HABITAT FACTORS RELATED TO PRONGHORN PRODUCTIVITY ON THE SOUTHERN HIGH PLAINS

By

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PREFACE

Many areas of the Southern High Plains provide valuable habitat for pronghorn (*Antilocapra americana*). However, in recent years pronghorn numbers have declined over much of this region (M. Snider, Range Conservationist, USFS, and F. Carlile, Wildlife Biologist, Okla. Dept. of Wildl. Cons. 1976 personal communication). During the past five years, pronghorn populations on the Comanche National Grassland (CNG) in southeastern Colorado have decreased sharply. Therefore, this study was undertaken to learn more about pronghorn habitat and certain pronghorn behavioral factors in this area of the Southern High Plains.

After conferring with the U.S. Forest Service area personnel, two study areas were selected on the CNG near Springfield, Colorado. At the outset of the study, there were several unanswered questions pertaining to pronghorn on the Southern High Plains and particularly on the two study areas selected. To what extent, if any, are pronghorn populations affected by (1) vegetation composition and structure, (2) quality of forage, (3) climatic extremes and fluctuations, (4) land use, (5) predation, (6) poaching, and (7) interaction of all these factors. The first four questions were selected for research during this study.

This thesis is presented in chapters to facilitate publication as technical articles in scientific periodicals. Each chapter represents a separate article. The style and format of each chapter is in accord-

ance with guidelines from The Journal of Wildlife Management and The Journal of Range Management. Permission to present this thesis in this manner was granted by the Oklahoma State University Graduate School.

I would like to express my deepest appreciation to my wife, Sally, for her extreme patience and understanding during these six years of college. Without her support and belief in this project it would not have succeeded. Special thanks are due my mother-in-law and father-in-law, Mr. and Mrs. E. D. Fairweather, for their encouragement during the last six years of my academic work. Very special thanks are also extended to my parents, Mr. and Mrs. W. H. Barrington, for their long years of tolerance and hard work on my behalf.

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Very special recognition is due my major advisor, Dr. Jeff Powell, Associate Professor of Agronomy, who labored through endless pages of disorganization which later became my thesis. Dr. Powell is also recognized for his guidance and constructive criticism throughout my graduate program. Appreciation is also extended to all of the members of my graduate committee. Dr. James Lewis, Technical Editor, U.S. Fish and Wildlife Service and Dr. Fritz Knopf, Assistant Professor of Biological Sciences, are recognized for their professional advice on wildlife biology and ecology. The statistical expertise provided by Dr. Larry Claypool, Associate Professor of Statistics, is also greatly appreciated. Mr. E. H. McIlvain, Research Agronomist, USDA, Southern Great Plains Research Station, is also acknowledged for his help in plant species verification and practical advice.

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CHAPTER I

Study Area

The study area is on the Comanche National Grassland (CNG) in southeastern Colorado and in additional areas of Cimarron County, Oklahoma. These areas are within the High Plains physiographic region. The High Plains are remments of a former Plain which extended from the Rocky Mountains eastward to the central lowland (Fenneman 1931). Due to erosional forces, this plain is heavily dissected, particularly east of the mountains. These dissected areas were subdivided by early geologists into different "sections" depending on their surface relief and parent material. One of these sections (Raton Section) extends onto a portion of the study area.

The eastern portions of the CNG are in sharp contrast to the western mesa-dominated area. This eastern portion is characteristic of most High Plains areas being relatively level with little relief. As a result of this localization of physiographic differences, vegetation and climate are also vastly different between the eastern and western portions of the CNG.

Two study areas (sand sagebrush and shortgrass) (Fig. 1 & 2) were selected on the CNG. These areas were located in the far eastern and far western portions of the CNG. The areas were chosen to include differences in (1) yearly fawn recruitment, (2) types of vegetation, and (3) climatic conditions.

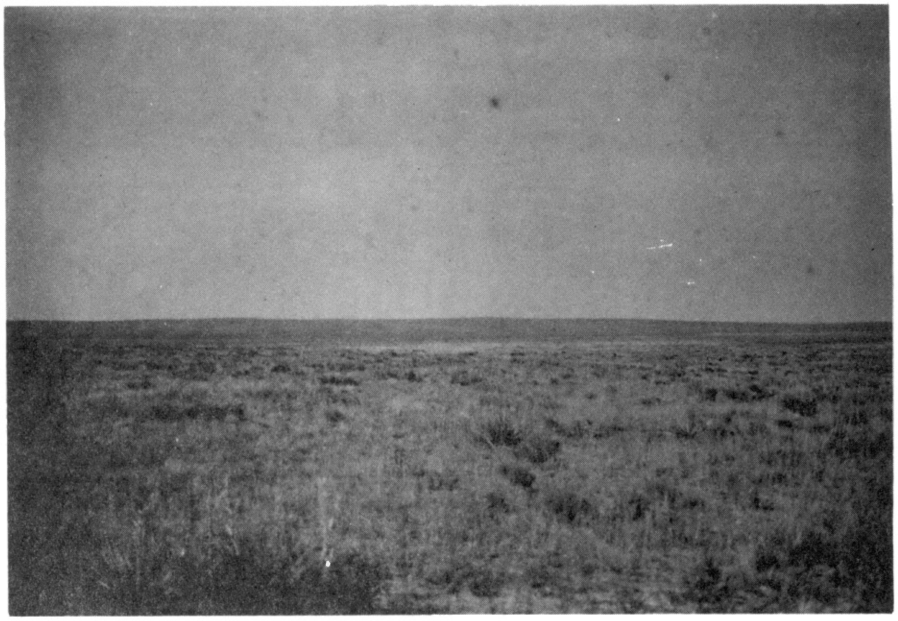

Figure 1. The sand sagebrush study area.

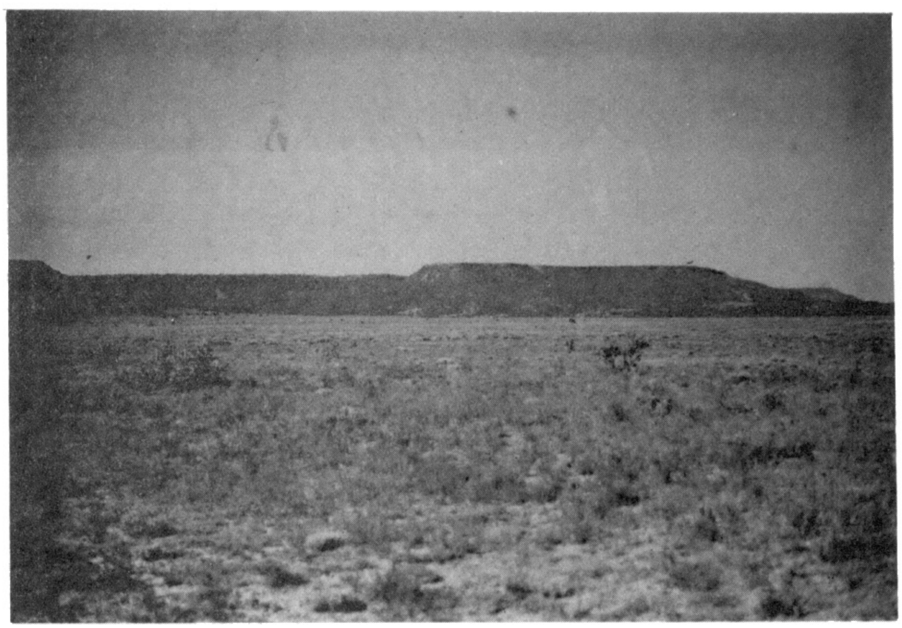

Figure 2. The shortgrass study area.

Vegetation maps were constructed during 1977. Vegetation and land use types were determined by a combination of data acquired from ground transects, aerial photos, and soil surveys. Each section of land on both areas was surveyed on the ground and mapped on section plat sheets. These sheets were then modified to incorporate information from aerial photos and soils maps. The area occupied by each vegetation type was determined with a dot grid. Names for vegetation types were chosen, insofar as possible, to coincide with names of similar vegetation types described in the literature.

Sand Sagebrush Area (SSB)

The sand sagebrush area is located in the southeast portion of the CNG (latitude 37° 0' - 37° 7' North, longitude 102° 20' - 102° 34' West) (Fig. 3). The total sand sagebrush study area occupied 23,300 ha. Elevations average 1,200 m above sea level. Land surfaces are relatively flat to rolling with the exception of the southeastern portion of the area which is dominated by the influence of the Cimarron River. The southern and eastern portions are dissected by numerous dry washes or arroyos.

The dominate vegetation types of this area are shortgrass (31%) intermingled with areas of sand sagebrush (9%) (Fig. 4). Principle plant species on the coarser textured soils include sand sagebrush (*Artemisia filifolia*) (ARFI), red threeawn (*Aristida longeseta*) (ARLO), yucca (*Yucca glauca*) (YUGL), and sand dropseed (*Sporobolus cryptandrus*) (SPCR). The hardland sites are dominated by blue grama (*Bouteloua gracillis*) (BOGR) and buffalo grass (*Buchloe dactyloides*) (BUDA).

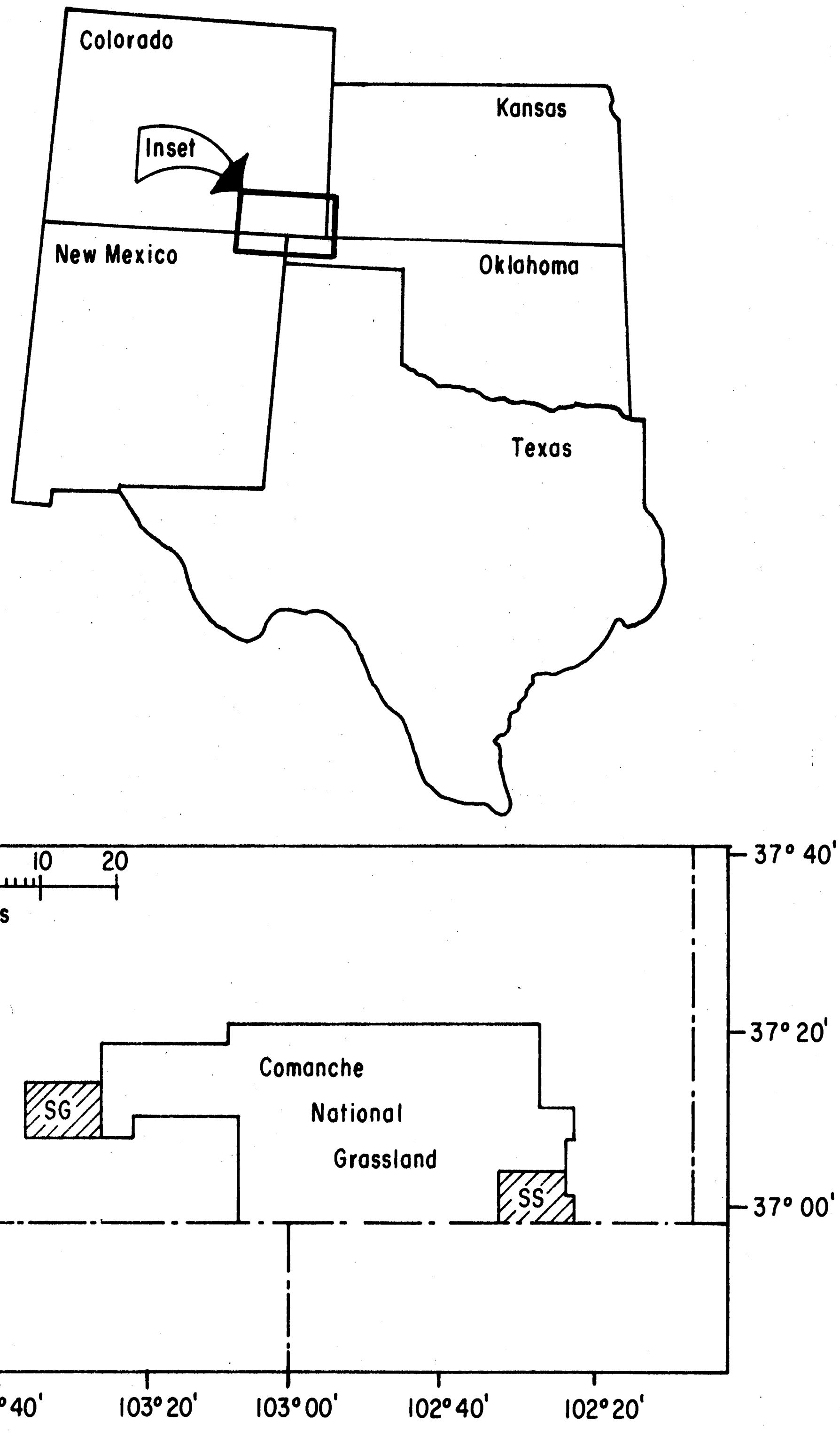

Figure 3. Geographic locations of study areas.

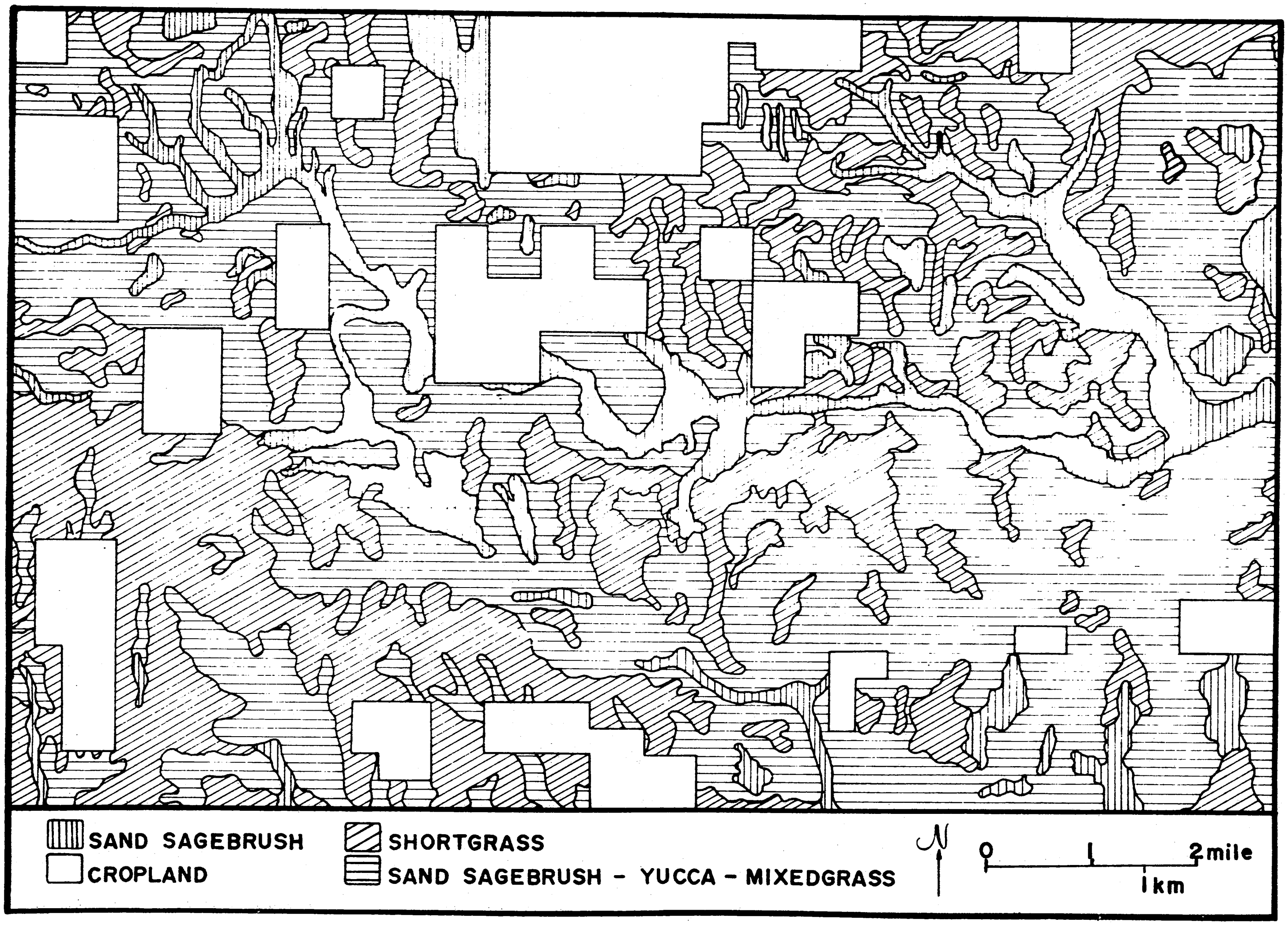

Figure 4. Natural vegetation and cropland of the sand sagebrush study area.

These two vegetation types blend together in many places to form the sand sagebrush-yucca-mixedgrass type (46%).

Forb production on the composite area as well as on other areas of the High Plains is dependent on the amount and seasonal distribution of precipitation (Weaver 1968). However, during most years this area produces variable quantities of scarlet globemallow (Sphaeralcea coccinea) (SPCO), russian thistle (Salsola kali) (SAKA) and greenthread (Thelesperma megapotamicum) (THME).

Most (90%) of the soils in this area are classified as sandy loams and loamy sands. The ramining 10% are classified as loams and gravelly loams (Soil Conservation Service 1973). Most of the sand loam soils in this area are cultivated, whereas the loamy sands and the gravelly loams remain as rangeland.

About (40%) of the area is privately owned land and 60% is public land. Much of the private land and all of the public land is good condition rangeland. Private rangeland plus all public leased land is under cultivation with principle crops of wheat, alfalfa, milo and broomcorn. Cultivated land comprises 14% of this area.

The area is semi-arid and receives an average of 440 mm of precipitation per year (Fig. 5). Precipitation is frequently of short duration and sporadic in occurrence with prolonged periods of drought being somewhat common. Most of the precipitation falls as rain during the months of April through July. Snowfall is usually light, but can be a serious threat to livestock when accompanied by the frequent and persistent high winds of the area.

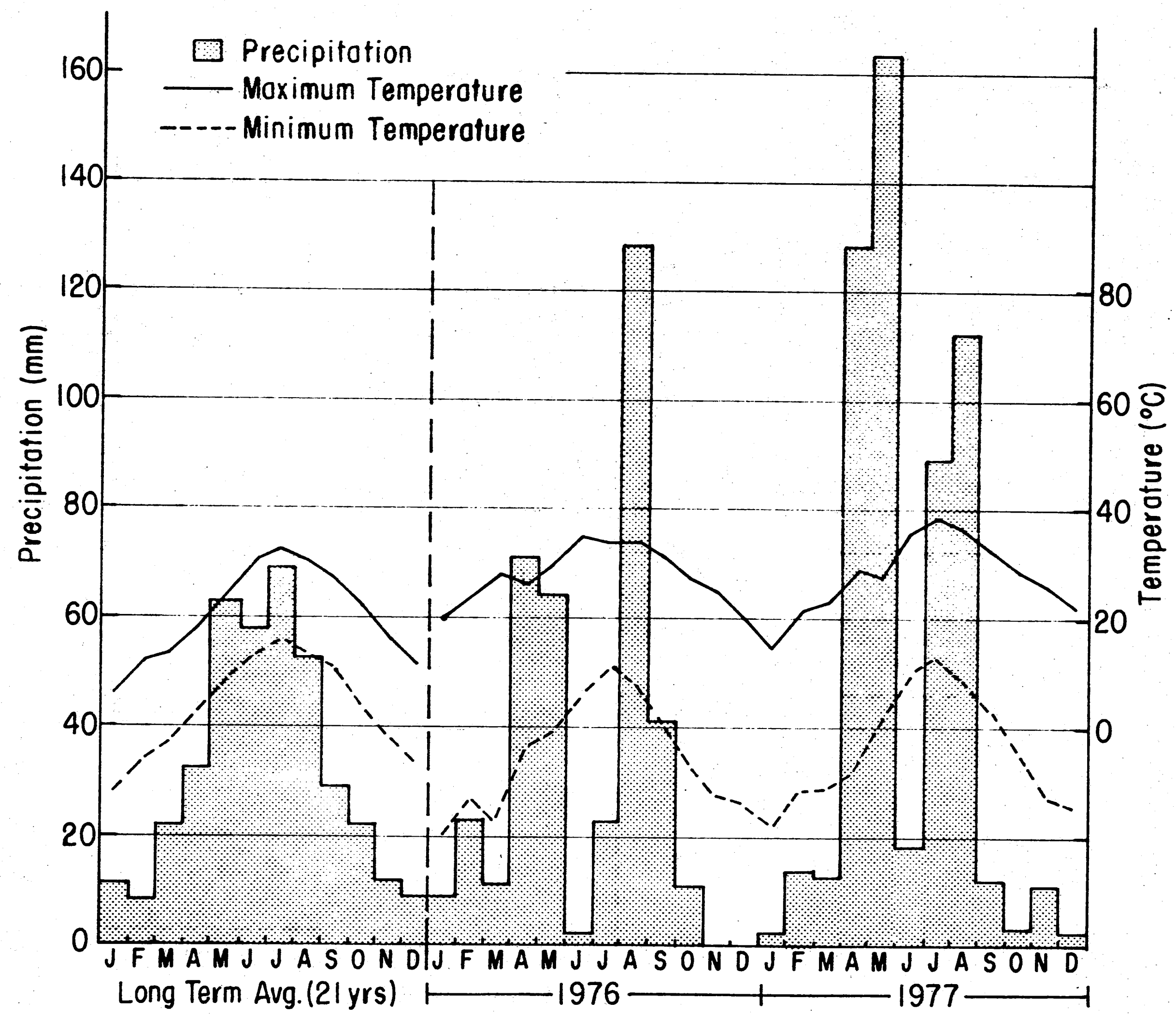

Figure 5. Long term and study period temperature and precipitation for the sand sagebrush study area.

Summers are often long and hot with temperatures exceeding 32°C being common July - August. Prolonged periods of cold temperatures are not as common as prolonged periods of heat. The average annual temperature for this area is about 12°C. The growing season averages 164 days. The 195-day growing season begins about 30 April and ends about 11 October (Soil Conservation Service 1973).

Shortgrass Area (SG)

The shortgrass study area of 21,700 ha is located in the very western tip of the CNG (latitude 37° 10' - 37° 17' North, longitude 103° 25' - 103° 38 West) (Fig. 3). Elevation averages 1,700 m above sea level with significant local relief variation in some areas. The dominate landmark in this area is Mesa DeMaya, an extensive basalt capped mesa. In variable forms, this mesa extends along the Colorado-New Mexico border forming a ridge between the Cimarron and the Purgatoire drainage systems. The mesa itself has been dissected into numerous outliers, some of which are known locally as separate mesas. This volcanic influence which includes several vents and dikes extends as far southeast as the northwestern portion of the Cimarron County of Oklahoma (Fenneman 1931).

Most of the study area is on the level plain between Mesa DeMaya and the breaks of the Purgatoire River Drainage. The plain itself lies at about 1,600 m elevation and is gently rolling in most places.

A more diverse combination of vegetation types characterizes this area as opposed to that in the sand sagebrush area (Fig. 6). Vegetation was classified as (1) shortgrass-shrub (SGS), (2) mixedgrass-

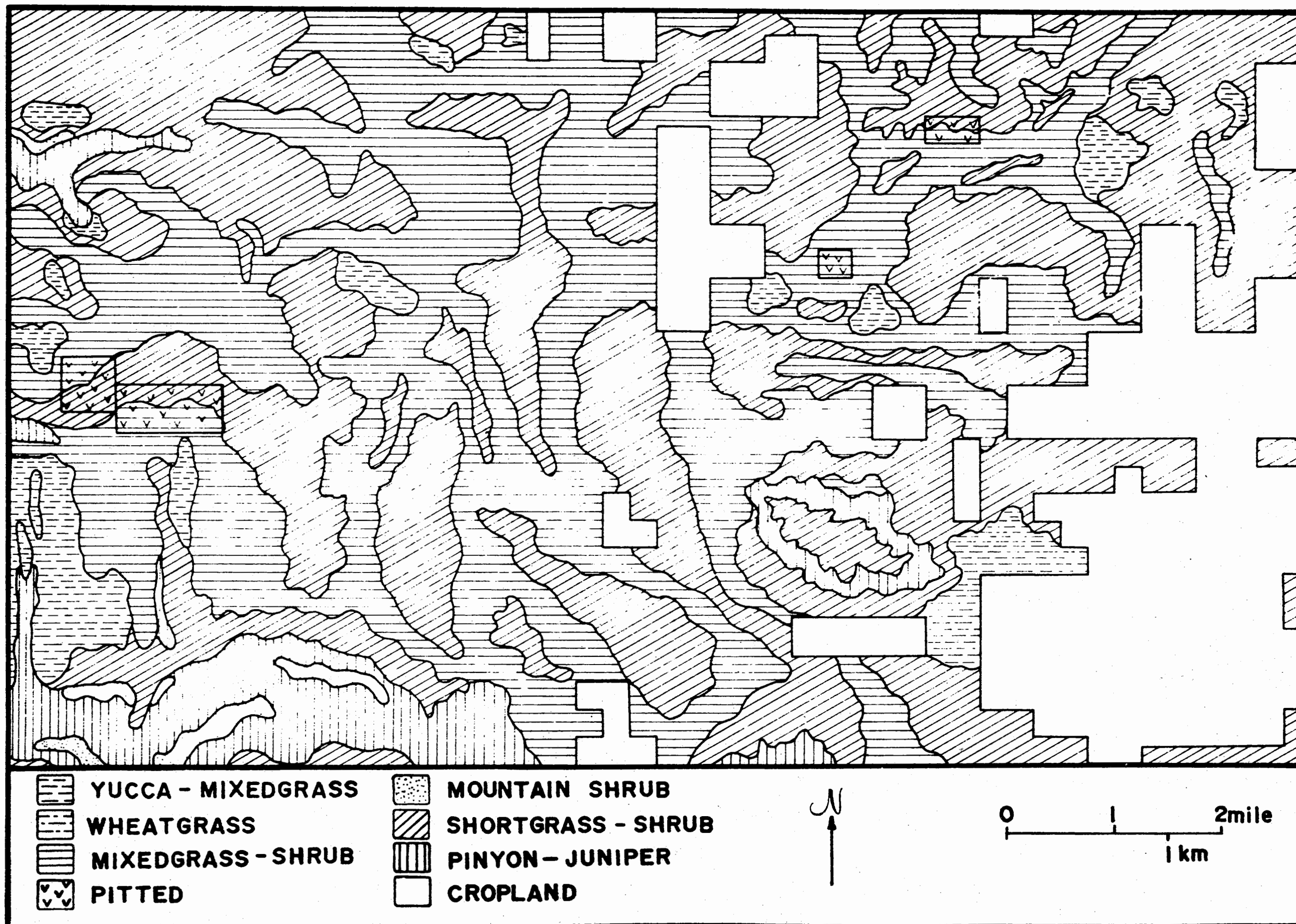

Figure 6. Natural vegetation and cropland of the shortgrass study area.

shrub (MGS), (3) wheatgrass (WG), (4) yucca-mixedgrass (YMG), (5) pinyon-juniper (PJ), and (6) mountain shrub (MS).

The SGS areas (36% of total area) are dominated by BOGR, BUDA, torrey muhly (_Muhlenbergia torreyi_) (MUTO), and rabbitbrush (_Chrysothamnus nauseosus_) (CHNA). The MGS type (32%) is characterized by an abundance of BOGR, SPCR, western wheatgrass (_Agropyron smithii_) (AGSM), and CHNA. The WG type (1%) is dominated almost exclusively by AGSM. These WG areas are mainly confined to "playas" or natural depressions. YUGL, needle and thread (_Stipa comata_) (STCO), BOGR, and SPCR are the dominant plants occurring on the YMG type (4%). The PJ type (6%) is dominated by pinyon pine (_Pinus edulis_) (PIED), one-seed juniper (_Juniperus monosperma_) (JUMO), BOGR, and with scattered populations of ponderosa pine (_Pinus ponderosa_) (PIPO) plus isolated clones of aspen (_Populus tremuloides_) (POTE). True mountain-mahogany (_Cercocarpus montanus_) (CEMO), scrub oak (_Quercus undulatum_) (QUUN), waffer ash (_Ptelea baldwinii_) (PTBA), and wolfberry (_Lycium pallidum_) (LYPA) are the common plants on the MS type (1%).

