Ecology of Pronghorns on the Piñon Canyon Maneuver Site, Colorado

by

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(ABSTRACT)

During January 1983 - July 1985 the population dynamics, movements, and habitat use of pronghorns (*Antilocapra americana*) were studied on the 1040 km^2 Piñon Canyon Maneuver Site, in southeastern Colorado, prior to initiation of military training. Forty-seven adults and 32 fawns were radio marked; 247 adults were color collared or ear tagged only. Using aerial strip and quadrat surveys, I estimated a summer population for 1983, 1984, and 1985 of 694, 690, and 657 respectively. Adult female pregnancy rate was approximately 98%, mean litter size for females $>$ 1.5 years was 1.9, and fetal and fawn sex ratios were not different from 1:1. Fawn mortality was 89% in 1983 and 80% in 1984. Adult mortality was 20% in 1983 and 28% in 1984. Annual rate of increase (λ) over the 2 year study was .806. Home range size of pronghorns was extremely variable within and between sexes and among seasons. Winter ranges were 2-fold and 5-fold larger than summer range for females and males, respectively. Sixty-five percent of all weekly movements were $<$ 3 km. Females preferred open grassland in all seasons, and cholla grassland in winter. Yucca grassland was preferred in spring and fall, and cholla/open grass edges were highly preferred in all seasons. Males preferred open grassland in all seasons but winter, and preferrred cholla grassland in all seasons but spring, cholla/open grass edges were also preferred in all seasons. Fawns used open grassland and cholla/open grass edges more than expected, while using woodland and shrub habitats less than expected.

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GENERAL INTRODUCTION

In 1977 the Department of the Army initiated an environmental impact study for the proposed acquisition of a 1040 km^2 tract of land in Las Animas County, Colorado. The proposed land use would include remote military training and routine combat maneuvers by the 4th Infantry Division (Mechanized) of Fort Carson, Colorado.

These training exercises could be quite incompatable with wildlife. From the environmental impact study of the Piñon Canyon Site, it was estimated that in a single year 25 - 75% of the vegetative ground cover would be lost in portions of important wildlife habitat. The impact on shrub species, in particular, will be extremely detrimental. Browse species represent an important component in the diet of the pronghorn (*Antilocapra americana*)(Bayless 1969, Hoover 1966), particularly in winter (Beale and Smith 1973). Shrub canopy cover and shrub height have been identified as important variables in the calculations for a habitat suitability model for pronghorns in winter (Irwin and Cook 1985). Not only does this shrub component represent an important food source, but recent studies of fawn survival indicate the possible importance of structural cover in fawning areas, which may increase fawn survival (Autenreith 1980).

Few studies have been conducted to document the impacts of large scale disturbance on pronghorn populations, and most of the work that has been done refers to mining operations (Amstrup 1978, Helms 1978, Segerstrom 1982). The movement of pronghorns in the immediate area disturbed by maneuvers will be inevitable, but the long term effects on the population dynamics, movements, and habitat use are unknown.

With severe impacts likely for many wildlife species on the Piñon Canyon Maneuver Site, the environmental impact assessment process mandated wildlife studies be initiated prior to military operations, allowing for the development of a comprehensive wildlife management program. This was a unique opportunity to study the species prior to maneuvers, and continue once maneuvers begin, to assess the impacts of such activity on the pronghorn population.

The objectives of the study were: (1) to document the density and distribution of pronghorns on the study area; (2) to determine the fecundity and survivorship of pronghorns on the PCMS; (3) and to determine movement patterns, home range, and habitat preference of pronghorns on the PCMS. The study was conducted from September 1982 through May 1986, with 1983 and 1984 devoted entirely to field work.

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CHAPTER ONE

POPULATION ECOLOGY OF PRONGHORNS IN SOUTHEASTERN COLORADO

Abstract

During January 1983-July 1985 I studied pronghorn (*Antilocapra americana*) population dynamics on the 1040 km^2 Piñon Canyon Maneuver Site in southeastern Colorado. Forty-seven adult pronghorns were radio marked and 247 were color collared or ear tagged. Using aerial strip transect and quadrat surveys I estimated a summer population of 683 (.95/km^2), and winter population of 954 (1.3/km^2). Annual buck:doe ratios increased each year and averaged 40:100. Using aerial strip transect, quadrat, and Lincoln-Petersen (L/P) estimators, 5 population estimates were obtained for each of the survey dates. The observer efficiency for the 1.6 km strips was 55% in the summer and 63% in winter. L/P estimates from quadrat surveys and actual strip counts were biased underestimates of the population. A mean of the three remaining estimators, gave summer estimates for 1983, 1984, and 1985 of 694 (0.96/km^2), 690 (0.96/km^2), and 657 (0.91/km^2) respectively. Late summer fawn:doe ratios in 1983, 1984, and 1985 were 36:100, 22:100, and 31:100 respectively. The adult female pregnancy rate was approximately 98%; the mean litter size for females > 1.5 years was 1.9, and the sex ratios of both fetuses and captured newborn fawns was not different than 1:1. Fawn mortality was 91% in 1983 and 83% in 1984; 71% of fawn mortality was due to coyote (*Canis latrans*) predation. Adult mortality was 20% in 1983, and 28% in 1984; coyote predation accounted for 43%, and hunting for 36% of adult mortality. The calculated annual rate of increase (λ) for the two year study was 0.806, indicating a 19% decline in the population per year. In contrast, the observed annual rate of increase ($\lambda = 1.01$) indicated a stable population. Increased immigration resulting from cattle removal and increased forage availability may help explain the disparity between the 2 rates. Low fawn recruitment coupled with occasional severe winter conditions appear important in holding the population at its present level.

Introduction

During 1982-83 the Department of the Army acquired a 1040 km^2 tract of ranch land in southeastern Colorado for use by the Fort Carson Training Command as a remote mechanized training area for routine combat maneuvers. In 1983 Fort Carson initiated a comprehensive research program to assess the impacts of intensive military training on wildlife residing on the newly designated Piñon Canyon Maneuver Site (PCMS). This study was part of this research program, and was conducted during January 1983 - July 1985. Our objectives were to determine the status and dynamics of the PCMS pronghorn population prior to the initiation of military maneuvers in 1985, as a means to provide baseline information to assess the impacts of military maneuvers on the population.

Study Area

The 1040 km² Piñon Canyon Maneuver Site, located in north central Las Animas County, in southeastern Colorado, is part of the eastern Colorado shortgrass prairie community (Costello 1954). Elevation ranges from 1370 - 1680 m; annual precipitation is 28 - 33 cm.

Grassland within the study area was dominated by blue grama (*Bouteloua gracilis*), in association with galleta (*Hilaria jamesii*), western wheatgrass (*Agropyron smithii*), ring muhly (*Muhlenbergia torreyi*), broom snakeweed (*Xanthocephalum sarathrae*), and walkingstick cholla (*Opuntia imbricata*).

The Purgatoire River and associated steep rocky side canyons form the eastern border of PCMS (Fig. 1). Pinyon pine (*Pinus edulis*), and one-seed juniper (*Juniperus monosperma*), dominated the canyon vegetation, along with skunkbush ((*Rhus trilobata*), mountain mahogany (*Cercocarpus montanus*), fourwing saltbrush (*Atriplex canescens*) , and rabbitbrush (*Chrysothamnus nauseosus*). Pinyon-juniper woodlands with grassy understories or exposed limestone characterize the Black Hills, Bear Spring Hills, and the Big Arroyo Hills along the northeast, north central, and northwestern borders respectively. The entire study area has a history of cattle and sheep grazing as well as very limited dry land farming.

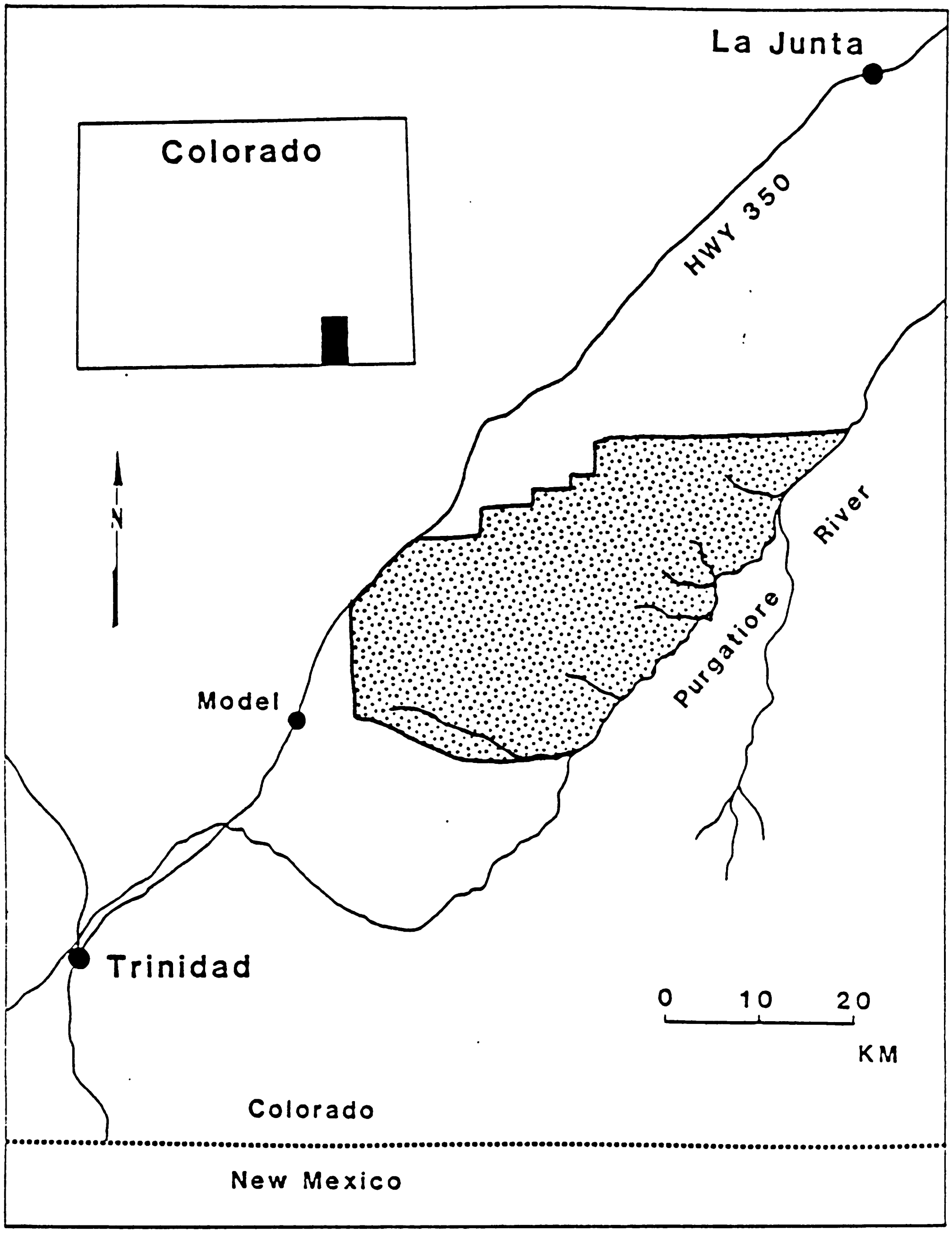

Fig. 1. Location of the Piñon Canyon Maneuver Site (PCMS), Colorado.

Methods

Capture and Marking

Adults

Adult pronghorns were trapped and marked at 4 separate locations during the winters of 1982-83 through 1984-85. Groups of pronghorns were herded by helicopter into a corral trap (Spillet and Zobell 1967), as modified by Moody et al. (1982). Corralled pronghorns were allowed to rest before being manually restrained, processed and released. We also used a hand-held net gun fired from a helicopter to capture adult pronghorns (Firchow et al. 1986).

Most pronghorns were marked with eartags and fitted with either a transmitter collar (Advanced Telemetry Systems, Bethel, MN) or a 10 cm wide numbered color collar. All pronghorns were aged from patterns of tooth replacement and wear (Dow and Wright 1962).

Fawns

Pronghorn fawns were located by observing post-parturient does from approximately 400 m - 2.2 km until the position of the fawns was revealed at times of nursing and grooming. Bedded fawns were captured by hand or with a 1 m diameter landing net on a 2 m pole (Amstrup et al. 1980). Captured fawns were measured, weighed, and age was determined using a combination of behavioral and physical characteristics (Bromley 1977).

In 1983, fawns were equipped with either solar panel (23 g) or battery powered (32 g) eartag transmitters. A battery powered transmitter mounted on an expandable, breakaway elastic collar (80-90 g) was used in 1984.

Pronghorn fawns were relocated daily with a portable receiver for the first 2 months after capture, then once every 3-4 days thereafter. Adults were also located once every 3-4 days using hand-held and truck mounted 2, 3, & 5 element antennas. Ground locations were supplemented by aerial locations from rotary and fixed-wing aircraft.

Census Flights

Pronghorns were censused on PCMS by quadrat (Kufeld et al. 1980) and standard strip transect methods during January 1983-July 1985. Surveys were conducted to estimate population size, distribution, and herd structure.

The strip surveys consisted of east/west transects spaced 1.6 km apart over the entire study area, giving 100% coverage. The surveys were flown in a UH-1 helicopter with 2 pilots and a navigator; observers were located on each side of the aircraft. I assumed observers could see pronghorn up to 0.8 km on each side of the aircraft. Strips were flown at 120-138 km/hr, and 33-39 m above ground level.

Thirty-four quadrats (2.59 km^2) were established within a 720 km portion of the study area, which I designated as suitable pronghorn habitat. Quadrats were selected at random, with 2 constraints: (1) that no quadrats be adjacent to each other; and (2) that no quadrats touch corners. These constraints reduced the chance of bias incurred by recounting animals, or flushing animals away from adjacent quadrats during the search procedure. Many quadrat corners were naturally marked by fencelines and existing roads. Those quadrats not so marked were flagged with 5 cm wide surveyor tape streamers and two 20 x 25 cm white flags attached to 1.2 m poles.

