AN ABSTRACT OF THE THESIS OF

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Title: Utilization of Tallgrass Prairie by Pronghorn in Winter and Spring Based on GIS techniques

Abstract approved: Elmer J. Finck

A portion of the Flint Hills of eastern Kansas is currently occupied by a herd of pronghorn (Antilocapra americana) that co-exist with cattle. This portion of Kansas was previously occupied by pronghorn that benefitted by a commensal relationship with bison (Bos bison). Disturbed areas around salt licks put out for cattle were noticed to be used by pronghorn during winter. A Geographical Information System (GIS) database was developed and used to help study the utilization of disturbed areas by pronghorn during winter and spring.

Pronghorn were observed foraging at disturbed areas during winter and were generally more approachable than at other times of the year. Herds were located with the aid of radio telemetry and were plotted on topographical maps. Thirty-eight disturbed sites were located. Locations of herds and disturbed sites were entered into the GIS along with digitized information of the roads and streams within the study area. Ten bands with 200 m widths were created around disturbed sites to show proximity of pronghorn herds. Of the 158 plotted herd locations, 13.3% were within 200 m and 29.7% were within 400 m of a disturbed site. Results

showed that herd site locations were greater than expected ($P < 0.001$) on or near disturbed sites when compared to the entire area used by pronghorn during my study.

Disturbed sites were analyzed with corresponding reference sites to look for differences. Disturbed sites contained significantly less dead forb cover ($P = 0.0003$) and dead grass ($P = 0.0001$) cover, but less bare ground ($P = 0.0001$). Disturbed sites that were used by pronghorn contained significantly less ($P < 0.05$) rock, dead forb cover, and dead grass cover, and more bare ground. Salt lick areas were likely used during winter for their concentration of green vegetation and salt content.

UTILIZATION OF TALLGRASS PRAIRIE BY PRONGHORN IN WINTER AND SPRING BASED ON GIS TECHNIQUES

A Thesis

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This project is dedicated to the memory of my father, Raymond D. Eccles.

PREFACE

My thesis has been prepared in the style appropriate for the Journal of Wildlife Management. Running heading is: use of tallgrass prairie by pronghorn. Key words include: pronghorn, Antilocapra americana, tallgrass prairie, GIS, salt licks, overgrazing, Flint Hills, and Kansas.

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INTRODUCTION

Pronghorn (Antilocapra americana) were once abundant on the Great Plains, including what is now the state of Kansas. Brennan (1932) found mention of them in notes written by Coronado in 1540 and by Hernandez in 1651. Zebulon Pike once passed through what is now Chase County and noted that antelope were common (Sexson and Choate 1981). Early explorers were not the only ones to see pronghorn in this locality. While documenting mammals in Kansas, Allen (1874), a biologist, wrote that pronghorn were common as far east as the middle of the state and formerly ranged much further eastward. Meade (1899), a professional trapper, commenting on the natural history of Kansas, wrote that pronghorn were abundant everywhere. In fact, Kansas was once inhabited by myriads of pronghorn (Nelson 1925).

Approximately 35 million pronghorn inhabited North America before the arrival of Europeans (O'Gara 1978). Pronghorn were so abundant that they were perhaps more plentiful than bison (Bos bison), which were estimated at 30 million (McHugh 1972). Bison, being very efficient grazers of prairie grasses, more so than domestic cattle (Bee et al. 1981), were well known for their capacity to overgraze areas. Since pronghorn and bison were able to co-exist at such high population levels, Kindschy et al. (1978) hypothesized that pronghorn enjoyed a symbiotic relationship with bison. They suggested pronghorn were benefiting from the bison's heavy use of forage. The overgrazing of areas

by bison and the revegetative effect on the area by early successional plant species created a forage composition more favorable to pronghorn. Bison may not have been the only large herbivore to create desirable habitats for pronghorn. Prior to the arrival of Europeans, pronghorn also grazed rangelands in common with wild sheep (Ovis canadensis), deer (Odocoileus spp.), and elk (Cervus elaphus) (Yoakum and O'Gara 1990).

However, along with the continued westward settlement of North America by Europeans came the demise of the great wild herds of bison and pronghorn. Native wild ungulates were extirpated from most areas. By 1923 pronghorn were almost eliminated from the state of Kansas (Nelson 1925). Domestic cattle were brought in to graze the open ranges. Like their wild counterparts before them, domestic livestock also have the potential to severely impact rangeland, though ranchers try to employ techniques to keep this from occurring. Kindschy et al. (1978) stated that domestic livestock use of vegetation alters range ecosystems more extensively and profoundly than any other means of range management activities.

Pronghorn and livestock have co-existed on western rangelands for three centuries (Yoakum and O'Gara 1990), but competition for forage does not appear to be a serious problem for rangelands in good condition (Yoakum 1975). Rangelands with an abundance of grasses can be heavily

grazed by livestock, causing increased production of forbs and shrubs. Cattle are primarily grazers of graminoids, whereas pronghorn prefer forbs and shrubs (Yoakum and O'Gara 1990) with forbs a preferred forage class whenever available (Yoakum 1990).

In the shortgrass prairie, pronghorn are more selective than cattle. Ellis and Travis (1975) state that pronghorn appear to choose carefully which plant or plant part will be consumed. They also state that the proportion of foods in the diet of pronghorn departs much more from actual availability than in cattle. Although pronghorn prefer forbs and shrubs, their diet largely depends upon what forage is available. In Kansas, there is a high availability of grasses, and shrubs appear to be very low in availability as compared to more western states. Thus, in western Kansas pronghorn appear to use more grass than in other states, such as Colorado, Wyoming, and Texas (Hlavachick 1968). Pronghorn seem to survive on a variety of available forage and through selective feeding, ingest a higher quality diet than cattle (Ellis and Travis 1975).