Most of the soils (80%) in this area are classified as clay loams, 7% are rocky loams, 10% are sandy loams and loams on upland breaks and rock outcrops and 3% are well drained rocky, sandy loams on steep hills and canyons (Soil Conservation Service 1972).

Climatically, this area is similar to the sand sagebrush area but receives less annual precipitation (250 mm) (Fig. 7). Most precipitation falls as rain between April and July. Rainfall is sometimes very localized and the runoff created is often rapid and violent in the washes or arroyos.

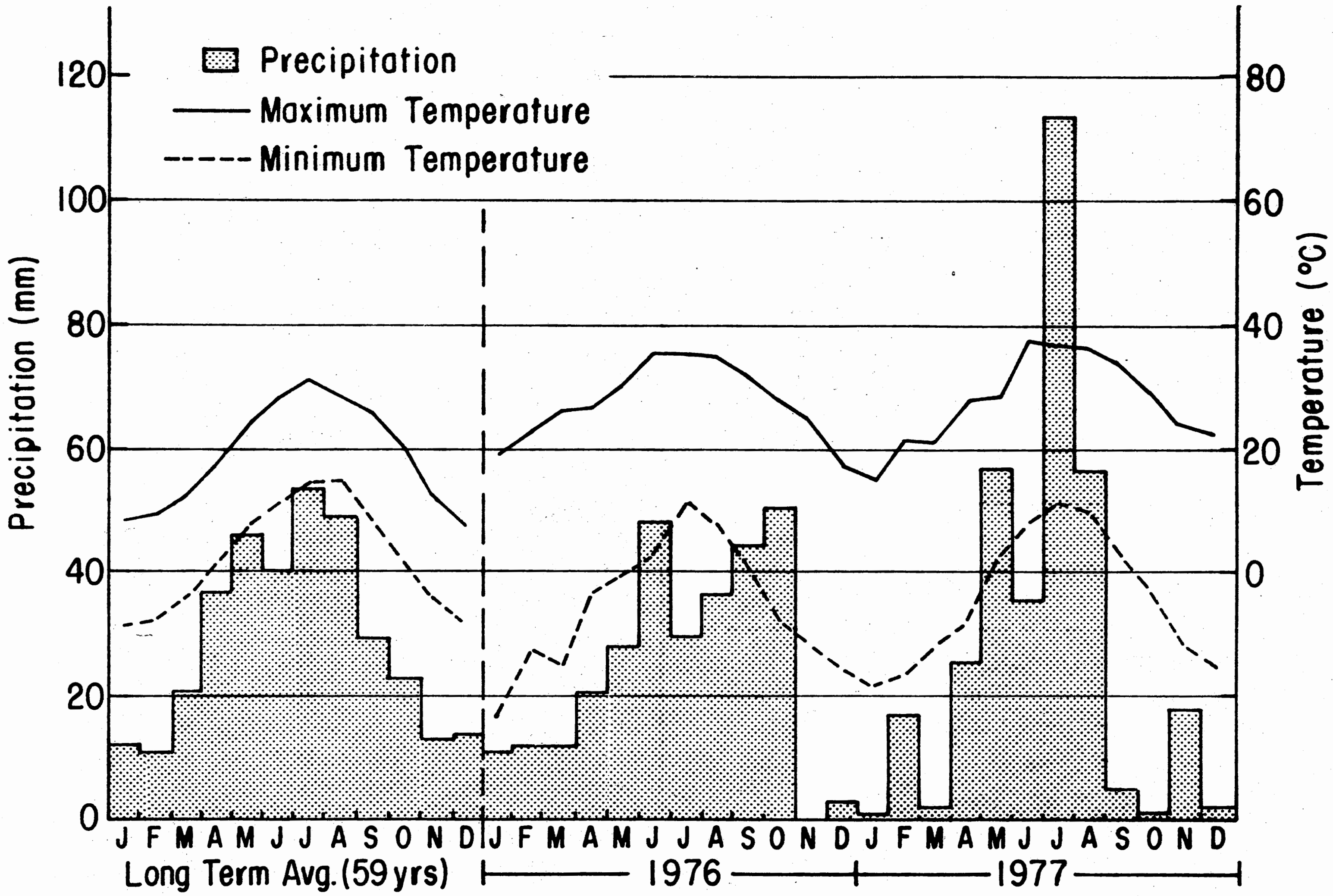

Figure 7. Long term and study period temperature and precipitation for the shortgrass study area.

Due to the higher elevation of this area, summer temperatures seldom are as high as in the sand sagebrush area. However, winter temperatures often drop will below 0°C. Winter blizzards in this area are sometimes more severe than those experienced in the sand sagebrush area. The 150-day growing season begins about 5 May and ends about 7 October.

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CHAPTER II

SUMMER AND FALL VEGETATION TYPE UTILIZATION BY PRONGHORN ON THE SOUTHERN HIGH PLAINS

The utilization of different vegetation types by pronghorn (*Antilocapra americana*) (Fig. 1) has been investigated and documented in many areas of the western United States (Bayless 1969, Beale and Scotter 1968, Mitchell and Smoliak 1971, Smith et al. 1965, Yoakum 1975). However, little information on pronghorn or pronghorn habitat is available for the Southern High Plains region. To acquire baseline information on vegetation type utilization by pronghorn on the Southern High Plains, studies were conducted on the Comanche National Grassland (CNG) in southeastern Colorado. Two study areas were selected within two contrasting geographic areas. These two areas exhibited differences in yearly fawn recruitment (M. Snider, Range Conservationist, USFS, 1976, personal communication). The objective of this study was to determine the vegetation type utilization and distribution of pronghorn on each area seasonally.

Methods

In addition to observation of pronghorn feeding areas, standard survey routes were established in each study area. A portion of these routes passed through or near each vegetation type present in each study area (Fig. 2 & 3). Existing roads were utilized for this

Figure 1. Pronghorn feeding in the mixedgrass-shrub vegetation type.

purpose. However, exceptions were made with respect to isolated vegetation types. Existing roads were utilized because these routes could be verified and used by subsequent investigations, pronghorn were accustomed to vehicle traffic in these areas and little environmental damage was caused by repeated use of these routes.

Survey routes were driven four times per week. Surveys were made from mid May to late August, 1976 and from early June to late December, 1977. When bands or individuals were sighted, their location and vegetation type were recorded. Detailed notes on herd composition (males, females, immature) were also recorded at the same time.

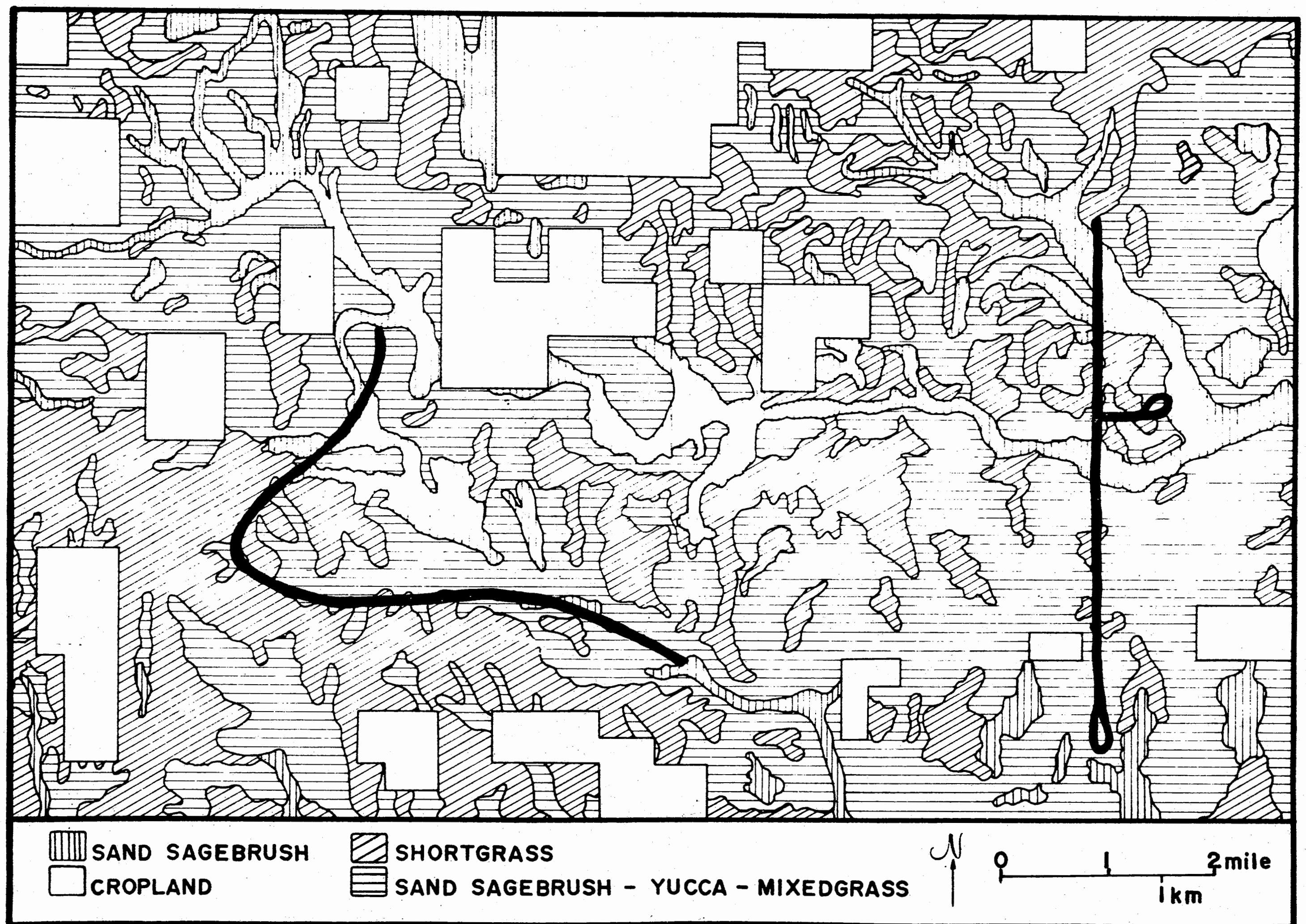

Figure 2. Pronghorn survey routes in the sand sagebrush study area.

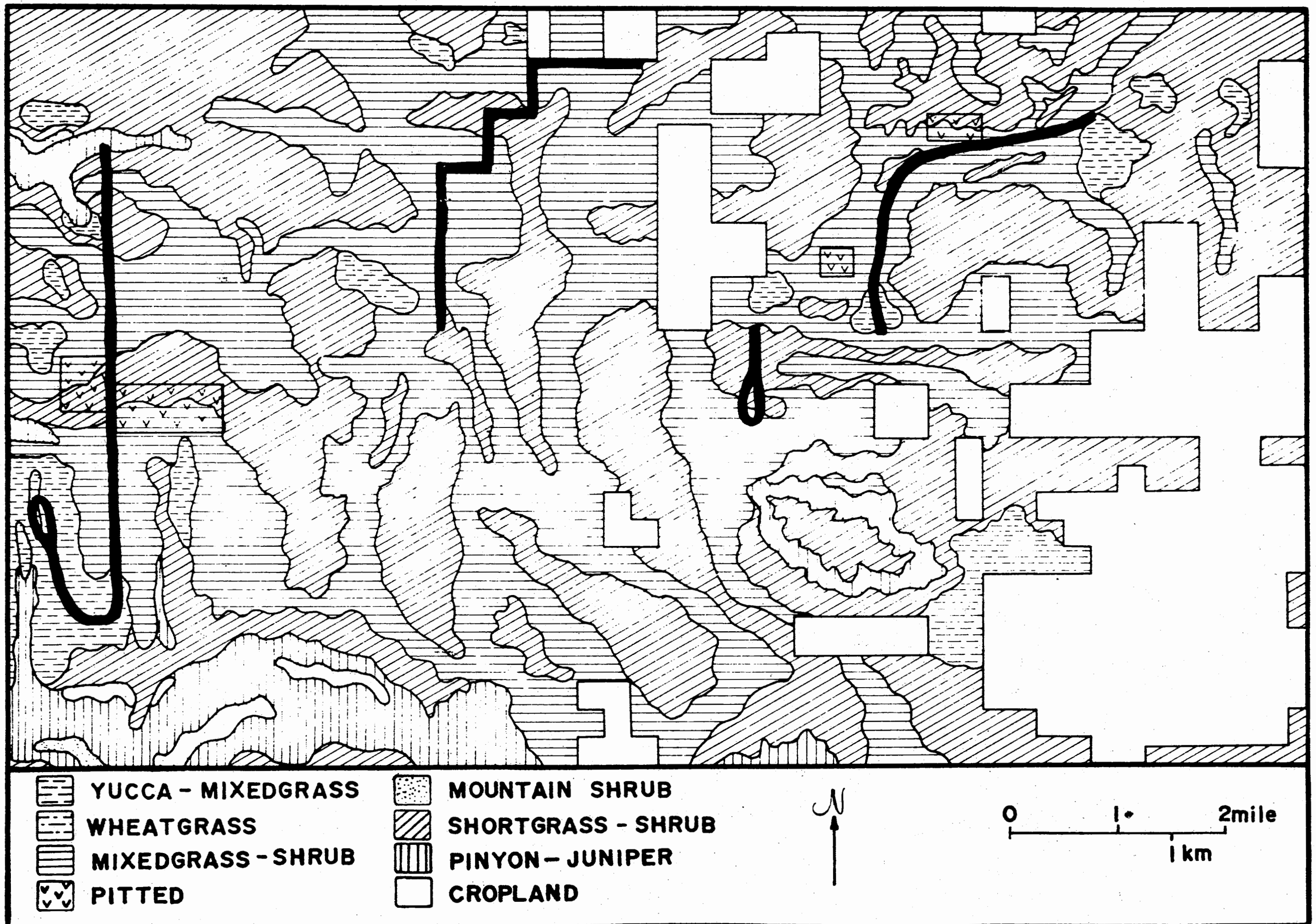

Figure 3. Pronghorn survey routes in the shortgrass study area.

After routes were completed each day, we returned to areas where pronghorn were observed in order to acquire additional information on other habitat components and movements of animals still in the area. Data obtained in the above procedures were tabulated but did not permit statistical analyses.

Results and Discussion

Sand Sagebrush Study Area

During a portion of the fawning period in 1976, from 15 May to 15 June, pronghorn does utilized areas where *Artemisia filifolia* (ARFI) was a dominant plant species. This is similar to results from studies on other pronghorn ranges where fawning areas were often associated with woody plant species (Autenrieth 1976). However, the dense sand sagebrush type was almost always avoided by pronghorn (Table 1). Where ARFI formed dense stands, the understory vegetation was very sparce and bare ground was very common. Areas where ARFI was moderately dense and the understory vegetation was vigorous and diverse, seemed to be more heavily utilized by pronghorn does for fawning.

The most frequent associate of ARFI on fawning areas was *Aristida longiseta* (ARLO). ARLO produced a dense understory while maintaining moderately low growth ($<$ 30 cm). The height of ARFI in most of the fawning areas was about 75 cm. Observations of does in these areas indicated this to be the optimum combination of plant growth forms and structure for fawning sites. As a general rule, pronghorn are usually observed in vegetation with a height of approximately 60 cm or less (Yoakum 1975).

Table 1. Vegetation type utilization by pronghorn in the sand sagebrush study area.

Year Period	Sand Sagebrush (17%)[1]	Shortgrass (29%)	Sand sagebrush- yucca- mixedgrass (54%)	All Types (100%)
1976				
May 15-June 15[2]	1[3]/1[4] 2[5] 0.1[6]	20/13 50 1.7	19/9 48 0.9	40/23
June 16-July 15	0/0 0 0	36/8 78 2.7	10/4 22 0.4	46/12
July 16-August 25	0/0 0 0	75/8 53 1.8	67/13 47 0.9	142/21
1977				
June 1-June 15	0/0 0 0	29/5 100 3.5	0/0 0 0	29/5
June 16-July 15	0/0 0 0	6/2 100 3.5	0/0 0 0	6/2
July 16-August 15	1/1 3 0.2	31/4 97 3.3	0/0 0 0	32/5
August 16-September 15	0/0 0 0	16/2 100 3.5	0/0 0 0	16/2
September 16-October 15	0/0 0 0	0/0 0 0	19/3 100 1.9	19/3
October 16-November 15	0/0 0 0	0/0 0 0	0/0 0 0	0/0
November 16-December 15	17/1 100 5.9	0/0 0 0	0/0 0 0	17/1

1/ Percentage of total routes occupied by each vegetation type.

2/ Months were subdivided to coincide with the termination of fawning season (June 15).

3/ Total number of pronghorn sighted in each vegetation type.

4/ Total number of pronghorn bands sighted in each vegetation type.

5/ Percentage of individual pronghorn sighted in each vegetation type.

6/ Vegetation type preference ratio (TPR)=(Percentage of individual pronghorn in each type)/(Percentage of total routes occupied by each type).

Most male pronghorn were observed in shortgrass vegetation during the period from 15 May - 15 June in the 1976 season. These were primarily scattered sightings of individual bucks and a few group sightings. Total number of pronghorn sightings, for all vegetation types, are tabulated in Table 2.

Table 2. Pronghorn herd composition on each study area.

	Sand sagebrush		Shortgrass	
	1976	1977	1976	1977
Total[1/]				
Bucks	26	18	70	49
Does	147	50	196	140
Fawns	42	48	104	108
Ratios				
Buck/Doe	1:5.6	1:2.3	1:2.8	1:2.9
Doe/Fawn	1:0.3	1:1.0	1:0.5	1:0.8

[1/] Based on total number of pronghorn sightings.

From 16 June - 15 July, most pronghorn, of all classes were sighted on areas dominated by short and midgrasses. A few of the sightings during this period occurred in areas where ARFI was present, but not dominant. All classes of pronghorn were sighted on those areas where ARFI was present. Pronghorn does apparently moved out of the fawning areas during this time period.

As the season progressed, pronghorn bands became larger in size and more conspicuous. From 15 July - 25 August, the number of sightings were almost evenly divided between areas dominated by shortgrasses and areas where midgrasses appeared frequently. However, shortgrass areas appeared to be more heavily utilized during this period.

Results of the 1977 season differed from those of the 1976 season. During the first period thought to be the remainder of the fawning period, all sightings were on shortgrass vegetation. Proportionally the same number of sightings occurred in both years. However, fewer bands were sighted in 1977.

The period from 16 June - 15 July produced similar results to the preceeding period. The number of sightings during this period is decreased due to greater mobility of bands and family groups. This may be due to the increased ability of the fawns to travel and incorporation of family groups into larger bands. From this period on, pronghorn became much more difficult to find.

During the period from 16 July - 15 August, the number of total sightings on the shortgrass areas increased by a large degree. The additional sightings for the shortgrass areas is not attributed to pronghorn movement into the area, but rather to location of bands on the study area. However, the one sighting on the sand sagebrush type is attributed to immigration. Pronghorn observed on ARFI dominated areas, after fawning season, appeared nervous and probably were not residents.

During the August-September period, all sightings occurred on shortgrass vegetation. Band size was comparable to the previous period, but fewer bands were observed.

The period from 16 September - 16 October produced a change interpreted as a biological break in pronghorn vegetation type utilization. All sightings during this time period took place in the sand sagebrush-yucca-mixedgrass type. Band size was similar to the previous period. Precipitation for this time period was 75% below the longterm average and about 75% below the precipitation received in the same period of the previous year. This lack of moisture may have been the driving force to coarser soils dominated by ARFI.

No pronghorn were observed during the October-November period. This period coincided with a special hunt conducted in the area. Most of the pronghorn in the area were thought to have moved south into Oklahoma where there was no season.

All sightings during the November-December period occurred in the sand sagebrush type. During this time, only one band of 17 pronghorn were sighted in this area.

Pronghorn in the sand sagebrush area seemed to utilize grasses and some forbs as a spring and summer food supply. Utilization of grass species was observed to be higher than that reported in the literature. Many studies concluded pronghorn rely mainly on forb species during spring and summer on other pronghorn ranges (Buechner

1950, Mitchell and Smoliak 1971, and Severson et al. 1968). However, recently Schwartz and Nagy (1976) reported pronghorn in northeastern Colorado utilized grasses heavily, particularly Bouteloua gracilis (BOGR), during spring and summer months.

The diversity of forb species may have influenced pronghorn distribution in this area. Favored forage species such as Sphaeralcea coccinea (SPCO), Thelesperma megapotamicum (THME), Haplopappus spinulosus (HASP), Lygodesmia juncea (LYJU), and Psoralea tenuiflora (PSTE) were numerous on these shortgrass areas. Yucca glauca (YUGL) blooms and upper stalks were also heavily utilized by pronghorn during spring and early summer. Therefore, summer range of pronghorn in this area should be typified by short vegetation dominated by BOGR and numerous forb species.

Fall and winter distribution of pronghorn in this area is not well understood. It may be influenced by precipitation and management decisions such as special hunts. The winter use of ARFI by pronghorn was not well documented during this study, but ARFI may have a definite role in winter pronghorn habitat in this area.

Shortgrass Study Area

Pronghorn in the shortgrass study area seemed to be more localized in their seasonal movements than those in the sand sagebrush area. Studies conducted on other shrub dominated ranges indicated the same findings (Beale and Scotter 1968, Severson et al. 1968). The use of a single type of vegetation for fawning was not observed in this area. However, does were observed in areas of moderate shrub cover. The understory vegetation on these areas varied greatly in species composition and density. Heavily wooded areas around mesas and canyons were consistantly avoided by all classes of pronghorn.

Between 15 May and 15 June, 1976 only one band of 8 pronghorn was observed. This observation was on the mixedgrass-shrub type (Table 3). During the period from 15 June - 15 July, pronghorn utilized a greater diversity of vegetation types. Shortgrass-shrub areas were utilized proportionally more than were the mixedgrass-shrub and pitted types. Also, a large number of band sightings occurred on the shortgrass-shrub type. Precipitation amounts for the study area during June 1976 were higher than average and succulent forage may have been a major factor in the increased utilization of these shortgrass areas. Of the 14 bands sighted, 11 were observed on shortgrass types.

The July-August period exhibited a continuation of the trend of utilization diversity in vegetation types. A total of 215 sightings occurred on five vegetation types. The yucca-mixedgrass and cropland types were utilized during this period, although only one band sighting occurred on each of these types. The shortgrass-shrub areas were utilized four times as much as they were in the previous period. Band size remained about the same on this type and consistantly larger on the pitted type.

Total spring and summer sightings were fewer in 1977 on the shortgrass study areas than in 1976. This was also true in the sand sagebrush area. The 1977 season produced type utilization results similar to those obtained during 1976. During the period 1 June -

Table 3. Vegetation type utilization by pronghorn in the shortgrass study area.

Year Period	Wheat-grass (1%)[1]	Yucca-mixed-grass (10%)	Short-grass-shrub (13%)	Mixed-grass-shrub (67%)	Pitted (6%)	Cropland (3%)	All Types (99%)[2]
1976							
	0[4]/0[5]	0/0	0/0	8/1	0/0	0/0	8/1
May 15-June 15[3]	0[6]	0	0	100	0	0	
	0[7]	0	0	1.5	0	0	
	0/0	0/0	40/11	10/3	10/1	0/0	60/15
June 16-July 15	0	0	66	17	17	0	
	0	0	5.1	0.3	2.8	0	
	0/0	5/1	163/30	5/2	36/3	6/1	215/37
July 16-August 25	0	2	76	2	17	3	
	0	0.2	5.9	0.1	2.8	1.0	
1977							
	0/0	0/0	15/8	0/0	0/0	0/0	15/8
June 1-June 15	0	0	100	0	0	0	
	0	0	7.7	0	0	0	
	0/0	0/0	18/5	5/2	0/0	0/0	23/7
June 16-July 15	0	0	78	22	0	0	
	0	0	6.0	0.3	0	0	
	18/2	2/1	60/10	4/2	6/2	0/0	90/17
July 16-August 15	21	2	66	4	7	0	
	21.0	0.2	5.1	0.1	1.2	0	
	0/0	0/0	10/1	0/0	0/0	0/0	10/1
August 16-September 15	0	0	100	0	0	0	
	0	0	7.7	0	0	0	
	0/0	2/1	11/1	4/1	0/0	0/0	17/3
September 16-October 15	0	12	65	23	0	0	
	0	1.2	5.0	0.3	0	0	
	0/0	0/0	0/0	62/3	0/0	0/0	62/3
October 16-November 15	0	0	0	100	0	0	
	0	0	0	1.5	0	0	
	0/0	0/0	0/0	21/1	14/1	0/0	35/2
November 16-December 15	0	0	0	60	40	0	
	0	0	0	0.9	6.7	0	

[1] Percentage of total routes occupied by each vegetation.

[2] Pinyon-Juniper (0.5%) and mountain shrub (0.5%) not shown.

[3] Months were subdivided to coincide with the termination of fawning season (June 15)

[4] Total number of pronghorn sighted in each vegetation type.

[5] Total number of pronghorn bands sighted in each vegetation type.

[6] Percentage of individual pronghorn sighted in each vegetation type.

[7] Vegetation type preference ratio (TPR)=(Percentage of individual pronghorn in each type)/(Percentage of total routes occupied by each type).

15 June, the shortgrass-shrub type was the only vegetation type utilized. Band size was somewhat small during this period at about two animals per sighting. This seems to indicate fawning season was still in progress or just over. In 1976, one band of 8 was sighted during this period, whereas in 1977, 8 bands of about 2 each were observed during the same period.

The June-July period also exhibited relatively low diversity in vegetation type utilization by pronghorns. Pronghorn continued to use the shortgrass type to a large extent (78% of sightings) along with less utilization (22%) of the mixedgrass-shrub type. All other vegetation types present on the area continued to be unutilized. Band size continued to increase during this period, indicating fawns were becoming more mobile.

During the July-August period, all vegetation types were utilized except the cropland type. The shortgrass-shrub type was the most heavily utilized type. Bands observed on the shortgrass-shrub type were among the largest observed during this period. The wheatgrass type received its only evidence of utilization during this period. Bands observed on the wheatgrass area were relatively large indicating a further solidification of bands in this area. The increased utilization of the wheatgrass type may have been the result of increased precipitation in the area during the later part of the preceeding period. Precipitation for this period was over twice the average. Almost all of the wheatgrass type occurred in "playas" or natural depressions which retained excess runoff. August precipitation was only about average and these playas tended to conserve moisture while plants on upland areas may have been low in moisture during the same period. Agropyron smithii (AGSM), the dominant species in the playas, is a cool season grass. AGSM or some other species in the playas may have increased in relative palatability compared to plants on upland, more xeric soils during this period.

During the August-September period, no pronghorn sightings occurred in the wheatgrass type. Precipitation for this period was only 50% of average. The effect of precipitation on the distribution of pronghorn in this area is not well understood, and additional research on this aspect is needed. The shortgrass-shrub type continued to be the only type utilized during this period and only one band of 10 was sighted within it.

The number of total sightings was also low in the September-October period. One band of 11 was sighted on the shortgrass-shrub type and 2 small bands of 2 and 4 pronghorns were sighted on the mixedgrass-shrub and yucca-mixedgrass types.

Overall band size increased greatly in the October-November period indicating even more solidification. A large change occurred in pronghorn vegetation type utilization during the October-November period. This may be interpreted as a biological break such as the one occurring on the sand sagebrush study area during the September-October period. Very limited precipitation during this period may have affected pronghorn distribution. Precipitation was only 10% of average during this period. Cool season species were more common in the mixedgrass-shrub type than in other types and may have attracted the pronghorn.

The utilization pattern for the November-December period was similar to the preceeding period. Above normal precipitation may have prompted use of pitted areas which retained moisture. One band of 21 pronghorn was observed in the mixedgrass-shrub type and one band of 14 in the pitted areas. Band size during this period was the largest to date.

Vegetation type utilization by pronghorn in the shortgrass area seemed to depend, at least partly, on the amount and distribution of seasonal precipitation. Cool season grass species such as AGSM and *Oryzopsis hymenoides* (ORHY) may supplement browse species in the diets of pronghorn in this area during fall and early winter. The reaction of these cool season species to precipitation may have a significant influence on pronghorn distribution on the shortgrass study area.

During late fall, pronghorn seemed to utilize more areas where *Chrysothamnus nauseosus* (CHNA) and *Ceratoides lanata* (CELA) were most frequent. CHNA was the most widespread of the 2 species occurring on the study area. However, CELA was found in concentrated pockets throughout the study area. CELA appeared to be the more heavily utilized of the 2 species, particularly during late fall.