Quadrat surveys also were flown in a UH-1 helicopter with two pilots and a navigator, but with the 2 observers on the same side of the aircraft. The perimeter of each quadrat was flown first to identify individuals and groups within the quadrat. A criss-cross pattern through the center of the quadrat also was flown. Dense vegetation (usually woodland) and topography in some quadrats required a more thorough search.

In July 1985, I conducted quadrat surveys on 3 consecutive days to test the repeatability of the survey technique itself. The surveys were conducted at approximately the same time of day, with the same pilots and navigator.

Population estimates were based on number counted (strip surveys) and extrapolation (quadrat; Scheaffer et al. 1979). An estimate based upon the total number of pronghorns observed and the ratio of marked pronghorns observed to total marked pronghorns present on the survey area (Lincoln-Petersen estimate) for both strip and quadrat surveys was also calculated. An adjusted count for strip surveys was obtained by applying the mean observability (number marks observed/number marks available) to the total count.

Total number of marked pronghorns available during each survey was determined using the status of the radio marked animals just prior to the survey. A disappearance rate for color collared animals was obtained by applying the mortality and emigration rate of radio marked pronghorns to the color collar marked animals, making the assumption that color collared pronghorns behave the same as radio marked animals (Rolley & Keith 1980).

Fecundity

Pregnancy rates were determined by direct observation of pregnant females during the first 2 weeks of May. Female reproductive tracts were collected from road killed animals, trap mortalities, and hunter kills in the area, to determine litter size and pregnancy rate. Number of breeding does in the population was determined from the age structure of our sample of 294 trapped animals.

Survival

Survival rates were calculated for fawns and adults using telemetry data (Heisey and Fuller 1985). Where appropriate, 2 estimates were made, the first assuming all lost signals were still alive, the second assuming all lost signals were dead (Trent and Rongstad 1974). Adult survival was calculated at bimonthly intervals, fawn survival at monthly intervals. Annual rates were calculated by summing the radio days and mortalities for each year, then recalculating the rate. Survival rates for fawns and yearlings were also obtained by constructing life tables from the age distribution over 3 years (Fig. 2, Table 7; Caughley 1977).

Results

Population Estimates

During January 1983- July 1985 I flew eleven 100% coverage strip surveys and six 12% coverage quadrat surveys (Table 1). Strip survey actual counts ranged from 260 in June 1983 to 647 in February 1984.

The observation efficiency from strip surveys was 55% (S.E.=12.8) during summer, and 63% (S.E.=19.9) during winter. The adjusted strip estimates ranged from 613 to 714 (Table 2). The Lincoln-Petersen estimate for the strip survey compared closely to the adjusted estimates except in January 1985, when very few collars were seen in relation to the number available.

The vegetative composition of the 34 quadrats sampled was representative of the entire survey area ($X^2=8.0$, df=4, p=0.092). Neither the quadrat estimates nor the L/P estimate for

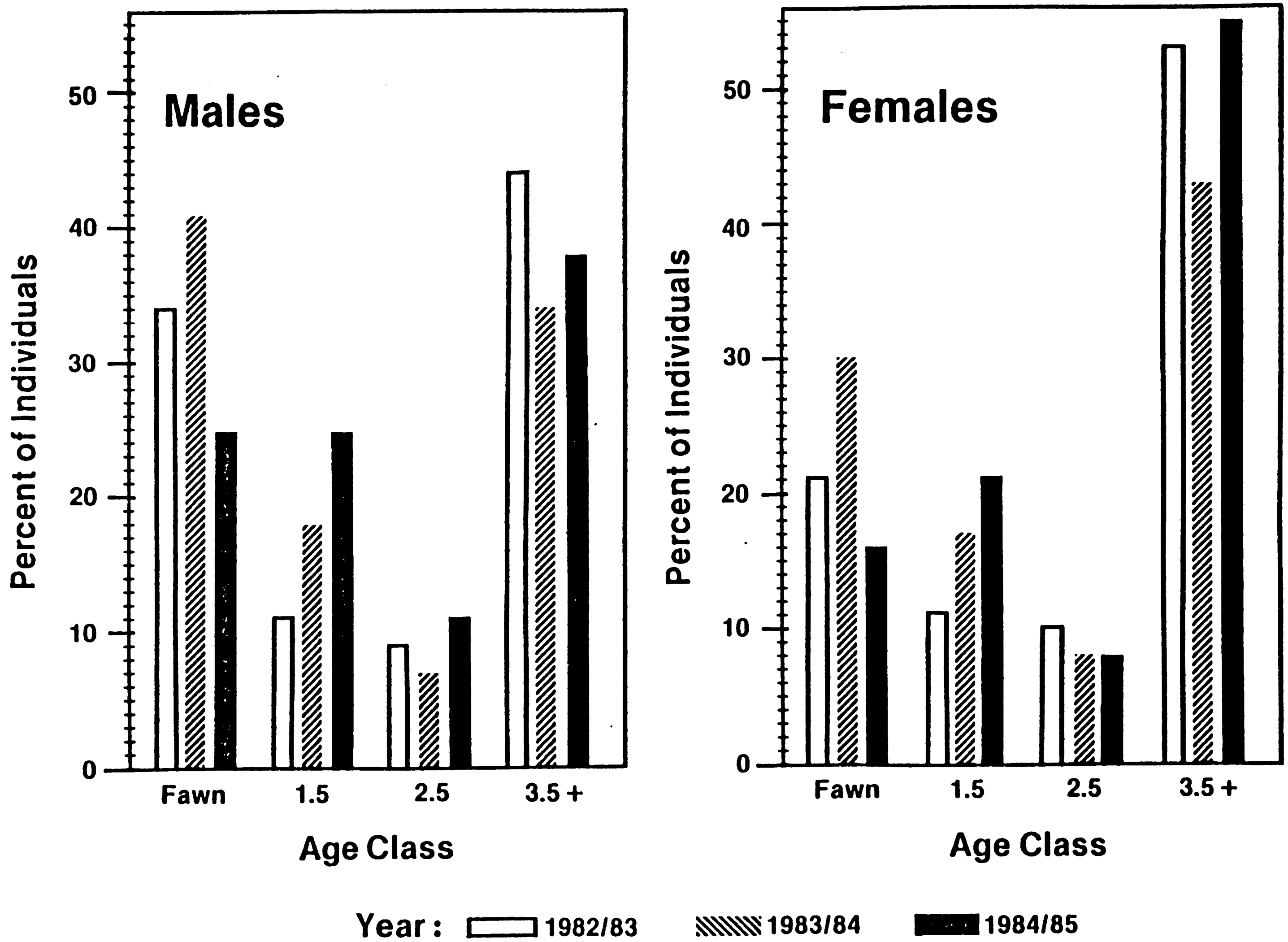

Fig. 2. Age structure of trapped pronghorns on the Pinon Canyon Maneuver Site (PCMS) in southeastern Colorado, 1982/83 through 1984/85.

Table 1. Results of aerial surveys for pronghorns on the Pinon Canyon Maneuver Site, Colorado, 1983-1984.

Year	Month	Survey Type	Total Adults	Male: Female	Fawn: Female
1983	Jan	Strip	350	29:100	
1983	May	Strip	321	34:100	
1983	June	Strip	260	40:100	28:100
1983	Aug	Strip	314	39:100	33:100
1983	Aug	Quadrat	128	47:100	39:100
1983	Dec	Strip	455	29:100	
1984	Feb	Strip	647	28:100	
1984	June	Strip	341	59:100	27:100
1984	June	Quadrat	84	55:100	17:100
1984	Aug	Strip	328	46:100	27:100
1984	Aug	Quadrat	94	25:100	17:100
1984	Dec	Strip	384	28:100	
1985	Jan	Strip	450	40:100	
1985	Jan	Quadrat	104	76:100	
1985	June	Strip	337	36:100	18:100
1985	June	Quadrat	114	27:100	24:100
1985	July	Quadrat	123	37:100	31:100

Table 2. Population estimates and 90% confidence intervals using 5 estimation techniques for pronghorns on the Pinon Canyon Maneuver Site, Colorado, 1983-1985. Individuals per km² in parentheses.

Technique	August 83	June 84	August 84	January 85	June 85
Quadrat	770±368(1.1)	687±253(.95)	851±346(1.2)	857±456(1.2)	834±259(1.2)
Lincoln-Peterson for Quadrat	343±98(.48)	396±136(.55)	635±274(.88)	476±121(.66)	385±97(.53)
Actual Count Strip	388(.54)	341(.47)	388(.54)	450(.62)	337(.47)
Adjusted Strip[a] Count	705(.98)	620(.86)	705(.98)	714(.99)	613(.85)
Lincoln-Peterson	605±104(.84)	584±93(.81)	695±117(.96)	1291±281(1.8)	524±64(.73)

a-Adjusted estimate using an index of observability from marked animals. Index of observability $\doteq$ # marks observed/# marks available.

quadrats differed across seasons ($p > 0.05$)(Table 2). Lincoln-Petersen estimates for strip surveys were similar ($p > 0.05$) across all seasons except January 1985, which was higher ($p < 0.05$) than the other survey dates. The actual counts and adjusted strip estimates did not appear different across seasons. Combining the 5 estimation techniques, we obtain an average summer estimate of 563 in 1983, 591 in 1984, and 539 in 1985.

Fawn:doe ratios did not differ ($p > 0.05$) between survey types during any of the survey dates (Table 3). Fawn:doe ratios were different ($p < 0.05$) across survey dates within the two survey types. Buck:doe ratios between survey types were different ($p < 0.05$) in August 1984 and January 1985; on the former date the strip survey estimate was higher, on the latter the quadrat survey estimate was higher. Buck:doe ratios were different ($p < 0.05$) across survey dates for both the techniques.

Because very little work had been done with quadrat surveys on pronghorn I tested its repeatability by surveying on 3 consecutive days in July 1985. The quadrat estimates declined by more than 50% from the the first to the third day, but the Lincoln-Petersen estimate remained statistically similar ($p > 0.05$) over all 3 days (Table 4). Even though I observed fewer animals, the ratio of marked-to-unmarked animals remained the same. Fawn:doe ratios were not different ($p > 0.05$) over the 3 consecutive surveys, but male:female ratios increased more than 50% from the first to the third survey. The quadrat estimate for the July 29 survey was not different ($p > 0.05$) from the 30 July estimate, but was greater than ($p < 0.05$) the July 31 estimate.

Herd Structure

The age structure of the PCMS herd was determined from 294 pronghorns trapped during 1983-1985 (Fig. 2). Generally, both males and females declined in number with increased age, but there was much fluctuation within age classes and between years. Buck:doe ratios ranged from 25:100 to 76:100 (Table 1). The annual buck:doe ratio differed among years

Table 3. Fawn:Female and Male:female ratios obtained from strip and quadrat surveys of pronghorn on the Pinon Canyon Maneuver Site, Colorado, 1983-1985. Sample size in parentheses.

Technique	August 83	June 84	August 84	January 85	June 85
Fawns:100 Females					
Strip	33 (300)	27 (272)	27 (285)	.....	18 (291)
Quadrat	39 (121)	17 (63)	17 (88)	.....	24 (112)
Males:100 Females					
Strip	39 (314)	59 (341)	48 (328)	40 (450)	36 (337)
			*	*	
Quadrat	47 (128)	56 (84)	25 (94)	76 (104)	27 (114)

*$p < 0.05$ chi-square test

Table 4. Results of random quadrat surveys conducted on 3 consecutive days during July 1985, on the Pinon Canyon Maneuver Site, Colorado. Estimates given with 90% confidence limits.

	29 July 85	30 July 85	31 July 85
Population Estimates			
Random Quadrat	890±326	656±304	409±128
Lincoln-Peterson	530±152	528±182	505±223
Fawns:100 Females	31 (118)	34 (75)	35 (39)
Males:100 Females	37 (123)	61 (90)	93 (56) **

** $p < 0.01$ chi-square test across survey dates.

Sample size in parentheses.

($X^2 = 11.1$, $p < 0.05$) and averaged 36:100, 40:100, and 43:100 for 1983, 1984, and 1985 respectively.

Reproduction

Fawning occurred as early as 13 May and as late as 30 June. The mean birth date calculated from the estimated ages of 32 captured fawns (Bromley 1977) during 1983-1984 was 29 May. Seventy-five percent of the captured fawns were born between 25 May and 6 June. The sex ratio of fawns captured in both years ($n = 32$) and of fetuses from reproductive tracts ($n = 17$) was not different ($p > 0.05$) from 1:1.

Based on analysis of 17 female reproductive tracts, the mean litter size for females 1.5 years and older was 1.9; none of 3 females < 1.5 years was pregnant. Pregnancy rate of pronghorns on PCMS was determined by direct observation of females during the first 2 weeks of May 1983 and 1984. Recounting individuals was kept to a minimum by only counting radio marked females and their associated herd. Seventy-nine percent of all females I observed were pregnant ($n = 194$). The age structure of 274 corral trapped and 18 net gun captured pronghorns on PCMS indicate that 78% of the female population was of breeding age. Since the observed pregnancy rate was 79%, the pregnancy rate for breeding age females was nearly 100%.

Survival

Fawns

I calculated 30 day survival rates from May - September for fawns radio-marked (N = 32) the summers of 1983 and 1984 (Heisey and Fuller 1985). One fawn died 4 days after capture, of apparent malnutrition/starvation, and was not included in the survival estimates. The 150 day interval survival rate for summer 1983 was 0.11 (Table 5). Mortality was highest in the first 3 weeks after birth. The 150 day interval survival rate during summer 1984 (0.20) was higher ($p < 0.05$) than in 1983 (0.11).

Seventy-one percent of all known fawn mortalities were due to coyote predation (Table 6). Twenty-nine percent of the remaining known mortalities were scavenged by coyotes, but actual cause of death was unknown. The mean 150 day interval fawn mortality rate over 2 years was 84%.

The late August fawn:doe ratio from aerial surveys was 26:100. Assuming 1.8 fawns per breeding doe (this study and others), or approximately 1.5 fawns per female in the population, and assuming no adult female mortality during the summer, an 84% fawn mortality rate would result in a late August fawn:doe ratio of 24:100. The similarity of these two independent estimates of fawn mortality indicate that late August aerial surveys may accurately estimate the fawn mortality rate of PCMS pronghorns.

