# Habitat Suitability and Food Habits of Pronghorn Antelope in the Carrizo Plains National Monument, California

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**WESTERN ECOLOGICAL RESEARCH CENTER**

## Executive Summary

Prior to the 1800s, pronghorn antelope (*Antilocapra americana*) were abundant in the Central Valley of California but disappeared from the region between 1924 and 1938. To reestablish the population, approximately 90 pronghorn were released onto the Carrizo Plain National Monument between 1987 and 1990. Initially, the population in the monument flourished, and by 1995 numbered an estimated 150 animals. Since that time, the population has declined and in 2004 had been tentatively estimated at 54 animals (Bob Stafford pers. comm.). The purpose of this study was to investigate potential causes of the population decline as related to habitat quality, including fawn bedding conditions, and to initiate a study of pronghorn food habits.

We adapted habitat suitability criteria for grassland and grassland/scrub communities for use with GIS to evaluate the quantity and quality of pronghorn antelope habitat in 46 pastures encompassing over 490 $km^2$ of area in the relatively lower elevation areas of the monument. Overall, habitat suitability for pronghorn in Carrizo Plain N.M. ranked moderate to low. Although distances to water and slope values were indicative of high quality habitat, shrub cover and diversity ranked low. Only 14.3 $km^2$ of the area evaluated was rated suitable as grassland habitat. Pastures with the best grassland/scrub habitat comprised 68.4 $km^2$. Our results suggest that without habitat rehabilitation, the present-day Carrizo Plain may not contain enough suitable habitat to support a viable population of pronghorn antelope.

The locations of seven fawn bedding sites were recorded during 2003 and 23 bedding sites were recorded in 2004. Fawn bed site locations differed between years but most (68%) of the bed sites were located in pastures rated as suitable grassland habitat. Higher grass cover, less herb cover and bare ground at the bed site, and greater average surrounding vegetation height, were the most significant variables determining the location of fawn bed sites.

From April 2003 through June 2004, pronghorn diets consisted of 34 herbaceous or forb species, 9 grasses, and 9 shrub species. Five of these species are known to be toxic to livestock. Pronghorn also ate unidentified species of seeds, nuts and berries and insects. The annual diet consisted of 66.2 % (11.9%, SE) forbs, 13.5% (3.8%, SE) grasses, 9.5% (3.3% SE) shrubs, 8.0% (2.4% SE) seeds, nuts and berries, and 1.1 % (0.3% SE) insects. The remaining 1.7% of the annual diet was an unknown plant eaten during September 2003. Forbs consistently formed the greatest proportion of forage in the diet, but there were monthly and seasonal fluctuations in the use of forage classes. During spring, pronghorn mostly ate forbs and grasses. The proportion of grass in the diet decreased during summer and the proportion of seeds, nuts and berries in the diet increased. During autumn, pronghorn increased their use of shrubs and the proportion of forbs and grass in the diet decreased. Seeds, nuts and berries were also eaten during fall and winter months. Insects were a minor component in the diet through most of the year and may have been inadvertently consumed as animals fed on plant material. Potentially toxic plants found in the diet of pronghorn at Carrizo Plain N.M. were species in the genus *Astragalus*, *Salsola*, *Senecio*, *Solanum*, and *Quercus*. The proportion of these plants in the diet was highest during autumn months except for *Astragalus spp.*, which was found in the diet all

year, and *Salsola* spp., found in the diet during most months. Pronghorn ate *Astragalus* spp. during periods coinciding with early gestation, late gestation, and weaning of fawns. The ingestion of *Astragalus* spp. may cause a lower than normal birth rate and/or a higher than normal predation rate among the pronghorn population.

There were no seasonal differences in fecal nitrogen (FN) or in fecal diaminopimelic acid (FDAPA) FN and FDAPA were correlated with each other but were independent of monthly total rainfall and average monthly maximum temperature.

We recommend that managers promote long-term survival of this pronghorn population by increasing vegetative cover and plant species diversity, and by planting relatively tall perennial grass as additional cover for bedding sites for fawns. Additionally, long-term monitoring of available biomass during summer, fall and winter would provide information about forage availability under varying environmental conditions. Monitoring of fecal indices such as FN and FDAPA also should continue because these indices can be used to assess diet quality and provide a baseline for comparison with future diet quality measurements.

## Introduction

Pronghorn antelope (*Antilocapra americana*) were once abundant in the grasslands of the Central Valley of California. They disappeared from the area in the early 1900s due to a combination of over-hunting and the conversion of native grasslands to cultivated crops (Yoakum 2004a). To reestablish the population, approximately 350 pronghorn antelope were translocated into the region between 1987 and 1990. About 90 of these animals were released onto the Carrizo Plain National Monument (CPNM). Initially, the population thrived and by 1995 an estimated 150 pronghorn inhabited the monument. Since then the population has declined and in 2002 was estimated at 54 animals (Bob Stafford, BLM pers. comm.).

The translocation of animals to reestablish extirpated populations or augment critically small populations is a common conservation practice (World Conservation Union 1993). Although translocation can be an effective tool, it is not always a successful one (Griffith et al. 1989, Wolf et al.1996). In general, successful translocations depend on a number of factors that include the use of healthy animals, number of animals released, general adaptability of the translocated species, habitat suitability, and the location of the release site in relation to the historical range (Wolf et al.1996). Pronghorn antelope translocations are most successful if animals are released into high quality habitat that is similar to that of the translocation source. Without high quality habitat the chances for success are low, regardless of the number of pronghorn released or how well prepared they are for the release (Griffith et al. 1998, O'Gara et al. 2004). Our goal was to investigate potential causes of the population decline in the Carrizo Plain N.M. as related to habitat suitability.

Most pronghorn antelope inhabit grassland or shrubsteppe biomes, although a few are found in southwestern deserts (Alldredge et al. 1991, Canon and Bryant 1997, Yoakum 2004a). They depend on speed and the ability to detect moving predators at long distances, and thus prefer habitat with no greater than 30 percent slope and vegetation structure averaging 15 to 24 inches (38-61 cm) in height (Allen et al. 1984, Yoakum 2004b). Vegetation tall enough to conceal fawns is essential during the fawning period (Yoakum 1980, Alldredge et al. 1991, Clemente et al. 1995, Ockenfels et al. 1996, Canon and Bryant 1997). Areas with relatively greater herbaceous and grass cover and relatively lesser shrub cover are considered optimal for both foraging and predator avoidance (O'Gara and Yoakum 1992). Pronghorn prefer a diversity of forbs and forb preference ratios exceed those of shrubs or grasses. When forbs are not available, both seasonally and during periods of drought, shrubs are more important (O'Gara and Yoakum 1992). Graminoids provide a minor part of the diet in all biomes. However, pronghorn on grasslands consume twice as much grass as they do on shrub steppes (Beale and Smith 1970, Kitchen 1974, McNay 1980, O'Gara and Yoakum 2004). Unobstructed access to permanent water is especially critical during the dry months (Allen et al. 1984, Yoakum 1979, Okenfels et al. 1996). Pronghorn are generally found within 8.0 km of water (Yoakum 2004a).

Vegetation on the Carrizo Plain N.M. is characterized as Great Valley grassland with desert shrub elements (Hickman 1993). Historically the area was thought to have a greater abundance of perennial grasses but it is now inundated with introduced annual

grasses (Munz and Keck 1975, Hickman 1993). In the past the area was used for dry farming and livestock grazing. At the time of our study, cattle grazed the monument as part of an active management plan designed to remove standing biomass and alter plant species composition in an effort to restore native plant communities (but see Kimball and Schiffman 2003). A number of pronghorn habitat studies have been conducted on perennial grassland and desert shrubland communities (for review see Yoakum 2004a), but we know of no habitat studies using quantitative methods that have been conducted in an annual grassland/scrub community comparable to the Carrizo Plain National Monument, nor have food habit studies been conducted for this population.

Objectives:

1. Conduct a habitat suitability analysis in the Carrizo Plain National Monument based on known habitat requirements of pronghorn antelope.
2. Determine environmental correlates of pronghorn antelope fawn bed sites in the Carrizo Plain National Monument.
3. Determine food habits and nutritional quality of pronghorn antelope diets in the Carrizo Plain National Monument.

## Study Area

The Carrizo Plain N.M. is located in the Coast Ranges, on the southwest edge of the San Joaquin Valley, California (34°N, 120ºW). The monument encompasses a total of 253,628 acres. Topography along the valley floor is generally flat with rolling hills that extend to the base of the Caliente Range on the southwest and the Temblor Ranges on the northeast. Elevation on the plain averages 615 m. The highest elevation is in the Caliente Range at 1,556 m. Average minimum temperature over the last 30 years was 5.8°C (S.D. = 0.84) and average maximum temperature was 24.0°C (S.D. = 0.84). Annual rainfall occurs primarily between December and April and averages 22.21cm. Rainfall can be highly variable (S.D. = 10.21 cm, min. = 8.58 cm, max. = 45.89 cm) (Fig.1). Annual rainfall during the study was 15.64 cm in 2003 and 13.03 cm in 2004 (Fig. 2).

Vegetation at the lowest elevations consists of a complex of barrens, grasslands, and scrublands, dominated by spiny saltbush (*Atriplex spinifera*), and iodine bush (*Allenrolfea occidentalis)*. Annual grasses, notably brome (*Bromus* spp.) and wild oats (*Avena* spp.) are dominant in grasslands. Juniper-oak cismontane woodland and cismontane juniper woodland and scrub are found in the higher elevations (USFWS 1995). The monument is divided into fenced pastures, although many of the fences have been removed.

## Methods

### Habitat suitability

To incorporate the complexity of vegetation types found on the Carrizo Plain N.M., we evaluated pronghorn habitat using criteria for both grassland and grassland/scrub communities (Table 1). We chose habitat criteria from models based on vegetation

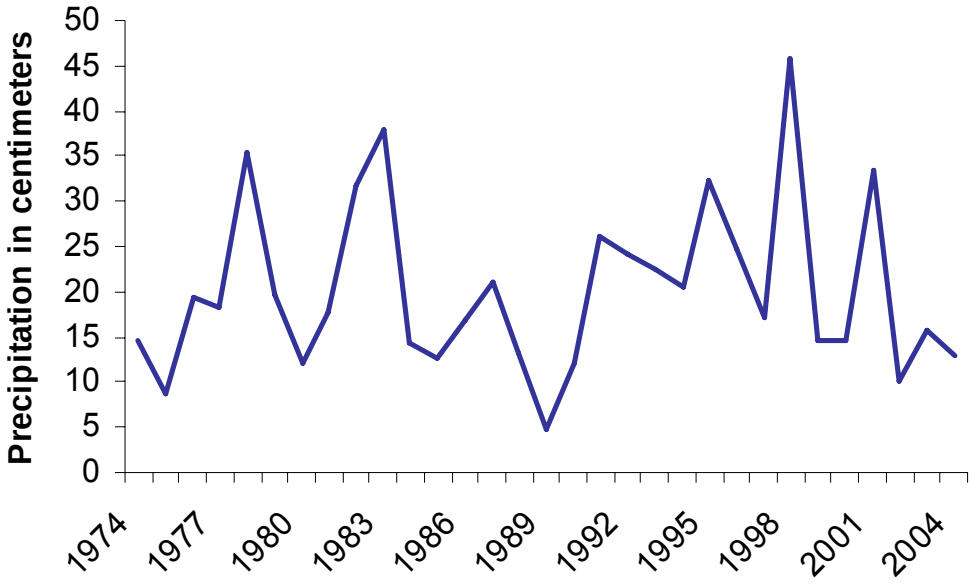


Figure 1. Estimated annual rainfall for a 30-year period from 1974 through 2004 at Carrizo Plain National Monument, California. Precipitation data were collected at the New Cuyama Fire Station, located approximately 3 kilometers south of the monument. Source: Western Regional Climate Center.

characteristics most similar to those found on the Carrizo Plain. Pronghorn antelope habitat suitability criteria for grassland and grassland/scrub communities were modified from Yoakum (2004a), Okenfels et al. (1996), O'Gara and Yoakum (1992) and Allen et al. (1984). Habitat rankings for high, low and moderate qualities were not available for grassland habitat. Using these criteria and a GIS, we evaluated the quantity and quality of pronghorn antelope habitat in 46 pastures encompassing over 490 $km^2$of area in the relatively lower elevation areas of the CPNM. GIS analyses were performed using ArcView 3.2 and ArcMap 9.0 (Environmental Systems Research Institute, Redlands, California). Topographic information was derived from 1:24,000 scale 30-meter digital elevation models (DEM) (USGS 1993). The BLM office in Bakersfield, California provided GIS shape files of pasture boundaries, roads and pasture fence lines.

Water source locations were obtained using a GPS (NAD 83). On the CPNM., water sources consist of cement troughs (approx. 3m length x 1m height x 1 m width) that were historically (and presently in some areas) used by cattle. A water source was considered available to pronghorn if it was in good working condition, not obscured by

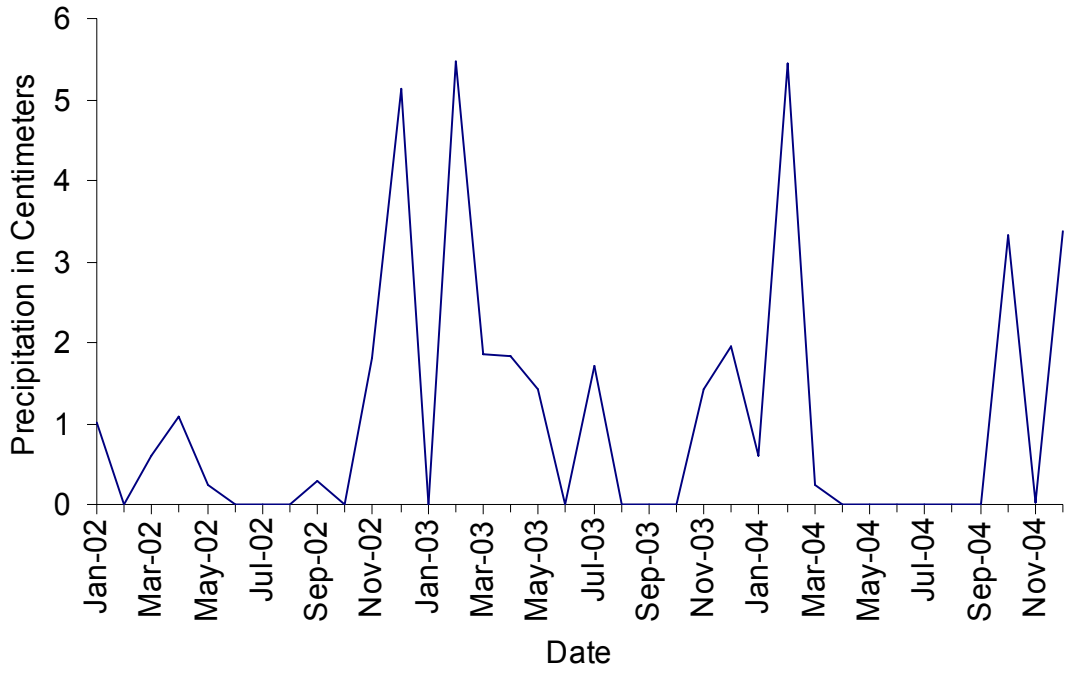


Figure 2. Estimated monthly precipitation for Carrizo Plain National Monument, California, from January 2002 through November 2004. Precipitation data were collected at the New Cuyama Fire Station. The fire station is located approximately 3 kilometers south of the monument. Source: Western Regional Climate Center.

structures or fences, and occurred in areas with less than 30% slope. A total of 31 water sources were used in the analyses (Fig. 3).

