AN ABSTRACT OF THE THESIS OF

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Title: Behavior, Home Range, and Habitat Use of Pronghorn Translocated to Tallgrass Prairie in East-central Kansas

Abstract approved: Elmer J. Finck

Twenty-five radio-collared pronghorn were monitored from 27 January - 20 September 1991 to determine post-release dispersal, home ranges, mortality, diurnal activity, and habitat use after translocation to a tallgrass prairie in east-central Kansas. Habitat characteristics of the tallgrass prairie study area were measured and compared to recommended characteristics for pronghorn in grassland/sagebrush habitat (Yoakum 1980). Analysis of habitat characteristics indicates that the tallgrass prairie study area exceeds the recommendation for vegetative cover, grass cover, and grass species richness. In addition, annual precipitation exceeds recommendations for grassland/sagebrush habitats used by pronghorn. Twenty-two pronghorn dispersed in a westward (homeward) direction from the release site, with a maximum dispersal of 14 km from the release site. Individual home ranges during fawning and rut life cycle seasons were variable within and among seasons. Mean home ranges of all females, adult females, yearling females, and all individuals did not differ ($\underline{P} > 0.05$) within seasons. A 2% trap mortality was observed for all animals captured. A 12% post-release mortality of radioed pronghorn was observed; all mortalities were yearling females which died within 10 days after release. A 21% mortality of radioed animals was observed for the entire study. Females were observed loafing 57% of the time during both fawning and rut seasons. Foraging constituted 33% and 40% of diurnal observations during fawning and rut, respectively. During fawning and rut, daily activities of females were not evenly distributed among three daily time periods. Foraging was more common in the morning and late afternoon, whereas, loafing was more common during midday. Female pronghorn used slopes more than available and used uplands less than available during both seasons. My results indicate that restoration efforts for pronghorn to the tallgrass prairie ecosystem may prove successful. However, further work is warranted to determine if the tallgrass prairie can sustain a viable population.

BEHAVIOR, HOME RANGE, AND HABITAT USE OF PRONGHORN TRANSLOCATED TO TALLGRASS PRAIRIE IN EAST-CENTRAL KANSAS

A Thesis
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Master of Science

by

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Approved for Major Department

Approved for Graduate Council

Approved by Major Advisor

Approved by Committee Member

Approved by Committee Member

Approved by Committee Member

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PREFACE

This thesis has been prepared in a style appropriate for the Journal of Wildlife Management.

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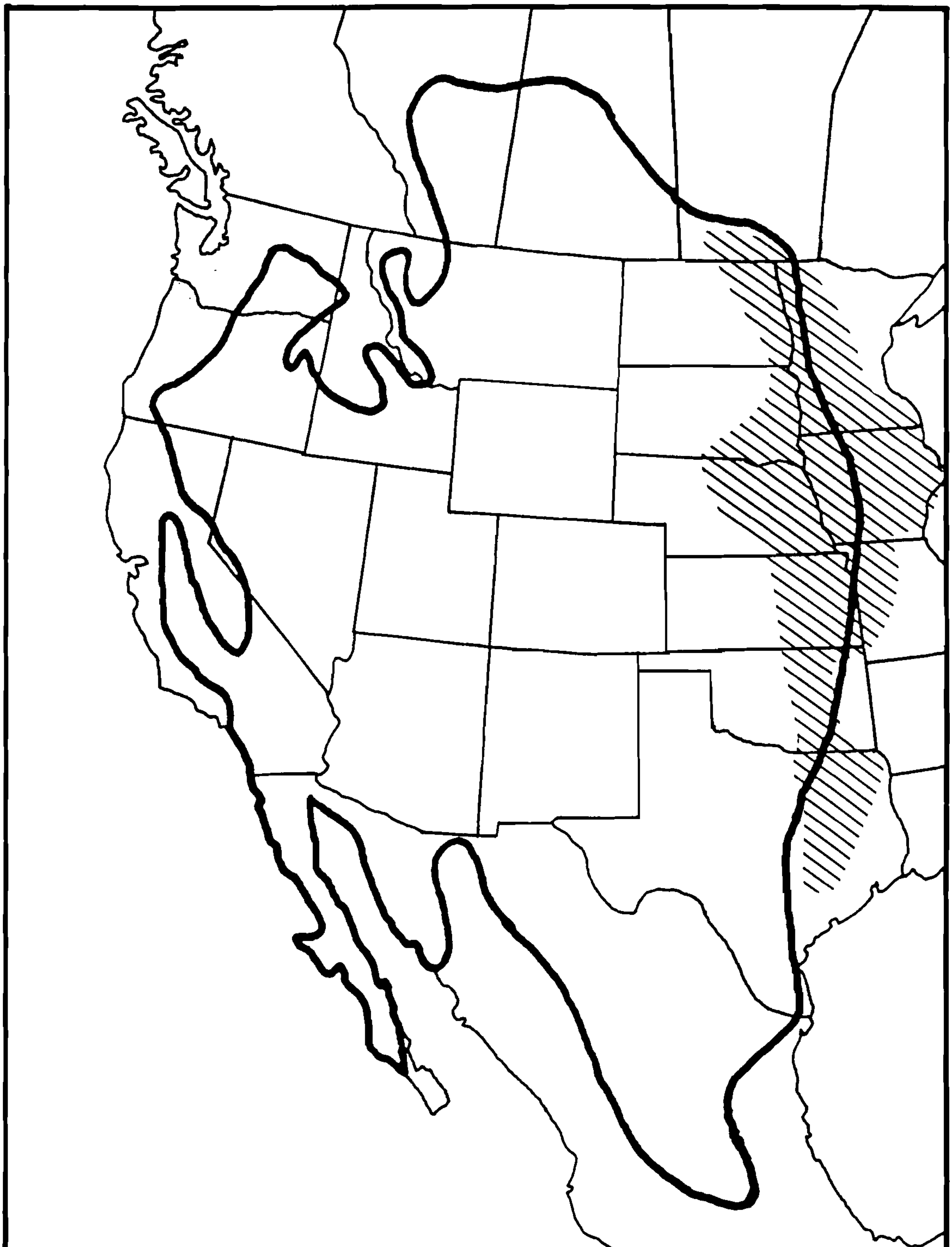
INTRODUCTION

Pronghorn (*Antilocapra americana*) roamed in vast herds throughout the western half of the United States, extending into the tallgrass prairie (TGP) ecosystem of Kansas, Iowa, North Dakota, South Dakota, Nebraska, Oklahoma, and Minnesota (Fig. 1), until the western advancement of Europeans in the late 1800's (Nelson 1925, Einarsen 1948, Yoakum 1978*a*). With European settlement came the destruction of native grasslands and the massive slaughter of North American ungulates. Even though pronghorn populations were historically estimated to be equal to or greater than bison (*Bos bison*), the population fell to 13,000 by 1920 (Nelson 1925). In Kansas, for example, as few as 10 pronghorn remained in the extreme south-west portion of the state in 1923 (Nelson 1925, Yoakum 1978*a*, 1986).

These alarmingly low numbers created the need for intensive management for pronghorn, including research on their ecology, harvest regulations, and protection of remaining suitable habitat. Beginning in 1922, the first extensive census of pronghorn recorded 26,700 individuals in the United States (Nelson 1925). During the next decade, pronghorn populations increased to over 130,000, and by 1976 the population reached 404,400 individuals. Today the population stands at more than a half million, primarily because of translocating pronghorn back into previously occupied areas with suitable habitat. In Kansas, 1,100

Fig. 1. Historical distribution of pronghorn (solid line) and tallgrass prairie (shaded area) in North America. (adapted from Nelson 1925 and Reichman 1987).



individuals inhabited the western most counties in 1976, (Yoakum 1978a, 1986) with the present population estimated to be 1,600 (K. Sexson, Kans. Dep. Wildl. and Parks, pers. commun.). Eighty percent of all pronghorn inhabit shortgrass prairie or a grassland/shrubland mixture (Yoakum 1978a).

Translocating pronghorn to areas where they once occurred is a management technique in effect since 1924 (Nelson 1925). One of the first successful transplants of pronghorn to its former range occurred in New Mexico in 1937 (Howard et al. 1984). Since then, techniques have improved to make translocations more efficient and successful. Additionally, extensive research has determined habitat requirements of pronghorn, aiding in the selection of transplant sites (Yoakum 1980). Although the success of a translocation is attributed to the establishment of a population into formerly occupied areas, not every translocation is successful (Hlavachick 1970, Sexson and Choate 1981, Delmonte and Kothmann 1984, Goldsmith 1987).