Annual fawn mortality rate was obtained by combining the life table calculation (Table 7) for older fawns (6 mos. - 1 year) and the calculation based on telemetry of fawns from birth to 5 months. The first year mortality rate for 1983 and 1984 was 91% and 83%, respectively. The annual mortality rate for yearlings based on the life table was 32%.

Table 5. Monthly survival rates of radio-marked pronghorn fawns from May-September 1983-84, on the Pinon Canyon Maneuver Site, Colorado.

	Month	Radio days	Mortality	Monthly Survival
1983	May	40	1(1)[a]	.57
	June	207	3(1)	.60
	July	124	1(4)	.53
	August	65	0	1.0
	September	32	0	1.0
			1983 Rate	**.11**
1984	May	32	1	.62
	June	281	8	.42
	July	284	1	.89
	August	279	0	1.0
	September	144	1	.90
			1984 Rate	**.20**

[a] 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.

Table 6. Fates of 45 adult and 32 fawn pronghorns radio-marked on the Pinon Canyon Maneuver Site, Colorado, 1983-1984.

	Adults	Fawns	Total
Coyote Predation	2	12	14
Hunting	5	0	5
Snowstorm (Coyote predation)	4	0	4
Scavenged (Unknown)	3	5	8
Signals lost	2	6	8
Remained alive	29	9	38
Totals	45	32	77

Table 7. Life table for pronghorns on the Piñon Canyon Maneuver Site, Colorado, calculated from the age distribution of 184 corral trapped animals during 1983-1985.

Age	f(x)	l(x)	d(x)	q(x)	s(x)
Fawn (6-18 mos.)	88	1.0	.255	.255	.745
Yearling (1.5-2.5 yr)	65	.745	.268	.359	.641
2.5 (2.5-3.5 yr)	31	.477			

Adults

In both 1983 and 1984 bimonthly survival rates (Hiesey and Fuller 1985) for adult pronghorns were lowest in March/April and in September/October (Table 8). The 1983 annual survival rates for males (0.79) and females (0.82) were similar ($p > 0.05$), but in 1984 males had a higher survival rate ($p < 0.05$) than females. Mean annual survival rate for adults on PCMS during 1983-1984 was 0.76 (Table 8).

Hunting accounted for 36% ($n=5$) of adult mortality (Table 6). Predation following a severe snowstorm in March 1984 accounted for 29% of the mortality, 14% was due to coyote predation under normal conditions, and the cause of death was not determined for 21% of the mortalities.

Discussion

Population Estimation

Only 3 of the 5 estimators I used provide reliable population estimates (Table 2). Pojar et al. (1982) in Colorado, determined from preliminary tests that the observed density did not differ between strip widths of 0.8 km and 1.6 km, and therefore used 1.6 km strips. The average observability estimate at PCMS for 1.6 km strips was only 58% (range 34 - 79), indicating an adjustment for observer efficiency or a reduction in the strip width is necessary to accurately estimate pronghorn density in the shortgrass prairie habitat. Additional testing of the visibility/strip-width relationship for pronghorns may be necessary to determine observer efficiency for other habitat types.

Table 8. Bimonthly survival rates of radio-marked adult pronghorns on the Piñon Canyon Maneuver Site, Colorado, January 1983-December 1984.

	Bimonthly period	Radio days Female/Male	Mortality Females	Survival Females	Mortality Males	Survival Males
1983	Jan.,Feb.	243/100	1	1.0	0	1.0
	Mar.,Apr.	789/305	0	.93	0	1.0
	May,June	732/305	0	1.0	0	1.0
	July,Aug.	744/310	0	1.0	0	1.0
	Sept.,Oct.	699/270	1	.92	1	.80
	Nov.,Dec.	671/244	0	1.0	0	1.0
			Annual Rate	.82		.79
1984	Jan.,Feb.	1139/458	0	1.0	0	1.0
	Mar.,Apr.	1171/658	2(2)[a]	.86	2	.83
	May, June	1030/793	2	.88	0	1.0
	July, Aug.	992/806	0	1.0	0	1.0
	Sept.,Oct.	898/754	1	.93	2	.85
	Nov.,Dec.	831/732	0	1.0	0	1.0
			Annual Rate	.66		.77

a-Signals were lost on 2 transmitters, a mean survival estimate is presented, from calculations considering them both dead and then both still alive.

I derived 2 estimates from quadrat surveys: 1) extrapolation of the mean of the sampled quadrats to the entire study area; and 2) a marked-to-total ratio estimate. The latter averaged only 56% of the former. Possible causes for this disparity may have been: (1) counting marked individuals more than once; (2) our quadrat selection procedure was not truly random; (3) color marked animals were not distributed randomly in the population; (4) an incorrect assumption that color collared animals behaved similar to radio-marked animals in regard to mortality, emigration, and collar retention.

I do not believe I counted marked animals more than once, since the collars were numbered to identify each individual uniquely. With the two constraints placed on the quadrat selection, an almost systematic distribution of sample quadrats was obtained. However, I do not believe there was a systematic or regular pattern to the distribution of pronghorns which may have biased our estimate obtained from this sample. Pronghorns were marked at 4 different locations within the study area. Even though marked animals were subsequently located throughout the study area, there were greater numbers near the original trap sites. This clumped distribution may have biased the estimates.

Another likely explaination for the low estimates in the quadrat marked-to-total ratio may lie in the assumption of similar behavior of color collared and radio collared animals. The age structure of our radio marked sample was 2% fawns, 22% yearlings, and 76% adults (N = 47), compared to 28% fawns, 17% yearlings, and 55% adults (N = 247) for the color collared sample. The low number of fawns radio-marked would not reveal the generally higher mortality rate for that age class, which comprised 28% of the color collared sample. This difference could result in a underestimate of the disappearance rate of color collared animals. This would lead to an overestimate of the number of collars available at the time of the survey, resulting in a conservative estimate of the total population.

It appears that a combination of factors related to using trap marked pronghorns, and their subsequent distribution may explain the disparity between quadrat estimates and the Lincoln-Petersen estimates. Eliminating the actual strip count and the Lincoln-Petersen estimate for quadrats, I believe the best estimate of the pronghorn population is a mean of the random quadrat, the adjusted strip count, and the Lincoln-Petersen estimate for strips, which gives a summer estimate of 694 (0.96/km^2) in 1983, 690 (0.96/km^2) in 1984, and 657 (0.91/km^2) in 1985.

The Lincoln-Petersen population estimate for the January 1985 strip survey appears to be an outlier (Table 2), possibly due to new and untrained observers. By eliminating this estimate from the analysis I obtain a winter 1984/85 population estimate of 786 (1.1/km^2); though higher than the summer estimates it is not significantly so ($p > 0.05$).

The quadrat survey technique appears repeatable from the first two days of data. The general decline in random quadrat estimates and the large change in buck:doe ratios during these consecutive surveys indicates a possible behavioral response to the surveys. Females moved out of the quadrats, giving a lower total count of animals and leaving a preponderance of males in the second and third surveys.

Strip survey estimates when adjusted by an observer efficiency index were similar ($p > 0.05$) to the random quadrat estimates across all survey dates, fawn:doe ratios were also similar. If an index to observibility is unknown, the quadrat technique may be preferred, even though it would require more manhours, particularly in marking quadrat corners.

Herd Structure

The generally higher proportion of females than males in the older age classes may be a reflection of differential mortality between the sexes. Adult males have generally higher mortality rates than females, due to the greater hunting pressure.

Buck:doe ratios were extremely variable over the 2 1/2 year study (Table 1). Though there was a general increase in the buck:doe ratio over these 2 1/2 years, an estimate from any single survey may be misleading. Understanding this variability becomes important when herd management statistics are gathered from only one survey per year.

Fawn Survival

Fawn mortality was highest during the first 3 weeks after birth, which is similar to fawn mortality reported by Barrett (1984) in Alberta, and Von Gunten (1978) in Montana. The 150 day interval fawn mortality rate of 84% is much higher than the 50% reported by Barrett (1984), and 60% reported by Autenrieth (1984) in Idaho. Fawn mortality rates of 90% have been reported in Montana (Von Gunten 1978).

Rate of Increase

The population estimates for PCMS (Table 2) suggest a generally stable population. The rate of increase (λ) calculated from the best estimate of summer populations was 1.01. I also calculated a rate of increase (λ) for the PCMS population using age-specific survival and fecundity schedules (Krebs 1978:165). Since mortality rates for adults and fawns differed among years, two separate rate of increase estimates were calculated. For the 1983 calculation I used a first year mortality rate of 91%, a yearling mortality rate of 32%, and adult female mortality was 18%. A 98% pregnancy rate among adult females, and a birth rate of .9 female fawns per breeding female were used in the analysis. In 1984 I used a first year mortality rate of 83%, yearling mortality rate of 32%, and adult mortality at 34%.

The rate of increase (λ) for 1983 was 0.838 indicating a 16% decline in the population, assuming a stable age structure. In 1984 the rate of increase (λ) was 0.783 indicating a decline of 22%. Using the mean mortality rates for the two years we obtain our best estimate of a rate of increase of 0.806, assuming a stable age structure of 48% fawns, 8% yearlings, and 44% adults. The observed age structure based on trapped animals (Fig. 2), was 29% fawns, 17% yearlings, and 54% adults, and was not considered stable.

From the population estimates for PCMS, it appears that the pronghorn population was stable, but the age-specific survival and fecundity schedules indicate a 20% decline in the population. The calculated rate of increase assumes that immigration and emigration are equal, but they may be disproportionate, and aid in explaining the decline that the rate of increase analysis indicates. A minimum of 5000 cattle were removed from PCMS during late 1982 and early 1983, and as a result the available forage appears to be much greater on PCMS than outside the study area. Anderson and Denton (1978) in Idaho, using a combination of body weight and percent of forage competition between cattle and pronghorns calculated that it took 59.2 pronghorns to consume the same forage as one animal unit month (AUM). This potential increase in the carrying capacity and improvement in range conditions may have stimulated movement of pronghorns onto the area. The low fawn recruitment coupled with occasional severe winter conditions appear to be important in depressing population growth.

Management Implications

Aerial strip surveys are commonly used to obtain herd composition and density estimates of pronghorn populations, for establishing harvest schedules. The mark-reobservation data from aerial surveys indicate that in shortgrass prairie habitat I was observing only 55 - 65% of the total number of animals within a 1.6 km strip. This relatively low observability, could lead to gross inaccuracy in total population estimates and therefore, inappropriate harvest levels. Alternatively, the observability of quadrat surveys is very high, especially with the search methods and habitats in which I worked. Strip surveys are relatively simple and efficient to conduct, while quadrat surveys are more difficult to navigate, are inefficient in terms of actual flight time per area covered, and initial time spent in locating and marking corners. Further work on observability of pronghorns in different habitat types may aid pronghorn managers in the future.

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CHAPTER TWO

MOVEMENTS AND HABITAT USE OF PRONGHORNS IN SOUTHEASTERN COLORADO

Abstract

During 1983 - 1984 I studied the movements and habitat use of pronghorns (*Antilocapra americana*) on the 1040 km^2 Piñon Canyon Maneuver Site, in southeastern Colorado. Forty-seven adults and 32 fawns were radio marked, and 247 adults were color collared or ear tagged. Mean convex polygon home range size ranged from 9.8 km^2 to 67.1 km^2, and was extremely variable within and between sexes and seasons. Winter range was 2-fold and 5-fold larger than summer range for females and males, respectively. Seasonal home range size differed ($p < 0.05$) between males and females only in summer. Females moved farther between range centers in all seasonal comparisons. Twenty-four percent of the movements

from winter to summer activity centers were < 2 km, 48% were 3 - 10 km, and 28% were > 10 km. All range shifts > 10 km were by females. Sixty-five percent of the weekly movements within seasons, for both males and females were < 3 km. Habitat use by females (SI=.96) and males (SI=.96) was similar from season to season. Females preferred open grassland in all seasons, cholla grassland in winter, and yucca grassland in spring and fall; use of cholla/open grassland edge was 40% greater than expected. Males preferred open grassland in all seasons but winter, and preferred cholla grassland in all seasons but spring. Use of cholla/open grassland edges by males was 49% greater than expected. Fawns preferred open grassland and cholla/open grassland edge; they avoided woodland and shrub habitats.

Introduction

In 1983 the U.S. Army inititated a comprehensive research program to assess the impacts of intensive mechanized military training on several wildlife species inhabiting the 1040 km² Piñon Canyon Maneuver Site (PCMS), in southeastern Colorado. The preliminary environmental impact study estimated that in a single year 25-75% of the ground cover vegetation in shrubland and other habitats important to wildlife would be lost. Shrub canopy cover and height have been identified as important variables in habitat suitability models for pronghorns (*Antilocapra americana*) (Irwin and Cook 1985), and recent studies have indicated the possible importance of vegetation structure to fawn survival (Autenreith 1980). In addition, browse species represent an important component of their diet (Hoover 1966, Bayless 1969). This study was designed to determine the seasonal home range and habitat selection of pronghorns and to document distribution and movement patterns of pronghorns prior to the initiation of military maneuvers in 1985, in order to provide baseline information necessary to assess the military impacts on the population.

Study Area

The 1040 km^2 Piñon Canyon Maneuver Site, located in north central Las Animas County, in Southeastern Colorado, is part of the eastern Colorado shortgrass prairie community (Costello 1954). Elevation ranges from 1370 m - 1680 m; annual precipitation is 28 - 33 cm. The Purgatoire River and associated steep rocky side canyons form the eastern border of PCMS. Pinyon-juniper woodlands with grassy understories or exposed limestone characterize the Black Hills, Bear Spring Hills, and the Big Arroyo Hills, along the northeast, northcentral, and northwestern borders respectively. The entire study area has a history of cattle and sheep grazing as well as dry land farming.

Vegetation Types

Eight relatively discrete vegetation types were delineated on the study area, based on habitats that may be important for wildlife on the area.