Data pertaining to percent cover of vegetation, bare ground, and diversity of vegetation species were provided by the Bakersfield, California, BLM office. The data were derived from 1194 one-meter square plots measured during April and May of 2003. Percent cover for each species was calculated using the Daubenmire Scale method (Daubenmire 1959) (see below). Species were combined into grass, herbaceous, and shrub categories and average percent cover of these three vegetation categories were then calculated for each pasture. The Daubenmire Scale method estimates total cover for plants with potentially overlapping canopies. As a result, total estimated canopy cover often exceeds 100%. To standardize cover values for the habitat suitability analysis, average percent cover values derived from the Daubenmire Scale method were scaled to sum to 100%.

Diversity indices of vegetation species were determined by counting the number of grass, herbaceous, and shrub species within each pasture. Only those species that covered

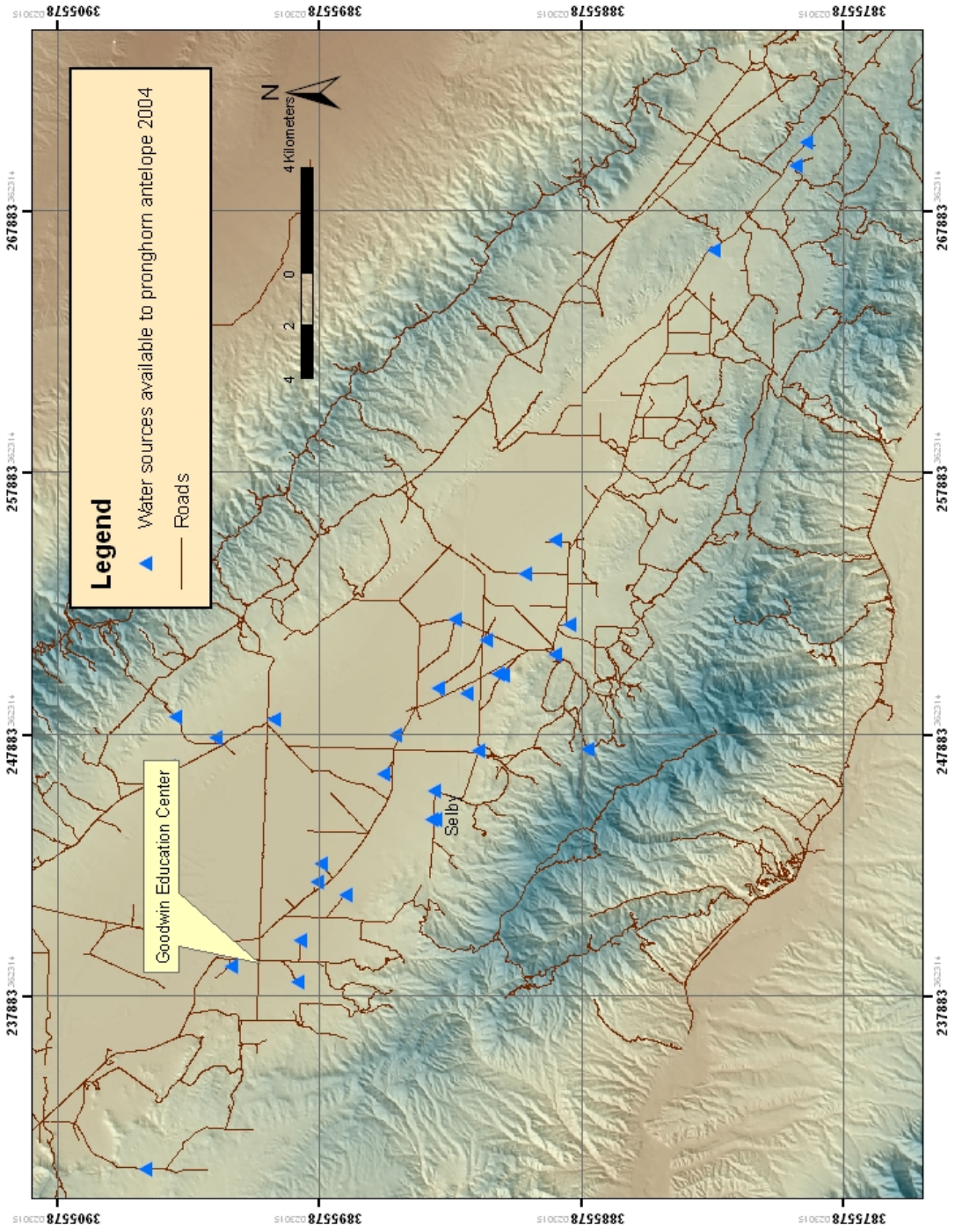


Figure 3. Locations of water sources available to pronghorn antelope on the Carrizo Plain National Monument, California, 2004.

Table 1. Habitat suitability criteria used for pronghorn antelope in grassland and grassland-scrub communities. Habitat requirements were modified from Allen et al. (1984), O'Gara and Yoakum (1992) Okenfels et al. (1996), and Yoakum (2004a). Habitat categories for high, moderate, and low quality were not available for grassland habitat.

| Habitat Variables | Grassland Habitat | Grassland-Scrub Habitat | | |
|---|---|---|---|---|
| | General | High Quality | Moderate Quality | Low Quality |
| Area (sq. km) | ≥ 5 sq km | ≥ 5 sq km | >1 < 5 sq km | < 1 sq km |
| Slope (%) | ≤ 5 % | ≤ 5 % | > 5 ≤ 20% | > 20% |
| Herb cover (%) | 10 - 20% | 10 - 30% | 5 - 10 % | < 5% |
| Grass cover (%) | 50% - 80% | 30 - 50% | 15 - 30% | <15% |
| Shrub cover (%) | <5% | 5 - 15% | 2 - 5% | < 2% |
| Bare ground cover (%) | 20 - 30% | 20 - 30% | 10 - 20% | < 10% |
| Vegetation height (cm) | 25 - 45 cm | 25 - 45 cm | 15 - 25 cm | < 15 or > 50 cm |
| Distance to water (m) | ≤ 3 km | ≤ 3 km | > 3 ≤ 6 km | > 6 km |
| Species diversity ( herbs/forbs) | ≥ 4 species | ≥ 4 species | ≥ 2 < 4 species | < 2 species |
| Species diversity: grass | ≥ 4 species | ≥ 4 species | ≥ 2 < 4 species | < 2 species |
| Species diversity: shrubs | ≥ 4 species | ≥ 4 species | ≥ 2 < 4 species | < 2 species |

at least 5% of the pasture and had been documented as a forage species for pronghorn antelope (Beale and Smith 1970, McInnis and Vavra 1987, Smith et al. 1998) were used to calculate vegetation diversity indices for the three vegetation categories within each pasture. Average heights of each species were either measured on-site during April and May of 2004 or estimated from species descriptions in Hickman (1993). To prevent bias towards uncommon plant species, the average height of vegetation for each pasture was then calculated using a weighted mean (formula: $\sum$ (% cover * vegetation height) / $\sum$ % cover).

Habitat variable measurements from each pasture were imported as a table into the GIS. Queries were conducted within the GIS to find which pastures on the monument contained habitat variables of moderate or high quality, based on criteria listed in Table 1. After identifying pastures containing the best habitat, we further delineated specific areas of pronghorn habitat within these pastures using the distance to water and slope criteria in Table 1. These specific areas were then presented as a map of best suitable habitat.

To determine how pronghorn were using habitat in relation to the results of the suitability evaluation, locations of pronghorn groups were plotted on the map of predicted suitable habitat. To obtain pronghorn locations, we conducted systematic surveys throughout the monument for adult pronghorn antelope two days each month by vehicle. The survey route allowed us to survey approximately 460 sq. km. (Fig 4). For our purposes, a group was defined as ≥2 adult animals. We did not use telemetry collars to obtain information about habitat use because the population size was small and the risk of injury or death associated with capturing and handling pronghorn (O'Gara et al. 2004) could have negatively impacted the population. Surveys were conducted from May 2003 through August 2004. We did not survey during February 2004 because access in the monument

was restricted due to inclement weather. Universal Transverse Mercator (UTM) coordinates of all pronghorn groups were recorded with a GPS unit (NAD 83).

**Microhabitat Characteristics at Neonatal Bed Sites**

Pronghorn antelope fawns were located during systematic surveys conducted within the monument from May to September in 2003 and from April to August in 2004 (Fig. 4). When an individual female or group of pronghorn antelope was located, they were observed for approximately 90 minutes from a distance of > 2 km. This time frame and distance was considered an appropriate balance between allowing the mother to relocate the fawn (or the fawn to move) and allowing the researchers to complete the survey route within 1 day (Fig 5). After the fawn moved from the bed site, the site location was recorded with a GPS unit.

To determine whether fawns were selecting for specific characteristics when choosing bed sites within a pasture, vegetation cover and height were measured within the immediate area of each bed site. One hundred meter transects were conducted along four equal-distant compass directions centered on the bedding site. Percent cover and height of shrub, grass, and herbaceous species, and percent cover of bare ground were measured at 10m intervals using a line-intercept method (Bonham 1989). The ability to see horizontally from a bedding site was measured in four equidistant compass directions from the bed site center from a height of 1m (representing the adult doe standing position). The proportion of a measuring pole visible from the bedding site was measured at 10m intervals to 50m and then again at 100m (modified from Canon and Bryant 1997). Slope (in percent) and aspect for each site were measured with a GIS. Distance to fences, roads, water sources, and man-made structures were also measured with the GIS. Using GIS, random points equal in number to the bed sites were placed within the pastures where bed sites were found. Random points were produced using the random point generator in ArcMap. Points falling on areas deemed impossible to be used as bedding sites (boulders, buildings) were excluded from the analyses. The same methods used to measure vegetation, topography, and distances around bedding sites were used at the randomly chosen sites.

Principal component analysis was used to reduce the dimensionality of the data set and derive independent principal components for further analyses. For the principal component analysis, we combined measurements of cover at 5-100 m to obtain an average cover value for points in each of the four cardinal directions. Binary logistic regression was used to compare principal component scores between bedding sites and randomly chosen sites to model relative probabilities of bed site selection within pastures (McGarigal et al. 2002).

**Food Habits and Nutritional Quality**

Food Habits

Botanical composition of pronghorn antelope diets was estimated using micro-histological identification of plant epidermal fragments in fecal material (Koerth et al. 1984). Samples were collected from April 2003 through June 2004. For collection of fresh samples, pronghorn were visually located with binoculars and a spotting scope.

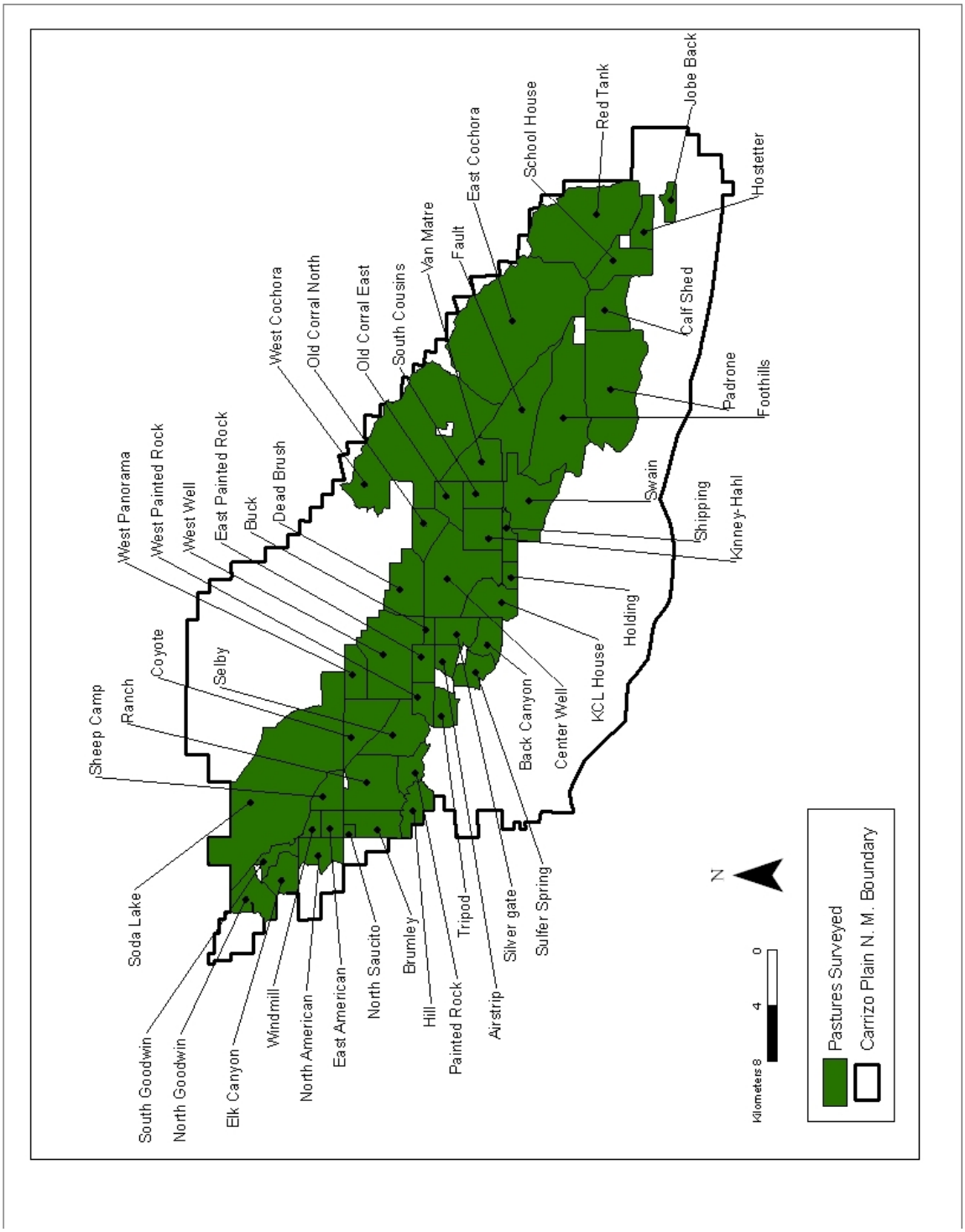


Figure 4. Pastures surveyed for pronghorn antelope in Carrizo Plain National Monument, California. Surveys were conducted from May 2003 through August 2004.