Kansas Department of Wildlife and Parks (KDWP) began a restoration program for pronghorn in 1964, releasing 75 individuals in Wallace County (Hlavachick 1970). Other translocations followed (1966-1967) in Barber, McPherson, Ellsworth, and Edwards counties but were unsuccessful (Sexson and Choate 1981). By 1969, the only successful translocation was in Wallace County, which had an annual population increase of 17% (Hlavachick 1970).

In an attempt to establish a population in the eastern most part of their former range, KDWP released 37 pronghorn in 1978 and another 98 individuals in 1979, to the Flint Hills (FH) region of the TGP in Chase County, Kansas (Funk 1978, 1979, Sexson and Choate 1981). Additional releases of 127 and 24 animals followed in 1982 and 1983, respectively. Bi-annual surveys since 1986 estimated the population to be approximately 46 individuals.

No other translocations in the TGP are being attempted at the present time. However, future translocations are anticipated on Konza Prairie Research Natural Area, in the northern FH of Riley County, Kansas (T. Barkley, Kansas State Univ., pers. commun.) and the Prairie Preserve in Osage County, Oklahoma (B. Hamiliton, pers. commun.). Both sites are property of The Nature Conservancy.

Renewed interest was expressed by KDWP for restoring pronghorn to once occupied areas in Kansas that have potential for population growth, like the TGP. The KDWP pronghorn strategic plan states a need "to restore animals to areas determined to be suitable for their expansion and to determine limiting factors acting on the population" (KDWP 1987). This creates an opportunity to study pronghorn ecology and behavior in an ecosystem that had been depleted of pronghorn until 1978. In addition, it will provide information for future translocation attempts in other areas of the TGP.

Since only 46 from the 286 animals previously released occur in the FH, KDWP wants to identify limiting factors that may be involved in establishing a viable population in this region. By releasing pronghorn into their former range in the FH region, it would be possible to complete a post-release survey and to monitor their behavior following release. A post-release survey is essential to determine success or failure of the translocation and to evaluate the translocated population's future potential and viability (McCarthy and Yoakum 1984, Nielsen 1988, O'Gara and Yoakum 1990). Since information is lacking on TGP pronghorn, other than bi-annual aerial surveys to estimate population size, I wanted to document the characteristics of pronghorn behavior in TGP following translocation. Therefore, I determined post-release dispersal, home range establishment, habitat use, and behavior of translocated pronghorn in a TGP of east-central Kansas.

STUDY AREA

The study area was located in south-east Chase and south-west Lyon counties, Kansas, in the 10,000 km^2 FH region, the largest continuous tract of TGP remaining in North America (Fig. 2). The study area was semi-confined by the Kansas Turnpike, Interstate 35, on the south and east, the Cottonwood River on the north, and the South Fork of the Cottonwood River on the west (Fig. 3). Along the turnpike there was a net-woven wire fence, flush at ground level, to deter pronghorn from getting onto the turnpike. The rivers were deeply channeled and were bordered by riparian habitat that could deter pronghorn from crossing. The study area within the semi-confined prairie was 335 km^2.

The study area was privately owned by several landowners and was grazed by cattle (Bos tarus) from 15 April through 15 October, with some cattle being removed by 15 August (Horak 1985). The entire area was burned in late March 1991 and is usually burned annually. Less than 2% of the study area was cultivated, mainly occurring in the river valleys. Human access was limited; two county roads ran north/south on each end of the study area and a road maintained for Williams Pipeline Company (Tulsa, OK) ran east/west in the southern part of the study area.

The topography of this region of the FH was gently to steep sloping hills (1 to 50%), with moderately deep soils that have a subsoil of silty clay and shallow clay loam (Neill 1974). Elevation ranges from 335 - 460 m.

Fig. 2. Location of Flint Hills (shaded) and study area (darkened area) in Chase and Lyon counties, Kansas.

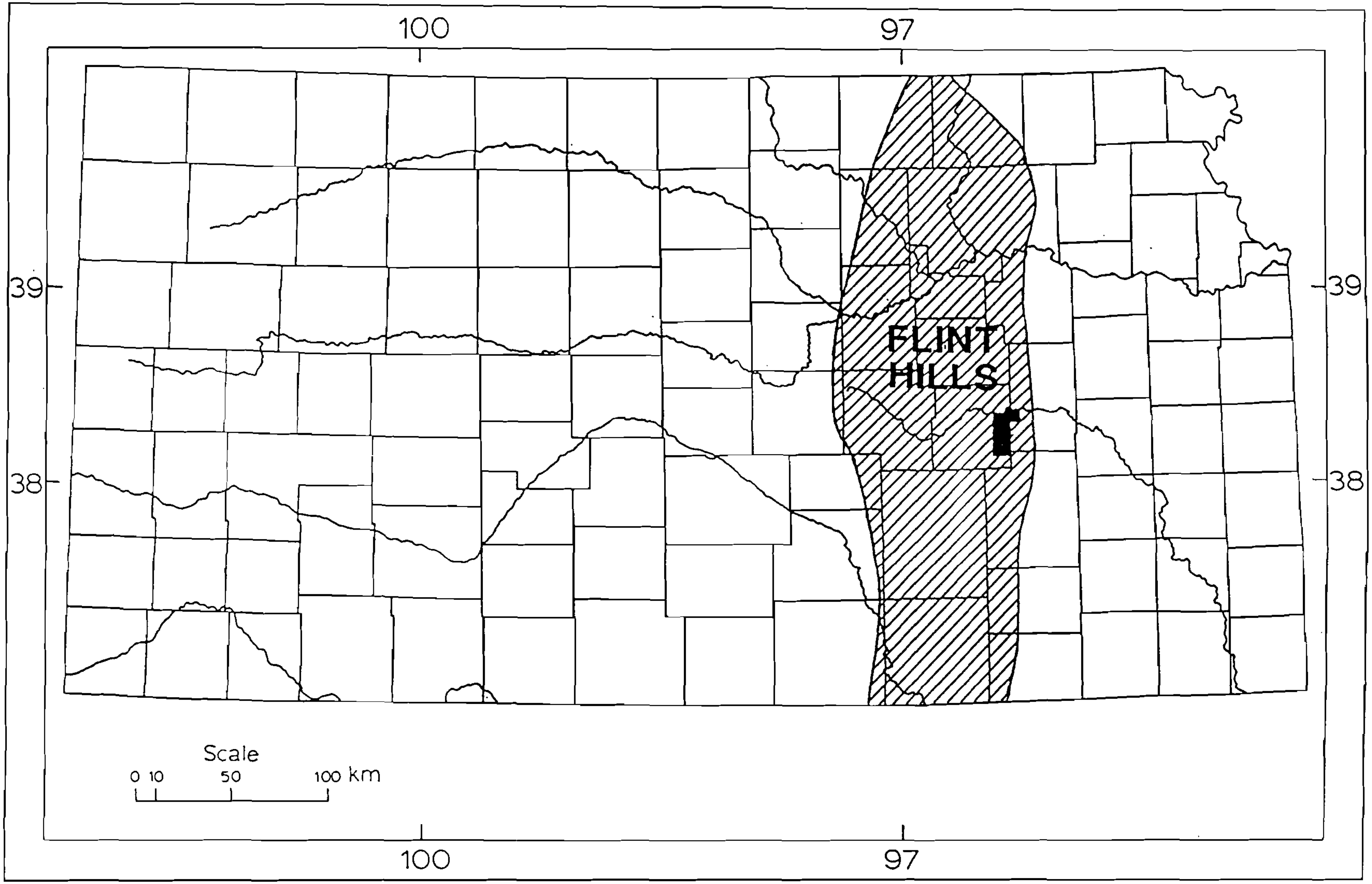
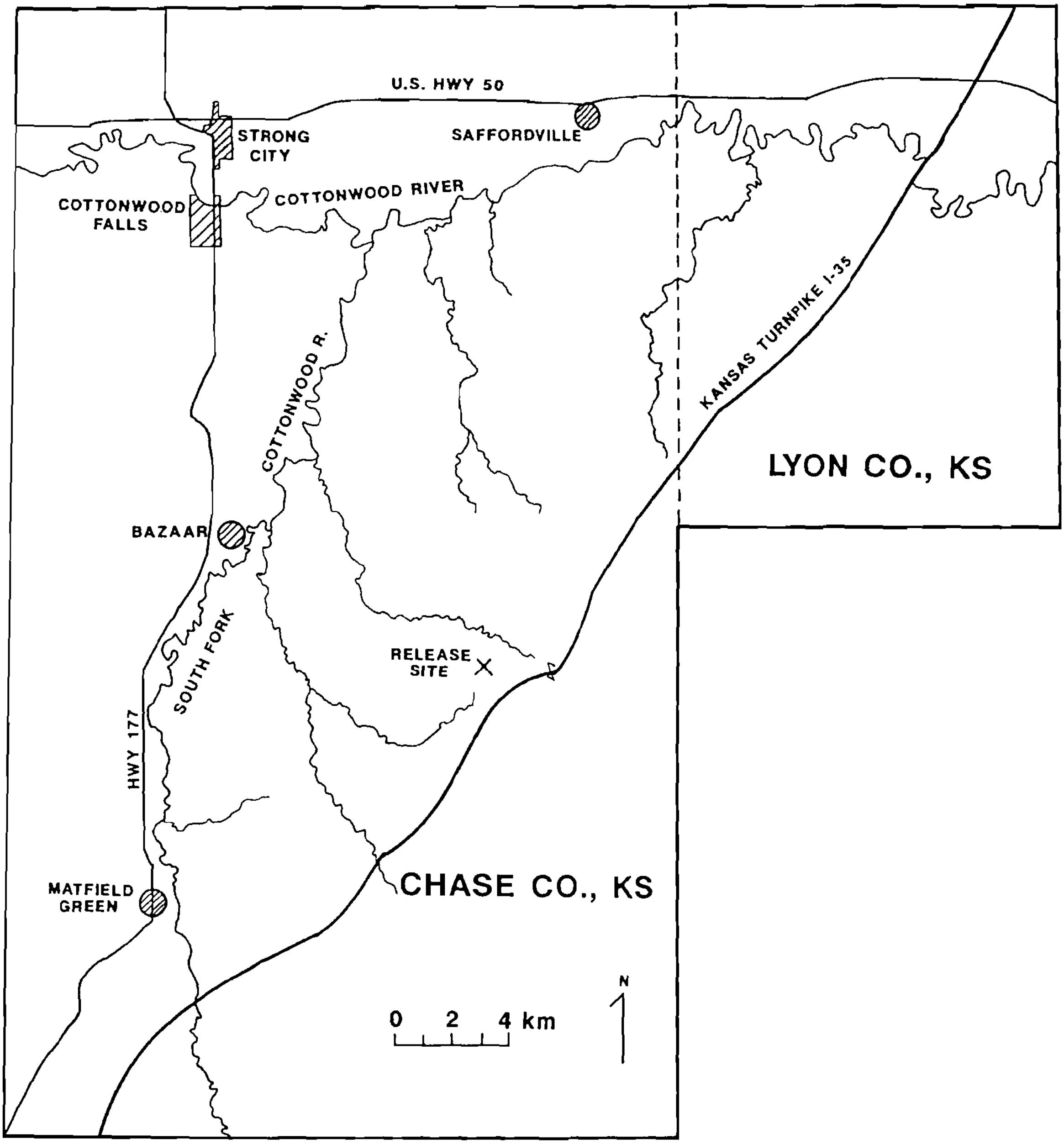