Pinyon-juniper Sandstone (PJSS).--Evergreen woodlands within canyons and on canyon rims in which tree cover exceeds 15%; dominant species include Pinyon pine (*Pinus edulus*), and one-seed juniper (*Juniperus monosperma*). Shrub species include mountain mahoghany (*Cercocarpus montanus*), skunkbush (*Rhus trilobata*), and walkingstick cholla (*Cholla imbricata*), with exposed sandstone substrate.

Pinyon-juniper Limestone (PJLM)--Evergreen woodlands in upland areas in which tree cover exceeds approximately 15%, dominated by pinyon pine and one-seed juniper, and associated with limestone breaks. Understory species include spiny greasebush (*Forsellesia spinescens*), bigelow sage (*Artemesia bigelowii*), cholla, four-o-clocks (*Mirabilis multiflora*), and various grasses. PJLM and PJSS compose 20% of the study area.

Open grassland (OPGR).--Predominently blue grama (*Bouteloua gracilis*) grassland, in association with galleta (*Hilaria jamesii*), and western wheatgrass (*Agropyron smithii*). Areas of broom snakeweed (*Guterrezia sarathrae*), needle and thread grass (*Stipa neomexicana*), Indian rice grass (*Oryzopsis hymenoides*), and ring muhly (*Muhlenbergia torreyi*) are mixed throughout. Winterfat (*Eurotia lanata*), and numerous seasonal forbs including sunflower (*Helianthus annuus*) and copper mallow (*Sphaeralcea coccinea*) are common.

Cholla grassland (CHGR).--A grassland similar to open grassland but contains approximately 15% or greater cover of walkingstick cholla.

Shrub grassland (SHGR).-- A grassland community usually found in drainages and arroyos and characterized by 15% or greater shrub cover. Dominant shrub species include fourwing saltbush (*Atriplex canescens*), wolfberry (*Lycium palidum*), and greasewood (*Sarcobatus vermiculatis*).

Yucca grassland (YUGR).--Open grassland with at least 15% coverage of small soapweed (*Yucca glauca*). Sites are generally sandy with needle and thread grass, Indian rice grass, and often cholla.

OPGR, CHGR, SHGR, and YUGR comprise approximately 55% of the study area; OPGR comprises 45% of all grassland.

Canyon shrub (SHCY).--Areas of shrubby vegetation within the canyons; dominant species include skunkbush, rabbitbrush (*Chrysothamnus nauseosus*), mountain mahagony, and gooseberries (*Ribes sp.*), with abundant exposed sandstone substrate.

Edge.--When 2 habitats occurred within the same 50.8 x 50.8 m mapping cell, the cell was classified as "edge". The five edge categories were: woodland/shrubs, shrubs/shrubs, woodland/open grass, cholla/open grass, and shrubs/open grass. "Shrubs" included shrub grassland, yucca grassland, and shrub canyon habitats. "Woodlands" included both pinyon-juniper habitat catagories. Twenty-four percent of the study area was classified as edge.

Standing water is scattered throughout the study area, mostly in ponds associated with erosion control dams.

METHODS

Adult and yearling pronghorns were captured during the winters of 1982-83 through 1984-85 in corral traps (Spillet & Zobell 1967) modified according to Moody et al. (1982). A hand-held net gun fired from a helicopter was also used to capture adults (Firchow et al. 1986). Captured animals were aged by tooth replacement and wear (Dow & Wright 1962), marked with eartags and either a transmitter collar (Advanced Telemetry Systems, Bethel, MN) or a 10 cm wide numbered color collar, and immediately released.

Pronghorn fawns were located by observing post-parturient does from approximately 400 m - 2.2 km until the position of the fawn was revealed at times of nursing and grooming. Bedded fawns were captured by hand or with a 1 m diameter landing net on a 2 m pole (Amstrup et al. 1980). In 1983, fawns were equipped with solar panel or battery powered eartag transmitters (Gerlach et al. 1985); battery powered transmitters mounted on expandable, breakaway elastic collars were used in 1984. Pronghorn fawns were located daily for the first 2 months after capture, then once every 3 - 4 days thereafter. Adults were located once every 3 - 4 days using hand-held and truck mounted 2, 3, & 5 element antennas. Visual ground locations were supplemented by aerial locations from rotary and fixed-wing aircraft. Locations in difficult topography or at night were obtained by triangulation (Tester et al. 1964). Locations were plotted on 1:24,000 USGS topographic maps using the UTM grid system. Ninety-three percent of all telemetry locations were visual.

Habitat Assessment

High level infrared photographs were used to delineate distinct habitats on the study area. The habitat map was digitized, then transformed into 50.8 x 50.8 m cells for computer analysis. An error matrix constructed from 869 ground truth points and analyzed by the Kappa statistic (Bishop et al. 1975:393-400) was used to test the accuracy of the map. Availability of a particular habitat was defined as the number of cells of that habitat as a proportion of the total number of cells for the entire study area.

Analysis

Seasonal distribution of pronghorns on the PCMS was documented during 8 aerial strip transect surveys over the entire study area in late summer and mid-winter of 1983 and 1984 (Chapter 1). Activity areas were calculated using the minimum convex polygon method (Mohr 1947) and the harmonic mean tranformation method (Dixon and Chapman 1980). A minimum of 22 locations per sex-season-year combination was used for each home range calculation; locations taken less than 6 hours apart were considered dependent and eliminated from the analysis. The minimum of 22 locations per sex-season-year combination used for home range calculations was based on the distribution of our location data (Fig. 3) and the assumed relationship between sample size and estimated home range size (Smith et al. 1981). Only radio-marked animals were used in the analysis of movements and home range, but all marked animals were used in the habitat use analysis.

Geometric centers of activity and distance moved between consecutive locations were calculated by program TELEM (Koeln 1980). Activity centers were calculated for each sex and season combination; movement between seasonal activity centers for males and females was also calculated. Since no difference was found between geometric activity centers calculated with a minimum of 15 vs. 22 locations, I used 15 as the minimim number of locations for calculating activity centers.

Seasons were defined on the basis of pronghorn behavior. Winter (16 November to 15 March) began post rut and encompassed formation and break-up of large winter groups. Spring (16 March until 15 May) was the prefawning period following break up of winter groups.

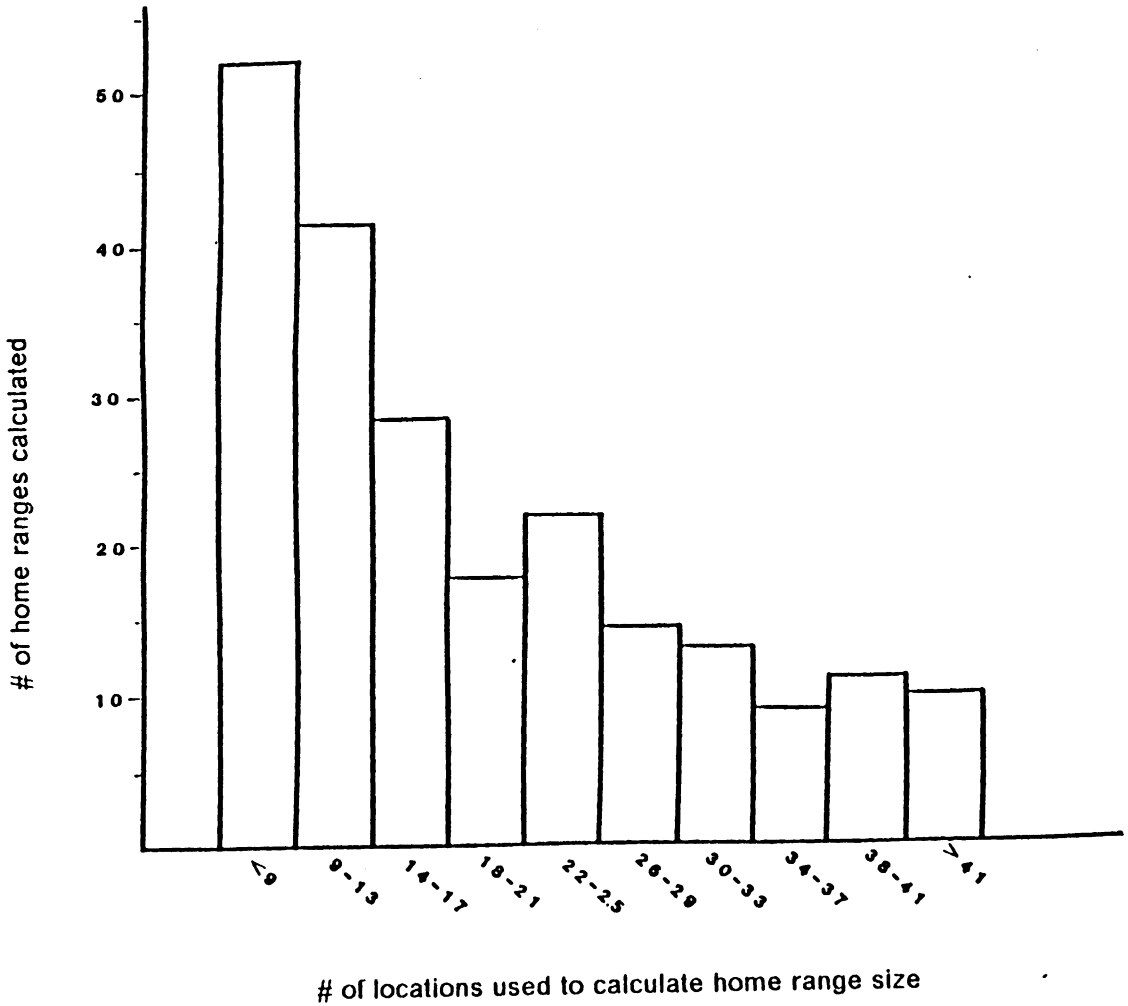

Fig. 3. Frequency distribution of the number of radio locations used to calculate home range size for pronghorns on PCMS, Colorado, 1983-1984.

Summer (16 May through 31 August) was the fawn rearing period, and fall (1 September until 15 November) encompassed the rut and shedding of horn sheaths.

Chi-square analysis was used to compare the distribution of male, female, and fawn pronghorns among vegetation types for each of the seasons.

Within each season-sex-habitat combination, a Bonferroni Z statistic was used to estimate whether a specific observation occurred more or less frequently than expected at probability level 0.05 (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 between June, July, and August. Nonparametric rank multiple comparisons were used to compare home range sizes (Hollander and Wolfe 1973).

Results

During 1983-1985 I captured 294 adult and yearling pronghorns and marked 47 with radio transmitters; the remainder received color collars, or ear tags only. The age structure of captured pronghorns was 29% fawns, 17% yearlings, and 54% adults; the male:female ratio was 60:100 (Chapter 1; Fig. 2). I also captured and radio marked 32 newborn fawns during 1983-1984.

Seasonal Distribution

Pronghorns were scattered during the summer and clumped during the winter; mean group size was 3.5 and 22.9 respectively (Fig. 4). Pronghorns that were on Tyrone Flats on the western border of the site in summer moved east into Burke and Taylor Arroyos in winter. However, pronghorns that concentrated in the Red Rock Arroyo in the north central portion of the study area, in the far northeast corner, and in the southeastern section of the site in summer, remained there during winter (Fig. 4).

Seasonal Home Range

The size of seasonal home ranges using both the minimum convex polygon and the harmonic mean transformation (HMT) were highly variable (Table 9). Winter convex polygon home ranges were 2-fold and 5-fold larger than summer ranges for males and females respectively. In both sexes, spring and fall ranges were only slightly smaller than summer ranges. The 95% HMT estimates were on average 45% greater than the 95% convex polygon estimates. With both estimates, male and female winter home ranges were larger ($p < 0.05$) than in other seasons. Fall and spring range size for females was not different, neither was spring and summer range, but summer range was larger ($p < 0.05$) than fall range. For males, spring, summer, and fall home range sizes did not differ ($p < 0.05$). Males had larger ($p < 0.05$) convex home ranges than females only during winter. On average, the 50% HMT "core" areas (Dixon and Chapman 1980) were contained within 13% of the 95% HMT home range area. This trend was similar in all seasons and in both sexes.
Mean fawn home range size was approximately 20% smaller than adult female home range size in summer.

Seasonal Movements

Females moved greater distances than males between range centers in all seasons. The greatest mean distance moved between seasonal activity centers was 7.8 km by females between winter and spring ranges (Fig. 5). Movements between spring/summer

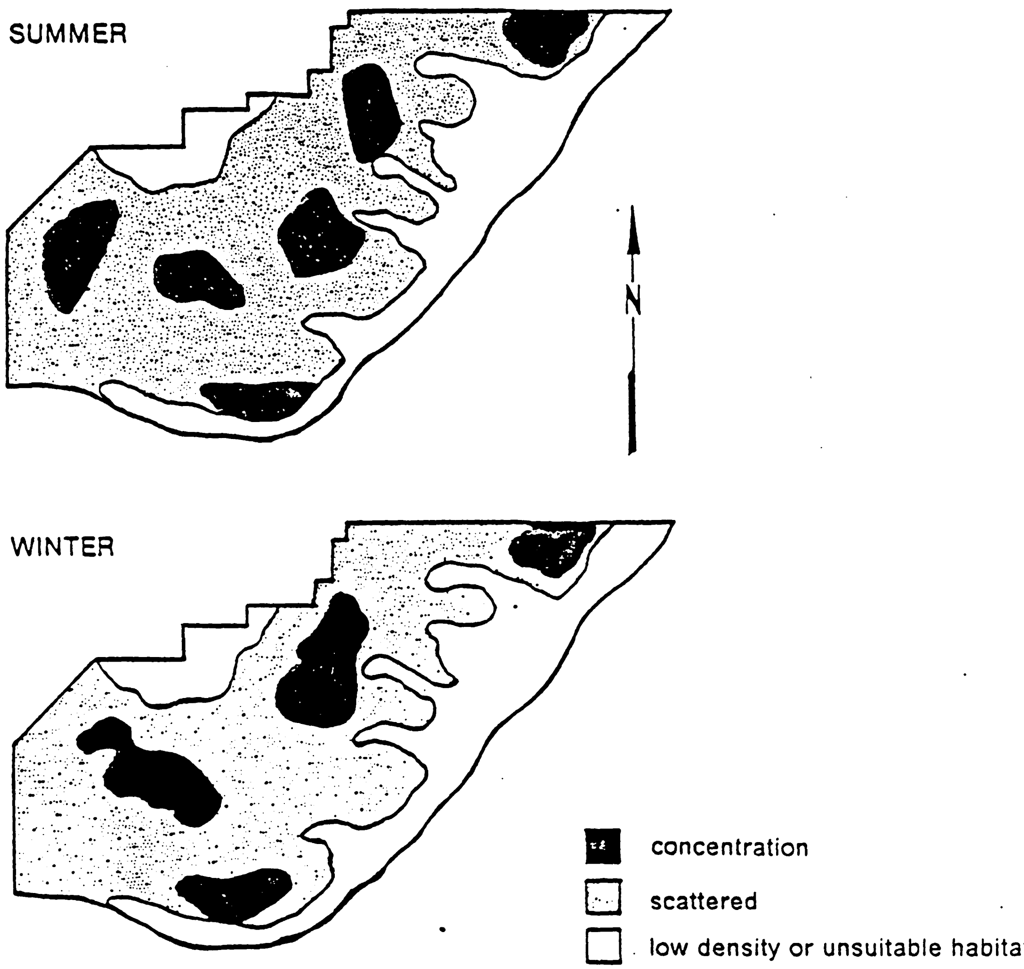

Fig. 4. Seasonal distribution of pronghorns on the Piñon Canyon Maneuver Site, Colorado, 1983-1984.