The use of pitted areas in the shortgrass study area seemed to be determined by precipitation frequency and distribution. Precipitation also appeared to influence the utilization of the cropland areas. Pronghorn appeared to be utilizing annual forbs such as *Salsola kali* (SAKA) and *Helianthus annuus* (HEAN) rather than crops on these areas.

Conclusions

Pronghorn on both study areas seemed to depend on shortgrass during summer months when precipitation was near normal. However, pronghorn herds in both areas seemed to be much more mobile during periods of below precipitation, particularly when warm season species began to mature and dry. During late fall, both herds began to change their patterns of vegetation type utilization. Pronghorn in the shortgrass area seemed to depend more on areas where cool season species dominated. Pronghorn in the sand sagebrush areas began to utilize areas where ARFI was a dominant component.

Winter use was not studied during this investigation. However, winter habitat factors may be important to consider when comparing these two areas. Any future research done on pronghorn habitat in this area needs to consider winter habitat preferences. The importance of ARFI in the winter habitat should be determined.

Winter wheat also seemed to be of some importance to pronghorn in the sand sagebrush study area. The absence of palatable woody species in this area may be one of the major limiting factors on pronghorn in the sand sagebrush area. This could also be interpreted as a deficiency in the natural protein sources in the area.

Pronghorn in the shortgrass study area utilized vegetation types which reflected the true nature of that area. During summer months they were observed more frequently in shortgrass areas and in mixed-grass areas during fall months. This balance of types plus the abundance of palatable shrub species apparently supported a higher total pronghorn population in this area.

The shortgrass area appeared to be the better habitat for pronghorn on the basis of better winter habitat. The percentage of winter wheat was about the same for both areas. The better fall and winter habitat in the shortgrass area was reflected in higher fawn recruitment. Because of apparent winter habitat limitations, the sand sagebrush type may not be good yearlong habitat for pronghorn.

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CHAPTER III

PLANT SPECIES COMPOSITION ON SOUTHERN HIGH PLAINS PRONGHORN FEED GROUNDS

The main southeastern extention of pronghorn range in the United States roughly coincides with the eastern boundary of the Southern High Plains (Sundstrom et al. 1973). Many areas along this line are devoid of pronghorn. This is not well understood but may be the result of land-use changes, climate (precipitation) or vegetation communities or community structure. Much of this region is dominated by shortgrasses such as Bouteloua gracilis and Buchloe dactyloides with very sparse shrub cover. This absence of palatable shrub cover may contribute to the scattered distribution of pronghorn in this region. In other areas of pronghorn range, the presence of woody species has been demonstrated to benefit pronghorn populations (Beale and Scotter 1968, Severson et al. 1968). Forb abundance and diversity may also influence the distribution of pronghorn on the Southern High Plains.

Since areas dominated by Artemisia filifolia and areas dominated by shortgrasses are common on the Southern High Plains, a study was conducted to determine the effect of plant communities on pronghorn distribution on these types. The study took place on the Comanche National Grassland in southeastern Colorado. The primary objective of this study was to determine the herbaceous and woody plant species composition, and woody plant density on a large study area and the pronghorn feed grounds within it.

Methods

Pronghorn feed grounds were determine by observing bands of pronghorn throughout the sand sagebrush study area. Bands were observed as close as possible without disturbing their feeding activities. Time pronghorn spent feeding and movements relative to soil or vegetation types were recorded. These feed grounds were stratified into soil types according to the time pronghorn spent feeding on each type. The percent feeding time by soil type was determined using the following equation: Feeding time (%) by soil=[time (min.) feeding on each soil type x 100]/[total time (min.) observed in total feeding area]. From this equation the number of transects to be established on each soil type was calculated.

The step-point method (Evans and Love 1957) was modified to determine the herbaceous species composition and ground cover on these feeding areas. Every 2 m a pointer was touched to the ground and the ground cover (bare ground, vegetation, litter and rock) contacted was recorded. The nearest herbaceous plant, in a forward direction, was also recorded at each point.

The shrub species frequency and density were determine using the point-centered quarter procedure (Cottam and Curtis 1956). Every fifth point, along the step-point transect, (10 m apart) the transect was divided into four quarters. The closest woody species was recorded for each quarter along with the distance (meters) to it from the observation point. Using methods described by Dix (1961), density (plants/ha) was then calculated for each woody species on a particular feed ground. The equation is as follows: $[(10{,}000/\pi r^2)(N/\Sigma N)$=plants per ha], where r represents the average distance to all woody plants encountered, πr^2 represents the average area occupied by all woody plants, N denotes the number of observations on a particular species and ΣN represents the number of observations for all species.

Using these same methods, the total sand sagebrush study area was also described. The area was stratified by soil type using the soils maps described by SCS (1972). A dot grid of appropriate scale was used to determine the size of area occupied by each soil type. The percentage of each soil type on the study area was then calculated. The number of transects to be established on each soil type was then determined and their location was arbitrarily selected so the total length of each transect fell within a particular soil type. When more than one transect was selected for a soil type, the transects were positioned to obtain equal spatial distribution between transects within the soil type boundaries. Transects were also located in different geographical areas in which particular soil types occurred to provide a measure of random variation within each soil type. At least one transect was established on each soil type present on the study area.

Results and Discussion

Range Site and Soil Type Utilization

Pronghorn in the study area preferred feed grounds on the finer textured soils (Table 1). Sand soils predominated the study area,

Table 1. Range site and soil type utilization by pronghorn in the sand sagebrush study area and feed grounds.

RANGE SITE Soil Series	% of Study Area	% of Feed Grounds	Ratio FG/SA
SANDY PLAINS	79.7	53.9	0.7
Dalhart sandy loam	8.5	7.6	0.9
Dalhart sandy loam	1.4	0.0	0.0
Manter-Vona sandy loam	29.4	15.4	0.5
Otero sandy loam	19.6	19.3	1.0
Otero sandy loam	4.9	0.0	0.0
Vona loamy sand	14.5	11.6	0.8
Vona sandy loam	1.4	0.0	0.0
LOAMY PLAINS	6.9	30.9	4.5
Baca clay loam	1.9	0.0	0.0
Campo clay loam	1.3	0.0	0.0
Harbord loam	0.3	0.0	0.0
Harvey loam	0.3	0.0	0.0
Kim loam	0.1	0.0	0.0
Wages loam	0.2	0.0	0.0
Wiley loam	2.8	30.9	11.0
GRAVEL BREAKS	5.6	15.2	2.7
Gravelly land	0.7	0.0	0.0
Otero-Potter complex	3.8	7.6	2.0
Potter gravelly loam	1.1	7.6	6.9
DEEP SANDY	5.0	0.0	0.0
Tivoli sand	5.0	0.0	0.0
SANDY BOTTOMLAND	2.7	0.0	0.0
Bankard sand	1.6	0.0	0.0
Glenberg sandy loam	1.1	0.0	0.0

but received only about one-half the total utilization observed. Almost 50% of the observed feed grounds were on the Loamy Plains and Gravel Breaks range sites which contributed 15% to the total area of the study area.

A very large number of the pronghorn observations occurred on the Wiley loam and the Potter gravelly loam. These two soil types were dominated by Bouteloua gracilis and Buchloe dactyloides and numerous forb species. Areas such as these were utilized almost exclusively during spring and summer months.

Coarse sand soil types were not observed to be utilized for feeding by pronghorn during spring and summer. However, these areas produced a dominant understory of forbs known to be pronghorn foods.

Ground Cover Frequency

Between all soils used for feeding areas by pronghorn, no significant differences in ground cover was observed (Table 2). However, some differences were observed between soil textures. In general, sandy soils were higher in percent bare ground and lower in litter and vegetation than on loamy soils. When feeding areas were compared to the study area, feeding areas were usually higher in percent bare ground and lower in the other two catorgories.

Herbaceous Species Composition

Grasses dominated the study area as well as feed grounds (Table 3). The higher percentage of BOGR and BUDA on feed grounds than on the study area was indicative of the soil types utilized by pronghorn.

Table 2. Average ground cover frequency (%) in the sand sagebrush study area (SA) and feed grounds (FG).

SOIL TEXTURE Soil Series	Ground Cover Bare Ground SA[1/]	 FG[2/]	 Litter SA	 FG	 Vegetation SA	 FG
Average	82.8	84.0	16.4	15.5	0.6	0.4
SANDY SOILS						
Sandy Plains	83.4	87.5	16.0	11.9	0.5	0.5
Dalhart sandy loam	88.8	96.0	10.2	3.0	0.8	1.0
Manter-Vona sandy loam	85.6	88.0	14.0	11.5	0.4	0.5
Otero sandy loam	76.9	86.0	22.6	13.2	0.5	0.8
Vona loamy sand	82.4	80.0	17.2	20.0	0.2	0.0
LOAMY SOILS						
Loamy Plains						
Wiley loam	78.8	80.0	20.5	19.6	1.1	0.3
Gravel Breaks	89.2	93.0	10.0	6.5	0.7	0.5
Otero-Potter complex	84.5	92.0	15.0	8.0	0.5	0.0
Potter gravelly loam	94.0	94.0	5.0	5.0	1.0	1.0

[1/] Average frequency on the total study area.

[2/] Average frequency on the feed grounds.

Table 3. Average herbaceous species frequency (%) in the sand sagebrush study area and feed grounds.

Species	(Symbol)	Study Area (N=107)[1/]	Feed Grounds (N=30)	Probability Level
GRASSES		88.4	90.6	
Aristida longiseta	(ARLO)	8.9	3.2	.15
Bothriochloa saccharoides	(BOSA)	1.2	0.5	.51
Bouteloua curtipendula	(BOCU)	4.1	1.5	.45
Bouteloua gracilis	(BOGR)	41.5	54.0	.44
Buchloe dactyloides	(BUDA)	4.5	10.1	.28
Chloris verticillata	(CHVE)	1.3	0.6	.34
Hilaria jamesii	(HIJA)	T[2/]	0.2	.40
Muhlenbergia porteri	(MUPO)	0.6	0.7	.71
Munroa squarrosa	(MUSQ)	0.7	1.3	.68
Sporobolus airoides	(SPAI)	0.2	T	.14
Sporobolus cryptandrus	(SPCR)	24.6	18.1	.54
Miscellaneous		0.8	0.4	
FORBS		11.5	9.2	
Ambrosia coronopifolia	(AMPS)	1.5	1.4	.92
Aster tanacetifolius	(ASTA)	0.3	1.0	.28
Chenopodium leptophyllum	(CHLE)	1.9	0.3	.29
Cryptantha minima	(CRMI)	0.9	T	.12
Eriogonum annum	(ERAN)	1.8	0.5	.26
Salsola kali	(SAKA)	1.1	1.8	.70
Sphaeralcea coccinea	(SPCO)	1.2	1.5	.74
Zinnia grandiflora	(ZIGR)	0.5	0.0	.07
Miscellaneous		2.3	2.7	

[1/]Number of 50-point transects.

[2/]Less than 0.1%.

Two species of bunchgrasses, ARLO and SPCR, were also common on both the study area and the feed grounds, Forb composition was similar on both areas, although a comparison by soil series indicated possible differences.

Large differences in relative abundance of certain species on the study area and feed grounds were observed on sandy textured soils (Table 4). Grasses on the Sandy Plains feed grounds were about as abundant as on the area-wide feed grounds, but somewhat less abundant on the Sandy Plains study area. Relatively taller grasses, such as ARLO, BOSA, BOCU and SPCR, were much more common on the Sandy Plains study area then they were on feed grounds. However, shortgrasses, such as BOGR and BUDA, were substantially more frequent on feed grounds than on the study area. Although valid statistical tests could not be made, interactions between soil series and frequencies of certain species (e.g., BOGR and SPCR) were indicated.

Noticeable differences also existed in frequencies of certain forbs on certain soils in the study area and feed grounds (Table 5). CHLE, CRMI, ERAN and ZIGR were less abundant on feed grounds, whereas ASTA and SAKA tended to be more abundant on feed grounds than on the study area. Most other forb species were present on both areas in nearly equal amounts.

The loamy soils utilized by pronghorn on Loamy Plains and Gravel Breaks range sites were dominated by the sod-forming grasses, BOGR and BUDA (Table 6). The average frequency of BOGR on loamy soil feed grounds was slightly lower than that on the loamy soil portion of the study area. However, the difference in frequency of BOGR was much larger on Wiley loam, the only Loamy Plains soil utilized by pronghorn.

Table 4. Average grass species frequency (%) in the sand sagebrush study area (SA) and feed grounds (FG) on sandy textured soils (Sandy Plains range site).

Species	(Symbol)	Average SA (N=78)[2/]	Average FG (N=15)	Dalhart Sandy Loam SA (N=9)	Dalhart Sandy Loam FG (N=2)	Manter-Vona Sandy Loam SA (N=30)	Manter-Vona Sandy Loam FG (N=4)	Otero Sandy Loam SA (N=25)	Otero Sandy Loam FG (N=6)	Vona Loamy Sand SA (N=14)	Vona Loamy Sand FG (N=3)
Total		81.3	89.7	84.3	69.0	72.5	92.0	89.0	99.6	78.7	97.8
Aristida longiseta	(ARLO)	12.3	5.1	9.3	2.0	6.7	13.0	26.5	2.4	6.1	3.3
Bothriochloa saccharoides	(BOSA)	1.6	0.8	0.0	0.0	0.4	3.5	6.3	0.0	0.0	0.0
Bouteloua curtipendula	(BOCU)	7.3	2.4	0.0	0.0	6.8	1.0	21.9	8.8	0.0	0.0
Bouteloua gracilis	(BOGR)	16.7	44.3	24.8	6.0	3.4	37.0	17.3	68.4	21.5	64.6
Buchloe dactyloides	(BUDA)	0.7	4.2	0.0	0.0	T[2/]	6.0	2.0	6.8	0.8	4.0
Chloris verticillata	(CHVE)	2.7	1.0	4.8	3.0	1.2	1.0	2.0	0.0	1.4	0.0
Hilaria jamesii	(HIJA)	T	0.7	0.0	0.0	0.2	1.5	0.0	0.0	0.0	0.0
Muhlenbergia porteri	(MUPO)	T	0.5	0.0	0.0	0.0	0.5	0.5	1.6	0.0	0.0
Munroa squarrosa	(MUSQ)	1.2	2.2	3.3	9.0	1.2	0.0	0.3	0.0	0.2	0.0
Sitanion hystrix	(SIHY)	T	T	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.6
Sporobolus airoides	(SPAI)	0.4	0.0	0.8	0.0	0.0	0.0	0.9	0.0	0.0	0.0
Sporobolus cryptandrus	(SPCR)	37.3	23.6	41.3	49.0	52.4	27.5	11.3	11.6	48.7	25.3
Tridens pilosus	(TRPI)	T	0.2	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0

[1/] Number of 50-point transects.

[2/] Less than 0.1%.

Table 5. Average forb species frequency (%) in the sand sagebrush study area (SA) and feed grounds (FG) on sandy textured soils (Sandy Plains range site).

Species	(Symbol)	Average SA (N=78)[2/]	Average FG (N=15)	Dalhart Sandy Loam SA (N=9)	Dalhart Sandy Loam FG (N=2)	Manter-Vona Sandy Loam SA (N=30)	Manter-Vona Sandy Loam FG (N=4)	Otero Sandy Loam SA (N=25)	Otero Sandy Loam FG (N=6)	Vona Loamy Sand SA (N=14)	Vona Loamy Sand FG (N=3)
Total		18.7	10.3	15.7	31.0	27.5	8.0	11.0	0.4	21.3	2.2
Ambrosia coronopifolia	(AMPS)	2.7	2.5	4.0	7.0	2.2	2.5	4.3	0.0	0.4	0.6
Aster tanacetifolius	(ASTA)	0.3	1.8	0.8	4.0	0.9	3.5	T[2/]	0.0	T	0.0
Chenopodium leptophyllum	(CHLE)	3.7	0.5	0.6	2.0	10.4	0.0	0.6	0.0	1.7	0.0
Cryptantha minima	(CRMI)	1.7	0.0	0.6	0.0	2.3	0.0	0.0	0.0	4.0	0.0
Croton texensis	(CRTE)	T	0.2	0.2	1.0	T	0.0	0.0	0.0	0.0	0.0
Eriogonum annuum	(ERAN)	3.2	0.8	1.1	3.0	6.0	0.5	0.0	0.0	5.5	0.0
Evolvulus nuttallianus	(EVNU)	0.3	0.0	0.2	0.0	0.0	0.0	0.4	0.0	0.4	0.0
Haplopappus spinulosus	(HASP)	0.3	0.0	1.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Helianthus petiolaris	(HEPE)	T	0.0	0.0	0.0	0.2	0.0	T	0.0	0.0	0.0
Liatris punctata	(LIPU)	T	T	0.0	0.0	0.0	0.0	T	0.4	0.0	0.0
Mentzelia stricta	(MEST)	T	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Psoralea tenuiflora	(PSTE)	T	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Salsola kali	(SAKA)	1.9	3.4	3.7	13.0	3.4	0.0	T	0.0	0.4	0.0
Sphaeralcea coccinea	(SPCO)	1.5	0.9	0.6	0.0	0.4	1.5	2.0	0.0	2.7	1.3
Zinnia grandiflora	(ZIGR)	0.9	0.0	1.5	0.0	0.6	0.0	0.0	0.0	1.1	0.0

[1/] Number of 50-point transects.

[2/] Less than 0.1%.

Table 6. Average herbaceous species frequency (%) in the sand sagebrush study area (SA) and feed grounds (FG) on loamy textured soils (Loamy Plains and Gravel Breaks range sites).

				Loamy Plains		Gravel Breaks			
		Average		Wiley loam		Otero-Potter complex		Potter gravelly loam	
Species	(Symbol)	SA (N=8)[1/]	FG (N=15)	SA (N=3)	FG (N=9)	SA (N=3)	FG (N=4)	SA (N=2)	FG (N=2)
GRASSES		99.0	96.5	99.9	99.2	98.0	96.0	98.0	93.0
Aristida longiseta	(ARLO)	4.7	0.7	2.1	2.1	12.0	0.0	0.0	0.0
Bothriochloa saccharoides	(BOSA)	0.5	0.0	0.0	0.0	1.5	0.0	0.0	0.0
Bouteloua curtipendula	(BOCU)	0.0	0.2	0.0	0.6	0.0	0.0	0.0	0.0
Bouteloua gracilis	(BOGR)	75.1	69.3	85.3	58.0	56.0	68.0	84.0	82.0
Buchloe dactyloides	(BUDA)	10.8	19.3	5.0	31.0	24.0	23.0	2.0	4.0
Muhlenbergia porteri	(MUPO)	1.0	1.0	0.0	0.0	3.0	3.0	0.0	0.0
Sitanion hystrix	(SIHY)	0.3	1.0	0.0	0.0	0.0	0.0	1.0	3.0
Sporobolus cryptandrus	(SPCR)	6.6	5.0	7.5	7.5	1.5	2.0	11.0	4.0
FORBS		1.0	3.4	0.1	0.8	2.0	4.0	2.0	7.0
Eriogonum annuum	(ERAN)	0.0	0.3	0.1	0.0	0.0	0.0	0.0	1.0
Mentzelia stricta	(MEST)	T	0.4	0.0	0.0	0.5	1.0	0.0	0.0
Plantago purshii	(PLPU)	T	0.4	0.0	0.3	0.5	1.0	0.0	0.0
Sphaeralcea coccinea	(SPCO)	1.0	2.6	0.0	0.5	1.0	2.0	2.0	6.0

[1/] Number of transects.

BUDA was much more abundant on Wiley loam feed grounds than on the general Wiley loam area or any other soil. As on the sandy soils, ARLO was less abundant on loamy soil feed grounds, but this may have been because of the difference on Otero soils. Forbs were sparse on loamy soils, but in general, relatively more abundant on feed grounds than on the overall loamy soil study area.

Woody Species Frequency and Density

Because of the variation in density of different woody species along transects, average differences in density and frequency for all soils were significant at probability levels of 0.33 or greater for all species. Except for ARFI, the average density of most species was slightly greater on feed grounds (Table 7). A possible interaction between pronghorn feed ground selection on different soils and woody plant density may have masked any evidence of feed ground selection by pronghorn.

Although the average frequency of ARFI on sandy feed grounds was much lower than that on the overall sandy study area, the difference was not consistent (Table 8). ARFI frequency on transects was lower on Manter-Vona and Otero sandy loam feed grounds, higher on Vona loamy sand feed grounds and similar on Dalhart sandy loam feed grounds than that on transects from comparable soils of the overall sandy study area.

Three species, ECHI, MAMM and OESE, were found only on one soil series. Where they were found, OPUN and SERI were more abundant on feed ground transects than on study area transects. XASA and YUGL

Table 7. Average woody species density (plants/ha) and frequency (%) in the sand sagebrush study area (SA) and feed grounds (FG).

Species	(Symbol)	Density SA	Density FG	Frequency SA	Frequency FG
Artemisia dracunculus	(ARDR)	0	<1	0.0	0.3
Artemisia filifolia	(ARFI)	392	295	48.9	19.9
Artemisia frigida	(ARFR)	0	2	0.0	1.7
Echinocereus sp.	(ECIN)	0	<1	0.0	1.7
Mammillaria sp.	(MAMM)	<1	<1	T[1/]	0.2
Oenothera serrulata	(OESE)	2	0	1.2	0.0
Opuntia spp.	(OPUN)	6	8	2.2	7.5
Senecio longilobus	(SELO)	2	22	2.2	12.9
Senecio ridellii	(SERI)	3	9	2.3	6.5
Xanthocephalum sarothrae	(XASA)	42	24	9.3	21.3
Yucca glauca	(YUGL)	327	41	23.1	28.1
Total		775	404		

[1/] Less than 0.1%.

Table 8. Average woody species frequency (%) in the sand sagebrush study area (SA) and feed grounds (FG) on sandy soils (Sandy Plains range site).

Species	(Symbol)	Average		Dalhart Sandy Loam		Manter-Vona Sandy Loam		Otero Sandy Loam		Vona Loamy Sand	
		SA (N=78)[1]	FG (N=15)	SA (N=9)	FG (N=2)	SA (N=30)	FG (N=4)	SA (N=25)	FG (N=6)	SA (N=14)	FG (N=3)
Artemisia filifolia	(ARFI)	60.1	37.8	90.0	96.0	81.2	12.0	18.5	9.6	70.2	90.0
Echinocereus sp.	(ECIN)	0.0	3.3	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0
Mammillaria sp.	(MAMM)	T[2]	0.3	0.0	0.0	0.0	0.0	0.2	0.8	0.0	0.0
Oenothera serrulata	(OESE)	1.5	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0
Opuntia spp.	(OPUN)	1.8	9.1	0.0	0.0	T	4.0	4.8	19.2	1.4	2.0
Senecio longilobus	(SELO)	T	0.7	0.0	0.0	0.0	1.0	T	0.4	0.2	1.3
Senecio ridellii	(SERI)	1.0	5.5	0.0	0.0	0.3	4.5	2.5	10.0	0.2	1.3
Xanthocephalum sarothrae	(XASA)	10.0	8.2	7.1	3.0	2.7	12.0	21.-	10.0	8.1	4.0
Yucca glauca	(YUGL)	25.2	35.6	2.8	1.0	15.6	54.0	48.1	50.0	19.5	5.3

[1] Number of 50-point transects.

[2] Less than 0.1%.

were generally more abundant on Manter-Vona and Otero sandy loam soils, but the differences in frequencies on study area and feed ground transects were not consistent. Because of differences in species frequencies on the Vona loamy sand and the Manter-Vona complex, the feed ground transects located on the Manter-Vona complex may have been on the Manter sandy loam rather than the Vona loamy sand portion of the complex. No definite conclusions can be formed because of the relatively low number of transects on feed grounds on these soil series. Several of the differences are large enough to warrant additional research.

Although differences in density values for woody species on different soils were comparable to differences in frequency values, density value differences were relatively greater and seemed to be more indicative of definite pornghorn selection for feed grounds. ARFI density was highest on Dalhart sandy loam and lowest on Otero sandy loam (Table 9). Relative differences in ARFI density on feed grounds and study areas were greater on the Otero and Manter-Vona complex than on the Dalhart and Vona soils. Densities of almost all woody species were lower on Otero and Manter-Vona complex feed grounds than on study areas on comparable soils. XASA and YUGL densities were consistently lower on feed grounds of all sandy soils, whereas densities of less abundant species, such as OPUN,SELO and SERI, were generally higher on feed grounds.

The average relative abundance for woody species on all loamy soils utilized by pronghorn was different on feed grounds and the general loamy soil study areas. The average relative abundance of

Table 9. Average woody species density (plants/ha) in the sand sagebrush study area (SA) and feed grounds (FG) on sandy soils (Sandy Plains range site).

Species	(Symbol)	Average SA (N=78)[1/]	Average FG (N=15)	Dalhart Sandy Loam SA (N=9)	Dalhart Sandy Loam FG (N=2)	Manter-Vona Sandy Loam SA (N=30)	Manter-Vona Sandy Loam FG (N=4)	Otero Sandy Loam SA (N=25)	Otero Sandy Loam FG (N=6)	Vona Loamy Sand SA (N=14)	Vona Loamy Sand FG (N=3)
Artemisia filifolia	(ARFI)	482	588	2003	3063	249	3	46	9	785	877
Echinocereus sp.	(ECIN)	0	1	0	0	0	3	0	0	0	0
Mammillaria sp.	(MAMM)	1	1	0	0	0	0	1	1	0	0
Oenothera serrulata	(OESE)	2	0	0	0	0	0	7	0	0	0
Opuntia spp.	(OPUN)	7	11	0	0	1	1	12	16	14	25
Senecio longilobus	(SELO)	1	4	0	0	0	1	1	1	4	16
Senecio ridellii	(SERI)	3	5	0	0	1	1	7	9	2	8
Xanthocephalum sarothrae	(XASA)	52	20	147	78	9	3	52	7	85	28
Yucca glauca	(YUGL)	402	35	61	40	52	13	1052	38	213	57
Total		950	659	2211	3181	311	25	1176	79	1103	983

[1/] Number of 50-point transects.

SERI and YUGL was lower and that of XASA was higher on feed grounds than on the study areas (Table 10).

The relationship of relative abundance of most woody species on feed grounds and study areas on loamy soils was opposite to that on sandy soils. The relative abundance of OPUN, SERI and YUGL on feed grounds was lower than that on study areas on loamy soils and higher on sandy soils. The relative abundance of ARFI and XASA on feed grounds was higher than that on study areas on loamy soils and lower on sandy soils.

On loamy soils pronghorn appeared to consistently select feed grounds with a higher density of all woody species (Table 11). The average density of all woody species combined was 950 plants/ha on sandy soil study areas and 640 plants/ha on sandy soil feed grounds. The average density of all woody species combined was about 40 plants/ha on loamy soil study areas and about 140 plants/ha on loamy soil feed grounds. This indicates the possibility of an optimum density of woody plants depending on the species and soil. If an optimum density and species composition by range site is substantiated and described, pronghorn habitat management would be greatly facilitated.

Conclusions

Pronghorn in the study area utilized more heavily those areas where loamy soils predominated. Ground cover on these areas was characterized by relatively high percentages of bare ground and litter. Grass species, especially sod-forming grasses, were the predominant herbaceous species present. BOGR and BUDA were the major plant species

Table 10. Average woody species frequency (%) in the sand sagebrush study area (SA) and feed grounds (FG) on loamy soils (Loamy Plains and Gravel Breaks range sites).

				Loamy Plains		Gravel Breaks			
						Otero-Potter complex		Potter gravelly loam	
		Average		Wiley loam					
Species	(Symbol)	SA (N=8)[1/]	FG (N=15)	SA (N=3)	FG (N=9)	SA (N=3)	FG (N=4)	SA (N=2)	FG (N=2)
Artemisia dracunculus	(ARDR)	0.0	0.6	0.0	1.0	0.0	0.0	0.0	0.0
Artemisia filifolia	(ARFI)	1.0	2.0	0.0	3.1	2.0	0.0	1.0	1.0
Artemisia frigida	(ARFR)	0.0	3.4	0.0	5.6	0.0	0.0	0.0	0.0
Opuntia spp.	(OPUN)	9.9	6.0	17.8	10.0	8.5	0.0	0.0	0.0
Senecio longilobus	(SELO)	25.5	25.0	18.3	13.3	29.0	47.0	31.0	34.0
Senecio ridellii	(SERI)	17.5	7.4	15.0	2.5	21.0	13.0	16.0	18.0
Xanthocephalum sarothrae	(XASA)	13.9	33.8	29.1	54.6	4.0	1.0	6.0	4.0
Yucca glauca	(YUGL)	32.2	22.2	19.6	9.6	35.5	39.0	46.0	45.0

[1/]Number of 50-point transects.