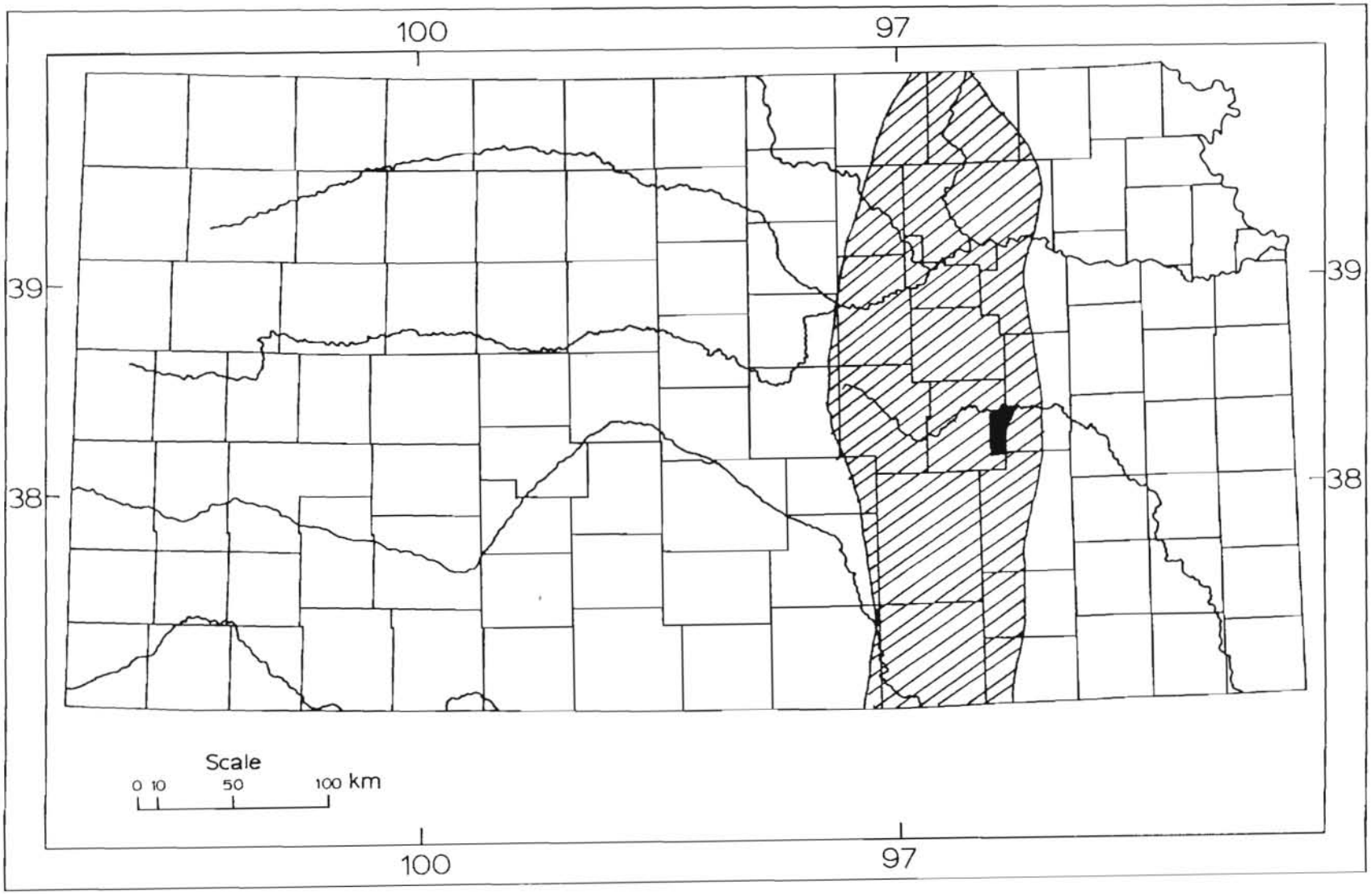
Pronghorn were mostly neglected in Kansas until 1962, when the Kansas Fish and Game Commission found 37 pronghorn in the far western portion of the state (Sexson et al. 1981). After this discovery, it was decided to augment the known population by bringing in pronghorn from outside of Kansas. By late 1964, 84 animals had been released into

Wallace and Sherman counties of far western Kansas (Sexson and Choate 1981). Since the release the herd grew to an estimated 250 head by 1969 (Hlavachick 1970). This release was the beginning of a program designed to reintroduce the pronghorn to selected regions it once occupied within Kansas. The introductions were made with the hope that isolated populations would come into contact and gene flow among them would be reestablished (Sexson and Choate 1981).

Pronghorn were reintroduced into the tallgrass prairie of Chase County, Kansas by Kansas Department of Wildlife and Parks (KDWP) in an effort to restore a viable population to a portion of the Flint Hills region of eastern Kansas (Fig. 1). Thirty-seven, 98, 127, and 24 pronghorn were translocated to Chase County during 1978, 1979, 1982, and 1983, respectively (Rothchild 1993). Aerial surveys were the only method used to monitor these reintroductions. In January 1991, and February 1992, 50 and 41 pronghorn, respectively, were released into the same area. These most recent additions to the Chase County herd are being more intensely monitored. The objectives of these recent reintroductions were: 1) to provide studies to help KDWP determine if pronghorn can be successfully reintroduced into the tallgrass prairie, and 2) to determine what effect pronghorn have on the tallgrass ecosystem.

Home ranges and habitat use characteristics of adults of the Chase County herd were studied by Simpson (1992).

Figure 1. Location of Flint Hills region (shaded area) and area of pronghorn reintroduction efforts (darkened area) in eastern Kansas.


100
97
39
38
Scale
0 10 50 100 km

Fawn mortality studies were conducted during the fawning seasons of 1991 and 1992 (Rothchild 1993), and were continued in 1993 and 1994 by James Regehr (pers. comm.). My study focused on winter and spring use of areas by pronghorn. I developed a Geographical Information System (GIS) database to help study herd site selection.

GIS technology is being used in federal, state, and local governments, and the private sector at a steadily increasing rate (Mead 1982). Although often considered a map-making tool, a GIS is an integrated computer system that collects, stores, retrieves, manipulates, transforms, analyzes, and displays spatial (geographically referenced) information (Burrough 1986). A GIS has the ability to allow the user to view different layers of information for a given area. Due to the layering effect that can be produced, it is very useful to compare associations of points from two different layers. This aspect is particularly useful when determining an animal's response to habitat changes or characteristics.

Literature supports the contention that winter habitats are critical for pronghorn on northern ranges (Dirschl 1963, Martinka 1967, Bayless 1969). During winter in the tallgrass prairie range forage quality is low due to the large reduction of available nutrients found in grasses, namely crude protein (Cook and Harris 1950). Also, there is a severe reduction in forage quantity when annual spring

burns occur, which covers almost the entire study area. In the summer this leads to large areas that are dominated by C_4 grasses, namely big bluestem (Andropogon gerardii), little bluestem (A. scorparius), switchgrass (Panicum virgatum), and Indian grass (Sorghastrum nutans) (Gibson and Hulbert 1987). Key habitat use areas probably exist in the winter in the tallgrass prairie like in other ecosystems within the historic range of pronghorn. Simpson (1992) suggested that key areas may include areas heavily grazed by cattle. Rothchild (1993) supported this idea by making some casual observations of the Chase County herd. He observed that pronghorn seem to depend upon areas, which were heavily grazed by cattle during summer, for winter forage. Disturbed areas that contain active vegetation should contain higher forage quality during late winter and early spring and are likely to be selected by pronghorn during this time of year. These disturbed areas should occur at moderately to severely overgrazed sites near salt licks or mineral bunks.