Table 9. Home range size and range of radio-marked adult pronghorns on the Pinon Canyon Maneuver Site, Colorado, January 1983-December 1984.

	n	95% Convex (km^2)	K/W[a]	50% Harmonic (km^2)	K/W	95% Harmonic (km^2)	K/W
FEMALES							
Winter	10	50.9 (20.2-111.6)		13.4 (4.9-24.5)		104.9 (37.7-347.8)	
Fall	15	19.5 (5.5-90.0)		3.1 (1-12)		23.1 (4.9-86.1)	
Spring	8	24.7 (2.8-104.7)		4.0 (.8-9.6)		36.2 (10.1-85.1)	
Summer	20	25.6 (8.0-94.2)		6.5 (1.9-16.1)		50.3(12.6-123)	
MALES							
Winter	6	67.1 (17-131.1)		7.1 (3.1-15.3)		88 (24.8-180.4)	
Fall	9	9.8 (4.7-14.5)		2.9 (1.1-5.7)		18.6 (8.2-39.4)	
Spring	3	11.6 (4.8-17.1)		1.9 (1.7-2.2)		17.2 (8.4-23)	
Summer	15	13.0 (3.4-48.4)		4.4 (1.5-10.8)		24.2 (4.8-82.5)	
FAWNS							
Summer	11	19.9 (3.8-58.1)		4.2 (2-7.3)		33.5 (9.3-49.7)	

[a]K/W = Kruskal-Wallis multiple comparison.

and summer/fall ranges were less than 3.3 km for both sexes. Fidelity to summer range was high, i.e. the mean distance between summer activity centers for 1983 and 1984 were 1.4 and 2.4 km for males and females, respectively.

Movement between summer and winter activity centers was of 3 general types (Fig. 6); (1) movements < 2 km (24%); (2) movements 3-10 km (48%); and (3) movements > 10 km (28%). All movements > 10 km ($n=5$) were by females; 3 of the 5 were yearlings. Seasonal movement patterns were not migratory, and long distance movements did not appear spurred by weather. Two yearling females that made long distance movements off the study area did not return.

Movement Within Home Ranges

Distance moved every 7-10 days was similar ($p > 0.05$) for male and female pronghorns (Fig. 7). Sixty-five percent of all weekly movements were less than 3 km. The longest movement within a one week period was 41 km by a pregnant female in early May.

To determine when most middle range and long distance moves occurred, I plotted the percent of monthly movements by males and females that were > 5 km (Fig. 8). Overall, 19% ($N = 1101$), of female movements and 15% ($N = 511$) of male movements were > 5 km. A higher proportion of females than males moved long distances in winter and in early summer (May - July). Most long distance movements by males occurred in February, March, and April.

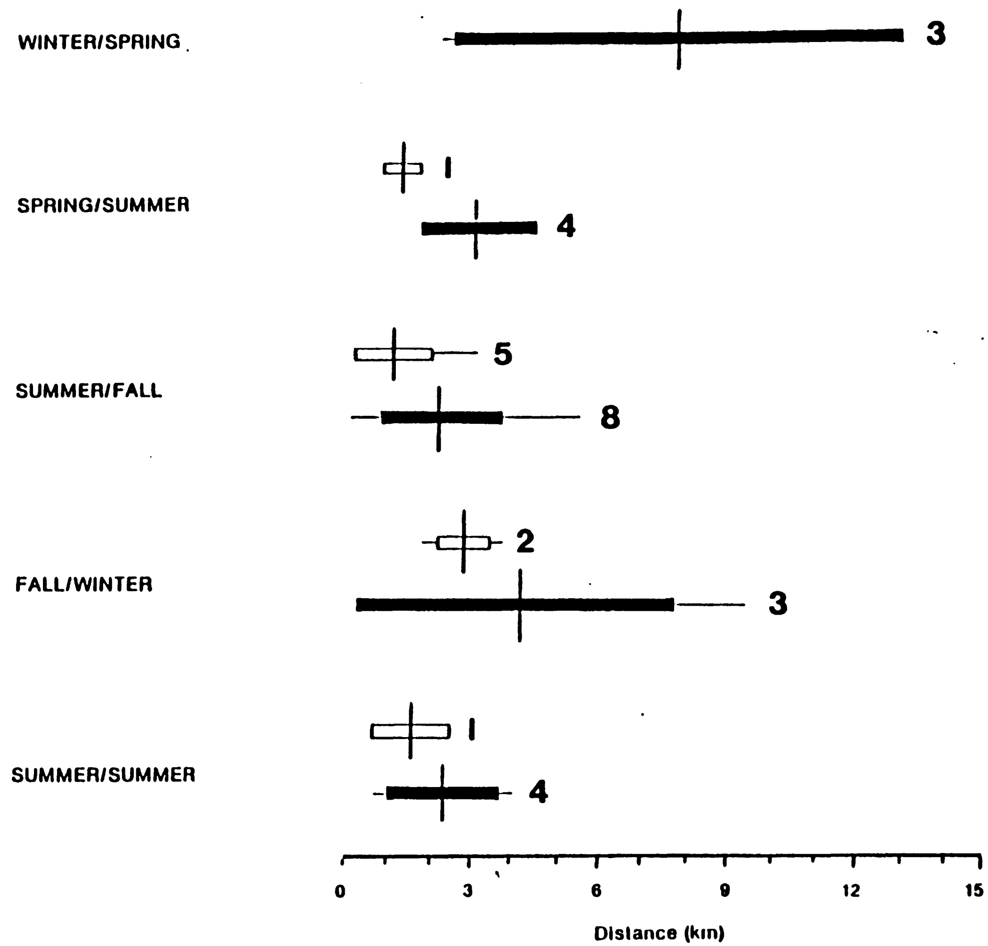

Fig. 5. Movement between seasonal activity centers for pronghorns on PCMS, Colorado, 1983-1984. Vertical line = mean, horizontal bar = standard error, horizontal line = range, number of animals per calculation shown at right.

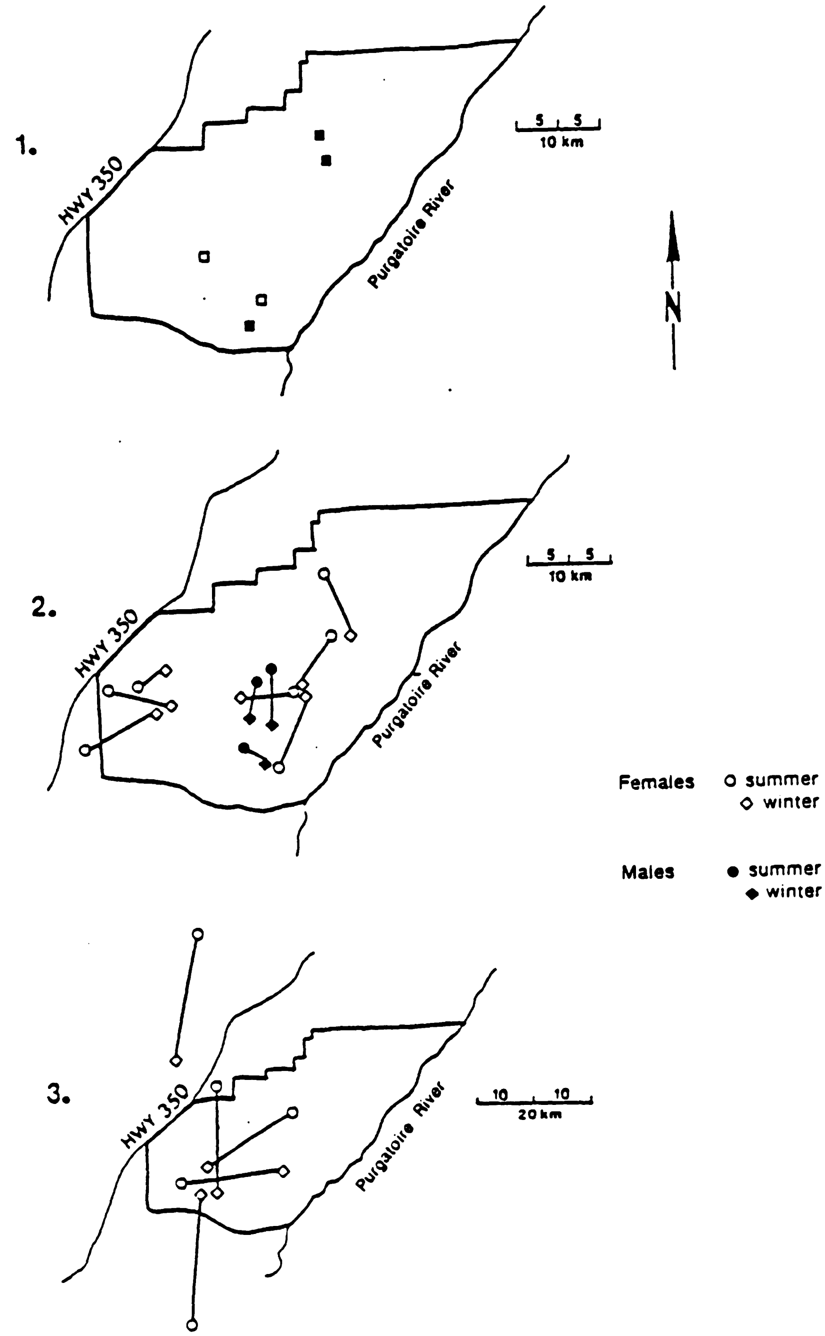

Fig. 6. Movement between summer and winter activity centers for pronghorns on PCMS, Colorado, 1983-1984. (1) movements < 2 km, (2) movements 3-10 km, (3) movements > 10 km.

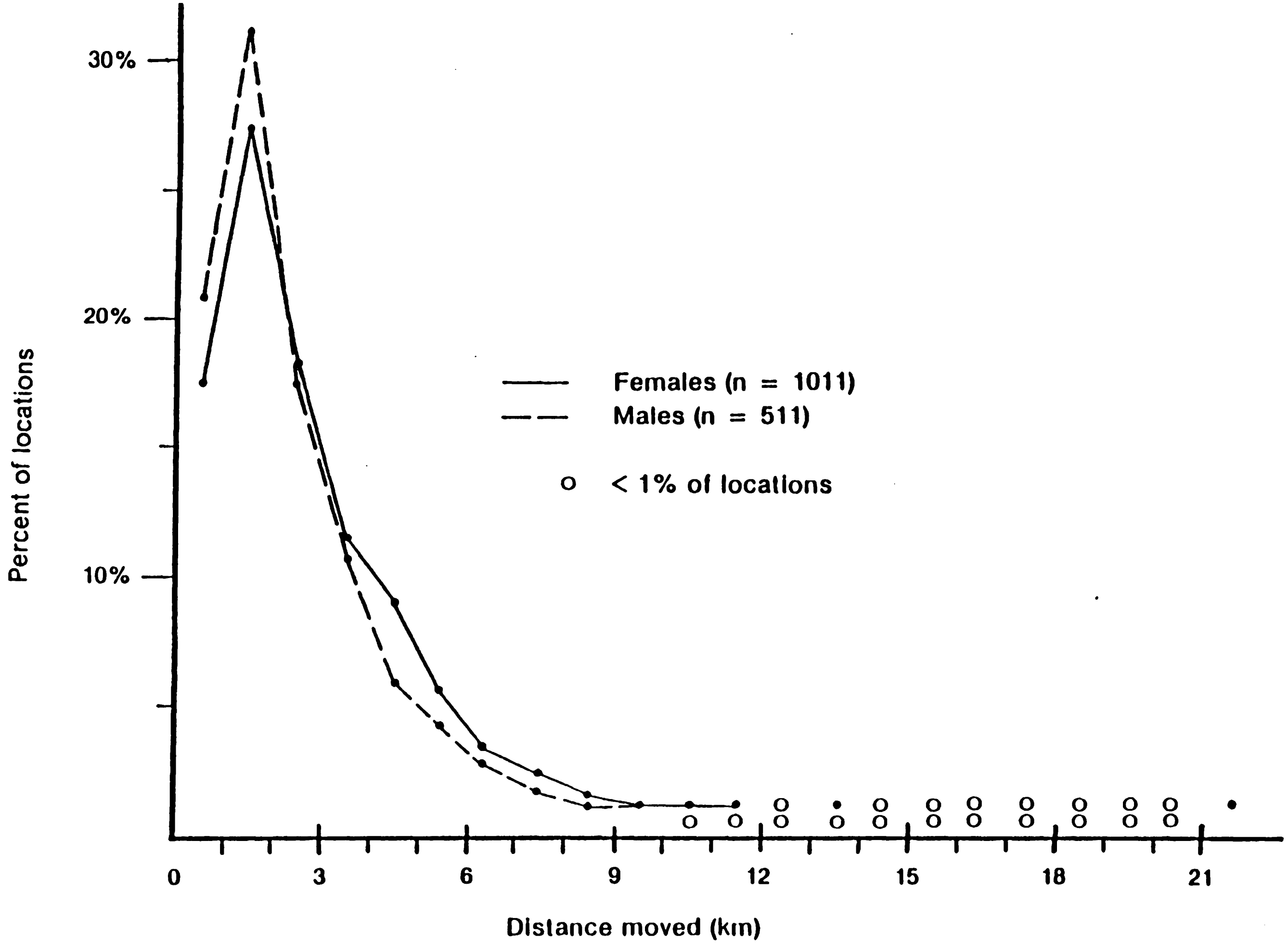

Fig. 7. Frequency distribution of distance moved weekly for pronghorns on PCMS, Colorado, 1983-1984.