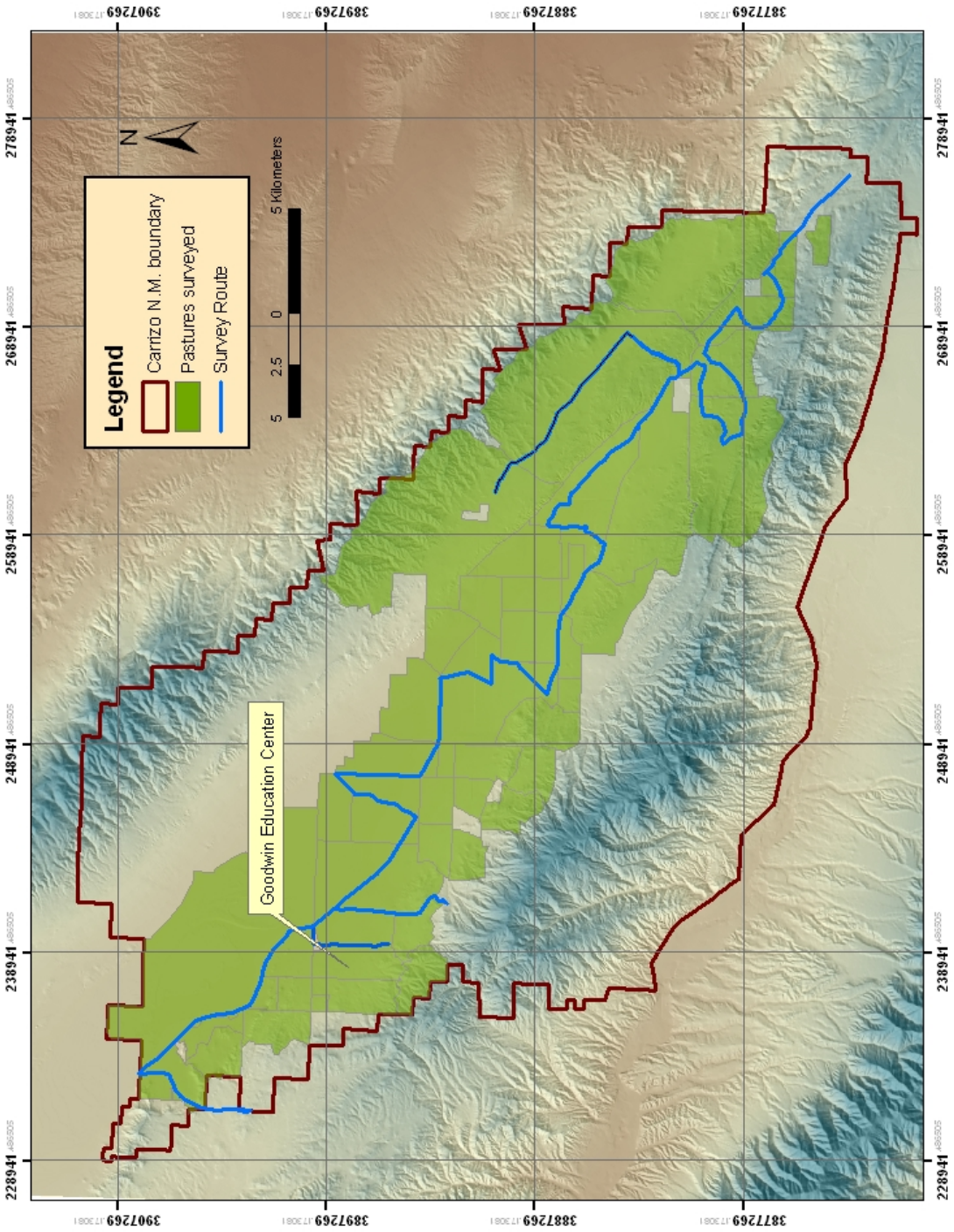


Figure 5. Survey route and area surveyed for pronghorn antelope in Carrizo Plain National Monument, California. Surveys were conducted from May 2003 through August 2004.

Sample sizes ranged from 10 to 23 pellet groups per month, except during May and June 2003, where only7and 9 samples respectively were collected. Samples were not collected during February 2004 because access onto the monument was limited due to inclement weather. Samples were oven-dried and ground in a Wiley mill through a 1 mm mesh screen. A one-gram sub-sample was taken from each fecal sample and sub-samples from each season were composited for analysis (Jenks et al. 1989). One hundred fifty microscope fields per composite sample were inspected for plant composition (Davitt and Nelson 1980). Principal food items were those plant taxa that were eaten in proportions greater than 5%. We were not able to analyze forage species for differential digestibilities due to the short time frame of the study (one year).

Diet Quality

Fecal analysis was also used to evaluate the nutritional quality of pronghorn diets on the monument (Koerth et al. 1984). Fecal samples were analyzed for percent fecal nitrogen (FN) and diaminopimelic acid (FDAPA) at the Wildlife Habitat Nutrition Laboratory, Washington State University Pullman (Hodgman et al. 1996). We did not implement digestibility corrections because this was a one-year study and having no previous information on pronghorn food habitats in the CPNM, we could not collect preferred forage items concurrently with fecal pellets (Hansen et al. 2001).

Statistical Analyses

For statistical comparisons of diet composition and quality, we combined monthly values of forbs, grasses, shrubs, seeds/nuts, insects, FN and FDAPA into the following seasons; spring 2003 (April and May), summer 2003 (June, July, and August), autumn 2003 (September, October, and November), winter 2003/2004 (December and January), and spring 2004 (March, April and May 2004). We used one-way ANOVA to compare diet composition and quality among seasons. Proportional data were arcsine transformed to meet assumptions of normality.

Standard multiple linear regression techniques were used to explore the relationships between diet quality and weather variables. We used the $\log_e$ of FN to linearize the relationship between and apparent digestibility (Wehausen 1995). FN and FDAPA were dependent variables and mean daily temperature and precipitation were independent variables. A simple correlation coefficient (Pearson *r*) was used to examine relationships between NF, FDAPA, monthly total precipitation, and mean monthly maximum temperatures.

## Results

### Habitat suitability

Grassland habitat

When using grassland criteria to evaluate habitat suitability for pronghorn, we found the best available grassland habitat to be located in three pastures, East American, Painted Rock, and Ranch Pastures (Figure 6). Qualitative rankings relative to pronghorn habitat requirements for these pastures are listed in Table 2. These pastures are located on the

Table 2. Pastures within the Carrizo Plain National Monument, California, having the best available habitat for pronghorn antelope as of 2003. Qualitative rankings relative to pronghorn habitat requirements were given for each habitat variable measured. H = high; M = moderate; and L = low quality. Pastures were rated using habitat suitability criteria for grassland/scrub habitat.

| Pasture Name | Herb cover | Grass cover | Shrub cover | Bare cover | Veg. ht | Herb diverse | Grass diverse | Shrub diverse | Area | Dist to water | Slope |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Airstrip | H | M | L | M | H | M | M | L | M | H | H |
| Brumley | M | H | M | L | H | M | H | L | H | H | H |
| E American | H | H | L | M | M | M | M | L | M | H | H |
| E Painted Rock | H | M | L | M | H | M | M | L | M | H | H |
| Painted Rock | H | M | M | L | H | M | M | L | M | H | H |
| Ranch | H | M | L | M | M | M | M | L | H | H | H |
| Selby | H | M | M | M | H | M | M | L | H | H | H |
| Sheep Camp | H | M | L | H | M | H | L | L | M | H | H |
| Shipping | H | H | M | L | M | M | M | L | M | H | H |
| Silver Gate | H | M | L | H | M | H | M | L | M | H | H |
| Soda Lake | H | H | H | M | H | M | M | L | H | H | H |
| South Cousins | H | M | M | H | H | M | M | L | M | H | H |
| Swain | H | H | L | L | M | M | M | L | H | H | H |
| W Painted Rock | H | M | L | M | H | M | M | L | M | H | H |
| Windmill | M | M | L | L | H | M | M | L | M | H | H |

northwest side of Carrizo Plain N.M., directly south and east of the Goodwin Educational Center. They represent approximately 3% (14.3 $km^2$) of the area evaluated.

Grassland/scrub habitat

When evaluating habitat suitability for pronghorn on the monument using criteria for grassland/scrub communities, we found that none of the pastures ranked consistently high for all habitat variables. All pastures ranked high in terrain type and water availability, and most pastures ranked high or moderate for herbaceous cover (Tables 2 and 3). Shrub cover ranked high in one pasture (Soda Lake) and moderate in five pastures. The remaining pastures ranked low. Shrub diversity always ranked low. Fifteen pastures with the best available habitat are shown in Figure 7. When selecting pastures with the best quality habitat, we constrained each habitat variable to moderate or high values except in the cases of shrub cover, shrub diversity, and bare cover. We allowed pastures with low quality shrub cover, shrub diversity, and bare cover into our selections. Constraining these three variables would have eliminated almost the entire Carrizo Plain. Consequently, we determined the best available habitat on the monument was of moderate quality. The 15 pastures comprise an area of 68.4 $km^2$ or approximately 15% of the total area evaluated and are located along the western and northwestern portion of the valley. Habitat values for pastures with lower quality habitat are listed in Tables 4 and 5. As a result of averaging vegetation variables across pastures, suitable areas have a boundary that follows the edges of the pastures.

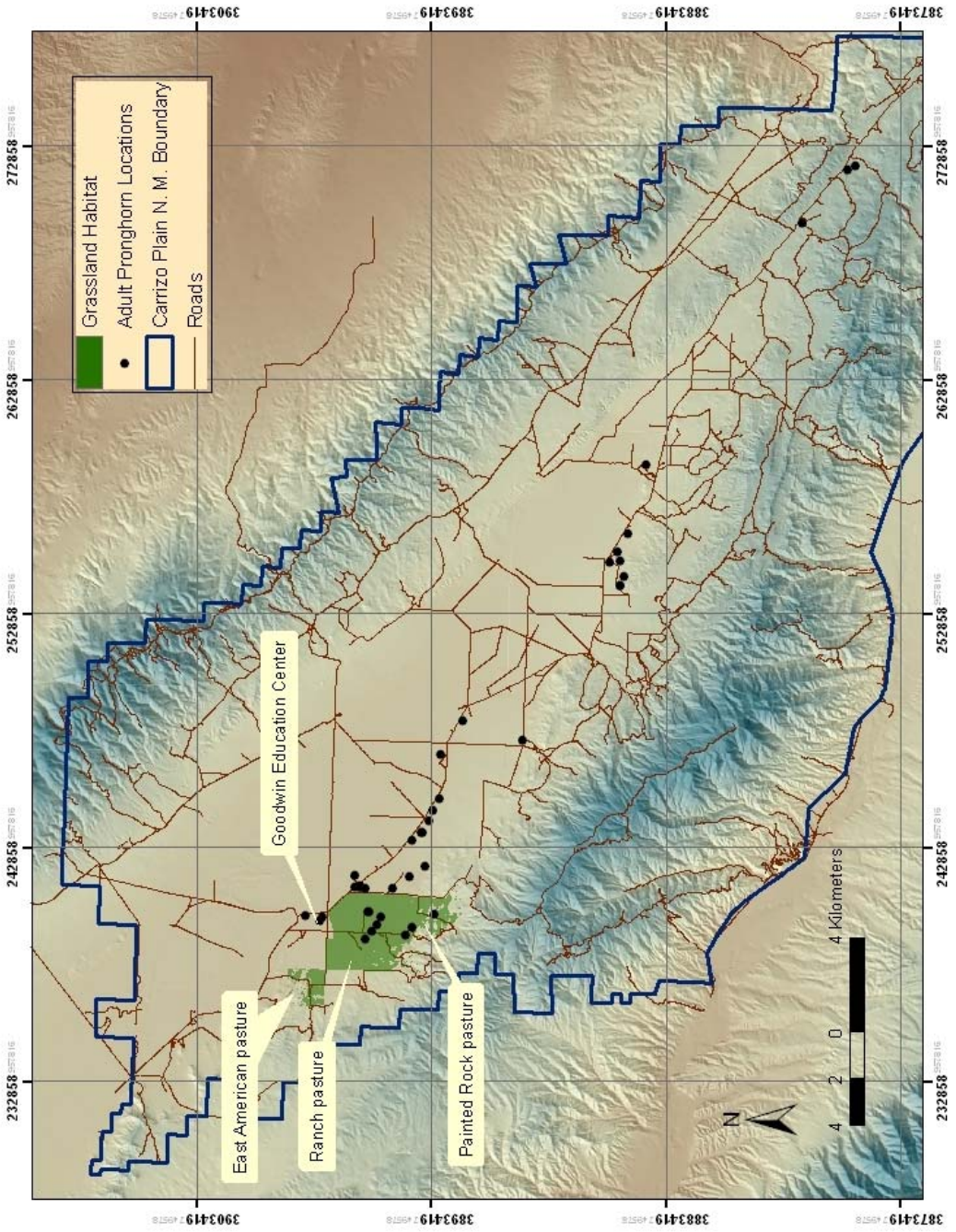


Figure 6. Location of grassland-type habitat suitable for pronghorn antelope on the Carrizo Plain National Monument, California in 2003. Coordinates are in UTM. Pronghorn locations consist of groups of one or more individuals.