100
97
39
38
FLINT
HILLS
Scale
0 10
50
100 km

Fig. 3. Layout of Flint Hills study area in Chase and Lyon counties, Kansas.


U.S. HWY 50
STRONG CITY
SAFFORDVILLE
COTTONWOOD FALLS
COTTONWOOD RIVER
COTTONWOOD R.
KANSAS TURNPIKE I-35
LYON CO., KS
BAZAAR
SOUTH FORK
RELEASE SITE
HWY 177
MATFIELD GREEN
CHASE CO., KS
0 2 4 km
N

Warm season grasses, little bluestem (*Andropogon scoparius*), big bluestem (*A. gerardii*), indian grass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*) and cool season grasses, Kentucky bluegrass (*Poa pratensis*), Scribner's panicum (*Panicum scribnerianum*), and Canada wild rye (*Elymus canadensis*) were the dominant vegetation of the study area. Black sampson (*Echinacea angustifolia*), western ironweed (*Vernonia baldwinii*), broomweed (*Xanthocephalum dracunculoides*), common ragweed (*Ambrosia artemisiifolia*), sunflower (*Helianthus* spp.), and goldenrod (*Solidago* spp.) were common forbs. Lead plant (*Amorpha canescens*) was the most abundant shrub.

The water supply on the site was generally dependable and of good quality. Ponds were constructed on intermittent springs and watersheds to provide a reliable source of water for livestock. Fifty-five year average annual rainfall was 80.4 cm, with 71% falling between April and September (Neill 1974). During 1991, annual rainfall was 62.0 cm, with 62% falling between April and July.

Summers were characterized as hot and dry, winters as cold and dry. The mean annual maximum temperature during 1991 and the 55 year average was 20.2 C. Mean annual minimum temperature during 1991 and the 55 year average was 7.2 C and 6.5 C, respectively. Snowfalls were light, averaging 42.5 cm per year, often melting within a week (Neill 1974).

METHODS AND MATERIALS

Pronghorn were captured in a shortgrass prairie 24 km south of Lamar, Colorado, on the morning of 26 January 1991. Pronghorn were herded by helicopter into a modified corral-type drive trap (Fisher 1942, Spillett and Zobell 1967) and were captured with a drop net to immobilize the animals. Fifty individuals were captured in three attempts. All animals were aged (Hoover et al. 1959, Dow and Wright 1962), sexed, and marked for identification. Yearlings and adults received yellow numbered eartags, and 25 individuals were fitted with radio collars (Advanced Telemetry Systems, Ibanti, MN) weighing 590 g (Table 1). The remaining individuals were fitted with orange numbered collars made of rubber with numbers corresponding to the yellow eartags. Fawns received orange numbered eartags.

Yearlings and adults were tranquillized with 1.0 cc of acepromazine and injected with 1.0 cc of ivomec for parasites. Fawns received 0.5 cc of each (McKenzie 1984). Blood samples were tested for brucellosis, all were negative. Horn tips were clipped on adult males to prevent injury to others during transporting.

Once processed, pronghorn were separated by age and sex, loaded into compartmentized stock trailers, and transported 580 km to the release site in Chase County, Kansas. The animals were released immediately upon arrival at the release site at 2230 hours on the same day of capture.

Table 1. Number of pronghorn captured and radio-collared (in parenthesis) 26 Jan 1991 near Lamar, Colorado and released in Chase County, Kansas, by age and sex.

	Age		
Sex	Adults	Yearlings	Fawns
Male	3 (2)	0	8
Female	19 (13)	11 (10)	9

Using a hand-held H-element antennae, I tracked pronghorn from 27 January - 20 September 1991 to monitor post-release dispersal and home ranges during two annual life cycle seasons. Home ranges were determined for post-release dispersal (27 Jan - 12 Mar), fawning (28 Apr - 29 Jun), and rut (1 Aug - 20 Sep) seasons. Total home range was also determined for the entire study period (27 Jan - 20 Sep). Locations were recorded by visual observations to the nearest 1 ha on 7.5 minute United States Geological Survey (USGS) maps via Universal Transverse Mercator coordinates. One location was recorded per day.

Upon direct observation of the animal, activity, daily time period, and topographic site were recorded. Three daily time periods were used: morning (sunrise - 1100), midday (1101 - 1500), and late afternoon (1501 - sunset). Topographic sites were identified as uplands, lowlands, and slopes. Only observations that did not influence the animal's location, activity, or topographic site were included in analysis.

Habitat characteristics described by Yoakum (1972, 1978a, b, 1980), and Kindschy et al. (1982) as important components in pronghorn range were determined using the modified step-loop (Owensby 1973, Wilk 1984). A minimum of two, 100 point transects were completed in March, May, July, and September to determine percent basal cover of grass, forb, shrub, openness, and litter on each topographic site.

Vegetation height was measured at every tenth point on each transect.