I used the GIS to plot herd locations in order to determine if pronghorn were actively selecting disturbed sites. I also compared vegetation within and between disturbed sites versus reference sites. My objectives were: 1) to find out if pronghorn exhibited a selection toward the vicinity of disturbed sites, 2) to determine if disturbed sites were different from reference sites, and 3) to

determine if disturbed sites used by pronghorn were different from disturbed sites that were not used.

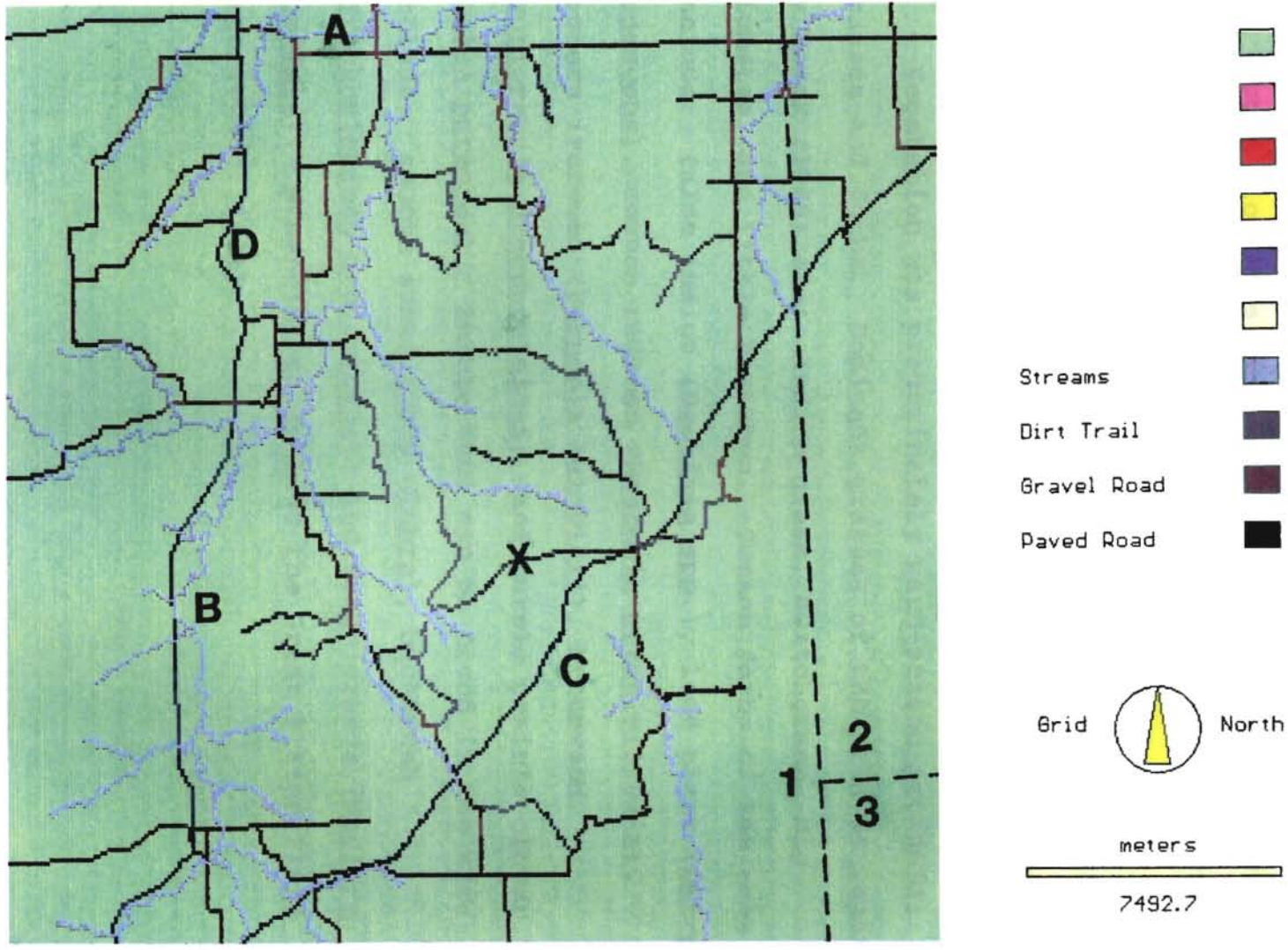
STUDY AREA

The study area is located in southeastern Chase County and a small portion of southwestern Lyon County within the Flint Hills of Kansas. The study area (Fig. 2) is bordered by the Cottonwood River on the north, the South Fork of the Cottonwood River on the west, and the Kansas Turnpike on the southeast. The surface area of the land in this semi-confined area consists of 335 km^2 (Rothchild 1993). The area is privately owned by several landowners and is grazed by cattle from 15 April through 15 October, with some cattle being removed by 15 August (Horak 1985). Annual burning occurs during March and April.

Winters in the study area are characterized by cold, dry weather. The first and last frost dates are likely to occur in 50% of the years are 9 October and 20 April, respectively (Neill 1974). The month of January has the lowest average daily minimum/maximum temperatures of -7°C and 5.6°C, respectively. Snowfall is light, averaging 42.5 cm per year and usually melts within a week. The area receives an average of 80.4 cm of rainfall a year (Neill 1974).

Topography in this region of the Flint Hills consists of gently sloping to steeply sloping uplands. Vegetation composition as reported by Simpson (1992) was predominately grasses (71%), followed by bare ground (13%), forbs (11%), litter (4%), and shrubs (1%). Simpson also reported that a water source was available on average 1/km^2 and the average

Figure 2. Study area showing streams, paved roads, gravel roads, and dirt trails. Labeled items are: (A) Cottonwood River, (B) South Fork of the Cottonwood River, (C) Kansas Turnpike, (D) Highway 177, (X) pronghorn release site, (1) Chase County, (2) Lyon County, (3) Greenwood County.


A
D
B
X
C
1
2
3
Streams
Dirt Trail
Gravel Road
Paved Road
Grid
North
meters
7492.7

distance from ground level to bottom wire of fence was 35.5 cm, except along the Kansas Turnpike, where net-woven wire fence was flush with the ground. The height of the bottom wire of fence is shorter than the recommended 41-46 cm as recommended by O'Gara and Yoakum (1992), but pronghorn appear to have only moderate difficulty finding a place to cross within the study area.