Table 3. Habitat variables for 15 pastures within the Carrizo Plain National Monument, California, with the best available habitat for pronghorn antelope as of 2003. Pastures were rated using habitat suitability criteria for grassland/scrub habitat. Quantitative values are given for each habitat variable measured. d water = distance to water.

| | | | | | | Diversity | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pasture Name | herb cover | grass cover | shrub cover | bare cover | Veg ht (cm) | Herbs | Grass | Shrub | Area (ha) | d water (km) | Slope (%) |
| Airstrip | 35.0 | 20.0 | 0.0 | 18.0 | 31.0 | 3.0 | 2.0 | 0.0 | 276.7 | 3.0 | 5.0 |
| Brumley | 59.0 | 32.0 | 2.0 | 4.0 | 33.6 | 2.0 | 4.0 | 0.0 | 602.2 | 3.0 | 5.0 |
| E American | 23.0 | 50.0 | 1.0 | 16.0 | 21.6 | 3.0 | 2.0 | 0.0 | 260.5 | 3.0 | 5.0 |
| E Painted Rck | 35.0 | 20.0 | 0.0 | 18.0 | 31.3 | 3.0 | 2.0 | 0.0 | 361.5 | 3.0 | 5.0 |
| Painted Rock | 10.0 | 82.0 | 2.0 | 8.0 | 40.0 | 2.0 | 2.0 | 0.0 | 394.4 | 3.0 | 5.0 |
| Ranch | 20.0 | 69.0 | 1.0 | 10.0 | 22.9 | 1.0 | 2.0 | 0.0 | 1256.4 | 3.0 | 5.0 |
| Selby | 37.0 | 15.0 | 2.0 | 12.0 | 29.1 | 2.0 | 2.0 | 0.0 | 951.1 | 3.0 | 5.0 |
| Sheep Camp | 65.0 | 16.0 | 4.0 | 15.0 | 22.2 | 4.0 | 1.0 | 0.0 | 439.0 | 3.0 | 5.0 |
| Shipping | 43.0 | 21.0 | 2.0 | 8.0 | 22.0 | 2.0 | 2.0 | 0.0 | 267.0 | 3.0 | 5.0 |
| Silver Gate | 65.0 | 16.0 | 0.0 | 18.0 | 22.4 | 2.0 | 2.0 | 0.0 | 496.1 | 3.0 | 5.0 |
| Soda Lake | 30.0 | 48.0 | 10.0 | 12.0 | 41.4 | 2.0 | 2.0 | 1.0 | 5592.3 | 3.0 | 5.0 |
| S Cousins | 32.0 | 20.0 | 2.0 | 24.0 | 26.5 | 2.0 | 2.0 | 0.0 | 464.5 | 3.0 | 5.0 |
| Swain | 34.0 | 30.0 | 0.0 | 7.0 | 21.8 | 3.0 | 3.0 | 0.0 | 1293.1 | 3.0 | 5.0 |
| W Painted Rock | 30.0 | 25.0 | 0.0 | 15.0 | 35.2 | 3.0 | 2.0 | 0.0 | 329.4 | 3.0 | 5.0 |
| Windmill | 51.0 | 23.0 | 0.0 | 15.0 | 27.3 | 2.0 | 3.0 | 0.0 | 179.9 | 3.0 | 5.0 |

Table 4. Pastures within the Carrizo Plain National Monument, California, having low quality habitat for pronghorn antelope as of 2003. Qualitative rankings relative to pronghorn habitat requirements were given for each habitat variable measured. H = high; M = moderate; and L = low quality and are based on criteria listed in Table 1.

| Pasture Name | herb cover | grass cover | shrub cover | bare cover | veg height | herb diverse | grass diverse | shrub diverse | area | dist to water | slope |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Calf Shed | M | M | L | M | L | M | L | L | H | H | M |
| Center Well | M | L | L | M | M | M | L | L | H | H | H |
| N American | M | M | L | L | H | M | M | L | H | M | M |
| N Saucito | H | M | L | H | M | M | M | L | L | H | M |
| Back Canyon | H | H | L | L | H | L | H | L | M | H | M |
| Buck | M | L | L | L | M | L | L | L | M | H | H |
| Coyote | M | L | M | H | L | M | M | L | H | H | H |
| Dead Brush | M | L | L | M | M | M | L | L | H | H | H |
| E Cochora | H | M | H | H | M | L | M | L | H | M | M |
| Elk Canyon | M | L | L | L | M | M | H | L | M | H | H |
| Fault | H | M | M | M | M | L | M | L | H | M | H |
| Foothills | M | M | L | M | M | M | M | L | H | M | H |
| Hill | H | H | L | L | H | M | M | L | M | M | M |
| Holding | M | L | L | M | M | L | M | L | M | H | H |
| Hostetter | M | L | L | M | M | L | M | L | M | H | M |
| Jobe Back | M | L | L | L | M | M | M | L | M | M | M |
| KCL House | H | M | L | L | H | L | H | L | H | H | M |
| Kinney-Hahl | M | L | L | M | M | M | L | L | H | H | H |
| North Goodwin | M | L | L | L | H | M | H | L | H | H | H |
| Old Corral E | H | M | L | H | M | M | L | L | M | H | H |
| Old Corral N | H | M | L | H | M | M | L | L | H | H | H |
| Padrone | M | M | L | M | M | H | L | L | H | M | M |
| Red Tank | M | L | L | H | M | M | L | L | H | H | M |
| School House | M | L | L | H | M | M | L | L | H | H | M |
| S Goodwin | H | H | L | L | H | L | H | L | M | M | H |
| Sulfur Spring | L | H | M | L | H | L | M | L | M | H | M |
| Tripod | H | H | L | L | H | L | M | L | M | H | M |
| Van Matre | H | L | L | H | M | L | M | L | H | H | H |
| W Cochora | M | M | H | H | H | L | M | L | H | M | M |
| W Panorama | M | L | M | M | M | M | L | L | M | H | H |
| W Well | M | L | L | M | M | M | L | L | H | H | H |

Table 5. Pastures within the Carrizo Plain National Monument, California, containing low quality habitat for pronghorn antelope as of 2003. Quantitative measures are given for each habitat variable measured. Pastures were rated using habitat suitability criteria for grassland-scrub habitat modified from Okenfels et al. (1996), O'Gara and Yoakum (1992) and Allen et al. (1984).

| Pasture Name | Herb cover | Grass cover | Shrub cover | Bare Ground Cover | Veg ht (cm) | Herb diverse | Grass diverse | Shrub diverse | area (ha) | Dist to water (km) | Slope (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Back Canyon | 30.0 | 32.0 | 1.0 | 5.0 | 33.6 | 1.0 | 4.0 | 0.0 | 439.8 | 3.0 | 6.0 |
| Buck | 66.0 | 6.0 | 0.0 | 3.0 | 22.2 | 1.0 | 1.0 | 0.0 | 131.8 | 3.0 | 5.0 |
| N American | 51.0 | 23.0 | 0.0 | 6.0 | 27.0 | 2.0 | 3.0 | 0.0 | 532.7 | 4.0 | 6.0 |
| N Saucito | 27.2 | 18.9 | 0.0 | 27.8 | 21.0 | 3.0 | 2.0 | 0.0 | 64.5 | 3.0 | 6.0 |
| Calf Shed | 45.0 | 21.0 | 0.0 | 13.0 | 2.0 | 3.0 | 1.0 | 0.0 | 857.0 | 3.0 | 6.0 |
| Center Well | 55.0 | 7.0 | 0.0 | 15.0 | 20.6 | 2.0 | 0.0 | 0.0 | 1964.0 | 3.0 | 5.0 |
| Coyote | 50.0 | 9.0 | 2.0 | 39.0 | 14.1 | 2.0 | 2.0 | 0.0 | 916.8 | 3.0 | 5.0 |
| Dead Brush | 54.0 | 5.0 | 0.0 | 18.0 | 23.5 | 2.0 | 1.0 | 0.0 | 908.1 | 3.0 | 5.0 |
| E Cochora | 37.0 | 20.0 | 5.0 | 25.0 | 24.5 | 1.0 | 3.0 | 0.0 | 5321.2 | 4.0 | 6.0 |
| Elk Canyon | 46.0 | 13.0 | 0.0 | 4.0 | 24.5 | 2.0 | 4.0 | 0.0 | 463.9 | 3.0 | 5.0 |
| Fault | 34.0 | 21.0 | 2.0 | 19.0 | 23.5 | 1.0 | 3.0 | 0.0 | 1650.2 | 4.0 | 5.0 |
| Foothills | 38.0 | 24.0 | 1.0 | 13.0 | 21.9 | 2.0 | 2.0 | 0.0 | 2629.5 | 4.0 | 5.0 |
| Hill | 31.0 | 35.0 | 1.0 | 9.0 | 41.9 | 3.0 | 4.0 | 0.0 | 488.7 | 4.0 | 6.0 |
| Holding | 52.0 | 12.0 | 0.0 | 10.0 | 23.2 | 1.0 | 2.0 | 0.0 | 172.5 | 3.0 | 5.0 |
| Hostetter | 45.0 | 11.0 | 0.0 | 10.0 | 21.6 | 1.0 | 2.0 | 0.0 | 398.6 | 3.0 | 6.0 |
| Jobe Back | 47.0 | 9.0 | 0.0 | 4.0 | 23.7 | 2.0 | 2.0 | 0.0 | 199.7 | 4.0 | 6.0 |
| KCL House | 33.0 | 27.0 | 0.0 | 5.0 | 27.1 | 1.0 | 5.0 | 0.0 | 739.8 | 3.0 | 6.0 |
| Kinney-Hahl | 55.0 | 7.0 | 0.0 | 15.0 | 21.5 | 2.0 | 1.0 | 0.0 | 682.7 | 3.0 | 5.0 |
| North Goodwin | 46.0 | 13.0 | 0.0 | 4.0 | 24.8 | 2.0 | 4.0 | 0.0 | 649.9 | 3.0 | 5.0 |
| Old Corral E | 30.0 | 21.0 | 0.0 | 31.0 | 21.0 | 2.0 | 1.0 | 0.0 | 467.4 | 3.0 | 5.0 |
| Old Corral N | 30.0 | 21.0 | 0.0 | 31.0 | 21.2 | 2.0 | 1.0 | 0.0 | 538.8 | 3.0 | 5.0 |
| Padrone | 45.0 | 21.0 | 0.0 | 13.0 | 20.3 | 5.0 | 1.0 | 0.0 | 2624.4 | 4.0 | 6.0 |
| Red Tank | 61.0 | 7.0 | 0.0 | 20.0 | 23.4 | 2.0 | 1.0 | 0.0 | 2972.5 | 3.0 | 6.0 |
| School House | 55.0 | 5.0 | 0.0 | 22.0 | 22.2 | 2.0 | 1.0 | 0.0 | 788.2 | 3.0 | 6.0 |
| S Goodwin | 34.0 | 30.0 | 0.0 | 7.0 | 29.8 | 1.0 | 4.0 | 0.0 | 261.3 | 4.0 | 5.0 |
| Sulfur Spring | 0.0 | 33.0 | 2.0 | 4.0 | 35.6 | 1.0 | 3.0 | 0.0 | 440.7 | 3.0 | 6.0 |
| Tripod | 23.0 | 35.0 | 0.0 | 8.0 | 38.1 | 1.0 | 2.0 | 0.0 | 360.1 | 3.0 | 6.0 |
| Van Matre | 31.0 | 14.0 | 0.0 | 24.0 | 24.1 | 1.0 | 2.0 | 0.0 | 809.3 | 3.0 | 5.0 |
| W Cochora | 37.0 | 20.0 | 5.0 | 25.0 | 25.0 | 1.0 | 2.0 | 0.0 | 5097.6 | 4.0 | 6.0 |
| W Panorama | 48.0 | 8.0 | 2.0 | 17.0 | 23.5 | 2.0 | 1.0 | 0.0 | 491.3 | 3.0 | 5.0 |
| W Well | 54.0 | 5.0 | 0.0 | 18.0 | 23.5 | 2.0 | 1.0 | 0.0 | 1843.1 | 3.0 | 5.0 |

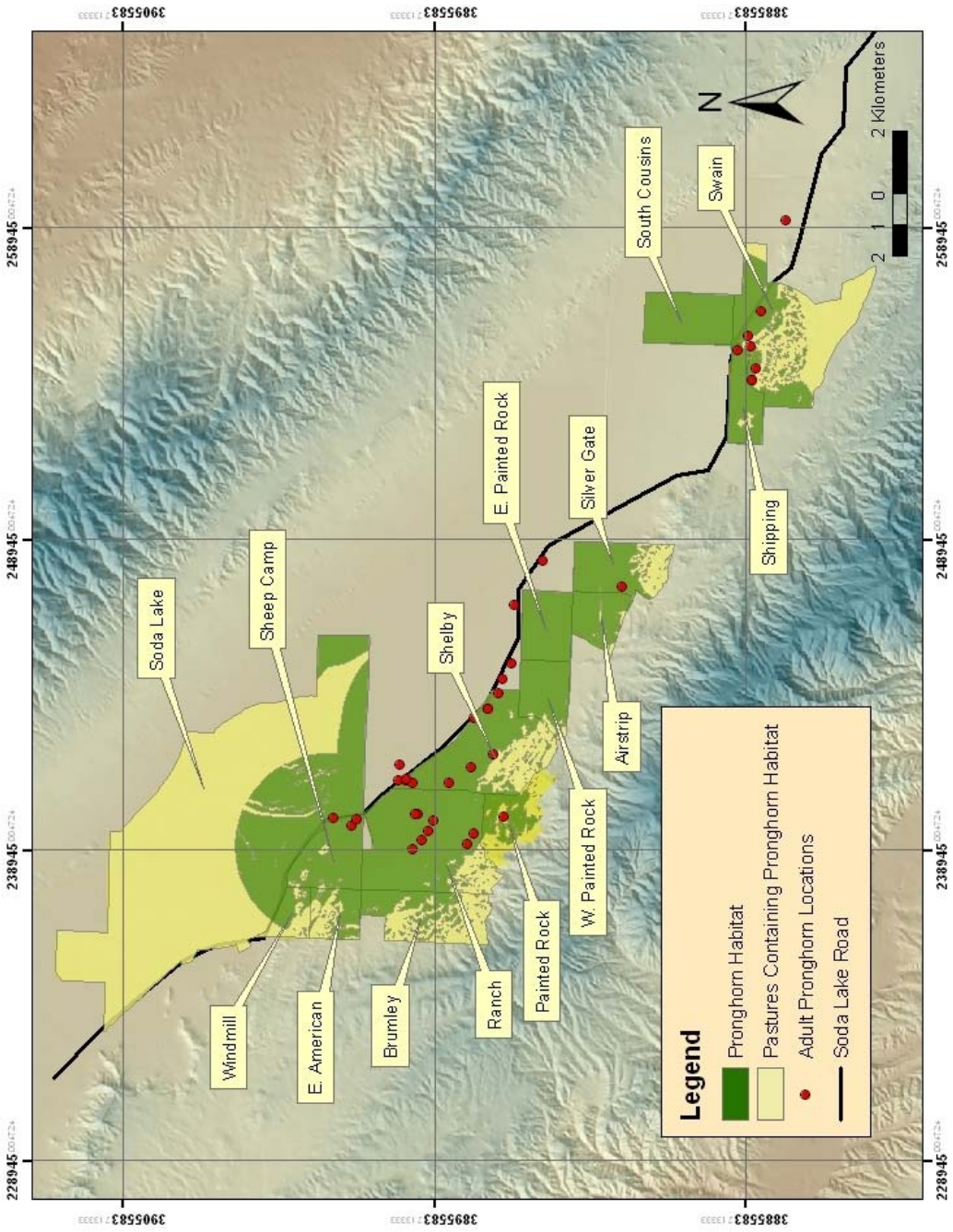


Figure 7. Location of 15 pastures in the study area rated most suitable for pronghorn antelope in grassland-scrub habitat, Carrizo Plain National Monument, California in 2003. Coordinates are in presented using the UTM (Universal Transverse Mercator) system.

Pronghorn locations

Locations of 40 pronghorn antelope groups, representing 329 individual sightings were plotted on the map of the 15 pastures with highest rated habitat quality. Total numbers and composition of pronghorn groups observed during monthly surveys are in Appendix A. Information on pronghorn observed on private land northwest of the CPNM during monthly surveys is in Appendix B. We conducted more surveys during spring months, especially during fawning. To prevent weighting toward these months, 3-4 groups were randomly chosen for each month with additional surveys. Of the 40 random group locations, 36 of these (90%) were located within or adjacent to pastures with the most suitable habitat (Figure 7). Mean habitat variables underlying the pronghorn antelope locations are presented in Table 6.