Number of water sources was obtained from USGS maps and ground truthing. Fence height from ground level to bottom wire was measured at fences within the study area.

McPAAL software (M. Stuwe and C. E. Blohowiak, Conserv. Res. Cent., Natl. Zool. Park, Smithsonian Inst., Front Royal, Va., 1985) with minimum convex polygon (Mohr 1947) was used to determine home range size of radio-collared pronghorn. A minimum of 25 locations was used to determine home range in each season. Using SAS/STAT (SAS Inst. Inc. 1987), analysis of variance (ANOVA) and Duncan's multiple range test were used to determine differences in home ranges among dispersal, fawning, and rut seasons. Mann-Whitney U-test was used to detect differences between movement patterns displayed during post-release dispersal, and to analyze differences between age and sex groups within each home range season. Distances traveled from the release site were measured as straight lines.

Log-likelihood ratio for contingency tables was used to test if female foraging and loafing observations were evenly distributed among the three daily time periods during fawning and rut seasons. Chi-square goodness-of-fit analysis was used to test the null hypothesis that activities were evenly distributed on each topographic site based on availability. Availability of each topographic site was determined by tracing these sites from USGS maps to velum paper, then cutting and weighing each to determine the percent of each topographic site. If the null hypothesis was rejected, Neu et al. (1974) was used to test for preference or avoidance of activity on a particular topographic site. Null hypotheses were rejected at $\underline{P} < 0.05$.

RESULTS

Post-Release Dispersal

Twenty-two of 25 radioed individuals dispersed from the release site in a homeward, westward to south-west direction. Distance traveled from the release site 12 h following release ranged from 0 - 6 km. Three radioed pronghorn that did not move from the release site were found alone, while group size increased with distance from release site. Group size of radioed animals the day after release was 2, 3, 5, and 10. Group size and composition changed frequently thereafter. Radioed pronghorn did not coalesce with existing animals until 10 days after release.

The 22 animals exhibited five different movement patterns. Movement patterns were directional (east-west), to and from the release site. Individuals that exhibited the same movement pattern did not remain together or follow the same route during dispersal.

Mean home range size for movement patterns ranged from 10.9 to 53.3 km^2, with a maximum distance traveled from release site ranging from 7.5 to 10.0 km (Table 2). Individual home ranges varied from 5.5 to 64.7 km^2 (Table 3), with 73% being <40 km^2. No difference in home range size among age and sex classes was detected within dispersal type using Mann-Whitney U-test ($\underline{P}$ < 0.05). Movement patterns and home ranges overlapped and all were confined to the southern half of the study area.

Table 2. Post-release dispersal patterns, mean minimum convex polygon home range size (km^2), and maximum distance traveled (km) from release site of radio-collared pronghorn translocated to Chase County, Kansas, 1991.

Movement Pattern	n	Home Range Size $\bar{x}$	SE	Maximum Distance
Release site (RS)	3	21.7	3.1 A[a]	7.5
Westward	5	10.9	3.2 A	9.1
RS - Westward	8	32.8	1.4 B	9.6
Westward - RS	4	53.3	4.0 C	8.5
West - RS - West	2	43.4	1.6 C	10.0

[a] Means followed by same letter are not different ($\underline{P}$ > 0.05) between movement patterns using Mann-Whitney U-test.

Table 3. Individual minimum convex polygon home range sizes (km^2) of radio-collared pronghorn translocated to Chase County, Kansas, 1991.

		Season			
ID	Age/Sex	Dispersal	Fawning	Rut	Total
Y01	A/F	5.53	11.05	3.78	16.43
Y02	Y/F	6.37	----	----	----
Y03	A/F	18.38	NA	NA	79.55
Y04	A/F	39.45	4.14	3.49	40.78
Y06	A/F	16.81	46.91	----	----
Y07	A/F	27.84	4.78	6.70	38.88
Y08	Y/F	41.75	14.18	5.30	60.39
Y10	A/F	45.00	13.08	13.20	59.19
Y11	A/F	33.53	18.54	27.08	61.20
Y12	Y/F	48.68	87.96	27.93	124.99
Y13	Y/F	32.03	???	???	???
Y14	A/F	20.39	8.54	5.34	29.30
Y15	A/M	5.53	8.38	8.16	15.36
Y16	Y/F	47.24	27.33	12.30	60.88
Y17	A/F	52.70	37.53	NA	110.02
Y18	A/F	31.83	22.26	9.03	41.43
Y20	Y/F	32.73	19.74	9.53	51.36
Y21	A/F	25.57	22.27	5.00	54.52

Table 3 Continued.

		Season			
ID	Age/Sex	Dispersal	Fawning	Rut	Total
Y22	A/F	31.20	33.54	10.62	50.33
Y23	A/F	36.27	3.38	4.02	37.73
Y24	Y/F	18.98	23.68	6.75	56.21
Y25	A/M	64.69	24.72	22.69	99.11

A = adult, Y = yearling, F = female, M = male, NA = not enough observations to calculate home range for period, ---- = dead, ??? = status unknown.

Home Ranges

Individual home ranges were variable within and among annual life cycle seasons (Table 3). Home ranges during fawning were not significantly smaller for all post-release dispersal groups (Table 4). Home ranges during rut were not significantly smaller than fawning for all groups analyzed, except all females. The two adult males were quite different from one another, although not tested for significance because of sample size. Home ranges were <9 km^2 for one adult male (Y15), while the other male (Y25) was $\geq$22 km^2 during the three seasons. Home ranges of yearling females were larger, though not significantly, during fawning than dispersal, while all other groups gradually decreased from dispersal to rut. No difference was detected among age and sex classes within fawning or rut seasons.

Home ranges for the entire study period were not significantly different for all individuals, all females, adult females, yearling females, and adult males (Table 5). Yearling females had the largest home range for the entire study, however not significantly. Home ranges for all groups for the entire study period were significantly larger than home ranges during dispersal, except for adult males which were not tested.

Home ranges were located in the southern half of the study area (Figs. 4, 5) during fawning and rut seasons. One yearling female (Y12) made a four day journey during fawning

Table 4. Mean minimum convex polygon home ranges (km^2) by season of radio-collared pronghorn translocated to Chase County, Kansas, 1991.

Group	Dispersal		Fawning		Rut	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
All Females	30.6	3.0 A[a,b]	23.5	5.0 A	10.0	2.0 B
Adult	29.6	3.5 A	18.8	4.1 AB	8.8	2.3 B
Yearling	32.5	5.8 A	34.6	12.1 A	12.4	4.1 A
Adult Males[c]	35.1	29.6	16.6	8.2	15.4	7.3
All Animals	31.0	3.3 A	22.7	4.5 AB	10.6	1.9 B

[a] Means followed by same letter are not different ($P > 0.05$) within row using ANOVA.

[b] No difference ($P > 0.05$) was detected in mean home range size between age and sex groups within season using Mann-Whitney U-test.

[c] Not tested

Table 5. Mean minimum convex polygon home ranges (km^2) for the entire study of radio-collared pronghorn translocated to Chase County, Kansas, 1991.

Group	Home Range Size	
	$\bar{x}$	SE
All Females	57.3	6.6[a]
Adult	51.6	7.1
Yearling	70.8	13.7
Adult Males	57.2	41.9
All Animals	57.3	6.7

[a] = No difference ($P > 0.05$) in mean home range size among groups using Mann-Whitney U-test.

Fig. 4. Home range location (solid line) of all radio-collared pronghorn translocated to Chase County, Kansas, 1991, during fawning (28 Apr - 29 Jun). Dashed line represents four day movement of Y13.