Vegetation was predominately warm-season perennial grasses and forbs. Dominant grasses of the area as reported by Horak (1985) are: Indian grass, switchgrass, big bluestem, and little bluestem. Common forbs of the area include: false indigo (Baptisia spp.), lead plant (Amorpha canescens), common ragweed (Ambrosia artemisiifolia), western ironweed (Vernonia baldwinii), broomweed (Gutierrezia dracunculoides), and purple prairie clover (Dalea purpurea). Shrubs that can be found in the area include: smooth sumac (Rhus glabra), buckbrush (Symphoricarpos orbiculatus), and osage orange (Maclura pomifera). Nomenclature follows the Great Plains Flora Association (1986).

MATERIALS AND METHODS

During the fall pronghorn form herds, making it easier to monitor the movements of many individuals. Determining locations of herds was made possible by tracking radio-collared individuals in the population. In 1991, 15 radio-collared pronghorn (13 does, 2 bucks) were released. In 1992, 23 radio-collared individuals (21 does, 2 bucks) were released. By the end of this study there were only 4 pronghorn (3 does, 1 buck) in the study area with active radio collars. The remainder of radio-collared animals introduced in 1991 and 1992 either moved off the study site, died, or had transmitter batteries expire.

Herd Data

Pronghorn herds were studied from 12 December 1993 to 18 April 1994. Location of the herds was aided by the use of radio telemetry, binoculars, spotting scopes, and a four wheel drive pickup supplied by KDWP. Herd site locations were recorded to the nearest 1 ha on 7.5 minute United States Geological Survey (USGS) maps using Universal Transverse Mercator (UTM) coordinates. As defined by Bayless (1968), two or more pronghorn together were considered to represent a herd. The number of individuals and the number of bucks, does, and fawns in each herd were recorded. Efforts were made to make accurate counts of herd size. When herds would flee from the observer, it was often difficult to obtain accurate counts of herd composition. Location data from herds were collected 3 days a week during

the majority of the censusing period.

Roads and streams within the area were digitized separately using TOSCA (Clark University, Worcester, Mass.) from adjoining USGS topographical maps. Vector files containing the roads and stream information were concatenated and then edited to achieve continuous line data. Pronghorn herd locations were plotted onto an image file using IDRISI (Clark University) in an x/y format. Vector files containing the roads and stream information were then overlaid (Fig. 3). Disturbed sites were plotted onto a separate image file using the same coordinate system. Locations of disturbed sites are shown in Figure 4. Ten concentric bands with 200 m intervals were created around each pixel representing a disturbed site to show distance from each disturbed site. This image was then combined with the pronghorn location data (Fig. 5) to produce an image showing the use of areas by pronghorn in winter and spring.

Vegetation Sampling

Vegetation data were collected from 9 October to 23 November 1994. Sampling was conducted at 38 disturbed sites and corresponding reference sites, yielding 76 sample sites located in areas used by pronghorn. Disturbed sites were salt and/or mineral licks that had large areas of barren ground of over 10 m in diameter when measured with 2 perpendicular transects. Sampling techniques were adapted from Gibson (1989) who sampled vegetation at relict bison

Figure 3. Pronghorn herd locations by month on the study area during winter 1993 - 1994.

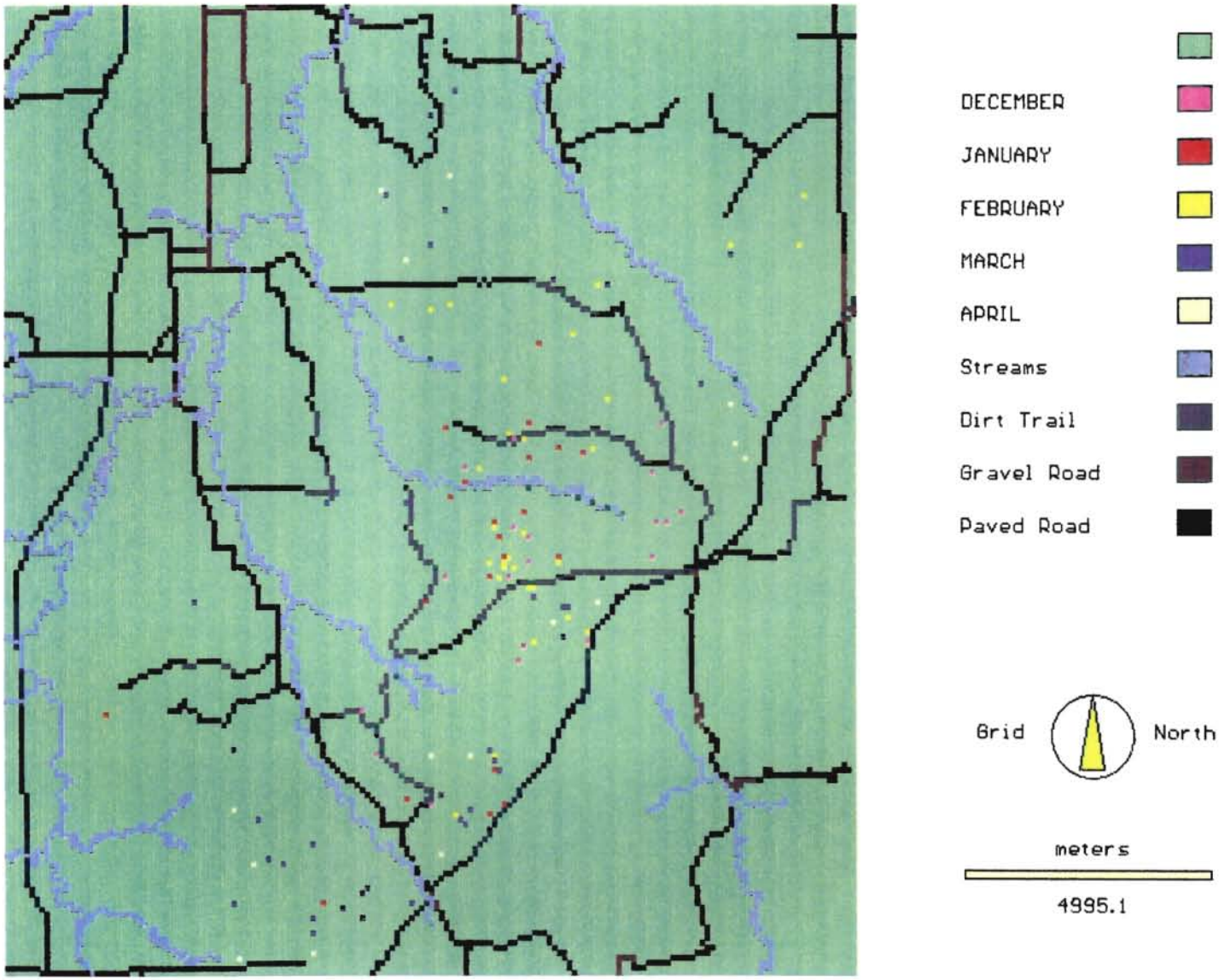

DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
Streams
Dirt Trail
Gravel Road
Paved Road
Grid
North
meters
4995.1

Figure 4. Locations of salt lick areas that were classified as disturbed (Dis.) sites on the study area.