Table 11. Average woody species density (plants/ha) in the sand sagebrush study area (SA) and feed grounds (FG) on loamy soils (Loamy Plains and Gravel Breaks range site).

				Loamy Plains		Gravel Breaks			
		Average		Wiley loam		Otero-Potter complex		Potter gravelly loam	
Species	(Symbol)	SA (N=8)[1/]	FG (N=15)	SA (N=3)	FG (N=9)	SA (N=3)	FG (N=4)	SA (N=2)	FG (N=2)
Artemisia dracunculus	(ARDR)	0	1	0	1	0	0	0	0
Artemisia filifolia	(ARFI)	1	2	0	3	2	0	1	5
Artemisia frigida	(ARFR)	0	4	0	6	0	0	0	0
Opuntia spp.	(OPUN)	4	5	1	9	9	0	0	0
Senecio longilobus	(SELO)	11	39	2	11	25	60	5	123
Senecio ridellii	(SERI)	8	13	2	2	19	18	2	49
Xanthocephalum sarothrae	(XASA)	3	28	3	41	3	2	1	25
Yucca glauca	(YUGL)	15	46	2	10	33	53	8	192
Total		42	138	10	83	91	133	16	394

[1/] Number of 50-point transects.

present on pronghorn feeding areas. SAKA and SPCO were the major forb species occurring on the feeding areas during spring and summer.

Probably the most important factor effecting pronghorn populations in the study area at the present time is lack of palatable, nutritious browse plants. Several woody or fruticose plants exist on the area in moderate numbers but they may become very unpalatable during winter months. The differential utilization by pronghorn on different soil textures suggests that overabundance of woody plants on sandy soils may be detrimental to pronghorn distribution, particularly during spring and summer. Pronghorn feed grounds on sandy soils almost always contained fewer woody species than a comparable area in the overall study area. However, on loamy soils the inverse is true of woody species on feed grounds. There were always more woody species per hectare in pronghorn feed grounds than on study area transects. Therefore, optimum shrub density on the sand sagebrush study area may be somewhere between the density values for the feed grounds and the study area.

The observed use of winter wheat by pronghorn in this area (M. Snider, Range Conservationist, USFS, 1976, personal communication) may also reflect a need for additional nutrient intake during winter. This suggests that woody plants are not sustaining winter dietary needs of pronghorn in this area. More research is badly needed to fill this void in knowledge about winter habitat. It could be possible that pronghorn utilization of shrubs on loamy soils may decline in winter months in favor of the more dense shrub stands on sandy soils. Future research should provide valuable data to better manage pronghorn in this area.

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CHAPTER IV

PLANT SPECIES COMPOSITION OF AREAS UTILIZED BY PRONGHORN ON THE SOUTHERN HIGH PLAINS

The presence or absence of certain plant species has a dramatic effect on pronghorn abundance and distribution in any area (Beale and Smith 1970, Buechner 1950a). On most areas of pronghorn range, the abundance of certain forb species is an indication of good pronghorn habitat (Buechner 1950a), Mitchell and Smoliak 1971, Sundstrom 1973, Yoakum 1975). The presence of palatable browse species also characterized good yearlong pronghorn habitat (Beale and Scotter 1968, Beale and Smith 1970, Severson et al. 1968). However, very few studies have been conducted to investigate and quantify the ground cover, herbaceous and woody species composition on areas utilized by pronghorn. This is particularly true on the Southern High Plains where an abundance of palatable woody plant cover is often limited.

In order to acquire baseline information on the plant species composition of areas utilized by pronghorn, a study was conducted on the Comanche National Grassland in southeastern Colorado. The objective of this study was to determine the differences in plant species composition on pronghorn feeding areas in sand sagebrush and shortgrass vegetation types.

Methods

Areas used for feeding by pronghorn bands were located and pronghorn were observed as close as possible without disturbing their feeding activities. Feeding locations where observation time was less than one hour were not used in food habit calculations. The time pronghorn were actually observed feeding was recorded for calculation in later sampling procedures. In the sand sagebrush study area, feeding areas were stratified by soil type. The percent feeding time by soil type was determine using the following equation: Feeding time (%) by soil= [time (min.) feeding on each soil type x 100] / [total time (min.) observed in total feeding area]. From this equation the number of transects to be established on each soil was then calculated.

The step-point method (Evans and Love 1957) was utilized to determine species composition and ground cover on these feeding areas. A pointer was touched to the ground every 2 m along a line and the ground cover (bare ground, vegetation, litter, rock) contacted was recorded. At the same time, the nearest herbaceous species to the pointer was also recorded. During the 1976 season, the nearest woody species to the pointer was recorded at alternate points. A total of 50 observation points constituted a transect of 100 m.

During the 1977 season, the point-centered quarter method (Cottam and Curtis 1956) was modified and used with the step-point procedure in order to determine woody species frequency and density. At every fifth point (10 m apart) the transect was divided into four quarters. The closest woody species was recorded in each quarter and the distance to that plant from the pointer was also recorded in meters. Then, using methods described by Dix (1961) density was calculated for each woody species on each feeding area. An equation was then formulated to calculate the number of plants per hectare [$(10{,}000/\pi r^2)(N/\Sigma N)=$ plants per ha]. Where πr^2 represents average density of all woody species, N represents the number of observations of a particular species and Σ N represents total observations.

Vegetation densities and frequencies on the feeding areas were then compared to these on the entire study area, using the Statistical Analysis System (Barr et al. 1976) and the Oklahoma State University IBM 370/158 computer.

Feeding areas in the shortgrass type were evaluated differently. Since a detailed soil survey was unavailable for that area, feeding areas were not stratified according to soil types. Two, 50-point transects were established on each of nine feeding areas and no attempt was made to compare vegetation on these feeding areas with that on the entire shortgrass study area.

Results and Discussion

Ground Cover

Bare ground values in feeding areas in the shortgrass study area (87.4%) were slightly higher than those (81.4%) on the sand sagebrush areas (Table 1). Since the number of direct hits on vegetation was about the same for both areas, litter values were consequently higher on sand sagebrush areas. Even though the aspect of the two areas was quite different, ground cover values were relatively similar. Variation in ground cover values was greater on the sand sagebrush area because of a wider variation in soil types.

Table 1. Average ground cover frequency (%) on feed grounds in the shortgrass (SG) and sand sagebrush (SS) study areas.

Ground Cover	Study Area		Probability Level[1/]
	Shortgrass	Sand sagebrush	
Bare ground	87.4	81.4	.21
Litter	11.5	17.6	.14
Vegetation	1.0	0.8	.83

[1/]Probability level for differences in ground cover frequency on the SG and SS study areas.

Herbaceous Species Composition

Eighteen transects and 900 points were located in the shortgrass feeding areas, whereas thirty transects and 1500 points were located in the sand sagebrush feeding areas. Because of climatic and soil differences, plant communities in the shortgrass and sand sagebrush areas were different. Forbs composed about 35% of the species composition in shortgrass feeding areas and only about half (18%) that amount in sand sagebrush feeding areas (Table 2). Many species were not found in both areas. AMAR, CHLE, HASP, POAV, SAKA and SPCO were the most frequent forbs on shortgrass feeding areas. These species

Table 2. Herbaceous species frequency (%) on feed grounds in the shortgrass (SG) and the sand sagebrush (SS) study area.

Species	(Symbol)	Study Area SG	Study Area SS	Probability Level
FORBS		34.7	18.2	
Amaranthus sp.	(AMAR)	6.0	0.2	.43
Ambrosia coronopifolia	(AMPS)	0.0	1.8	.22
Aster tanacetifolius	(ASTA)	0.0	0.6	.09
Astragalus sp.	(ASTR)	0.2	0.0	.42
Chenopodium leptophyllum	(CHLE)	2.9	4.8	.77
Sryptantha minima	(CRMI)	0.3	0.1	.59
Croton texensis	(CRTE)	0.0	0.2	.09
Eriogonum annum	(ERAN)	0.0	0.2	.23
Gaura coccinea	(GACO)	0.1	0.7	.39
Grindelia squarrosa	(GRSQ)	0.4	0.0	.42
Haplopappus spinulosus	(HASP)	2.3	3.0	.61
Helianthus petiolaris	(HEPE)	0.7	0.3	.77
Hymenoxys acaulis	(HYAC)	0.2	0.0	.42
Ipomoea leptophylla	(IPLE)	0.0	0.2	.42
Melilotus alba	(MEAL)	0.3	0.0	.42
Mentzelia stricta	(MEST)	0.0	0.3	.29
Physalis lobata	(PHLO)	0.5	0.0	.42
Plantago purshii	(PLPU)	0.5	0.2	.69
Polygonum aviculare	(POAV)	1.0	0.0	.42
Psoralea tenuiflora	(PSTE)	0.1	0.3	.34
Ratibida tagetes	(RATA)	0.1	0.3	.60
Salsola kali	(SAKA)	7.4	1.1	.10
Sphaeralcea coccinea	(SPCO)	10.7	3.0	.31
Miscellaneous		1.0	0.9	
GRASSES		65.1	82.3	
Agropyron smithii	(AGSM)	12.5	1.1	.11
Aristida longiseta	(ARLO)	6.7	5.7	.73
Bothriochloa saccharoides	(BOSA)	0.0	3.7	.37
Bouteloua curtipendula	(BOCU)	0.1	1.0	.35
Bouteloua gracilis	(BOGR)	34.4	38.5	.84
Buchloe dactyloides	(BUDA)	0.1	13.2	.01
Chloris verticillata	(CHVE)	0.1	0.2	.54
Hilaria jamesii	(HIJA)	0.1	0.1	.69
Muhlenbergia porteri	(MUPO)	0.0	0.3	.42
Muhlenbergia torreyi	(MUTO)	1.2	0.0	.35
Munroa squarrosa	(MUSQ)	0.1	1.4	.20
Oryzopsos hymenoides	(ORHY)	0.7	0.0	.69
Schedonnardus paniculatus	(SCPA)	0.5	0.4	.92
Sitanion hystrix	(SIHY)	4.3	0.1	.01
Sporobolus cryptandrus	(SPCR)	4.0	16.4	.01
Miscellaneous		0.3	0.2	

composed 30.3% of the species composition on shortgrass feeding areas and 12.1% on sand sagebrush feeding areas. AMCO was also relatively abundant on sand sagebrush feeding areas, but was not found on shortgrass feeding areas. Variation in frequency values between transects in each area was relatively high; therefore, differences in frequency values for the same individual species in different areas had relatively high probability levels.

Grasses composed about 65% of the species composition in shortgrass feeding areas and 82% in sand sagebrush feeding areas. AGSM, ARLO, BOGR, SIHY and SPCR were the most frequent grasses in shortgrass feeding areas. Collectively they composed about 62% of the species composition in both areas, but the relative abundance of several individual species in the two areas was greatly different. Frequency percentages for the shortgrass and sand sagebrush feeding areas, respectively, were 12.5 and 1.1 for AGSM, 0.1 and 13.2 for BUDA, 4.3 and 0.1 for SIHY, and 4.0 and 16.4 for SPCR. The two major cool season grasses, AGSM and SIHY, were much more abundant on shortgrass feeding areas. BOCU, BOGR and BUDA were relatively abundant on sand sagebrush feeding areas although these species are not characteristic of sandy soils. Feeding areas within the sand sagebrush study area were frequently on the finer-textured soils.

In spring and summer the abundance of forb species, such as ASTA, CRTE, HASP, MEST, PLPU and SPCO, on feeding areas is in agreement with most other studies on pronghorn range (Beale and Smith 1970, Beale and Scotter 1968, Buechner 1950a). However, the abundance of BUDA and BOGR on feeding areas has not been previously reported by many scientists. Schwartz and Nagy (1976) indicated pronghorn in northeastern Colorado consumed more grasses, particularly BOGR. The diversity of forb species was higher on the finer-textured soils and areas within the sand sagebrush study area. With the exception of ASTA, the most palatable perennial forb species occurred on shortgrass areas rather than in sand sagebrush vegetation.

Woody Species Frequency and Density

The presence or absence of certain woody species in feeding areas may be the single most important factor in pronghorn productivity in this area of the Southern High Plains. In general, pronghorn feeding areas in the shortgrass areas had a much higher density of woody plants than in the sand sagebrush areas. Because of the two methods used to determine density and frequency, these two parameters were not highly correlated as would be expected from randomly distributed populations.

Three different woody species occurred in the shortgrass feeding areas that were absent in the sand sagebrush areas (Table 3). Five different species occurred in the sand sagebrush feeding areas and not on the shortgrass areas. Two of the species found only in the shortgrass areas, CHNA and CELA, were observed to be heavily utilized in this area. However, the woody species found only in the sand sagebrush areas, appeared to be relatively unpalatable or were of low density.

The most frequent woody species found on the shortgrass feeding areas were XASA, CHNA and OPAR. CELA did not occur in large quantities on the shortgrass areas but was utilized heavily by pronghorn particularly during fall months.

Table 3. Average woody species density (plants/ha) and frequency (%) in feed grounds in the shortgrass (SG) and sand sagebrush (SS) study areas.

Species	(Symbol)	Density SG (N=18)[1]	Density SS (N=30)	Frequency SG (N=18)	Frequency SS (N=30)	Probability Level[2]
Artemisia dracunculus	(ARDR)	0	<1	0.0	0.7	.29
Artemisia filifolia	(ARFI)	0	22	0.0	18.7	.14
Artemisia frigida	(ARFR)	1	1	T[3]	0.7	.45
Ceratoides lanata	(CELA)	70	0	3.1	0.0	.41
Chrysothamnus nauseosus	(CHNA)	246	0	21.2	0.0	.01
Echinocereus sp.	(ECIN)	0	2	0.0	0.8	.42
Mammillaria sp.	(MAMM)	0	<1	0.0	T	.42
Opuntia arborescens	(OPAR)	23	0	16.3	0.0	.36
Opuntia sp.	(OPUN)	100	5	4.8	9.6	.48
Senecio longilobus	(SELO)	3	8	0.4	7.3	.18
Senecio ridellii	(SERI)	0	4	0.0	7.7	.13
Xanthocephalum sarothrae	(XASA)	630	16	53.6	17.2	.01
Yucca glauca	(YUGL)	2	24	0.1	36.5	.03
Total		1075	82			

[1] Number of transects.

[2] Probability level for differences in species frequency in the shortgrass and sand sagebrush study areas.

[3] Less than 0.1%.

YUGL was the most common woody species on sand sagebrush feeding areas. ARFI and XASA were also relatively common on these areas.

Several woody species found on the sand sagebrush feeding areas have been observed by other authors to be utilized by pronghorn. MAMM was utilized by pronghorn in Montana (Mitchell and Smoliak 1971). The use of OPUN has been documented by Buechner (1950a) and Hoover et al. (1959). Pronghorn were reported to utilize ARFR in Montana by Bayless (1969) and Cole (1956) and in Colorado by Schwartz and Nagy (1976). The use of XASA by pronghorn was documented by Cole (1956). Hoover (1971) observed utilization of SELO by pronghorn in northeastern Colorado. With the exception of Hlavachick (1968) working in Kansas, there has been no documentation on the use of ARFI by pronghorn. However, ARFI extends over large amounts of land in the sand sagebrush area. Therefore, ARFI appears to be very low in palatability to pronghorn in this area.

Conclusions

Forbs and shrubs, especially palatable species, were more abundant on shortgrass feeding areas, whereas grasses were more abundant on sand sagebrush feeding areas. Cool season grasses were more abundant on shortgrass feeding areas. Based on observations and the high percentage ($>50\%$) of BOCU, BOGR and BUDA in the sand sagebrush feeding areas, grasses may be a significant component in the spring and summer diet of pronghorn. Therefore, the limited areas of finer-textured soils in the sand sagebrush area may be of particular importance to pronghorn.

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CHAPTER V

CHEMICAL COMPOSITION OF PRONGHORN HABITAT COMPONENTS ON THE SOUTHERN HIGH PLAINS

One of the major factors determining the use of certain areas of rangeland by domestic livestock and wildlife is the nutrient content of the components of that rangeland. A slight deficiency in such nutrients as protein adversely affects reproduction, lactation and other physiological processes. A deficiency in phosphorus or a wide phosphorus to calcium ratio may cause retarded growth, weak young, decreased lactation and failure to conceive (Dietz 1972).

In most cases, rangeland in good condition is typified by a diversity of vegetation and plant types. An optimum combination of grasses, forbs and shrubs is desired on most areas of rangeland in order to support large numbers of livestock or wildlife species throughout the year. Woody species usually retain larger amounts of most nutrients during fall and winter than do grasses and forbs. However, during spring and summer months most grasses and forbs are more nutritious than shrub species. Therefore, a forage species is evaluated seasonally on its ability to meet the nutritional requirements for the physiological function of the animal (Cook 1972).

The plant community composition, both physical and chemical, may be of importance on rangeland which might be considered only marginal pronghorn habitat. This may be especially true on areas where shrub communities are at a minimum. To test the above hypothosis, a study was initiated on the Comanche National Grassland in southeastern Colorado. Two study areas were selected, one in an area with a moderate diversity and high density of shrub species and one in an area with low diversity and moderate density of shrub species. The objectives of this study were to determine (1) plants utilized by pronghorn during summer and fall on both areas and (2) the chemical composition of these plants along with the soils and water sources in areas utilized by pronghorn.

Methods

Food habits of pronghorn were determined by direct observation and examination of the feeding areas. The animals were observed as long as possible and at the closest possible distance. Those plants which were observed to be utilized were noted at this time. Additional species were noted to be utilized after extensive examination of the feeding areas.

Samples of at least 50 grams were collected of each species utilized within the feeding area. Plants that were common to the area, but not found to be utilized, were also collected. Also plant species that were found to be utilized by pronghorn in other studies were collected even though they were not observed to be utilized during this study. Only the parts of each plant that were utilized, such as leaves and flowers, were included in the sample.

Plant samples were weighed and dated at the time of collection then allowed to air dry from 30 to 60 days then reweighed. The difference in the wet weight and the dry weight of the sample was interpreted as the percent moisture of the sample. After drying, these samples were ground through a 2 mm screen in a wiley mill then analyzed for percent nitrogen, phosphorus, potassium, and calcium by the Oklahoma State University Soil and Water Testing Lab.

At the time of collection of plant samples, a composite soil sample was collected from the A horizon within the feeding area. An attempt was made to collect the percent of each soil type accordingly to the percent of each within the feeding area. Soil samples were also allowed to air dry, were reweighed then ground through a 2 mm screen. These samples were analyzed for pH and the percent organic matter, nitrogen, sodium, potassium, and calcium.

Those water sources utilized by pronghorn were also sampled. Samples were collected from earthen overflow pits, dugouts, and natural water sources. Water samples were not collected from metal holding tanks because of contamination by the tank and avoidance by the pronghorn. An attempt was made to collect several sub samples from as many locations as possible around the water source. These samples were collected and stored in 10 oz. plastic containers in a cool, dark place. A maximum of 10 days was allowed before lab analysis was begun. These samples were analyzed for nitrates, chlorides, phosphates, and conductivity.

Results and Discussion

General Food Habits

The direct observation method of feeding pronghorn proved to be somewhat lacking in its effectiveness to delineate the plant species being utilized. Examination of the feeding areas helped considerably in many areas where domestic livestock were not present. The utilization of woody and forb species was much easier observed than was utilization on shortgrasses such as *Bouteloua gracilis* (BOGR) and *Buchloe dactyloides* (BUDA). In other words, there tended to be a bias in favor of woody and forb species. To aleviate this, data on food habits of pronghorn from other studies were used to deleiate the species most likely to be used during a particular time period (Table 1). This proved a satisfactory procedure for determining general food habits on both areas.

During spring and summer months, pronghorn on both areas appeared to prefer succulent forbs and grasses. Plant moisture percentage appeared to be a major factor in the utilization of certain species, particularly during summer months. BOGR appeared to be one of the most stable food supplies of pronghorn on both areas. Pronghorn, particularly in the sand sagebrush area, seemed to prefer areas dominated by BOGR and BUDA. *Aristida longiseta* (ARLO), although present on much of both areas, received little use during both seasons. *Agropyron* smithii (AGSM) received some use during spring and late fall. *Sporobolus cryptandrus* (SPCR) received moderate utilization during spring and summer on both areas. *Sitanion hystrix* (SIHY) received only minimal use during all seasons. *Muhlenbergia racemosa* (MUTO), although present in large quantities on the shortgrass area, received no observable use during this study.

Forb species contributed significantly to pronghorn diets on both areas during spring and summer. Species such as *Gaura coccinea* (GACO), *Haplopappus spinulosus* (HASP), *Psoralea tenuiflora* (PSTE), *Sphaeralcea*

Table 1. Literature reporting pronghorn utilization on those plant species also found in the shortgrass and sand sagebrush study areas.

Species	Location	Vegetation Type[1]	Type of Study[2]	Season of Use	Authority
Browse					
Artemisia filifolia	Kan.	SG	O	W	Hlavachick (1969)
Artemisia frigida	Mont.	SB	O&R	W	Bayless (1969)
" "	Colo.	SG	O	W,Sp,Su	Hoover (1971)
" "	Utah	DS	O&R	Su	Beale and Smith (1970)
" "	Mont.	SB	O&R	W,Sp,Su,F	Cole (1956)
" "	Albe.	SG	R	W,Sp,Su,F	Mitchell and Smoliak (1971)
" "	Colo.	SG	O	W,Sp,Su,F	Schwartz and Nagy (1976)
" "	Utah	SB	O	Su	Smith and Malechek (1974)
Ceratoides lanata	Utah	DS	O&R	W,F	Beale and Smith (1970)
" "	Mont.	SB	O&R	Sp	Cole (1956)
" "	Wyo.	SB	O&R	W,F	Severson et al. (1968)
Chrysothamnus nauseosus	Colo.	SG	O	W	Hoover (1971)
" "	Mont.	SB	O&R	W	Bayless (1969)
" "	Utah	DS	O&R	W,F	Beale and Smith (1970)
" "	Mont.	SB	O&R	W,Sp,Su,F	Cole (1956)
" "	Wyo.	SB	O&R	W,Su,F	Severson et al. (1968)
" "	Colo.	SG	O	W,Sp,Su,F	Schwartz and Nagy (1976)
" "	Utah	SB	O	Su	Smith and Malechek (1974)
Juniperus monosperma	Tex.	DG	O	W	Buechner (1950a)
Mammillaria	Albe.	SG	R	W,Sp,Su,F	Mitchell and Smoliak (1971)
Opuntia arborescens	Tex.	DG	O	F	Buechner (1950a)
Opuntia sp.	Kan.	SG	O	Su,F	Hlavachick (1968)
" "	Utah	DS	O&R	Su	Beale and Smith (1970)
" "	Tex.	DG	O	Su	Buechner (1950a)
Rhus trilobata	Mont.	SB	O&R	Su	Cole (1956)
" "	Tex.	DG	O	Su	Buechner (1950a)
Senecio longilobus	Tex.	DG	O	W,Sp,Su,F	Buechner (1950a)
" "	Colo.	SG	O	Sp,Su	Hoover (1971)

Table 1. (Continued)

Species	Location	Vegetation Type[1/]	Type of Study[2/]	Season of Use	Authority
Senecio ridellii	Tex.	DG	0	W,Sp,Su,F	Buechner (1950a)
Xanthocephalum sarothrae	Colo.	SG	0	W,Sp,Su	Hoover (1971)
" "	Utah	DS	O&R	F	Beale and Smith (1970)
" "	Mont.	SB	O&R	Su	Cole (1956)
" "	Tex.	DG	0	F	Buechner (1950a)
" "	Colo.	SG	0	W,Sp,Su,F	Schwartz and Nagy (1976)
" "	Utah	SB	0	Su	Smith and Malechek (1974)
Grasses					
Agropyron smithii	Colo.	SG	0	Sp,Su	Hoover (1971)
" "	Wyo.	SB	O&R	W,Sp,Su	Severson et al. (1968)
" "	Colo.	SG	0	W,Sp,Su,F	Schwartz and Nagy (1976)
Aristida longiseta	Colo.	SG	0	W	Hoover (1971)
" "	Kan.	SG	0	Sp,Su,F	Hlavachick (1968)
Bouteloua curtipendula	Kan.	SG	0	F	Hlavachick (1968)
" "	Tex.	DG	0	W,Sp,Su,F	Buechner (1950a)
Bouteloua eriopoda	Tex.	DG	0	F	Buechner (1950a)
Bouteloua gracilis	Colo.	SG	0	W,Sp,Su	Hoover (1971)
" "	Kan.	SG	0	Sp,Su,F	Hlavachick (1968)
" "	Utah	DS	O&R	Sp	Beale and Smith (1970)
" "	Tex.	DG	0	W,Sp,Su,F	Buechner (1950a)
" "	Colo.	SG	0	W,Sp,Su,F	Schwartz and Nagy (1976)
Bouteloua hirsuta	Tex.	DG	0	W,Sp,Su,F	Buechner (1950a)
Buchloe dactyloides	Colo.	SG	0	W	Hoover (1971)
" "	Tex.	DG	0	Sp	Buechner (1950a)
Festuca octoflora	Colo.	SG	0	W,Sp,Su,F	Schwartz and Nagy (1976)
" "	Colo.	SG	0	Su	Hoover (1971)
Lycurus phleoides	Tex.	DG	0	F	Buechner (1950a)
Oryzopsis hymenoides	Utah	DS	O&R	Sp	Beale and Smith (1970)
" "	Wyo.	SB	O&R	Sp,Su,F	Severson et al. (1968)

Table 1. (Continued)

Species	Location	Vegetation Type 1/	Type of Study 2/	Season of Use	Authority
Panicum obtusum	Tex.	DS	O	Su	Buechner (1950a)
Sitanion hystrix	Colo.	SG	O	Su	Hoover (1971)
" "	Utah	DS	O&R	Sp	Beale and Smith (1970)
Sporobolus cryptandrus	Colo.	SG	O	Su	Hoover (1971)
" "	Kan.	SG	O	Sp,Su,F	Hlavachick (1968)
" "	Utah	DS	O&R	Sp	Beale and Smith (1970)
Stipa comata	Colo.	SG	O	W	Hoover (1971)
" "	Utah	DS	O&R	Sp	Beale and Smith (1970)
" "	Wyo.	SB	O&R	Su,F	Severson et al. (1968)
Tridens pilosus	Tex.	DG	O	Su	Buechner (1950a)
Forbs					
Amaranthus hybridus	Tex.	DG	O	Su	Buechner (1950a)
Astragalus crassicarpus	Albe.	SG	R	Su	Mitchell and Smoliak (1971)
Aster tanacetifolius	Colo.	SG	O	Su	Hoover (1971)
" "	Tex.	DG	O	F	Buechner (1950a)
Astragalus sp.	Utah	DS	O&R	Sp	Beale and Smith (1970)
" "	Albe.	SG	R	Su	Mitchell and Smoliak (1971)
Bahia oppositifolia	Colo.	SG	O	W,Sp,Su	Hoover (1971)
" "	Mont.	SB	O&R	Su	Cole (1956)
" "	Colo.	SG	O	W,Sp,Su,F	Schwartz and Nagy (1976)
Berlandiera lyrata	Tex.	DG	O	F	Buechner (1950a)
Chenopodium album	Utah	DS	O&R	Sp,Su	Beale and Smith (1970)
" "	Utah	SB	O	Su	Smith and Malechek (1974)
Chrysopsis villosa	Mont.	SB	O&R	Su	Cole (1956)
" "	Albe.	SG	R	W,Su	Mitchell and Smoliak (1971)
" "	Colo.	SG	O	W,Sp,Su,F	Schwartz and Nagy (1976)
Convolvulus incanus	Tex.	DG	O	Sp	Buechner (1950a)
Cucurbita foetidissima	Tex.	DG	O	Sp	Buechner (1950a)
Dalea jamesii	Tex.	DG	O	Su	Buechner (1950a)

Table 1. (Continued)