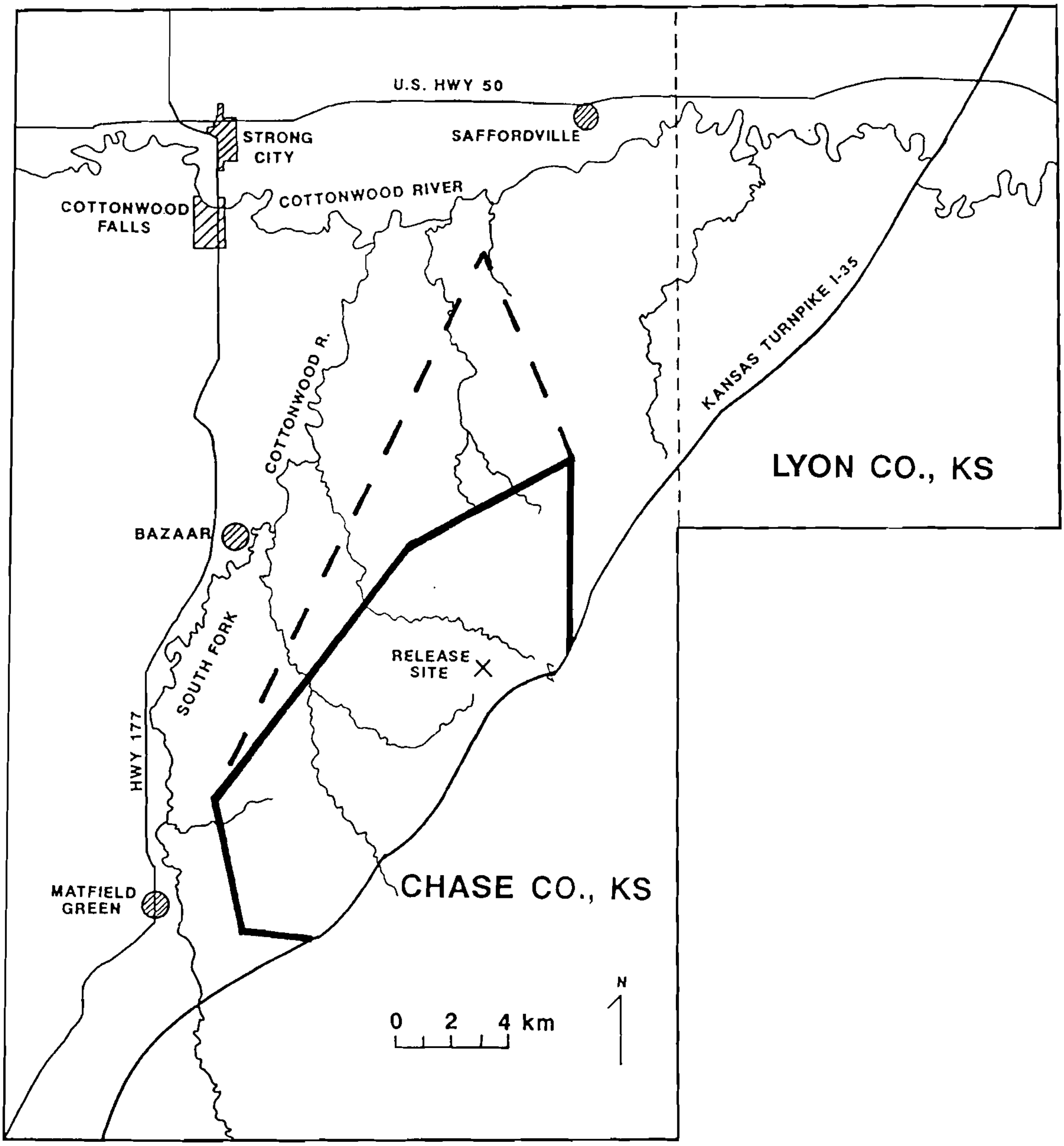
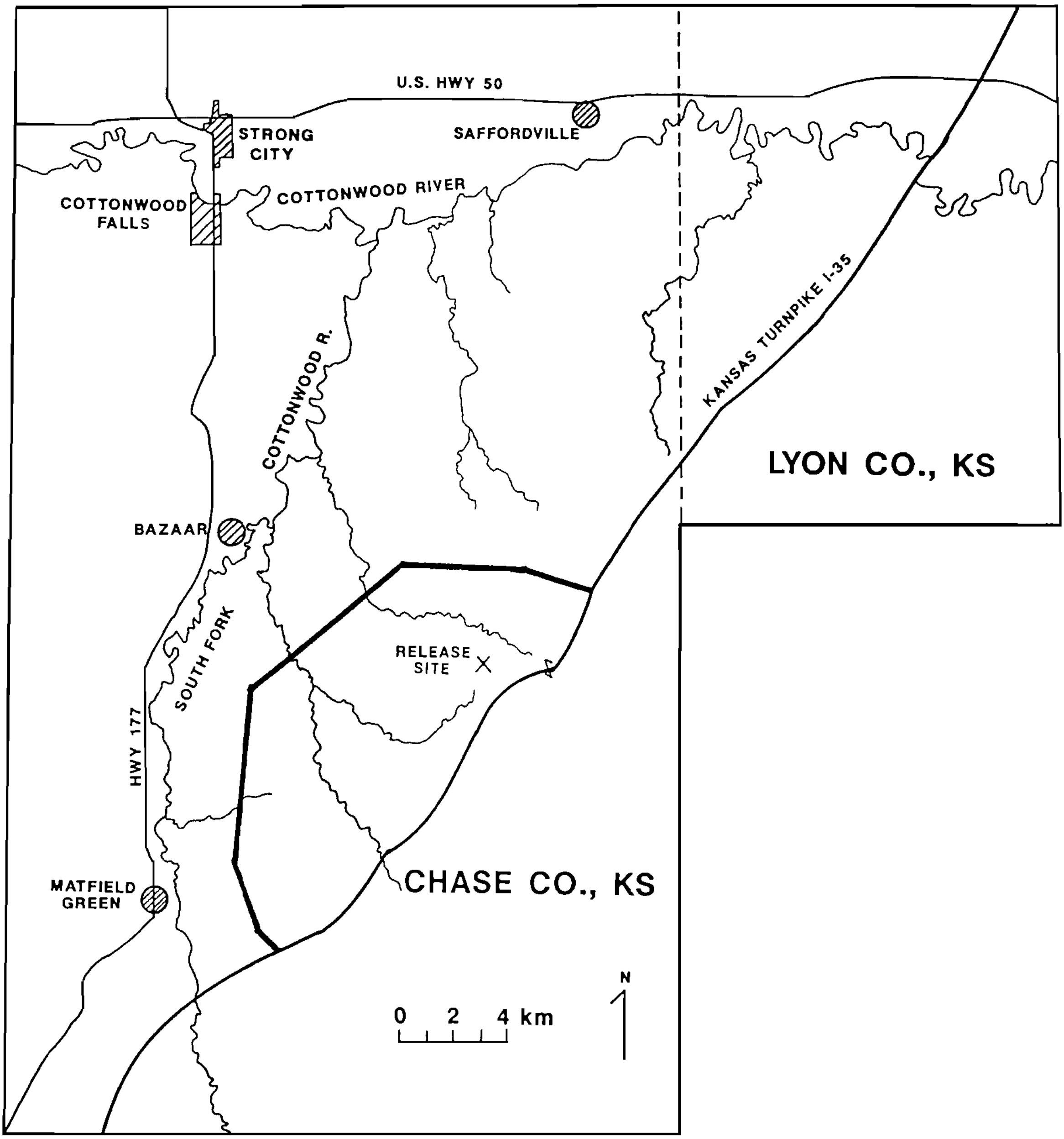

U.S. HWY 50
STRONG CITY
SAFFORDVILLE
COTTONWOOD FALLS
COTTONWOOD RIVER
COTTONWOOD R.
KANSAS TURNPIKE I-35
LYON CO., KS
BAZAAR
SOUTH FORK
RELEASE SITE
HWY 177
MATFIELD GREEN
CHASE CO., KS
N
0 2 4 km

Fig. 5. Home range location (solid line) of all radio-collared pronghorn translocated to Chase County, Kansas, 1991, during rut (1 Aug - 20 Sep).


U.S. HWY 50
STRONG CITY
SAFFORDVILLE
COTTONWOOD FALLS
COTTONWOOD RIVER
COTTONWOOD R.
KANSAS TURNPIKE I-35
LYON CO., KS
BAZAAR
SOUTH FORK
RELEASE SITE
HWY 177
MATFIELD GREEN
CHASE CO., KS
0 2 4 km
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season. She traveled a straight line distance of 14.5 km to the north, near the Cottonwood River, and returned to the area she had occupied before leaving. This was the only known individual to make a trip from the southern part of the study area towards the north during the entire study.

Mortality

Of the 50 animals transported one adult female arrived alive that was unable to walk. She was taken to Kansas State University Veterinarian Medicine School for necropsy. Necropsy indicated that blood was found in the hind quarters and she suffered trauma related injuries from the capture.