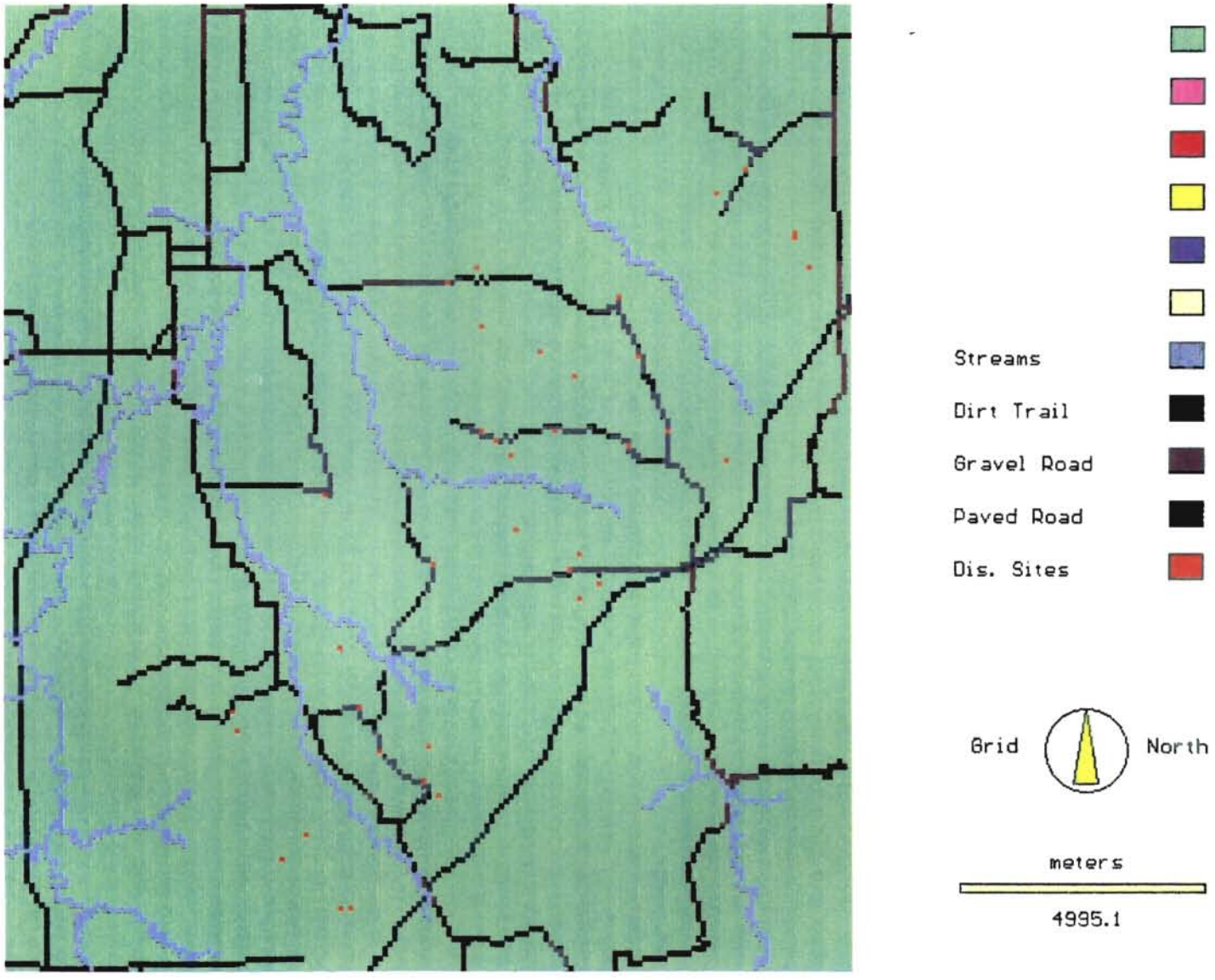

Streams
Dirt Trail
Gravel Road
Paved Road
Dis. Sites
Grid
North
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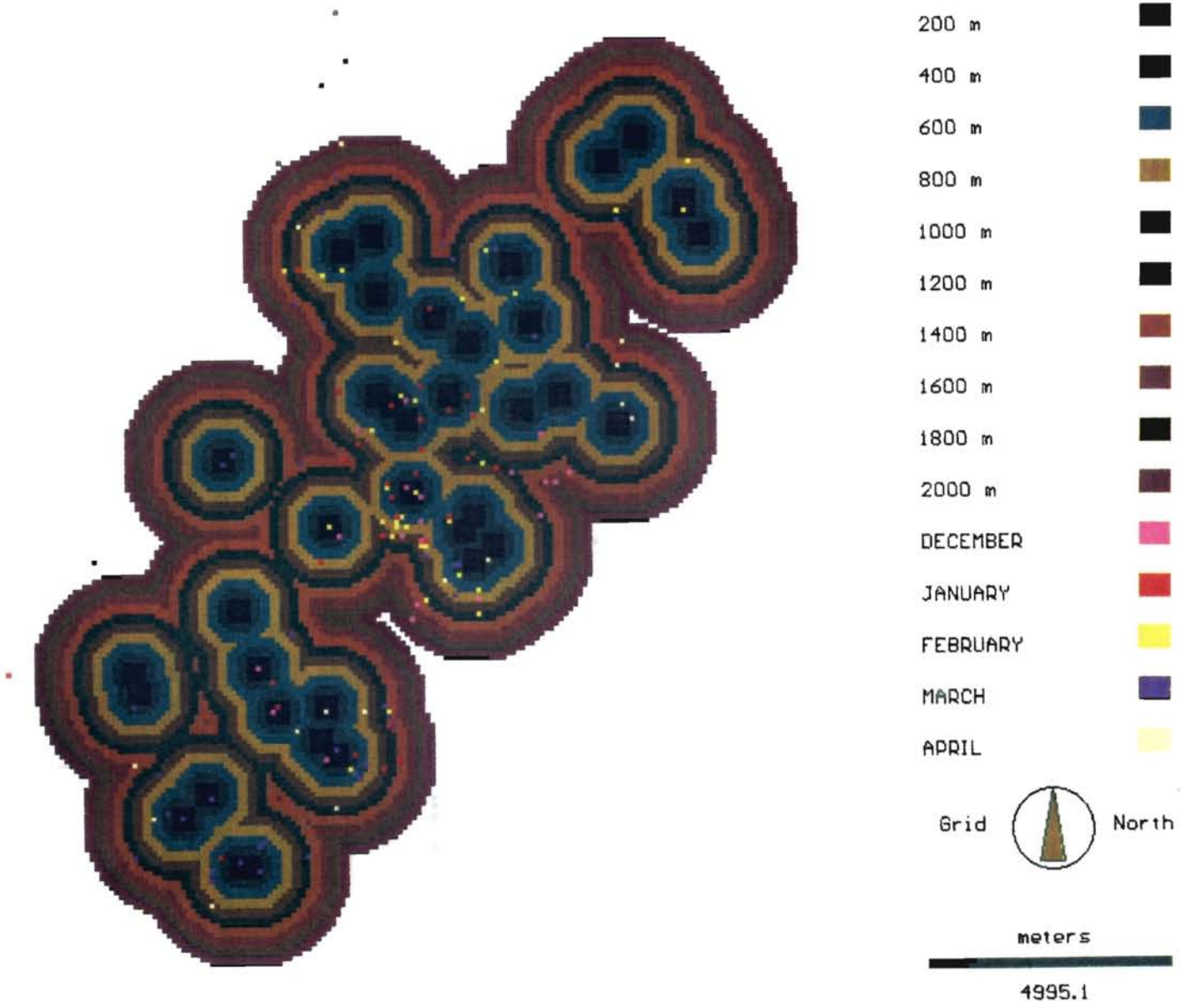
Figure 5. Disturbed sites with 200 m band widths showing relationship to pronghorn herd locations during winter 1993 - 1994.


200 m
400 m
600 m
800 m
1000 m
1200 m
1400 m
1600 m
1800 m
2000 m
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
Grid
North
meters
4995.1

wallows on Konza Prairie and Rothchild (1993), who sampled fawn bed sites of pronghorn in the Chase County herd.

Disturbed sites were sampled during late fall in order to determine percent of rock, bare ground, dead forb, and dead grass canopy cover at each site. The lengths and widths of the barren ground within the disturbed area were also measured in order to determine the area of the disturbance. Vegetation within a 10 m periphery of the center of the site was quantified using a 1.0 x 1.0 m quadrat frame. Twelve, 10 m transects radiating out from the site center in 30° increments from north comprised the periphery site. Ten transects were randomly selected and the location along each transect was also randomly selected for placement of the quadrat. For each disturbed site examined, a reference site was examined using the same methods. Reference sites were located at 100 m in a random direction from the disturbed site center.

Vegetation Analyses

The mean percent of rock, bare ground, dead forb, and dead grass cover was calculated for each site. Statistical analysis was performed on the mean percent composition for each site. A pairwise t-test (SAS 1985) was used to determine differences between disturbed and reference sites. Comparisons between disturbed sites that were used by pronghorn and disturbed sites that were not used were analyzed using a 2-sample t-test (SAS 1985).

RESULTS

Herd Data

Pronghorn herd data were collected on 49 days between 12 December 1993 and 18 April 1994. The highest count of 80 animals was obtained on two occasions in December 1993. Herd sizes ranged in size from 2 to 66 with an overall average herd size of 14.2. Individuals did not remain associated with a single herd. Some mixing of herds was observed, but it was not known to what extent due to an insufficient number of marked individuals. Herd sizes averaged larger during the months of December (18.4), January (21.5), and February (17.4), but then fell sharply during the months of March (8.0) and April (5.0). The overall herd composition ratios were established as having an adult buck to doe ratio of 70:100 and a fawn to adult doe ratio of 30:100.

