0.4 m quadrat was used for grasses and forbs. The following cover class scale was used: 0-5, 5-25, 25-50, 50-75, 75-95, and 95-100% (Daubenmire 1959).

The percent rock or bare ground and percent canopy cover of trees at each bed site was measured using the point intercept method. Shrubs over 1.5 m were considered trees. Twenty stations at 1-m intervals were placed along 2 bisecting right angle 10-m lines centered over the bed site. The presence of rock or bare ground at each station was noted and percentages were calculated for each variable. Slope and aspect also were measured.

Vegetation and topography also were measured at 4 randomly selected sites. Random sites were located by pacing off a random distance, between 0 and 100 m in the 4 cardinal directions from the bed site. Sampling of random sites was limited to 100 m because fawns were never observed traveling more than 100 m from an area to which the does brought them.

Means for data collected at bedding sites were calculated by year and fawn age (1-20 days and 21+ days). The 21 day break-off point was chosen because after 21 days fawns were more active and generally flushed when approached. ANOVA was used to test for differences in bed site characteristics by age and year. SAS (paired-comparisons t-test, and MANOVA) was also used to test for selection of bed sites. For the paired t-test we used the mean of the four random measurements paired with its associated bed site measurement.

Results and Discussion

Slopes associated with fawn bedding sites ranged from 7-35% in 1983 and 10-16% in 1984. Slope of bed sites differed ($P < 0.01$) between years, but did not differ ($P > 0.05$) with fawn age, although there was a tendency for fawns to use steeper slopes as they matured. Aspects selected by fawns did not change with fawn age ($P > 0.05$); however, in 1984 more bed sites were found on gentle slopes with southerly aspects ($P < 0.05$). This was a result of deer use of dense shrubby vegetation along drainages in prairie habitat adjacent to pinyon-juniper covered breaks. These areas may have been avoided in 1983 because of the presence of cattle. Dood (1978) reported that observed changes in mule deer fawn range use was correlated with changes in cattle distribution.

Fawns on PCMS generally selected level areas on moderate slopes and shrubby drainages as bedding sites, and often bedded in small, bare ground depressions with vegetation, rocks or an earthen bank behind them. Riley and Dood (1984) reported that mule deer fawns used "middle" slopes rather than ridge tops and coulee bottoms, but drainages were used extensively by fawns on PCMS, possibly because of denser vegetation and presence of water. Seventy-six percent of all bedsite locations were in or along drainages.

During 1984 fawn bed sites had greater ($P < 0.05$) tree canopy cover, and greater ($P < 0.05$) ground cover of shrubs and forbs than in 1983. Ground cover of grass did not differ ($P > 0.05$) between years (Table 8). Young fawns (< 21 days) selected bed sites with more forb cover than older fawns; no other variable differed with age (Table 8). During both 1983 and 1984 fawn bed sites had a greater ($P < 0.01$) percent canopy cover of trees, shrubs and grasses than random sites. The use of shrubby drainages and arroyos in 1984 may explain the greater tree, shrub and forb cover at fawn bed sites. The lower ground cover of forbs with fawn age may be due to dessication of forbs in late summer.

Fawn bed sites had more ($P < 0.05$) rock substrate in 1983 than in 1984 and the bed sites of older fawns had more bare ground ($P < 0.05$) due to natural senescence of vegetation (Table 9). There was no difference in bare ground and rock substrate between bed sites and random sites ($P > 0.05$). This also may be associated with the greater use of gentler slopes and shrubby drainages, which had less rock substrate than the basaltic hogback and juniper covered sandstone and limestone breaks.

During 1984 fawn bed sites had greater ($P < 0.05$) concealment cover at the 0-0.5 m interval (Table 12). Concealment cover at the 0.5-1.0, 1.0-1.5, 1.5-2.0 m intervals did not differ ($P > 0.05$) between years or with fawn age ($P > 0.05$) (Table 10). During both 1983 and 1984 fawn bed sites had greater ($P < 0.05$) concealment cover at all 0.5 m intervals than random sites. Fawns on PCMS appear to maintain a certain level of concealment at bed sites regardless of age or the vegetation type. Riley (1982) also found no difference in cover at fawn bed sites with age and reported that fawns maintained high concealment cover by shifting habitat use. Huegel et al. (1986) reported that white-tailed deer fawns in Iowa selected bedsites in different habitats irrespective of individual

Table 8. Adjusted mean (SE) tree canopy cover (%) and shrub, grass and forb ground cover (cover class scale) at 150 bed sites and 600 random sites by year and fawn age (young: 1-21 days, old: 21 days and older) for 28 mule deer fawns on the Pinon Canyon Maneuver Site, Colorado, 1983-1984.