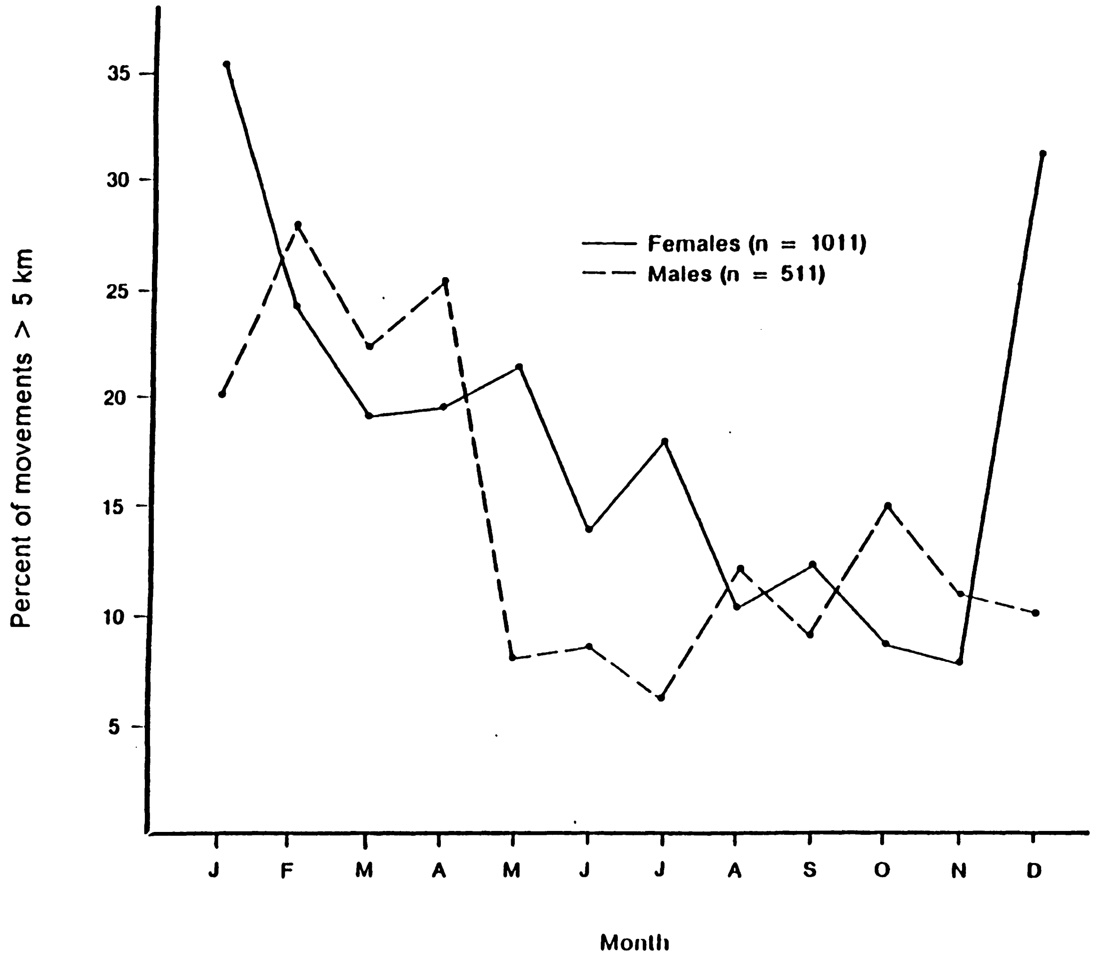

Fig. 8. Frequency of weekly movements > 5 km for pronghorns on the PCMS, Colorado, 1983-1984.

Habitat Use

Map Accuracy

The overall measure of agreement between the PCMS habitat map and the 869 ground truthed points, based on the Kappa statistic (K) (Bishop et al. 1975:393-400), was 0.787 (Table 10). SHGR (K=0.642) and SHCY (K=0.659) were lowest in agreement, while PJLM (K=0.943) was highest.

Females

I tested the null hypothesis that pronghorns used habitat in equal proportion to its availability. Adult female pronghorns used woodland habitats less than expected in all seasons except PJLM in the fall (Table 11). Cholla grassland was used more than expected in winter, and open grassland was used more than expected year round. Female pronghorns used shrub grassland in proportion to availability in winter and spring, but less than expected in summer and fall. Yucca grasslands were prefered in spring and fall.

Mapping cells that contained more than one vegetation type were classified as "edge", and the various edge combinations were analyzed separately (Table 12). Edge as a whole was used in proportion to availability, but not when divided into subcategories. Females used woodland/open grassland edge less than expected in all seasons, but used cholla/open grassland more than expected in all seasons. The latter represents low density cholla and use averaged 40% greater than expected. Shrub/open grassland was used more than expected in spring.

The mean similarity index (Pianka 1974) for habitat use by female pronghorns from season to season was 0.98 (S.E.=.005), for both pure stand habitat and edge habitat use.

Table 10. Measure of agreement between the digitized habitat map and 869 ground truth points on PCMS, Colorado.

Habitat Type	Kappa[a]
PJLM	.943
PJSS	.911
CHGR	.826
OPGR	.779
SHGR	.708
YUGR	.643
SHCY	.659
Overall	.787

a-Based on the Kappa statistic (Bishop et al. 1975). 1.0 = 100% agreement.

Table 11. Frequency of female pronghorn locations in 8 vegetation types during all seasons on the Piñon Canyon Maneuver Site, Colorado, 1983-1984.

Vegetation Type	Expected Freq.	Observed Frequency			
		Winter	Spring	Summer	Fall
PJLM	.045	.005*	.011*	.007*	.037
PJSS	.154	.011*	.014*	.027*	.026*
CHGR	.086	.192*	.094	.116	.096
OPGR	.448	.514*	.588*	.595*	.551*
SHGR	.016	.009	.011	.004*	.006*
YUGR	.004	.016	.028*	.002	.035*
SHCY	.006	.000	.000	.004	.004
EDGE	.240	.250	.250	.243	.240
N[a]		551	350	686	457
X^2[b]		198.1*	127.7*	142.1*	186.5*

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

a-N = total number of locations.

b-X^2 tested the hypothesis that use = availability.

Table 12. Frequency of female pronghorn locations in 5 edge habitats during all seasons on the Piñon Canyon Maneuver Site, Colorado, 1983-1984.

Edge Type	Expected Freq.	Observed Frequency			
		Winter	Spring	Summer	Fall
Woodland/shrubs	.058	.007*	.011*	.054	.054
Shrubs/shrubs[c]	.008	0	0	0	0
Woodland/open grass	.451	.203*	.148*	.287*	.252*
Cholla/open grass	.377	.681*	.670*	.593*	.558*
Shrubs/open grass	.105	.108	.170*	.066	.135*
N[a]		138	88	167	111
X^2[b]		59.9*	45.6*	34.4*	21.3*

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

a-N = total number of locations.

b-X^2 tested the hypothesis that use = availability.

c-"Shrubs" include shrub grassland, yucca grassland, and shrub canyon habitats.

Males

Males used wooded habitats less than expected in all seasons except PJLM in spring (Table 13). Cholla grasslands were prefered in all seasons except spring, and open grassland was preferred in all seasons except winter. Yucca grassland was used in proportion to availability year round, while shrub grassland was used less than expected in spring and summer. Edge was used more than expected in winter.

Even though edge was used in proportion to availability during all seasons except winter, use within the 5 edge categories was not random (Table 14). Adult males used woodland/open grassland edge less than expected in all seasons; but used cholla/open grassland edge more than expected in all seasons, the latter averaged 49% greater than expected. Shrub/open grassland edge was used less than expected in winter and spring, and woodland/shrub edge was used less than expected in summer.

The mean similarity index for habitat use among seasons for male pronghorns was 0.96(S.E.=0.02) for pure stands and 0.99 (S.E.=.01) for edge habitats. The mean similarity index of habitat use between sexes within each season was .99 (S.E.=0.005) for pure stands, and .98 (S.E.=0.004) for edge habitats.

Fawns

Pronghorn fawns did not use their habitat randomly (Table 15). Both woodland categories were used less than expected by fawns, as were SHGR and edge as a whole. Open grassland and cholla/open grassland edge were preferred by fawns, but shrub/open grassland edge was avoided. Fawns used their habitat similarly (SI=.98, S.E.=0.0) during June, July, and August.

Table 13. Frequency of male pronghorn locations in 7 vegetation types during all seasons on the Piñon Canyon Maneuver Site, Colorado, 1983-1984.

Vegetation Type	Expected Freq.	Observed Frequency			
		Winter	Spring	Summer	Fall
PJLM	.045	.008*	.027	.016*	.014*
PJSS	.154	.012*	.012*	.014*	.017*
CHGR	.086	.175*	.103	.143*	.153*
OPGR	.448	.466	.603*	.571*	.584*
SHGR	.016	.012	.004*	.004*	.011
YUGR	.004	0	.008	.007	.007
EDGE	.240	.326*	.240	.244	.213
N[a]		251	252	557	281
X^2[b]		72.9*	52.9*	128.5*	68.4*

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

a-N = total number of locations.

b-X^2 tested the hypothesis that use = availability.

Table 14. Frequency of male pronghorn locations in 5 edge habitats during all seasons on the Piñon Canyon Maneuver Site, Colorado, 1983-1984.

Edge Type	Expected Freq.	Observed Frequency			
		Winter	Spring	Summer	Fall
Woodland/shrubs	.058	0	0	.007*	.033
Shrubs/shrubs[c]	.008	0	0	0	0
Woodland/open grass	.451	.120*	.213*	.184*	.233*
Cholla/open grass	.377	.844*	.720*	.713*	.650*
Shrubs/open grass	.105	.036*	.066*	.095	.067
N[a]		82	61	136	60
X^2[b]		75.7*	31.6*	69.6*	20.1*

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

a-N = total number of locations.

b-X^2 tested the hypothesis that use = availability.

c-Shrubs include shrub grassland, yucca grassland, and shrub canyon habitats.

Table 15. Frequency of fawn pronghorn locations in 8 habitat types and 5 edge types during summer on the Piñon Canyon Maneuver Site, Colorado, 1983-1984.

Vegetation Type	Expected Freq.	Summer Obs. Freq.
PJLM	.045	.002*
PJSS	.154	.020*
CHGR	.086	.071
OPGR	.448	.755*
SHGR	.016	.002*
YUGR	.004	0
SHCY	.006	.004
EDGE	.240	.147*
N[a]		551
X^2[b]		234.5*
Woodland/shrub	.058	.098
Shrub/shrub[c]	.008	0
Woodland/open grass	.451	.320
Cholla/open grass	.377	.540*
Shrub/open grass	.105	.037*
N[a]		81
X^2[b]		15.2*

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

a-N = total number of locations.

b-X^2 tested the hypothesis that use = availability

c-Shrubs include shrub grassland, yucca grassland, and shrub canyon habitats.

Discussion

Home Range

Pronghorn home range size varied seasonally, and may have been dependent on biological and/or physical features. It is generally thought that ungulate ranges are smallest in winter, but on our study area winter ranges were 2 and 5-fold larger than summer ranges for females and males, respectively. Amstrup (1978) in Montana and Wyoming reported winter ranges 3-fold larger than summer ranges for pronghorns. Hoskinson and Tester (1980) in Idaho, reported that in years of severe winter conditions pronghorn winter ranges were similar in size to summer ranges, but in mild winters, winter range size was as much as 4-fold greater than summer range.

The distance moved and the size and location of pronghorn winter range have been attributed to winter severity, snow depth, moisture content of the vegetation, and availability of food (Martinka 1967, Bromley 1977, Hoskinson and Tester 1980, Rosendale et al. 1980). In Idaho, fall migration appeared to be stimulated by moisture content in the vegetation, while spring migration was stimulated by the break up of snow cover (Hoskinson and Tester 1980). Bruns (1977) termed pronghorn winter activity in Alberta "conservative", attributing low winter activity to low ambient temperatures and difficulty of movement in deep snow. Thus, pronghorns apparently minimize activity during harsh conditions to conserve energy.

Bruns (1977) concluded that pronghorns migrate if forced by extreme weather or habitat conditions. However, migration stops as soon as these conditions are moderated. This migration may involve movement to more favorable habitat, or movement to milder climatic conditions. Winter conditions in southeastern Colorado are relatively mild. The average winter (Dec.-Feb.) temperature is 5° C and the annual precipitation is 28 - 33 cm, thus winter conditions do not appear to limit PCMS pronghorns winter movement.

Migratory movements have not been noted in southern pronghorns (Buechner 1950, Hoover et al. 1959). However, during dry seasons, pronghorns need mobility to reach free water and succulent forage (Autenreith 1978). Hoover et al. (1959) reported notable shifts in some Colorado pronghorn herds as a drought became more severe and water sources dried up, but these movements were not migratory. Thus, the drier conditions in southern Colorado may help explain the large summer ranges on PCMS compared to northern populations.