Species	Location	Vegetation Type[1/]	Type of Study[2/]	Season of Use	Authority
Engelmannia pinnatifida	Tex.	DG	O	Su	Buechner (1950a)
Eriogonum annum	Colo.	SG	O	W,Sp,Su	Hoover (1971)
" "	Colo.	SG	O	W,Sp,Su,F	Schwartz and Nagy (1976)
Eriogonum sp.	Utah	DS	O&R	W,Sp,Su,F	Beale and Smith (1970)
Eriogonum tenellum	Tex.	DG	O	W	Buechner (1950a)
Euphorbia dentata	Okla.	TG	O	Su	Buechner (1950b)
" "	Kan.	SG	O	W,Sp,Su	Hlavachick (1968)
Evolvulus nuttallianus	Colo.	SG	O	Sp	Hoover (1971)
Gaura coccinea	Colo.	SG	O	Su	Hoover (1971)
" "	Mont.	SB	O&R	Su	Cole (1956)
" "	Albe.	SG	R	Su	Mitchell and Smoliak (1971)
" "	Tex.	DG	O	W,Sp,Su,F	Buechner (1950a)
Gaillardia pinnatifida	Tex.	DG	O	Sp	Buechner (1950a)
Gaillardia pulchella	Tex.	DG	O	Sp	Buechner (1950a)
" "	Okla.	TG	O	Su	Buechner (1950b)
Glycyrrhiza lepidota	Mont.	SB	O&R	Su,F	Cole (1956)
Grindelia squarrosa	Mont.	SB	O&R	F	Cole (1956)
Haplopappus spinulosus	Colo.	SG	O	Su	Hoover (1971)
" "	Mont.	SB	O&R	F	Cole (1956)
Hoffmanseggia jamesii	Tex.	DG	O	Su	Buechner (1950a)
Krameria lanceolata	Tex.	DG	O	Su	Buechner (1950a)
Lappula redwoskii	Colo.	SG	O	Su	Hoover (1971)
Lepidium densiflorum	Colo.	SG	O	Su	Hoover (1971)
" "	Albe.	SG	R	Sp,Su,F	Mitchell and Smoliak (1971)
" "	Tex.	DG	O	Sp	Buechner (1950a)
" "	Colo.	SG	O	W,Sp,Su,F	Schwartz and Nagy (1976)
Linium lewisii	Utah	DS	O&R	Su,F	Beale and Smith (1970)
" "	Utah	SB	O	Su	Smith and Malechek (1974)
Liatris punctata	Colo.	SG	O	Sp	Hoover (1971)
" "	Tex.	DG	O	Sp	Buechner (1950a)

Table 1. (Continued)

Species	Location	Vegetation Type[1/]	Type of Study[2/]	Season of Use	Authority
<u>Lygodesmia</u> <u>juncea</u>	Kan.	SG	O	W,Sp,Su	Hlavachick (1968)
" "	Tex.	DG	O	W	Buechner (1950a)
<u>Melilotus</u> <u>alba</u>	Mont.	SB	O&R	F	Cole (1956)
" "	Albe.	SG	R	Su,F	Mitchell and Smoliak (1971)
<u>Melampodium</u> <u>cinereum</u>	Tex.	DG	O	Su	Buechner (1950a)
<u>Oenothera</u> <u>albicaulis</u>	Colo.	SG	O	Sp,Su	Hoover (1971)
<u>Oxytropis</u> <u>lambertii</u>	Colo.	SG	O	Su	Hoover (1971)
<u>Penstemon</u> <u>albidus</u>	Colo.	SG	O	W,Sp,Su	Hoover (1971)
<u>Petalostemon</u> <u>purpureum</u>	Okla.	TG	O	Su	Buechner (1950a)
<u>Physalis</u> <u>lobata</u>	Tex.	DG	O	F	Buechner (1950a)
<u>Polygonum</u> <u>aviculare</u>	Colo.	SG	O	Su	Hoover (1971)
<u>Psoralea</u> <u>argophylla</u>	Kan.	SG	O	Sp,Su	Hlavachick (1968)
" "	Mont.	SB	O&R	Su	Cole (1956)
<u>Psoralea</u> <u>tenuiflora</u>	Colo.	SG	O	Su	Hoover (1971)
" "	Kan.	SG	O	W,Sp,Su,F	Hlavachick (1968)
" "	Mont.	SB	O&R	Su	Cole (1956)
" "	Tex.	DS	O	Su	Buechner (1950a)
<u>Ratibida</u> <u>columnifera</u>	Colo.	SG	O	Su	Hoover (1971)
" "	Mont.	SB	O&R	Su,F	Cole (1956)
" "	Tex.	DG	O	W,Sp,Su,F	Buechner (1950a)
<u>Salsola</u> <u>kali</u>	Colo.	SG	O	W,Su	Hoover (1971)
" "	Utah	DS	O&R	Su	Beale and Smith (1970)
" "	Mont.	SB	O&R	Su	Cole (1956)
" "	Colo.	SG	O	W,Sp,Su,F	Schwartz and Nagy (1976)
" "	Utah	SB	O	Su	Smith and Malechek (1974)
<u>Solanum</u> <u>elaeagnifolium</u>	Tex.	DG	O	Su	Buechner (1950a)
<u>Sphaeralcea</u> <u>coccinea</u>	Colo.	SG	O	Sp,Su	Hoover (1971)
" "	Kan.	SG	O	Sp,Su,F	Hlavachick (1968)
" "	Utah	DS	O&R	W,Sp,Su,F	Beale and Smith (1970)
" "	Mont.	SB	O&R	Sp,Su,F	Cole (1956)

Table 1. (Continued)

Species	Location	Vegetation Type[1/]	Type of Study[2/]	Season of Use	Authority
Sphaeralcea coccinea	Tex.	DG	O	F	Buechner (1950a)
" "	Colo.	SG	O	W,Sp,Su,F	Schwartz and Nagy (1976)
Teucrium laciniatum	Tex.	DG	O	F	Buechner (1950a)
Thelesperma megapotamicum	Colo.	SG	O	Su	Hoover (1971)
" "	Tex.	DG	O	Sp	Buechner (1950a)
Thelesperma trifidum	Colo.	SG	O	Sp,Su	Hoover (1971)
" "	Tex.	DG	O	Sp	Buechner (1950a)
Tragopogon dubius	Albe.	SG	R	Su,F	Mitchell and Smoliak (1971)
Verbena sp.	Colo.	SG	O	W,Su	Hoover (1971)
" "	Mont.	SB	O&R	Su	Cole (1956)
Zinnia grandiflora	Tex.	DG	O	W,Sp,Su,F	Buechner (1950a)
Cultivated Crops					
Medicago					Yoakum (1975)
"	Mont.				Cole (1956)
Triticum	Mont.				Cole and Wilkins (1958)
"	Kan.				Hlavachick (1968)

1/Vegetation type: SG-Shortgrass, SB-Sagebrush, DS-Desert Shrub, DG-Desert Grassland, TG-Tallgrass.

2/Type of study: O-Observation, R-Rumen analyses.

coccinea (SPCO), *Salsola kali* (SAKA), and *Thelesperma megapotamicum* (THME) were heavily preferred by pronghorn on both areas. However, the above species contributed only small percentages to the total plant cover of both areas. *Astragalus* sp. (ASTR) and *Gillia sinuata* (GISI) were only found on the shortgrass area but were two of the most heavily utilized species in this area during spring and summer. *Lygodesmia juncea* (LYJU) and *Liatris punctata* (LIPU) were only found in significant numbers in the sand sagebrush area and then only in small percentages of the total plant cover. However, they were heavily utilized during spring and summer months.

The utilization of browse was almost exclusively limited to the fall season on both areas. *Artemisia filifolia* (ARFI) was used only slightly during late fall by pronghorn in the sand sagebrush area. ARFI contributed significantly to the total plant cover of the sand sagebrush area. *Artemisia frigida* (ARFR) appeared to be utilized to a moderate extent on both areas during summer months. ARFR was scattered on the sand sagebrush area but appeared more often on the shortgrass area. *Chrysothamnus nauseosus* (CHNA) was limited to the shortgrass area where it appeared in moderate amounts. CHNA received moderate use during fall months in the shortgrass area. *Ceratoides lanata* (CELA) was also only found on the shortgrass area and then only in moderate amounts. However, it was heavily sought after during late fall on the shortgrass area. CELA appeared to be the most important woody species present on the shortgrass area. *Xanthocephalum sarothrae* (XASA) appeared in moderate to heavy amounts on both areas but received little use except during late fall when new growth emerged along the stems. *Senecio longilobus* (SELO) appeared in small quantities on the sand sagebrush area and received only light use during summer and late fall. *Yucca glauca* (YUGL) appeared in moderate quantities on both areas, however, it received use only during bloom. YUGL blooms were highly preferred during spring months.

Chemical Composition of Pronghorn Forage

The chemical composition of all plants sampled on both areas within each season did not vary a great deal (Tables 2 and 3). However, most plants present on both study areas were most usually higher in percent nitrogen on the shortgrass area than on the sand sagebrush area. The percent calcium in the plants on the shortgrass area were usually higher than those same plants in the sand sagebrush area. The inverse was true of the phosphorous contents of plants common to both areas.

Chemical composition of browse species. Only three woody species occurred on feeding areas on both study areas, ARFR, XASA, and YUGL. ARFR maintained virtually the same levels of N on both areas during summer. However, ARFR plants on the sand sagebrush area appeared to retain higher amounts of N through the fall months than those plants on the shortgrass area. The percentages of other chemical components of ARFR appeared to be the same for both areas over time. XASA showed the same characteristics as did ARFR concerning percentage of N and P. However, XASA plants in the shortgrass area were considerably lower in K percentages during summer months than those in the sand sagebrush area but during fall months retained larger amounts of K in the shortgrass area. XASA plants in the shortgrass area also retained higher amounts of Ca during both seasons than those in the sand sagebrush

Table 2. Nitrogen (N), phosphorus (P), potassium (K) and calcium (Ca) contents (%) (means and standard deviations) in forage on feed grounds during summer and fall in the shortgrass and sand sagebrush study area.

		Summer						Fall					
		Shortgrass			Sand sagebrush			Shortgrass			Sand sagebrush		
Species (Plant parts)[1/]	Factor	No. of Samples	$\overline{X}$	± Sd	No. of Samples	$\overline{X}$	± Sd	No. of Samples	$\overline{X}$	± Sd	No. of Samples	$\overline{X}$	± Sd
BROWSE													
Artemisia	N				2	2.180	0.82				1	1.600	
dracunculus	P				2	0.186	0.00				1	0.185	
(L,T)	K				2	1.702	0.30				1	1.489	
	Ca				2	2.605	1.76				1	1.360	
Artemisia	N				7	1.511	0.25				4	1.352	0.23
filifolia	P				7	0.160	0.06				4	0.122	0.06
(L,T)	K				7	1.337	0.67				4	0.893	0.42
	Ca				7	0.934	0.37				4	0.806	0.12
Artemisia	N	4	1.540	0.39	5	1.482	0.50	1	1.000		3	1.185	0.65
frigida	P	4	0.186	0.07	5	0.200	0.11	1	0.142		3	0.138	0.11
(L,T)	K	4	1.782	0.84	5	1.576	0.78	1	1.093		3	1.082	0.36
	Ca	4	0.825	0.12	5	1.391	0.89	1	0.712		3	0.805	0.26
Chrysothamnus	N	13	1.676	0.35				6	1.406	0.25			
nauseosus	P	13	0.148	0.06				6	0.094	0.03			
(L,T)	K	13	1.829	0.91				6	1.072	0.53			
	Ca	13	0.903	0.41				6	0.651	0.10			
Ceratoides	N	10	1.982	0.60				5	1.576	0.44			
lanata	P	10	0.110	0.05				5	0.067	0.01			
(L,T)	K	10	1.491	0.59				5	1.079	0.36			
	Ca	10	1.580	0.52				5	1.673	0.43			
Xanthocephalum	N	14	1.523	0.41	6	1.611	0.31	7	1.318	0.44	2	1.535	0.54
sarothrae	P	14	0.122	0.06	6	0.166	0.04	7	0.076	0.04	2	0.133	0.06
(L,T)	K	14	1.509	0.81	6	2.254	1.05	7	0.955	0.56	2	0.256	0.15
	Ca	14	1.124	0.62	6	1.025	0.52	7	0.847	0.23	2	0.704	0.01
Senecio	N				4	1.972	0.64				1	1.250	
longilobus	P				4	0.175	0.09				1	0.073	
(L,T)	K				4	2.713	1.00				1	1.223	
	Ca				4	1.464	0.58				1	0.633	
Yucca	N	1	1.370		1	1.720							
glauca	P	1	0.109		1	0.187							
(F)	K	1	0.937		1	1.273							
	Ca	1	0.600		1	0.785							

Table 2. (Continued)

		Summer						Fall					
		Shortgrass			Sand sagebrush			Shortgrass			Sand sagebrush		
(Plant parts)[1/]	Factor	No. of Samples	$\overline{X}$	$\pm$ Sd	No. of Samples	$\overline{X}$	$\pm$ Sd	No. of Samples	$\overline{X}$	$\pm$ Sd	No. of Samples	$\overline{X}$	$\pm$ Sd
Yucca glauca (L)	N							1	1.370		1	1.720	
	P							1	0.109		1	0.187	
	K							1	0.937		1	0.273	
	Ca							1	0.600		1	0.785	
GRASSES													
Agropyron smithii (L,F)	N	10	1.117	0.36	3	0.943	0.28	5	0.834	0.24	1	0.620	
	P	10	0.093	0.06	3	0.115	0.09	5	0.042	0.02	1	0.012	
	K	10	1.184	0.85	3	0.814	0.63	5	0.580	0.42	1	0.096	
	Ca	10	0.452	0.11	3	0.512	0.56	5	0.423	0.15	1	0.097	
Aristida longiseta (L,F)	N	3	0.506	0.06	4	0.785	0.10	3	0.506	0.06	2	0.715	0.05
	P	3	0.030	0.01	4	0.072	0.02	3	0.030	0.01	2	0.053	0.01
	K	3	1.502	1.84	4	1.009	0.94	3	1.502	1.84	2	1.353	1.46
	Ca	3	0.443	0.14	4	0.337	0.04	3	0.443	0.14	2	0.307	0.03
Bouteloua curtipendula (L,F)	N				2	0.965	0.13				1	0.870	
	P				2	0.111	0.05				1	0.074	
	K				2	0.820	0.34				1	0.575	
	Ca				2	0.901	0.52				1	0.532	
Bouteloua gracilis (L,F)	N	14	1.275	0.40	9	1.190	0.29	7	0.981	0.24	4	0.912	0.19
	P	14	0.124	0.07	9	0.138	0.06	7	0.059	0.02	4	0.094	0.05
	K	14	0.932	0.57	9	0.860	0.49	7	0.481	0.31	4	0.399	0.18
	Ca	14	0.607	0.23	9	0.495	0.08	7	0.597	0.17	4	0.466	0.06
Buchloe dactyloides (L,F)	N				2	1.365	0.18						
	P				2	0.152	0.03						
	K				2	0.742	0.08						
	Ca				2	0.558	0.02						
Muhlenbergia torreyi (L,F)	N	2	1.080	0.25									
	P	2	0.109	0.02									
	K	2	0.720	0.20									
	Ca	2	0.665	0.16									
Oryzopsis hymenoides (L,F)	N	2	0.620	0.09				2	0.620	0.09			
	P	2	0.020	0.01				2	0.020	0.01			
	K	2	0.248	0.10				2	0.248	0.10			
	Ca	2	0.840	0.29				2	0.840	0.29			

Table 2. (Continued)

Species (Plant parts)[1/]	Factor	Summer						Fall					
		Shortgrass			Sand sagebrush			Shortgrass			Sand sagebrush		
		No. of Samples	$\overline{X}$	Sd	No. of Samples	$\overline{X}$	Sd	No. of Samples	$\overline{X}$	Sd	No. of Samples	$\overline{X}$	Sd
Schedonnardus	N	1	1.590		1	2.240							
paniculatus	P	1	0.127		1	0.301							
(L,F)	K	1	2.320		1	3.287							
	Ca	1	0.660		1	1.189							
Sitanion	N	5	1.116	0.27				2	0.970	0.29			
hystrix	P	5	0.095	0.05				2	0.053	0.02			
(L,F)	K	5	0.817	0.28				2	0.695	0.39			
	Ca	5	0.465	0.19				2	0.681	0.03			
Sporobolus	N	2	1.495	0.09	4	1.460	0.33				3	1.363	0.33
cryptandrus	P	2	0.207	0.03	4	0.159	0.03				3	0.154	0.04
(L,F)	K	2	1.427	0.16	4	1.062	0.58				3	0.786	0.24
	Ca	2	0.400	0.03	4	0.566	0.20				3	0.471	0.08
Stipa	N							1	0.480				
comata	P							1	0.008				
(L,F)	K							1	0.128				
	Ca							1	0.640				
FORBS													
Ambrosia	N				3	2.526	0.75				1	3.310	
coronopifolia	P				3	0.228	0.01				1	0.226	
(T,L)	K				3	2.537	0.37				1	2.159	
	Ca				3	4.524	0.76				1	3.973	
Aster	N				1	2.000					1	2.000	
tanacetifolius	P				1	0.160					1	0.160	
(T,L,F)	K				1	1.933					1	1.933	
	Ca				1	2.003					1	2.003	
Astragalus	N	1	2.810										
sp.	P	1	0.155										
(T,L,F)	K	1	2.315										
	Ca	1	0.961										
Bahia	N	1	2.680										
oppositifolia	P	1	0.511										
(T,L,F)	K	1	5.290										
	Ca	1	4.470										

Table 2 (Continued)

		Summer						Fall					
		Shortgrass			Sand sagebrush			Shortgrass			Sand sagebrush		
(Plant parts)[1/]	Factor	No. of Samples	$\overline{X}$	± Sd	No. of Samples	$\overline{X}$	± Sd	No. of Samples	$\overline{X}$	± Sd	No. of Samples	$\overline{X}$	± Sd
Helianthus	N	4	2.130	0.16									
annus	P	4	0.316	0.09									
(T,L,F)	K	4	2.743	1.27									
	Ca	4	2.952	1.33									
Helianthus	N				1	1.930							
petiolaris	P				1	0.286							
(T,L,F)	K				1	2.868							
	Ca				1	3.796							
Ipomoea	N	1	2.420										
leptophylla	P	1	0.351										
(T,L,F)	K	1	2.298										
	Ca	1	0.717										
Liatris	N				4	1.317	0.43				2	1.060	0.38
punctata	P				4	0.091	0.04				2	0.071	0.03
(T,L,F)	K				4	1.064	0.91				2	0.941	0.58
	Ca				4	1.286	0.29				2	1.237	0.48
Lygodesmia	N				4	1.185	0.36				1	0.650	
juncea	P				4	0.107	0.05				1	0.042	
(T,L)	K				4	1.132	0.57				1	0.510	
	Ca				4	0.948	0.15				1	1.030	
Mentzelia	N				1	2.030							
stricta	P				1	0.154							
(T,L,F)	K				1	1.989							
	Ca				1	6.630							
Plantago	N	1	1.550										
purshii	P	1	0.219										
(T,L,F)	K	1	2.227										
	Ca	1	1.120										
Psoralea	N	2	1.805	0.41	5	1.904	0.77				1	0.760	
tenuiflora	P	2	0.106	0.01	5	0.117	0.04				1	0.060	
(T,L,F)	K	2	1.091	0.94	5	1.299	0.66				1	0.393	
	Ca	2	2.413	0.75	5	1.770	0.22				1	1.526	

Table 2 (Continued)

Species (Plant parts)[1/]	Factor	Summer Shortgrass No. of Samples	Summer Shortgrass $\bar{X}$	Summer Shortgrass ± Sd	Summer Sand sagebrush No. of Samples	Summer Sand sagebrush $\bar{X}$	Summer Sand sagebrush ± Sd	Fall Shortgrass No. of Samples	Fall Shortgrass $\bar{X}$	Fall Shortgrass ± Sd	Fall Sand sagebrush No. of Samples	Fall Sand sagebrush $\bar{X}$	Fall Sand sagebrush ± Sd
Chenopodium	N				1	1.810							
leptophyllum	P				1	0.211							
(T,L,F)	K				1	1.181							
	Ca				1	2.080							
Engelmannia	N				1	1.720							
pinnatifida	P				1	0.217							
(T,L,F)	K				1	3.371							
	Ca				1	3.980							
Erysimum	N	1	1.580										
asperum	P	1	0.424										
(T,L,F)	K	1	2.995										
	Ca	1	6.460										
Eriogonum	N	1	1.860		1	1.800		1	0.650				
sp.	P	1	0.146		1	0.188		1	0.052				
(T,L,F)	K	1	1.426		1	1.213		1	1.141				
	Ca	1	2.420		1	1.608		1	2.230				
Gaura	N	1	2.380										
coccinea	P	1	0.237										
(T,L,F)	K	1	2.035										
	Ca	1	3.750										
Gillia	N	1	2.400										
sinuata	P	1	0.376										
(T,L,F)	K	1	2.997										
	Ca	1	1.067										
Grindelia	N	1	2.050										
squarrosa	P	1	0.260										
(T,L,F)	K	1	4.160										
	Ca	1	3.020										
Haplopappus	N	1	1.680		3	1.526	0.28						
spinulosus	P	1	0.142		3	0.125	0.02						
(T,L,F)	K	1	2.261		3	2.422	0.28						
	Ca	1	2.900		3	1.187	0.04						

Table 2 (Continued)

Species (Plant parts)[1/]	Factor	Summer: Shortgrass No. of Samples	$\overline{X}$	$\pm$ Sd	Summer: Sand sagebrush No. of Samples	$\overline{X}$	$\pm$ Sd	Fall: Shortgrass No. of Samples	$\overline{X}$	$\pm$ Sd	Fall: Sand sagebrush No. of Samples	$\overline{X}$	$\pm$ Sd
Ratibida columnifera (T,L,F)	N				2	1.750							
	P				2	0.313	0.05						
	K				2	2.003	1.12						
	Ca				2	3.905	2.77						
Ratibida tagetes (T,L,F)	N	3	1.650	0.33	5	1.308	0.33	2	1.540	0.38	2	1.160	0.42
	P	3	0.181	0.13	5	0.179	0.04	2	0.111	0.06	2	0.134	
	K	3	1.724	0.86	5	2.060	0.77	2	1.452	1.02	2	1.447	0.68
	Ca	3	3.480	1.91	5	2.360	1.02	2	2.375	0.17	2	1.957	1.84
Salsola kali (T,L)	N	5	2.222	0.21	3	2.313	0.05	1	1.990		1	2.340	
	P	5	0.292	0.15	3	0.204	0.04	1	0.112		1	0.192	
	K	5	4.119	0.94	3	4.555	2.44	1	3.493		1	3.259	
	Ca	5	4.348	2.13	3	5.555	3.50	1	3.891		1	3.445	
Sphaeralcea coccinea (T,L,F)	N	7	1.777	0.26	3	1.483	0.06	2	1.650	0.17			
	P	7	0.186	0.07	3	0.125	0.04	2	0.107	0.01			
	K	7	1.788	0.76	3	2.079	0.72	2	1.536	0.33			
	Ca	7	2.682		3	1.909	0.41	2	2.824	0.09			
Thelesperma megapotamicum (T,L,F)	N	1	1.080		4	0.982	0.33				1	0.650	
	P	1	0.101		4	0.083	0.04				1	0.027	
	K	1	1.344		4	1.159	0.67				1	0.283	
	Ca	1	3.610		4	0.952	0.25				1	0.871	
Zinnia grandiflora (T,L,F)	N				2	1.440	0.07						
	P				2	0.123	0.04						
	K				2	1.703	0.80						
	Ca				2	2.486	0.27						

[1/]Plant part utilized (L-leaves, T-twigs, F-flowers).

Table 3. Average dry matter (DM), nitrogen (N), phosphorus (P), potassium (K), and calcium (Ca) contents (%) in forage on feed grounds during summer and fall in the shortgrass and sand sagebrush study area.

Species (Plant parts)[1/]	Factor	Summer (June-August) Shortgrass	Sand sagebrush	P[2/]	Fall (September-November) Shortgrass	Sand sagebrush	P
BROWSE							
Artemisia frigida (L, T)	DM	59.00	50.00	.03			
	N	1.54	1.48	.87			
	P	0.18	0.20	.62			
	K	1.78	1.57	.88			
	Ca	0.82	1.39	.18			
Xanthocephalum sarothrae (L, T)	DM	57.67	52.13	.22	87.53	77.63	.36
	N	1.52	1.61	.62	1.31	1.53	.57
	P	0.12	0.16	.55	0.07	0.13	.16
	K	1.50	2.25	.16	0.95	0.25	.49
	Ca	1.12	1.02	.64	0.84	0.70	.43
GRASSES							
Agropyron smithii (L, F)	DM	69.03	57.47	.14			
	N	1.11	0.94	.12			
	P	0.09	0.11	.46			
	K	1.18	0.81	.32			
	Ca	0.45	0.51	.36			
Aristida longiseta (L, F)	DM				91.07	90.54	.92
	N				0.50	0.71	.03
	P				0.03	0.05	.14
	K				1.50	1.35	.93
	Ca				0.44	0.30	.29

Table 3. (Continued)

Species (Plant parts)1/	Factor	Summer (June-August) Shortgrass	Summer (June-August) Sand sagebrush	P2/	Fall (September-November) Shortgrass	Fall (September-November) Sand sagebrush	P
	DM	77.68	71.55	.35	79.81	87.65	.46
Bouteloua gricilis	N	1.27	1.19	.30	0.98	0.91	.64
(L, F)	P	0.12	0.13	.51	0.05	0.09	.15
	K	0.93	0.86	.45	0.48	0.39	.64
	Ca	0.60	0.49	.49	0.59	0.46	.17
FORBS							
	DM	62.38	47.77	.41			
Sporobolus cryptandrus	N	1.49	1.46	.26			
(L, F)	P	0.20	0.15	.61			
	K	1.42	1.06	.25			
	Ca	0.40	0.56	.05			
	DM	44.39	45.53	.89			
Psoralea tenuiflora	N	1.80	1.90	.40			
(L, T)	P	0.10	0.11	.23			
	K	1.09	1.29	.47			
	Ca	2.41	1.77	.17			
	DM	51.21	44.96	1.00	80.61	76.82	.90
Ratibida tagetes	N	1.65	1.30	.32	1.54	1.16	.23
(L, T, F)	P	0.18	0.17	.05	0.11	0.13	.64
	K	1.72	2.06	.79	1.45	1.44	.99
	Ca	3.48	2.36	1.00	2.37	1.95	.44
	DM	36.24	28.37	.14			
Salsola kali	N	2.22	2.31	.90			
(L, T)	P	0.29	0.20	.28			
	K	4.11	4.55	.57			
	Ca	4.34	5.55	.45			

Table 3. (Continued)

Species (Plant parts)[1/]	Factor	Summer (June-August)		P[2/]	Fall (September-November)		P
		Shortgrass	Sand sagebrush		Shortgrass	Sand sagebrush	
Sphaeralcea coccinea (L, T, F)	DM	58.28	59.52	.85			
	N	1.77	1.48	.09			
	P	0.18	0.12	.06			
	K	1.78	2.07	.76			
	Ca	2.68	1.90	.50			

[1/]Plant part utilized (L-leaves, T-twigs, F-flowers).

[2/]Probability level for differences between study areas within each season.

area. YUGL leaves were only sampled during the fall months on both areas, although they received no utilization by pronghorn. These leaves were consistantly higher in all components in the sand sagebrush area.

ARDR, ARFI and SELO only appeared on feeding areas in the sand sagebrush area. ARDR contained high percentages of N during the summer months but retained little over half that amount during fall months. P and K remained stable during both seasons in ARDR. However, over 50% of the Ca in ARDR was lost from summer to fall.

ARFI retained stable proportions of N and P during both seasons. However, almost 50% of the K was lost after summer months and 25% of the Ca was lost during the same period. SELO retained moderate amounts of N during the summer but lost almost 50% of that amount by fall. Roughly 75% of P, K and Ca were lost from summer to fall in SELO.

CHNA and CELA occurred only on the shortgrass area and YUGL blooms were only analyzed for the shortgrass area. YUGL blooms were also utilized by pronghorn in the sand sagebrush area but were not found in large enough quantities for collection. The percentage of N and P in CHNA on the shortgrass area remained stable during summer and fall. However, 50% of K and Ca contents were lost during this same time period. N and P contents in CELA dropped almost 50% from summer to fall, while K and Ca contents remained stable. The chemical components of YUGL blooms compared favorably with the components of other woody plants during summer months.