Since the most recent reintroductions of pronghorn into the Chase County herd in January 1991 until April 1994, 24 known deaths of radio-collared individuals have occurred. Chi-square analysis failed to reject the hypothesis at $P > 0.2$ that these dates occurred evenly throughout the twelve months of the year. Cause of death for a majority of the 24 animals is uncertain except for 3 individuals that died during my study. In all three of these cases a radio collar was found, but the animal carcass was gone. Small pieces of hide were found in the immediate vicinity with no musculature attached. At one of these locations, leg bones

were found nearby that had been cut off. The former two animals were likely poached during the night based on evidence at the kill sites, the latter was likely poached during daylight hours.

During early winter, pronghorn were often seen grazing at a distance too great to discern what vegetation they were consuming. However, there were times in late winter when the herds became more tolerant of being observed and were less likely to flee when they were approached. I occasionally observed them foraging on dead plants that were relatively large and easily identifiable through a spotting scope. Plants identified as being browsed were: ironweed, ragweed, false indigo, and broomweed. In early January a mixed herd was located in the same draw for a period of just over a week. They were usually seen foraging among buckbrush that was abundant in the draw. It was not determined whether or not pronghorn were browsing on the shrubs.

Pronghorn herds were observed on (within 200 m) areas designated as disturbed sites 21 times and near disturbed areas (within 400 m) 47 times. This amounts to 13.3% of all the plotted herd locations being within 200 m of a disturbed site and 29.7% within 400 m. Results of a chi-square analysis showed that herd site locations were greater than expected on ($P < 0.001$) or near ($P < 0.001$) disturbed sites as compared to the entire area used by pronghorn in my

study. This shows that pronghorn were selecting disturbed sites during winter. Pronghorn were observed foraging on plants surrounding the disturbed sites and were also observed licking the bare ground in the middle of the disturbed areas where salt blocks had been placed out for cattle during the summer. On a few occasions they were even observed licking the barren ground inside of old tractor tires that previously contained salt blocks.

Vegetation Analyses

Results of a Wilcoxon signed rank test (SAS 1985) showed that 3 of the 4 composition classes contained statistically significant differences between disturbed and reference sites. Reference sites contained higher amounts of dead forb ($P = 0.0003$) and dead grass ($P = 0.0001$) cover, but less surface area of bare ground ($P = 0.0001$)) than disturbed sites. However, rocks ($P = 0.80$) were not found to be significantly different between the two site types. The Wilcoxon signed rank test was used in place of a paired t-test because the data were not normally distributed, even though the paired t-test contained the same results. General differences between disturbed and reference sites further support the findings of the Wilcoxon signed rank test (Table 1).