Variable	Bed sites		Random sites	
	1983	1984	1983	1984
Trees	16.48 (3.11)*	27.21 (4.75)*	3.04 (1.48)*	7.06 (0.97)*
Shrubs	1.73 (0.10)*	2.08 (0.14)*	1.28 (0.16)	1.37 (0.11)
Grasses	2.18 (0.15)	2.00 (0.10)	1.67 (0.08)*	1.89 (0.05)*
Forbs	1.18 (0.05)*	1.30 (0.03)*	1.11 (0.02)	1.12 (0.01)
	Bed sites		Random sites	
	Young	Old	Young	Old
Trees	21.69 (2.81)	22.00 (4.93)	4.15 (0.87)	5.95 (1.54)
Shrubs	2.02 (0.09)	1.79 (0.15)	1.41 (0.10)	1.25 (0.17)
Grasses	2.18 (0.09)	2.00 (0.16)	1.86 (0.05)	1.71 (0.08)
Forbs	1.33 (0.03)*	1.16 (0.05)*	1.15 (0.09)*	1.09 (0.02)*

(*) indicates differences ($P < 0.05$) in estimates across fawn age and years for bed sites and random sites.

Table 9. Adjusted mean (SE) percent bare ground and rock at 150 bed sites and 600 random sites by year and fawn age (young: 1-21 days, old: 21 days and older) for 28 mule deer fawns on the Pinon Canyon Maneuver Site, Colorado, 1983-1984.

Variable	Bed sites		Random sites	
	1983	1984	1983	1984
Bare ground	37.62 (3.90)	41.29 (2.69)	41.65 (4.38)	38.57 (3.02)
Rock	37.60 (4.46)*	27.34 (3.08)*	42.82 (3.53)	31.77 (5.39)
	Bed sites		Random sites	
	Young	Old	Young	Old
Bare ground	32.39 (2.48)*	46.51 (4.21)*	36.21 (2.78)	44.02 (4.71)
Rock	35.19 (2.84)	29.77 (4.81)	39.23 (3.19)	35.37 (5.60)

(*) indicates differences ($P < 0.05$) in estimates across years and fawn age for bed sites and random sites.

plant species composition, but bedsite structure was similar and differed from random sites. He also stated that the vegetative structure selected resulted in greater visual concealment.

The hypothesis of no difference in characteristics of bedding and random sites of mule deer fawns was rejected. Overall, mule deer fawns selected bed sites that differed (Hotelling-Lawley Trace, $F = 141.6$, $df = 11, 141$, $P < 0.01$) from random sites. Concealment cover at the 0-0.5 m interval made the largest contribution to the vector of all the variables measured. Other important variables included percent ground cover of grasses, and shrubs, and concealment cover at the 1.1-1.5 m interval.

The presence of at least 70% concealment cover from 0 to 1 m at bed sites appears to be important to mule deer fawns on PCMS. Concealment cover from 1 to 2 m also appears to be important, possibly as protection from avian predators. Dense bed site cover was determined to be critical to fawn survival in Montana (Dood 1978, Riley 1982) and Arizona (Smith and LeCount 1979). Also, Garner et al. (1979) reported that short herbaceous species and/or sparce cover deter fawns from using an area.

Table 10. Adjusted mean (SE) density score (1: least - 5: greatest) at 4 cover board heights at 150 bed sites and 600 random sites by year and fawn age (young: 1-21 days, old: 21 days and older) for 28 mule deer fawns on the Pinon Canyon Maneuver Site, Colorado, 1983-1984.

Board height (m)	Bed sites		Random sites	
	1983	1984	1983	1984
0.0-0.5	3.96 (0.11)*	4.30 (0.08)*	2.02 (0.08)	2.10 (0.06)
0.5-1.0	3.16 (0.19)	3.46 (0.13)	1.53 (0.07)	1.63 (0.05)
1.0-1.5	2.89 (0.24)	3.04 (0.16)	1.26 (0.05)*	1.45 (0.07)*
1.5-2.0	2.66 (0.24)	2.79 (0.16)	1.21 (0.05)*	1.42 (0.07)*
	Bed sites		**Random sites**	
	Young	Old	Young	Old
0.0-0.5	4.25 (0.07)	4.01 (0.12)	1.93 (0.06)*	2.19 (0.09)*
0.5-1.0	3.39 (0.12)	3.23 (0.21)	1.39 (0.05)*	1.79 (0.08)*
1.0-1.5	3.03 (0.15)	2.91 (0.25)	1.23 (0.05)*	1.49 (0.07)*
1.5-2.0	2.75 (0.15)	2.69 (0.26)	1.17 (0.04)*	1.45 (0.07)*

(*) indicates differences ($P < 0.05$) in estimates across years and fawn age for bed sites and random sites.