Chemical composition of grass species. Several grass species appeared on both areas. However, the discussion will be limited to those species which occurred frequently on feeding areas or were utilized by pronghorn.

ARLO appeared on both areas in rather large amounts, but received little utilization by pronghorn during both seasons. The percentage of all chemical components of ARLO were low for all seasons, but remained stable amoung seasons. The percentage of K actually went up from summer to fall.

AGSM retained relatively high percentages of N on both areas during summer. AGSM plants on the shortgrass area retained slightly higher amounts of N over time than did those plants in the sand sagebrush area during the same time period. The P content of AGSM was comparable for both areas over time. The percentage of K was higher for the shortgrass area during both seasons. The Ca content of AGSM was higher for the sand sagebrush area during summer months, however, declined sharply during fall months. At the same time, the Ca content of AGSM in the shortgrass area remained stable.

The chemical components of BOGR were similar for both study areas with slightly higher percentages on the shortgrass area in all catagories. The percentages of all factors in BOGR on both areas decreased by about 50% from summer to fall.

Of all grass species present on both areas, SPCR appeared to retain the highest percentages of nutrients over time. The percentages of N and P only decreased by 25% from summer to fall while K and Ca contents decreased by 50% in the same time period.

Chemical composition of forb species. Only those species which appeared frequently on pronghorn feeding areas or were utilized heavily will be discussed here. Refer to Table 2 for information on other species which were collected during the study.

GACO was utilized only during the summer on the shortgrass area. It retained relatively high amounts of N and moderate amounts of P and K. The Ca content of GACO was rather high during this same time period compared to other grasses and forbs during this time.

HASP was highly preferred during summer months on both areas. It retained moderate amounts of all nutrients during this time with slightly higher amounts of all nutrients for those plants in the short-grass feeding areas.

During summer months, LYJU was highly preferred on the sand sage-brush area but received little utilization during fall months. The percentages of N, P and K dropped by 50% from summer to fall. However, the percentage of Ca actually increased 25% during the same time period.

LIPU was also a highly preferred forb species by pronghorn in the sand sagebrush area during summer months. The percentage of N and P only dropped by 30% from summer to fall. Over 75% of the K was lost in the same amount of time. The Ca content remained stable in LIPU from summer to fall.

During summer months, PSTE was one of the most highly preferred forage species in both areas. PSTE retained high amounts of all nutrients studied except P which was relatively low compared to most other forb species. However, PSTE did not retain the levels of nu-trients during fall months that it did during summer. All nutrients declined by 65% in PSTE during fall months except Ca which remained rather stable.

RATA was also heavily utilized by pronghorn during spring and summer on both areas. Nutrient levels of RATA were similar for both areas. However, the levels of Ca were slightly higher for RATA plants on the shortgrass area. N and P levels in RATA on both areas showed little change from summer to fall. The levels of K and Ca dropped by half on both areas during the same amount of time.

SPCO was highly preferred in both areas during summer months and continued to be utilized during fall months on the shortgrass area where it was much more abundant. The nutrient content of SPCO was comparable for both areas with an edge to those plants on the shortgrass area. On the shortgrass area, SPCO maintained moderate nutrient levels through fall months with the exception of P which declined by 50%.

SAKA was another highly preferred forb species on both areas during summer and fall months. The peak of utilization by pronghorn on SAKA occurred during early summer months on both study areas. During this time period, SAKA maintained one of the highest levels of nutrients of any forb species from summer to fall. Only 25% of each nutrient level was lost from summer to fall on both areas. Nutrient levels in SAKA were similar for both study areas during both seasons.

Pronghorn on both areas also showed a preference for THME, particularly during summer months. THME did not maintain particularly high nutrient levels during the study but it was composed of a high percentage of water during summer months. THME lost about 50% of all nutrients from summer to fall on the sand sagebrush area. No utilization by pronghorn was observed on THME during fall months in the shortgrass area.

Chemical Composition of Soils in Pronghorn Feeding Areas

The soils on feeding areas in both study areas were comparable in most cases (Table 4). The pH values were within one-tenth of each other at 7.9 for the shortgrass area and 7.8 for the sand sagebrush area. Organic matter contents for soils of the shortgrass area were some higher at 1.793% than those of the sand sagebrush area which had a mean value of 1.364%.

The percentages of nitrogen in soils on both areas were somewhat low. The shortgrass area had a mean value of 0.140% whereas the sand sagebrush area had a mean value of 0.109%. Potassium values for the shortgrass area were much higher at 826.875 ppm than those values for the sand sagebrush area at 631.636 ppm. Calcium levels for the shortgrass area were twice as high at 8230.625 ppm than those in the sand sagebrush area at 4797.727 ppm. The levels of magnesium in the shortgrass soils were also much higher at 531.187 ppm than those in the sand sagebrush area at 302.181 ppm. The levels of sodium were about equal for both areas.

Chemical Composition of Water Sources Near Pronghorn Feeding Areas

The levels of factors studied here seem to set no noticeable pattern (Table 5). However, the variability in factors among samples was much greater in the sand sagebrush area than it was in the shortgrass area.

The pH values were about the same for both areas with 7.8 for the shortgrass area and 7.9 for the sand sagebrush area. The levels of nitrates were somewhat higher in water samples in the sand sage-

Table 4. Chemical composition of soils in feeding areas in the shortgrass and sand sagebrush study areas.

Factor	Shortgrass	Sand sagebrush	P[1/]
pH	7.9	7.8	.68
Organic matter (%)	1.79	1.36	.08
Nitrogen (%)	0.14	0.10	.10
Potassium (ppm)	830	630	.14
Calcium (ppm)	8230	4800	.02
Magnesium (ppm)	530	300	.01
Sodium (ppm)	190	185	.15

[1/] Probability level for differences between study areas.

Table 5. Chemical composition of water sources in proximity of feeding areas in the shortgrass and sand sagebrush study areas.

Factor	Shortgrass (N=6)	Sand sagebrush (N=4)	P[1/]
pH	7.8	7.9	.81
Nitrates (ppm)	4.4	7	.06
Chlorides (ppm)	24	31	.64
Sulfates (ppm)	260	146	.63
Phosphates (ppm)	0.061	0.025	.25
Conductivity	830	920	.88

[1/]Probability level for differences between study areas.

brush area than those in the shortgrass area. Chloride levels were also higher for the sand sagebrush area compared to the shortgrass area. The levels of sulfates was almost twice as high in the shortgrass area at 260.33 ppm as it was in the sand sagebrush study area at 146.00 ppm. The levels of phosphates were also some higher in the shortgrass area than in the sand sagebrush area. However, the conductivity values were somewhat higher for the sand sagebrush area than for the shortgrass area.

Conclusions

Overall forage and soil quality in the shortgrass area seem to be slightly higher than in the sand sagebrush area. The abundance of palatable forage species and the quality of those species were greater on the shortgrass area. The above points seem to substantiate the conclusion that the shortgrass area will and does support larger numbers of pronghorn.

The presence of certain woody species on the shortgrass area also seem to contribute to better quality pronghorn habitat. ARFR, CELA, CHNA, OPAR, and OPUN are noticeably more frequent on the shortgrass area. Of the above species CELA, CHNA, and OPAR are only found on the shortgrass area. CELA was observed to be a winter food source of pronghorn in Utah (Beale and Smith 1970) and in Wyoming (Severson et al. 1968). CHNA was observed to be a winter food source of pronghorn in Colorado (Hoover 1971), Montana (Bayless 1969), Utah (Beale and Smith 1970) and Wyoming (Severson et al. 1968). OPAR was found to be utilized by pronghorn in Texas during fall months (Buechner 1950a).

A winter food source relatively high in crude protein, in the form of woody species, may be the difference between the two areas. The sand sagebrush area also has a relatively high density of woody plants. However, the woody plant diversity of the sand sagebrush area is very low. ARFI is the only woody species which is found frequently on this area, but it receives little utilization by pronghorn except during winter months. Palatability of ARFI appeared to be very low for pronghorn. I conclude that pronghorn in the sand sagebrush area utilize ARFI during fall and winter months simply because of the lack of a better food source. This may also be reflected by the fact that pronghorn in the sand sagebrush area utilize more winter wheat than those in the shortgrass area even though winter wheat is equally available in the shortgrass area. There seems to be some indication here that a natural winter protein source is lacking or entirely absent in the sand sagebrush area. Therefore, winter climatic extreames may have a much more direct effect on pronghorn in the sand sagebrush area because of the lack of tall, nutritious, woody vegetation. This is concluded as one of the major limiting factors on pronghorn numbers in this area.

The other major point to consider, when comparing habitat component quality of the two areas, is the abundance and quality of forb species. Most of the forbs, which are considered good pronghorn forage, are more prevalent and higher in nutrients on the shortgrass area. BAOP, CHAL, GACO, SAKA, and SPCO are much more prevalent on the shortgrass area than they are on the sand sagebrush area. BAOP was observed to be utilized by pronghorn in Colorado (Hoover 1971) and (Schwartz and Nagy 1976) and in Montana (Cole 1956) during spring, summer and fall. CHAL was found to be utilized in Utah during spring and summer (Beale and Smith 1970; Smith and Malecheck 1974). GACO was utilized during summer months in Colorado (Hoover 1971), Montana (Cole 1956), Alberta (Mitchell and Smoliak 1971) and throught the year in Texas (Buechner 1950a). SAKA was utilized during summer months in Colorado (Hoover 1971), Utah (Beale and Smith 1970; Smith and Malecheck 1974) and year round in Colorado (Schwartz and Nagy 1976). SPCO is probably the most widespread and most utilized forb on pronghorn range. It is utilized during spring and summer in Kansas (Hlavachick 1968), Colorado (Hoover 1971) and Montana (Cole 1956), during fall in Texas (Buechner 1950a) and year round in Utah (Beale and Smith 1970) and Colorado (Schwartz and Nagy 1976).

Based on the above data, I conclude that pronghorn numbers on both study areas are directly affected by the quality and abundance of preferred plant species. One of the major reasons for higher pronghorn numbers in the shortgrass area is the high diversity of palatable browse and forb species and the high quality of those species.

The sand sagebrush area seems to provide adequate spring and summer habitat in the form of high quality forb and grass species. However, palatable nutritious winter forage seems to be lacking in this area. It is concluded that the shortgrass area is superior pronghorn habitat because of better year round, nutritious forage supplies.

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APPENDIX A

GROUND COVER FREQUENCY IN THE
SAND SAGEBRUSH STUDY AREA

Range Site Soils	% of Study Area	No. of Transects (N)	Ground Cover: Bare ground	Litter	Vegetation
All Sites	100	107	84.9	14.2	0.9
Sandy Plains	79.7	82	83.8	15.5	0.7
Dalhart sl[1/]	8.5	9	88.8	10.2	0.8
Dalhart sl	1.4	2	74.0	25.0	1.0
Manter-Vona sl	29.4	30	85.6	14.0	0.4
Otero sl	25.5	25	77.5	21.6	0.9
Vona ls	14.5	14	82.4	17.2	0.2
Vona sl	1.4	2	95.0	5.0	0.0
Loamy Plains	6.9	11	71.3	26.3	2.4
Baca cl	1.9	2	76.0	19.0	5.0
Campo cl	1.3	1	62.0	34.0	4.0
Harbord l	0.3	1	76.0	18.0	6.0
Harvey l	0.3	1	62.0	38.0	0.0
Kim l	0.1	1	50.0	50.0	0.0
Wages l	0.2	1	92.0	8.0	0.0
Wiley l	2.8	3	81.2	17.6	1.2
Gravel Breaks	5.6	6	89.5	10.0	0.5
Gravelly land	0.7	1	90.0	10.0	0.0
Otero-Potter Complex	3.8	3	84.5	15.0	0.5
Potter gravelly loam	1.1	2	94.0	5.0	1.0
Deep Sandy (Tivoli s)	5.0	5	88.4	11.2	0.4
Sandy Bottomland	2.7	3	91.5	8.0	0.5
Bankard s	1.6	2	91.0	8.0	1.0
Glenberg sl	1.1	1	92.0	8.0	0.0

[1/]Soil texture: sl-sandy loam, ls-loamy sand, cl-clay loam, l-loam, s-sand.

APPENDIX B

HERBACEOUS SPECIES FREQUENCY IN THE SAND SAGEBRUSH STUDY AREA

Species	(Symbol)	Average[1/] (N=107)[2/]	Sandy Plains (N=82)	Loamy Plains (N=11)	Gravel Breaks (N=6)	Deep Sandy (N=5)	Sandy Bottomland (N=3)
GRASSES		79.7	82.7	96.9	97.5	57.8	61.5
Aristida longiseta	(ARLO)	4.3	11.7	3.0	5.3	0.4	1.0
Bothriochloa saccharoides	(BOSA)	0.5	1.4	0.0[3/]	0.5	0.0	0.0
Bouteloua curtipendula	(BOCU)	3.2	7.0	2.4	6.6	0.0	0.0
Bouteloua gracilis	(BOGR)	33.6	25.3	75.2	68.1	0.4	10.0
Buchloe dactyloides	(BUDA)	3.7	1.0	8.2	9.3	0.0	0.0
Chloris verticillata	(CHVE)	0.5	1.3	0.0	0.0	1.4	0.0
Muhlenbergia porteri	(MUPO)	0.4	T[4/]	1.2	1.0	0.0	0.0
Munroa squarrosa	(MUSQ)	1.8	0.8	0.0	0.0	0.8	7.5
Sporobolus cryptandrus	(SPCR)	28.3	32.5	5.3	5.8	54.8	43.0
Miscellaneous		0.8	1.6	1.6	0.9	0.0	0.0
FORBS		20.3	17.3	2.0	2.5	41.4	36.5
Ambrosia coronopifolia	(AMPS)	0.9	2.3	0.0	0.0	0.0	2.5
Aster tanacetifolius	(ASTA)	0.6	0.5	0.0	0.0	0.8	1.0
Chenopodium leptophyllum	(CHLE)	4.5	4.2	0.0	0.0	13.2	1.0
Cryptantha minima	(CRMI)	0.6	1.1	0.0	0.0	2.0	0.0
Eriogonum annuum	(ERAN)	9.1	5.2	0.0	0.3	18.0	22.0
Mentzelia stricta	(MEST)	0.5	T	0.0	T	0.4	2.0
Sphaeralcea coccinea	(SPCO)	1.1	1.0	1.2	1.0	0.0	2.0
Salsola kali	(SAKA)	2.2	1.2	0.0	0.0	6.0	2.5
Miscellaneous		1.9	1.7	1.4	1.1	1.4	3.5

[1/] Average for all transects on all soils and sites.

[2/] Number of 50 point transects.

[3/] Species not found on transects on this range site.

[4/] Less than 0.1%.

APPENDIX C

WOODY SPECIES FREQUENCY IN THE

SAND SAGEBRUSH STUDY AREA

Species	(Symbol)	Average[1/] (N=107)[2/]	Sandy Plains (N=82)	Loamy Plains (N=11)	Gravel Breaks (N=6)	Deep Sandy (N=5)	Sandy Bottomland (N=3)
Artemisia filifolia	(ARFI)	56.2	52.2	29.2	1.6	99.2	98.0
Mammillaria sp.	(MAMM)	T[3/]	T	0.0	0.0	0.0	0.0
Oenothera serrulata	(OESE)	T	0.8	0.0	0.0	0.0	0.0
Opuntia sp.	(OPUN)	6.5	7.6	21.3	2.8	0.8	0.0
Senecio longilobus	(SELO)	6.4	2.3	7.0	22.6	0.0	0.0
Senecio ridellii	(SERI)	4.1	0.4	7.2	12.3	0.0	0.0
Xanthocephalum sarothrae	(XASA)	9.9	14.2	25.0	8.6	0.0	2.0
Yucca glauca	(YUGL)	16.7	22.1	10.0	51.8	0.0	0.0

1/ Average for all transects on all soils and sites.

2/ Number of 50 point transects.

3/ Less than 0.1%.

APPENDIX D

WOODY SPECIES DENSITY IN THE SAND SAGEBRUSH STUDY AREA

Species	(Symbol)	Average[1/] (N=107)[2/]	Sandy Plains (N=82)	Loamy Plains (N=11)	Gravel Breaks (N=6)	Deep Sandy (N=5)	Sandy Bottomland (N=3)
Artemisia filifolia	(ARFI)	703	290	4	1	1399	1824
Mammillaria sp.	(MAMM)	1	1	0	0	0	0
Oenothera serrulata	(OESE)	1	5	0	0	0	0
Opuntia sp.	(OPUN)	10	9	3	11	28	0
Senecio longilobus	(SELO)	5	3	2	18	0	0
Senecio ridellii	(SERI)	5	4	3	16	0	0
Xanthocephalum sarothrae	(XASA)	6	24	4	4	0	62
Yucca glauca	(YUGL)	14	40	2	30	0	0
Total		745	376	18	80	1427	1886

[1/]Average overall range sites and soils.

[2/]Number of 50 point transects.

APPENDIX E

THE SOILS OF THE SAND SAGEBRUSH STUDY AREA

Name	Range Site	Family	Subgroup	Order
Dalhart sandy loam*1/	Sandy Plains	Fine-loamy, mixed, mesic	Aridic Argiustolls	Mollisols
Manter and Vona sandy loams*	Sandy Plains	Coarse-loamy, mixed mesic	Aridic Argiustolls	Mollisols
Otero sandy loam*	Sandy Plains	Coarse-loamy, mixed (calcareous), mesic	Ustic Torriorthents	Entisols
Vona loamy sand*	Sandy Plains	Coarse-loamy, mixed, mesic	Ustollic Haplargids	Aridisols
Vona sandy loam*	Sandy Plains	Coarse-loamy, mixed, mesic	Ustollic Haplargids	Aridisols
Baca clay loam*	Loamy Plains	Fine, montmorillonitic, mesic	Ustollic Haplargids	Aridisols
Campo clay loam*	Loamy Plains	Fine, montmorillonitic, mesic	Ustollic Paleargids	Aridisols
Harbord loam*	Loamy Plains	Fine-loamy, mixed, mesic	Ustollic Haplargids	Aridisols
Harvey loam*	Loamy Plains	Fine-loamy, mixed, mesic	Ustollic Calciorthide	Aridisols
Kim loam*	Loamy Plains	Fine-loamy, mixed (calcareous), mesic	Ustic Torriorthents	Entisols
Wages loam*	Loamy Plains	Fine-loamy, mixed, mesic	Aridic Argiustolls	Mollisols

Name	Range Site	Family	Subgroup	Order
Wiley loam*	Loamy Plains	Fine-silty, mixed, mesic	Ustollic Haplargids	Aridisols
Gravelly land	Gravel Breaks	Fine-carbonatic, mesic shallow	Ustollic Calciorthids	Aridisols
Otero-Potter complex	Gravel Breaks	Fine-carbonatic, mesic shallow	Ustollic Calciorthids	Aridisols
Potter gravelly loam*	Gravel Breaks	Fine-carbonatic, mesic shallow	Ustollic Calciorthids	Aridisols
Tivoli sand*	Deep Sandy	Mixed, thermic	Typic Ustipsamments	Entisols
Bankard sand*	Sandy Bottomland	Sandy, mixed (calcareous), mesic	Ustic Torrifluvents	Entisols
Glenberg sandy loam*	Sandy Bottomland	Coarse-loamy, mixed (calcareous), mesic	Ustic Torrifluvents	Entisols
Travessilla stony sandy loam*	Sandstone Breaks	Loamy, mixed (calcareous), mesic	Lithic Ustic Torriorthents	Entisols

1/Soil Series Profile in Appendix F.

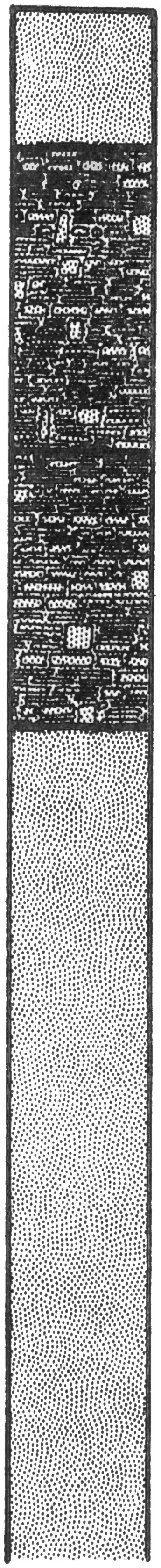
APPENDIX F

PROFILE DESCRIPTIONS OF SOILS PRESENT IN THE SAND SAGEBRUSH STUDY AREA

The descriptions of horizons were modified from: Soil Conservation Service. 1973. Soil survey of Baca County, Colorado. U.S. Govt. Printing Office. Washington, D.C.

BACA SERIES

Loamy Plains Range Site



Ap - Light brownish-gray (10YR 6/2) light clay loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; noncalcareous, pH 7.8; clear, smooth boundary.

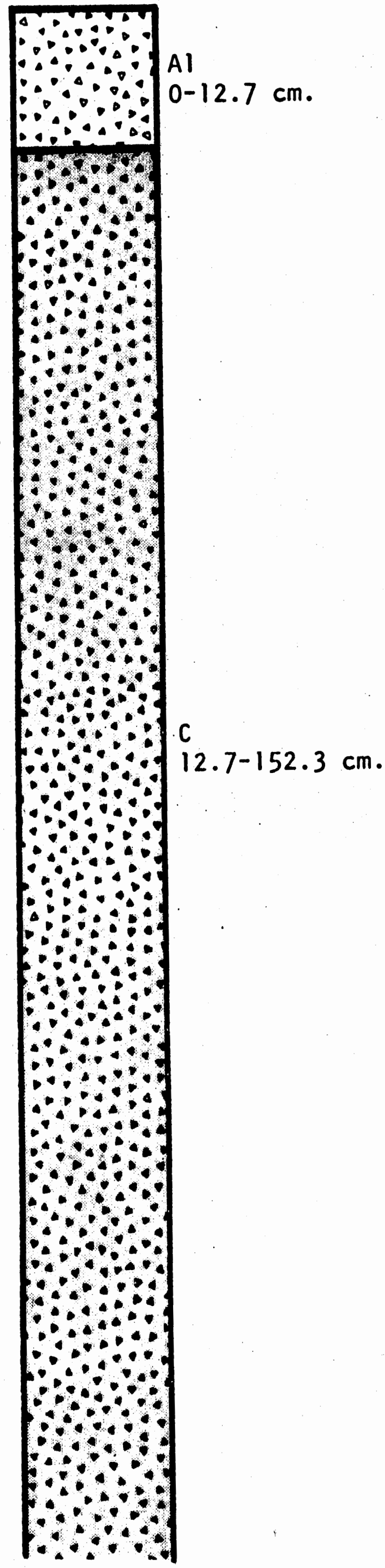
B2t - Grayish-brown (20YR 5/2) clay loam, dark grayish-brown (10YR 4/2) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist; thin nearly continuous clay skins; noncalcareous in upper part, slightly calcareous in lower part, pH 8.4; clear smooth boundary.

B3ca - Grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky; hard when dry, friable when moist; very strongly calcareous, pH 8.6; clear, smooth boundary.

Cca - Pale-brown (10YR 6/3) silt loam brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist, lime spots are plentiful; very stongly calcareous, pH 8.9.

BANKARD SERIES

Sandy Bottomland Range Site



Al - Pale-brown (10YR 6/3) sand, dark brown (10YR 4/3) when moist; single grain; loose when dry, very friable when moist; strongly calcareous, pH 7.5; abrupt, smooth boundary.

C - Brown (10YR 5/3) sand, dark brown (10YR 4/3) when moist; single grain; loose when dry, very friable when moist; strongly calcareous, pH 8.0.

A1
0-10.2 cm.
B1
10.2-15.2 cm.
B2t
15.7-95.7 cm.
B3ca
45.7-101.6 cm.
Cca
101.6-152.3 cm.

CAMPO SERIES

Loamy Plains Range Site

A1 - Light brownish-gray (10YR 6/2) clay loam, dark grayish-brown (10YR 4/2) when moist; moderate, medium to fine, granular structure; hard when dry, firm when moist; noncarcareous; clear, smooth boundary.

B1 - Pale-brown (10YR 6/3) silty clay, dark brown (10YR 3/3) when moist; weak, medium, subangular blocky structure; hard when dry, firm when moist; thin continuous clay skins; noncalcareous; clear, smooth boundary.

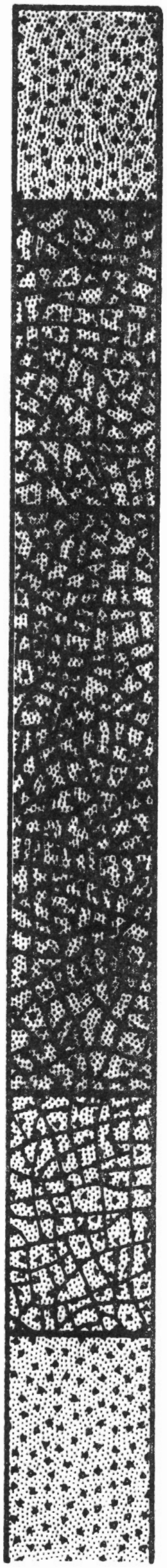
B2t - Brown (10YR 5/3) clay, dark brown (10YR 3/3) when moist; moderate, medium, prismatic structure that parts to strong, medium to fine subangular blocky; hard when dry, firm when moist; moderate continuous clay skins; noncalcareous; clear, smooth boundary.

B3ca - Very pale brown (10YR 7/3) silty clay loam, brown (20YR 5/3) when moist; weak, medium, subangular blocky structure; hard when dry, firm when moist; common lime spots 1/4 to 1/8 inch in diameter; very strongly calcareous; clear, smooth boundary.

Cca - Very pale brown (10YR 7/3) silty clay, loam, pale brown (10YR 7/3) when moist; very weak, coarse, subangular blocky structure; hard when dry, friable when moist; moderately limy; very strongly calcareous; gradual smooth boundary.

DALHART SERIES

Sandy Plains Range Site



A1
0-20.3 cm.

B1
20.3-40.6 cm.

B2t
40.6-76.2 cm.

B3
76.2-91.4 cm.

Cca
91.4-152.3 cm.

A1 - Dark-brown (10YR 4/3) loamy sand, dark brown (10YR 3/3) when moist; single grain; loose when dry, very friable when moist; noncalcareous, pH approximately 7.6; clear, smooth boundary.

B1 - Dark-brown (7.5YR 4/4) light sandy clay loam, dark brown (10YR 4/3) when moist; weak, coarse, prismatic structure that parts to weak, medium, subangular blocky; slightly hard when dry, friable when moist; thin, patchy clay skins; noncalcareous, pH 7.8; clear, wavy boundary.

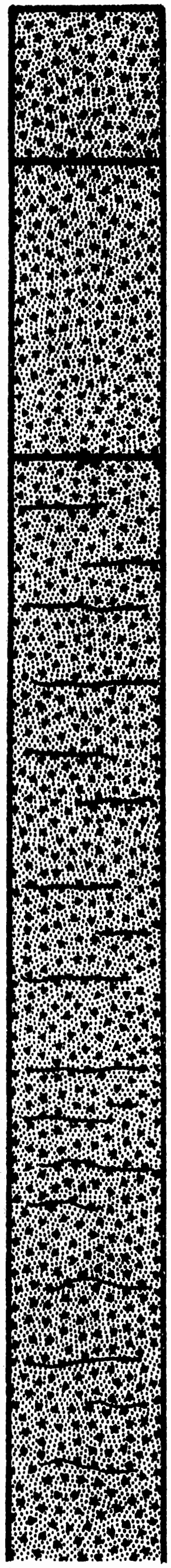
B2t - Brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure that parts to moderate, medium, subangular blocky; hard when dry, firm when moist; thin, continuous clay skins; noncalcareous, pH 7.8; clear, smooth boundary.

B3 - Yellowish-brown (10YR 5/4) sandy loam, dark yellowish brown (10YR 4/4) when moist; weak, coarse, prismatic structure; slightly hard when dry, friable when moist; weak calcareous, pH 7.9; clear, smooth boundary.

Cca - Pale-brown (10YR 6/3) loamy sand, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; scattered limy spots; very strongly calcareous, pH 7.9.

GLENBERG SERIES

Sandy Bottomland Range Site



A1
0-12.7 cm.

AC
12.7-38.1 cm.

C
38.1-152.3 cm.

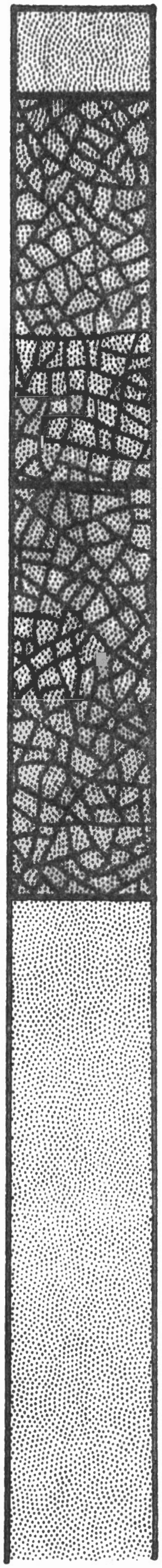
A1 - Pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; weak, fine, granular structure; loose when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

AC - Pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; weak, coarse, subangular blocky structure; soft when dry, very friable when moist; thin strata of loamy sand; strongly calcareous; clear, smooth boundary.

C - Pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; strongly stratified with thin lenses of clay loam, sandy loam, loamy sand, and sand in the lower portion; strongly calcareous; clear, smooth boundary.

HARBORD SERIES

Loamy Plains Range Site



Ap
0-7.6 cm.

B21t
7.6-40.6 cm.

B22cab
40.6-73.6 cm.

Cca
73.6-152.3 cm.

Ap - Brown (7.5YR 5/3) loam, dark brown (7.5YR 4/3) when moist; moderate, fine, granular structure; hard when dry, firm when moist; very strongly calcareous; clear, smooth boundary.

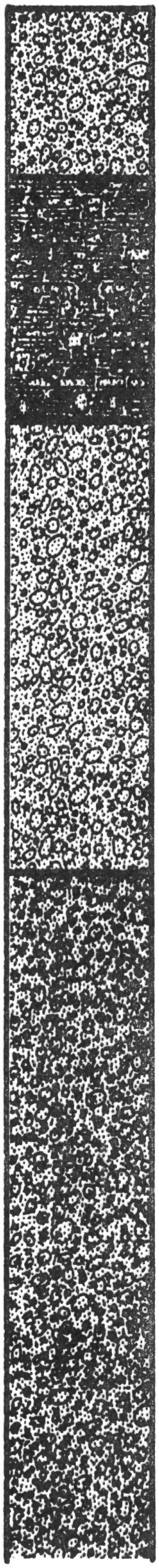
B21t - Brown (7.5YR 5/4) silty clay loam, dark brown (7.5YR 4/4) when moist; moderate, coarse, prismatic structure that parts to moderate, medium, subangular blocky; hard when dry, very firm when moist; thin, patchy clay skins; noncalcareous; gradual, wavy boundary.

B22cab - Light-brown (7.5YR 6/4) clay loam, dark brown (7.5YR 4/4) when moist; weak, medium prismatic structure that parts to moderate, medium, subangular blocky; hard when dry, firm when moist; thin, patchy clay skins; very strongly clacareous; gradual, wavy boundary.

Cca - Pink (7.5YR 8/4) clay loam, pink (7.5YR 7/4) when moist; massive; slightly hard when dry, firm when moist; very strongly calcareous.

HARVEY SERIES

Loamy Plains Range Site



Ap - Light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, fine, grandular structure; slightly hard when dry, friable when moist; few scattered gravels; very strongly calcareous, pH 7.8; clear, smooth boundary.

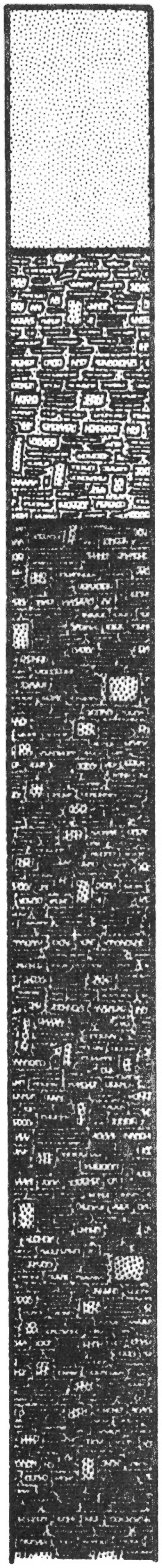
AC - Pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; weak, medium, subangular blocky structure; slightly hard when dry, firm when moist; scattered gravels; very strongly calcareous, pH 7.8; clear, smooth boundary.

Clca - Very pale brown (10YR 7/3) sandy clay loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, firm when moist; many lime spots and scattered gravels; very strongly calcareous, pH 7.9; clear, smooth boundary.

C2ca - Very pale brown (10YR 7/3) sandy loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; sand and gravel mixed; very strongly calcareous, pH 8.1.

KIM SERIES

Loamy Plains Range Site



A1
0-22.8 cm.

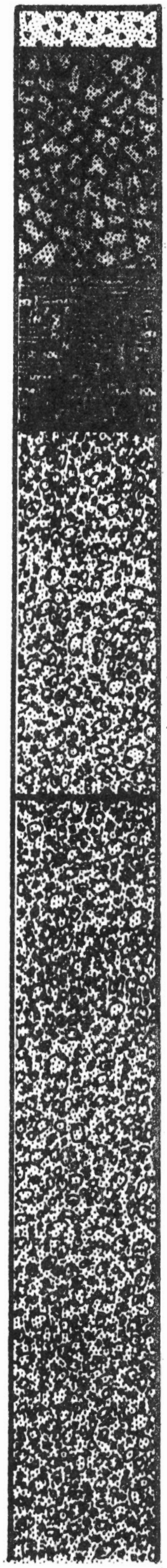
AC
22.8-43.1 cm.

Cca
43.1-152.3 cm.

A1 - Grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; hard when dry, friable when moist; strongly calcareous; gradual, smooth boundary.

AC - Grayish-brown (10YR 5/2) clay loam, dark grayish-brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; hard when dry, firm when moist; strongly calcareous; clear, smooth boundary.

Cca - Brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; very weak, medium, subangular blocky structure; hard when dry, firm when moist; thin, patchy clay skins; many white lime spots; strongly calcareous.



A1
0-5.0 cm.

B2t
5.0-22.8 cm.

B3
22.8-35.5 cm.

C1ca
35.5-71.1 cm.

C2
71.1-152.3 cm.

MANTER SERIES

Sandy Plains Range Site

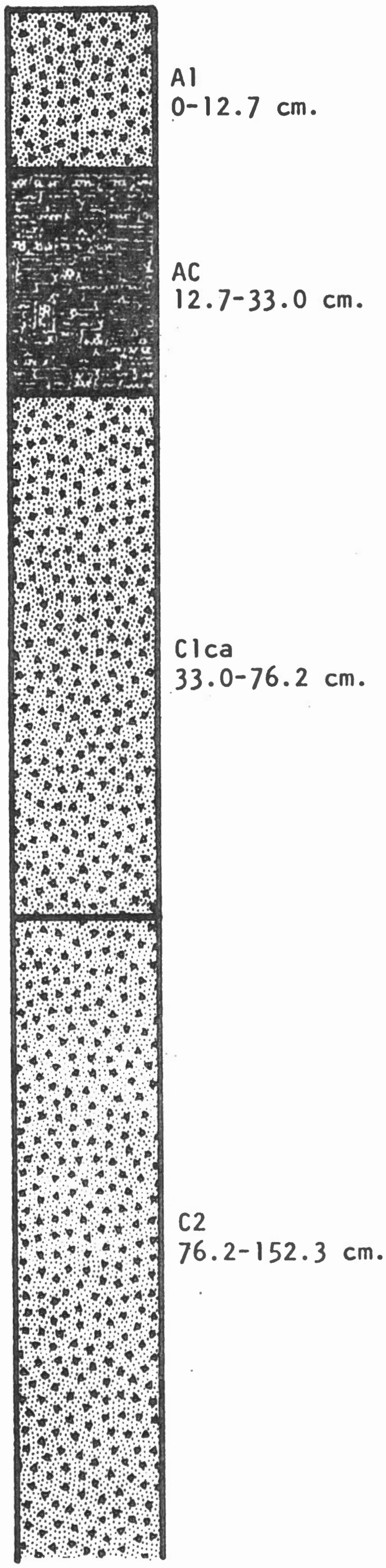
A1 - Grayish brown (10YR 5/2) sandy loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; noncalcareous, pH 7.5; abrupt, smooth boundary.

B2t - Dark brown (10YR 4/3) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic structure that parts to weak, medium to fine, subangular blocky; slightly hard when dry, friable when moist; thin, patchy clay skins; noncalcareous, pH 7.4; clear, smooth boundary.

B3 - Brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) when moist; weak medium, subangular blocky structure; slightly hard when dry, friable when moist; noncalcareous, pH 7.4; clear, smooth boundary.

C1ca - Very pale brown (10YR 7/3) sandy loam, brown (10YR 5/3) when moist; very high content of lime; scattered pebbles; very strongly calcareous, pH 7.6; clear, smooth boundary.

C2 - Very pale brown (10YR 7/3) sandy loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; sand and gravel mixed; very strongly calcareous, pH 7.6.



OTERO SERIES

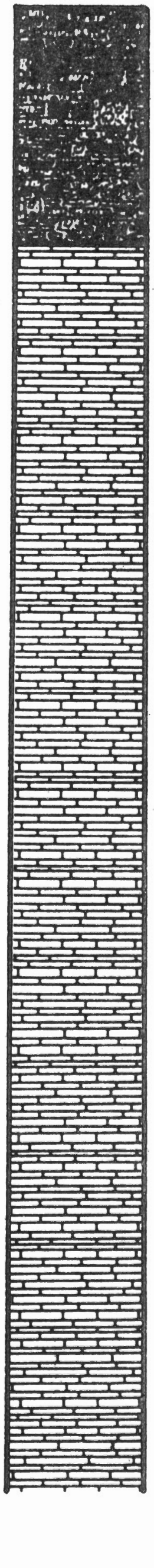
Sandy Plains Range Site

A1 - Light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, very fine, granular structure; soft when dry, very friable when moist; weakly calcareous, pH 7.2; clear, smooth boundary.

AC - Light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; very weak, medium subangular blocky structure; soft when dry, very friable when moist; strongly calcareous, pH 7.5; gradual, smooth boundary.

C1ca - Very pale brown (10YR 7/3) sandy loam, pale brown (10YR 6/3) when moist; massive; slightly hard when dry, very friable when moist; lime concretions; very strongly calcareous, pH 7.8; clear, smooth boundary.

C2 - Very pale brown (10YR 7/4) sandy loam, light yellowish brown (10YR 6/4) when moist; single grain; soft when dry, very friable when moist; thin lenses of loamy sand; few lime concretions; very strongly calcareous, pH 8.0.



A1
0-5.0 cm.

AC
5.0-20.3 cm.

R
20.3 cm.---

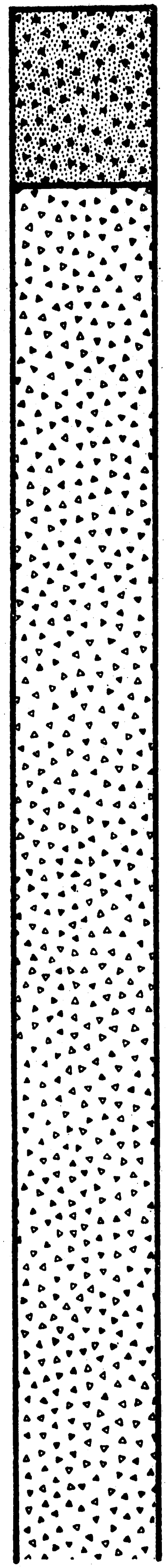
POTTER SERIES

Gravel Breaks Range Site

A1 - Grayish-brown (10YR 5/2) gravelly loam, dark grayish brown (10YR 4/2) when moist; very weak to weak, fine, platy structure; soft when dry, friable when moist; small limestone fragments; very strongly calcareous, pH 7.8; clear, smooth boundary.

AC - Grayish-brown (10YR 5/2) gravelly loam, dark grayish brown (10YR 4/2) when moist; very weak to weak, medium, subangular blocky structure; slightly hard when dry, friable when moist; plentiful lime-covered gravel; very strongly calcareous, pH 8.0; clear, smooth boundary.

R - Caliche bedrock.



TIVOLI SERIES

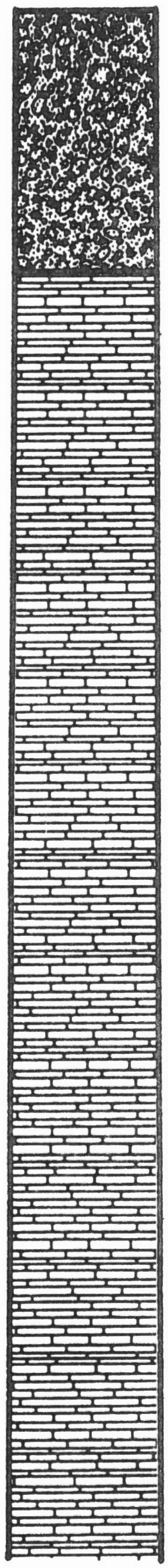
Deep Sand Range Site

A1 - Pale-brown (10YR 6/3) sand, dark brown (10YR 3/3) when moist; single grain; loose when dry, very friable when moist; noncalcareous; clear, wavy boundary.

C - Yellowish-brown (10YR 5/4) sand; dark yellowish brown (10YR 4/4) when moist; single grain; loose when dry, very friable when moist; noncalcareous.

TRAVESSILLA SERIES

Sandstone Breaks Range Site



A
0-22.8 cm.

R
22.8 cm.---

A - Grayish-brown (10YR 5/2) stony sandy loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; scattered sandstone chips; strongly calcareous; clear, smooth boundary.

R - Hard sandstone that in the top 2 or 3 inches is slightly weathered, with a few cracks.

VONA SERIES

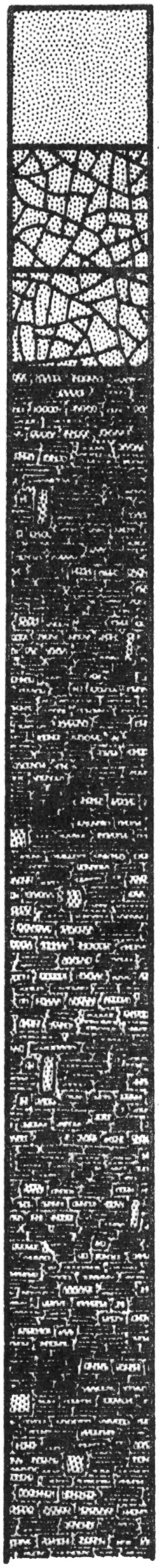
Sandy Plains Range Site

A1 - Pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; weak, fine, granular structure; soft when dry, friable when moist; noncalcareous; clear, smooth boundary.

B2t - Light brownish-gray (10YR 6/2) sandy loam, grayish brown (10YR 5/2) when moist; moderate, medium, subangular blocky structure; hard when dry, firm when moist; thin patchy clay skins; few lime spots; weakly calcareous in upper 10 inches, strongly calcareous in lower 5 inches; gradual, smooth boundary.

C1 - Light yellowish-brown (10YR 6/4) sandy loam, yellowish brown (10YR 5/4) when moist; massive; slightly hard when dry, friable when moist; lime spots; strongly calcareous; clear, smooth boundary.

C2 - Light yellowish-brown (10YR 6/4) sand, yellowish brown (10YR 5/4) when moist; massive to single grain; loose when dry, very friable when moist; strongly calcareous.



A1
0-10.1 cm.

B2t
10.1-20.3 cm.

B3
20.3-30.4 cm.

C
30.4-152.3 cm.

WAGES SERIES

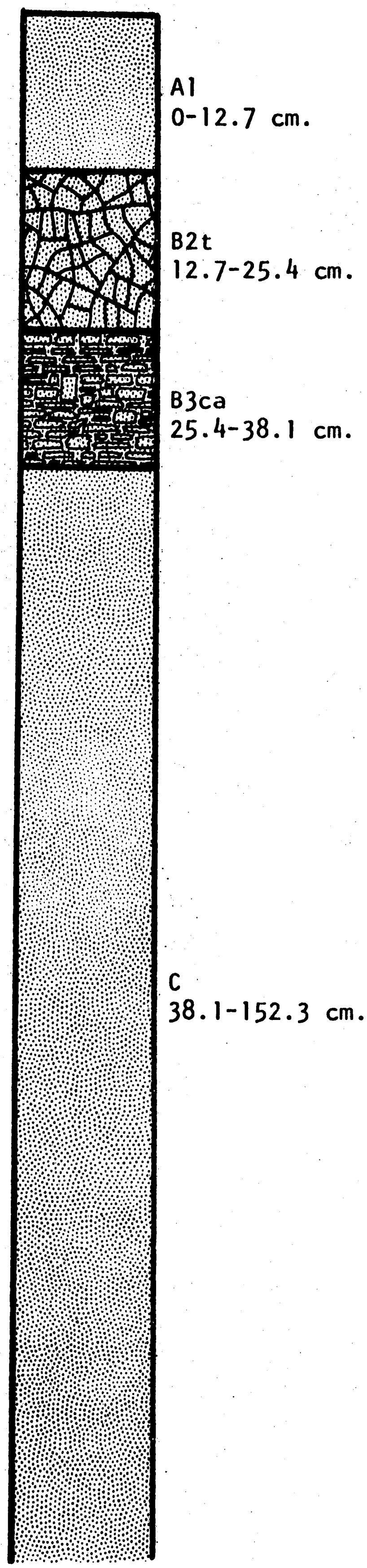
Loamy Plains Range Site

A1 - Grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; noncalcareous, pH 7.5; abrubt, smooth boundary.

B2t - Grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, prismatic structure that parts to moderate, medium to fine, subangular blocky; hard when dry, firm when moist; thin, patchy clay skins; noncalcareous, pH 7.6; clear, smooth boundary.

B3 - Grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak, medium, prismatic structure that parts to weak, medium, subangular blocky; hard when dry, firm when moist; strongly calcareous, pH 7.8; clear, smooth boundary.

C - Brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; very weak, medium, subangular blocky structure; hard when dry, friable when moist; strongly calcareous, pH 8.1.



WILEY SERIES

Loamy Plains Range Site

A1 - Light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; small lime concretions; strongly calcareous; clear, smooth boundary.

B2t - Grayish brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; weak to moderate, medium, prismatic structure that parts to weak to moderate, medium, subangular blocky; hard when dry, friable when moist; thin, patchy clay skins; weakly calcareous; clear, smooth boundary.

B3ca - Pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) when moist; very weak to weak, medium sub-angular blocky structure; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.

C - Pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; about 5 percent lime spots; strongly calcareous.

APPENDIX G

PLANT SPECIES COLLECTED DURING THE STUDY

Code	Scientific Name	Common Name
Forb Species		
ABFR	Abronia fragrans Nutt. ex Hook	Sandverbena
ALTE	Allium textile Nels. & Macbr.	Textile Onion
AMHY	Amaranthus hybridus L.	Slim Amaranth
AMAR	Amaranthus spp.	Amaranth
AMPS	Ambrosia coronopifolia T. & G.	Western Ragweed
APOC	Apocynum spp.	Dogbane
ARHO	Arenaria hooker: Nutt. ex T. & G.	Hooker Sandwort
ARIN	Agremone intermedia Sweet	Pricklepoppy
ARLU	Artemisia ludoviciana Nutt.	Louisiana Sagebrush
ASAS	Asclepias asperula (Dene.)	
ASLA	Asclepias latifolia (Torr.) Raf.	Broadleaf Milkweed
ASST	Asclepias stenophylla Gray	
ASVE	Asclepias verticilliata L.	Whorled Milkweed
ASKU	Aster kumleini Fries in Rydb.	
ASTA	Aster tanacetifolius H.B.K.	Tansyleaf Aster
ASCE	Astragalus ceramicus Sheld.	
ASPU	Astragalus puniceus Osterh.	
ASTR	Astragalus sp.	Milkvetch
BOAP	Bahia oppositifolia (Nutt.) DC.	Plains Bahia
BELY	Berlandiera lyrata Benth.	
CACI	Castilleja citrina Pennell	
CHAL	Chenopodium album L.	Lambsquarters Goosefoot
CHLE	Chenopodium leptophyllum Nutt. Apud. Moq. DC.	Slimleaf Goosefoot
CHHI	Chrysopsis hispida (Hook.) DC.	
CHVI	Chrysopsis villosa (Pursh) Nutt. ex DC.	Hairy Goldaster
CIOC	Cirsium ochrocentrum A. Gray	
CLSE	Cleome serrulata Pursh	Bee Spiderflower
COIN	Convolvulus incanus Vahl.	Nebraska Glorybind
CONV	Convolvulus spp.	Glorybind
CRTE	Croton texensis (Klotzsch) Muell. Arg. in DC.	Texas Croton
CRMI	Cryptantha minima Rydb.	
CRTH	Cryptantha thyrsiflora (Greene) Payson	
CUFO	Cucurbita foetidissima H.B.K.	Buffalogourd
DAAU	Dalea aurea Nutt. in Pursh	Silktop Dalea
DAEN	Dalea enneandra Nutt.	Plume Dalea
DAJA	Dalea Jamesii (Torr.)	James Dalea
DEVI	Delphinium virescens Nutt.	Plains Larkspur
DYPA	Dyssodia papposa (Vent.) Hitchc.	Prairie Dogweed
ECAN	Echinacea angustifolia DC.	Blacksamson Echinacea
ENPI	Engelmannia pinnatifida T. & G.	
EQUI	Equisetum spp.	Horsetail
ERBE	Erigeron bellidiastrum Nutt.	Fleabane
ERAN*1/	Eriogonum annuum Nutt.	Annual Buckwheat
ERJA	Eriogonum jamesii Benth. in DC.	Antelope-sage Buckwheat

Code	Scientific Name	Common Name
ERLA	Eriogonum lachnogynum Torr. ex Benth in DC.	
ERIO	Eriogonum spp.	Buckwheat
ERTE	Eriogonum tenellum Torr.	
ERAS	Erysimum asperum (Nutt.) DC.	Plains Wallflower
EUDE	Euphorbia dentata Michx.	Toothed Euphorbia
EUMA	Euphorbia marginata Pursh	Snow-on-the-Mountain
EVNU	Evolvulus nuttallianus R. & S.	Nuttall Evolvulus
GAPI	Gaillardia pinnatifida Torr.	Rayless Gaillardia
GAPU	Gaillardia pulchella Foug.	Rosering Gaillardia
GACO	Gaura coccinea Nutt. ex Pursh	Scarlet Gaura
GAPA	Gaura parviflora Dougl. ex Hooker	
GAVI	Gaura villosa Torr.	
GISI	Gillia sinuata Dougl. ex Benth.	
GRSQ	Grindelia squarrosa (Pursh) Dunal	Curlycup Gumweed
HAFR	Haplopappus fremontii A. Gray	Fremont Goldenweed
HASP	Haplopappus spinulosus (Pursh) DC.	Ironplant Goldenweed
HEAN	Helianthus annus L.	Common Sunflower
HEPE	Helianthus petiolaris Nutt.	Prairie Sunflower
HECO	Heliotropium convolvulaceum (Nutt.) A. Gray	Bindweed Heliotrope
HOJA	Hoffmanseggia jamesii T. & G.	James Rushpea
HYFL	Hymenopappus flavescens Gray	
HYAC	Hymenoxys acaulis (Pursh) Parker	Stemless Hymenoxys
IPLE	Ipomoea leptophylla Torr. in Frem.	Bush Morningglory
KRLA	Krameria lanceolata Torr.	
LARE	Lappula redowskii (Hornem.) Greene	
LEDE	Lepidium densiflorum Schrad.	Prairie Pepperweed
LEOV	Lesquerella ovalifolia Rydb. in Britt. & Brown	
LIPU	Liatris punctata Hook.	Dotted Gayfeather
LILE	Linium lewisii Pursh	Lewis Flax
LYJU	Lygodesmia juncea (Pursh) D. Don.	Rush Skeletonplant
MAVU	Marrubium vulgare L.	Common Hoarhound
MALO	Martynia louisianica Mill.	
MECI	Melampodium cinereum DC.	Plains Blackfoot
MEAL	Melilotus alba Desr. in Lam.	White Sweetclover
MEOF	Melilotus officinalis (L.) Lam.	Yellow Sweetclover
MEST	Mentzelia stricta (Osterh.) Stevens	Bractless Mentzelia
MILI	Mirabilis linearis (Pursh) Heimerl.	Plains Four-O'clock
MOPE	Monarda pectinata Nutt.	Pony Beebalm
OEAL	Oenothera albicaulis Pursh	
OXLA	Oxytropis lambertii Pursh	Lambert Crazyweed
PAMA	Palafoxia macrolepis (Rydb.) Cory	
PEAL	Penstemon albidus Nutt.	White Penstemon
PEAM	Penstemon ambiguus Torr.	Gilia Penstemon
PEBA	Penstemon barbatus (Cav.) Roth.	Beardlip Penstemon
PELA*	Penstemon laxiflorus Pennell	
PENS	Penstemon sp.	Penstemon

Code	Scientific Name	Common Name
PECA	Petalostemon candidum Michx.	White Prairieclover
PECO	Petalostemon compactus (Spreng.) Swezey	
PEPU	Petalostemon purpureum (Vent.) Rydb.	Purple Prairieclover
PHCU	Phyla cuneifolia (Torr.) Greene	
PHLA	Physalis lanceolata Michx.	
PHLO	Physalis lobata Torr.	
PHYS	Physalis sp.	Groundcherry
PLPU	Plantago purshii Roem. & Schult.	
POAL	Polygala alba Nutt.	White Polygala
POAV	Polygonum aviculare L.	Prostrate Knotweed
PSAR	Psoralea argophylla Pursh	Silverleaf Scurfpea
PSLA	Psoralea lanceolata Pursh	Lemon Scurfpea
PSTE	Psoralea tenuiflora Pursh	Slimflower Scurfpea
RACO	Ratibida columnifera (Nutt.) Woot. & Standl.	Upright Prairiecone-flower
RATA	Ratibida tagetes (James) Barnh.	Small Prairieconeflower
RUCR	Rumex crispus L.	Curly Dock
RUVE	Rumex venosus Pursh	Veiny Dock
SALA	Saggittaria latifolia Willd.	Common Arrowhead
SAKA	Salsola kali L.	Common Russianthistle
SEMU	Senecio mutabilis Greene	
SOEL	Solanum elaeagnifolium Cav.	Silverleaf Nightshade
SORO	Solanum rostratum Dunal	Buffalobur Nightshade
SOPE	Solidage petiolaris Ait.	
SPCO	Sphaeralcea coccinea (Pursh) Rydb.	Scarlet Globemallow
STPI	Stanleya pinnata (Pursh) Britton	Desert Princesplume
STPA	Stephenomeria pauiflora (Torr.) A. Nels.	
TELA	Teucrium laciniatum Torr.	
THME	Thelsperma megapotamicum (Spreng.) Kuntze	
THTR	Thelesperma trifidum (Poir.) Britt.	
TOSE	Townsendia sericea Hook.	
TRRA	Tragia ramosa Torrey	Branching Noseburn
TRDU	Tragopogon dubius Scop.	Salsify
VETH	Verbascum thapsus L.	Flannel Mullein
VEAM	Verbena ambrosifolia Rydb. in Small	
VEBR	Verbena bracteata Lag. & Rodr.	Bigbract Verbena
VERN	Vernonia spp.	
VIAM	Vicia americana Muhl. ex Willd.	American Vetch
XASP	Xanthium spinosum L.	Spiny Cocklebur
ZIGR	Zinnia grandiflora Nutt.	Rocky Mountain Zinnia

Woody Species

AMCA	Amorpha canescens Pursh	Leadplant Amorpha
ARDR	Artemisia dracunculus L.	Falsetarragon
ARFI	Artemisia filifolia Torr.	Sand Sagebrush

Code	Scientific Name	Common Name
ARFR	Artemisia frigida Willd.	Fringed Sagebrush
CEOC	Celtis occidentalis L.	Plains Hackberry
CELA	Ceratoides lanata	Common Winterfat
CEMO	Cercocarpus montanus Raf.	True Mountainmahogany
CHNA	Chrysothamnus nauseosus (Pallas)	Rubber Rabbitbrush
CHRY	Chrysothamnus sp.	Rabbitbrush
DAFO	Dalea formosa Torr.	Feather Dalea
ECIN	Echinocereus spp.	Echinocereus
GLTR*	Gleditsia triacanthos L.	Honey Locust
GLLE	Glycyrrhiza lepidota Pursh	Wild Licorice
JUMO	Juniperus monosperma (Engelm.) Sarg.	One-Seed Juniper
LYPA	Lycium pallidum Miers	Pale Wolfberry
MAMA	Mammillaria spp.	Mammillaria
MIBO	Mimosa borealis A. Gray	
OESE	Oenothera serrulata Nutt.	
OPAR	Opuntia arborescens Engelm in Wislizenus	
OPUN	Opuntia spp.	Pricklypear
PIED	Pinus edulis Engelm. in Wisliz.	Pinyon Pine
PIPO	Pinus ponderosa Dougl. ex P. Lawson	Ponderosa Pine
POSA	Populus fremontii Dode	Fremont Cottonwood
POTR	Populus tremuloides Michx.	Quaking Aspen
PRVI	Prunus virginiana L.	Common Chockecherry
PTBA	Ptelea baldwinii T. & G.	Baldwin Hoptree
QUUN	Quercus undulata Torr.	Wavyleaf Oak
RHTR	Rhus trilobata Nutt. ex. T. & G.	Skunkbush Sumac
RIAU	Ribes aureum Pursh	Golden Currant
RICE	Ribes cereum Dougl.	Wax Currant
RUDE	Rubus deliciosus Torr.	Boulder Raspberry
SAAM	Salix amygdaloides Anderss.	Peachleaf Willow
SAIN	Salix interior Rowlee	Sandbar Willow
SCHR	Schrankia spp.	
SELO	Senecio longilobus Benth.	Threadleaf Groundsel
SENE	Senecio ridellii T. & G.	Ridell Groundsel
TAGA	Tamarix gallica L.	Tamarisk
XASA	Xanthocephalum sarothrae (Pursh) Britton & Rusby	Broom Snakeweed
YUGL	Yucca glauca Nutt.	Small Soapweed

Grass Species

Code	Scientific Name	Common Name
AGSM	Agropyron smithii Rydb.	Western Wheatgrass
ANHA	Andropogon hallii Hack.	Sand Bluestem
ARLO	Aristida longiseta Steud.	Red Threeawn
BOSA	Bothriochloa saccharoides Rydb.	Silver Bluestem
BOCU	Bouteloua curtipendula (Michx.) Torr. in Emory	Sideoats Grama
BOER	Bouteloua eriopoda (Torr.) Torr.	Black Grama

Code	Scientific Name	Common Name
BOGR	*Bouteloua gracilis* (H.B.K.) Lag.	Blue Grama
BOHI	*Bouteloua hirsuta* Lag.	Hairy Grama
BRIN	*Bromus inermis* Leyss.	Smooth Brome
BUDA	*Buchloe dactyloides* (Nutt.) Engelm.	Buffalograss
CEPA	*Cenchrus pauciflorus* Benth.	Mat Sandbur
CHVE	*Chloris verticillata* Nutt.	Tumble Windmillgrass
DIST	*Distichlis stricta* (Torr.) Rydb.	Inland Saltgrass
ELCA	*Elymus canadensis* L.	Canada Wildrye
ERTR	*Eragrostis trichodes* (Nutt.) Wood	Sand Lovegrass
FEOC	*Festuca octoflora* Walt.	Sixweeks Fescue
HIJA	*Hilaria jamesii* (Torr.) Benth.	Galleta
HOPU	*Hordeum pusillum* Nutt.	Little Barley
LYPH	*Lycurus phleoides* H.B.K.	Wolftail
MUPO	*Muhlenbergia porteri* Scribn.	Bush Muhly
MURA	*Muhlenbergia racemosa* (Michx.) B.S.P.	Green Muhly
MUTO	*Muhlenbergia torreyi* (Kunth) Bush	Ring Muhly
MUSQ	*Munroa squarrosa* (Nutt.) Torr.	False Buffalograss
ORHY	*Oryzopsis hymenoides* (R. & S.) Ricker	Indian Ricegrass
PAOB	*Panicum obtusum* H.B.K.	Vine-Mesquite
PAVI	*Panicum virgatum* L.	Switchgrass
POMO	*Polypogon monspeliensis* (L.) Desf.	Rabbitfootgrass
SCPA	*Schedonnardus paniculatus* (Nutt.) Trel. in Bran. & Cov.	Tumblegrass
SIHY	*Sitanion hystrix* (Nutt.) J. G. Sm.	Bottlebrush Squirrel-tail
SPAI	*Sporobolus airoides* (Torr.) Torr.	Alkali Sacaton
SPCR	*Sporobolus cryptandrus* (Torr.) A. Gray	Sand Dropseed
STCO	*Stipa comata* Trin. & Rupr.	Needleandthread
STNE	*Stipa neomexicana* (Thurb.) Scribn.	New Mexico Feathergrass
STRO	*Stipa robusta* (Vasey) Scribn.	Sleepygrass
TREL	*Tridens elongatus* (Buckl.) Nash in Small	Rough Tridens
TRPI	*Tridens pilosus* (Buckl.) Hitchc.	Hairy Tridens

[1/]Scientific names by - Waterfall, U. T. 1972. Keys to the flora of Oklahoma. 246 p.

Unless otherwise noted, all scientific names follow: Harrington, H. D. 1964. Manual of the plants of Colorado. Swallow Press. Chicago, Ill. 666 p.

Common names of plants follow: Nickerson, M. F., G. E. Brink and C. Feddema. 1976. Principal range plants of the central and southern Rocky Mountains: Names and Symbols. USDA for. Serv. Gen. Tech. Rep. RM-20, 121 p. Rocky Mt. For. and Range Exp. Stn., Ft. Collins.

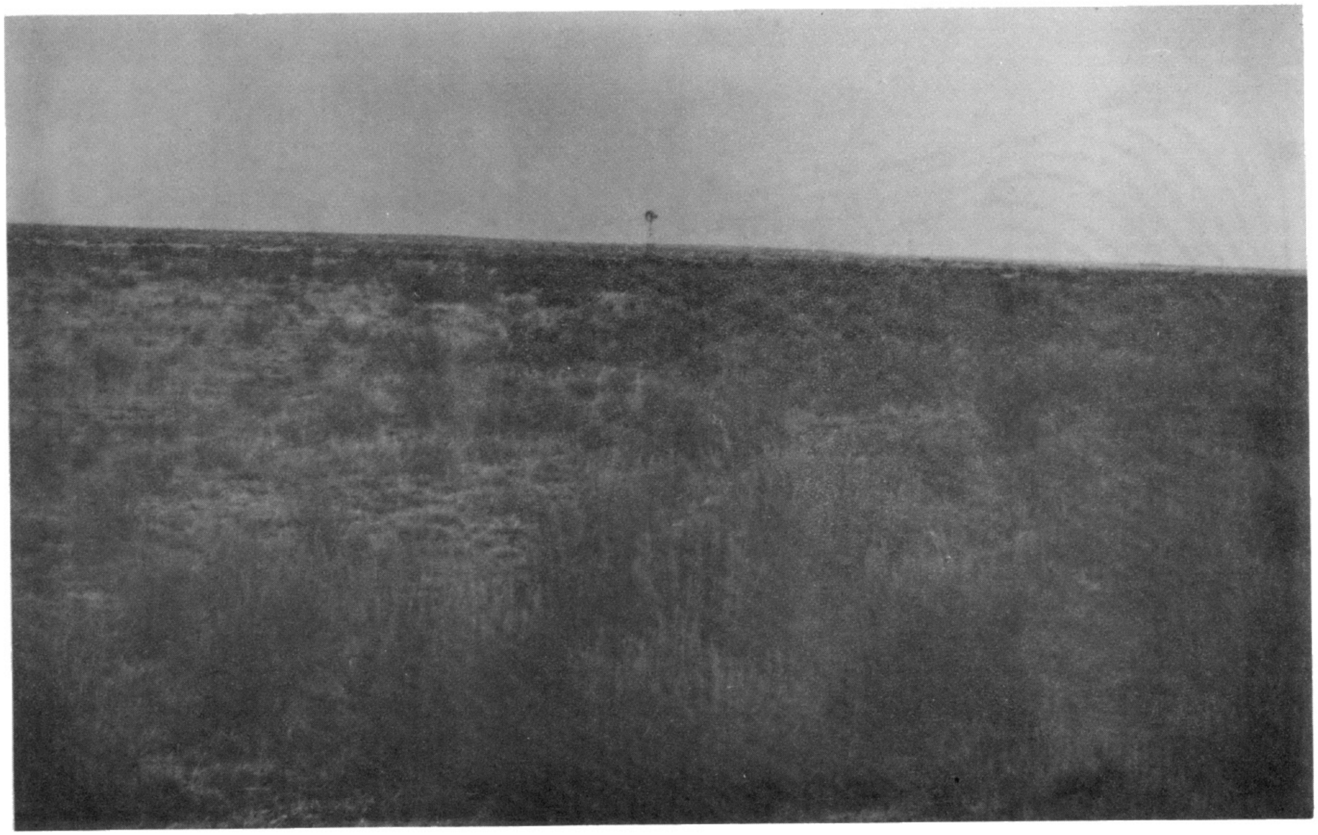
Voucher specimens on file in the Oklahoma State University herbarium, Stillwater, Oklahoma, and Comanche National Grassland headquarters, Springfield, Colorado.

APPENDIX H

VEGETATION TYPES OF THE SAND SAGEBRUSH STUDY AREA

The sand sagebrush-yucca-mixedgrass vegetation type.

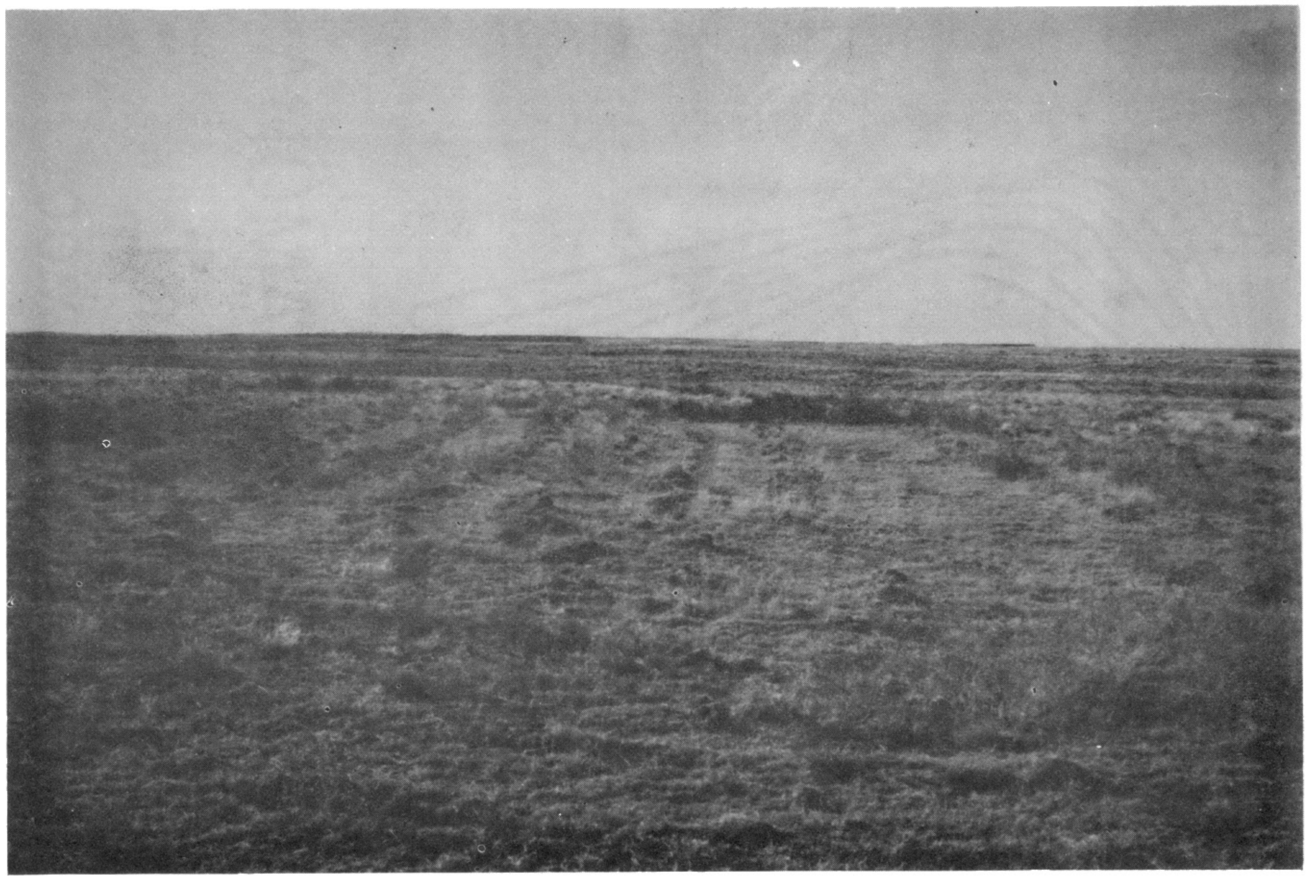
The shortgrass vegetation type.



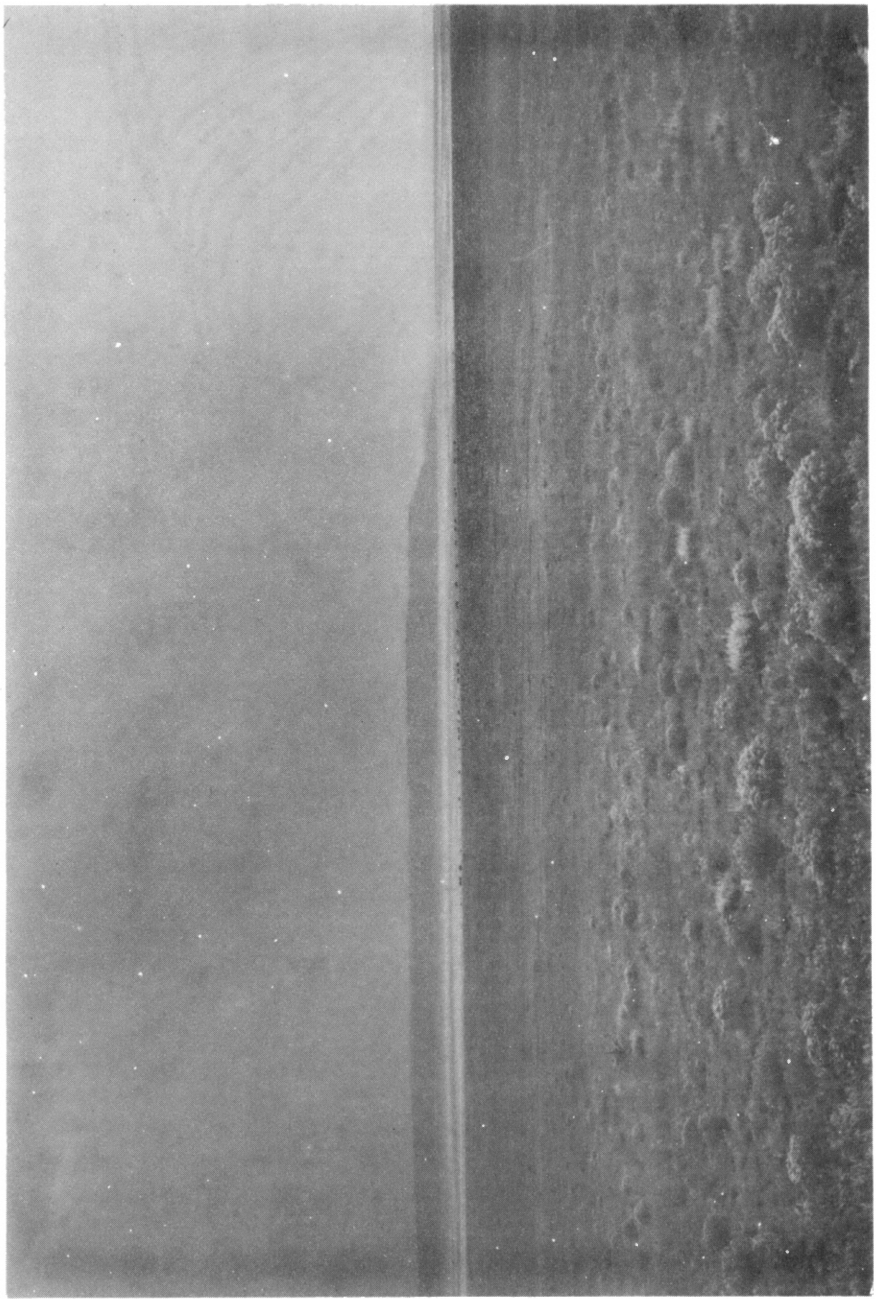
The sand sagebrush vegetation type.

APPENDIX I

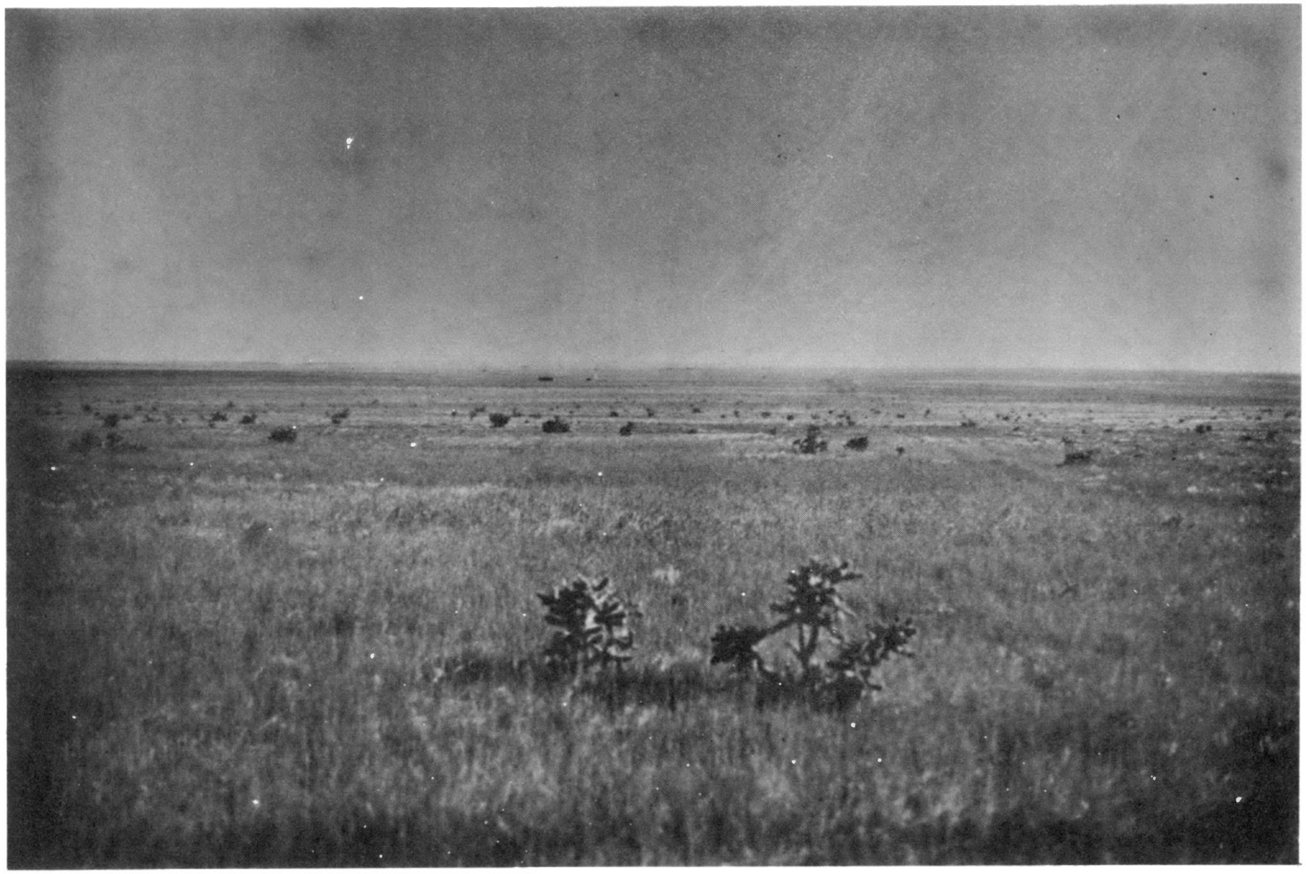
VEGETATION TYPES OF THE SHORTGRASS STUDY AREA



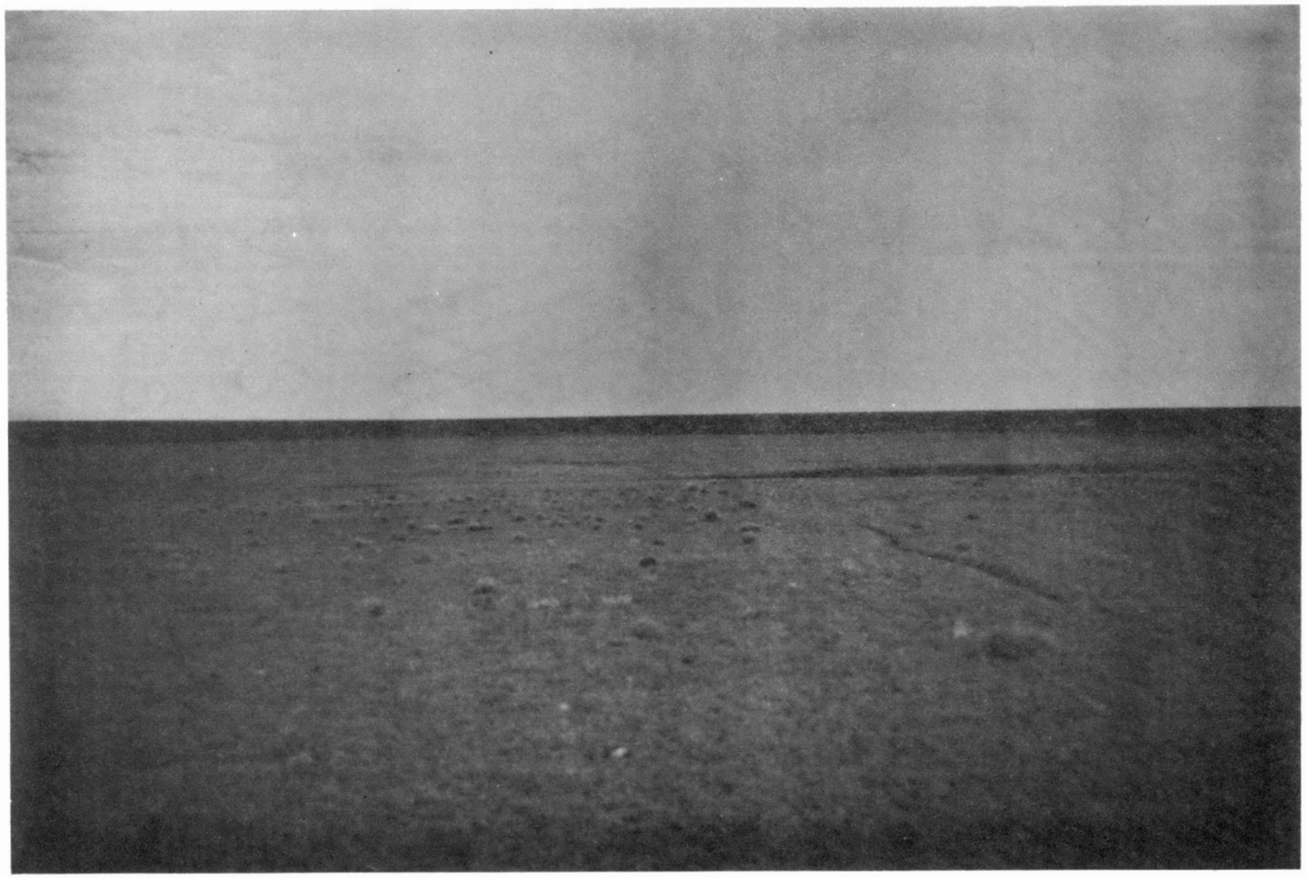
The "pitted" type.



The shortgrass-shrub vegetation type.

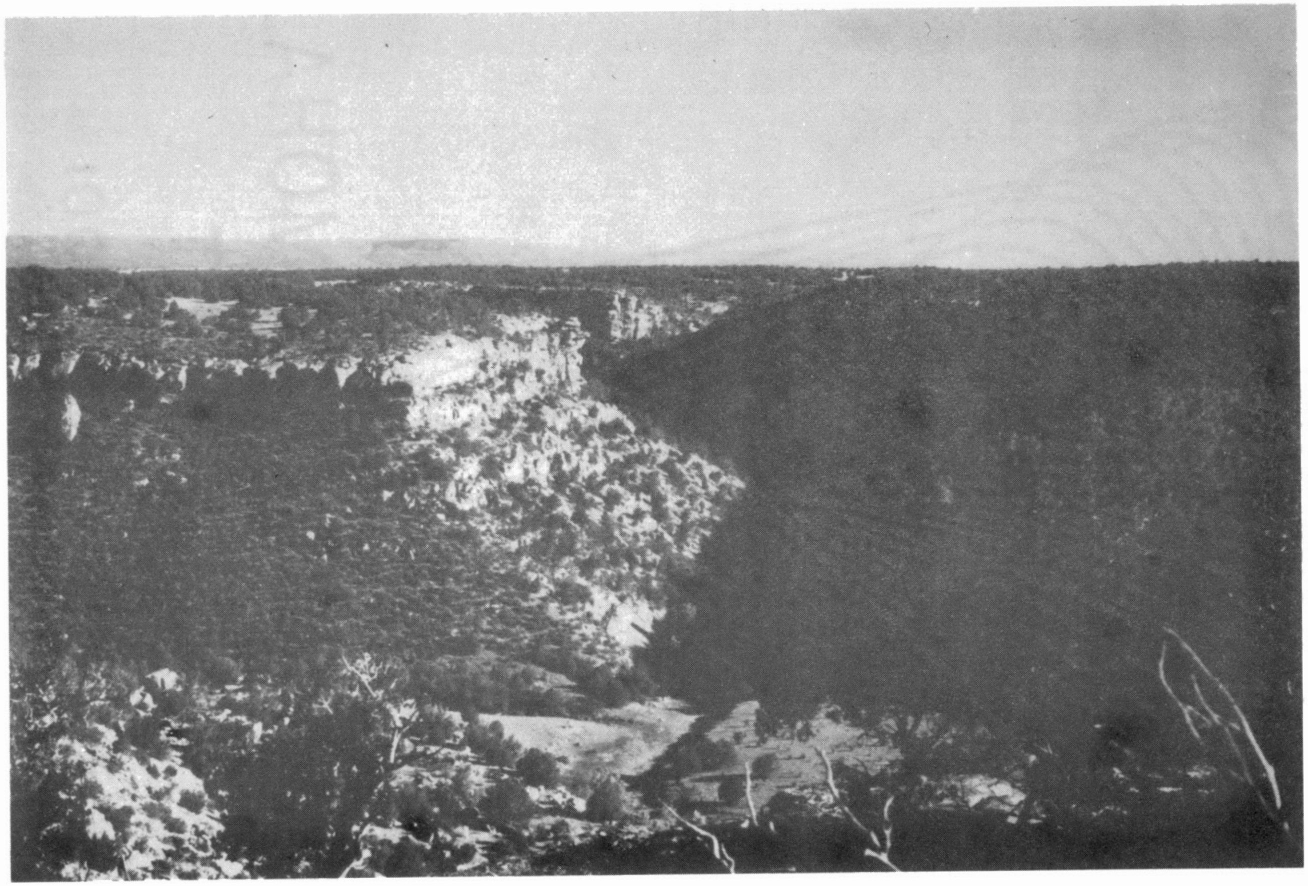


The mixedgrass-shrub vegetation type.



The wheatgrass vegetation type.

The pinyon-juniper vegetation type.



The mountain shrub vegetation type.

VITA[2]

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