A number of pronghorn antelope were also observed on private (agricultural) lands outside the monument boundaries (Appendix C). These animals formed a single group that was located on private pastureland to the northwest of the monument from April of 2004 through August of 2004. Without marked individuals, it was not possible to determine whether these animals moved on and off the National Monument throughout the year or whether they were permanent residents off the monument.

**Microhabitat Characteristics at Neonatal Bed Sites**

Bed site locations

The locations of seven fawn bedding sites were documented during 2003 and 23 bedding sites were documented in 2004 (Fig. 8). UTM locations of fawn bed sites are in Appendix C. Fawn bed site locations differed between years but the most (68%) bed sites found on the monument were located in pastures rated as suitable grassland habitat. Six of the seven bedding sites found in 2003 were in the Sheep Camp/southern Soda Lake Pastures, within 1.2 km of the Goodwin Education Center (UTM 239220.0E, 3897850.0N) and within 350 m of each other. In 2004, 19 of the 23 bed sites were located within 4.3 km south-southwest of the Goodwin Education Center. One bed site was located in the Painted Rock pasture, 1 in Swain, 1 in Shipping, 3 in Selby, and 15 were in the Ranch Pasture. The remaining two bed sites were found on private agricultural land (oat fields) northwest of the Carrizo Plain National Monument (Fig. 9).

Table 6. Habitat variables (means and standard errors) associated with the 40 pronghorn antelope group locations on the Carrizo Plain National Monument, CA. These groups represent 329 individuals.

| Variable | Mean | SE | Range |
|---|---|---|---|
| Slope (%) | 3.32 | 1.06 | 0 - 43.4 |
| Herb cover (%) | 38.7 | 2.85 | 10.0 - 75.0 |
| Grass cover (%) | 27.4 | 3.86 | 5.0 - 82.0 |
| Shrub cover (%) | 1.5 | 0.21 | 0.0 - 5.0 |
| Bareground cover (%) | 14.8 | 1.41 | 3.0 - 39.0 |
| Vegetation height (cm) | 28.3 | 1.57 | 14 - 51.2 |
| Distance to water (m) | 1324.7 | 141.3 | 134.2 - 4548.1 |
| Distance to roads (m) | 181.42 | 27.1 | 0.0 - 948.7 |
| Distance to fences (m) | 436.88 | 65.5 | 5.0 - 1590.0 |

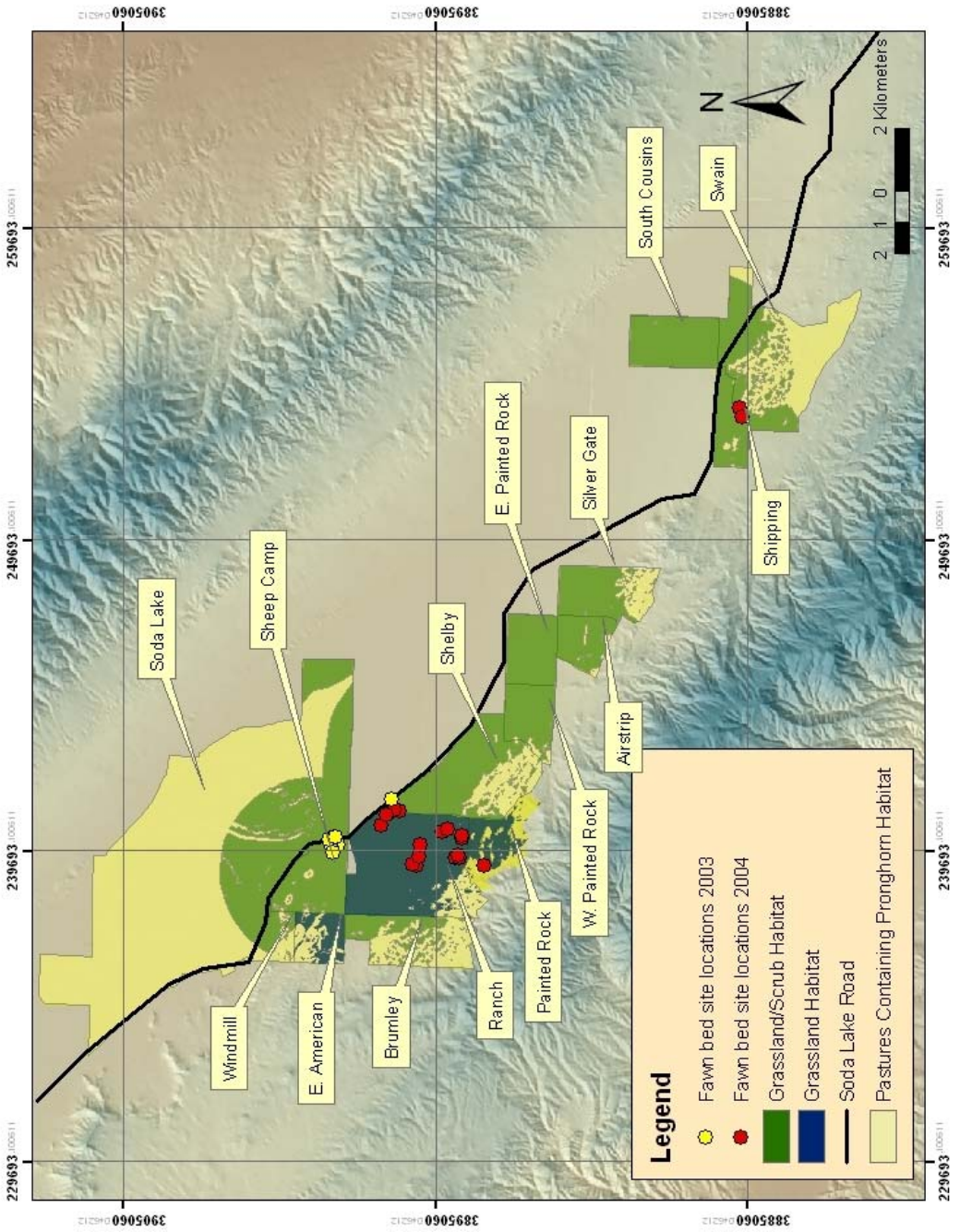


Figure 8. Pronghorn fawn bed site locations on the Carrizo Plain National Monument, CA during spring 2003 and 2004.

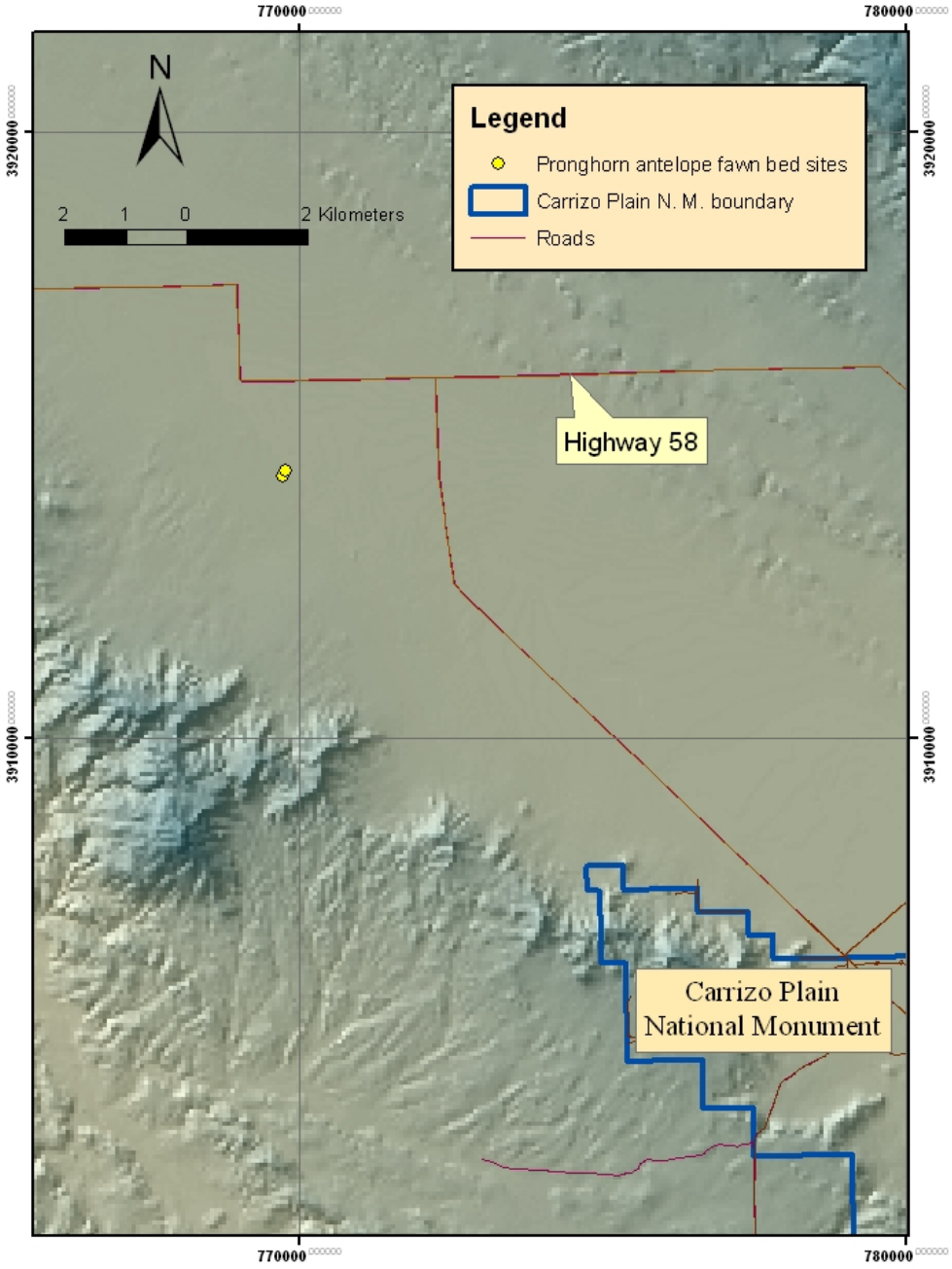


Figure 9. Locations of pronghorn fawn bed sites on private pastureland north of the Carrizo Plain N. M., CA. in 2004.

Microhabitat analyses at bedding sites

We measured habitat variables at 30 fawn bed sites and 30 random non-bed sites to analyze habitat characteristics at fawn bed sites (Table 7). Grass cover contributed significantly to the first component (PC) (Table 8). Herbaceous cover and bare ground contributed negatively. Vegetation height at the bed site contributed significantly to the second PC. In the 3rd component, slope and distance to water were most significant. Variables in the 3rd component were correlated because most water sources were placed in areas with lowest slope. Shrub cover contributed to the 4th principal component. These four PCs accounted for 82.3% of the total variance in the original habitat data set. The logistic regression analysis shows a significant difference between fawn and random locations (Chi-square = 32.938, df = 4, $P < 0.0001$) (Table 9). Higher grass cover, less herb cover and bare ground at the bed site and greater average surrounding vegetation height were the most significant variables characterizing fawn bed site locations (Chi-square = 12.119, df = 1, partial $P = 0.0005$).

Table 7. Microhabitat characteristics at 30 bed sites of pronghorn antelope fawns in the Carrizo Plain National Monument, California during 2003 and 2004.

| Habitat Variable | Mean (cm) | ± SE | Range (cm) |
|---|---|---|---|
| Vegetation height at bed site (cm) | 34.2 | 1.7 | 6.0 - 64.0 |
| Vegetation height 5 m from bed site (cm) | 27.2 | 1.7 | 5.0 - 60.0 |
| Vegetation height 10 m from bed site (cm) | 28.1 | 2.6 | 9.0 - 56.0 |
| Vegetation height 20 m from bed site (cm) | 31.2 | 1.7 | 9.0 - 78.0 |
| Vegetation height 50 m from bed site (cm) | 28.3 | 1.6 | 3.0 - 36.0 |
| Vegetation height 100 m from bed site (cm) | 29.2 | 1.6 | 9.0 - 61.0 |
| Shrub cover at bed site (%) | 2.3 | 0.7 | 0.0 - 20.0 |
| Grass cover at bed site (%) | 58 | 5.1 | 5.0 - 90.0 |
| Herbaceous/forb cover at bed site (%) | 20.8 | 3.2 | 0.0 - 50.0 |
| Bare ground cover at bed site (%) | 19.2 | 2.5 | 3.0 - 58.0 |
| Slope (%) | 1.87 | 0.32 | 0.0 - 10.4 |
| Distance to roads (m) | 262.3 | 40.6 | 10.0 - 750.0 |
| Distance to fences (m) | 419.8 | 83.9 | 4.0 - 1590.0 |
| Distance to water (m) | 1250.6 | 95.6 | 480.0 - 2753.0 |

Table 8. Loadings of 4 principal components (PC) from 30 antelope bed sites in the Carrizo Plain National Monument, California. Measurements were taken during April of 2003 and 2004. PC's are rotated using the varimax method.

| Habitat Variable | PC 1 | PC 2 | PC 3 | PC 4 |
|---|---|---|---|---|
| Vegetation height at bed site center | 0.099 | 0.944 | 0.044 | -0.052 |
| Average surrounding vegetation height | 0.397 | 0.868 | 0.119 | 0.004 |
| Shrub cover % at bed site | 0.032 | 0.221 | -0.152 | -0.863 |
| Grass cover % at bed site | 0.937 | 0.197 | 0.104 | 0.202 |
| Herb cover % at bed site | -0.866 | -0.102 | -0.084 | -0.055 |
| Bare cover % at bed site | -0.789 | -0.352 | -0.033 | 0.058 |
| Slope % | 0.201 | 0.038 | 0.852 | 0.243 |
| Distance to roads | 0.189 | 0.446 | -0.097 | 0.668 |
| Distance to fence | 0.573 | -0.040 | -0.255 | 0.555 |
| Distance to water | -0.062 | 0.076 | 0.907 | -0.202 |

Table 9. Results of binary logistic regression of 30 antelope fawn bed sites and 30 random sites as dependent variables and PC scores of 4 varimax-rotated principal components as independent variables.

| Variable | Beta | SE | Wald | df | Significance |
|---|---|---|---|---|---|
| PC 1 | -0.776 | 0.3915 | 3.934 | 1 | 0.0473 |
| PC 2 | 1.7001 | 0.4884 | 12.1197 | 1 | 0.0005 |
| PC 3 | 1.7864 | 0.5891 | 9.1972 | 1 | 0.0024 |
| PC 4 | 0.6672 | 0.3712 | 3.2305 | 1 | 0.0723 |

**Food Habits and Nutritional Quality**

Food habits

From April 2003 through June 2004 pronghorn consumed a total of 52 species. Of these, 34 were herbaceous or forb species, 9 were grasses, and 9 were shrub species (Appendix E). Also eaten were unidentified species of seeds, nuts, berries and insects. Based on percent composition by forage class, the annual diet (April 2003 through March 2004), consisted of 66.2 % (11.9%, SE) forbs, 13.5% (3.8%, SE) grasses, 9.5% (3.3% SE) shrubs, 8.0% (2.4% SE) seeds, nuts and berries, and 1.1 % (0.3% SE) insects. The remaining 1.7% of the annual diet was an unknown plant eaten during September 2003.