Quantity and quality of food may also influence the degree of pronghorn movement (Hoskinson and Tester 1980). Limited winter diets have been implicated as the cause of larger winter movements in many areas of pronghorn range (Amstrup 1978, Bayless 1969, Cole and Wilkins 1958). Limited food may in part explain the large winter ranges and the large percent of weekly movements in winter > 5 km for PCMS pronghorns. Unfortunately, the quantity and quality of foods consumed by PCMS pronghorns have not been evaluated.

Amstrup (1978) and Bruns (1977) suggested that pronghorns not hampered by physical conditions may move to take advantage of beneficial conditions, such as quality forage or thermal cover. Large home ranges on PCMS may indicate low or patchy availability of forage, especially in winter.

Large spring ranges like that described by Amstrup (1978) in Montana and Wyoming were not found on PCMS. On the contrary, fall and spring ranges were smaller than summer ranges in all cases. However, Pyrah's (1970) discussion of the "spring shuffle" of erratic movements in Montana, is similar to the increase in middle and long distance movements documented in male pronghorn on PCMS in spring.

Movement Patterns

The timing and length of pronghorn seasonal movements vary with altitude, latitude, and range condition (O'Gara 1978). Pronghorn on PCMS were relatively sedentary, i.e. 86% of the radio marked adults remained on the study area year round. Seasonal movements were generally short and non-migratory, unlike those documented for northern pronghorns that are subject to harsher winter conditions (Bruns 1977, Hoskinson and Tester 1980, Martinka 1967).

Both males and females on PCMS were relatively stationary within home ranges, as evidenced by small "core" areas. In addition, 65% of all weekly movements were < 3 km. The largest weekly movement was 41 km by an adult female in summer, but such movements are infrequent and not characteristic of PCMS pronghorns. Females moved farther than males, and younger animals were more likely to move longer distances. Fidelity to summer range by PCMS pronghorns was high. In contrast, Amstrup (1978) and Kitchen (1974) in Montana, and Autenrieth (1976) in Idaho reported general shifts in summer areas between years.

Free flowing or standing water is available to pronghorns on PCMS at intervals within 5 km. Nineteen eighty-three was a relatively dry year, and daily summer movements to water were regular, but did not appear any longer than summer movements in 1984 when water was more abundant. Sundstrom (1968) and Boyle (1984) found most pronghorns in Wyoming within a 5.0 - 6.5 km radius of water.

The variation in pronghorn movement patterns across their entire range may be related to annual precipitation or evaporation and its influence on biomass production (Fig. 9). Though summer home range size for pronghorns showed little relationship to evaporation rates ($r^2=.19$), there was an apparent relationship between summer home range size and annual precipitation ($r^2=.76$). Pronghorns in wetter regions of their range generally had small home ranges and long distances between seasonal ranges (Gregg 1955, Cole and Wilkins 1958, Kitchen 1974, Amstrup 1978), while pronghorns in drier regions, including PCMS, generally had larger ranges and relatively short movements between seasonal ranges (Buechner 1950, Beale and Smith 1973, Hailey 1979, Tucker 1979, Yoakum 1980, Hoskinson and Tester 1980, Bromley pers. comm.) On drier ranges biomass production is lower, thus pronghorns may need to move over larger areas to obtain adequate forage. Conversely, areas of higher precipitation and biomass production make it possible for pronghorns to obtain adequate forage within small home ranges.

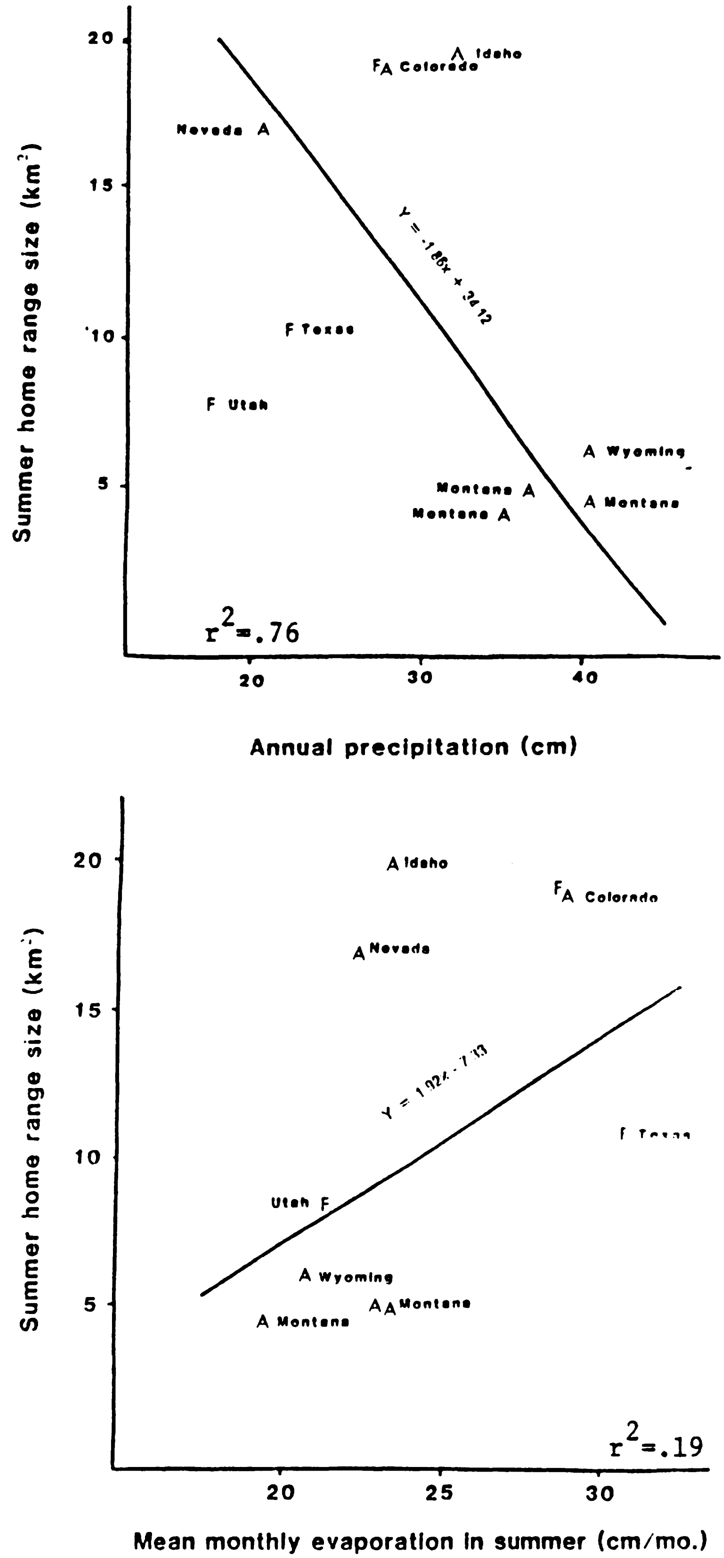

Fig. 9. Relationship between pronghorn summer home range size and annual precipitation and evaporation. A = adults, F = fawns.

Seasonal movements may also be linked to availability of forage to pronghorns during critical periods. On wetter ranges, forage can be unavailable to pronghorns during winter because of snow cover, forcing animals to move until conditions improve (Bruns 1977). Drier ranges rarely have periods of snow cover where forage remains unavailable.

With this model of pronghorn movement patterns we would expect extreme southern populations in very arid areas to be almost nomadic. Animals would have to travel often to obtain adequate forage. Since regeneration time is relatively long for plants in arid regions, pronghorns also risk denuding the vegetation if they become too sedentary. Very little movement data on extreme southern populations are currently available.

Movement patterns may also be influenced by habitat availability and relative distribution of preferred habitats. PCMS pronghorns consistently preferred CHGR, OPGR, and cholla/open grassland edge habitats. These habitats comprise 62% of the study area, are distributed throughout, and are available to pronghorns year round. Long movements were not necessary to find preferred habitats.

Habitat Use

Use of habitats by pronghorns is related closely to food habits and seasonal availability of food. Southern pronghorns use more forbs and less browse than northern pronghorns (O'Gara 1978). Hlavachick (1966) in Kansas documented pronghorns using 40% cactus, 22% grass (mostly wheat), 20% forbs, and 18% browse. High use of cactus by pronghorns was also documented by Larsen (1966) in New Mexico. Although we did not analyze food habits of pronghorn on the PCMS, 100% of the trap mortalities in winter (N=18) contained cholla fruits in the rumen.

Both males and females preferred cholla grassland habitat types in winter, and the use of low density cholla areas in the cholla/open grassland edge habitat was highly preferred by males and females in all seasons. Cholla grassland provides both cover and a good source of winter food for pronghorns. Sparse cholla (cholla/open grassland edge) areas may be preferred to dense cholla areas for ease of travel and visibility.

Woodland habitats and woodland edge habitats were used consistently less than expected by males, females, and fawns, and do not appear important to pronghorn for either food or cover. Both males and females preferred the open grassland habitat in all seasons. Open grassland habitat provides a variety of forb food plants throughout the growing season, and half shrub species (broom snakeweed, rabbitbrush, and winterfat) are available during the non-growing season.

Shrub grassland habitats were never preferred by either males or females, and were actually used less than expected in winter and spring by females, and spring and summer by males. Many shrub edge categories were also used less than expected. Although the species compostion of the shrub grassland habitats include important browse species for pronghorns, such as saltbush and rabbitbrush, other factors may explain the low use of these areas. Shrub grassland areas are usually found along arroyos, where much bare ground and loose soil exists. Coyotes (*Canis latrans*) frequently den in these arroyos, and both coyotes and bobcats (*Lynx rufus*) use these drainages as travel corridors (E.Gese, pers. comm.). A combination of high predator activity and the low visibility in shrub areas may explain the low use of these habitats on the PCMS.

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CHAPTER THREE

CAPTURING PRONGHORNS WITH A HAND-HELD NET GUN

Abstract

A hand-held netgun was used to capture pronghorns (*Antilocapra americana*) on the Piñon Canyon Maneuver Site (PCMS) in southeastern Colorado. Eighteen adult pronghorns were captured successfully during April and December of 1984 and March 1985. Two of 20 (10%) captured or pursued for capture died of injuries. Capture myopathy (CM) was not obvious during our operations. The net gun proved to be a useful tool for capturing individual pronghorns under certain conditions. Rapid processing of captured animals, experienced pi-

lots and gunner, small herds (3-12 individuals) and open grassland hbitats all contributed to the success of this technique.

Introduction

Free-ranging pronghorn antelope (*Antilocapra americana*) have been captured in corral type traps, linear tangle nets, drop nets, and cannon nets (Amstrup et al. 1980, Moody et al. 1982). These methods are time consuming, labor intensive, and nonselective with respect to age and sex (Barrett et al. 1982). Drug immobilization of pronghorns can be selective but is limited by the effectiveness of available drugs (Copeland et al. 1978, Amstrup et al. 1980) and generally high mortality rates (10-19%) (Amstrup and Segerstrom 1981, Autenrieth et al. 1981).

Barrett et al. (1982) described the use of a hand-held net gun for capturing large mammals including pronghorns. Of the 5 pronghorns captured by Barrett et al. (1982), 1 of 3 adult females broke its leg, and both fawns captured developed acute metabolic stress; no adult males were captured. They concluded that pronghorns are captured easily with this technique; however, considerable effort may be required to reduce CM and losses from trauma. I evaluated the hand-held net gun for capturing pronghorns and suggest ways to reduce stress and injury related mortality.

Methods

During April and December 1984 and March 1985 pronghorns were captured on the Piñon Canyon Maneuver Site (PCMS) in southeastern Colorado using a hand-held net gun (Coda Enterprises, Mesa, Ariz.).

The maneuver site consists of flat to rolling short grass prairie with pinyon pine (*Pinus edulis*)-one seed juniper (*Juniperus monosperma*) woodlands scattered throughout. All captures were executed from a UH-1 (Bell 212) military helicopter. Pilots and gunner had experience in the net-gun capture of mule deer (*Odocoileus hemionus*) and coyotes (*Canis latrans*). Pronghorn herds were hazed until they "lined out" in single file. A low approach was made, and one of the trailing animals was shot. After a successful shot the aircraft landed and processing began within 30 sec. All captured animals were aged, eartagged, radio collared, and released in < 10 min.

Results and Discussion

Eighteen (11 male and 7 female) adult pronghorns were captured successfully using a hand-held net-gun during 3 capture operations on the PCMS, Colorado (Table 8). Twenty-two capture attempts were unsuccessful. Temperatures ranged from 7 to 24 C during the gunning, and snow was not present to slow the animals' movement.

Mean pursuit time for successful attempts ($\bar{x}$ = 3.75 min) was less ($P < 0.05$) than mean pursuit time for unsuccessful attempts ($\bar{x}$ = 5.75). Twenty shots were fired to capture 18 pronghorns on successful attempts, and 14 shots were fired during unsuccessful attempts. Mean group size for successful captures ($\bar{x}$ = 6.22) was less ($P < 0.05$) than the mean group size for unsuccessful attempts ($\bar{x}$ = 11.20); handling time for captured animals averaged 6.2 min.

Two of 20 pronghorns (10%) captured or pursued for capture died. One pronghorn fell during hazing and broke its leg, the other fell and broke its neck when tangled in the net. Captured pronghorns did not show obvious signs of shock or CM. One adult female was found dead and scavenged 4 weeks after capture, the remaining pronghorns were alive > 12 weeks

Table 16. Results of using a hand-held net gun for capturing pronghorns on the Piñon Canyon Maneuver Site, Colorado, 1984-1985.

	Successful	Unsuccessful
Capture attempts (male,female)	18	22
Male	11	
female	7	
Pursuit time (min)		
$\bar{x}$	3.8	6.1*
Range	1.5 - 10	1 - 12
Shots fired	2	14[a]
Handling time (min)		
$\bar{x}$	6.3	
Range	2 - 12	
Group size		
$\bar{x}$	6.2	11.2*
Range	2 - 12	2 - 28
Injuries/mortality	1	1[b]

(*) Significant at $P < 0.05$.

a-Two missfires included.

b-Broken leg during pursuit.

after capture. Five females captured in March and April were pregnant and carried their fawns to full term.