Two radioed yearling females were found dead within three days of release and another radioed yearling female died 10 days after release. It is assumed that they died from stress related factors, possibly capture myopathy, from the release. Coyotes (*Canis latrans*) and other scavengers had consumed too much of both the carcasses to allow a necropsy.

One yearling female (Y02) died 72 days after release and an adult female (Y05) was found dead 159 days after release. Cause of death is unknown for both individuals. Animal Y02 had patches of hair missing in several spots throughout her body; the skin where the hair was missing was black in color. These areas may have become infected, leading to her death. Observations of Y05 prior to dying showed no indications of suffering or injury and she appeared to be in good health. She was found with a rumen full of forage in the area she had occupied since release. Poaching was probably not a cause of death because no bullet wounds were found in the pelage or carcass.

A yearling female (Y13) was last observed 151 days after release. She was not found after an aerial flight to locate her. Possible explanations for not locating her included dispersing a long distance from the study area, transmitter failure, or poached with the transmitter being destroyed.

Activity and Habitat Use

Foraging accounted for 33% and 40% of behavioral observations during fawning and rut seasons, respectively. Loafing constituted 57% of the observations during both seasons.

During both seasons, daily activities of females were not evenly distributed among daily time periods. Foraging was most common during morning and late afternoon, however, loafing was relatively the same at these time periods (Tables 6, 7). Loafing was most frequent during midday for both seasons.

In relation to topographic site and daily time period, foraging occurred more on slopes in the morning and remained relatively the same on uplands and slopes in late afternoon during the fawning season. During the rut, foraging was more common on uplands during morning and late afternoon

Table 6. Observations (%) of radio-collared female pronghorn during fawning (28 Apr - 29 Jun) translocated to Chase County, Kansas, 1991, by activity, daily time period, and topographic site.

	Foraging				Loafing			
Time	Upland	Lowland	Slope	All	Upland	Lowland	Slope	All
Morning	42	10	48	40	29	2	69	47
Midday	28	11	61	16	35	6	59	74
L. afternoon	51	0	49	49	8	3	89	47

Table 7. Observations (%) of radio-collared female pronghorn during rut (1 Aug - 20 Sep) translocated to Chase County, Kansas, 1991, by activity, daily time period, and topographic site.

	Foraging				Loafing			
Time	Upland	Lowland	Slope	All	Upland	Lowland	Slope	All
Morning	58	2	40	49	33	7	60	47
Midday	30	17	53	33	17	14	69	64
L. afternoon	60	13	27	47	0	19	81	50

(Tables 6, 7). Slopes were used more during midday for foraging for both seasons. Loafing was most common on slopes during all daily periods for both seasons.

During fawning and rut, foraging occurred in proportion to availability on each topographic site. However, loafing did not occur in proportion to availability of topographic sites for both seasons (Table 8). Pronghorn selected slopes and avoided uplands for loafing in both seasons. Lowlands were used less for loafing than expected during the fawning season.

All behavioral observations pooled showed pronghorn used uplands less than expected during rut (Table 8). Lowlands were used more than expected during rut, but less than expected during fawning. Slopes were preferred only during fawning.

Habitat Characteristics

Vegetation analysis of the FH indicated that grass (Poaceae) or grass-like species (Cyperaceae, Juncaceae) comprised the greatest percentage of vegetation (Table 9). Fifteen percent of the area was classified as open, which included bareground, rock, or cow pie. Forbs, litter, and shrubs comprised less than 18% of the study area, with shrubs comprising the least of any group. The highest percentage of grass occurred on uplands and the least on lowlands. Forbs and litter were common in lowlands and open was more common on slopes (Table 9).

Table 8. Habitat use (%) by radio-collared female pronghorn translocated to Chase County, Kansas, 1991, by season, topographic site, and activity.

		Fawning		Rut	
	% of	loafing	all	loafing	all
Topo Site	area	(n=165)	(n=315)	(n=162)	(n=318)
Upland	37	27 -[a]	33	20 -	29 -
Lowland	8	4 -	5 -	12	13 +
Slope	55	69 +	62 +	68 +	58

[a] - = use < available and + = use > available ($P < 0.05$) from Bonferroni Z analysis (Neu et al. 1974).

Table 9. Vegetation composition (%) in the Flint Hills study area in Chase County, Kansas, 1991.

	Topographic Site			
Class	Upland	Lowland	Slope	Mean
Grass	71 A[a]	60 B	69 AB	67
Forb	11 A	15 A	9 A	11
Shrub	1 A	2 A	2 A	2
Litter	4 A	8 A	3 A	5
Open	13 A	15 A	17 A	15

[a] Values followed by same letter within row are not different ($\underline{P} > 0.05$) using ANOVA.

Vegetation height was variable among topographic sites and time of sampling (Table 10). Vegetation was taller in lowlands during all months sampled, while on uplands vegetation was usually shorter, but only significantly so during March and September. Vegetation was shorter on lowlands and slopes during May, probably due to the prescribed burning in late March.

A water source was available on average 1/km^2. Distance from ground level to bottom wire of fence ranged from 10 - 46 cm, with an average of 35.5 cm.

Table 10. Mean vegetation height (cm) in the Flint Hills study area in Chase County, Kansas, 1991.

Month	Upland		Lowland		Slope	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Mar	12.95	1.62 A[a]	30.80	3.53 B	22.68	2.01 C
May	18.42	1.03 A	19.93	1.41 A	12.98	0.51 B
Jul	26.58	1.33 A	29.43	2.46 A	25.31	1.27 A
Sep	22.85	0.89 A	37.63	1.84 B	29.84	0.88 C

Topographic Site spans Upland, Lowland and Slope.

[a] Means sharing same letter are not different ($P > 0.05$) within month sampled using ANOVA.

DISCUSSION

Post-Release Dispersal

Dispersal from an area is often a cause for a failed translocation. Ungulates have the capability to move great distances in a short time (Rogers 1988). Pronghorn translocated to the TGP in the FH dispersed a short distance, maximum 10 km during post-release dispersal and 14.5 km overall, from the release site as compared to other studies, e.g., ranging from 4.6 to 144 km in western Kansas (Hlavachick 1970), and from 16 -120 km in California (Goldsmith 1987). Pronghorn captured at the same trap site near Lamar, Colorado, and released in Morton County, Kansas one week later than pronghorn released in Chase County, Kansas in 1991, were found approximately 169 km north of the release site several months after release (M. Mitchener, Kans. Dep. Wildl. and Parks, pers. commun.). Menzel and Suetsugu (1966) reported a successful release where pronghorn were found as far away as 325 km following release, with 32% moving less than 26 km and 12% moving more than 96 km.

The immediate dispersal in the homeward direction by 22 individuals in my study is not clearly understood. I am not certain whether this was intentional or coincidental. However, Goldsmith (1987) reported dispersal of pronghorn in the homeward direction, and Rogers (1988) reviewed literature of homing tendencies of large mammals, which suggests that there is a possible mechanism that influences homing in large mammals, rather than random movement.

Dispersal from the release site in the translocated FH animals may have been minimized by the presence of existing pronghorn from previous translocations. Goldsmith (1987) suggested the presence of pronghorn from previous releases provided a cue to translocated pronghorn that the habitat is adequate, therefore, they did not disperse as far. In addition, Goldsmith (1988) reported the percent of pronghorn remaining in the release area increased as the number of translocations increased and Britt (1980) found that a successful translocation occurred after three attempts. Therefore, in future attempts to translocate pronghorn into other areas of TGP, consideration should be directed toward the number and frequency of releases that may be necessary to make the translocation successful.

My assumption that the two rivers in the study area would prevent pronghorn from dispersing a long distance may not be valid. After an ice storm in late October 1991, four radioed individuals moved back and forth across the South Fork of the Cottonwood River and were often found in an alfalfa field (pers. obs.). Ranchers and the general public also reported unmarked pronghorn west of the river. Goldsmith (1987) reported pronghorn traversed through areas predetermined as unsuitable habitat that were assumed to be barriers to movement. Einarsen (1948) also reported pronghorn crossing large rivers. This adds additional support to the hypothesis that the presence of existing animals may have minimized the distance moved from the release site.

Weather at the time of release may also have been a factor in the distance traveled. If a large amount of snow or ice had been present, the distance moved may have been greater because the animals may have searched for suitable forage, as they did in October after an ice storm. Forage quality, succulence, and availability (Yoakum 1978a, Hoskinson and Tester 1980) are thought to be important aspects that influence movements. Therefore, these factors may have influenced the rather short dispersal distance if they were acceptable to pronghorn following release in the FH.

Movement patterns were directional, east to west and/or vice versa, whereas Goldsmith (1987) reported circular movement. Other than Goldsmith (1987) and my study, there is little information available about movement patterns of pronghorn following release. The directional movements and area covered indicate that little exploratory behavior was exhibited during the immediate post-release season, again suggesting the habitat was adequate. Why pronghorn moved back and forth from the west side of the study area to the release site is not clear.

The mean area covered during dispersal in the FH is similar to established populations' winter and/or summer ranges (Bayless 1969, Pyrah 1970, Amstrup 1978, Hoskinson and Tester 1980, Reynolds 1984). Again, indicating little movement occurred during the post-release season in the FH as compared to movements in established western pronghorn ranges.

Home Ranges

Individual home ranges exhibited by FH pronghorn were variable within and among annual life cycle seasons. Home ranges, in general, were not different among all animals, adult females, yearling females, and all animals from dispersal to fawning and fawning to rut. However, all females differed in home range size between fawning to rut. Yoakum and O'Gara (1990) reported that if cattle are using preferred habitat during pronghorn fawning they will displace pronghorn does, resulting in increased movement. Einarsen (1948) suggested that preferred fawning grounds are determined by vegetation height and terrain.

Goldsmith (1987) found a decreasing trend month to month in home range size following release, but also found that home ranges in the second year after release were similar to those of the year of release. However, home ranges are variable from year to year and between herds separated by a valley in Idaho (Hoskinson and Tester 1980)

Yearling females had larger home ranges than adult females within all sampling seasons. Hoskinson and Tester (1980) found yearling females' home ranges were 2 - 5 times larger than adults during the summer. Home ranges calculated for summer months (Appendix A) were slightly larger for yearling females than adult females.

As stated previously these home ranges in the FH are similar to other established populations and to Goldsmith (1987) following translocation. However, since different methods of collection and analysis were used in obtaining the data, only general comparisons can be made. Also, density of animals (Sanderson 1966) and length of sampling periods influence home range sizes, which differed among the studies compared.

Home ranges for the entire study were relatively small, however they are approximately 30 km larger than dispersal indicating pronghorn moved into different areas after dispersal. Home ranges determined for annual life cycle seasons did not pick up these movements, indicating that the movements were not frequent, and once they moved, they remained in an area for a period of time. Buechner (1950) reported that pronghorn remained in a small area for over a week at a time before shifting to a new range.

Hoskinson and Tester (1980) reported that habitat quality and forage availability influence home range size and movements. If this is true, then habitat and forage quality were acceptable during the seasons sampled in the FH.

Why pronghorn did not disperse in other directions and why home ranges were established only in the south-west corner of the study area is not clear. I assume that they were able to obtain the resources they needed in the release area.

Autenrieth (1978) reported that key range areas for pronghorn are variable in relation to land use, geographic location, climate, soils, and habitat types. Most of these key areas have been identified in western habitats, however not in the FH. Key areas may influence home range size, movements, and carrying capacity of pronghorn. Thus, key areas should be determined for the FH. These areas may include areas heavily grazed by cattle, winter ranges if different than summer range, and areas that allow pronghorn to cross the rivers when heavy snow or ice accumulates in the inhabited area.

Mortality

Mortality of animals following release is another factor that can influence the fate of the translocation. When trapping and/or translocating ungulates it is assumed that some will die due to capture related injuries or stress (Rongstad and McCabe 1984). Different aspects of mortality can be considered when releasing wild animals, including trap, post-release, and natural mortality.

A 2% trap mortality was observed in the FH translocation. Radioed FH animals had a post-release mortality of 12%, all of which were yearling females and occurred in the first 10 days following release. A 21% mortality of radioed animals was observed for the entire study. These figures are similar to other pronghorn trapping operations, e.g., Hoover et al. (1959) with 2.8 - 10.6% and 4.6 - 17% trap and total mortality, respectively. In addition, Menzel and Suetsugu (1966) found 4.1% died prior to release and 2% died after release, whereas Moody et al. (1982) reported 2% and 4% trap and post-release mortality of pronghorn translocated, respectively,. Guenzel et al. (1982) noted a 3.6% trap mortality in Wyoming, and Hoskinson and Tester (1980) reported 6.9% trap mortality in Idaho for pronghorn that were not translocated to other areas. Mortality observed in the FH may be acceptable given that successful translocations have occurred with similar mortalities.

From personal observations throughout this study, I found that translocated pronghorn fawns may have survived better than adults and yearlings. One day in late summer of 1991, I found 16 of the 17 released fawns. This suggests that fawns may increase chances of a successful translocation and that number of fawns should be considered. While trapping animals for this study, fawns struggled less in the trap and were easier to handle during processing than adults and yearlings. Therefore, fawns may increase their chance of survival because they appear to be less affected by the pressures of trapping.

Other than stress related mortality, poaching may be an important problem in establishing a viable population (Delmonte and Kothmann 1984). Although poaching was not found to be the cause of death for any animal in my study, the misconception that some people have toward pronghorn, and their visibility and curiosity make them an easy target for illegal activities. Poaching may have a large impact on the viability of a population when densities are low.

Winter mortality may also have an impact on the viability of the population. Winter mortality often results from inadequate forage quality and/or severe weather (Martinka 1967, Bayless 1969, Mautz 1978, Barrett 1982, Guenzel et al. 1982). In addition, during severe winters when forage is inadequate, fawn production and survival can be affected the following spring (Mautz 1978, Guenzel et al. 1982). Since little is known about nutritional requirements (Yoakum 1990) for pronghorn and forage quality and quantity in the TGP, I recommend that further work be directed to these issues. Forage quality and quantity should be carefully analyzed for all seasons to determine if adequate food is available. Since many factors may influence winter survival prior to winter (Mautz 1978) it is important to look at all seasons, if we are to determine what limiting factors are associated with establishing a viable population of pronghorn in the TGP. For example, if forage quality is poor during fall, pronghorn will enter winter in poor condition, possibly resulting in winter mortality not actually associated with winter.

The winter following my study was mild with respect to temperature and snowfall in Chase County, Kansas. Snow did not accumulate on the study area for more than two days at a time. The mean maximum and minimum temperature during December, January, and February was 10 C and -2 C, respectively. Two radio-collared pronghorn died during the winter following my study, both of unknown causes.

Activity and Habitat Use

Pronghorn activity in the FH is dependent on time of day. The peaks in foraging during morning and evening and loafing at midday are similar to other studies (Buechner 1950, Ellis and Travis 1975, Amstrup 1978, Reynolds 1984). Percent time spent foraging and loafing from these studies varied from 30 - 73% and 20 - 65%, respectively. In general, FH animals exhibited comparable levels of foraging and loafing.

When foraging, female pronghorn in my study used topographic sites in proportion to availability during fawning and rut seasons. However, during summer (Appendix B) females foraged on uplands more than expected and lowlands less than expected. Although not significant, pronghorn did forage more on uplands than available during the fawning and rut seasons, indicating forage quality, availability, and succulence may be greater on upland habitats than lowlands and slopes. Species diversity and richness of plants has been found to be higher on uplands in annually burned TGP (Abrams and Hulbert 1987, Gibson and Hulbert 1987). This suggests that forage quality and abundance may be greater on upland sites, which may be a result of the shallow soil on uplands. Ryder and Irwin (1987) and Barrett (1980) found habitat selection is related to forage abundance and topography during winter. The shift in foraging on uplands during morning to slopes at midday may have a thermodynamic benefit, being cooler and less windy on slopes.

Abrams and Hulbert (1987) found that lead plant increases on burned uplands and lowlands and that lowland soils hold more water in a TGP. Since little information is known about pronghorn food habits in the TGP, the extent of use of lead plant is unknown. However, if lowlands hold more water, one would predict that succulence would be greater in lowlands, therefore, foraging would also be greater in the lowlands. However, since female pronghorn foraged more on uplands, although not significantly (except during summer), one would suspect that succulence may not be greater in lowlands or that succulence alone may not be the determining factor for foraging.

Annual burns may also increase habitat quality and affect habitat use (Courtney 1989). Fire not only improves nutritional quality of forage and recycles nutrients in ungrazed TGP, but also decreases forb and woody plants (Abrams et al. 1986), some of which are desirable forage for pronghorn. However, cattle grazing also influences the vegetation community by favoring forbs.

In the FH, cattle heavily used areas around gates and areas where ranchers have placed mineral blocks, which were usually on uplands. Heavy use on these areas has changed the plant community to favor cool season grasses and forbs. These cool season grasses may provide adequate forage when other species are not available or palatable, particularly during fall, winter, and early spring. If pronghorn prefer to forage on uplands because of some factor related to the plant community derived from these disturbed sites, then these disturbed uplands may become the limiting factor for pronghorn in TGP and serve as key areas. Future study should determine what benefits these disturbed sites may provide.

The selection of slopes and avoidance of uplands for loafing during all seasons indicates that pronghorn may be selecting these areas for a thermodynamic benefit (Bruns 1977, Barrett 1980) or vegetative structure (Autenrieth 1976). Amstrup (1978) found pronghorn preferred slopes that provided high visibility of their surroundings. However, slopes in Amstrup's study are different than slopes in the FH, because FH slopes do not provide the elevation needed to detect predators at a distance and visibility is usually limited to 180 degrees.

I recommend that further study determine why topographic areas are selected and avoided for specific activities to better understand habitat use in the FH. Possible suggestions for using a particular topographic site include: vegetative structure and height, forage quality and availability, succulence, and relief from weather.

Habitat Characteristics

Vegetative cover, grass or grass-like (graminoids) species composition, and graminoid species richness in the FH study area exceeded the amount recommended for suitable habitat for pronghorn in grassland/sagebrush communities (Yoakum 1972, 1978b, 1980, Kindschy et al. 1982) (Table 11). What impact, if any, these three biotic factors will have on the establishment of pronghorn in the TGP is not known. However, there is a possibility that these three biotic components may have some benefit by providing a diverse plant community that offers a variety of abundant forage. Therefore, forage quality and availability may not be limiting.

Graminoid composition comprises the highest percentage of all vegetative cover in the FH, followed by forbs and openness. The high percentage of vegetative cover and graminoids was expected.

One abiotic factor in the TGP, in general, and particularly in the FH that could be a potential problem is

Table 11. Comparison of abiotic and biotic factors in the Flint Hills study area in Chase County, Kansas, 1991, versus recommended values for grassland/sagebrush community (Yoakum 1980).

Variable	Flint Hills	Yoakum (1980)
Area (km^2)	335	>260
Precipitation (cm)	80.4$^+$	25 - 38
Water every km^2	1	1.6 - 7
Vegetative cover (%)	81$^+$	50
Grass composition (%)	67$^+$	15 - 20
Forb composition (%)	11	5 - 15
Shrub composition (%)	2	2.5 - 15
Grass species (#)	>21$^+$	5 - 10
Forb species (#)	50	10 - 50
Shrub species (#)	5	5 - 10
Veg. height (cm)	13 - 38	25 - 38
Fence height (cm)	10 - 46	41

$^+$ = value exceeds recommendation by Yoakum (1980).

annual precipitation. Over 2-3 times the amount of precipitation falls in these areas than is recommended as suitable for pronghorn (Yoakum 1980). This may become a problem if a large amount of precipitation falls during the fawning season, resulting in high fawn mortality due to exposure. During 1991, 31.6% (19.6 cm) of the annual precipitation fell during May and June, which is during the peak fawning season.

According to Yoakum (1978a) and O'Gara and Yoakum (1990) too much or too little of any biotic or abiotic factor may become the component that limits productivity and/or survival of pronghorn. Therefore, the combination of rainfall and vegetative cover may become factors that determine the viability of pronghorn in TGP.

Water sources are plentiful, $1/km^2$ and easily accessible in the FH, therefore, water should not be a limiting factor. In addition, the plentiful water supply should allow complete distribution of pronghorn throughout the FH study area. Sundstrom (1968) found pronghorn distribution was related to water sources in Wyoming.

Height of the bottom wire of fence ranged from 10 - 46 cm, with an average of 35.5 cm. It is recommended by Yoakum (1980) that the bottom wire be at least 41 cm from ground level. The low of 10 cm was uncommon and occurred in only a short stretch. Average fence height in the FH is just below the recommended height and could be a problem. However, pronghorn were observed going under fences with variable heights and appeared to have little difficulty. Some areas along the fenceline showed extensive use. Therefore, I suggest that fence height in the FH is not a factor that limits pronghorn movements.

MANAGEMENT IMPLICATIONS

Translocations have been and will continue to be a reliable technique to restore animals into previously occupied areas. Previous attempts to translocate pronghorn into the FH region of the TGP ecosystem provided little information about the success or viability of pronghorn after translocation. The results of my study suggest that remaining TGP habitat may provide additional areas to restore pronghorn within their historical range.

Current management guidelines for pronghorn are primarily aimed at habitats west of the TGP. However, these guidelines seem to be applicable to the TGP and provided groundwork necessary for successful management of pronghorn in TGP. It would be expected that some of the recommendations for suitable habitat would not be met in the TGP. One of the most noticeable and uncontrollable characteristic is the amount of precipitation that occurs in the TGP as opposed to areas in the west. The TGP receives approximately 2-3 times the recommended precipitation. This precipitation ultimately influences the biotic characteristics, e.g., grass cover, grass richness, and total vegetative cover, that do not meet recommendations.

However, these biotic characteristics can be manipulated, e.g., by grazing, burning, or placement of mineral blocks, to arrive at desirable levels beneficial for pronghorn throughout the entire year. Therefore, land use management practices should continue to be studied to determine how they influence habitat characteristics in the TGP and what the desirable habitat characteristics are for the establishment of pronghorn into the TGP ecosystem. The opportunity exists to collect the information needed to develop management considerations for TGP pronghorn in the FH of Chase County, Kansas, as long as a good working relationship is maintained with the ranchers and landowners.

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APPENDIX

Appendix A. Individual minimum convex polygon home ranges during summer (1 Jun - 1 Sep) of pronghorn translocated to Chase County, Kansas, 26 Jan 1991.

ID	Age	Sex	Home Range Size
Y01	A	F	5.26
Y04	A	F	4.34
Y07	A	F	8.49
Y08	Y	F	3.87
Y10	A	F	15.37
Y11	A	F	30.99
Y12	Y	F	43.56
Y14	A	F	5.19
Y15	A	M	6.33
Y16	Y	F	14.21
Y17	A	F	49.63
Y18	A	F	8.19
Y20	Y	F	17.10
Y21	A	F	10.80
Y22	A	F	13.16
Y23	A	F	4.26
Y24	Y	F	10.87
Y25	A	M	19.58

Appendix B. Mean minimum convex polygon home range size (km^2) during summer (1 Jun - 1 Sep 1991) of radio-collared pronghorn translocated to Chase County, Kansas.

Group	Home Range Size	
	$\bar{x}$	SE
All Females	15.3	3.5[a]
Adult	14.2	4.2
Yearling	17.9	6.8
Adult Males	13.0	6.6
All Animals	15.1	3.2

[a] No difference ($P > 0.05$) in mean home range size between groups using Mann-Whitney U-test.

Appendix C. Observations (%) of radio-collared female pronghorn during summer (1 Jun - 1 Sep 1991) translocated to Chase County, Kansas, by activity, daily time period, and topographic site.

	Foraging				Loafing			
Time	Upland	Lowland	Slope	All	Upland	Lowland	Slope	All
Morning	70	8	22	50	42	8	50	42
Midday	35	10	55	25	16	17	67	68
L. afternoon	54	15	31	31	21	17	62	57

Appendix D. Habitat use (%) during summer (1 Jun - 1 Sep 1991) by radio-collared female pronghorn translocated to Chase County, Kansas, by topographic site and activity.

	Activity		
Topo Site	foraging (n=113)	loafing (n=189)	all (n=360)
Upland	56 +[a]	23 -	35
Lowland	10	14 +	13 +
Slope	34 -	63 +	52

[a] - = use < available and + = use > available (P < 0.05) from Bonferroni Z analysis (Neu et al. 1974).

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