Results of a Wilcoxon 2-sample test (SAS 1985) on used (herd sites within 200 m) versus non-used disturbed sites showed that used sites contained significantly ($P < 0.05$)

less rock, dead forb, and dead grass cover, and more bare ground (Table 2). The surface area of barren ground at disturbed sites was not significantly different in size. There were no preconceived notions of which of these sites would be used, so data were analyzed using a 2-tailed test. The Wilcoxon 2-sample test was used in place of a parametric 2-sample t-test because the data were not normally distributed and did not have homogeneity of variances. General differences between used and non-used sites are detailed in Table 3. The range of values for rocks, dead forbs, and dead grass cover for disturbed sites not used are identical to the values of the disturbed sites listed in Table 1.

Table 1. Range, mean, and standard deviation of percent cover classes and the area (m^2) of barren ground at disturbed (Dis.) and reference (Ref.) sites.

	% ROCK		% BARE GROUND		% FORB		% GRASS		AREA (m^2)
	Dis.	Ref.	Dis.	Ref.	Dis.	Ref.	Dis.	Ref.	Dis.
N	38	38	38	38	38	38	38	38	38
Range Low	0.0	0.0	32.5	1.0	0.0	1.0	0.0	8.5	123
Range High	61.0	27.0	100	27.5	15.5	40.5	43.5	97.5	3847
Mean	3.68	3.03	88.87	9.70	2.99	6.24	4.46	79.03	824.29
± Std. dev.	10.63	6.34	16.65	5.45	4.19	6.70	9.55	15.55	797.25

Table 2. Results of a 2-tailed Wilcoxon 2-sample test on used (N=14) versus non-used (N=24) disturbed sites.

	Z score	Prob.
Rocks	-1.8097	0.0352
Bare Ground	2.6924	0.0036
Forbs	-1.8117	0.0036
Grasses	-2.0215	0.0216
Area	0.9991	0.1589

Table 3. Range, mean, and standard deviation of percent cover classes and the area (m^2) of barren ground at used and non-used disturbed sites.

	% ROCK		% BARE GROUND		% FORB		% GRASS		AREA (m^2)	
	Used	Not	Used	Not	Used	Not	Used	Not	Used	Not
N	14	24	14	24	14	24	14	24	14	24
Range Low	0.0	0.0	84.5	32.5	0.0	0.0	0.0	0.0	133	123
Range High	11.0	61.0	100	100	5.0	15.5	11.5	43.5	1923	3847
Mean	1.00	5.25	96.86	84.21	1.25	4.00	0.89	6.54	919.29	768.88
± Std. dev.	2.92	13.04	5.18	19.21	1.85	4.84	3.06	11.36	637.79	885.38

DISCUSSION

Key areas are those areas necessary to sustain a population during the most limiting time (O'Gara and Yoakum 1992). In my study, late winter and early spring could be considered as limiting seasons based upon observations and characteristics of pronghorn in the Flint Hills of Kansas. During this period, pronghorn are assumed to be in a weakened physical condition due to lack of a plentiful food source. Yet, the survival of the Chase County herd shows their capability to make do with the forage that is available. A major role in the survival of pronghorn during winter and early spring could be the use of key habitats such as disturbed areas.

Salt blocks put out for cattle during grazing seasons are heavily used by livestock. These areas can quickly become overgrazed and severely trampled. The salt provides an economical means of improving livestock distribution within pastures and usually must be provided (Stoddart et al. 1975). Placement of salt blocks in the Flint Hills often occurs along ridge tops where they can be easily accessed by ranchers. The same salt lick areas are generally used for years because of the severe effects to the vegetation.

The GIS was useful in showing how pronghorn used disturbed sites during winter and spring. Concentric rings created on the image around disturbed areas (Fig. 5) provided information relating herd locations to disturbed

sites. Bands of different color represent 200 m increments away from a disturbed site. These bands could also be used to show distance from roads, streams, or any other point or line data that are entered into the GIS. Using this type of a system allows the investigator to easily update it by entering more data, changing distance intervals, or changing display colors. It is also very useful for zooming in on any part of the image and allowing the investigator to see details.

Herd Data

In general, pronghorn herd locations appeared to closely match areas where disturbed sites were located. The main exception to this was during the month of March, when a herd moved to the north of the majority of the other herds for about 4 weeks (Fig. 3). This herd spent time in a pasture that received intensive grazing pressure and in which specific disturbed sites were not noticed. It is possible that pronghorn were selecting this area due to the grazing system being utilized by the land manager.

Other movements of herds were also notable. Herds would often move back and forth from the west side of the study area, as was also noted by Simpson (1992). In order to get to the west side they had to cross a small wooded creek, a behavior uncommon for pronghorn. However, parts of the Chase County herd have been observed to have crossed the South Fork of the Cottonwood River after an ice storm in

1991 (Simpson 1992). Simpson reported that other sightings of pronghorn on the west side of the river have also been made.

Pronghorn on the study area wintered in the area where the most recent releases were made, a behavior not observed by Hlavachick (1970) during pronghorn reintroduction efforts in south-central Kansas. The timing of the releases may have played a role in the site tenacity behavior of pronghorn in my study. Both of the recent releases were made during winter, in 1991 the release was made in January, and in 1992 the release was made in February. It would seem that the timing of the releases could have played a role in the return of pronghorn to the release site. But in order to keep them returning to the area and remaining for a period of time it would seem that suitable forage must somehow be available.

Vegetation Analyses

Disturbed sites contained significantly less dead forb and grass cover, but more bare ground than reference sites, as was expected. Percent composition of rocks was not significantly different, likely due to the wide spread dispersal of surficial rocks present in the Flint Hills. Bare ground was abundant at disturbed sites due to the overgrazing and trampling effects of cattle. The composition at the reference sites was an approximation of what the area should look like if the disturbed sites were

not present.

Differences were found between disturbed sites that were determined to be used and those not used by pronghorn. The used sites contained significantly less rock, dead forb cover, and dead grass cover, and more bare ground (Table 2). The areas of the disturbed sites were not significantly different because the size and shape of the disturbed sites were highly variable. Shapes of the disturbed sites were generally circular on relatively flat surfaces, but were usually oblong in shape when they occurred on a slope or directly along a vehicle trail.