The net gun technique worked best on small groups of pronghorn. Groups > 12 remained bunched, and a clean shot on a single animal could not be made. Lone pronghorns or pairs dodged and darted under the helicopter, making capture difficult.

Only 1 pronghorn was captured from each herd. I initially used 12 min as a cut-off point for hazing animals but switched to a 7-min maximum after signs of stress were noted in hazed animals during the 1st capture operation.

Seventeen of the 22 unsuccessful capture attempts occurred during December and March as I attempted to recapture radio-marked animals with expired transmitters. The average group size during December for unsuccessful attempts ($\bar{x} = 15.7$) was greater ($P < 0.05$) than the average group size for successful attempts ($\bar{x} = 8$). The average group size during March 1985 and April 1984 for successful attempts was 4.8 and 5.7 and for unsuccessful attempts 4.9 and 8.3, respectively. Selection of specific individuals was not possible in December or March with the 7-min hazing time limit, but selection of a specific sex and age class was possible. Capture of specific animals in April I984 was not attempted.

Barrett et al. (1982) cautioned that net guns may not be appropriate for the capture of species susceptible to CM such as pronghorns. However, CM was not obvious in this study and at most could have been involved in the latent death of 1 individual.

Chalmers and Barrett (1977) suggested that cold weather capture may reduce the occurrence of CM. Barrett et al. (1982) successfully captured pronghorns in February when temperatures ranged from -3 to -6 C. However, J.C. deVos (pers. commun.) successfully captured 10 Sonoran pronghorns (*A. a. sonoriensis*) with net guns at ambient temperatures < 28 C with no signs of CM and 100% survival.

CM was noted in corral-trapped pronghorns on PCMS during 1983-84 and accounted for mortality in 10 of 335 captured animals (3%). Twenty-two of 335 pronghorns (6%) died of traumatic injuries during the same corral trapping operations. Chalmers and Barrett (1977) reported 6% mortality related to CM in corral trapped pronghorns in Alberta. Keeping hazing time and handling time to a minimum, and avoiding the capture of fawns, may reduce the possibility of CM when net-gun capturing.

The lack of topographic relief or thick shrub cover on the study area may have enhanced our capture success. The only animal injured during pursuit was located in a dense stand of walkingstick cholla (*Opuntia imbricata*) and small soapweed (*Yucca glauca*). All other animals were pursued in open grassland or sparse cholla habitats.

In this study the net gun proved to be a useful tool for capturing pronghorns, if adequate recognition is given to the need for very rapid processing of captured animals. Experienced pilots and gunner, herd sizes > 2 but < 12, and establishment of a maximum hazing time apparently all contributed to the success of this technique for capturing free-ranging pronghorns.

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SUMMARY

This study was the first phase of a long-term study designed to measure the impacts of military training on free ranging pronghorns. The objective of the study was to gather baseline information on the population dynamics, movements, and habitat use of pronghorns prior to military operations, and provide a factual basis for subsequent management.

During 1983-1985 forty-seven adult and 32 newborn fawn pronghorns were radio-marked, 247 adults were color collared or ear tagged on PCMS. Using aerial strip transect and random quadrat surveys we estimated a summer population in 1983, 1984, and 1985 of 694 ($0.96/km^2$), 690 ($0.96/km^2$), and 657 ($0.91/km^2$), respectively. Late summer fawn:doe ratios in 1983, 1984, and 1985 were 36:100, 22:100, and 31:100 respectively, which are generally lower than reported elsewhere. Annual buck:doe ratios averaged 40:100.

The adult female pregnancy rate on PCMS was approximately 98%; the mean litter size for females $>$ 1.5 years was 1.9, and the sex ratio of fetuses and captured newborn fawns was not different than 1:1.

Pronghorn fawn mortality in the first 5 months after birth was high, 89% and 80% in 1983 and 1984 respectively. As in other areas, coyotes were the major predator on fawns. Seventy-one percent of the PCMS fawn mortality was due to coyote predation. Adult mortality was 18% in 1983, and 32% in 1984; coyote predation and hunting accounted for 79% of the adult mortality. Adult pronghorns were particularly susceptible to predation during periods of deep snow, when movement was restricted.

The annual rate of increase (λ) calculated from age-specific fecundity and survival schedules was 0.806, indicating a 19% decline in the population. In contrast, the annual rate of increase observed from the population estimates was 1.01. High immigration resulting from improved range conditions in response to removal of cattle, may help explain this disparity between the two estimates.

The population is fundamentally non-migratory, although some seasonal range shifts were observed. With a dramatic increase in foot, vehicular, and aerial activity by the military, pronghorn movements may be greatly affected. Home ranges for pronghorns were extremely variable within and between sexes and seasons. Winter range was 2-fold and 5-fold larger than summer range for females and males respectively. Females moved farther between range centers than males in all comparisons. All range shifts > 10 km were by females. Movement from summer to winter range was of three types: 24% was < 2 km; 48% was 3-10 km; and 28% was > 10 km. Yearling females showed the greatest seasonal shifts. Sixty-five percent of weekly movements were < 3 km.

Some degree of habitat destruction is inevitable with mechanized military maneuvers. Information regarding pronghorn habitat availablity and use prior to training will be important for mitigation and management of the species. Females preferred OPGR in all seasons, and CHGR in winter. YUGR was preferred in spring and again in fall, and use of cholla/open grassland edge was 40% greater than expected. Females used habitats similarly between season.

Males preferred OPGR in all season but winter and preferred CHGR in all seasons but spring. Use of cholla/open grassland edge was 49% greater than expected. Males used habitats similarly between seasons, and males and females had similar habitat use patterns in each season. Fawns preferred OPGR, and cholla/open grassland edge; and avoided woodland and shrub habitats.

Management

Population Aspects

Pronghorns are an important big game species in Colorado. All pronghorn rifle licenses are limited and require application; demand is greater than availability. The Piñon Canyon Maneuver Site offers excellent hunting opportunities for southeastern Colorado, where much of the land is in private ownership and often inaccessible.

Maintainence of a huntable pronghorn population will reflect a concern by the Army to make wildlife resources on their lands available for public use. During this study the population at best remained stable under a conservative harvest regime. The harvest quotas should remain conservative until the pronghorns response to military maneuvers is understood.

Detailed population data should continue to be gathered on PCMS pronghorns, since management recommendations are likely to change as the affects of maneuvers begin to show.

Habitat Aspects

Eighty-six percent of the radio-marked pronghorn were year round residents of PCMS, the distribution and seasonal home ranges crossed training unit boundaries. Effective habitat management for pronghorns on PCMS must address their year round requirements on a site-wide basis.

Pronghorns on PCMS had a strong preference for cholla grassland and especially sparse cholla found in the cholla/open grassland edge catagory. Cholla fruits were frequently fed upon through the fall and winter, and pronghorns frequently bedded amongst cholla in winter. Sparse cholla areas may have been preferred over dense cholla because they allow greater visibility, and still have the benefit of food and thermal cover.

Cholla plants on PCMS showed vigorous growth right after being damaged, but one year later most plants were dead. Changes in availability of these preferred habitats may effect the density, distribution, and movements of the PCMS pronghorns. Establishment of protection areas for cholla therefore would be beneficial.

OPGR was also consistently preferred habitat by pronghorns. The diversity of forbs found in OPGR throughout the growing season were an important part of the pronghorns diet. Tank traffic on the OPGR sites tends to reduce vegetative cover and expose top soil to invading weed species. These invaders are not necessarily benificial to pronghorns. Consideration should be given to revegetating the damaged range in plants suitable for pronghorns.

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APPENDIX

Table I. Means (S.E.) for weight, total length, girth, and hind foot of 13 captured pronghorn fawns on PCMS, Colorado, 1983.

Age	Weight (kg)	Length (cm)	Girth (cm)	Hind foot (cm)
> 1 day old (N=4)	3.44 (.30)	64.25 (2.25)	38.87 (2.73)	25.5 (.33)
1-2 days old (N=5)	3.50 (.22)	63.03 (2.41)	38.7 (.99)	25.9 (.75)
3-4 days old (N=3)	4.46 (.20)	66.33 (1.33)	43.3 (2.33)	26.33 (.33)
5-6 days old (N=1)	5.15	69.0	43.0	29.0

Table II. Means (S.E.) for weight, total length, ear, and hind foot of 19 captured pronghorn fawns on PCMS, Colorado, 1984.

Age	Weight (kg)	Length (cm)	Ear (cm)	Hind foot (cm)
> 1 day old (N=6)	3.47 (.23)	64.65 (.65)	8.37 (.29)	24.8 (.60)
1-2 days old (N=8)	3.83 (.23)	66.41 (3.16)	8.58 (.42)	26.0 (.77)
3-4 days old (N=3)	4.32 (.12)	68.83 (.76)	9.3 (.17)	26.5 (.52)
5-6 days old (N=2)	5.1 (.07)	73.5 (.71)	9.35 (.21)	28.75 (.35)

Table III. Means (S.E.) for total length, chest girth, and shoulder height of 119 adult pronghorns corral trapped in January and February 1983, on PCMS, Colorado.

	Females		Males	
	N	Mean (se)	N	Mean (se)
Total length				
Fawn	15	132 (11)	14	134 (6)
1.75 yrs	19	145 (5)	7	148 (6)
2.75 +	43	147 (4)	21	151 (6)
Chest girth				
Fawn	15	87 (7)	14	88 (6)
1.75 yrs	19	95 (4)	7	92 (17)
2.75 +	43	99 (5)	21	97 (3)
Shoulder height				
Fawn	15	87 (3)	14	83 (4)
1.75	19	87 (4)	7	89 (1)
2.75 +	43	89 (4)	21	90 (5)

Table IV. Means (S.E) for total length, hind foot, tail, ear, and horn of 51 hunter-killed pronghorns in September of 1983 and 1984, on PCMS, Colorado.

	Males		Females	
	N	Mean (se)	N	Mean (se)
Total length				
Fawn	3	116.3 (17.6)	.4	.
1.5 yrs	10	134.9 (4.6)	2	134.5 (7.7)
2.5 +	32	133.0 (7.0)	4	141.2 (6.1)
Hind foot				
Fawn	3	38.5	.	.
1.5 yrs	10	41.7 (.94)	2	42 (.71)
2.5 +	31	42.2 (1.2)	4	39.3 (1.9)
Tail				
Fawn	3	9 (3)	.	.
1.5	8	10.7 (1.2)	2	10.5 (.71)
2.5 +	30	10.9 (1.6)	4	10.7 (.58)
Ear				
Fawn	3	14.3 (.58)	.	.
1.5	8	13.8 (1.1)	2	15 (0)
2.5 +	30	14.3 (.73)	3	13.5 (1.7)
Horn				
1.5	9	13.5 (1.3)	.	.
2.5 +	30	33.1 (4.8)	.	.

Table V. Reproductive characteristics of female pronghorns on the Pinon Canyon Maneuver Site, Colorado, during 1983-1984.

Date	Age	Corpora lutea		Fetus		Sex		Crown rump		Mem. fused	Caruncle #	
		L	R	L	R	L	R	L	R		L	R
11 July 83	5	0	0	.	.	.	.	.	.	.	.	.
22 Sept 84	1.5	2	1	.	.	.	.	.	.	.	.	.
22 Sept 84	1.5	0	0	.	.	.	.	.	.	.	.	.
22 Sept 84	2.5	0	0	.	.	.	.	.	.	.	.	.
22 Sept 84	4.5	3	2	.	.	.	.	.	.	.	.	.
22 Sept 84	Fawn	0	0	.	.	.	.	.	.	.	.	.
25 Sept 83	4.5	L	2	.	.	.	.	.	.	.	.	.
25 Sept 83	Fawn	0	0	.	.	.	.	.	.	.	.	.
26 Sept 83	4.5	2	1	.	.	.	.	.	.	.	.	.
8 Dec 84	4.5	1	3	1	1	F	F	9.5	9.5	no	65	57
9 Dec 84	4.5	2	4	1	1	M	M	7.1	7.5	no	47	51
10 Dec 84	1.5	2	3	1	1	M	M	70	71	no	45	44
14 Jan 84	3.5	3	1	1	1	M	M	12.5	12.6	yes	80	74
14 Jan 84	4.5	2	2	1	1	F	F	12.8	13.5	yes	53	52
15 Jan 84	4.5	2	3	1	1	F	M	13.8	14.6	yes	60	55
15 Jan 84	Fawn	0	0	.	.	.	.	.	.	.	.	.
1 Feb 83	4.5	2	2	1	1	M	M	19.2	18.5	yes	80	89
2 Feb 83	4.5	2	3	1	1	F	M	16.8	18.3	yes	77	59
3 Feb 84	2.5	2	1	1	0	M	.	16.5	.	yes	60	.
25 Apr 83	4.75	2	5	1	1	M	M	35.5	38.5	.	42	45

L = Left ovary lost.

Table VI. Serological results from drive trapped pronghorns on the PCMS, Colorado, 1983-1984. Percent of samples testing positive.

	N	Brucella[a] abortus	Bluetongue[b] EDH complex	Leptospirosis[c] 6 serovars
1983	57	0	35%	0
1984	72	0	65%	0

a - Tested against *B. abortus* using the card agglutination test.

b - Tested by immunodiffusion against bluetongue viral antigen.

c - Tested by microscopic agglutination against six serovars; canicola, icterohaemorrgagiae, grippotyphosa, pyrogenes, pomona, and hardjo.

Table VII. Clinicochemical values of corral trapped pronghorns on the PCMS, Colorado, 1983-1984.

	N	Mean	Min	Max
CPK (iU/l)	29	523	64	2578
SGOT (iU/l)	29	643	332	1860
Glucose (mg/dl)	29	222	50	341
Creatinine (mg/dl)	29	2	.6	2.6
Urea N (mg/dl)	29	25	18	40
SGPT (iU/l)	29	150	80	342
Potassium (mmol/l)	29	6.36	5.1	11.2

SGOT = Serum glutamic-oxalacetic transaminase

SGPT = Serum glutamic-pyruvic transaminase

SCPK = Serum creatine phosphokinase

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