Although forbs always made up the majority of the monthly diet, the relative proportion of each forage class varied throughout the year (Figure 10). The use of forbs was negatively correlated with shrubs ($r = -0.595$, $P = 0.019$) and grass use was negatively correlated with seed use ($r = -0.540$, $P = 0.038$). Principal forb forage species were *Lepidium* spp., *Astragalus* spp., *Camissonia* spp., and *Phaecelia* spp. (Table 10). These species were found in the diet during all months of the study (Appendix E). *Erodium*, *Lotus* spp., and *Salsola tragus*, occurred in the diet during most months. Key grasses in

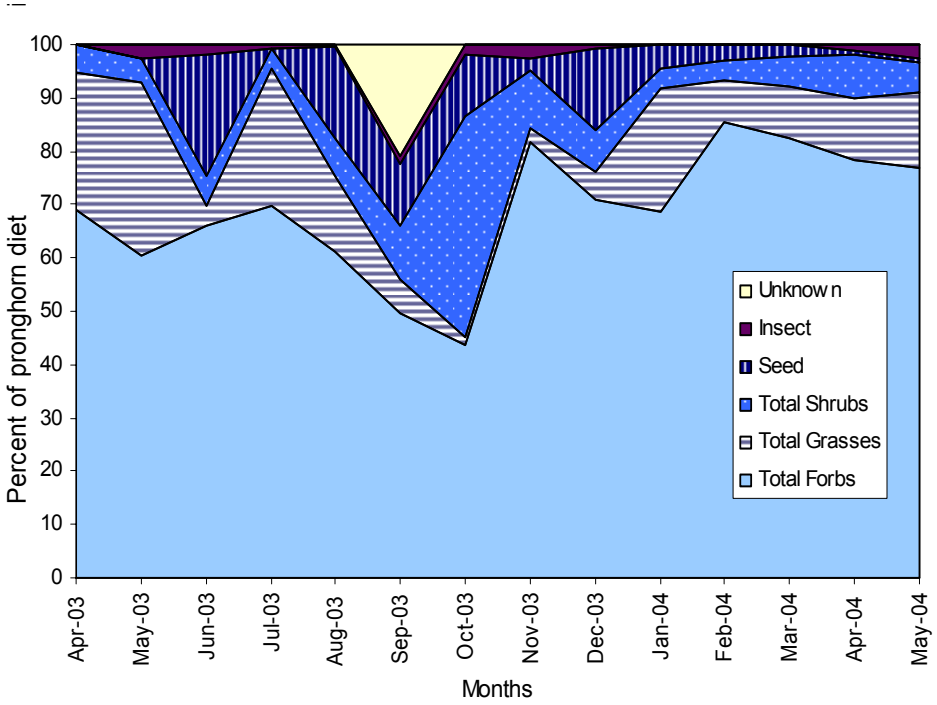


Figure 10. Percent composition of pronghorn diets from within the Carrizo Plain National Monument, California from April 2003 to June 2004. Seed category is comprised of seed, nuts, and berries. The category for forbs also includes moss, lichens, and mistletoe (*Phoradendron* spp.). Percentages are based on microhistological analysis of fecal samples.

the diet were *Bromus* spp., consumed during all months, and *Hordeum* spp., eaten during all but 2 months of the study. *Avena* spp. was important during May 2003 where it comprised 9% of the diet and during January, where it made up 5% of the diet. Principal shrub species included *Atriplex* spp. (10 months) and *Gutierrezia californica* (9 months). Pronghorn also consumed a small amount of insect material throughout the year (10 months).

Five plants consumed by pronghorn at Carrizo Plain N.M. are toxic to livestock. These were *Astragalus* spp., *Salsola tragus*, *Senecio* spp., *Solanum* spp., and *Quercus* spp. The proportion of these plants in the diet was highest during autumn except for *Astragalus* spp., which was found in the diet all year, and *Salsola tragus*, found in the diet during most months. During November and January, the proportion of *Astragalus* spp. in the diet of pronghorn at Carrizo Plain N.M. was 16.8%. The proportion of *Salsola tragus* (Russian thistle) in the diet was highest during May 2003 (11.4%). The greatest proportion of a single species consumed during the study period occurred during September 2003 when 30.1% of the diet consisted of *Quercus* spp.

Only the proportion of grasses in the diet were found to differ significantly between seasons ($F_{4,8} = 5.23$, $P = 0.023$) (Table 10). We did not include June 2004 in the seasonal

comparisons because it was the only month sampled during summer 2004. Grass consumption was highest during spring 2003 and lowest during autumn 2003 (Table 11). During spring of both years, pronghorn foraged mostly on forbs and grasses, which when combined, made up 93.9% and 92.8% of the diet in 2003 and 2004, respectively (Table 11). During summer, the proportion of grass in the diet decreased and the proportion of seeds increased. Forb and grass consumption was lowest during autumn 2003, when the proportion of shrubs in the diet increased.

Nutritional quality

Fecal nitrogen and FDAPA values were correlated (Pearson's r = 0.66, n = 13, $P$ = 0.014). Fecal nitrogen values ranged from a low of 1.83% during November 2003 to a high of 2.58% during June 2003 (Figure 11). Monthly FDAPA values ranged from 0.327 mg/gm during December 2003, to 0.795 mg/gm during April 2003 (Figure 12). There was no relationship between fecal nitrogen values and monthly total rainfall ($r$ = 0.076, $F_{1,12}$= 0.064, $P$ = 0.804), or fecal nitrogen and average monthly maximum temperature ($r$ = -0.043, $F_{1,12}$= .020, $P$ = 0.889). There was also no relationship between FDAPA and monthly total rainfall ($r$ = 0.073, $F_{1,12}$= 0.59, $P$ = 0.813), or FDAPA and average monthly maximum temperature ($r$ = 0.049, $F_{1,12}$= 0.026, $P$ = 0.874).

Table 11. Plant taxa comprising ≥ 5% of seasonal pronghorn antelope diets on the Carrizo Plain N.M., California from April 2003 through June 2004. Seasonal diets are averaged across months. Diet composition was determined by histological analysis. Values are in percentages. Seed species were unidentified but were included because as a single forage item they made up the greatest proportion of the summer diet.

| Plant Taxa | Spring[1] 2003 | Summer 2003 | Autumn 2003 | Winter[2] 2003-04 | Spring 2004 |
|---|---|---|---|---|---|
| Forbs | | Mean (SE) | | | |
| *Ambrosia acanthicarpa* | 8.6 (0.99) | 0.0 (0.0) | 0.6 (0.3) | 1.8 (1.4) | 2.4 (1.1) |
| *Astragalus* spp. | 3.8 (0.5) | 3.8(1.7) | 6.8(5.0) | 13.5(3.2) | 6.7(0.9) |
| *Camissonia* spp. | 5.5(2.2) | 11.6(4.3) | 3.1(1.5) | 10.2(1.1) | 13.0(0.4) |
| *Lepidium* spp. | 8.7(2.6) | 10.6(2.1) | 12.0(0.4) | 23.9(0.1) | 27.0(3.9) |
| *Lotus* spp. | 0.8(0.8) | 0.4(0.3) | 0.2(1.0) | 5.1(1.8) | 6.2(1.5) |
| *Salsola tragus* | 6.5(5.0) | 2.5(1.8) | 0.9(0.5) | 0.3(0.3) | 1.6(0.8) |
| *Solanum/Datura* spp. | 1.4(1.4) | 0.0(0.0) | 5.2(3.4) | 0.0(0.0) | 0.3(0.3) |
| Grasses | | | | | |
| *Bromus* spp. | 9.8(3.6) | 2.4(1.3) | 0.8(0.1) | 4.9(4.0) | 3.7(0.8) |
| Shrubs | | | | | |
| *Quercus* spp. | 0.0(0.0) | 0.0(0.0) | 10.6(9.7) | 0.0(0.0) | 0.5(0.5) |
| Other | | | | | |
| Seeds[3] | 0.0(0.0) | 13.2(6.8) | 8.5(3.1) | 9.9(5.3) | 2.1(0.6) |

[1]Includes April and May
[2] February excluded
[3] Includes unidentified species of seeds, nuts, and berries.

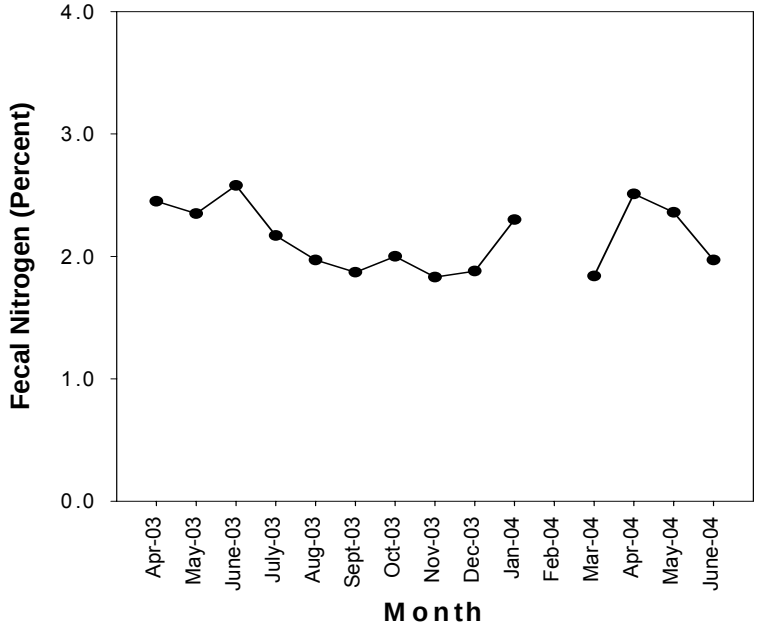


Figure 11. Measurements of fecal nitrogen from pronghorn antelope on the Carrizo Plain National Monument, California. Data are from samples collected from April 2003 through June 2004. No samples were collected during February 2004.

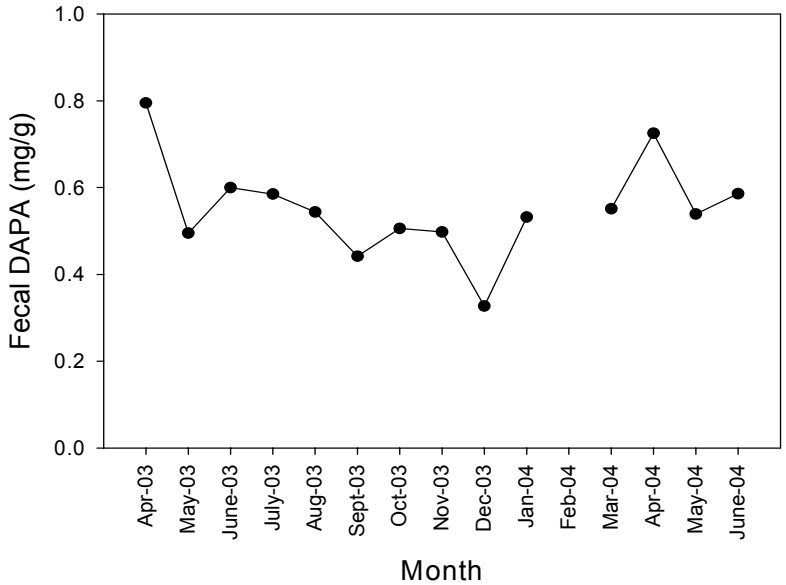


Figure 12. Measurements of fecal diaminopimelic acid (FDAPA) from pronghorn antelope on the Carrizo Plain National Monument, California. Data are from samples collected from April 2003 through June 2004. No samples were collected during February 2004.

Table 10. Forage classes in the seasonal diets of pronghorn antelope inhabiting the Carrizo Plain National Monument, California, from spring 2003 through spring 2004. Pronghorn diet composition was determined by histological analysis. Seasonal diets are averaged across months. Spring months in 2003 include April and May; spring months in 2004 are March through May. Summer months include June through August and autumn months are September through November. Winter months exclude February.

| Season | Percent Composition of Diet (SE) | | | | | |
|---|---|---|---|---|---|---|
| | Forbs | Grasses | Shrubs | Seeds[1] | Insects[2] | Unidentified spp[3] |
| Spring 2003 | 64.9 (4.2) | 29.0 (3.5) | 4.9 (5.5) | 0.0 (0.0) | 1.3 (1.3) | 0.0 |
| Summer 2003 | 65.7 (2.5) | 14.5 (6.6) | 5.6 (9.6) | 13.2 (6.8) | 1.0 (0.5) | 0.0 |
| Autumn 2003 | 59.0 (11.6) | 3.6 (1.5) | 20.8 (17.8) | 8.5 (3.1) | 1.9 (0.3) | 10.6 (9.8) |
| Winter 2003/04 | 69.7 (1.1) | 14.2 (8.9) | 5.8 (2.1) | 9.9 (5.3) | 0.5 (0.5) | 0.0 |
| Spring 2004 | 82.1 (2.1) | 10.7 (1.2) | 5.9 (1.2) | 2.1 (5.6) | 0.3 (0.3) | 0.0 |

[1] Includes unidentified species of seeds, nuts, and berries.
[2] Species unidentified
[3] A single unknown plant species eaten during September

Table 12. Seasonal means and standard errors of percent fecal nitrogen (FN) and fecal diaminopimelic acid (FDAPA, mg/g fecal dry matter) for pronghorn antelope in the Carrizo Plains National Monument, California, during 2003 and 2004.

| | Spring[1] 2003 | | Summer 2003 | | Autumn 2003 | | Winter[2] 2003/04 | | Spring 2004 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SE | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| FN | 2.40 | 0.05 | 2.24 | 0.18 | 1.90 | 0.05 | 2.09 | 0.21 | 2.23 | 0.20 |
| FDAPA | 0.645 | 0.150 | 0.575 | 0.017 | 0.482 | 0.020 | 0.429 | 0.103 | 0.605 | 0.060 |

[1] April and May 2003
[2] Excludes February

Seasonally, FN was highest during spring of 2003 and lowest during autumn 2003, but these differences were not significant ($F_{4,8}$= 1.34, $P$ = 0.335) (Table 12). FDAPA values were highest during spring 2003 and lowest during winter 2003/2004. Seasonal differences were also not significant ($F_{4,8}$= 1.57, $P$ = 0.272).