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CHAPTER FOUR

COMPARISON OF TWO HELICOPTER TYPES FOR NET GUNNING MULE DEER

Introduction

Hand-held net-guns have been used successfully to capture coyotes and 6 native ungulates in Alberta (Barrett et al. 1982), caribou (*Rangifer tarandus*) in Alaska (Valkenburg et al. 1983), mountain sheep (*Ovis canadensis*) in Montana (Andryk et al. 1983) and Arizona (Krausman et al. 1985) and mule deer and white-tailed deer (*O. virginianus*) in Arizona (Smith and Horejsi 1982, Krausman et al. 1985).

Small jet powered helicopters such as the Hughes 500 and the Bell 206 are most often used in net-gun capture operations because of their maneuverability and their availability. Working with the U.S. Army allowed us to choose between two helicopter types in our capture operation; the military OH-58 (Bell 206-Jet Ranger)(Fig. 3) and UH-1 (Bell 212-Huey)(Fig. 4).

This paper discusses the effectiveness of each helicopter type for capturing mule deer with a net-gun in pinyon- juniper woodland and canyons.

Methods

During April 1983-April 1984, mule deer were captured with a hand-held Coda net-gun (Coda Enterprizes, Mesa, Arizona). The gun discharged an 18-cm mesh triangular net, 5.8 m on a side. A .308 caliber charge propelled cylindrical weights attached to each corner of the net.

Military OH-58 and UH-1 helicopters were used in all captures. The UH-1 required a crew of three while the OH-58 required a crew of two. The same pilot was used when possible. Before takeoff, all doors were removed on the OH-58; the sliding rear door on the UH-1 made it possible for the gunner to open and close the door during flight. The gun was shot from the back seat of both helicopter types. A safety harness and sling system allowed the gunner to lean out past the skids and shoot.

Deer were hazed out of pinyon-juniper woodland or off steep slopes and canyon walls into open areas and approached for a shot. Deer in vegetative cover or inaccessible areas were followed until they broke into the open where they were intensively pursued with the helicopter about 3-5 m above ground level. All shots were fired from a distance of about 3 m. After the first few capture attempts, a maximum hazing time of 20 min was established.

Fig. 3. Military OH-58 helicopter used in net-gun capture of mule deer.


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Fig. 4. Military UH-1 helicopter used in net-gun capture of mule deer.

Results and Discussion

Twenty-four deer (9 males, 15 females) were captured on PCMS using the net-gun (Table 14). Hazing times varied from 3-26 min for all shots and 3-20 min for successful shots. Hazing time included low intensity as well as intense pursuit. Mean hazing time for the UH-1 ($\bar{x}$ = 6.8 +/- 3.9 min) was shorter (t = 2.20, 22df, $P < 0.05$) than for the OH-58 ($\bar{x}$ = 11 +/- 5.6 min). Capture efficiency (successful captures/shots fired) for the UH-1 (88%) and the OH-58 (82%) was not different (z = 0.47, $P > 0.05$).

Twenty-one capture attempts were abandoned because the deer could not be driven out of pinyon-juniper cover (Table 1). Hazing times for abandoned capture attempts varied from 8 to 26 minutes ($\bar{x}$ = 14.6 +/- 4.8 min) before pursuit was discontinued. Hazing times were not recorded for the first net-gun trial which included 6 abandoned capture attempts using the OH-58. These attempts were abandoned because the OH-58 lacked the power and maneuverability to keep up with the deer. The 20 min hazing limit was imposed on 3 capture attempts resulting in a lower average hazing time for abandoned capture attempts with the UH-1 than otherwise would have occurred. Mean hazing time for abandoned capture attempts was greater (t = 4.90, 28df, $P < 0.05$) than for successful captures in the UH-1 but not in the OH-58 (t = 1.20, 22df, $P > 0.05$). The ratio of successful captures to all capture attempts for the UH-1 (54%) was not different (z = 0.04, $P > 0.05$) from that of the OH-58 (53%).

The hourly rate charged by the U.S. Army for fuel and maintenance for the UH-1 and the OH-58 was $150.00 and $70.00, respectively. Thus the average cost for a successful capture with the UH-1 was $17.01 and $12.84 for the OH-58.

The increased power, maneuverability, cargo space, and pilot and gunner comfort of the UH-1 made it the favored aircraft, despite its greater operating cost. The greater rotorwash of the UH-1 only affected net deployment when the helicopter went into a steep bank during firing. Also, the extra pilot in the UH-1 allowed one pilot to concentrate on the deer while the other watched for obstacles, increasing the margin of safety for the operation.

Table 11. Comparative attributes of UH-1 and OH-58 helicopters in mule deer capture with a hand-held net-gun, April 1983- April 1984 on the Pinon Canyon Maneuver Site, Colorado.

	Helicopter type	
	UH-1	OH-58
Successful captures (n)	15	9
Shots fired (n)	17	11
Hazing time (min) $\bar{x}$ (range)	6.8 (3-16)	11.0 (3-20)
Abandoned capture attempts (n)	13	8
Shots fired (n)	5	2
Hazing time (min) $\bar{x}$ (range)	14.8 (8-26)	13.5 (12-15)*

(*) Hazing times not available for 6 abandoned capture attempts on the first net-gun trial.

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SUMMARY

This study, conducted during Januuary 1983- December 1984 completed the first phase of a project to determine the impact of Army maneuvers on the PCMS mule deer population. The primary objective of the study was to collect baseline information on the population dynamics, movements, and habitat use of mule deer prior to maneuvers and provide management recommendations. Research also was done on fawn bed site selection because of the possible impact of tactical vehicles on vegetative cover.

Thirty-eight adult and 28 fawn mule deer were radio-collared and 35 adults were color-collared or ear-tagged. Population estimates based on aerial quadrat surveys were 365 and 370 deer for 1983 and 1984, respectively. These estimates were similar to other deer populations in woodland / prairie habitats. Annual buck: doe ratios averaged 60:100 and were similar to unhunted deer populations in eastern Colorado and other areas in the southwest. Annual fawn survival was 29% and 22% in 1983 and 1984, respectively. Survival estimates based on survival of radio-collared fawns agreed with fawn: doe ratios from aerial surveys. Coyote predation was responsible for 76% of fawn mortality. The rate of increase, based on age specific survival and fecundity data indicated a stable population. The modest reproduction and high adult survival were sufficient to offset the low fawn survival.

The deer population on PCMS is nonmigratory and the longest movements (14-21 km) were made by bucks during the rut. All other movements by both sexes were restricted to seasonal home ranges. Annual home ranges were larger than home ranges of deer in the foothills but were similar to other herds in woodland / prairie habitats.

The pinyon-juniper woodland with its associated grassland and shrub edges was very important to mule deer on PCMS. This vegetation type offered sufficient forage close to cover. Also, water was available from stock ponds and drainages associated with this type. The shrub/ open grassland edge type also was important for fawns and does during the summer season.

Fawns commonly bedded on midslope benches and shrubby drainages. Bed sites selected by fawns were typified by 70% concealment cover at the 0-1.0 m layer and 30% at the 1-2.0 m layer. Fawns selected bed sites with greater cover of trees, shrubs and grasses than random sites. Cover at the 0-0.5 m interval was the most important variable measured at bed sites on PCMS. Other studies also have found that fawns seek out a certain level of concealment cover at bed sites.

MANAGEMENT RECOMMENDATIONS

The PCMS mule deer population should be managed conservatively based on the results of this study and the uncertainty of impacts by Army maneuvers. Any significant increase in adult doe mortality may depress the herd for several years, rather than stimulate a reproductive response. However, the population appears to be able to sustain a limited buck harvest.

If the Army is interested in increasing the harvestable surplus, early fawn survival must be increased. Coyote control is probably the best choice; however it has been shown that alternate prey availability also has a marked affect on early fawn survival (Hamlin et al. 1984). Before any management decision is made concerning coyote control, the status of alternate prey species, namely small mammals and lagomorphs should be determined. Intensive control just prior to the fawning season should reduce the coyote population during the fawn's most vulnerable period.

Another reason for managing conservatively is that the full effect of Army maneuvers is not understood. Tactical vehicles could directly impact mule deer by causing mortality and movements, or indirectively by affecting the food base in some manner and possibly the alternate prey balance of the coyote. Severinghaus and Goran (1981) documented reduced plant species richness, biomass, vegetative cover and increased dominance by introduced species resulting from tactical vehicle maneuvers on Fort Lewis, Washington. They also predicted impacts to the small mammal guild that consumed vegetative biomass.

The Army maneuvers have the potential of severely impacting the pinyon-juniper woodland vegetation type, which is very important to mule deer for food and cover requirements. The elevated knowls and rough terrain found in these types make them attractive areas from a military standpoint. During the first three Army maneuver rotations shrubs, grasses and forbs in the areas were uprooted and killed as vehicles maneuvered through the areas. This might reduce the carrying capacity of this vegetation type from a nutritional standpoint. Impacts on vegetation may influence foraging energetics by affecting both energy intake and costs. This would be especially important during times when energy balance is critical, such as lactation for females and winter for males and females. Fawn concealment cover also would be reduced.

Population data should be collected during the maneuver periods to determine the effects of maneuvers on the population. Also, an emphasis should be placed on possible effects on the quality and quantity of forage, because of the impact of nutrition on deer reproduction. Research should also consider methods for predicting potential impacts of habitat changes on the deer's ability to meet energy intake requirements.

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