Disturbed sites were comprised of a relatively large barren area with various species of forbs around the periphery. Dead forbs were numerous at the edge and became more sparse as distance from the disturbance increased. The distance from the edge to which forbs remained the dominant vegetation was not measured. Grasses and other vegetation of the tallgrass prairie gradually replaced forbs as the distance away from the center of the disturbance increased. The total area affected to some extent by the disturbance would be difficult to measure because there were no easily discernable breaks in the vegetation. Therefore, the only measurement taken to determine the size of the disturbance was the area of the barren ground in the middle of the disturbance. Active green vegetation within the barren area was not quantified.

By winter the majority of the vegetation in the Flint Hills appeared dead except for some C_3 plants that could be found growing underneath the canopy of dried C_4 vegetation. In November, short green forbs could be seen to begin growing in the barren areas of many disturbed sites. Observations and evidence of pronghorn activity on these disturbed sites seemed to indicate that they were foraging on the small forbs to some extent. However, pawing at the ground was also evident, so it was not easy to discern whether pronghorn were using these sites to forage or to gather salt. Based on my observations, I suggest that pronghorn were using these areas for both their salt content and the abundance of green forbs found at the sites. I further suggest that both of these played a role in providing valuable nutrients to the winter diet of pronghorn in the Flint Hills.

I think that disturbed areas created by livestock play a major role in the survival of pronghorn in the Flint Hills during winter and spring. Without these areas, I think that pronghorn would need other areas that had green vegetation, such as wheat (Triticum aestivum), which is heavily used by pronghorn in western Kansas (Sexson et al. 1981), or alfalfa (Medicago sativa) fields to rely on for forage in order to survive during this possibly limiting time. I also think that domestic cattle have replaced the bison as a large herbivore whose grazing action provides sufficient forage

for pronghorn in many areas, a hypothesis also mentioned by Yoakum (1975).

To date, the Chase County herd has not become established as a successful reintroduction, but I would not consider it a failure. There were 80 animals present on the study area during the 1993 - 94 winter. This count was taken two years after the last translocation of animals into the area. According to Shannon Rothchild (pers. comm.) several animals that were radio-collared in 1991 and 1992 were found dead, but still others were unaccounted for. Radio signals for some of these individuals were located off of the study area to the west. This further supports the presence of pronghorn off the west side of the study area reported by Simpson and by landowners (Simpson 1992). Still other reports have come in of sighting pronghorn to the east of the study area.

Causes of death of radio-collared pronghorn on the study area since spring 1993 include a female that had a breach birth due to a large blood clot and at least three that were poached. Most of the other deaths were of unknown causes. The poaching of those animals was unfortunate and the fact that those animals were wearing radio collars seems to imply blatant acts against the reintroduction program. The removal of 3 pronghorn with active radio collars made the study of the success of the herd more difficult.

I recommend the continued study of the Chase County

pronghorn herd and how it relates to the viability of pronghorn in the tallgrass prairie. In order to monitor the size of the herd from the ground it will be necessary to capture adults and fit them with radio collars to replace those that have died. This could be accomplished by tranquilizing animals from the ground on an individual basis. Corral-trapping animals is another option, but it would seem too costly and would require many people. For any study requiring the researcher to find individuals from the ground, it is essential that radio-collared animals be present. If radio collars are not added, the only means of sufficiently counting the herd would be from the air.

An important study that needs to be done is to determine the diet of pronghorn in the tallgrass prairie. Some observations of the forage used are noted in my study. Yet, a detailed study that looks at the diet throughout the year would provide valuable information. It would seem particularly interesting to find out exactly what pronghorn eat in the absence of shrubs and agricultural crops during the winter.

MANAGEMENT IMPLICATIONS

Pronghorn that make up the Chase County herd were translocated from different locations outside of Kansas. This would seemingly produce a fairly healthy mix within the gene pool and should rule out possible deleterious effects such as inbreeding in the immediate future. However, it may add to outbreeding depression (Shields 1982). Reed et al. (1986) recommend an effective population size of more than 50 for short-term survival. As of the winter of 1993 - 94, 80 animals were counted and would seem sufficient to maintain genetic diversity.

The number of bucks seems high in regard to the total population size. The adult buck to doe ratio of 70:100 is much higher than the 25:100 ratio that should be maintained for maximum recruitment into a population as suggested by Griffith (1962). O'Gara and Yoakum (1992) stated that this latter ratio will allow for greater production of younger age-class animals. The adult buck to doe ratio should be continued to be monitored in order to ascertain whether the trend of more bucks in the population continues to increase. Bruns (1977) suggests that bucks should be kept near the minimum number required for breeding in order to keep mature males from contributing to increased mortality of subordinate classes during winter. Aggressive behavior was not observed during my study. However, a few instances of two sparring bucks were observed, though this type of behavior was referred to as play by Bruns (1977).

A high number of bucks in a population may be attractive in terms of watchable wildlife, but do not serve much of a purpose with respect to further recruitment into the population. I suggest thinning the mature buck population by 5 as a step toward avoiding potential unhealthy confrontations between them and does. Eliminating mature bucks should have no effect on the availability of breeding bucks because Wright and Dow (1962) reported that even yearling males are capable of impregnating females. Removal of dominant bucks could be accomplished by net-gunning, but Ockenfels et al. (1994) found this method produces a high probability of capture-related mortality. A lottery of perhaps high dollar hunting tags could be made available by KDWP with most of the proceeds going toward necessary equipment and some compensation given to the landowners where pronghorn are located. Perhaps landowners in that area could see some potential for economic benefit and would become more amiable to the pronghorn that graze the same land as their beef cattle.

In order to provide an abundance of suitable forage during winter, agricultural cropland could be developed within close proximity to the herds. Plowing up a small portion of ground near the middle of the territory where pronghorn are located and planting wheat or alfalfa could provide better nutrition for pronghorn during winter. However, due to the rocky surface of the Flint Hills,

finding a suitable location to plant may not be feasible. Therefore, more subtle techniques of habitat management would have to be implemented.

In regard to providing adequate forage for pronghorn, Kindschy et al. (1978) stated that the primary pronghorn habitat management tool being used by land managers is livestock management. In the absence of available agricultural crops, management of salt lick areas and different spring burning regimes could help sustain nutritional requirements of pronghorn during winter. By seeding salt lick areas with a mixture of C_3 plants after cattle are removed, land managers could help assure better winter forage for pronghorn and could help cut down on localized wind and soil erosion. In addition, spring burning regimes could be modified so that a few areas are only burned every other year in order to help promote a more diversified forage base and to provide habitat for pronghorn immediately following spring burns.

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