## DISCUSSION

### Habitat Suitability

A number of habitat assessments have been conducted for pronghorn on perennial grasslands and scrublands (see Yoakum 2004a for review), but we know of no habitat studies that have been carried out in an annual grassland-scrub community comparable to the CPNM. Overall, habitat suitability ranked moderate to low. Distances to water and slope values were indicative of high quality habitat, but shrub cover and diversity ranked

low. Habitat with relatively greater herbaceous forbs and grass cover and relatively lesser shrub cover is considered optimal for foraging and predator avoidance (Yoakum 2004b). However, shrubs become important forage during periods of drought and when annual forbs are unavailable (O'Gara and Yoakum 1992). Results of our food habits study indicate that in the CPNM, shrubs are important forage during autumn months.

During dry years, low shrub diversity and cover coupled with low production of herbaceous vegetation during spring and summer, can indicate low carrying capacity. Drought conditions necessitated supplemental feeding of pronghorn on the monument during 2002 (Yoakum 2004b), and during 2003 and 2004 precipitation was lower than average. During our surveys at least 27 pronghorn were located on private land outside the monument. These animals may have been part of the monument herd. Whether these animals return to the monument is unknown. If pronghorn are moving off the monument during dry years, their movement may be an indication of low carrying capacity. Low quality habitat can cause population sinks, where deaths exceed births and immigration exceeds emigration; without immigration from other sources these populations may disappear (Pulliam 1988).

Although the Carrizo Plain is considered historic pronghorn range, overgrazing dating from 1769, dry-land wheat farming, and the subsequent introduction of exotic species have changed the composition of this region. Due to the anthropogenic impacts on the CPNM and the subsequent conversion from perennial grassland to non-native annual grassland, perennial shrubs may now be an important component of pronghorn habitat on the monument, especially during dry years. Our results suggest that without habitat rehabilitation, the present-day Carrizo Plain may not contain enough suitable habitat to support a viable population of pronghorn antelope.

**Microhabitat Characteristics at Neonatal Bed Sites**

Although the CPNM provides adequate areas with ≤ 5 % slope, we found few areas >5 square km with the vegetation height considered necessary for fawn bed site concealment. Only the Ranch, Brumley, Painted Rock, and Sheep Camp pastures (as well as the private pastures outside the Monument) appear to provide or partially provide the habitat factors of 30-50 cm vegetation height and long-range visibility considered necessary for pronghorn fawn concealment. These pastures comprised 26 of the 30 bed sites located on the Carrizo Plain National Monument. Coyotes are known to be the primary predator of pronghorn antelope fawns in many areas (Barrett 1984; Gregg et al. 2001) and appear to be the main source of predation on the monument (personal observation). Coyotes are known to kill up to 86% of fawns within the first 18 days of birth, and any condition that might allow this rate to increase could clearly be detrimental to pronghorn antelope population growth (Gregg et al. 2001). Coyotes hunt primarily by sight, and the concentration of fawn bed sites in the relatively small area of the Ranch, Brumley, Painted Rock, and Sheep Camp pastures might allow a greater than normal predation rate on pronghorn antelope fawns in the monument.

The correlation of greater vegetation height to pronghorn antelope fawn bed site choice concurs with several other studies of this type. Canon and Bryant (1997) found fawns on

a grassland-scrub habitat in Texas chose areas that had adequate concealment yet still provided long-range visibility of the surrounding area. Pronghorn fawns also selected areas with greater relative shrub cover (> 30% but < 50%) in a sagebrush-grassland region in south-central Wyoming (Alldredge et al. 1991). Barrett (1981) found fawn survival increased with greater vegetation cover at the bed sites. He also found that the use of small depressions for bed sites increased fawn survival (Barrett 1981).

One concern of resource professionals was whether the descendents of translocated pronghorn have changed their mating system to adapt to conditions at CPNM (pronghorn on the Carrizo are at least second generation). Pronghorn evolving in relatively northern areas, like that of the founder population for CPNM have distinct behavioral characteristics when compared with populations from southern regions. Animals in northern areas use different foods, evolve under different predation pressures, and adopt different mating systems to adapt to the different climates found in northern versus southern areas (Kitchen 1974). Mating in northern populations occurs from mid-September to late October, while those in southern areas occur from mid-July to mid-October (O'Gara 1978). During the time period of our study, most fawns were born in mid-April to early May, which places the breeding period in late August to mid-September. Studies indicate this time period to be during the latter part of what is considered normal for a southern population (O'Gara 1978).

**Food Habits and Nutritional Quality**

Food Habits

Adult pronghorn in Carrizo Plain N.M. fed on a number of different plant species. The majority of these were forbs, followed by an equal number of grass and shrubs. Only a relatively small number of species made up the bulk of the diet. These results were consistent with those from pronghorn food habit studies reviewed by Yoakum (2004b), who found species numbers in grassland habitats ranged from 242 species in the Trans-Pecos Texas to 50 in the Texas Panhandle. Species numbers in shrubsteppe habitat ranged from 17 in Red Desert Wyoming to 134 in Cold Desert, Utah (Yoakum 2004b). Yoakum (2004b) concluded that in both grassland and shrubsteppe biomes, pronghorn were generally forb eaters by preference, where 40-60 different forb species may be eaten at a single site but five to six species comprised the bulk of the diet.

At Carrizo Plain N.M., forbs were the most important diet component; grasses were second, followed by shrubs. In most studies reviewed by Yoakum (2004b) shrubs were generally second to forbs in preference and consumption, followed by grasses. In shrubsteppe biomes, pronghorn browsed large quantities of shrubs but for most populations, forbs were still the preferred forage class (Yoakum 2004b). Shrubs were most often eaten when forbs are desiccated and no longer available (Yoakum 2004b). Grasses were not generally a highly preferred forage class but were important at sites where shrubs were not plentiful (Yoakum 2004b). Pronghorn inhabiting grassland and shrubsteppe biomes consumed grasses in low proportions during all seasons but increased consumption during spring green-up and after summer or autumn precipitation (Yoakum 2004b). Grasses in shrubsteppe biomes were eaten all year but generally constituted

<10% of the diet. Grasses were also important as digestible energy during winter. The relatively high use of grass at Carrizo N.M. during summer may be related to low shrub availability. Desiccated annual grasses, including oats (*Avena* spp) may provide digestible energy during summer months.

Pronghorn are opportunistic foragers who shift use of forage classes in response to forage availability and quality (Yoakum and O'Gara 2000). Although forbs consistently formed the greatest proportion of the diet at Carrizo Plain N.M, we found monthly and seasonal fluctuations in the use of forage classes. During spring, pronghorn mostly ate forbs and grasses. Grass in the diet was most important during spring of 2003. During summer months the proportion of grasses in the diet decreased and the proportion of seeds, nuts and berries increased. During autumn the proportion of shrubs in the diet increased and the proportion of forbs and grass decreased. Grass consumption was at its lowest during autumn 2003. Seeds, nuts and berries were also found in the diet during fall and winter months. Insects were a minor component in the diet through most of the year and may have been picked up as animals fed on plant material. We found no other reports of insects in pronghorn diets.

Pronghorn are known to consume a number of plants that are toxic to livestock but are not detrimental to pronghorn unless eaten in large quantities (O'Gara 2004). These species are often found in pronghorn diets in low quantities (<1%) during dry periods when forage availability is low (Yoakum 2004b). Potentially toxic plants found in the diet of pronghorn at CPNM were species in the genus *Astragalus*, *Salsola*, *Senecio*, *Solanum*, and *Quercus*. The proportion of these plants in the diet was highest during autumn months except for *Astragalus spp.*, which was found in the diet all year, and *Salsola* spp., found in the diet during most months. *Astragalus* spp. contains swainsonine, a known toxin. Animals feeding on *Astragalus* spp. have shown severely detrimental effects on the reproductive system (Panter et al. 1999). Symptoms include ovarian dysfunction, delayed estrus, spontaneous abortions, failure of the embryo to attach to the uterine wall, and altered breeding behavior. Swainsonine passes to the fawn through the mothers' milk, passing the neurological disorders to the fawn. Although animals may recover normal reproductive function when withdrawn from *Astragalus*, permanent neurological damage may preclude normal reproductive behavior (Panter et al. 1999, 2002). Pronghorn at the monument ate *Astragalus* spp. during periods coinciding with early gestation, late gestation, and weaning of fawns. Further study is warranted because the ingestion of *Astragalus* may cause a lower than normal birth rate and/or a higher than normal predation rate among the pronghorn population.

Pronghorn on the monument also consumed Russian thistle during most months of the study. Consumption of small amounts of *Salsola* does not appear to be detrimental to pronghorn and may be important during dry years when forage availability is low. Russian thistle (*Salsola iberica*), is a common food of pronghorn in east central and north central New Mexico (Stephenson et al. 1985). However, Russian thistle can accumulate potassium nitrate, which can be toxic when reduced to potassium nitrite by bacteria in the rumen (O'Gara 2004). Nitrites cause hemoglobin to be converted to methemoglobin, which is unable to transport oxygen and the animal dies from asphyxia (O'Gara 2004).

The availability of forage species is often determined by rainfall and the number and type of plant species in the diet may change in response to variation in rainfall amounts. Our study describes pronghorn feeding habits during a single year during a time when rainfall was lower than average. Although our results show a relatively high consumption of *Salsola* spp. and *Astragalus* spp., whether it is negatively affecting pronghorn at these levels and whether these species constitute a similar proportion of the diet during wetter years is unknown.

**Diet Quality**

Diet quality is related to plant phenology and abundance of preferred forage species. FN was highest during June 2003 when the proportion of seeds, nuts, and berries in the diet was greatest and lowest during November 2003. FN was also high during April 2003 and 2004. FDAPA values were highest during April 2003 and 2004 and lowest during January 2004. Although seasonal differences were not statistically significant, seasonal trends matched those found for other pronghorn populations (Hansen et al. 2001). Diet quality, as indexed by percent FN and FDAPA levels, was not correlated with monthly precipitation or mean maximum temperature. Hansen et al. (2001) found mean daily temperature and precipitation during the current month at Hart Mountain National Refuge, explained 84% of variation in FN and 81% of the variation in FDAPA but these results were based on two years of data.

FN and FDAPA reflect seasonal changes in plant phenology and availability and are useful for within season comparison among years within a specific area or to compare diet composition among similar habitat (Leslie and Starkey 1987).The FN and FDAPA values for pronghorn at CPNM. appear to be similar to those found in Texas but lower than levels from Hart Mountain, Oregon and Sheldon National Wildlife Refuge, Nevada (Yoakum 2004b). Because the sampling period for this study occurred during a period of lower than average rainfall, diet quality as indexed by FN and FDAPA vary significantly in response to years with higher or lower rainfall.

## Pronghorn Antelope Management

Pronghorn antelope populations may have natural variations in size in response to variance in rainfall and other factors. Because of the relatively low population size at Carrizo Plain N.M., long-term monitoring of both population demographics in conjunction with habitat and environmental conditions would provide valuable information for managing this population into the future. Knowledge of pronghorn movement from the monument to and from nearby agricultural areas would be important when estimating population size.

Habitat quality for pronghorn at Carrizo Plain N.M ranked moderate to low. Distances to water and slope values were indicative of high quality habitat but shrub cover and diversity ranked low. Of the 490 $km^2$ of area in the relatively lower elevation areas of the monument only 14.3 $km^2$ of the area evaluated was rated suitable as grassland habitat while pastures with the best grassland/scrub habitat comprised 68.4 $km^2$. These results suggest that without habitat rehabilitation, the present-day Carrizo Plain may not contain enough suitable habitats to support a long term viable population of pronghorn antelope.

Measures to increase habitat suitability by increasing vegetative cover and diversity of forage species (particularly perennial grasses and shrubs) would promote long-term survival of this population. We recommend seeding with species that would increase perennial forage species diversity for antelope and/or would increase existing forage species abundance, especially with species that provide forage for summer and fall. Providing summer/fall forage is clearly a difficult problem, as this would necessitate seasonable rains that are inconsistent on the Carrizo Plain. However, the seeding of drought tolerant species might increase forage during the times of year not previously available (O'Gara and Yoakum 1992).

Vegetation height above 25-30 cm allows for concealment of pronghorn fawns during the critical first few weeks after birth. Seeding of areas with relatively tall perennial grass species that would provide cover during the fawning period of April to June may improve fawn survival. Seeding of these species should occur in areas with flat or low slopes with good visibility for pronghorn antelope and in areas greater than five square km.

Diet composition and quality vary among seasons and years due to differences in weather conditions. Our study describes pronghorn feeding habits during a single year at a time when rainfall was lower than average. It is important that estimates of diet quality are made in the context of weather patterns and other environmental conditions. Long-term monitoring of available biomass during summer, fall and winter would provide information about forage availability under varying environmental conditions and would promote long-term survival of this population. Fecal indices such as FN and FDAPA also should be monitored because these indices can help managers assess diet quality and provide a baseline for comparison with future diet quality measurements.

Our results also showed relatively high proportion of *Salsola* spp. and *Astragalus* spp. in the diet. Consumption of toxic plants in small quantities may not be detrimental to pronghorn but during years of low rainfall the proportion of these species in the diet may increase. Whether present amounts of toxic plants are negatively affecting pronghorn, and whether consumption of these species varies in relation to forage availability on the monument is unknown and warrants further study.

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Appendix A. Number of pronghorn observed during monthly surveys conducted on the Carrizo Plain National Monument, CA. from May 2003 through August 2004.

| Date | Bucks | Does | Fawns | Group Size (Range) |
|---|---|---|---|---|
| May 2003 | 1 | 13 | 6 | 2-3 |
| June 2003 | 4 | 15 | 4 | 2-9 |
| July 2003 | 2 | 23 | 8 | 2-25 |
| August 2003 | 2 | 20 | 2 | 2-22 |
| September 2003 | 3 | 13 | 6 | 2-14 |
| October 2003 | 2 | 24 | * | 2-26 |
| November 2003 | 1 | 13 | * | 2-14 |
| December 2003 | 4 | 40 | * | 14-30 |
| January 2004 | 2 | 29 | * | 2-31 |
| February 2004 | ** | ** | ** | ** |
| March 2004 | 0 | 20 | * | 3-17 |
| April 2004 | 2 | 17 | 1 | 2-16 |
| May 2004 | 4 | 14 | 9 | 2-9 |
| June 2004 | 5 | 21 | 6 | 3-15 |
| July 2004 | 1 | 19 | 4 | 3-19 |
| August 2004 | 3 | 10 | 4 | 2-17 |

* Young of the year were no longer considered fawns after September.

** No counts were made in February: rain limited access onto the monument.

Appendix B. UTM locations of the 30 pronghorn antelope fawn bed sites located in the Carrizo Plain National Monument, CA in 2003 and 2004. Datum is NAD 1983.

| Bed Site | Date | Easting | Northing | Bed Site | Date | Easting | Northing |
|---|---|---|---|---|---|---|---|
| 1 | 5/21/2003 | 239826 | 3898389 | 16 | 5/6/2004 | 240333 | 3894835 |
| 2 | 5/21/2003 | 239914 | 3898188 | 17 | 5/11/2004 | 253973 | 3885313 |
| 3 | 5/21/2003 | 239682 | 3898363 | 18 | 5/11/2004 | 239540 | 3895581 |
| 4 | 6/11/2003 | 240087 | 3898467 | 19 | 5/11/2004 | 239902 | 3895563 |
| 5 | 6/11/2003 | 240157 | 3898306 | 20 | 5/11/2004 | 239915 | 3895556 |
| 6 | 6/11/2003 | 240162 | 3898253 | 21 | 5/11/2004 | 239922 | 3895561 |
| 7 | 6/12/2003 | 241394 | 3896473 | 22 | 5/12/2004 | 769720 | 3914314 |
| 8 | 4/29/2004 | 241016 | 3896447 | 23 | 5/11/2004 | 769780 | 3914421 |
| 9 | 4/29/2004 | 241007 | 3896237 | 24 | 5/12/2004 | 253654 | 3885214 |
| 10 | 4/29/2004 | 241055 | 3896388 | 25 | 5/20/2004 | 240545 | 3895616 |
| 11 | 5/6/2004 | 239509 | 3894442 | 26 | 5/20/2004 | 239225 | 3893504 |
| 12 | 5/6/2004 | 239490 | 3894317 | 27 | 5/20/2004 | 240872 | 3896650 |
| 13 | 5/6/2004 | 239589 | 3894329 | 28 | 5/21/2004 | 240108 | 3894200 |
| 14 | 5/6/2004 | 239234 | 3895688 | 29 | 5/21/2004 | 240403 | 3894685 |
| 15 | 5/7/2004 | 239288 | 3895790 | 30 | 5/21/2004 | 240211 | 3894206 |

Appendix C. Number of pronghorn observed during monthly surveys on private land northwest of the Carrizo Plain National Monument, CA. These pronghorn formed a single group that was located on private pastureland to the northwest of the Carrizo in April of 2004 through August of 2004.

| Date | Bucks | Does | Fawns | Group Size (Range) |
|---|---|---|---|---|
| April 2004 | 1 | 15 | 0 | 13-16 |
| May 2004 | 1 | 12 | 2 | 6-13 |
| June 2004 | 1 | 8 | 4 | 6-8 |
| July 2004 | 1 | 21 | 5 | 2-27 |
| Aug 2004 | 3 | 18 | 6 | 2-27 |

Appendix D. Total fawn counts on the Carrizo Plain National Monument, California from May 2003 through August 2004.

| Date | Total Fawns Counted | Fawns < 2 weeks old | Fawns 2-3 weeks old | Fawns 3-4 weeks old | Fawns >4 weeks old |
|---|---|---|---|---|---|
| May-03 | 7 | 0 | 7 | 0 | 0 |
| Jun-03 | 5 | 0 | 1 | 4 | 0 |
| Jul-03 | 8 | 0 | 0 | 2 | 6 |
| Aug-03 | 2 | 0 | 0 | 0 | 2 |
| Sep-03 | 9 | 0 | 0 | 0 | 9 |
| * | * | * | * | * | * |
| Apr-04 | 1 | 1 | 0 | 0 | 0 |
| May-04 | 9 | 5 | 2 | 1 | 1 |
| Jun-04 | 6 | 0 | 0 | 0 | 6 |
| Jul-04 | 4 | 0 | 0 | 0 | 4 |
| Aug-04 | 4 | 0 | 0 | 0 | 4 |

* Young of year were no longer considered fawns after September

Appendix E. Percentages of plant taxa found in the diet of pronghorn antelope within the Carrizo Plain, National Monument, California. 2003-2004. Percentages are based on microhistological analysis of fecal samples.

| | Spring 2003 | | Summer 2003 | | | Autumn 2003 | | | Winter 2003/2004 | | | Spring 2004 | | Summer 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | April | May | June | July | August | Sept. | Oct. | Nov. | Dec. | Jan. | March | April | May | June |
| Forb | | | | | | | | | | | | | | |
| *Achillea* | | | | | | | | 0.7 | | | | | | |
| *Ambrosia acanthicarpa* | 7.9 | 9.3 | | | | 0.7 | | 1.1 | 2.8 | 0.8 | 1.2 | 2.5 | 3.4 | 16.6 |
| *Aster* spp. | | | 2.0 | 0.3 | | | | 3.6 | | | 0.3 | | | |
| *Astragalus* spp. | 4.2 | 3.3 | 3.3 | 6.9 | 1.2 | 1.4 | 2.2 | 16.8 | 10.3 | 16.7 | 8.5 | 5.6 | 6.1 | 5.5 |
| *Camissonia* spp. | 7.7 | 3.3 | 10.2 | 19.7 | 4.9 | 1.0 | 2.5 | 5.9 | 11.7 | 9.6 | 12.9 | 12.3 | 13.8 | 7.6 |
| *Castilleja* spp. | | | 1.1 | 0.7 | 0.6 | | 0.4 | | | | | 1.4 | 1.2 | 0.4 |
| *Centaurea* spp. | | | | 1.7 | 2.3 | 1.0 | 0.9 | | | | | | | |
| *Chenopodium* | | | | | | | | | | | | | | 1.2 |
| *Cirsium* | | | | | | | 3.6 | 6.1 | 3.7 | | 1.2 | | 1.0 | 2.3 |
| *Clarkia* spp. | 1.5 | 0.3 | | 2.0 | | | | | | | | 0.5 | | |
| *Delphinium* spp. | 1.3 | | | | | | | | | | | | | |
| *Epilobium* spp. | | | | | | | | | | | | 2.3 | | |
| *Eriogonum* spp. | 2.7 | | | | | 0.7 | 1.3 | | | | 0.6 | 4.2 | 1.4 | 2.5 |
| *Eriogonum* spp. *stem* | | | | | 1.4 | | | | | | | | | |
| *Erodium* spp. | 0.3 | 0.6 | 0.9 | 0.7 | 0.3 | 2.0 | | 1.4 | 1.6 | 3.1 | | 5.6 | 1.2 | 1.5 |
| *Euphorbia (Chamaesyce)* spp. | 1.2 | | 0.9 | 1.0 | 2.0 | | | 1.8 | | | | | | 0.4 |
| *Gilia* spp. | | | | | | | | | | | | | | 1.9 |
| *Helianthus annuus* | 0.6 | 1.6 | 1.6 | | 3.5 | 0.3 | | 2.9 | 0.5 | | 0.6 | | 0.5 | |
| *Lactuca serriola* | | 0.5 | 4.6 | 4.0 | 2.9 | 1.0 | | 3.6 | 1.4 | | 1.2 | | | |
| *Lepidium* spp. | 11.3 | 6.1 | 8.4 | 14.8 | 8.8 | 12.7 | 11.6 | 11.6 | 23.9 | 23.8 | 19.9 | 27.8 | 33.4 | 13.0 |
| *Lotus* spp. | 1.6 | | 0.2 | 1.0 | 0.1 | 0.2 | | 0.4 | 3.4 | 6.9 | 9.1 | 4.2 | 5.3 | 2.3 |
| *Lupinus* spp. | 2.1 | 0.8 | | 1.9 | 1.4 | | | | 1.8 | 1.9 | 0.6 | 1.6 | 1.0 | 2.5 |
| *Mentzelia* spp. | 0.9 | | 0.9 | 0.3 | 0.9 | | | | | | | | | |
| *Monarda* | | 0.8 | | | | | | | | | | | | |
| *Phacelia* spp. | 6.8 | 1.6 | 5.3 | 0.7 | 3.2 | 1.5 | 0.5 | 1.1 | 0.9 | 1.3 | 2.3 | 5.1 | 2.9 | 2.3 |
| *Phlox/Linanthus* | 3.3 | 3.8 | 1.9 | 2.4 | 0.6 | 2.7 | | | | 0.8 | 2.3 | 2.3 | 0.5 | 2.3 |
| *Plantago* spp. | | | 7.4 | | | | | | | | | | | |
| *Salsola tragus* | 1.5 | 11.4 | 0.6 | 0.7 | 6.1 | 1.0 | | 1.8 | 0.5 | | 2.3 | | 2.4 | 7.6 |

Appendix E. Continued

| | Spring 2003 | | Summer 2003 | | | Autumn 2003 | | | Winter 2003/2004 | | | Spring 2004 | | Summer 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Genus and/or Species of Plant | April | May | June | July | August | Sept. | Oct. | Nov. | Dec. | Jan. | March | April | May | June |
| *Salvia* spp. | 0.3 | 1.6 | 0.6 | | | | | | | | | | 0.5 | |
| *Senecio* | | | | 0.7 | | | | 5.4 | | | | | | |
| *Solanum/Datura* | 2.7 | | | | | 4.1 | 11.6 | | | | | 0.9 | | |
| *Sonchus* | | | 1.2 | | | | | | | | | | | |
| *Trifolium* spp. | 0.1 | | | | | | | | 0.7 | | 6.4 | | 0.2 | |
| *Yucca whipplei* | | | | | | 4.1 | | | | | | | | |
| Borage family | | 1.9 | 0.3 | | 0.6 | 0.7 | 1.3 | 0.4 | 1.8 | | 1.2 | | | |
| Composite hair | 5.9 | 5.9 | 0.9 | | 2.3 | 2.4 | 0.9 | 3.9 | 1.8 | | 5.0 | 0.9 | | |
| *Cruciferae* (Mustard family) | 0.3 | | | | | | | | | | 0.9 | | | |
| Legume pod | | 4.1 | 1.9 | 1.7 | 3.2 | 6.5 | | 0.7 | | 0.8 | 1.2 | | | |
| *Polygonaceae family* | | | | | | | | | | | | 2.1 | 0.5 | |
| Uknown Forb | 2.7 | 2.7 | 4.6 | 4.2 | 4.9 | 2.4 | 3.1 | 6.8 | 3.5 | 2.1 | 5.5 | 3.2 | 1.9 | 6.1 |
| *Phoradendron* (mistletoe) | | | | | | 3.7 | | 0.7 | | | | | | |
| Flower | 2.1 | | 7.1 | 0.7 | 6.4 | 1.7 | 3.6 | 5.0 | 0.5 | 0.8 | 2.3 | | 1.0 | |
| Lichen | | | | 1.3 | 1.7 | | | | | | | | | 0.8 |
| Moss | | 1.1 | | 2.4 | 2.0 | | | | | | | | | |
| Forb Total : | 69.0 | 60.7 | 65.9 | 69.8 | 61.3 | 51.8 | 43.5 | 81.7 | 70.8 | 68.6 | 85.5 | 82.5 | 78.2 | 76.8 |
| Grass | | | | | | | | | | | | | | |
| *Avena* spp. | | 9.0 | | 1.0 | 3.8 | | | | | 5.0 | | 0.9 | 1.0 | 1.1 |
| *Bromus* spp. | 6.2 | 13.4 | 0.6 | 5.0 | 1.7 | 0.7 | 0.9 | 0.7 | 0.9 | 8.8 | 3.5 | 5.1 | 2.4 | 4.6 |
| *Distichlis spicata* | | | | | 1.4 | | | | | | | | | |
| *Hordeum* spp. | | 7.4 | 1.9 | 3.4 | | 1.4 | 0.9 | 1.1 | | 4.6 | 1.2 | 1.9 | 5.3 | 5.3 |
| *Leymus triticoides* | 1.5 | | | 3.0 | 0.6 | | | | | | | | | |
| *Poa* spp. | 6.0 | 0.8 | | 3.0 | 0.9 | | | | 0.9 | 3.4 | 1.2 | | | |
| *Stipa (Nasella)* spp. | 8.6 | | | 4.0 | 0.6 | 1.4 | | | 1.8 | | | | 1.5 | |
| *Vulpia* spp. | | | | 1.3 | | | | | | | | | | |
| Unkown Grass | 3.3 | 1.9 | 1.2 | 5.0 | 5.2 | 2.7 | | 0.7 | 1.8 | 1.3 | 1.7 | 1.8 | 1.4 | 3.4 |
| *Carex* spp. | | | | | | 0.3 | | | | | | | | |
| Grass Total : | 25.6 | 32.5 | 3.7 | 25.7 | 14.2 | 6.5 | 1.8 | 2.5 | 5.4 | 23.1 | 7.6 | 9.7 | 11.6 | 14.4 |
| Shrubs | | | | | | | | | | | | | | |
| *Atriplex* spp. | 0.3 | 1.1 | | 1.0 | 2.0 | 4.1 | | | 0.9 | 0.8 | 1.7 | | 2.4 | 0.4 |
| *Chrysothamnus nauseosus* | 4.2 | | | 1.8 | 0.7 | 0.5 | | | | | | | 1.4 | |

Appendix E continued.

| | Spring 2003 | | Summer 2003 | | | Autumn 2003 | | | Winter 2003/2004 | | | Spring 2004 | | Summer 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | April | May | June | July | August | Sept. | Oct. | Nov. | Dec. | Jan. | March | April | May | June |
| *Ephedra viridis* | 0.9 | | | | | | | | | | | | | |
| *Krascheninnikovia lanata (Ceratoides l.) Eurotia* | | | | | | 0.3 | | | | | | 0.9 | 0.5 | |
| *Gutierrezia californica* | | | | | 1.2 | 1.7 | | 3.2 | 2.3 | 0.8 | 2.3 | 0.9 | | 1.1 |
| *Isocoma acradenia* | | | | | | | 5.8 | 4.7 | | | | | | 1.9 |
| *Prunus stem* | | | 2.5 | | | | | | | | | | | |
| *Quercus* spp. | | | | | | 1.7 | 30.1 | | | | | 1.4 | | |
| *Ribes quercetorum leaf* | | | | | | | 1.8 | | | | | | | |
| Shrub leaf | | | | | | 1.0 | 3.6 | 0.7 | 0.9 | | | | | |
| Thorn | | 2.7 | 1.9 | 0.7 | 1.2 | | | 2.5 | 2.8 | | | 0.9 | 3.4 | 0.8 |
| Shrub stem | | 0.5 | 1.5 | 0.3 | 2.0 | 0.7 | | | 0.9 | 2.1 | | 1.4 | 0.5 | 1.1 |
| Shrub Total: | 5.4 | 4.3 | 5.9 | 3.8 | 7.1 | 10.0 | 41.3 | 11.1 | 7.8 | 3.7 | 4.0 | 5.5 | 8.2 | 5.3 |
| Seeds | | | | | | | | | | | | | | |
| Seed | | | 22.6 | | 17.1 | 7.5 | 11.6 | | 15.1 | 0.8 | 2.9 | 2.3 | 1.0 | 0.8 |
| Berry | | | | | | | | 2.2 | | | | | | |
| Seed/Nut | | | | | | 4.1 | | | | 3.8 | | | | |
| Seed Total: | | | 22.6 | | 17.1 | 11.6 | 11.6 | 2.2 | 15.1 | 4.6 | 2.9 | 2.3 | 1.0 | 0.8 |
| Insects | | 2.5 | 1.9 | 0.7 | 0.3 | 1.4 | 1.8 | 2.5 | 0.9 | | | | 1.0 | 2.7 |
| Unknown plant | | | | | | 18.7 | | | | | | | | |
| Grand Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |