VEGETATION MONITORING

AT PUEBLO CHEMICAL DEPOT:

1998-2002

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Executive Summary

In 1998 the U. S. Fish and Wildlife Service (USFWS) contracted the Colorado Natural Heritage Program to set up a long-term vegetation monitoring program on Pueblo Chemical Depot (PCD) in Pueblo County, Colorado. The monitoring program was established to detect vegetation changes in shortgrass prairie, sandsage shrubland, and greasewood shrubland as a result of the removal of cattle grazing. Each vegetation type included areas with four different historic cattle grazing regimes: 1) grazed year-round until 1998, 2) grazed, but not year-round until 1998, 3) grazed lightly (several times/year) since 1942, and 3) ungrazed since 1942. For the purpose of this study I consider the first two regimes "grazed" and the latter two regimes "ungrazed." All further reference to the "grazed" regime refers to its historical use and not to management practices during the course of the monitoring. During the five years of monitoring discussed in this report, neither grazed nor ungrazed study plots received any livestock grazing.

To detect temporal changes in species canopy cover, composition, density, and frequency, I established randomly chosen permanent vegetation monitoring plots in 1998. Half of the plots were placed in each of the two treatments (grazed and ungrazed areas). After a power analysis following the 1998 field season, I added ten new plots though four existing plots were found to be disturbed and were subsequently dropped. In 2001, I added two additional plots on active prairie dog colonies. During 1999, 2000, 2001, and 2002 I re-sampled the plots between August 4 and September 22.

For greasewood shrubland I established 13 plots (7 grazed and 6 ungrazed), and for sandsage shrubland habitat I established 11 plots (5 grazed and 6 ungrazed). In shortgrass prairie I established 12 plots (7 grazed and 5 ungrazed). Plot gw04ug in the greasewood shrubland and plot sg63ug in the shortgrass prairie still have pass-through cattle grazing and although I resample the plots each year, I have eliminated them from the analysis. Six of the shortgrass prairie plots were located within prairie dog towns. In the riparian area of Chico Creek I established ten photo plots (5 grazed and 5 ungrazed). These plots do not have quantitative data associated with them. The ungrazed portion of Chico Creek still has pass-through cattle for several days in the spring and fall.

Repeated measures analysis of variance (ANOVAs) were used to assess differences among years, while unpaired *t*-tests and Mann Whitney *U*-tests were used to determine if there were differences between dominant species in grazed versus ungrazed areas in 1999 and 2001.

Bare ground was one of the best indicators as to the presence of cattle grazing in both greasewood and shortgrass prairie vegetation. There was significantly more bare ground in grazed areas than ungrazed areas. This difference was still visible five years after the cessation of grazing, although the amount of bare ground in the grazed plots decreased with time.

Sand dropseed and needle-and-thread grass were good indicators as to the presence of cattle grazing in sandsage vegetation. Both of these grasses are native, although sand dropseed is an increaser with grazing and needle-and-thread a decreaser. Sand dropseed had significantly higher frequency in grazed plots, even five years after the cessation of grazing. Needle-and-thread grass had significantly lower frequency in grazed plots, and this difference was still as prevalent five years after the cessation of grazing.

The presence of prairie dogs in the shortgrass prairie influenced the plant composition. Three-awn grass cover and frequency were significantly higher with the presence of prairie dogs, while prickly pear all but disappeared.

Few weeds were present, regardless of vegetation type, although Russian thistle and kochia were prevalent enough to measure frequency, especially in wet years. Russian thistle and kochia had their highest frequency in ungrazed greasewood and shortgrass prairie plots during 1999 – the wettest year. Both of these annuals were hardly present in 2002 – the driest year.

This study has taken place over varying annual precipitation, ranging from 14% above average in 1999 to 68% below average in 2002, the worst drought recorded. In general, the vegetative cover responded quickly, with good cover in wet years and poor cover in dry years, while density and frequency remained stable regardless of precipitation. Three shrub species deserve special mention in their reaction to wet versus dry years as they had very different responses. Sandsage (*Oligosporus filifolia*), the dominant shrub of the sandsage shrubland responded very quickly to annual precipitation. The average canopy cover of sandsage increased over 50% between 1998

and 1999, while it decreased over 80% between 2001 and 2002. In strong contrast to sandsage are greasewood (*Sarcobatus vermiculatus*) and rabbitbrush (*Chrysothamnus nauseosus)*, both co-dominants in the greasewood shrubland vegetation. This vegetation type is associated with a high ground water table and both greasewood and rabbitbrush are deep-rooted shrubs that tap into available ground water. Greasewood had no significant response, and rabbitbrush had only a slight response (decrease), in either cover or density, to variations in annual precipitation. Due to this community's reliance on ground water it is presumed that changes in the ground water level may result in altered composition of the greasewood shrubland vegetation.

The future integration of the co-occurring small mammal and invertebrate study will bring insight as to how the fauna responds to the cessation of grazing as well as to the annual precipitation.

Study Area and Background Information

Location and Vegetation

The Pueblo Chemical Depot (PCD) is located on rolling prairie in southeastern Colorado, east of the city of Pueblo, occupying about 23,000 acres (Fig. 1). The site is best characterized as a high plains ecosystem composed of a mosaic of vegetation types including shortgrass prairie, sandsage shrubland, greasewood shrubland, wetlands, and riparian vegetation (Fig. 2).

Shortgrass prairie. The shortgrass prairie is the matrix community at PCD, occupying nearly 11,500 acres. Most of the shortgrass is dominated by blue grama (*Chondrosum gracile*), but a few areas are dominated by either alkali sacaton grass (*Sporobolus airoides*) or galleta grass (*Hilaria jamesii*), depending on soil type. Some areas, especially where prairie dogs occur, may also have a significant portion of three-awn grass (*Aristida* spp.). Grass canopy cover generally averages between 35-50% and bare ground generally averages between 20-55%, depending on grazing regime. However, live (green) grass canopy cover dropped to less than 5% in 2002 in response to extended drought conditions.

Sandsage shrubland. The sandsage-dominated prairie occupies approximately 4,000 acres at PCD and is best characterized as a very sandy substrate dominated by sandsage with an average of 15% canopy cover. The ground cover is often sparse with a mix of grasses and forbs, although grasses are normally more dominant than forbs (at least during August and September). Blue grama, needle-and-thread, and sand dropseed (*Sporobolus cryptandrus*) are the most common grasses, but they seldom exceed 10% canopy cover. Plains buckwheat (*Eriogonum effusum*), zinnia (*Zinnia grandiflora*), and sunflowers (*Helianthus* spp.) are common forbs, and bush morning glory (*Ipomoea leptophylla*) and yucca (*Yucca glauca*) are common shrub-like plants.

Greasewood shrubland. This shrubland occupies approximately 2,400 acres on PCD with the largest occurrence along Boone Creek. This community is recognized by the presence of greasewood (*Sarcobatus vermiculatus*) with an average of 3% canopy cover; rabbitbrush (*Chrysothamnus nauseosus*) may co-dominate and cholla (*Cylindropuntia imbricata*) may be present. The grass cover averages 50% and is often dominated by alkali sacaton, blue grama, or galleta grass. On about 25 % of the acreage, erosion has removed the surface layer, leaving barren slick spots.

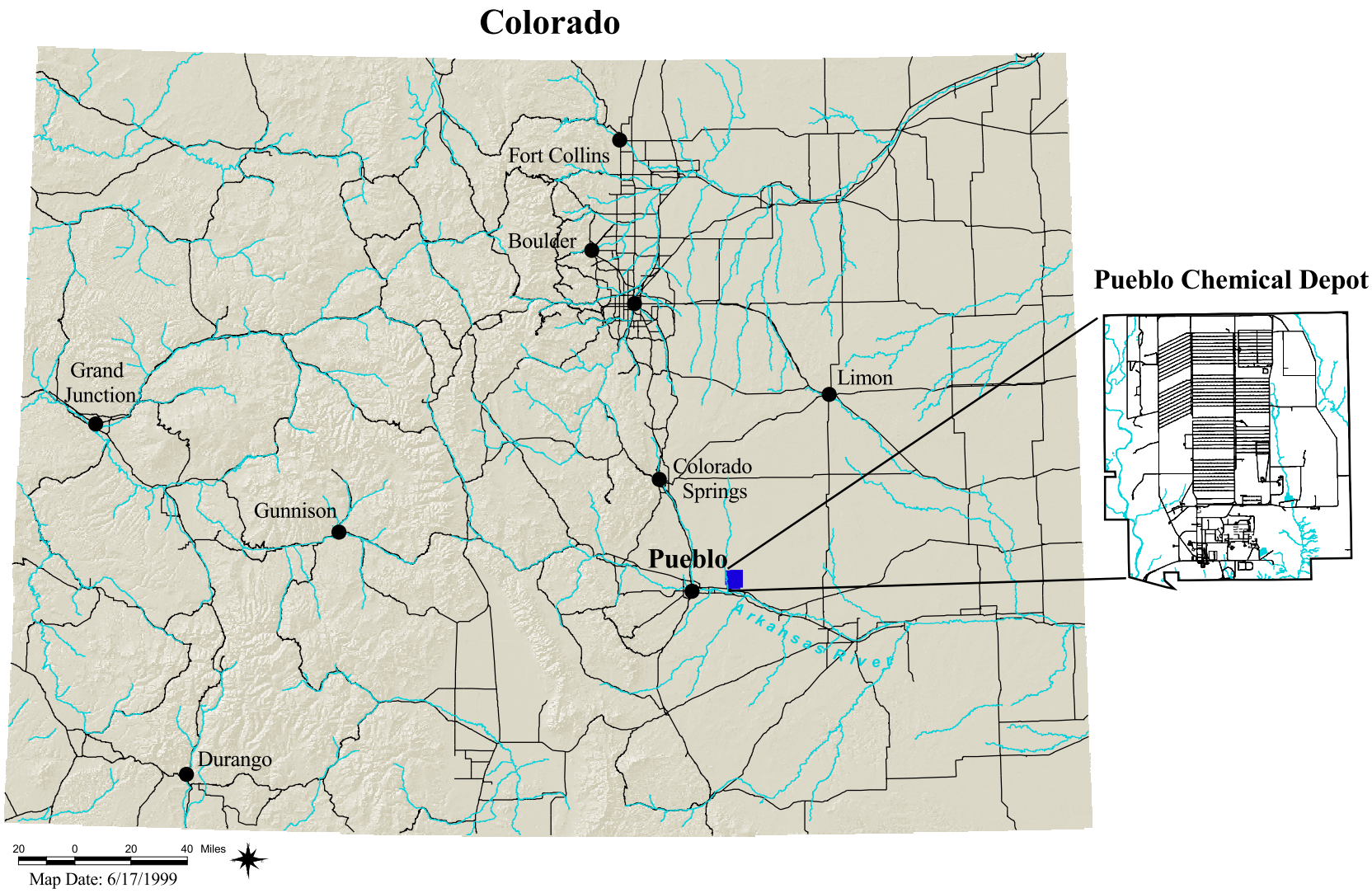


Figure 1. Location of Pueblo Chemical Depot.

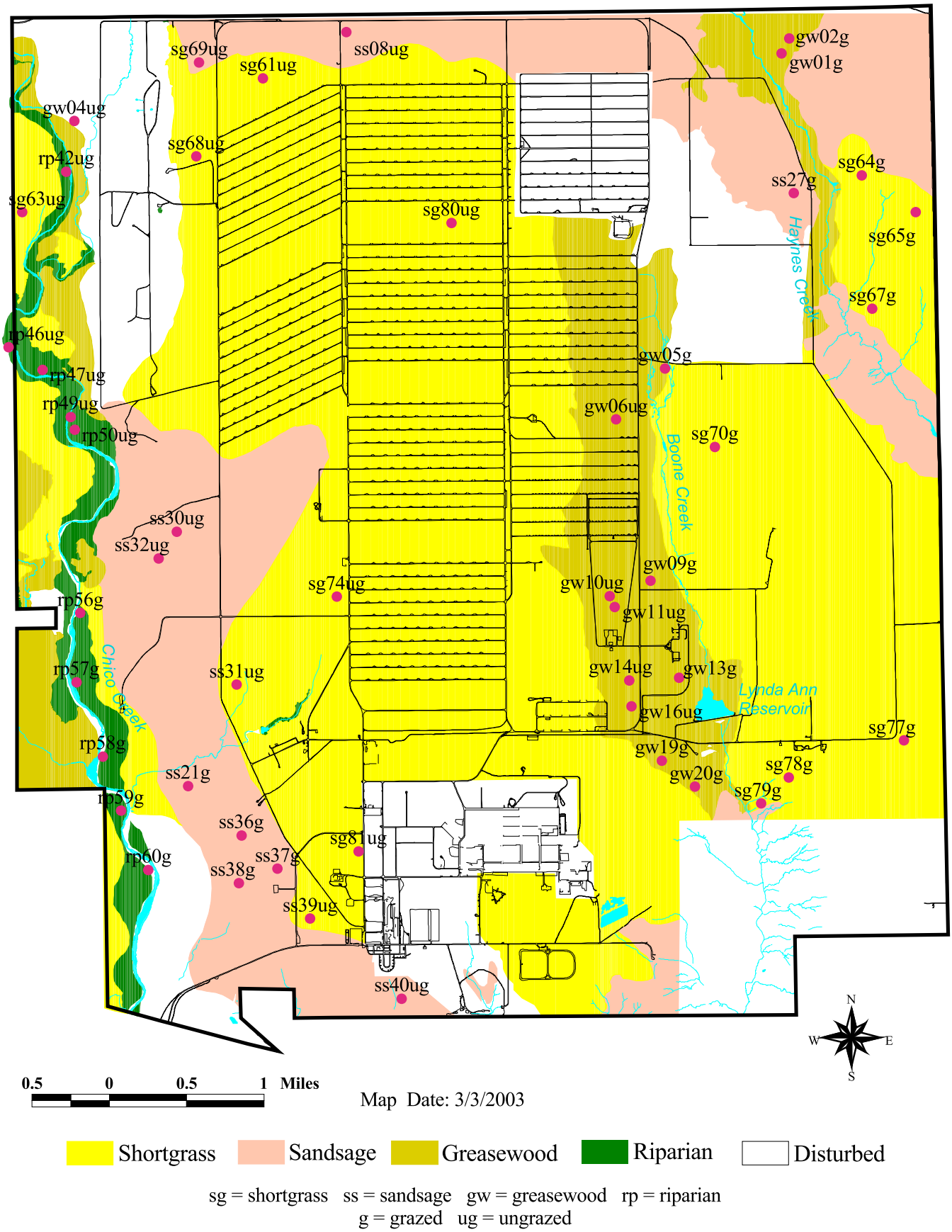


Figure 2. Vegetation types at PCD and locations of permanent vegetation sampling points.

Riparian. The wooded riparian habitat is found primarily on the west portion of PCD. The dominant vegetation of this wooded riparian area is plains cottonwood (*Populus deltoides*) with native bunch grasses, whereas the southern portion of Chico Creek is sparsely vegetated with some coyote willow (*Salix exigua*) and tamarisk (*Tamarix ramosissima*).

General Site History

Prior to settlement by Europeans, the eastern plains of Colorado were inhabited by many Native American tribes that relied heavily on bison (*Bison bison*) for subsistence. Although it is unclear how large the bison herd was in this area, we are certain that bison were a major influence on shortgrass prairies of Colorado (Benedict et al. 1996). As late as 1872 buffalo could be found in the Pueblo area. Hornaday (1889: 493) stated, "On the west, a few small bands ranged as far as Pikes Peak and the South Park, but the main body ranged east of the town of Pueblo, Colorado." Although bison populations were affected as early as the 17th century with the introduction of horses (Sherrow 2001, Martin and Szuter 1999), the major extermination of bison began in the 1840s and the final and largest killings took place between 1872 and 1874 (Hornaday 1889).

Some of the most notable early expeditions to pass through the area included those of Pike (1806-1807), Long (1820), Fremont (1843-1845), Gunnison-Beckwith (1853-1854), and Wheeler (1869-1879) (National Park Handbook 116, 1982). The Long expedition traveled along the Arkansas River just south of PCD on July 20, 1820 and did not mention any large herds of bison (Evans 1997).

From at least the early 1900s to 1941 the depot property was a mixture of privately- and state-owned parcels with cattle ranching as the primary use. The location of the depot was selected in 1941 prior to the entry of the United States into World War II and construction began in 1942. The depot functioned as a storage, maintenance, distribution, and disposal facility for munitions and other military equipment for the U.S. Army for approximately 52 years (1942-1994). During the Korean War, the depot reached its highest civilian strength of nearly 8,000 employees. The depot was designated for realignment in 1988 with all missions except storage of chemical munitions terminated on September 30, 1994. Although all conventional munitions were removed between 1991 and 1994, a small amount of mustard agent is currently stored at PCD.

Most of the ungrazed portions of shortgrass prairie have been altered by past activities. For example, in the munitions storage area a lot of disturbance occurred in order to build and maintain the bunkers. This included seeding followed by oil application to prevent wind erosion. In addition, many ditches were built to control runoff. The combination of seeding, ditching, and a vast network of roads has altered the plant species composition in ways that make much of the bunker area inappropriate for consideration as representative of ungrazed conditions.

Climate

The following data are from the Western Regional Climate Data Center, posted at www.wrcc.dri.edu. At the Pueblo Airport (six miles west of PCD), temperatures vary from a mean daily January minimum of 13.8° F (-10° C) to a mean daily July maximum of 92.4° F (33.5° C). Forty-two year mean annual precipitation has been 12 inches (SD = 3.2 inches) (30 cm, SD = 8 cm), about 33% of which falls during July-August, the period of maximum plant production (Fig. 3). On average, June experiences drought conditions with the average monthly precipitation falling below the average monthly temperature (Fig. 3). Annual precipitation varied over the years, from 14% above average in 1999 to 68% below average in 2002 (Fig. 4). On April 30, 1999 a large storm brought in more than 5 inches of rain creating a 100-year flood event in Chico Creek (average April rainfall is 1.1 inches (2.8 cm)).

Grazing History

PCD has experienced varied cattle grazing intensities, ranging from areas which have been ungrazed since 1942 within the munitions storage area to year-round heavy grazing in the eastern area (Fig. 5). From 1942 to 1998, cattle grazing was permitted on 7,600 of the 23,000 acres at PCD (Steranka 1996, as cited in Rust 1999). According to the U.S. Fish and Wildlife Service (1987) one cow per 35 acres was allowed, or approximately 220 head total. Although areas within the munition storage area have not been grazed by domestic livestock since acquisition of the post in 1942, this area was previously grazed. Areas within the ungrazed portion that were used for munitions storage were mechanically disturbed during construction of the weapons storage facilities in 1942. In 1995, an ecological study found differences in the amount of plant species canopy cover and relative plant abundance between the grazed and ungrazed areas (Rust

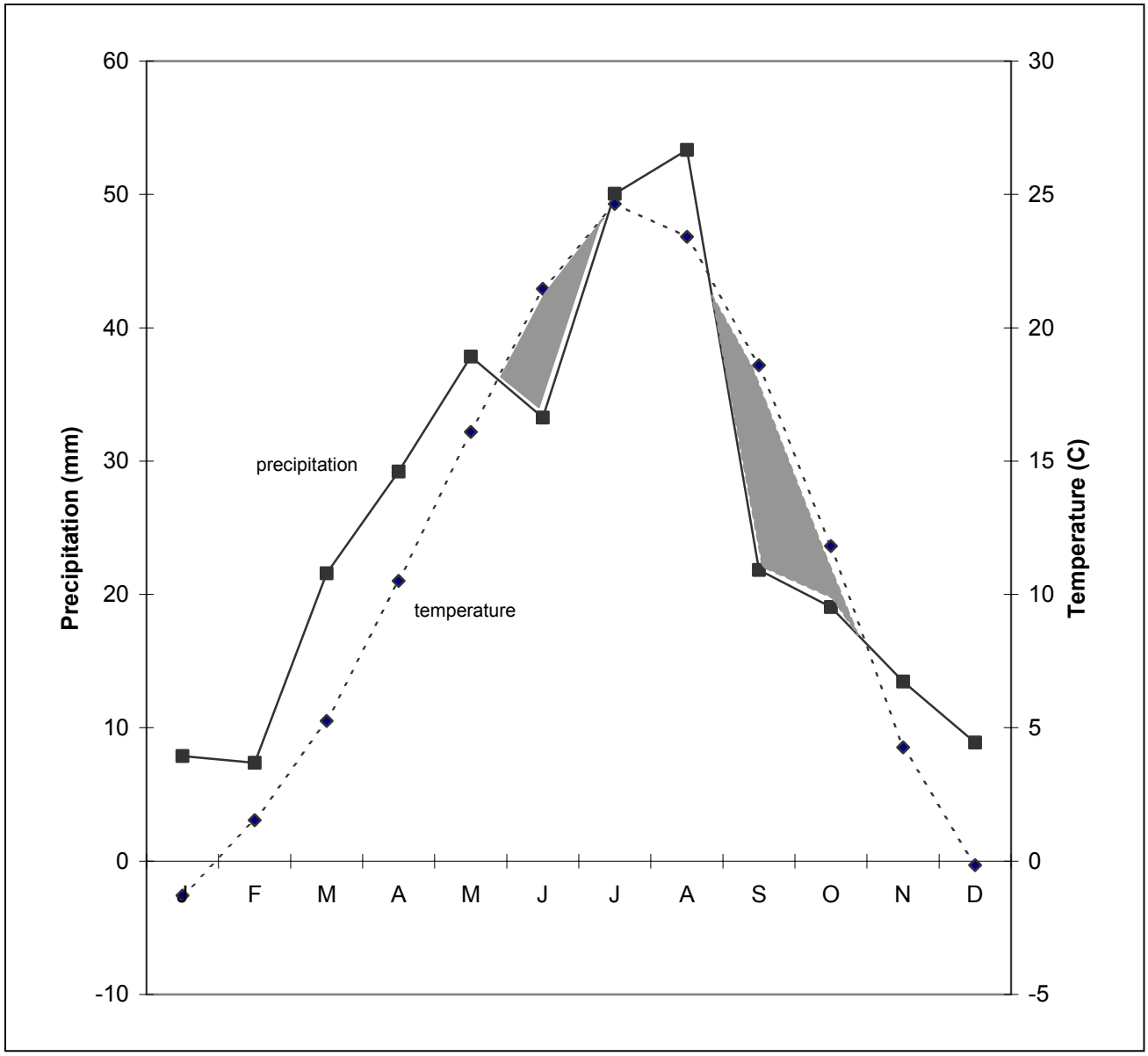


Figure 3. Mean monthly precipitation and temperature at the Pueblo WSO airport. Shaded areas indicate where precipitation falls below temperature and represent drought conditions. Data are from 1955-2000.

1999). Canopy cover and abundance of unpalatable grasses, forbs, and shrubs were found to be greater in grazed areas.

The increasing shrubs included sandsage, rabbitbrush, prickly pear cacti (*Opuntia* spp.), and cholla; the increasing grasses and forbs included purple three-awn (*Aristida purpurea*), squirreltail (*Elymus elymoides*), blue grama, horseweed (*Conyza canadensis*), annual sunflower

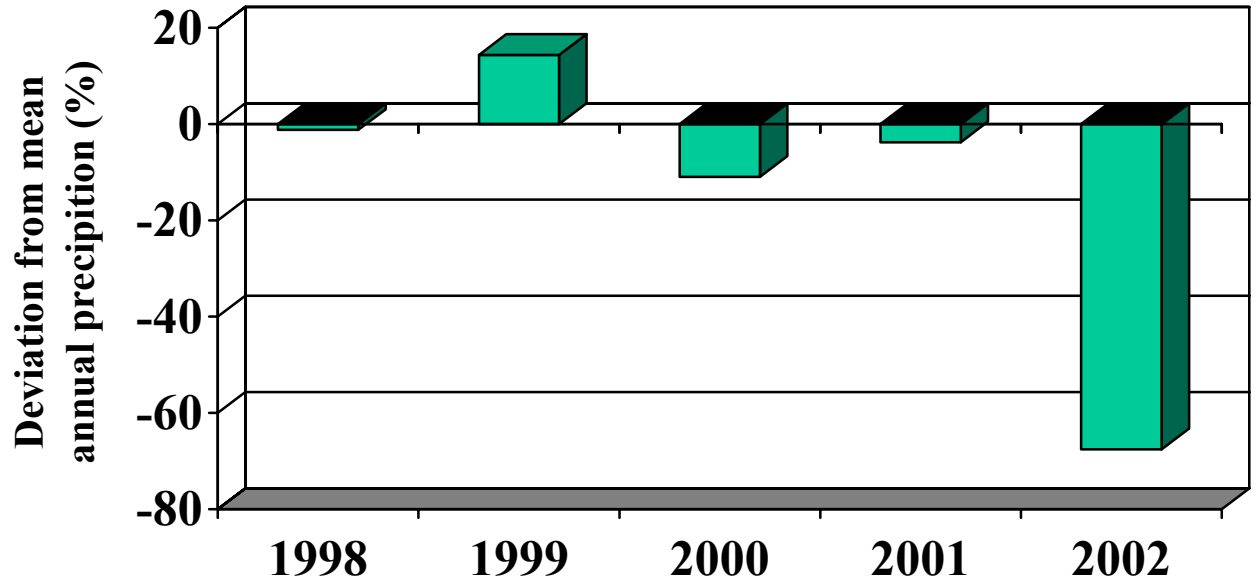
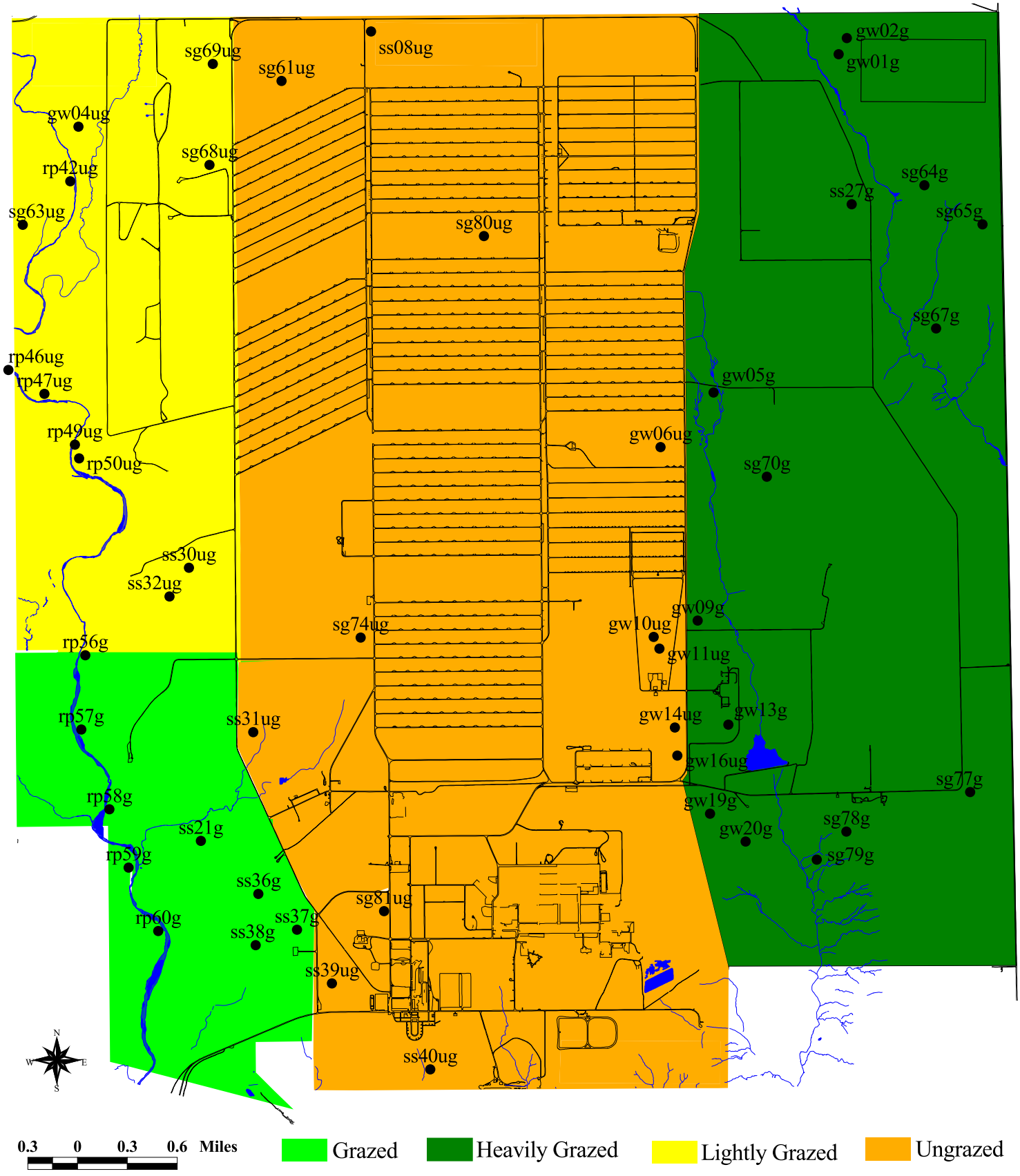


Figure 4. Deviation from mean annual precipitation at PCD (1998-2002). Mean is from 1957-2002.

(*Helianthus annuus*), western ragweed *(Ambrosia psilostachya)*, and alyssum (*Alyssum desertorum*). Rust (1999) also reported decreases in canopy cover and abundance of the following plant species in response to year-round grazing: spreading fleabane (*Erigeron divergens*), side-oats grama (*Bouteloua curtipendula*), sandreed grass (*Calamovilfa longifolia*), sand bluestem (*Andropogon hallii*), and switchgrass (*Panicum virgatum*).

In June of 1998, all livestock were removed from PCD, with the exception of pass-through cattle in spring and fall along Chico Creek. Although most livestock grazing has been eliminated from PCD, grazing may be reestablished in the future as a management tool. Currently, black-tailed prairie dogs (*Cynomys ludovicianus*) and pronghorn (*Antilocapra americana*) are the primary grazers of the shortgrass prairie of PCD. The prairie dogs form large towns that greatly influence the canopy cover and composition of the shortgrass prairie. In the early months of



Map Date: 7/21/2003

sg = shortgrass ss = sandsage gw = greasewood rp = riparian
g = grazed ug = ungrazed

Figure 5. Grazing regimes at PCD and locations of permanent vegetation sampling points.

1999 there were approximately 2,520 acres of live prairie dog towns at PCD (P. Young, pers. comm.). In May of 1999, plague-positive fleas were collected from prairie dog burrows and by September of 1999 prairie dog coverage had dropped ten fold, to approximately 250 acres (P. Young, pers. comm.). Recovery began in 2000, and as of 2002 approximately 1,985 acres were occupied by prairie dogs (P. Young, pers. comm.).

Soils

Soil type is an important abiotic factor that affects both flora and fauna, for example, prairie dogs occur more often in loams than in sand (Reading and Matchett 1997). PCD has a variety of soil types from well-drained sands, where sandsage dominates, to poorly drained clays, where greasewood dominates. The four dominant vegetation types in this study each occurred on multiple soil types. The plant species composition within these vegetation types was often associated with specific soil conditions. I briefly describe these soil types and their plant associations. The soil and plant composition descriptions are modified from the soil survey of the Pueblo area (USDA 1979).

Stoneham loam. This soil type is the dominant soil type for shortgrass prairie at PCD (Fig. 6). It consists of deep, well-drained loams and clay loams with a brownish color. Permeability is moderate and the available water capacity is high. The surface layer and the upper part of the subsoil are mildly alkaline, and the lower part of the subsoil is moderately alkaline. The native vegetation is mainly blue grama, galleta grass, sand dropseed, and cactus.

Plots on this soil type include: sg61ug, sg68ug, sg69ug, sg70g, sg74ug, sg77g, sg78g, sg80ug, and sg81ug.

Razor clay, eroded. This soil type also has shortgrass prairie vegetation but it occupies a smaller area than the Stoneham loam soils (Fig. 6). In addition to shortgrass vegetation, some of these soils have greasewood shrubland (Fig. 6). It consists of moderately deep, well-drained soils of heavy clay loam and silty clays at subsurface. These soils formed on uplands in clayey residuum weathered from shale. They are underlain by shale at a depth of 50 to 100 cm. The surface layer is a light olive-brown heavy clay loam about 10 cm thick. The main native grass is alkali sacaton. I have four shortgrass plots on this soil type of which only one (sg65g) is dominated by

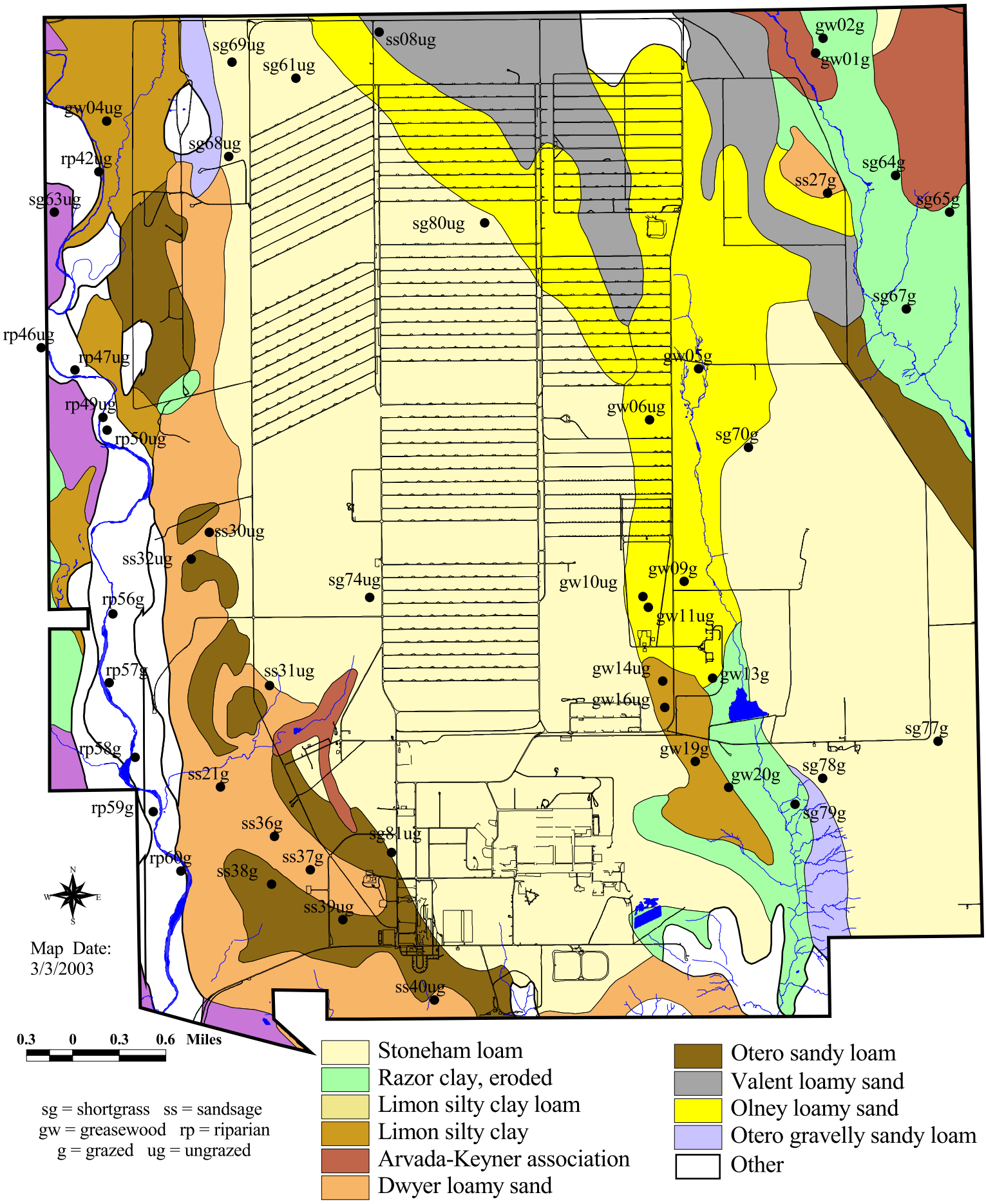


Figure 6. Soil types at PCD and locations of permanent vegetation sampling points.

alkali sacaton grass; the other three plots are dominated by blue grama. The two greasewood plots on this soil type are dominated by blue grama although alkali sacaton grass is present.

Plots on this soil type include: sg64g, sg65g, sg67g, sg79g, gw01g, and gw02g.

Limon silty clay loam. This soil type occurs on only a small portion of western PCD and is vegetated with four-winged saltbush (*Atriplex confertifolia*) and galleta grass (Fig. 6). It consists of deep, well-drained soils that formed on alluvial fans and terraces in clayey alluvium. The surface layer is grayish-brown silty clay loam about 10 cm thick. The subsurface layer is light brownish-gray silty clay about 35 cm thick. Permeability is slow and the available water capacity is high. The surface and subsurface layers are moderately alkaline and the underlying material is moderately alkaline or strongly alkaline. The native grasses are mainly galleta, blue grama, and alkali sacaton.

Plot on this soil type: sg63ug.

Arvada-Keyner association. This soil type is the dominant soil for the greasewood shrubland vegetation found at PCD (Fig. 6). It consists of deep, well to moderately drained soils that formed on terraces in loamy alluvium derived mostly from mixed sedimentary rock. The surface layer is light brownish-gray sandy loam about 8 cm thick. The upper part of the subsoil is brown, heavy clay loam about 5 cm thick, and the lower part is pale brown and very pale brown heavy clay loam about 5 cm thick. On about 25% of the acreage covered by the Arvada-Keyner association, erosion has removed the surface layer, leaving barren slick spots. Runoff is slow on the Arvada soil and medium on the Keyner soil. The native grasses are mainly alkali sacaton, blue grama, and galleta. Greasewood and cactus are abundant in places.

Plots on this soil type include: gw05g, gw06ug, gw09g, gw10ug, gw11ug, and gw13g.

Limon silty clay. This soil type also supports greasewood shrubland communities at PCD (Fig. 6). It consists of deep, well-drained soils that formed on fans and terraces in clayey alluvium. The surface layer is grayish-brown silty clay. The subsurface is light brownish-gray silty clay. Permeability is slow and the available water capacity is high. The surface and subsurface layers

are moderately alkaline and the underlying material is strongly alkaline. About 15% of the surface area is covered by barren slickspots. The native vegetation is mainly alkali sacaton, blue grama, galleta, and greasewood.

Plots include: gw04ug, gw14ug, gw16ug, gw19g, and gw20g.

Dwyer loamy sand. This soil type usually has sandsage shrubland vegetation. It consists of deep, excessively drained soils that formed on uplands in wind-blown sand. Permeability is very rapid and the available water capacity is low. The surface layer and subsurface layers are mildly alkaline. The native grasses are mainly needle-and-thread, blue grama, and sand dropseed. Yucca is also abundant.

Plots include: ss21g, ss27g, ss30ug, ss31ug, ss32ug, ss36g, ss37g, and ss40ug.

Otero sandy loam. This soil type intermingles with the Dwyer loamy sand and also supports sandsage shrubland vegetation (Fig. 6). It consists of deep, well-drained soils that formed on terraces in wind-sorted alluvium. Permeability is rapid and the available water capacity is moderate. The native vegetation is mainly sandsage, blue grama, sand dropseed, galleta grass, and yucca.

Plots include: ss32ug, ss38g, and ss39ug.

Valent loamy sand. This soil type occupies the northern portion of PCD (Fig. 6) and is primarily vegetated with sandsage shrubland. It consists of deep, excessively drained soils that formed on uplands in wind-deposited sand. Permeability is very rapid and the available water capacity is low. The native vegetation is mainly sand bluestem, sandreed grass, blue grama, sand dropseed, sandsage, and yucca. At PCD sand bluestem and sandreed grass are mostly absent.

Plot on this soil type: ss08ug.

Sampling and Management Objectives

In 1998 I developed sampling and management objectives. My primary sampling goal of monitoring the vegetation at PCD was to be able to detect a 20% change at $P = 0.1$ for dominant species canopy cover, density (for shrubs), and frequency. I was especially interested in the areas where grazing was removed in late spring of 1998.

The following management and sampling objectives were developed with only the vegetation component in mind. These were subject to change as an integrated ecosystem management approach was developed. For example, the vegetation objective "reduce the amount of bare ground" would merit modification if management for mountain plover (*Charadrius montanus*) was desired (Knopf and Miller 1996, Knopf and Rupert 1996). For example, a suitable objective for plover management would be to "maintain approximately 30% bare ground."

Management objectives have been modified from those originally reported (Rondeau and Kettler 1999; Rondeau 2001) and summarized below.

> **Management objective 1**: *Increase* the average cover of litter by 20% in the **grazed** portion of the shortgrass prairie and greasewood shrubland at PCD between 1998 and 2003. *Increase* the average canopy cover and frequency of needle-and-thread grass in the **grazed** portion of the sandsage shrubland between 1998 and 2003. *Increase* the average canopy cover of galleta grass in the grazed portion of the greasewood shrubland between 1998 and 2003.
>
> **Sampling objective 1**: I want to be 90% sure of detecting a 20% change in the absolute cover and frequency of needle-and-thread grass and galleta grass and cover of litter and will accept a 10% chance that change took place when it really did not (false-change error).
>
> **Management objective 2**: *Decrease* the average cover of bare ground in shortgrass prairie and greasewood shrubland and the cover and frequency of sand dropseed in sandsage shrubland by 20% in the **grazed** portions of PCD between 1998 and 2003.

Sampling objective 2: I want to be 90% sure of detecting a 20% change in the cover of bare ground and cover and frequency of sand dropseed in the grazed portions of PCD between 1998 and 2003 and will accept a 10% chance that change took place when it really did not (false-change error).

Methods

Upland

The uplands include shortgrass prairie, greasewood shrubland, and sandsage shrubland vegetation. In order to detect changes in species canopy cover, composition, density, and frequency over time, I established randomly-chosen permanent vegetation monitoring plots in 1998 with an equal number in the grazed versus ungrazed treatments. After the 1998 field season, I examined the variability of the first year's data and determined that ten additional plots were warranted to most likely meet the stated sampling objectives (Rondeau and Kettler 1999). At the same time, four plots that had been disturbed due to previous seeding and ditching activities were dropped from subsequent sampling (these plots are not included on the current maps). Figures 2 and 5 represent the placement of the plots relative to vegetation and grazing respectively. Figure 7 shows the placement of the plots as viewed with a 1995 aerial photo.

I resampled the plots once each year between August 4 and September 22. I generally resampled the plots within two weeks of their original sample date. For greasewood shrubland I established 13 plots (7 grazed and 6 ungrazed), and for sandsage shrubland habitat I established 11 plots (5 grazed and 6 ungrazed). In shortgrass prairie I established 12 plots (7 grazed and 5 ungrazed). As detailed in the grazing history section, plots labeled "grazed" were grazed by cattle until 1998 and plots labeled "ungrazed" have not been grazed by cattle since 1942.

Three of the grazed (sg70g, sg77g, and sg78g) and one of the ungrazed (sg61ug) plots in the shortgrass prairie are located within prairie dog towns. In 2001, I established two additional shortgrass prairie plots in areas ungrazed by cattle but within prairie dog towns (sg80ug and sg81ug). In April 1999, plague severely reduced prairie dogs at PCD, eliminating prairie dogs from plots sg61ug, sg70g, and sg78g. In 2002, prairie dogs moved back into plot sg61ug and were inactive in plots sg70g and sg78g. In 2002, the plots within active prairie dog colonies

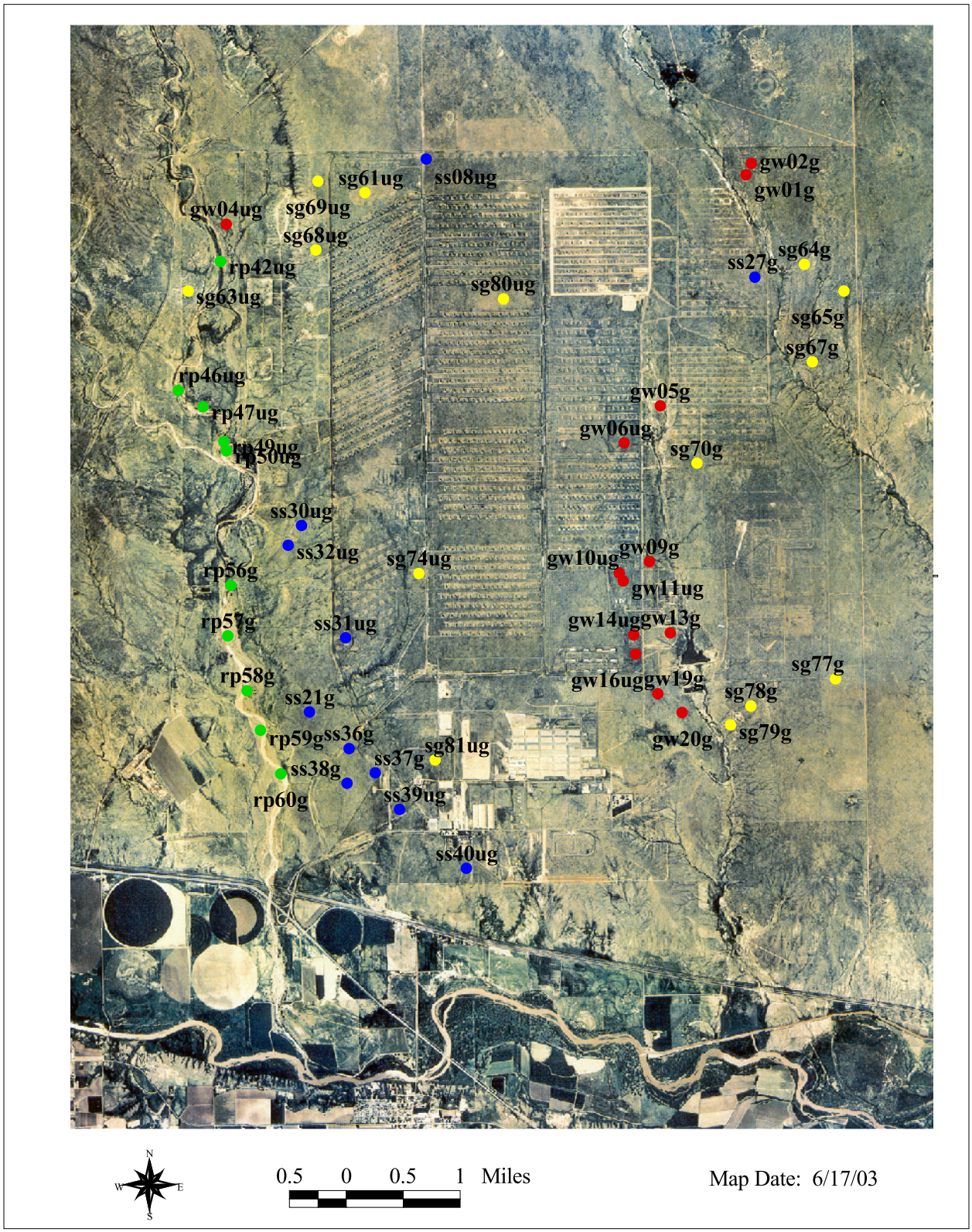


Figure 7. 1995 aerial photograph of PCD and locations of year 2002 permanent vegetation sampling points.

were sg61ug, sg77g, sg80ug, and sg81ug. In June of 2000, a lightning-induced fire burned the vegetation on sg65g plot. In November of 2001, a human-induced fire lightly burned plot sg70g.

To understand annual variation, I will measure the permanent plots on an annual basis through 2003.

Upland Plot Design

A stake was placed at the center of each site. Four transects were established at each plot by placing flexible 50 m tapes along the cardinal directions and marking the beginning (center of plot), middle, and end of each transect with two-foot rebar (Fig. 8).

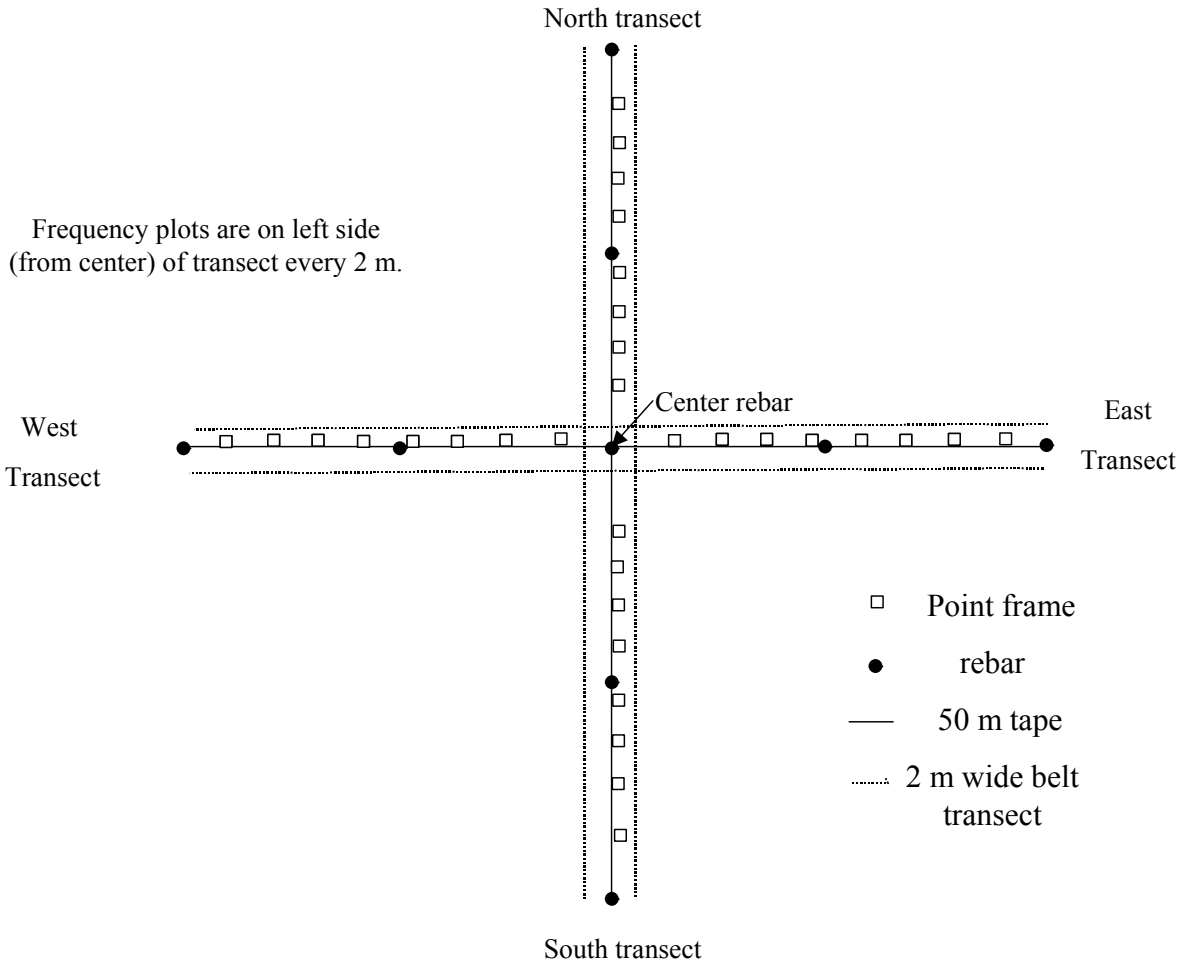


Figure 8. Configuration of an upland vegetation sampling site.

To estimate shrub canopy cover, a line-intercept method (Bonham 1989) was used along each of the four transects with 1 cm increments. Within the canopy of a plant, gaps in live green vegetation less than 10 cm in length were considered to be continuous cover.

To estimate herbaceous ground cover, eight point-frames (or microplots) (Bonham 1989), each 55 x 30 cm with 50 points (each point 5 cm apart) were placed every 5 meters along each of the four 50 m transects (Fig. 8). The first frame placement was randomly selected, then each subsequent frame was placed 5 m from the preceding one. Only live plants (green to light green) were measured.

Standing dead (usually brown in color), ground litter, or stump remains of grass clumps were considered litter. Bare soil, macrophytic crusts, or pebbles were considered bare ground. The percent of shrubs present within the microplot were not counted as cover because shrub cover was measured using the line-intercept method. The ground cover below the shrub (e.g. grass, litter, or bare ground) was recorded as cover for that location. In general, especially during dry years, canopy cover of grasses, forbs, litter, and bare ground sums to 100%. In wetter years, it was possible to have greater than 100% cover within a microplot because forbs (e.g. Russian thistle, and sunflower [*Helianthus*]) often form an overstory with blue grama or other species growing beneath.

To measure density (Bonham 1989) a 50 m x 2 m belt transect was used. This was done by measuring a 1 m band on both sides of each 50 m transect (Fig. 8). Any shrub that had vegetation within this area was counted; i.e., the plant did not have to be rooted within the area. Yucca is rhizomatous and therefore difficult to distinguish individual plants, hence we counted individual stems. It may also be difficult to distinguish individual greasewood plants. For this species we counted discrete clumps as individuals. All other shrubs were easily distinguished as individuals. To avoid double counting at the center point of the site, we counted only the north and south transects in the region of overlap.

Frequency of dominant or indicator species was measured with 25 nested-frequency plots per 50 m transect (Elzinga et al. 1998) placed every 2 m on the left side of the transect (as viewed from

center stake) beginning at the 2 m mark. The appropriate plot size for detecting statistical differences in the frequency of a species is influenced by the density and dispersion of that species within a community (Hyder et al. 1963, 1965, and 1975 as cited in Winter et al. 2002). Small plots sample the dominant species (e.g. blue grama grass) at optimal frequencies, but fail to detect less common species. I used three different plot sizes (nested frequency plots) because concurrent use of small and large sizes ensures adequate sampling of species which are common and abundant as well as species that are less commonly encountered (Hyder et al. 1975 as cited in Winter et al. 2002). The nested-frequency frame sizes used were as follows: a) 0.1 m x 0.1 m = scored as 2, b) 0.31 m x 0.31 m = scored as 3, and c) 1 m x 1 m = scored as 4. The 0.1 m x 0.1 m and 0.31 m x 0.31 m frame sizes were placed in the lower left corner (as viewed from center of 1 m x 1 m plot). The species included in the nested-frequency plots were three-awn grass, plains buckwheat, prickly pear, blue grama, alkali sacaton grass, sand dropseed, needle-and-thread grass, kochia (*Bassia sieversiana*), and Russian thistle (*Salsola* spp.). Prickly pear presence was based on existence of a pad within the sampling frame. All other species had to be rooted within the plot to be counted.

In addition to measuring canopy cover, density, and frequency, a species list was made for the entire 100 m x 100 m area of each site (see Appendix A for PCD plant list). Each 2-foot rebar that marked the ends and middle of the transect were labeled with the plot number engraved into aluminum tags. Universal Transverse Mercator (UTM) coordinates were recorded at the center post of each plot using a precision lightweight global positioning system receiver (PLGR).

Reference photographs were taken from both ends of each transect (landscape views) as well as at the 3rd and 5th microplots (views looking straight down). From 1998-2002, I used a Nikon 2000 35-mm camera with a 35-80 mm lens set for 35 mm. I used an Olympus digital camera in 2001 and 2002.

See Appendix B for sample field forms.

Riparian

For the grazed and ungrazed riparian areas I randomly selected five sites (Fig. 5). During 1998, 1999, and 2000, I collected frequency data, but this proved to be of limited value and I

discontinued the frequency monitoring. Repeat photos are the only data currently collected from Chico Creek.

Statistical Analysis

To ascertain if there was a detectable difference in canopy cover and density of dominant species among the years 1998-2002 I performed a repeated measures ANOVA (Glantz 1992) using Statview software. Since I am mostly interested in overall trends and not between-year differences, the repeated measures ANOVA was chosen over paired *t*-tests. A significant result from the repeated-measures ANOVA indicates that there is a year effect, but it does not indicate which pairs of years differ from each other (Elzinga et al. 1998: 246). Unpaired *t*-tests, or Mann-Whitney *U*-tests, were used to determine if there was a difference in canopy cover and frequency of dominant species in grazed versus ungrazed areas in 1999 and 2001. I chose 1999 instead of 1998 because the sample size in 1999 was larger than in 1998; 2001 was chosen over 2002 in order to avoid severe changes due to the 2002 drought.

Results

Greasewood Shrubland[1]

The year-to-year variation in cover and density of greasewood was not significant (Fig. 9; Tables C-1 and C-2 in Appendix C). Rabbitbrush, a co-dominant shrub with greasewood, showed only slight but significant year-to-year variation in cover and density (Fig. 9; Tables C-1 and C-2). In other words, these two shrubs are not closely tied to annual precipitation, as is sandsage (see below). In sharp contrast to the above, cover of grasses, bare ground and litter had significant year-to-year variation (Fig. 9; Table C-1). The trend in grasses closely followed the annual variation in precipitation with increases in cover with average and above average precipitation and decreases in cover with below average precipitation. The exception to this was with bare ground and litter. Bare ground decreased monotonically from 1998 to 2000 and then more or less stabilized, whereas litter increased monotonically from 1998 to 2002, with the exception of 2001 (Fig. 9; Table C-1).

[1] Plot gw04ug was excluded from statistical analyses because it still has pass-through cattle grazing.

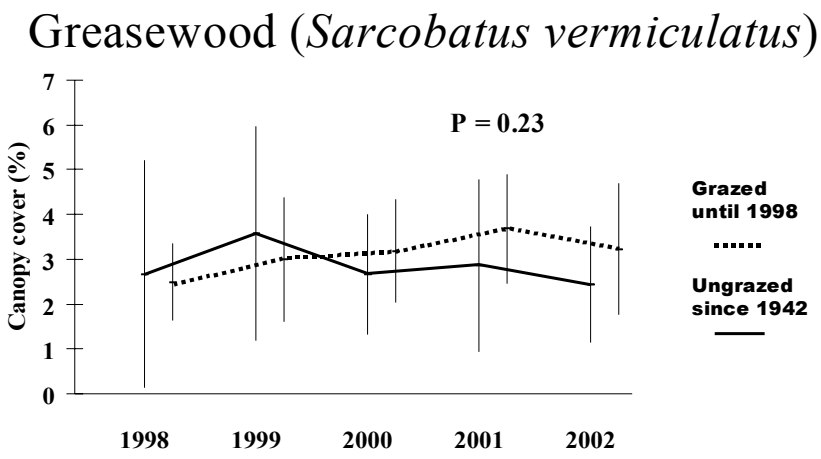
The year-to year variation in frequency of grasses was significant (Fig. 9; Table C-3). Similarly, the year-to-year variation in frequency of the annual weeds, Russian thistle and kochia, was significant. The year 1999 had the highest percent frequency for the annual weeds while all subsequent years were lower, with nearly 0% frequency in 2002.

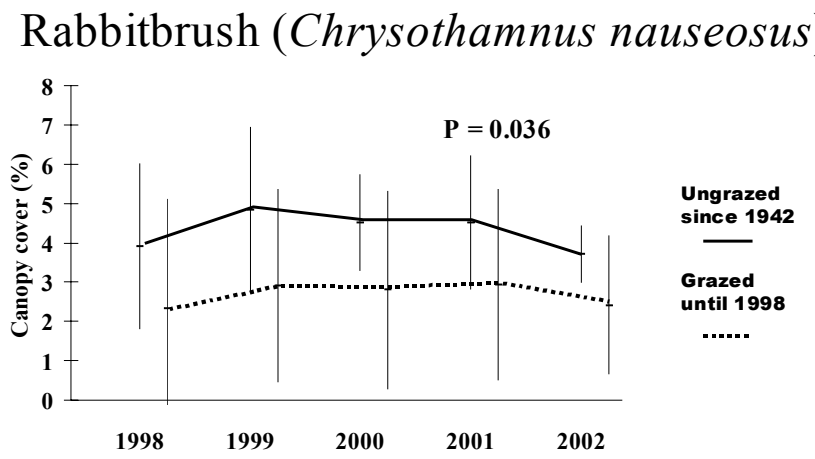
T-tests or Mann-Whitney *U*-tests performed on the 1999 data, between grazed and ungrazed plots confirmed a significant difference between grazed and ungrazed plots for galleta grass, litter, bare ground, Russian thistle, and kochia (Table 1), but did not substantiate all of the expected differences for the other species. Greasewood, rabbitbrush, blue grama, alkali sacaton grass, sand dropseed, prickly pear, and three-awn grass had little or no difference between grazed and ungrazed plots in cover, frequency, or density. *T*-tests or Mann-Whitney *U*-tests were conducted again for the 2001 data with results similar to those for the 1999 data (Table 1).

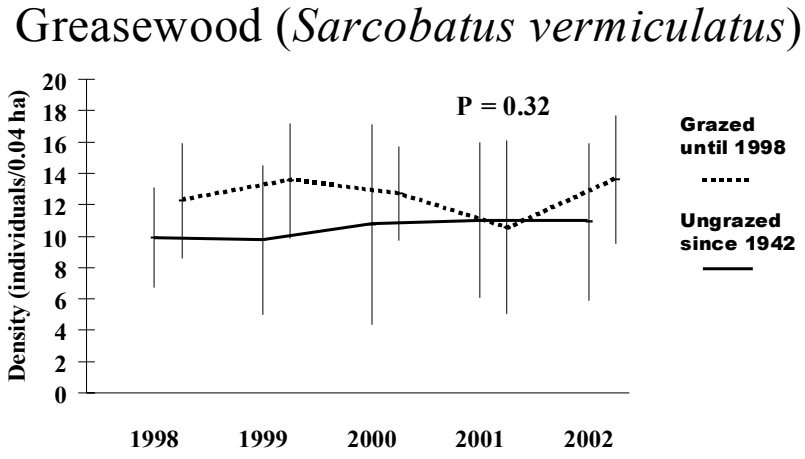
Sandsage Shrubland

There was year-to-year variation in cover resulting from changes in precipitation for sandsage, blue grama, three-awn grass, sand dropseed, and needle-and-thread grass (Fig. 12; Table C-4). The trend generally followed the annual variation in precipitation with increases in cover with average and above average precipitation and a severe decrease (over 80%) in response to the 2002 drought. In sharp contrast to greasewood and rabbitbrush, sandsage cover is closely associated with annual precipitation (Fig. 12; Table C-4). The amount of bare ground decreased from 1999 to 2000, remained nearly stable in 2001, and increased with the drought conditions in 2002 (Fig. 12; Table C-4). Litter increased in 1999 and 2000, remained nearly stable in 2001, and significantly increased in 2002 (Fig. 12; Table C-4).

There was little year-to-year variation in density of sandsage, even during the 2002 drought (normally at least one or two green leaves were present) (Fig. 12; Table C-5). The year-to-year variations in frequency of blue grama, three-awn, needle-and-thread grass, and the annual weed Russian thistle were significant (Fig. 12; Table C-6); however, the year-to-year variations in frequency of sand dropseed and prickly pear were not significant (Fig. 12; Table C-6).







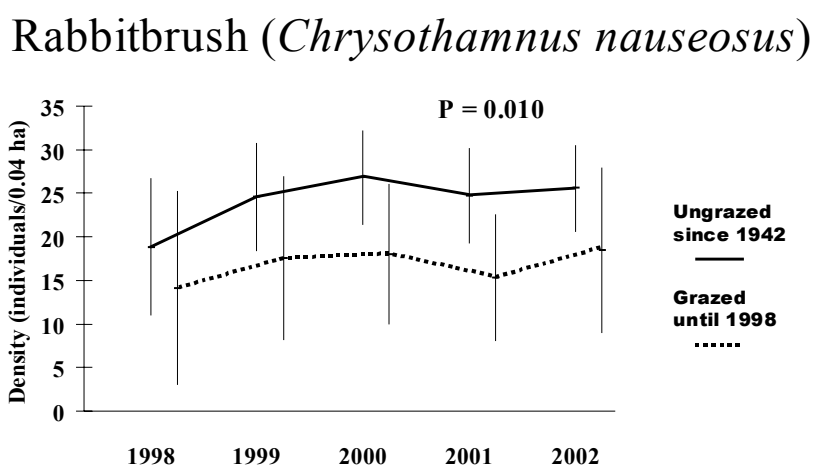
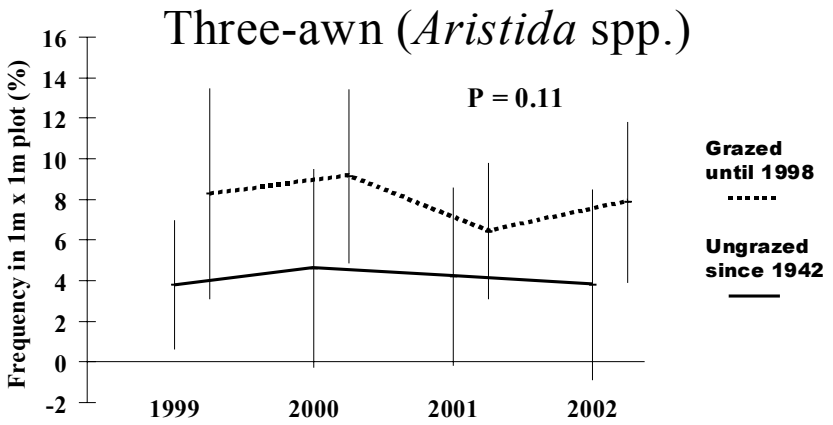
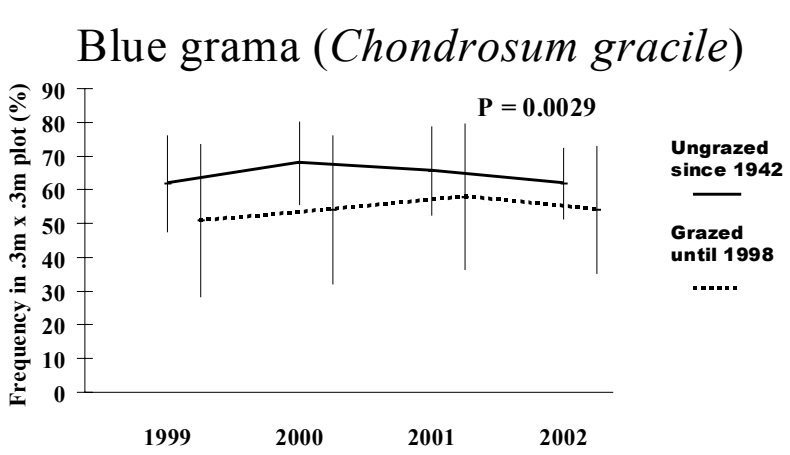
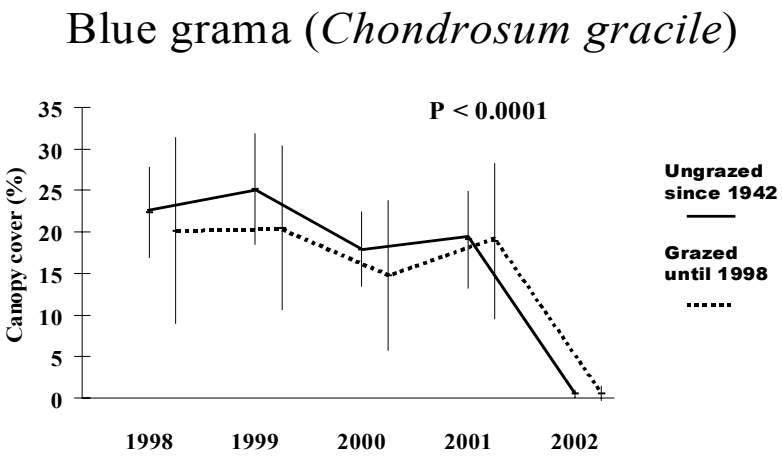


Figure 9. Mean canopy cover, density, and frequency for species within the **greasewood shrubland** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 3 plots ungrazed. Sample size for 1999-2002 is 7 plots grazed, 5 plots ungrazed. P-values calculated using 1999-2002 data.







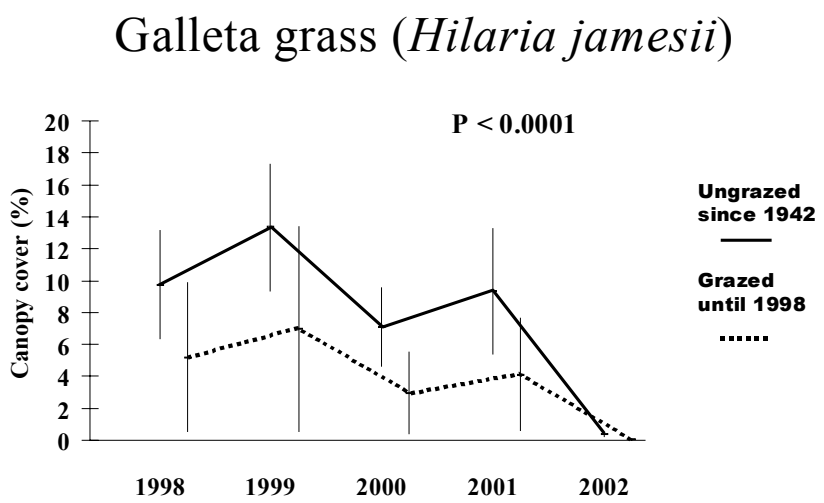
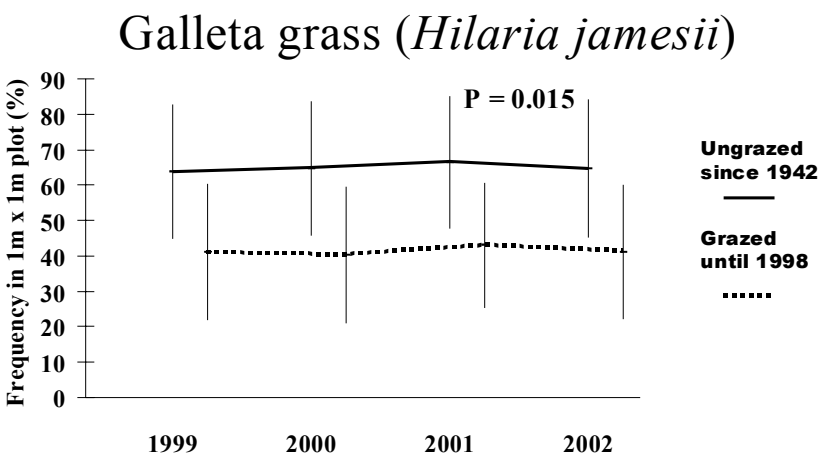
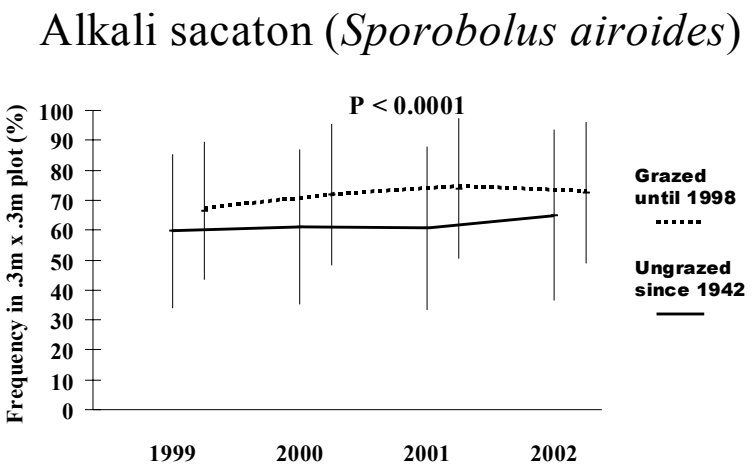
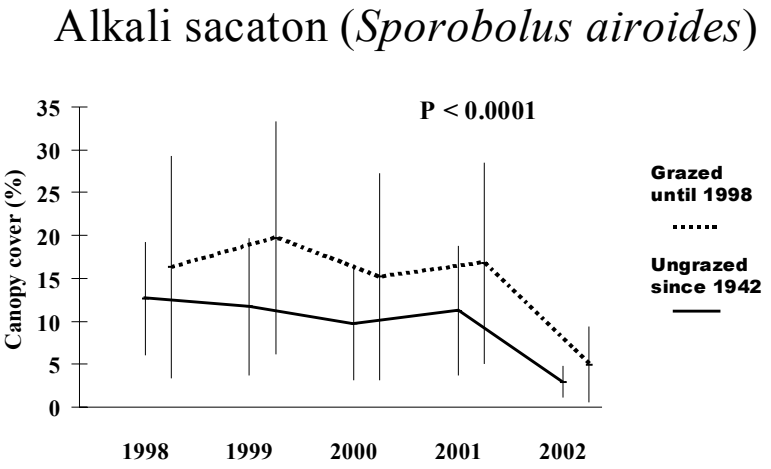


Figure 9 (continued). Mean canopy cover, density, and frequency for species within the **greasewood shrubland** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 3 plots ungrazed. Sample size for 1999-2002 is 7 plots grazed, 5 plots ungrazed. P-values calculated using 1999-2002 data.







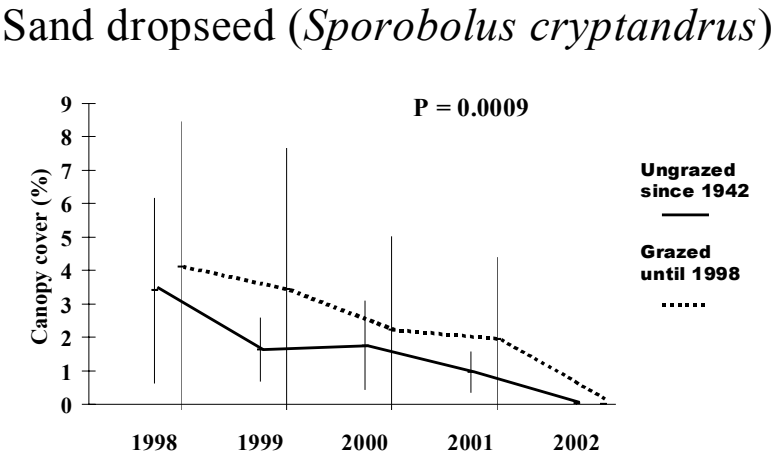


Figure 9 (continued). Mean canopy cover, density, and frequency for species within the **greasewood shrubland** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 3 plots ungrazed. Sample size for 1999-2002 is 7 plots grazed, 5 plots ungrazed. P-values calculated using 1999-2002 data.

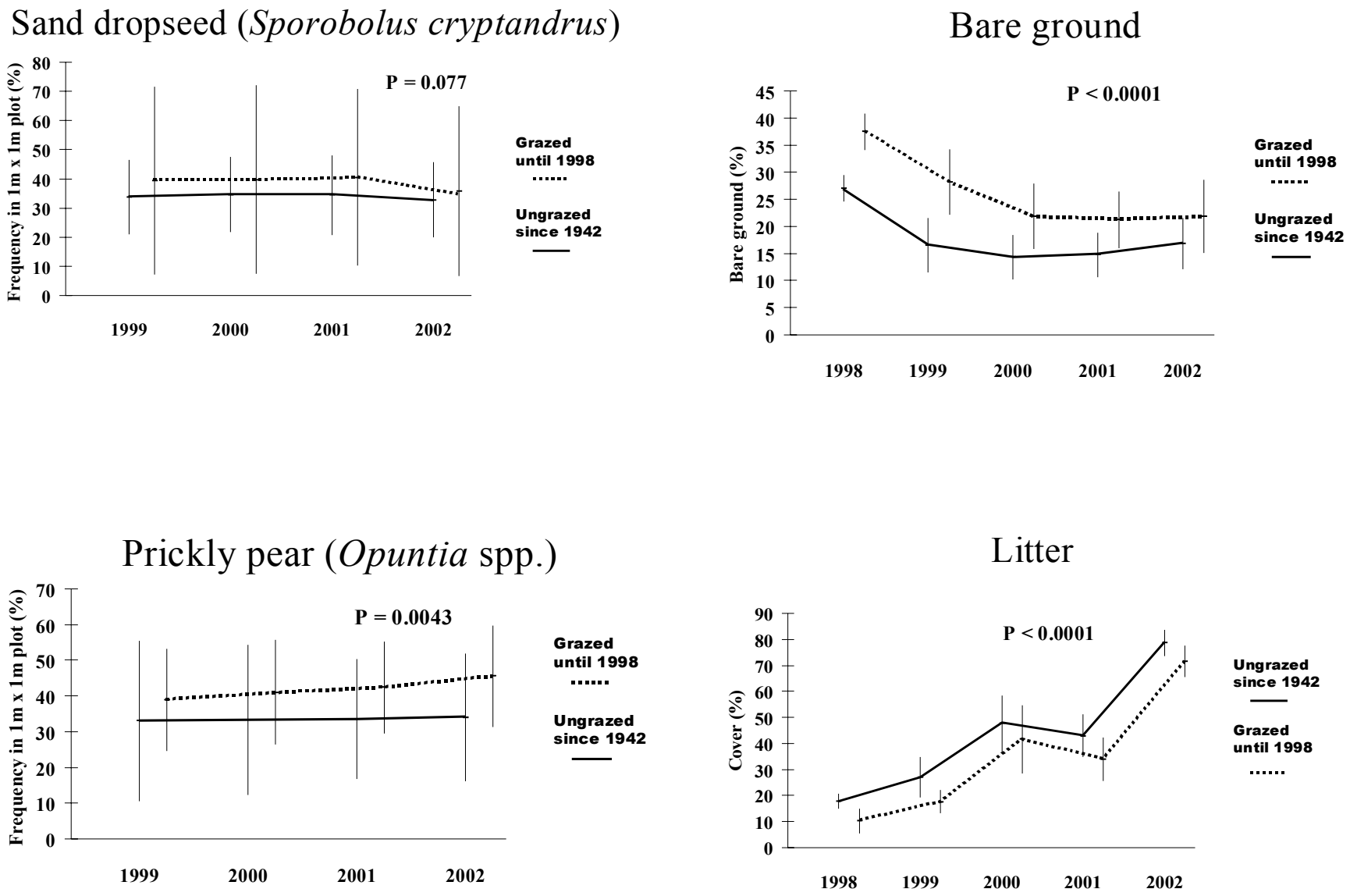
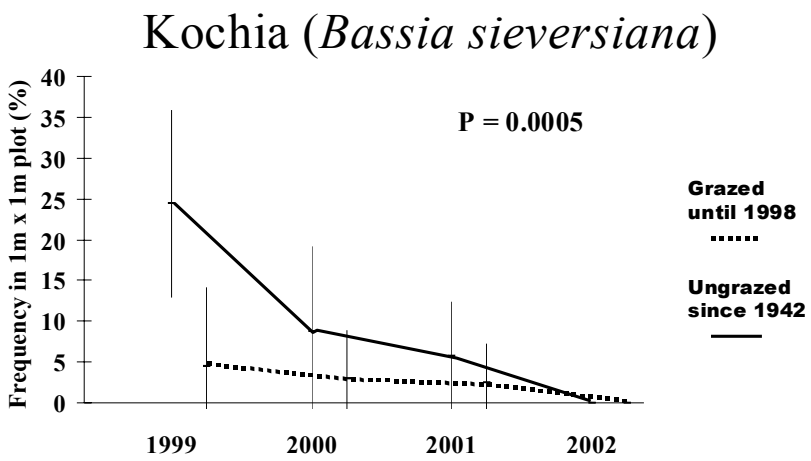


Figure 9 (continued). Mean canopy cover, density, and frequency for species within the **greasewood shrubland** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 3 plots ungrazed. Sample size for 1999-2002 is 7 plots grazed, 5 plots ungrazed. P-values calculated using 1999-2002 data.



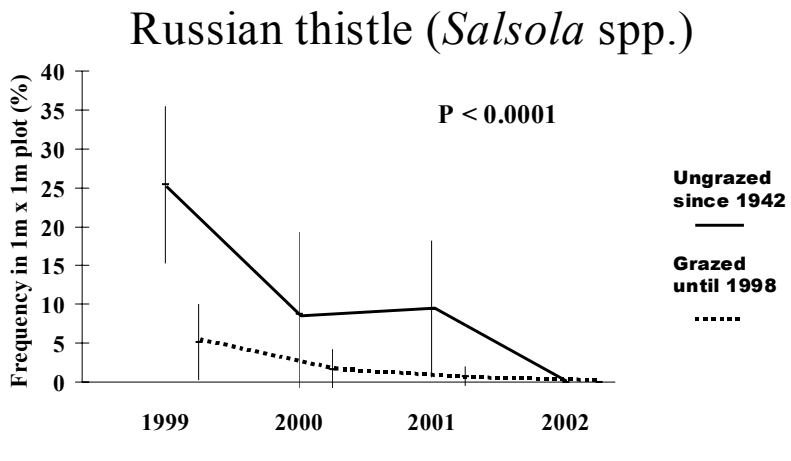


Figure 9 (continued). Mean canopy cover, density, and frequency for species within the **greasewood shrubland** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 3 plots ungrazed. Sample size for 1999-2002 is 7 plots grazed, 5 plots ungrazed. P-values calculated using 1999-2002 data.

Table 1. Desired trend for management objectives for **greasewood shrubland** vegetation on grazed areas at PCD. Cover and frequency are percent. Density is individuals per 0.04 hectare. Sample size for grazed = 7 plots, sample size for ungrazed = 5 plots. F4 = 1m x 1m frequency plot; F3 = .3m x .3m frequency plot. Kochia and Russian thistle were not within the stated management objectives.

Species		Observed differences		P-value	Stated expected direction of difference (grazed vs. ungrazed)	Observed direction of difference (grazed vs. ungrazed)
		Grazed (mean)	Ungrazed (mean)			
Greasewood						
1999	*Cover*	3	4	ns	>	0
	Density	14	10	ns	>	0
2001	*Cover*	4	3	ns	>	0
	Density	11	11	ns	>	0
Rabbitbrush						
1999	*Cover*	3	5	ns	>	0
	Density	18	25	ns	>	0
2001	*Cover*	3	5	ns	>	0
	Density	15	25	ns	>	<
Three-awn grass (F4)						
1999	*Cover*	1	0	ns	>	0
	Frequency	8	4	ns	>	0
2001	*Cover*	1	0	ns	>	0
	Frequency	6	4	ns	>	0
Blue grama grass (F3)						
1999	*Cover*	20	25	ns	>	0
	Frequency	51	62	ns	>	0
2001	*Cover*	19	19	ns	>	0
	Frequency	58	66	ns	>	0
Galleta grass (F4)						
1999	*Cover*	7	13	0.08	<	<
	Frequency	41	64	0.07	<	<
2001	*Cover*	4	9	0.04	<	<
	Frequency	43	66	0.07	<	<
Alkali sacaton grass (F3)						
1999	*Cover*	20	12	ns	>	0
	Frequency	45	27	ns	>	0
2001	*Cover*	17	11	ns	>	0
	Frequency	54	32	ns	>	0
Sand dropseed (F4)						
1999	*Cover*	3	2	ns	>	0
	Frequency	39	34	ns	>	0
2001	*Cover*	2	1	ns	>	0
	Frequency	40	34	ns	>	0

Table 1 continued. Desired trend for management objectives for **greasewood shrubland** vegetation on grazed areas at PCD. Cover and frequency are percent. Density is individuals per 0.04 hectare. Sample size for grazed = 7 plots, sample size for ungrazed = 5 plots. F4 = 1m x 1m frequency plot; F3 = .3m x .3m frequency plot. Kochia and Russian thistle were not within the stated management objectives.

Species		Observed differences		P-value	Stated expected direction of difference (grazed vs. ungrazed)	Observed direction of difference (grazed vs. ungrazed)
		Grazed (mean)	Ungrazed (mean)			
Prickly pear (F4)						
1999	*Frequency*	39	33	ns	>	0
2001	*Frequency*	42	34	ns	>	0
Bare ground						
1999	*Cover*	28	17	0.006	>	>
2001	*Cover*	21	15	0.04	>	>
Litter						
1999	*Cover*	18	27	0.06	<	<
2001	*Cover*	34	43	0.09	<	<
Kochia (F4)						
1999	*Frequency*	5	24	0.01	na	<
2001	*Frequency*	3	6	ns	na	0
Russian thistle (F4)						
1999	*Frequency*	5	25	0.005	na	<
2001	*Frequency*	1	9	0.04	na	<

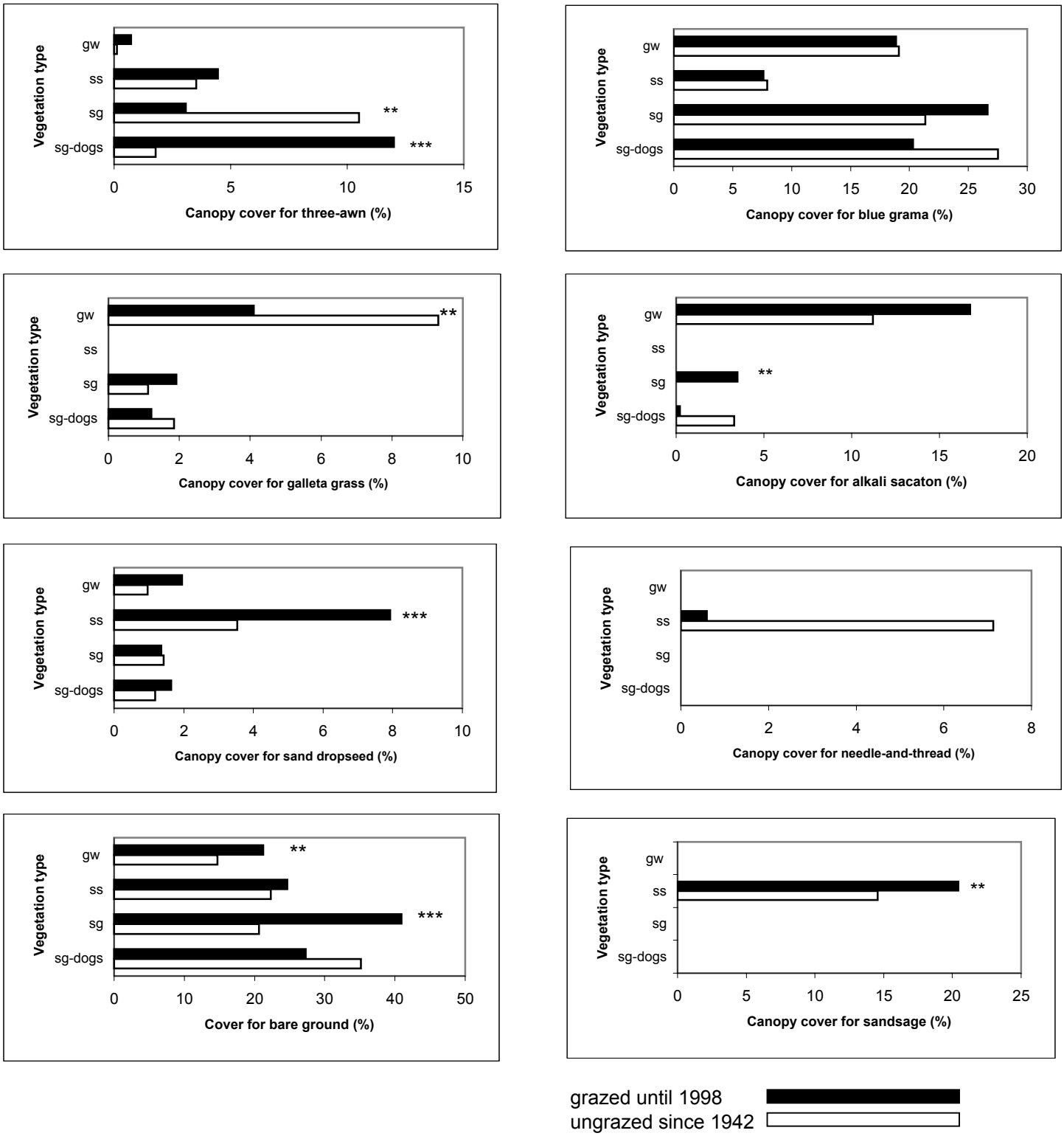
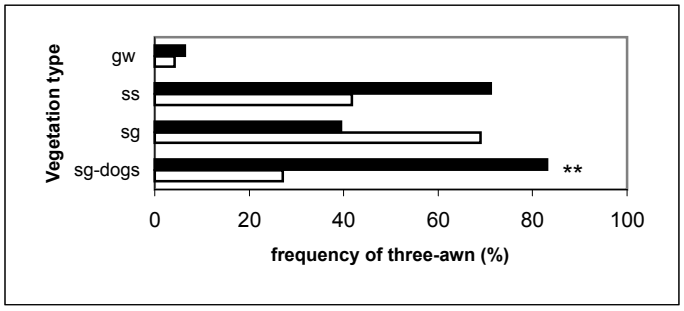
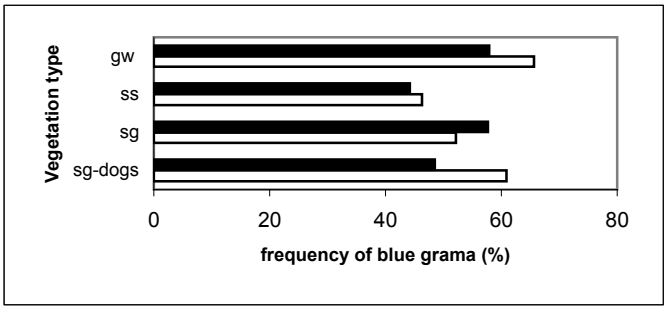
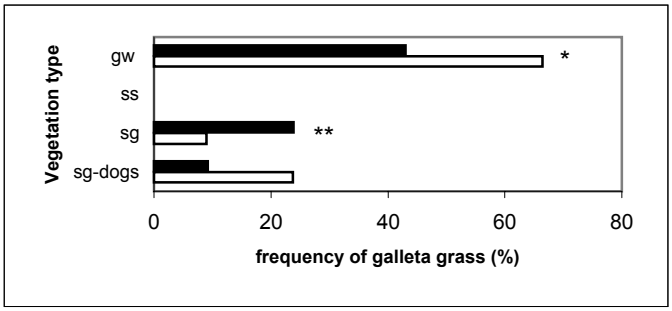
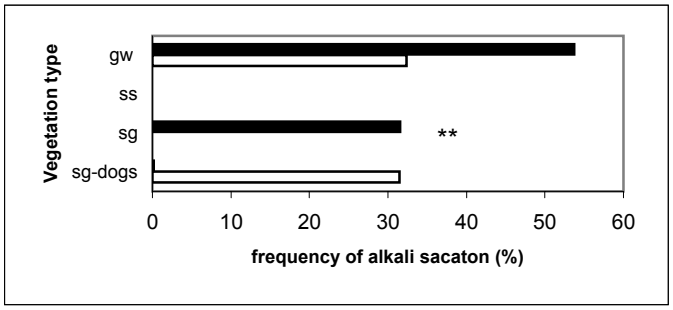


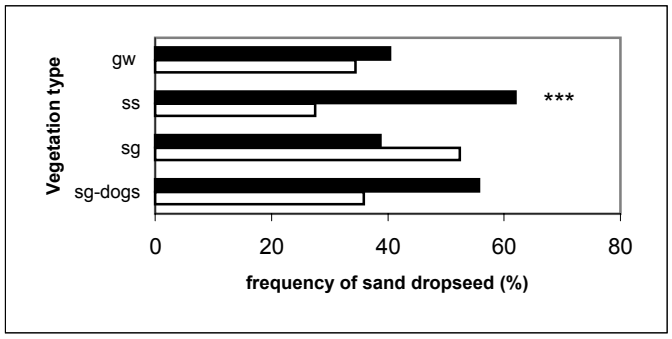
Figure 10. Mean canopy cover of six grasses, sandsage, and bare ground in 2001 within three different vegetation types: greasewood (gw), sandsage (ss), and shortgrass (sg).
Shortgrass-dogs indicates presence (grazed) or absence (ungrazed) of prairie dog town.
* = significant at 0.1, ** = significant at 0.05, *** = significant at 0.01
Sample size gw (7 plots grazed, 5 plots ungrazed); ss (5 plots grazed, 6 plots ungrazed)
sg (7 plots grazed, 6 plots ungrazed); sg-dogs (6 plots no dogs, 7 plots with dogs)
32 microplots per plot for grasses and bare ground; 4 50 m transects per plot for sandsage.

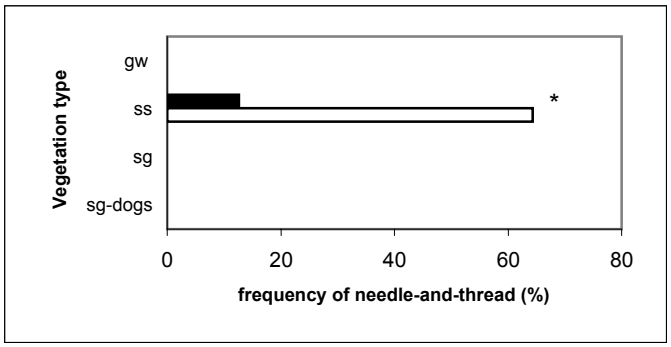


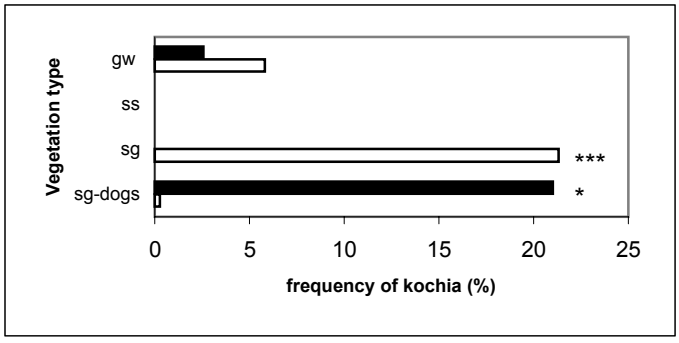


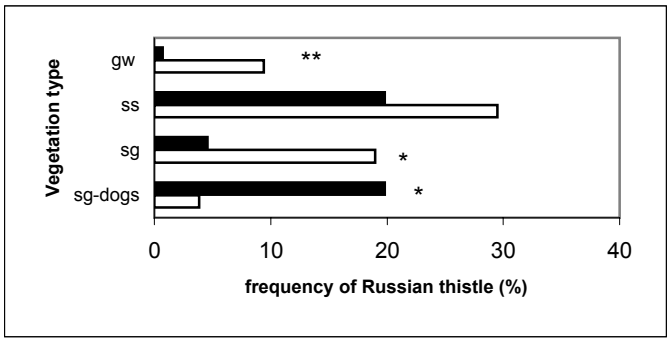


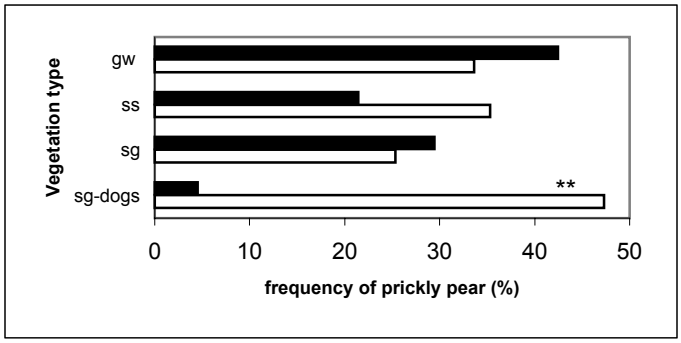












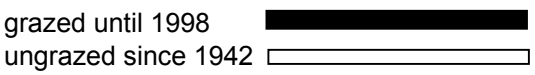


Figure 11. Mean frequency of grasses and forbs in 2001 within three different vegetation types: greasewood (gw), sandsage (ss), and shortgrass (sg). Shortgrass-dogs indicates presence (grazed) or absence (ungrazed) of prairie dog town.
* = significant at 0.1, ** = significant at 0.05,
*** = significant at 0.01

Sample size gw (7 plots grazed, 5 plots ungrazed); ss (5 plots grazed, 6 plots ungrazed)
sg (7 plots grazed, 6 plots ungrazed); sg-dogs (6 plots no dogs, 7 plots with dogs)

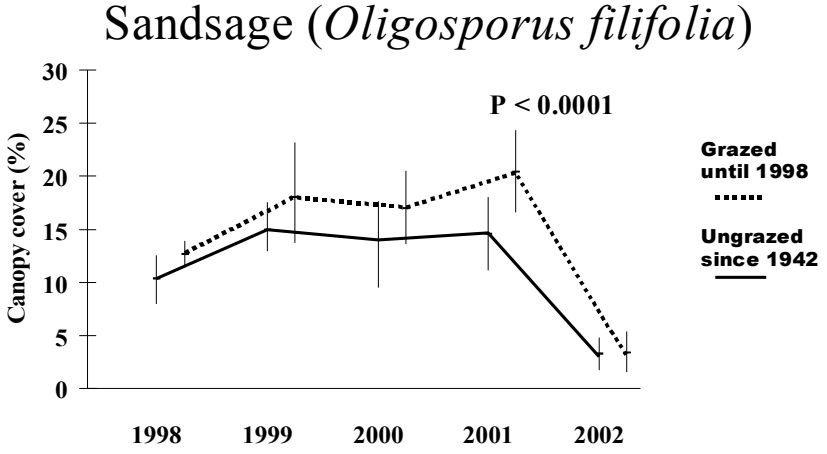
T-tests or Mann-Whitney *U*-tests confirmed a difference between grazed and ungrazed plots for frequency of sand dropseed and needle-and-thread grass (Table 2). Sand dropseed had significantly higher frequency in grazed plots (54% in 1999) versus ungrazed plots (28% in 1999) (P=0.01). Needle-and-thread grass had significantly lower frequency in grazed plots (9% in 2000) versus ungrazed plots (61% in 2000) (P=0.07). However, *t*-tests did not substantiate all of the expected differences for the other species. Sandsage, three-awn, blue grama, prickly pear, bare ground, litter, and Russian thistle had little or no difference between grazed and ungrazed plots in cover, frequency, or density. Results were similar for 1999 and 2001 data with the exception that in 2001, sandsage cover was lower in grazed plots than ungrazed plots (Table 2; Figs. 10 and 11).

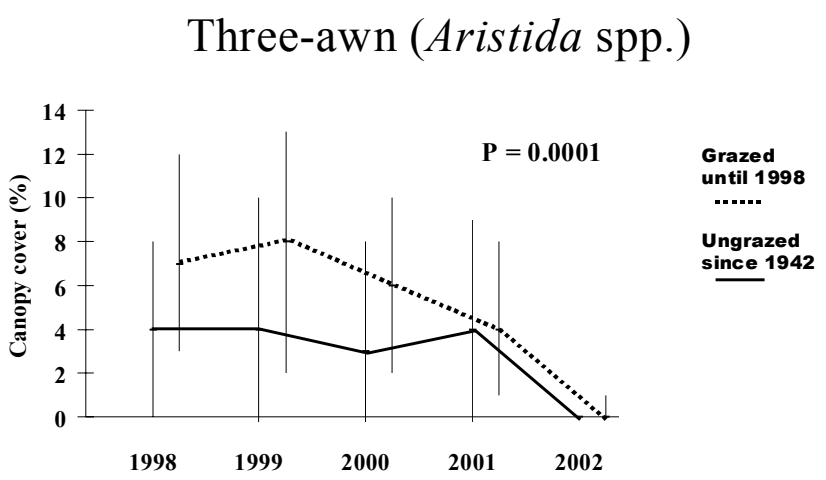
Shortgrass Prairie[2]

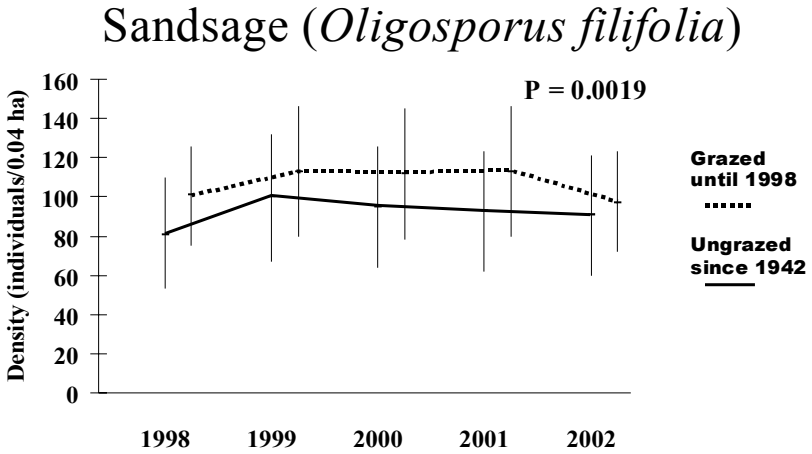
The year-to-year variation was significant for cover of blue grama, three-awn grass, and litter (Fig. 13; Table C-7). The trend closely followed the annual variation in precipitation with increases in cover with average and above average precipitation and decreases in cover with below average precipitation. Bare ground and litter are notable exceptions. The amount of bare ground decreased monotonically from 1998 to 2000, remained nearly stable in 2001, and increased with the drought conditions of 2002 (Fig. 13; Table C-7). Litter generally remained stable between years 1998 and 1999, and significantly increased in 2000 and 2002 (both years had below average precipitation).

The year-to-year variation in frequency of most species was not significant, with the exception of blue grama and sand dropseed (Fig. 13; Table C-8). Blue grama increased in percent frequency in year 2000 in plots with prairie dogs that were impacted by the 1999 plague (sg61ug, sg70g, sg78g) (Fig. 14; Table C-8). The plots that had active prairie dog towns in 2002 had a significant decrease in percent frequency of blue grama (sg61ug, sg77g, and sg81ug [sg80ug had no blue

[2] Plot sg63ug was excluded from statistical analyses because it still has pass-through cattle grazing.







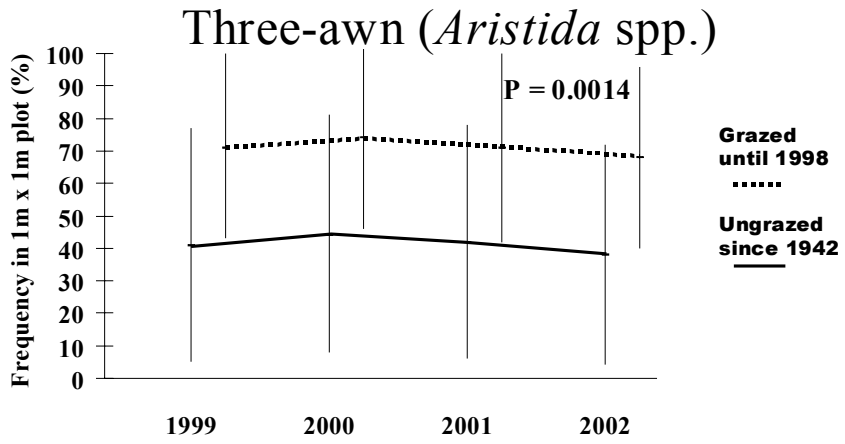
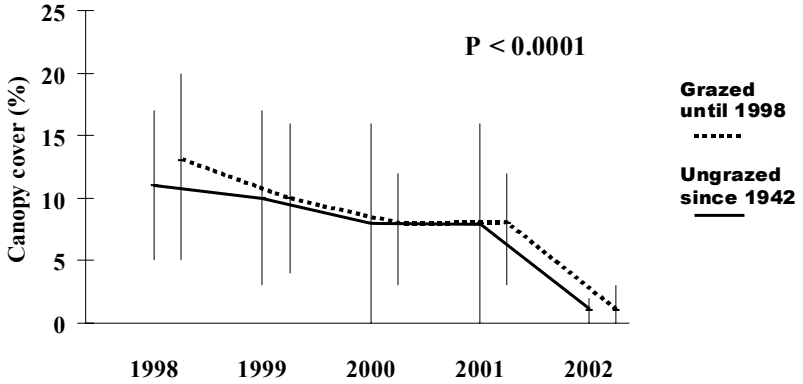
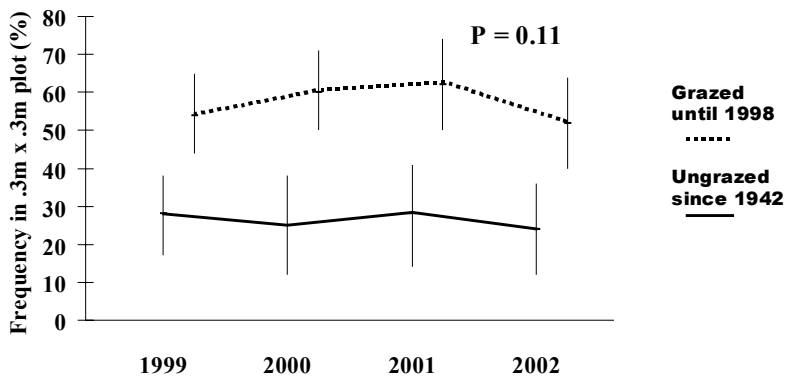
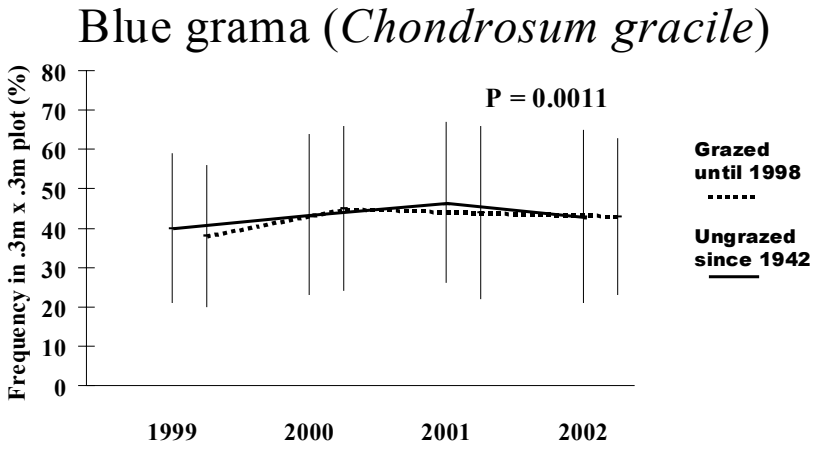


Figure 12. Mean canopy cover, density, and frequency for species within the **sandsage shrubland** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 5 plots ungrazed. Sample size for 1999-2002 is 5 plots grazed, 6 plots ungrazed. P-values calculated using 1999-2002 data.







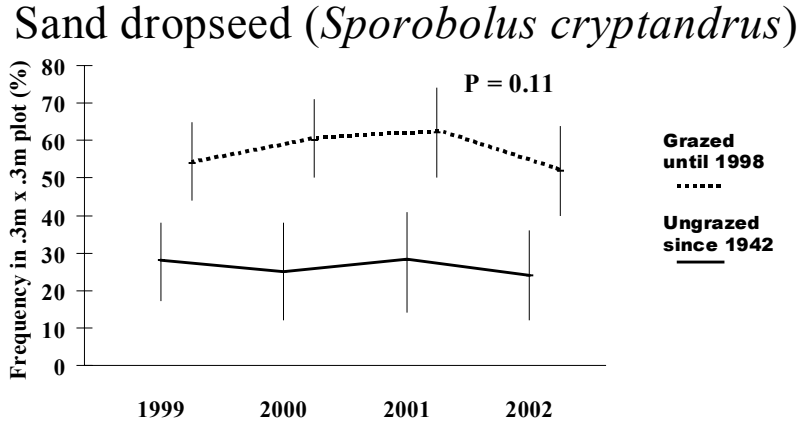
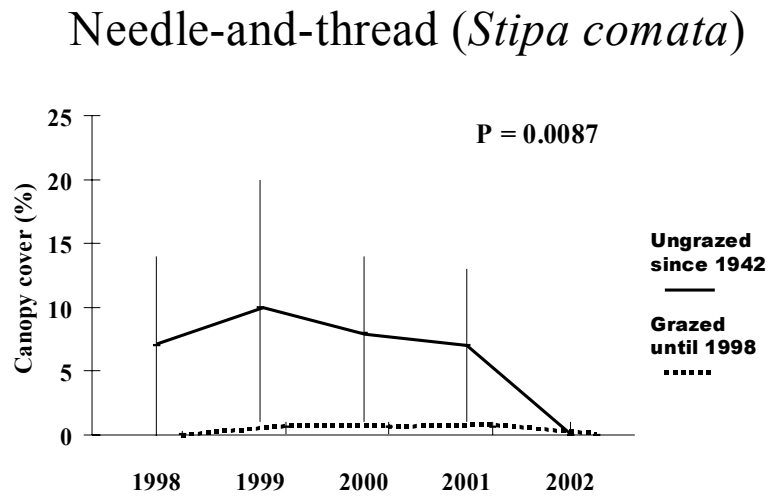
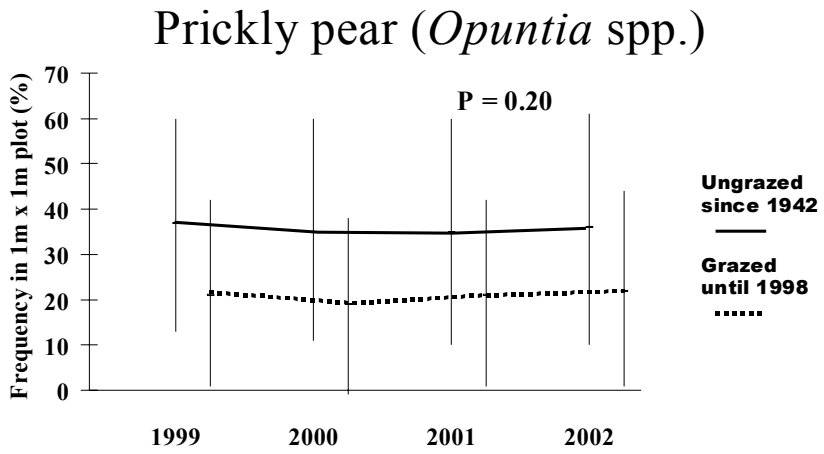
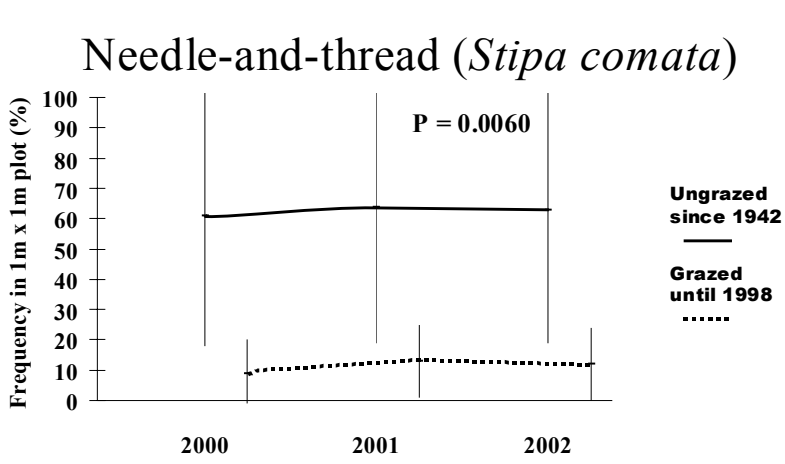


Figure 12 (continued). Mean canopy cover, density, and frequency for species within the **sandsage shrubland** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 5 plots ungrazed. Sample size for 1999-2002 is 5 plots grazed, 6 plots ungrazed. P-values calculated using 1999-2002 data.







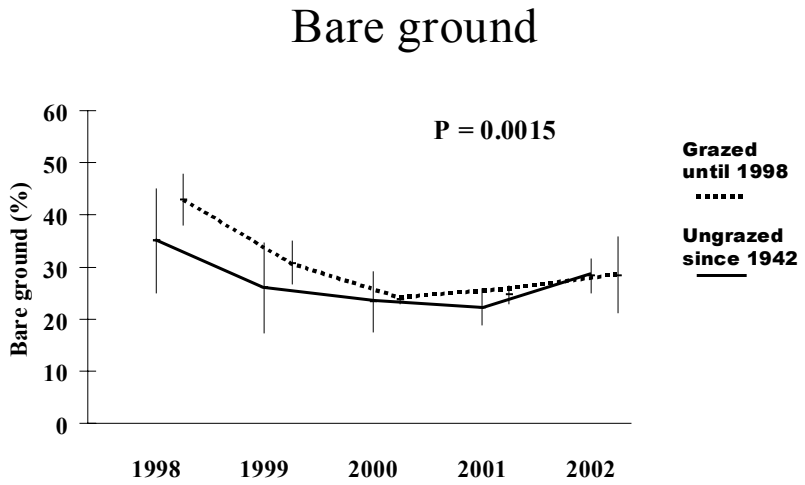
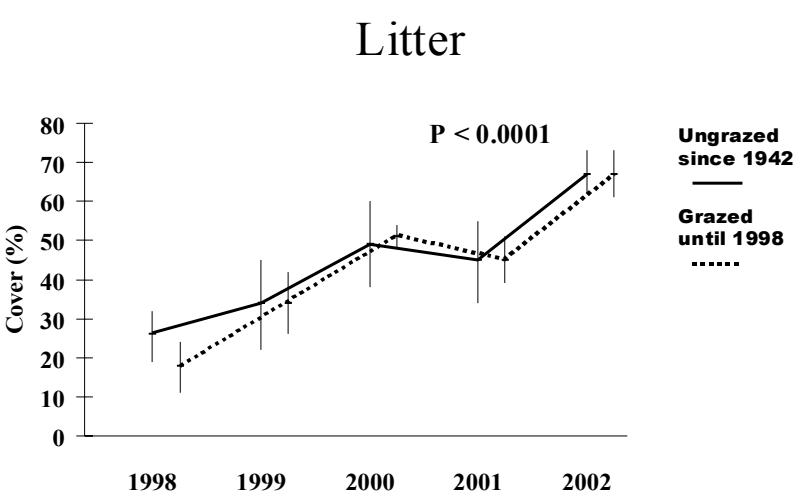


Figure 12 (continued). Mean canopy cover, density, and frequency for species within the **sandsage shrubland** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 5 plots ungrazed. Sample size for 1999-2002 is 5 plots grazed, 6 plots ungrazed. P-values calculated using 1999-2002 data.



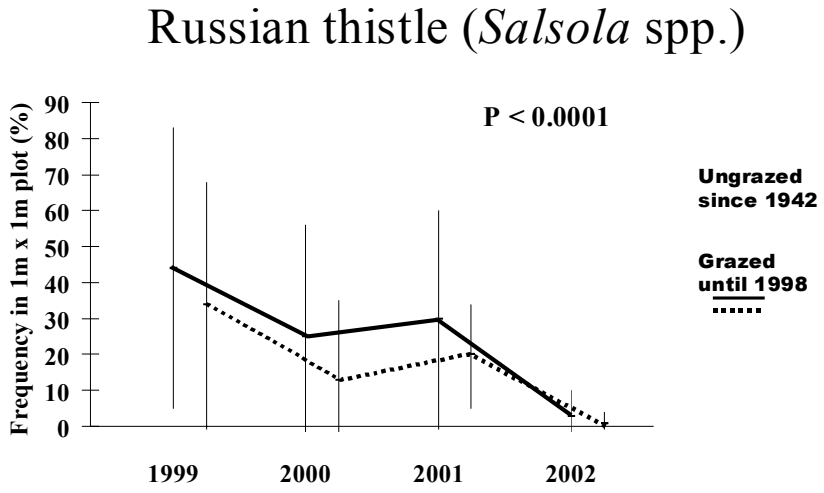


Figure 12 (continued). Mean canopy cover, density, and frequency for species within the **sandsage shrubland** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 5 plots ungrazed. Sample size for 1999-2002 is 5 plots grazed, 6 plots ungrazed. P-values calculated using 1999-2002 data.

Table 2. Desired trend for management objectives for **sandsage shrubland** vegetation on grazed areas at PCD. Cover and frequency are percent. Density is individuals per 0.04 hectare. Sample size for grazed = 5 plots, sample size for ungrazed = 6 plots. F4 = 1m x 1m frequency plot; F3 = .3m x .3m frequency plot. Russian thistle was not within the stated management objectives.

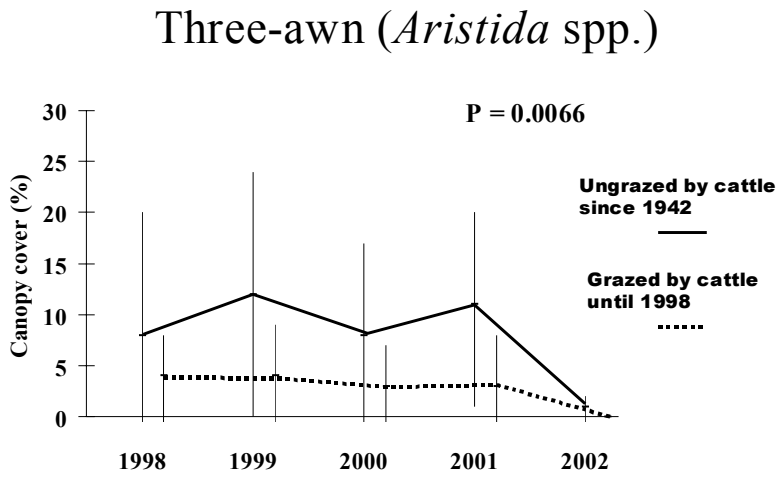
Species		Observed differences		P-value	Stated expected direction of difference (grazed vs. ungrazed)	Observed direction of difference (grazed vs. ungrazed)
		Grazed (mean)	Ungrazed (mean)			
Sandsage						
1999	*Cover*	18	15	ns	>	0
	Density	113	100	ns	>	0
2001	*Cover*	20	15	0.03	>	>
	Density	113	93	ns	>	0
Three-awn grass (F4)						
1999	*Cover*	8	4	ns	>	0
	Frequency	71	41	ns	>	0
2001	*Cover*	4	4	ns	>	0
	Frequency	71	42	ns	>	0
Blue grama grass (F3)						
1999	*Cover*	10	10	ns	>	0
	Frequency	38	40	ns	>	0
2001	*Cover*	8	8	ns	>	0
	Frequency	44	46	ns	>	0
Sand dropseed (F3)						
1999	*Cover*	8	5	ns	>	0
	Frequency	54	28	0.01	>	>
2001	*Cover*	8	4	0.01	>	>
	Frequency	62	50	0.006	>	>
Needle-and-thread grass (F4)						
1999	*Cover*	1	10	ns	<	0
2000	*Frequency*	9	61	0.07	<	<
2001	*Cover*	1	7	ns	<	0
	Frequency	13	64	0.1	<	<
Prickly pear (F4)						
1999	*Frequency*	21	37	ns	>	0
2001	*Frequency*	21	35	ns	>	0
Bare ground						
1999	*Cover*	31	26	ns	>	0
2001	*Cover*	25	22	ns	>	0
Litter						
1999	*Cover*	34	34	ns	<	0
2001	*Cover*	45	45	ns	<	0
Russian thistle (F4)						
1999	*Frequency*	34	44	ns	na	0
2001	*Frequency*	20	30	ns	na	0

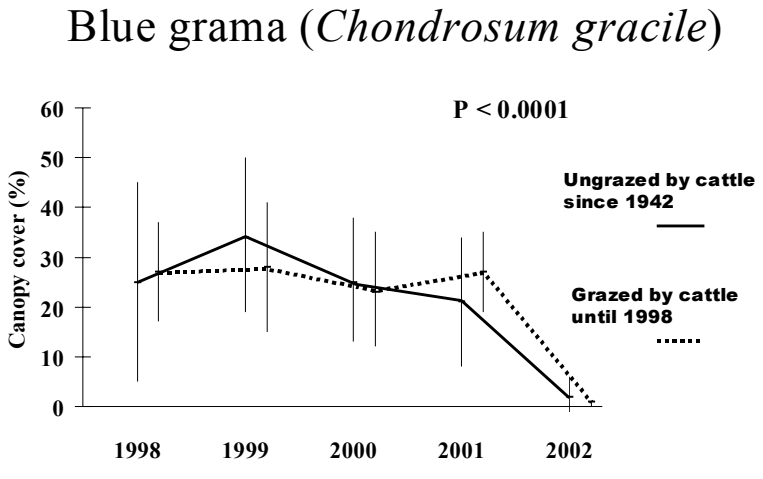
grama to start with and sg70g had a human-induced fire in November of 2001]). Interestingly, prickly pear frequency in sg77g declined in 2001 and 2002 (Table C-8). This plot has had an active prairie dog colony in all sampled years. The year-to-year variation in frequency of the annual weed Russian thistle was significant (Fig. 13; Table C-8).

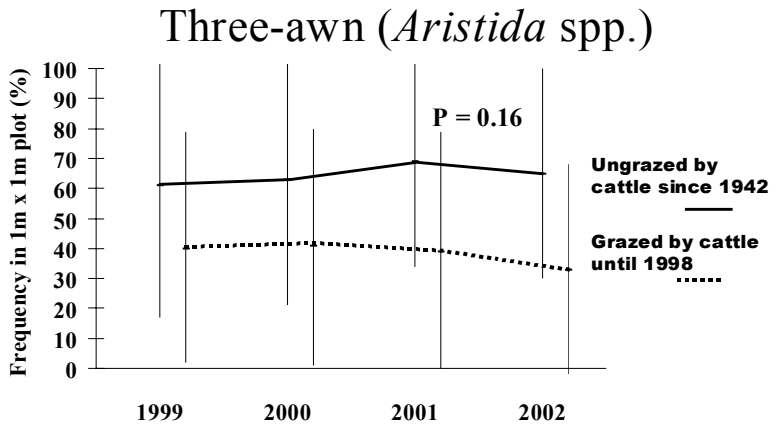
T-tests or Mann-Whitney *U*-tests performed on the 1999 data between grazed and ungrazed plots confirmed a difference between grazed and ungrazed plots for alkali sacaton grass (P=0.06), bare ground (P= 0.008), litter (P=0.02), kochia (P=0.008), and Russian thistle (P=0.05) but did not substantiate all of the expected differences for the other species (Table 3). Blue grama, three-awn grass, galleta grass, sand dropseed, and prickly pear had little or no difference between grazed and ungrazed plots in either cover or frequency. *T*-tests or Mann-Whitney *U*-tests were conducted again with the 2001 data with results similar to the 1999 data with the exceptions that three-awn grass had higher cover in ungrazed versus grazed plots (P=0.05) and galleta grass had higher frequency (P=0.03) in grazed plots versus ungrazed plots (Table 3; Figs. 10 and 11).

Because prairie dogs play such an important role in plant community composition, I conducted *t*-tests or Mann-Whitney *U*-tests between plots with prairie dogs and without prairie dogs (Table 4; Figs. 10 and 11). There was significantly lower frequency of prickly pear on prairie dog colonies than off (P=0.008 [1999] and P=0.0003 [2001]), and higher frequency and cover of three-awn grass) (Table 4; Figs. 10, 11, and 19). In 2001, plots within prairie dog colonies had a higher frequency of the annual weeds kochia and Russian thistle relative to plots without prairie dogs (Table 4; Figs. 10 and 11). Bare ground, litter, and other species did not significantly differ between plots with prairie dogs and plots without prairie dogs.

Results for all of the shortgrass prairie plots are reported (Appendix C, Tables C-7 and C-8) but sg63ug was not included in the statistical analyses.







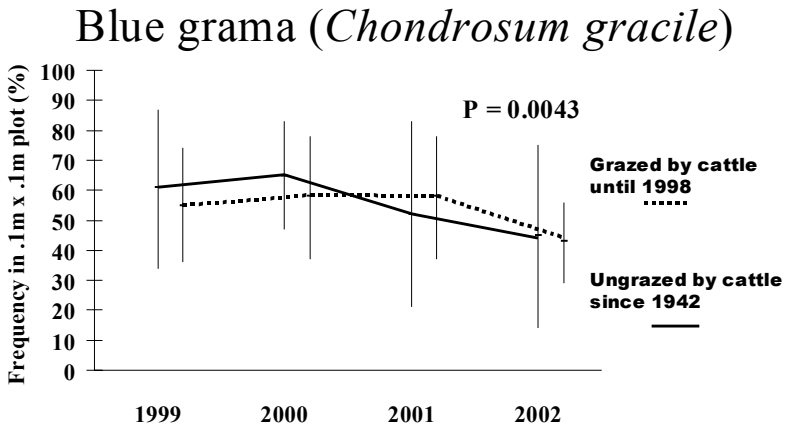
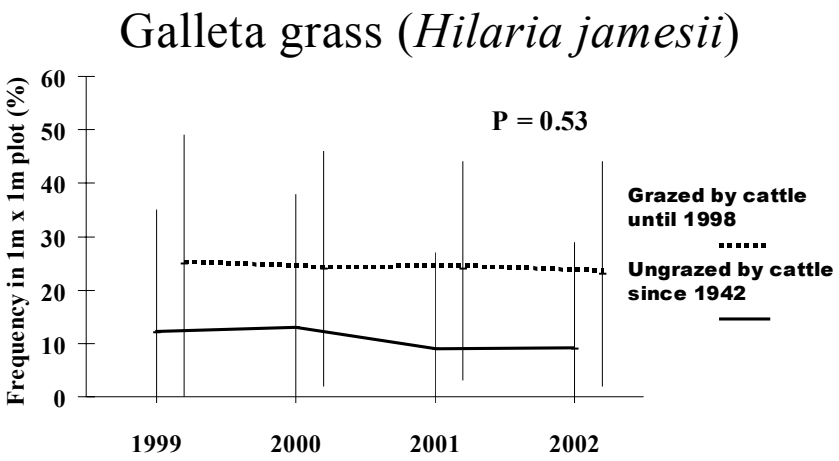
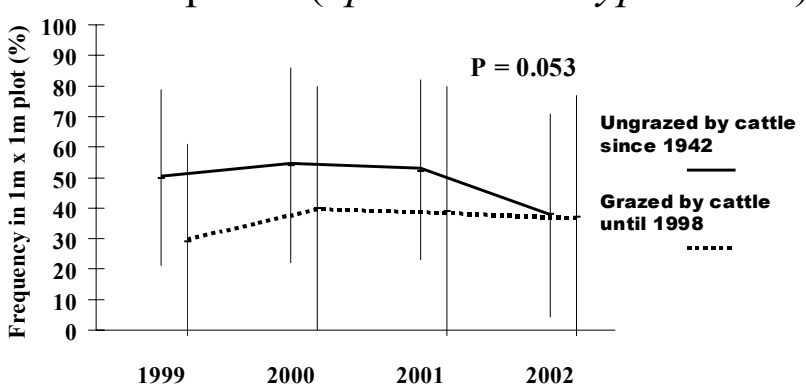
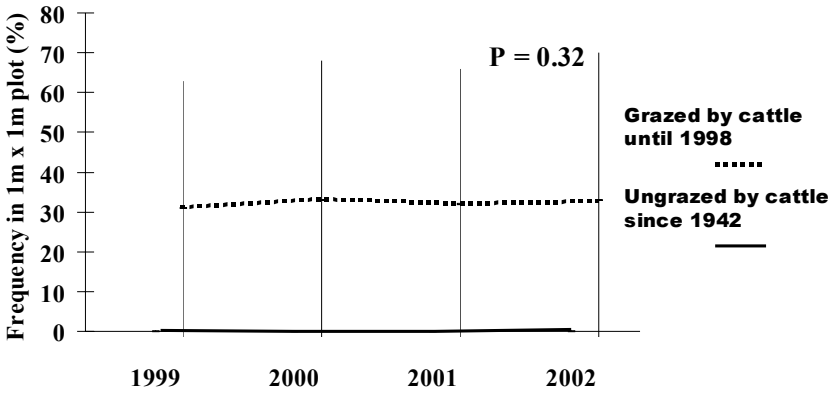


Figure 13. Mean canopy cover and frequency for species within the **shortgrass prairie** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 2 plots ungrazed. Sample size for 1999-2000 is 7 plots grazed, 4 plots ungrazed. Sample size for 2001-2002 is 7 plots grazed, 6 plots ungrazed. P-values calculated using 1999-2002 data.







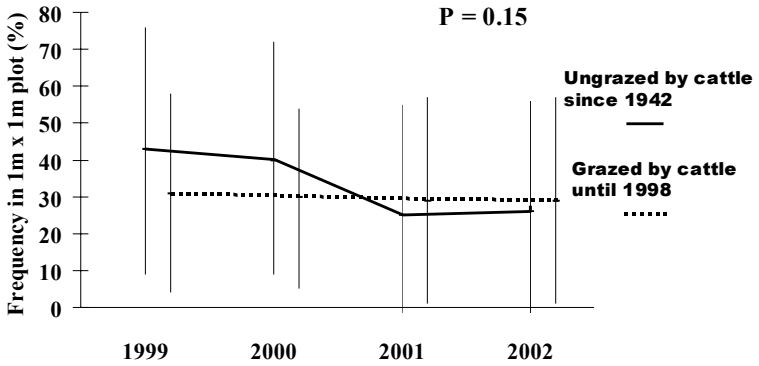
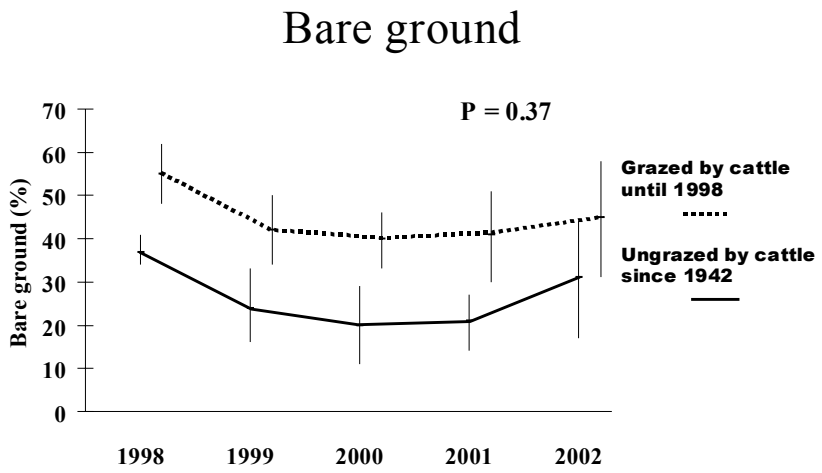
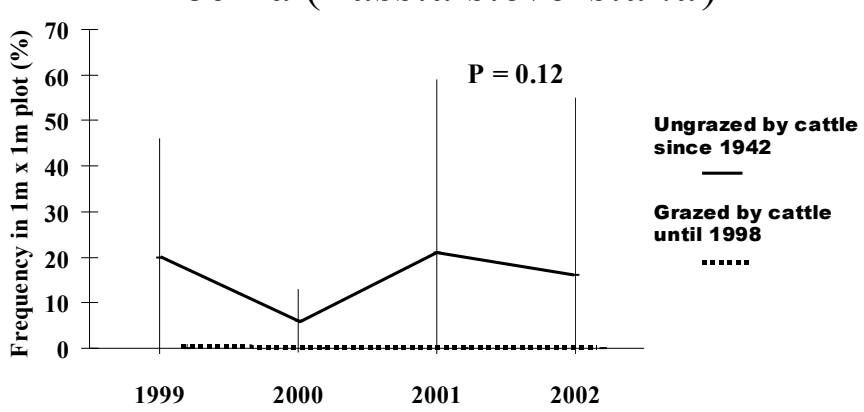
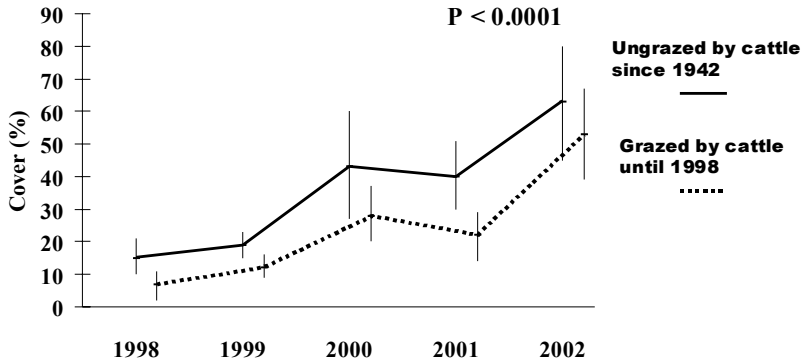


Figure 13 (continued). Mean canopy cover and frequency for species within the **shortgrass prairie** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 2 plots ungrazed. Sample size for 1999-2000 is 7 plots grazed, 4 plots ungrazed. Sample size for 2001-2002 is 7 plots grazed, 6 plots ungrazed. P-values calculated using 1999-2002 data.







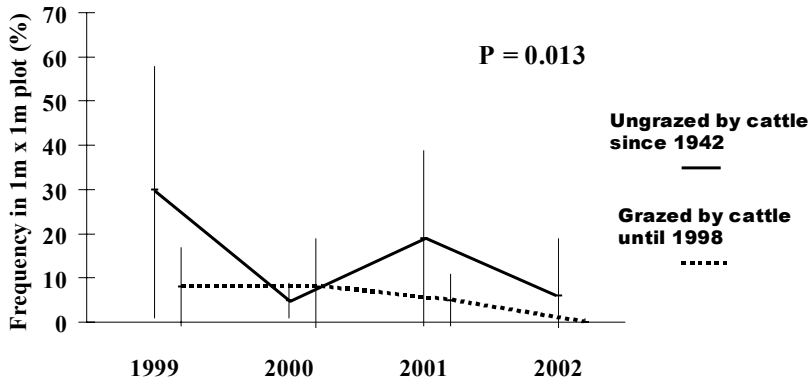
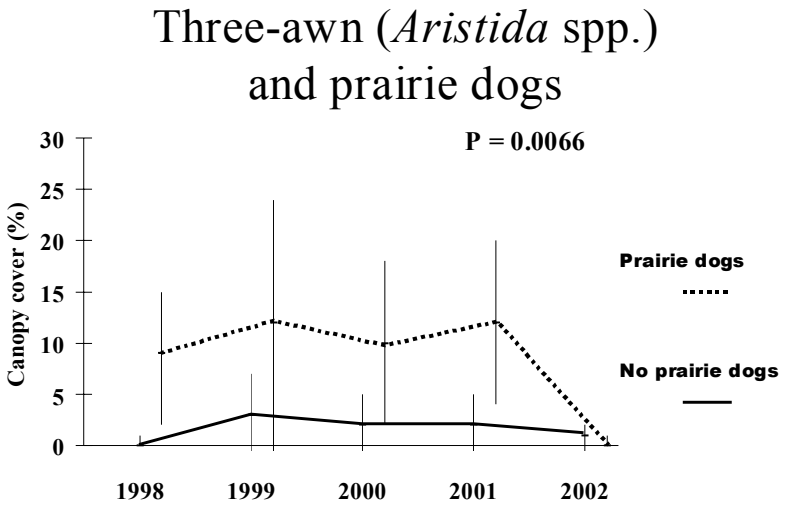
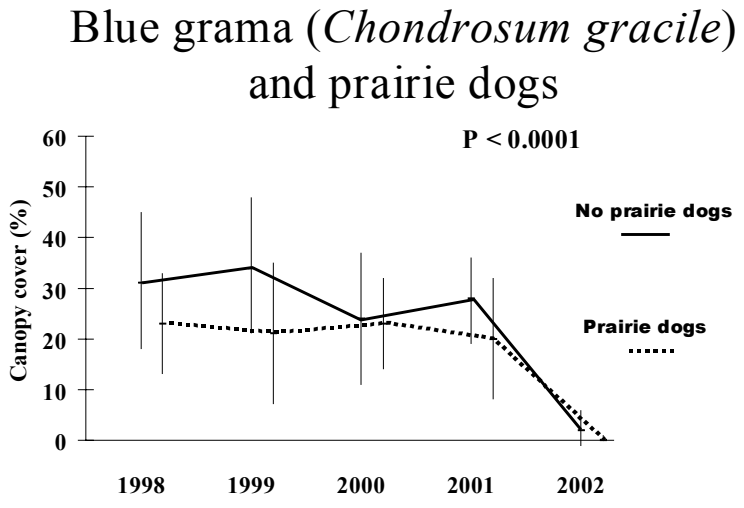


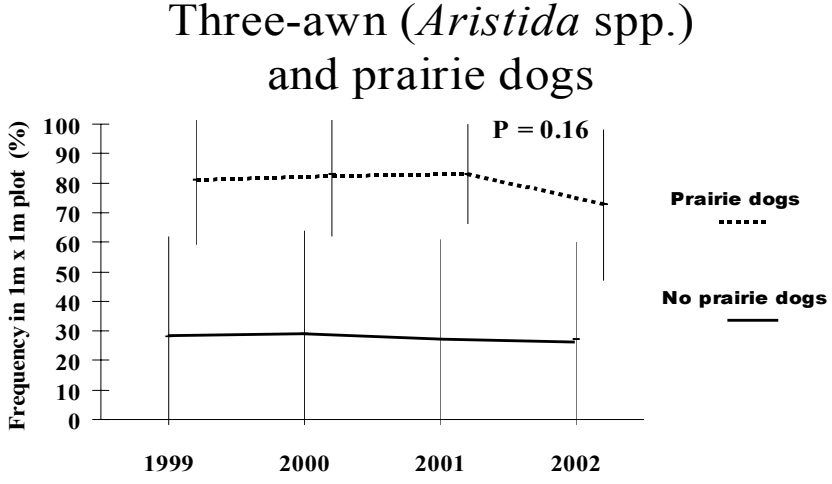
Figure 13 (continued). Mean canopy cover and frequency for species within the **shortgrass prairie** (bars indicate +/- one standard deviation). Sample size for 1998 is 5 plots grazed, 2 plots ungrazed. Sample size for 1999-2000 is 7 plots grazed, 4 plots ungrazed. Sample size for 2001-2002 is 7 plots grazed, 6 plots ungrazed. P-values calculated using 1999-2002 data.

Table 3. Desired trend for management objectives for **shortgrass prairie** vegetation on grazed areas at PCD. Cover and frequency are percent. Sample size for grazed = 7 plots, sample size for ungrazed = 4 plots in 1999 and 6 plots in 2001. F4 = 1m x 1m frequency plot; F2 = .1m x .1m frequency plot. Kochia and Russian thistle were not within the stated management objectives.

Species		Observed differences		P-value	Stated expected direction of difference (grazed vs. ungrazed)	Observed direction of difference (grazed vs. ungrazed)
		Grazed (mean)	Ungrazed (mean)			
Three-awn grass (F4)						
1999	*Cover*	4	12	ns	>	0
	Frequency	40	61	ns	>	0
2001	*Cover*	3	11	0.05	>	<
	Frequency	39	69	ns	>	0
Blue grama grass (F2)						
1999	*Cover*	28	34	ns	>	0
	Frequency	55	61	ns	>	0
2001	*Cover*	27	21	ns	>	0
	Frequency	58	52	ns	>	0
Galleta grass (F4)						
1999	*Cover*	3	2	ns	<	0
	Frequency	25	12	ns	<	0
2001	*Cover*	2	1	ns	<	0
	Frequency	24	9	0.03	<	>
Alkali sacaton grass (F4)						
1999	*Cover*	4	0	0.06	>	>
	Frequency	31	0	0.06	>	>
2001	*Cover*	3	0	0.03	>	>
	Frequency	32	0	0.03	>	>
Sand dropseed (F4)						
1999	*Cover*	1	3	ns	>	0
	Frequency	29	50	ns	>	0
2001	*Cover*	1	1	ns	>	0
	Frequency	39	52	ns	>	0
Prickly pear (F4)						
1999	*Frequency*	31	43	ns	>	0
2001	*Frequency*	29	25	ns	>	0
Bare ground						
1999	*Cover*	42	24	0.008	>	>
2001	*Cover*	41	21	0.002	>	>
Litter						
1999	*Cover*	12	19	0.02	<	<
2001	*Cover*	22	40	0.007	<	<
Kochia (F4)						
1999	*Frequency*	0	20	0.008	na	<
2001	*Frequency*	0	21	0.01	na	<
Russian thistle (F4)						
1999	*Frequency*	8	30	0.05	na	<
2001	*Frequency*	*5*	19	0.07	na	<







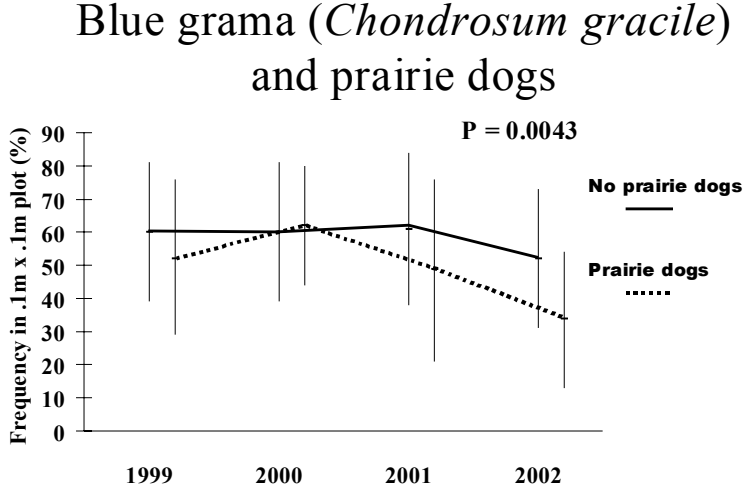
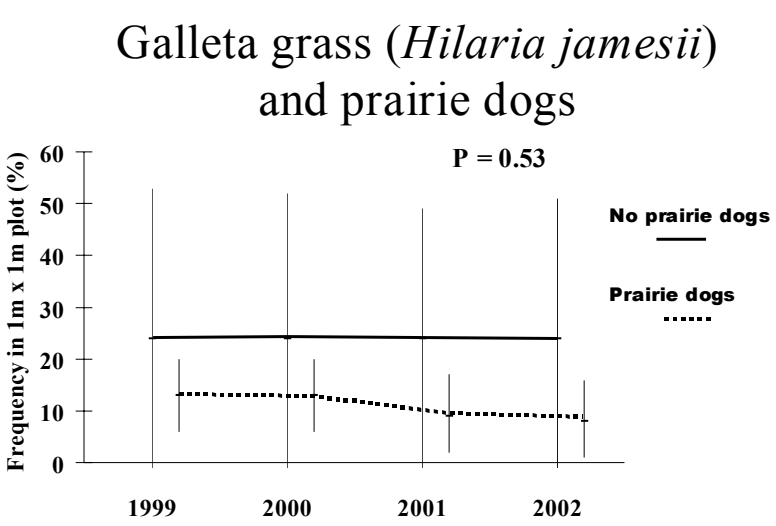
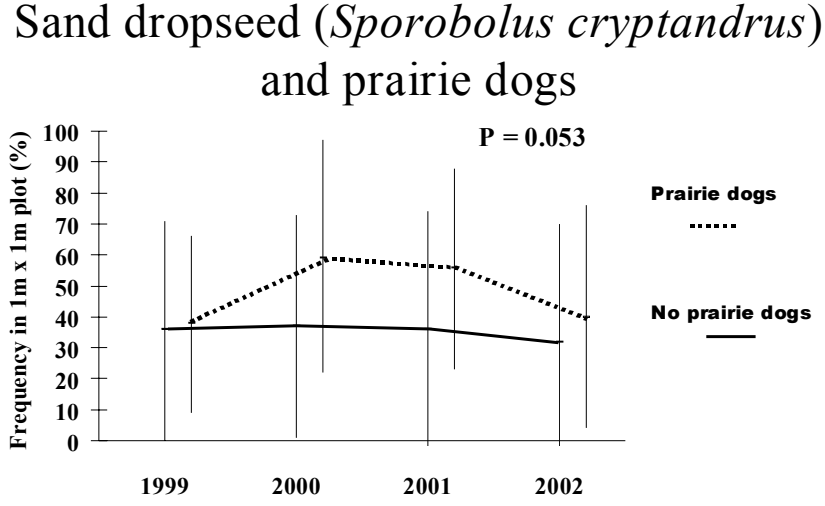
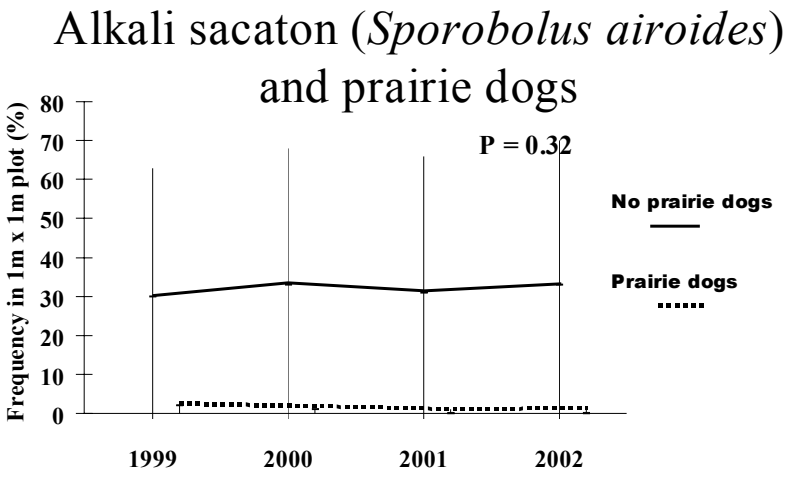


Figure 14. Mean canopy cover and frequency for species within the **shortgrass prairie** with and without **prairie dogs** (bars indicate +/- one standard deviation). Sample size for 1998 is 4 plots with prarie dogs, 3 plots without prairie dogs. Sample size for 1999-2000 is 4 plots with prairie dogs, 7 plots without prairie dogs. Sample size for 2001-2002 is 6 plots with prairie dogs, 7 plots without prairie dogs. P-values calculated using 1999-2002 data.







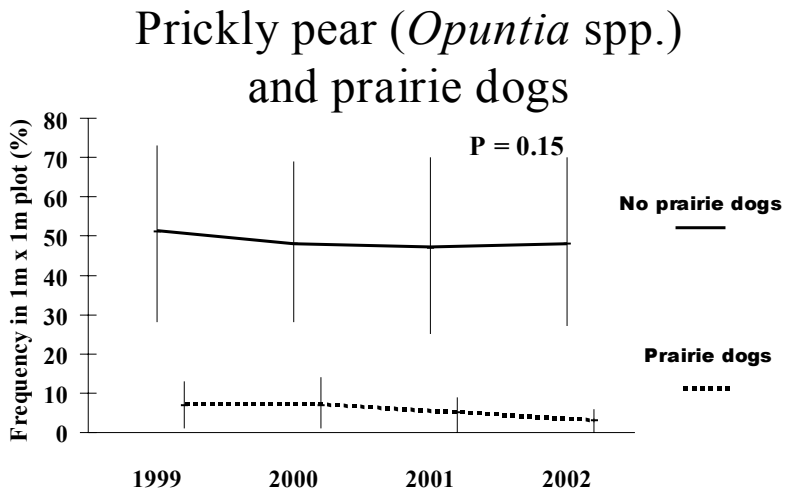
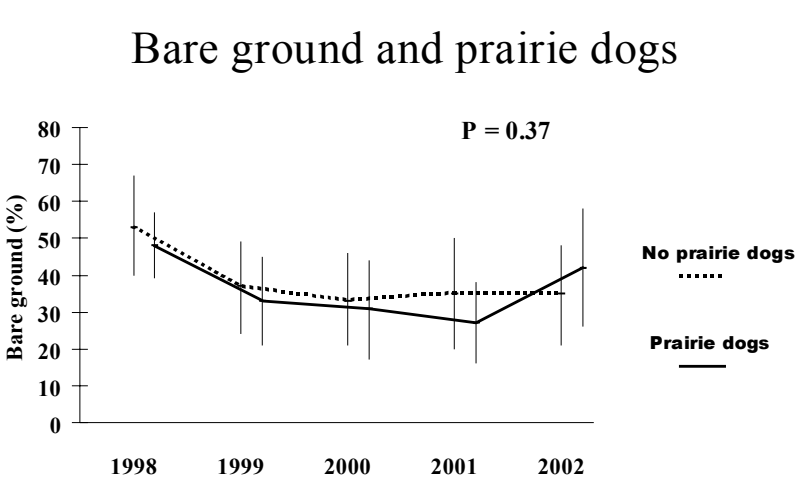
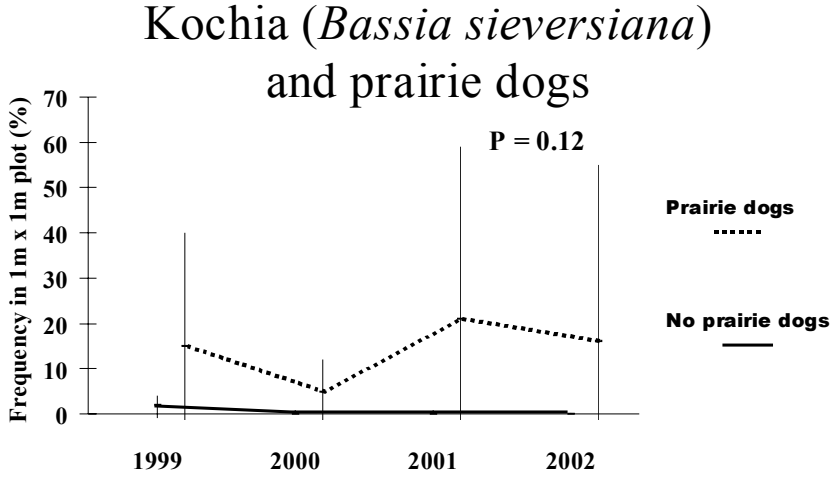
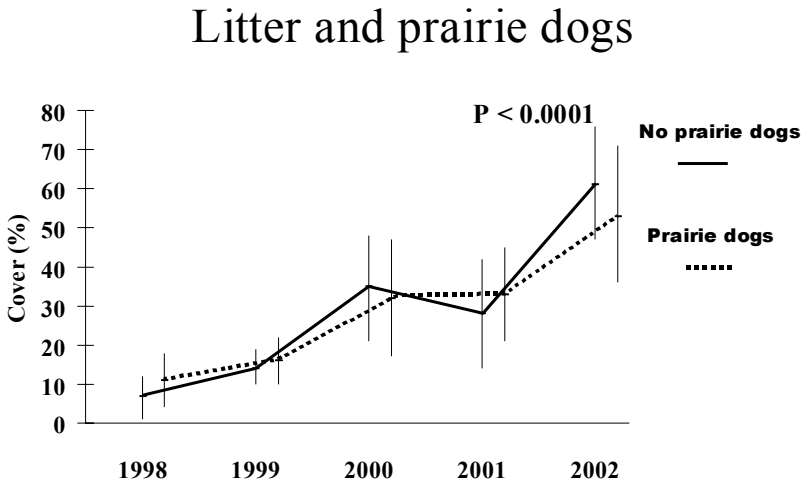


Figure 14 (continued). Mean canopy cover and frequency for species within the **shortgrass prairie** with and without **prairie dogs** (bars indicate +/- one standard deviation). Sample size for 1998 is 4 plots with prairie dogs, 3 plots without prairie dogs. Sample size for 1999-2000 is 4 plots with prairie dogs, 7 plots without prairie dogs. Sample size for 2001-2002 is 6 plots with prairie dogs, 7 plots without prarie dogs. P-values calculated using 1999-2002 data.







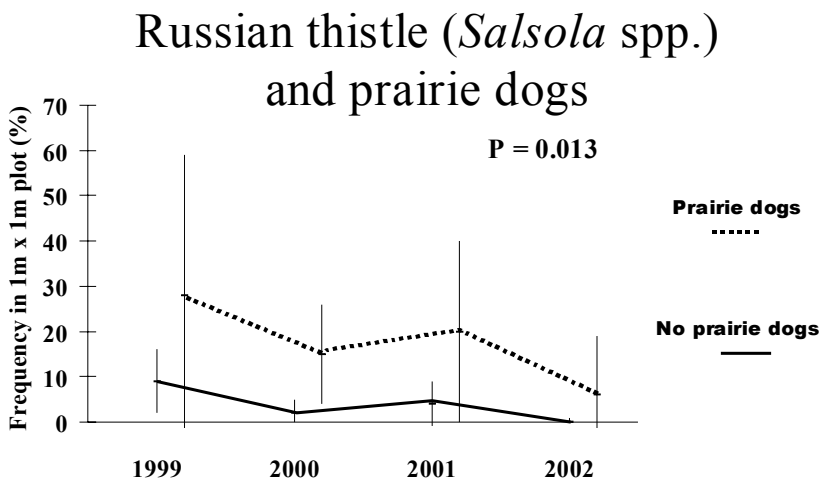


Figure 14 (continued). Mean canopy cover and frequency for species within the **shortgrass prairie** with and without **prairie dogs** (bars indicate +/- one standard deviation). Sample size for 1998 is 4 plots with prairie dogs, 3 plots without prairie dogs. Sample size for 1999-2000 is 4 plots with prairie dogs, 7 plots without prairie dogs. Sample size for 2001-2002 is 6 plots with prairie dogs, 7 plots without prairie dogs. P-values calculated using 1999-2002 data.

Table 4. Expected and observed differences for **shortgrass prairie** plots with **prairie dogs** and without prairie dogs. Cover and frequency are percent. Sample size for prairie dogs = 4 plots in 1999 and 6 plots in 2001, sample size for no prairie dogs = 8 plots. F4 = 1m x 1m frequency plot; F2 = .1m x .1m frequency plot.

Species		Observed differences		P-value	Expected direction of difference (p dogs vs. no p dogs)	Observed direction of difference (p dogs vs. no p dogs)
		Prairie dogs (mean)	No prairie dogs (mean)			
Three-awn grass (F4)						
1999	*Cover*	12	3	0.04	>	>
	Frequency	81	28	0.02	>	>
2001	*Cover*	12	2	0.01	>	>
	Frequency	83	27	0.02	>	>
Blue grama grass (F2)						
1999	*Cover*	21	34	ns	>	0
	Frequency	52	60	ns	>	0
2001	*Cover*	20	28	ns	>	0
	Frequency	49	61	ns	>	0
Galleta grass ((F4)						
1999	*Cover*	2	3	ns	<	0
	Frequency	13	24	ns	<	0
2001	*Cover*	1	2	ns	<	0
	Frequency	9	24	ns	<	0
Alkali sacaton grass (F4)						
1999	*Cover*	0	4	ns	>	0
	Frequency	2	30	ns	>	0
2001	*Cover*	0	3	ns	>	0
	Frequency	0	31	ns	>	0
Sand dropseed (F4)						
1999	*Cover*	1	2	ns	>	0
	Frequency	38	36	ns	>	0
2001	*Cover*	2	1	ns	>	0
	Frequency	56	36	ns	>	0
Prickly pear (F4)						
1999	*Frequency*	7	51	0.008	>	<
2001	*Frequency*	5	47	0.003	>	<
Bare ground						
1999	*Cover*	33	37	ns	>	0
2001	*Cover*	27	35	ns	>	0
Litter						
1999	*Cover*	16	14	ns	<	0
2001	*Cover*	33	28	ns	<	0
Kochia (F4)						
1999	*Frequency*	15	2	ns	na	0
2001	*Frequency*	21	0	0.06	na	>
Russian thistle (F4)						
1999	*Frequency*	28	9	ns	na	0
2001	*Frequency*	*20*	4	0.06	na	>

Discussion

Five years of monitoring at PCD has given us insight into the response of vegetation to the cessation of livestock grazing, to drought conditions, and to the presence of prairie dogs in Colorado's eastern shortgrass prairie. These insights and results are important to future management at PCD as well as for the greater Chico Basin area. Although PCD is small, relative to a large landscape level, it makes up the southern portion of an important landscape level conservation area – Chico Basin. The Nature Conservancy, Colorado Natural Heritage Program, and Rocky Mountain Bird Observatory, have identified Chico Basin as a high priority conservation area for Colorado. The primary reason that all three organizations have identified Chico Basin as significant is that it is a large (>200,000 acre) intact prairie landscape that incorporates the mosaic of shortgrass prairie, sandsage prairie, greasewood flats, wetlands, and riparian areas. This intact landscape supports a suite of species of concern, including but not limited to mountain plover, burrowing owl (*Athene cunicularia*), ferruginous hawk (*Buteo regalis*), long-billed curlew (*Numenius americanus*), black-tailed prairie dog, swift fox (*Vulpes velox*), massasauga rattlesnake (*Sistrurus catenatus*), and Arkansas darter (*Etheostoma cragini*).

Results from this study are applicable to much of the Chico Basin Conservation Area and should help with management choices on both PCD and the greater Chico Basin.

Cessation of Grazing

The cessation of grazing at PCD was a decision made by Team Pueblo in 1998, following a preliminary recommendation from an environmental study (Rust 1999). My primary task was to document the changes that took place as a consequence of this major management decision. After five years of monitoring, I have documented that the effects from the cessation of cattle grazing are most readily noticed by a decrease in the amount of visible bare ground in the shortgrass prairie and greasewood shrubland. Another way of saying this is that the amounts of vegetation and litter have increased following the cessation of cattle grazing. The composition of the vegetation has not changed drastically, but rather the cover of the dominant species has increased. Although the amount of bare ground in the grazed areas continues to decrease each year, especially in the greasewood shrubland, it has not equalized with the ungrazed areas.

There are relatively few species indicators at PCD that consistently denote the difference between grazed and ungrazed areas, regardless of vegetation type. There were no species within the shortgrass prairie that consistently indicated the presence of cattle, whereas greasewood shrubland had one indicator species and sandsage shrubland had two indicator species. Galleta grass was the best species indicator of the greasewood shrubland, with generally more cover and frequency in ungrazed areas, although grazed areas still had a substantial amount of galleta grass. The best indicator species for sandsage shrubland are sand dropseed and needle-and-thread grasses; the grazed areas consistently had more sand dropseed and less needle-and-thread grass than the ungrazed areas (Figs. 10 and 11; Table 2). Future comparison of the on-going invertebrate and small mammal studies on the same plots may show similar patterns.

Although other species had significant differences between grazed and ungrazed plots, e.g. three-awn cover in shortgrass, sandsage cover in northern sandhill, alkali sacaton in shortgrass, and Russian thistle and kochia in greasewood shrubland and sandsage shrubland, there are reasons not to consider them as good indicators of grazing treatment. For example, three-awn cover was higher in ungrazed shortgrass than in grazed shortgrass, however frequency was not significantly different and frequency may be a better sampling method. Sandsage cover was significantly higher in grazed versus ungrazed plots in 2001, but not so in 1999 (Rondeau and Kettler 1999); this difference in 2001 may be due to a sampling error, as sandsage density did not differ in either year. Alkali sacaton grass in shortgrass prairie was significantly higher in grazed plots, but this species is tightly associated with soils and therefore not a good indicator for the shortgrass prairie plots. The annual weeds, Russian thistle and kochia, were tightly associated with precipitation events and although their presence indicated a lack of grazing, they were nearly absent in all plots during drought years. Thus, the best indicators were consistent across years and sampling methods.

Although the amount of bare ground is one of the best indicators of grazing regimes in the shortgrass prairie and greasewood shrubland, it is unclear what the desired amount should be. The desire for less bare ground in the shortgrass prairie may, at first glance, appear to be a positive outcome, in that less erosion will take place. Yet, on the other hand, our knowledge of the prairie fauna indicates that several shortgrass prairie species prefer areas with high levels of bare ground. The best example of a species with this preference is the mountain plover. This

declining shortgrass prairie bird prefers areas that have over 30% bare ground and vegetation that is less than 3 inches high (Knopf and Miller 1996). The areas at PCD that have not been grazed since the 1940s, in general, do not meet these criteria, and therefore do not support nesting mountain plover, whereas the grazed areas, in general, do. Although, with the cessation of grazing, bare ground had decreased in grazed areas, there was still a noticeable difference between grazed and ungrazed treatments, even five years after the cessation of grazing.

Numerous studies have linked the mountain plover to areas where both prairie dogs and cattle grazing occur (Knowles et al. 1982, Olson and Edge 1985, Olson-Edge and Edge 1987, Dinsmore 2001). This combination, most likely, closely represents the historic combination of bison and prairie dogs. Fires are another natural process that can control cover and structure of vegetation. If PCD wishes to maintain or increase nesting mountain plover populations, they may want to consider alternatives such as conducting late fall to early spring (March) controlled burns to maintain the structure that mountain plover need. Another possibility would be to bring in cattle for a short time in early spring, prior to the arrival of mountain plover.

Of all the vegetation types at PCD, sandsage shrubland appears to have more undesirable impacts from cattle grazing than do shortgrass prairie or greasewood shrubland. The species composition is more drastically altered in the sandsage shrubland than in the greasewood shrubland or shortgrass prairie. It is unclear how many years of rest from grazing would be necessary for the grazed and ungrazed plots to become similar.

Changes in plant composition do not happen quickly, especially in dry environments. Several studies have reported that even 100 years may not be adequate time for certain soils and plant communities to readjust to an impact (Webb and Wilshire 1980). At several sites in Arizona, the removal of livestock grazing for up to 20 years had not resulted in increased perennial grass cover (Valone 2002). Another Arizona site was ungrazed for 39 years and there was significantly higher perennial grass cover inside the exclusion fence than outside, and nearly all the increase had occurred over the past 20 years (Valone 2002). There may be significant time lags at PCD to the response of vegetation after the removal of livestock, especially with the perennial bunch grasses of the sandsage shrubland. I expect, that with time, needle-and-thread grass will increase and sand dropseed will decrease in the grazed areas at PCD, but how much

time is needed before this happens is unknown. The near absence of sand bluestem (*Andropogon hallii*) and prairie sandreed (*Calamovilfa longifolia*) at PCD is still a mystery as these species are present just north and south of PCD borders.

Impacts of Drought

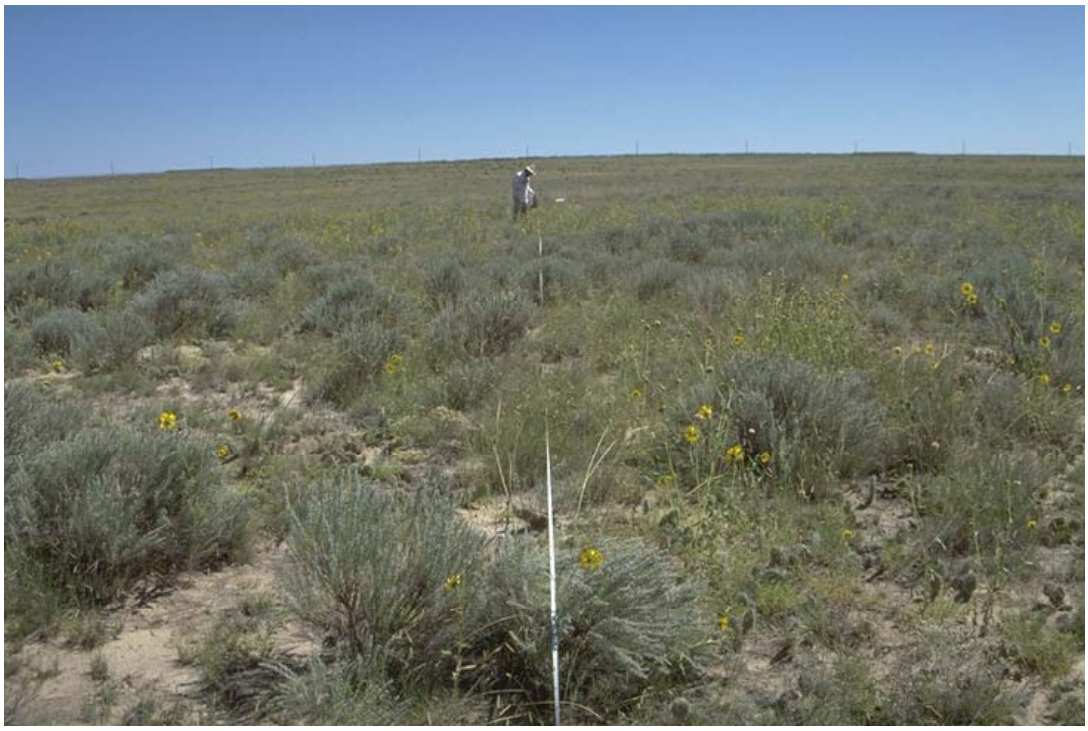
The occurrence of drought is seldom a desired event, yet it is drought, coupled with grazing and fire, that has shaped the composition of the flora and fauna that denotes the central shortgrass prairie. All of the dominant species have evolved to deal with the occasional serious drought. Most of the vegetation easily goes dormant during these extremes, but readily bounces back when the moisture returns. During extreme events, individuals may die, either during or just following a drought, resulting in a reduction in the population size for a few years. A study at the Central Plains Experimental Station, about 40 miles east of Fort Collins, reported a one-year lag time for changes in frequency for blue grama and three-awn (Hyder et al. 1975).

Warm season (C4) grasses, such as blue grama, are more responsive than cool season (C3) grasses, such as needle-and-thread, to additional water supplements (Skinner et al. 2002). Sala and Lauenroth (1982) reported that leaf water potential and leaf conductance to water in blue grama increased within 12 hours following a small (5 mm) precipitation event, and that improved leaf water relations lasted up to two days. This rapid response to rainfall would allow blue grama, with its dense, shallow root system (Bartos and Sims 1974, as cited in Skinner et al. 2002), to be highly competitive under fluctuating moisture conditions.

The effects of grazing intensity on plant responses to drought are species specific (Olson et al. 1985, as cited in Skinner et al. 2002), suggesting that the interaction between drought and grazing could significantly affect the botanical composition of rangelands. In one study, ungrazed plots were no less susceptible to drought than grazed plots (Skinner et al. 2002).

At PCD, we saw an immediate response to precipitation in cover by most of the vegetation. That is, 2002 had very little vegetation that was green (Fig. 15). With just a bit over three inches of rain in 2002, even sandsage, the dominant shrub in the sandsage shrubland, lost most of its leaves (Fig. 15). Throughout PCD, the grasses never greened up and the forbs never emerged, leaving the landscape looking like a fire had passed through (Fig. 16).

Figure 15. Photographs of sandsage shrubland plot ss32ug taken in 1998 (upper photo) and 2002 (lower photo). Photographs taken at end of west transect looking east.

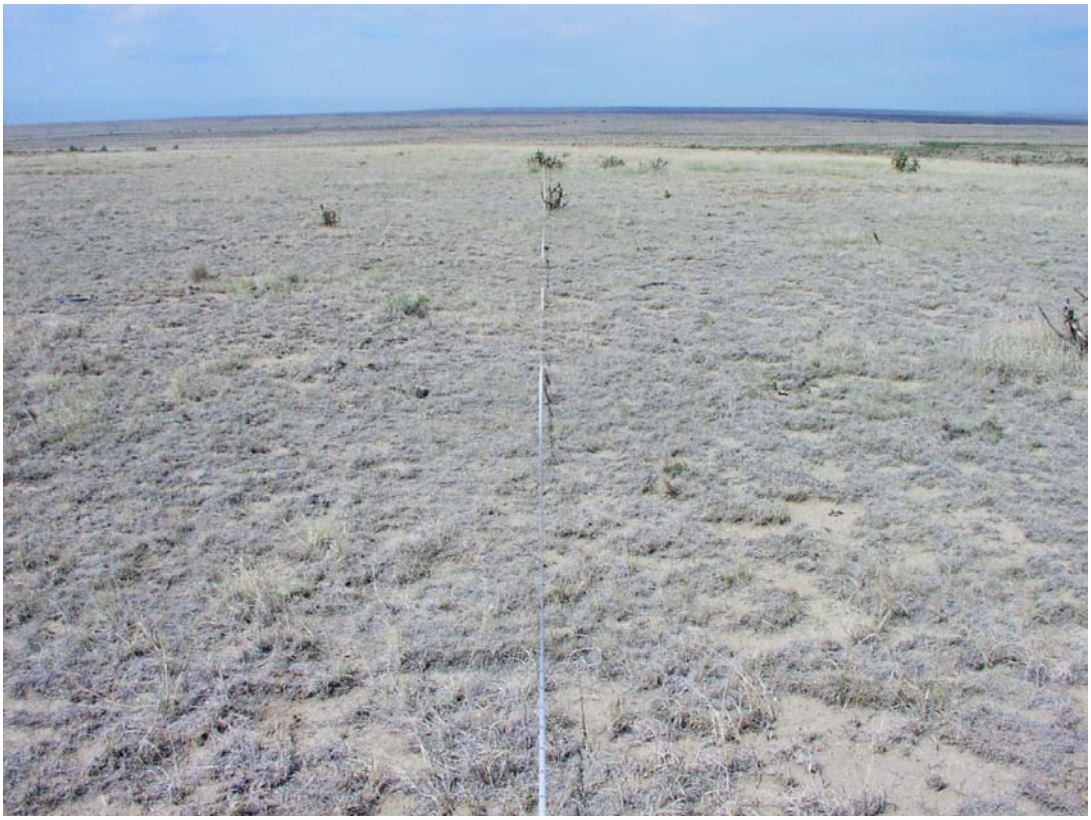


September 3, 1998

September 4, 2002

Figure 16. Photographs of shortgrass prairie plot sg68ug taken in 1998 (upper photo) and 2002 (lower photo). Photographs taken at center of plot looking west.

September 2, 1998



September 3, 2002

Drought effects were not limited to vegetation. Prairie dogs produced young but few of them survived (P. Young, pers. comm.). Some of the remaining prairie dogs were forced to venture onto new ground while others continued to chew down the remaining prickly pear and small remnants of grass. The existing prairie dog towns looked more like a desert than a shortgrass prairie (P. Young, pers. comm.) (Fig. 17). Even the chollas were wilted and girdled by prairie dogs. This 100-year event didn't even spare the grasshopper community that is normally quite prevalent. The grasshopper population plummeted, regardless of vegetation type (J. Sovell, pers. comm.). About the only vertebrate life that appeared unaffected by the drought were some of the small mammals. For example, the Ord's kangaroo rat (*Dipodomys ordii*) populations have remained steady throughout (J. Siemers, pers. comm.). One possible reason for this is the kangaroo rat strategy of storing seeds. They potentially have large enough caches to carry them through a large drought.

One of the most striking insights that we came away with during this drought event is the lack of response by greasewood and rabbitbrush. These two dominant shrubs remained bright green throughout this event (Fig. 18), while the grasses below the shrubs were completely brown. Greasewood and rabbitbrush avoid the drought by placing their roots into available ground water. The drought may still impact greasewood and rabbitbrush but there may be a multi-year lag time, in that ground water levels respond at a different spatial and temporal scale than surface water events. The only way to determine this is to continue to monitor the greasewood shrubland vegetation type as well as the ground water level. This insight into the ground water driven greasewood shrubland ecological system may be of interest to any future plans for increases in ground water pumping at PCD or further north into Chico Basin.

The annual weeds, Russian thistle and kochia, showed a response to annual variation in precipitation. Russian thistle and kochia had their highest frequency during 1999 (the wettest year) and were hardly present in 2002 (the driest year).

Prairie Dogs

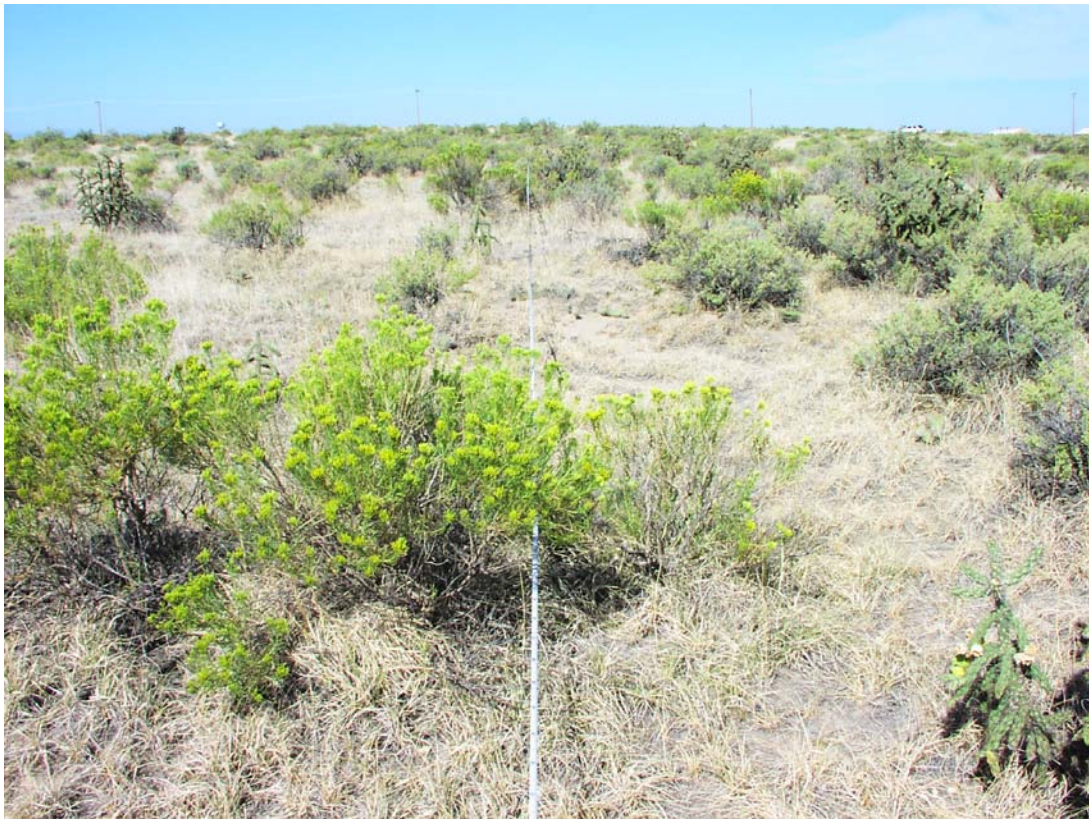
Although studying the impacts of prairie dogs on vegetation was not originally part of this study, it was hard to avoid. Because the sampling design required random samples, we inevitably

Figure 17. Photographs of shortgrass prairie plot sg77g taken in 1998 (upper photo) and 2002 (lower photo). Photographs taken at end of west transect looking east.

August 18, 1998

August 19, 2002

Figure 18. Photograph of greasewood shrubland plot gw19g taken in 2002. Photograph taken from center of plot looking west.



August 26, 2002

placed monitoring plots within prairie dog colonies. In 1998, the first year of monitoring, we had four shortgrass prairie plots within prairie dog colonies; three were in the grazed regime and one was in the ungrazed regime. As the study progressed, it became clear that prairie dogs had a significant impact on the vegetation. In order to equalize our design, in 2001 we added two additional prairie dog plots in the ungrazed regime. The effect of the prairie dogs became even more complicated with the 1999 plague event that eliminated prairie dogs from two of the plots in the grazed treatment and one of the plots in the ungrazed treatment. Then add the 2002 drought event and November 2002 fire at sg80ug (within a prairie dog colony) and things get complicated very quickly. But, even with all these permutations, we can still observe certain vegetation parameters that are tightly associated with the presence of prairie dogs.

Three affected clasess worthy of mention are purple three-awn, prickly pear, and bare ground. Purple three-awn is a perennial bunch grass that has often been used as an indicator of heavy cattle grazing. At PCD, I found this grass to be a better indicator of the presence of prairie dogs than cattle grazing. There was no significant difference in cover or frequency of purple three-awn in cattle-grazed versus cattle-ungrazed areas (Tables 1 through 3), yet there was a striking difference between prairie dog presence and absence (Fig. 14; Table 4). Prairie dog colonies had nearly three times as much cover and frequency of purple three-awn as areas without prairie dogs. Winter et al. (2002) had similar results, reporting 62% frequency for purple three-awn within prairie dog towns and 25% frequency outside of prairie dog towns; similarly, they reported 9% cover within prairie dog towns and 2% outside of prairie dog towns.

Rust (1999) stated that purple three-awn was an increaser with cattle grazing. We believe that Rust's sampling design did not take into account the variation in shortgrass prairie at PCD and had too small of a sample size and too few plots on prairie dog colonies to detect this important correlation.

Plot sg74ug was an ungrazed plot without prairie dogs, yet it had nearly 100% frequency of purple three-awn (Fig. 19). Returning to our original 1999 notes, when this plot was established, we noted that it had remnants of a few old prairie dog holes. Subsequent conversations with Max Canestorp (Fish and Wildlife Service) confirmed this observation. It is unclear how long the prairie dogs have been gone, but this may help explain why purple three-awn is so prevalent.

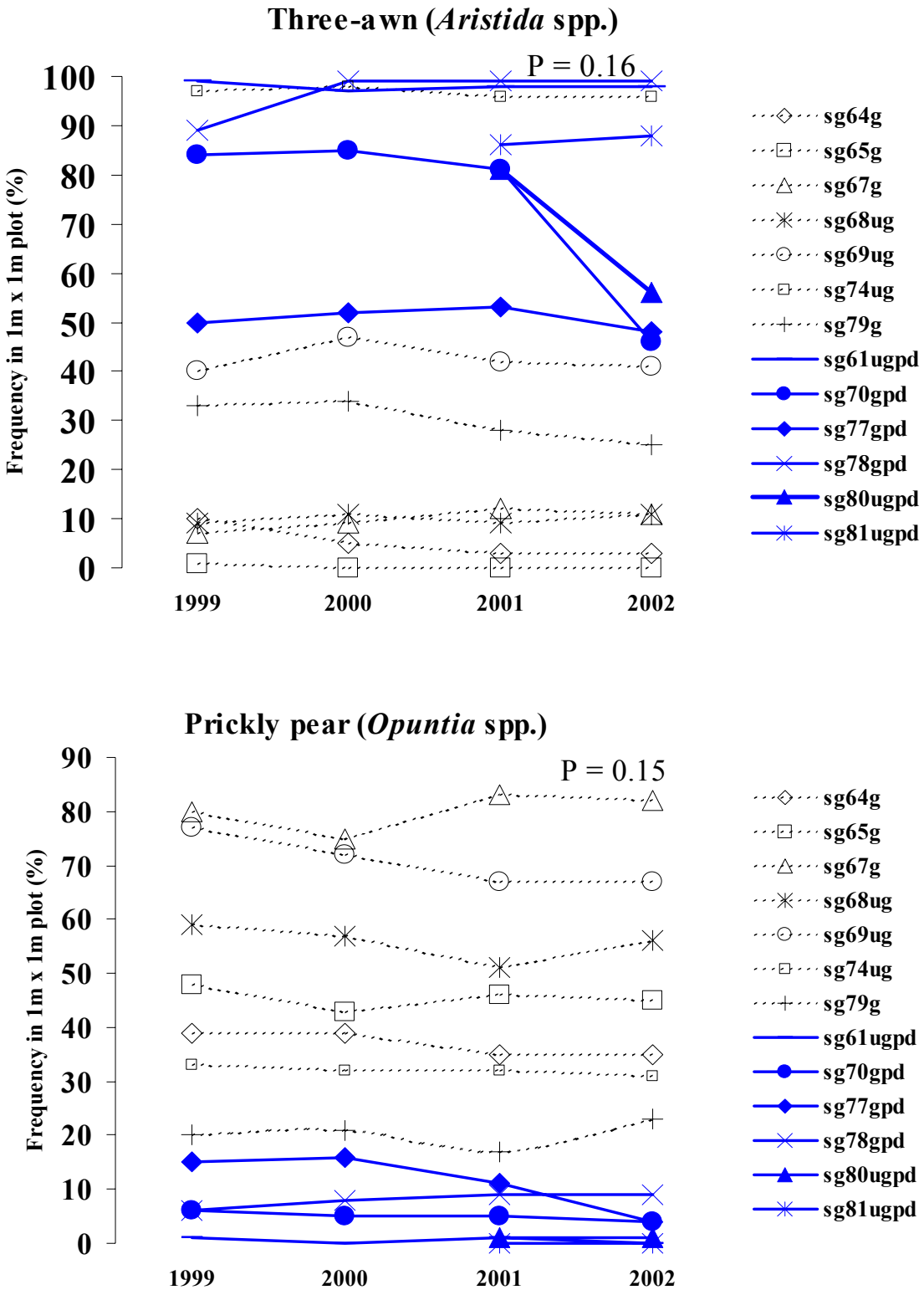


Figure 19. Mean frequency of three-awn and prickly pear in **shortgrass prairie** (1999-2002). Plots without prairie dogs are represented by dashed lines; plots with prairie dogs by solid lines.

Prickly pear cactus is very noticeable even to the casual observer and was often mentioned by early explorers (prior to the introduction of cattle and horses) as they crossed the plains (Hart and Hart 1997). It has long been used as an indicator of poor cattle management (Whitson et al. 1992) and may still be a good indicator in certain areas, but our study at PCD does not support this view. For example, the grazed plots in the sandsage shrubland had 21% frequency while the ungrazed plots had 35% frequency (Table 2); the difference was not statistically significant. The grazed plots in the greasewood shrubland had 42% frequency while the ungrazed had 34% frequency, again not a statistically significant difference. The shortgrass prairie had nearly equal frequency in grazed (29%) versus ungrazed (25%) plots. However, there was a striking difference with the presence or absence of prairie dogs. Prickly pear was hardly present on plots with prairie dogs (average frequency of 5%) while plots without prairie dogs had an average frequency of 47%. Plots sg74ug and sg79g, both without prairie dogs, had a low frequency of prickly pear (Fig. 19). Both of these plots were observed to have old prairie dog holes when we established the plots, which may help explain the low frequency of prickly pear.

Prairie dogs include prickly pear in their diets, especially in the winter (Summers and Linder 1978); this may explain the dearth of prickly pear on prairie dog towns.

Prairie dog towns noticeably stand out from areas without prairie dogs. This easily noted difference is usually due to the short cropped nature of the vegetation, allowing one to observe more of the ground. We found that the amount of bare ground did not necessarily increase in the presence of prairie dogs despite the overall appearance. Bare ground averaged 27% cover on prairie dog towns and 35% cover off of prairie dog towns (difference not statistically significant), which goes against the casual observation. The amount of bare ground is more likely to be correlated with the presence of cattle grazing, with significantly higher cover (41%) in grazed areas than ungrazed (21%) (Table 3).

An important point here is that the presence of prairie dogs alone (without cattle) may not provide adequate mountain plover nesting habitat, as mountain plover prefer greater than 30% bare ground as well as short vegetation (Knopf and Miller 1996). Therefore, the combination of grazing (cattle/bison) and prairie dogs that mimics historic disturbance may be important for some species.

Although PCD is not large enough to maintain the native grazing animals, i.e., bison, pronghorn, and prairie dogs, it probably is large enough to exhibit the natural mosaic that these animals provided. This natural mosaic should be one of different grazing intensities and fire regimes that provide a subtle but diverse landscape pattern. The initial monitoring program will provide excellent baseline data that will be useful in developing this subtle but diverse pattern.

I suggest that after 2003 the management objectives be re-evaluated to incorporate data from CNHP's monitoring program with that of an ecosystem management approach.

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Appendix A. Species list with codes for plant species found in plots at PCD.

Forbs code	***Latin name***
Amaret	*Amaranthus retroflexus*
Ambfra	*Ambrosia fragrans*
Ambpsi	*Ambrosia psilostachya*
Asceng	*Asclepias engelmannii (or linear leaf Asc.)*
Asclin	*=Asceng*
Ascspe	*Asclepias speciosa*
Astmol	*Astragalus mollissimus*
Astpec	*Astragalus pectinatus*
Astsho	*Astragalus shortianus*
Astsp1	*Astragalus sp.*
Bassie	*Bassia (Kochia scoparia) sieversiana*
Brieup	*Brickellia eupatorium*
Briros	*Brickellia rosmarinifolia*
Casjam	*Caesalpinia jamesii=Hoffmanseggia*
Chealb	*Chenopodium album*
Checyc	*Chenopodium cycloides*
Chesp.	*Chenopodium sp.*
Chesp1	*Chenopodium sp.*
Chesub	*Chenopodium subglabrum*
Cirarv	*Cirsium arvense*
Circan	*Cirsium canescens*
Cirsp.	*Cirsium sp.*
Cleser	*Cleome serrulata*
Concan	*Conyza canadensis*
Crotex	*Croton texensis*
Crysp	*Cryptantha sp.*
Cypari	*Cyperus aristatus*
Cypsp	*Cyperus sp.*
Dalcyl	*Dalea cylindreceps*
Dalnan	*Dalea nana*
Dipfas	*=Schpan*
Dyspap	*Dyssodia papposa*
Erifla	*Erigeron flagellaris*
Eribel	*Erigeron bellidastrum*
Eriogsp	*Eriogonum sp.*
Eupden	*Euphorbia dentata*
Eupser	*Euphorbia serpyllifolia*
Eupsp	*Euphorbia sp.*
Evonut	*Evolvulus nuttalianus*
Gaucoc	*Gaura coccinea*
Galpin	*Gaillardia pinnatifida*
Gilopt	*see Ipolax (Ipomopsis laxiflora)*
Graind	*Grammica indecora*
Helann	*Helianthus annus*
Helpet	*Helianthus petiolaris*
Helpum	should be *Helpet*

Forbs code	***Latin name***
Ipolax	*Ipomopsis laxiflora*
Ipolep	*Ipomoea leptophylla*
Iponut	see *Evonut*
Lactat	*Lactat*
Latsp	*Lathryus sp.*
Lygjun	*Lygodesmia juncea*
Macpin	*Machaeranthera pinnitifida*
Mactan	*Machaeranthera tanacetifolia*
Medsat	*Medicago sativa*
Melalb	*Melilotus alba*
Meloff	*Melilotus officinale*
Melsp	*Melilotus sp.*
Mennud	*Nuttalia (Mentzelia) nuda*
Nyctsp	*Nyctaginaceae sp.*
Oresp	*Oreocarya sp.*
Oxylin	*Oxybaphus linearis*
Oxysp	*Oxytropis sp.*
Pacsp	*Packera sp.*
Palsph	*Palifloxia sphaerlata*
Pecang	*Pectis angustifolia*
Porhal	*Portulaca halimoides*
Porole	*Portulaca oleracea*
Psoten	*Psoralidium tenuiflora*
Rattag	*Ratibida tagetes*
Salaus	*Salsola australis*
Senspa	*Senecio spartoides*
Solros	*Solanum rostratum*
Sphcoc	*Sphaeralcea coccinea*
Spurge	*see Euphorbia*
Suasp	*Suaeda spp.*
Syssp	*Sysimbrium sp.*
Talpar	*Talinum parviflorum*
Themeg	*Thelesperma megapotamicum*
Tradub	*Tragopogon dubius*
UNKFOR	*Unknown forb*
UNKSS30	*Unknown forb in SS30*
UNKSS78	*Unknown forb in SS78*
Versp	*Verbena sp.*
Zingra	*Zinnia grandiflora*
Zyghex	*Zygophllidium hexagonum*

Graminoids code	***Latin name***
Andhal	*Andropogon hallii*
Aridiv	*Aristida divaricata*
Aripur	*Aristida purpurea*
Boucur	*Bouteloua curtipendula*
Bucdac	*Buchloe dactyloides*
Callon	*Calimovilfa longifolia*
Chogra	*Chondrosum gracile (Bouteloua gracilis)*

Forbs code	***Latin name***
Chohir	*Chondrosum hirsuta (Bouteloua hirsutus)*
Cypacu	*Cyperus acuminatus*
Cypari	*Cyperus aristatus*
Dipfas	*see Schpan*
Disspi	*Distichlis spicata*
Elyely	*Elymus elymoides*
Hiljam	*Hilaria jamesii*
Lepfac	*see Schpan*
Muhtor	*Muhlenbergia torreyi*
Munsqu	*Munroa squarrosa*
Oryhym	*see Stihym*
Passmi	*Pascopyrum smithii*
Schpan	*Schedonnardus paniculatus*
Spoair	*Sporobolus airoides*
Spocry	*Sporobolus cryptandrus*
Sticom	*Stipa comata*
Stihym	*Stipa hymenoides (Oyzopsis hymenoides)*
Vuloct	*Vulpia octoflora*

Shrubs & Cacti code	***Latin Name***
Atrcan	*Atriplex canescens*
Atrcon	*Atriplex confertiflora*
Atrgar	*Atriplex gardeneri*
Chrnau	*Chrysothamnus nauseosus*
Corviv	*Coryphantha vivipara*
Cylimb	*Cylindropuntia imbricata*
Echvir	*Echinocereus viridulus*
Erieff	*Eriogonum effusum*
Gutsar	*Gutierriezia sarothrae*
Hetvil	*Heterotheca villosa*
Ipolep	*Ipomoea lepotophylla*
Olifil	*Oligosporus (Artemisia) filifolius*
Opomac	*Opuntia macrorhiza*
Opopol	*Opuntia polyacantha*
Opupha	*Opuntia phaecantha*
Sarver	*Sarcobatus vermiculatus*
Yucgla	*Yucca glauca*

Appendix B. Example of field forms.

Transect #_____

Site, Line-intercept, and Belt transect Data Form

Site name_____ Date (d/m/y)_____/2001 Time _____ Page 1 of 1
Cardinal Direction: N S E W
Photo Roll# _____ Photo# Beginning_____ End_____ Aerial Photo Number_____
Human disturbance signs? If so describe_____
Prairie Dog Town? None Active Inactive
Comments or notes:_____
Observers_____

Begin at 1 m mark on the E and W lines for belt transect (to avoid double counting)
Gaps less than 10 cm are counted as canopy cover; plant does not have to be rooted in belt transect in order to count.

Species Code	**Species name**	**Tape measurements (cm)**	**Total (m)**	**% cover Total/50 (m)**	**Belt transect count/total #**
Chrnau	**Chrysothamnus nauseosus** Rabbitbrush				
Cylimb	**Cylindropuntia imbricata** Candelabra Cholla				
Gutsar	**Gutierrezia sarothrae** Snakeweed				
Ipolep	**Ipomoea leptophylla** Bush morning glory				
Olifil	**Oligosporus filifolius** Sand sagebrush				
Sarver	**Sarcobatus vermiculatus** Greasewood				
Yucgla	**Yucca glauca** Yucca				

Transect #_____

Microplot cover data form

Site name_____ Date (d/m/y)_____/2001 Time _____ Page 1 of 2
Cardinal Direction: N S E W
Photo Roll# _____ Photo# 3rd _____ 5th _____
Observers:_____

The first microplot is selected randomly between 0 and 10 m. Thereafter every microplot is 5 m from the previous. Plot is always on right side of line (as looking from 0 to 50 m) and short axis centered at mark. Microplots are permanent and usually with aluminum round tag in middle of 3rd and 5th plot. Over 100% total cover is possible, e.g. Erieff plus Chogra underneath.

Species Code	**Species name**	**Plot ___ m**	**% Cover Total/50**	**Plot ___ m**	**% Cover**	**Plot ___ m**	**% Cover**	**Plot ___ m**	**% Cover**
Erieff	*Eriogonum effusum*								
Arispp	*Aristida* spp. Purple three-awn								
Chogra	*Chondrosum gracile* Blue grama								
Spoair	*Sporobolus airoides* Alkali sacaton								
Spocry	*Sporobolus cryptandrus* Sand dropseed								
Sticom	Stipa comata *Needle-and-thread*								
Bassie	*Bassia (Kochia scoparia) sieversiana*								
Eupspp	*Euphorbia* spp.								
Salaus	*Salsola australis* Russian thistle								
Bare ground									
Litter									

Transect #_____
Nested Frequency Plot form for Uplands
Page 1 of 2

Date_____1999 Comments:_____
Observers:_____
Along each 50 m transect a nested frequency plot is placed every two meters starting at the 2 m mark. All plots are on left side of line (looking from 0 m towards 50 m) with .1 x .1 m plot in lower left corner. Plant must be partially rooted in plot in order to count or for Opuntia spp. any pad whether rooted or not counts as in. Score is 0 = none, 1 = point, 2 = .1 x.1, 3 = .31 x .31 and 4 = 1 x 1 m.
Species include: Erieff, Opuspp, Arispp., Chogra, Hiljam, Spoair, Spocry, Schpan, Bassie, Salaus.

North	-	-	-	-	-	-	-	-	-	-	**South**	-	-	-	-	-	-	-	-	-	-
1											26										
2											27										
3											28										
4											29										
5											30										
6											31										
7											32										
8											33										
9											34										
10											35										
11											36										
12											37										
13											38										
14											39										
15											40										
16											41										
17											42										
18											43										
19											44										
20											45										
21											46										
22											47										
23											48										
24											49										
25											50										

Appendix C: Raw data tables.

Table C-1. Mean canopy cover (%) and standard deviation in greasewood shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects for shrubs and 32 microplots/plot for all others.

Plot number	Grazed	Mean Std dev	Rabbit-brush 98	Rabbit-brush 99	Rabbit-brush 00	Rabbit-brush 01	Rabbit-brush 02	Grease-wood 98	Grease-wood 99	Grease-wood 00	Grease-wood 01	Grease-wood 02	Three-awn 98	Three-awn 99
gw04ug	0	mean		0	1	1	1		3	4	4	3		0
gw04ug	0	std dev		0	0	0	0		1	1	1	1		0
gw06ug	0	mean	6	8	6	7	5	1	2	2	1	2	0	1
gw06ug	0	std dev	1	2	2	2	1	0	0	0	0	1	0	1
gw10ug	0	mean		4	3	3	3		4	3	3	3		0
gw10ug	0	std dev		1	1	1	0		1	1	1	0		0
gw11ug	0	mean	3	4	5	5	4	1	1	1	1	1	0	0
gw11ug	0	std dev	1	1	1	2	1	1	1	1	1	1	0	0
gw14ug	0	mean	2	3	4	4	4	6	6	4	5	3	0	0
gw14ug	0	std dev	1	1	2	2	2	1	1	1	0	0	0	0
gw16ug	0	mean		6	5	5	3		2	2	2	2		1
gw16ug	0	std dev		1	1	1	0		1	1	1	1		1
gw01g	1	mean	0	0	0	0	0	1	1	1	1	1	0	1
gw01g	1	std dev	0	0	0	0	0	1	2	3	3	2	0	1
gw02g	1	mean	1	1	1	1	0	3	4	4	4	3	0	0
gw02g	1	std dev	1	1	1	1	0	0	1	1	1	1	0	0
gw05g	1	mean	3	2	2	2	3	3	5	4	6	6	1	1
gw05g	1	std dev	1	1	1	1	1	1	1	1	1	1	1	2
gw09g	1	mean		3	3	4	3		4	4	4	4		0
gw09g	1	std dev		1	1	1	1		1	1	1	1		0
gw13g	1	mean	1	2	1	2	2	3	4	4	4	3	0	0
gw13g	1	std dev	1	1	0	1	1	2	2	2	2	2	0	0
gw19g	1	mean	7	7	7	7	5	2	1	1	2	2	1	3
gw19g	1	std dev	2	1	2	1	1	1	0	0	1	1	1	6
gw20g	1	mean		6	5	5	4		2	3	3	3		4
gw20g	1	std dev		2	1	1	1		0	1	1	1		4

Table C-1. Mean canopy cover (%) and standard deviation in greasewood shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects for shrubs and 32 microplots/plot for all others.

Plot number	Grazed	Mean Std dev	Three-awn 00	Three-awn 01	Three-awn 02	Blue grama 98	Blue grama 99	Blue grama 00	Blue grama 01	Blue grama 02	Galleta grass 98	Galleta grass 99	Galleta grass 00	Galleta grass 01	Galleta grass 02
gw04ug	0	mean	0	0	0		37	19	31	0		0	0	0	0
gw04ug	0	std dev	0	0	0		9	3	8	0		0	0	0	0
gw06ug	0	mean	0	0	0	28	31	25	17	0	6	11	3	3	0
gw06ug	0	std dev	0	0	0	12	13	12	10	1	4	7	3	3	0
gw10ug	0	mean	0	0	0		26	19	20	1		8	7	11	0
gw10ug	0	std dev	0	0	0		8	7	7	1		3	3	3	1
gw11ug	0	mean	0	0	0	18	14	14	12	0	12	17	10	10	0
gw11ug	0	std dev	0	0	0	6	4	3	3	0	5	10	5	7	1
gw14ug	0	mean	0	0	0	21	24	18	18	1	11	13	7	9	0
gw14ug	0	std dev	0	0	0	8	8	9	7	1	17	21	10	13	0
gw16ug	0	mean	0	1	0		30	14	28	0		18	8	14	1
gw16ug	0	std dev	1	1	0		6	4	4	0		6	3	6	1
gw01g	1	mean	0	1	0	35	35	29	34	2	2	2	1	1	0
gw01g	1	std dev	1	1	0	11	12	9	11	2	3	2	1	1	0
gw02g	1	mean	0	0	0	27	33	24	27	2	3	3	2	1	0
gw02g	1	std dev	0	0	0	12	14	10	12	3	3	2	1	2	0
gw05g	1	mean	1	1	0	5	8	3	4	0	12	20	5	4	0
gw05g	1	std dev	1	1	0	5	9	4	5	0	6	10	3	3	0
gw09g	1	mean	0	0	0		16	12	16	0		8	4	4	0
gw09g	1	std dev	0	0	0		15	9	11	0		4	2	2	0
gw13g	1	mean	0	0	0	19	18	17	18	0	1	1	1	1	0
gw13g	1	std dev	0	0	0	5	5	4	4	0	1	1	1	1	0
gw19g	1	mean	1	1	0	15	16	10	17	0	8	9	8	10	0
gw19g	1	std dev	2	2	0	7	8	5	7	0	6	5	2	4	0
gw20g	1	mean	2	3	0		18	8	16	0		7	1	7	0
gw20g	1	std dev	3	5	0		5	3	12	0		2	0	4	0

Table C-1. Mean canopy cover (%) and standard deviation in greasewood shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects for shrubs and 32 microplots/plot for all others.

Plot number	Grazed	Mean Std dev	Alkali sacaton 98	Alkali sacaton 99	Alkali sacaton 00	Alkali sacaton 01	Alkali sacaton 02	Sand dropseed 98	Sand dropseed 99	Sand dropseed 00	Sand dropseed 01	Sand dropseed 02
gw04ug	0	mean		13	5	7	0		0	0	0	0
gw04ug	0	std dev		10	5	6	0		0	0	0	0
gw06ug	0	mean	5	6	6	7	4	4	3	3	2	0
gw06ug	0	std dev	3	2	2	2	4	4	2	2	1	0
gw10ug	0	mean		18	14	18	5		2	0	0	0
gw10ug	0	std dev		9	7	7	3		2	1	1	0
gw11ug	0	mean	16	16	13	14	3	6	2	3	2	0
gw11ug	0	std dev	5	7	5	5	2	5	2	2	2	0
gw14ug	0	mean	17	18	16	18	3	0	0	2	1	0
gw14ug	0	std dev	13	14	14	14	3	1	1	3	1	0
gw16ug	0	mean		0	0	0	0		1	1	0	0
gw16ug	0	std dev		1	0	0	0		2	1	1	0
gw01g	1	mean	10	10	9	7	3	0	0	0	0	0
gw01g	1	std dev	8	6	5	4	2	1	0	0	0	0
gw02g	1	mean	7	5	3	3	1	2	3	2	1	0
gw02g	1	std dev	5	4	2	2	1	2	2	1	1	0
gw05g	1	mean	6	10	9	8	6	9	12	6	6	0
gw05g	1	std dev	5	8	7	7	4	6	8	4	4	0
gw09g	1	mean		32	26	30	10		1	0	0	0
gw09g	1	std dev		12	10	10	6		2	0	0	0
gw13g	1	mean	37	43	36	33	11	1	0	1	1	0
gw13g	1	std dev	11	11	6	5	4	1	1	2	1	0
gw19g	1	mean	22	22	17	19	1	9	6	7	5	0
gw19g	1	std dev	8	10	7	9	1	9	5	4	3	0
gw20g	1	mean		16	7	17	2		2	1	1	0
gw20g	1	std dev		6	4	8	2		2	1	1	0

Table C-1. Mean canopy cover (%) and standard deviation in greasewood shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects for shrubs and 32 microplots/plot for all others.

Plot number	Grazed	Mean Std dev	Kochia 98	Kochia 99	Kochia 00	Kochia 01	Kochia 02	Russian thistle 98	Russian thistle 99	Russian thistle 00	Russian thistle 01	Russian thistle 02
gw04ug	0	mean		0	0	0	0		0	0	0	0
gw04ug	0	std dev		0	0	0	0		0	0	0	0
gw06ug	0	mean	0	0	0	0	0	0	0	0	0	0
gw06ug	0	std dev	0	1	0	0	0	0	0	0	0	0
gw10ug	0	mean		0	0	0	0		0	0	0	0
gw10ug	0	std dev		0	0	0	0		0	0	0	0
gw11ug	0	mean	1	0	0	0	0	0	0	0	0	0
gw11ug	0	std dev	1	0	0	0	0	1	0	0	0	0
gw14ug	0	mean	1	0	0	0	0	2	1	2	0	0
gw14ug	0	std dev	1	1	0	0	0	2	1	2	0	0
gw16ug	0	mean		1	0	0	0		2	2	3	0
gw16ug	0	std dev		1	0	1	0		1	2	3	0
gw01g	1	mean	0	0	0	0	0	0	0	0	0	0
gw01g	1	std dev	0	0	0	0	0	0	0	0	0	0
gw02g	1	mean	0	0	0	0	0	0	0	0	0	0
gw02g	1	std dev	0	0	0	0	0	0	0	0	0	0
gw05g	1	mean	3	1	0	0	0	0	0	0	0	0
gw05g	1	std dev	3	1	0	0	0	0	0	0	0	0
gw09g	1	mean		0	0	0	0		0	0	0	0
gw09g	1	std dev		0	0	0	0		0	0	0	0
gw13g	1	mean	0	0	0	0	0	0	0	0	0	0
gw13g	1	std dev	0	0	0	0	0	0	0	0	0	0
gw19g	1	mean	0	0	0	0	0	0	0	0	0	0
gw19g	1	std dev	0	0	0	0	0	0	0	0	0	0
gw20g	1	mean		0	0	0	0		0	0	0	0
gw20g	1	std dev		0	0	0	0		0	0	0	0

Table C-1. Mean canopy cover (%) and standard deviation in greasewood shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects for shrubs and 32 microplots/plot for all others.

Plot number	Grazed	Mean Std dev	Bare ground 98	Bare ground 99	Bare ground 00	Bare ground 01	Bare ground 02	Litter 98	Litter 99	Litter 00	Litter 01	Litter 02
gw04ug	0	mean		40	24	25	24		12	52	37	76
gw04ug	0	std dev		9	11	8	6		5	10	6	6
gw06ug	0	mean	28	18	15	16	18	21	21	46	55	76
gw06ug	0	std dev	2	3	6	6	8	3	7	10	8	5
gw10ug	0	mean		11	10	10	11		34	50	40	82
gw10ug	0	std dev		4	3	3	3		3	4	4	5
gw11ug	0	mean	24	19	17	17	20	17	30	43	46	76
gw11ug	0	std dev	5	2	3	3	3	4	6	7	3	2
gw14ug	0	mean	29	23	19	20	22	15	17	35	32	74
gw14ug	0	std dev	17	15	14	14	13	8	8	13	14	17
gw16ug	0	mean		12	11	11	13		33	64	42	86
gw16ug	0	std dev		6	6	6	8		12	7	11	8
gw01g	1	mean	39	36	31	27	29	6	15	30	30	66
gw01g	1	std dev	9	7	9	8	12	3	6	7	10	12
gw02g	1	mean	39	35	29	28	33	10	16	40	38	63
gw02g	1	std dev	7	4	4	7	4	5	8	11	11	5
gw05g	1	mean	41	25	18	19	18	17	19	57	50	74
gw05g	1	std dev	9	12	15	14	12	3	7	16	16	14
gw09g	1	mean		19	15	13	13		24	42	34	75
gw09g	1	std dev		2	2	3	4		5	5	2	4
gw13g	1	mean	37	26	21	23	20	6	11	24	25	68
gw13g	1	std dev	4	5	3	1	2	3	4	3	4	5
gw19g	1	mean	32	26	19	19	19	13	17	39	28	79
gw19g	1	std dev	8	3	3	2	3	8	7	6	5	3
gw20g	1	mean		30	20	20	19		22	60	33	77
gw20g	1	std dev		2	4	4	6		5	4	3	8

Table C-2. Mean density (individuals per 0.04 hectare) and standard deviation per belt transect in greasewood shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects.

Plot number	Grazed	Mean Std dev	Rabbit-brush 98	Rabbit-brush 99	Rabbit-brush 00	Rabbit-brush 01	Rabbit-brush 02	Grease-wood 98	Grease-wood 99	Grease-wood 00	Grease-wood 01	Grease-wood 02
gw04ug	0	mean density		4	4	3	3		10	11	13	12
gw04ug	0	std dev		2	2	1	1		4	4	6	4
gw06ug	0	mean density	28	32	32	30	30	11	14	12	13	14
gw06ug	0	std dev	7	3	3	4	4	3	4	4	3	3
gw10ug	0	mean density		16	21	19	21		12	17	16	16
gw10ug	0	std dev		5	6	5	6		3	6	7	7
gw11ug	0	mean density	13	22	21	24	24	6	7	6	9	9
gw11ug	0	std dev	5	7	7	8	10	3	4	3	5	5
gw14ug	0	mean density	16	23	29	20	22	12	13	16	14	13
gw14ug	0	std dev	5	9	9	6	6	3	4	4	5	4
gw16ug	0	mean density		30	32	31	32		3	2	3	3
gw16ug	0	std dev		8	9	9	11		3	4	5	4
gw01g	1	mean density	3	4	5	3	3	6	6	7	7	7
gw01g	1	std dev	3	2	3	2	2	2	2	1	2	2
gw02g	1	mean density	6	9	11	9	8	12	15	14	12	13
gw02g	1	std dev	6	6	8	7	5	3	5	5	3	2
gw05g	1	mean density	17	20	20	17	20	15	14	14	13	13
gw05g	1	std dev	7	5	5	6	8	4	3	4	2	2
gw09g	1	mean density		21	22	19	23		14	14	12	13
gw09g	1	std dev		6	7	8	8		6	6	7	7
gw13g	1	mean density	13	15	18	17	20	16	19	17	17	21
gw13g	1	std dev	8	9	15	15	18	9	9	7	12	11
gw19g	1	mean density	31	31	28	24	30	13	13	13	14	14
gw19g	1	std dev	4	10	8	7	13	5	6	6	6	5
gw20g	1	mean density		25	25	21	26		13	11	13	14
gw20g	1	std dev		13	13	11	14		5	3	4	5

Table C-3. Frequency (%) and standard deviation in greasewood shrubland for 1999-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 100/plot.

Plot number	Grazed	Frequency plot size	Prickly pear 99	Prickly pear 00	Prickly pear 01	Prickly pear 02	Three-awn 99	Three-awn 00	Three-awn 01	Three-awn 02	Blue grama 99	Blue grama 00	Blue grama 01	Blue grama 02
gw04ug	0	.3 m x .3 m	16	12	11	11	0	0	0	0	69	69	69	67
gw04ug	0	1 m x 1 m	54	50	49	48	0	0	0	0	81	81	79	79
gw06ug	0	.3 m x .3 m	23	18	17	15	0	0	1	0	79	80	73	69
gw06ug	0	1 m x 1 m	73	71	63	66	2	2	2	0	98	98	98	97
gw10ug	0	.3 m x .3 m	7	8	10	11	0	0	0	0	65	67	68	66
gw10ug	0	1 m x 1 m	24	25	28	27	0	0	0	0	92	95	95	92
gw11ug	0	.3 m x .3 m	9	7	6	7	1	0	0	0	55	68	67	63
gw11ug	0	1 m x 1 m	22	22	21	23	3	2	2	2	90	95	96	94
gw14ug	0	.3 m x .3 m	8	9	10	10	3	6	5	4	41	48	43	43
gw14ug	0	1 m x 1 m	24	24	29	27	8	12	11	11	85	84	81	79
gw16ug	0	.3 m x .3 m	3	3	3	6	2	4	2	2	69	76	77	75
gw16ug	0	1 m x 1 m	22	25	27	27	6	7	6	6	97	96	93	92
gw01g	1	.3 m x .3 m	10	12	16	15	1	4	3	3	78	81	84	72
gw01g	1	1 m x 1 m	42	49	50	53	4	13	7	5	94	95	96	94
gw02g	1	.3 m x .3 m	12	13	15	16	6	5	8	7	87	88	90	87
gw02g	1	1 m x 1 m	49	56	52	58	12	12	11	11	97	98	98	98
gw05g	1	.3 m x .3 m	4	4	6	5	2	5	2	1	25	28	30	33
gw05g	1	1 m x 1 m	14	15	18	20	14	13	11	13	60	58	59	60
gw09g	1	.3 m x .3 m	12	10	15	18	2	1	1	1	44	52	55	52
gw09g	1	1 m x 1 m	54	49	51	54	3	2	2	2	74	78	79	81
gw13g	1	.3 m x .3 m	12	10	16	15	1	1	1	1	37	41	43	41
gw13g	1	1 m x 1 m	48	51	51	56	4	5	3	5	69	70	70	68
gw19g	1	.3 m x .3 m	6	7	7	9	9	5	2	3	39	41	54	51
gw19g	1	1 m x 1 m	25	29	32	33	15	11	7	10	67	66	77	72
gw20g	1	.3 m x .3 m	12	12	14	17	2	2	1	1	46	47	49	42
gw20g	1	1 m x 1 m	40	38	43	45	6	8	5	9	77	78	80	79

Table C-3. Frequency (%) and standard deviation in greasewood shrubland for 1999-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 100/plot.

Plot number	Grazed	Frequency plot size	Galleta grass 99	Galleta grass 00	Galleta grass 01	Galleta grass 02	Alkali sacaton 99	Alkali sacaton 00	Alkali sacaton 01	Alkali sacaton 02	Sand dropseed 99	Sand dropseed 00
gw04ug	0	.3 m x .3 m	0	0	0	0	37	34	33	34	0	0
gw04ug	0	1 m x 1 m	1	1	0	1	43	43	43	43	0	0
gw06ug	0	.3 m x .3 m	19	27	29	25	26	33	36	38	18	14
gw06ug	0	1 m x 1 m	41	41	43	39	61	70	75	76	45	43
gw10ug	0	.3 m x .3 m	28	37	40	39	33	45	33	52	7	9
gw10ug	0	1 m x 1 m	63	65	68	65	74	80	73	85	30	28
gw11ug	0	.3 m x .3 m	42	41	45	44	40	48	50	49	10	15
gw11ug	0	1 m x 1 m	60	63	63	65	79	75	76	81	35	41
gw14ug	0	.3 m x .3 m	33	40	42	39	32	35	39	42	14	18
gw14ug	0	1 m x 1 m	61	61	63	61	69	64	67	68	45	46
gw16ug	0	.3 m x .3 m	80	79	84	79	6	7	4	5	3	3
gw16ug	0	1 m x 1 m	94	94	95	94	15	16	12	15	14	15
gw01g	1	.3 m x .3 m	16	19	22	21	36	41	45	45	2	3
gw01g	1	1 m x 1 m	29	27	28	27	61	70	69	69	15	14
gw02g	1	.3 m x .3 m	23	25	25	25	22	25	30	23	17	18
gw02g	1	1 m x 1 m	41	44	49	45	50	50	52	49	47	41
gw05g	1	.3 m x .3 m	56	61	52	56	18	19	22	20	51	64
gw05g	1	1 m x 1 m	72	71	68	70	31	32	35	34	91	87
gw09g	1	.3 m x .3 m	21	19	22	21	71	74	76	74	5	5
gw09g	1	1 m x 1 m	37	36	40	39	93	95	96	95	11	13
gw13g	1	.3 m x .3 m	4	5	5	5	76	82	80	80	0	0
gw13g	1	1 m x 1 m	10	9	14	10	96	95	98	98	0	0
gw19g	1	.3 m x .3 m	29	30	33	30	45	57	57	58	36	38
gw19g	1	1 m x 1 m	50	48	55	53	64	75	80	76	58	69
gw20g	1	.3 m x .3 m	23	22	24	21	50	64	66	67	21	24
gw20g	1	1 m x 1 m	49	47	47	44	70	86	87	89	54	54

Table C-3. Frequency (%) and standard deviation in greasewood shrubland for 1999-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 100/plot.

Plot number	Grazed	Frequency plot size	Sand dropseed 01	Sand dropseed 02	Kochia 99	Kochia 00	Kochia 01	Kochia 02	Russian thistle 99	Russian thistle 00	Russian thistle 01	Russian thistle 02
gw04ug	0	.3 m x .3 m	0	0	8	2	2	0	0	0	0	0
gw04ug	0	1 m x 1 m	0	0	18	2	11	0	1	0	0	0
gw06ug	0	.3 m x .3 m	14	10	2	2	1	0	3	1	1	0
gw06ug	0	1 m x 1 m	44	40	6	6	1	0	15	3	8	0
gw10ug	0	.3 m x .3 m	13	9	3	1	2	0	3	0	0	0
gw10ug	0	1 m x 1 m	29	28	21	2	5	0	17	0	0	0
gw11ug	0	.3 m x .3 m	14	11	4	0	0	0	7	0	0	0
gw11ug	0	1 m x 1 m	36	37	31	0	1	0	23	1	3	0
gw14ug	0	.3 m x .3 m	17	18	6	2	0	0	7	3	1	0
gw14ug	0	1 m x 1 m	49	46	29	10	5	0	37	17	14	0
gw16ug	0	.3 m x .3 m	3	3	13	10	5	0	11	7	8	0
gw16ug	0	1 m x 1 m	14	13	35	26	17	0	35	23	22	0
gw01g	1	.3 m x .3 m	3	1	0	0	0	0	0	0	0	0
gw01g	1	1 m x 1 m	16	16	0	0	0	0	0	0	0	0
gw02g	1	.3 m x .3 m	18	7	0	0	0	0	0	0	0	0
gw02g	1	1 m x 1 m	42	27	0	0	0	0	6	1	0	0
gw05g	1	.3 m x .3 m	58	53	6	2	3	0	1	0	1	0
gw05g	1	1 m x 1 m	85	84	26	16	12	0	10	0	3	0
gw09g	1	.3 m x .3 m	7	5	2	0	0	0	5	1	0	0
gw09g	1	1 m x 1 m	18	13	4	4	6	0	13	3	0	0
gw13g	1	.3 m x .3 m	0	0	0	0	0	0	0	0	0	0
gw13g	1	1 m x 1 m	2	3	2	0	0	0	0	0	0	0
gw19g	1	.3 m x .3 m	35	22	0	0	0	0	0	1	1	0
gw19g	1	1 m x 1 m	69	60	0	0	0	0	4	7	2	0
gw20g	1	.3 m x .3 m	21	18	0	0	0	0	1	0	0	0
gw20g	1	1 m x 1 m	51	47	0	1	0	0	3	0	0	0

Table C-4. Mean canopy cover (%) and standard deviation in sandsage shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects for sandsage and 32 microplots/plot for all others.

Plot number	Grazed	Mean Std dev	Sandsage 98	Sandsage 99	Sandsage 00	Sandsage 01	Sandsage 02	Three-awn 98	Three-awn 99	Three-awn 00	Three-awn 01	Three-awn 02
ss08ug	0	mean		17	14	15	1		1	0	0	0
ss08ug	0	std dev		2	2	2	0		1	0	0	0
ss30ug	0	mean	8	12	9	13	5	12	15	13	14	0
ss30ug	0	std dev	2	3	2	2	1	4	8	6	7	0
ss31ug	0	mean	8	14	9	10	2	2	1	1	1	0
ss31ug	0	std dev	2	3	2	3	1	3	1	1	2	0
ss32ug	0	mean	12	16	17	19	3	4	5	5	4	0
ss32ug	0	std dev	1	1	2	2	1	3	3	2	2	0
ss39ug	0	mean	13	18	19	18	5	1	1	1	1	0
ss39ug	0	std dev	3	3	3	4	1	1	2	2	2	1
ss40ug	0	mean	11	14	12	13	3	2	1	1	1	0
ss40ug	0	std dev	2	1	0	1	1	3	3	1	2	0
ss21g	1	mean	13	25	21	23	4	4	5	3	3	0
ss21g	1	std dev	1	2	2	3	1	3	4	4	5	0
ss27g	1	mean	12	22	20	25	2	12	14	11	6	0
ss27g	1	std dev	1	3	3	4	1	4	7	5	4	0
ss36g	1	mean	13	14	16	20	3	6	4	3	4	0
ss36g	1	std dev	2	3	3	4	0	4	3	3	3	1
ss37g	1	mean	14	17	17	18	5	2	3	3	1	0
ss37g	1	std dev	1	1	1	1	1	4	5	5	1	0
ss38g	1	mean	11	14	12	16	5	13	14	9	9	1
ss38g	1	std dev	4	5	4	4	1	7	7	4	5	2

Table C-4. Mean canopy cover (%) and standard deviation in sandsage shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects for sandsage and 32 microplots/plot for all others.

Plot number	Grazed	Mean Std dev	Blue grama 98	Blue grama 99	Blue grama 00	Blue grama 01	Blue grama 02	Sand dropseed 98	Sand dropseed 99	Sand dropseed 00	Sand dropseed 01	Sand dropseed 02
ss08ug	0	mean		8	3	3	0		3	1	2	0
ss08ug	0	std dev		5	1	2	0		2	0	1	0
ss30ug	0	mean	20	23	23	23	3	5	4	3	3	0
ss30ug	0	std dev	4	4	3	3	2	5	3	2	2	0
ss31ug	0	mean	11	9	5	5	0	6	4	2	5	1
ss31ug	0	std dev	3	1	3	2	0	2	3	2	2	1
ss32ug	0	mean	13	12	10	9	2	6	8	5	6	0
ss32ug	0	std dev	5	5	5	4	1	4	3	2	3	0
ss39ug	0	mean	6	5	4	4	1	3	5	3	3	1
ss39ug	0	std dev	4	4	3	3	1	2	4	4	5	2
ss40ug	0	mean	5	5	3	3	0	10	8	3	3	0
ss40ug	0	std dev	6	3	3	3	0	7	6	2	3	0
ss21g	1	mean	10	7	4	5	1	15	12	8	12	1
ss21g	1	std dev	5	3	2	4	1	8	8	7	8	0
ss27g	1	mean	2	2	1	1	1	7	8	7	9	3
ss27g	1	std dev	2	1	1	1	0	4	2	1	2	2
ss36g	1	mean	16	13	11	12	1	6	5	4	5	0
ss36g	1	std dev	4	3	4	5	1	2	1	1	2	0
ss37g	1	mean	14	13	10	9	1	6	6	9	7	1
ss37g	1	std dev	6	4	4	5	1	1	1	3	3	1
ss38g	1	mean	22	17	11	10	4	8	9	7	7	1
ss38g	1	std dev	17	11	8	8	4	5	3	3	3	1

Table C-4. Mean canopy cover (%) and standard deviation in sandsage shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects for sandsage and 32 microplots/plot for all others.

Plot number	Grazed	Mean Std dev	Needle-and-thread 98	Needle-and-thread 99	Needle-and-thread 00	Needle-and-thread 01	Needle-and-thread 02	Russian thistle 98	Russian thistle 99	Russian thistle 00	Russian thistle 01	Russian thistle 02
ss08ug	0	mean		27	16	13	0		4	0	1	0
ss08ug	0	std dev		16	11	6	1		2	0	0	0
ss30ug	0	mean	0	0	0	0	0	0	0	0	0	0
ss30ug	0	std dev	0	0	0	0	0	0	0	0	0	0
ss31ug	0	mean	13	12	12	14	0	4	1	0	1	0
ss31ug	0	std dev	6	8	9	10	1	5	0	0	1	0
ss32ug	0	mean	0	1	0	1	0	0	0	0	0	0
ss32ug	0	std dev	0	1	0	1	0	0	0	0	0	0
ss39ug	0	mean	7	9	8	6	1	14	4	4	4	1
ss39ug	0	std dev	4	6	4	3	1	12	4	6	4	1
ss40ug	0	mean	16	14	10	9	0	3	1	0	1	0
ss40ug	0	std dev	10	8	6	5	0	4	1	0	1	0
ss21g	1	mean	0	1	1	1	0	0	0	0	1	0
ss21g	1	std dev	1	1	2	2	1	0	0	0	1	0
ss27g	1	mean	0	1	1	1	0	0	0	0	0	0
ss27g	1	std dev	1	2	1	1	0	0	0	0	0	0
ss36g	1	mean	0	0	0	0	0	2	0	0	0	0
ss36g	1	std dev	0	0	0	0	0	3	0	0	0	0
ss37g	1	mean	0	1	1	1	0	2	2	0	0	0
ss37g	1	std dev	0	1	1	2	1	1	2	0	0	0
ss38g	1	mean	0	0	0	0	0	1	1	1	1	0
ss38g	1	std dev	0	0	0	0	0	1	1	1	1	0

Table C-4. Mean canopy cover (%) and standard deviation in sandsage shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects for sandsage and 32 microplots/plot for all others.

Plot number	Grazed	Mean Std dev	Bare ground 98	Bare ground 99	Bare ground 00	Bare ground 01	Bare ground 02	Litter 98	Litter 99	Litter 00	Litter 01	Litter 02
ss08ug	0	mean		22	19	18	23		27	59	59	77
ss08ug	0	std dev		7	8	6	10		11	9	5	10
ss30ug	0	mean	47	41	30	28	33	15	15	30	30	63
ss30ug	0	std dev	7	4	2	3	4	5	5	4	5	7
ss31ug	0	mean	25	26	29	25	29	28	32	45	36	68
ss31ug	0	std dev	8	12	12	10	11	5	10	7	7	11
ss32ug	0	mean	44	29	27	23	29	24	39	47	48	65
ss32ug	0	std dev	8	5	5	8	8	4	11	8	9	7
ss39ug	0	mean	33	23	17	20	29	31	45	56	53	64
ss39ug	0	std dev	13	10	10	10	14	11	5	7	10	12
ss40ug	0	mean	26	15	18	20	28	30	45	56	43	68
ss40ug	0	std dev	9	8	12	13	11	5	7	11	9	11
ss21g	1	mean	38	29	24	24	32	28	40	55	39	63
ss21g	1	std dev	8	13	17	15	16	4	10	14	10	17
ss27g	1	mean	48	27	24	22	16	16	40	50	54	77
ss27g	1	std dev	3	10	6	3	3	3	11	10	4	4
ss36g	1	mean	39	30	24	26	34	20	39	53	40	64
ss36g	1	std dev	4	3	5	8	11	10	11	12	14	11
ss37g	1	mean	49	38	24	27	31	15	28	49	47	65
ss37g	1	std dev	10	17	10	12	12	11	16	14	14	13
ss38g	1	mean	41	30	22	24	29	10	24	49	43	64
ss38g	1	std dev	12	12	5	11	11	12	7	4	3	9

Table C-5. Mean density (individuals per 0.04 hectare) and standard deviation per belt transect in sandsage shrubland for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 4 50-m transects.

Plot number	Grazed	Mean Std dev	Sandsage 98	Sandsage 99	Sandsage 00	Sandsage 01	Sandsage 02
ss08ug	0	mean density		91	85	86	85
ss08ug	0	std dev		30	28	25	30
ss30ug	0	mean density	82	135	123	114	113
ss30ug	0	std dev	20	86	69	66	65
ss31ug	0	mean density	83	99	92	88	83
ss31ug	0	std dev	34	44	35	33	33
ss32ug	0	mean density	127	138	138	138	135
ss32ug	0	std dev	36	18	25	16	11
ss39ug	0	mean density	62	81	84	83	82
ss39ug	0	std dev	14	16	23	25	21
ss40ug	0	mean density	54	54	51	47	46
ss40ug	0	std dev	15	10	9	7	9
ss21g	1	mean density	122	151	157	148	136
ss21g	1	std dev	19	26	24	24	24
ss27g	1	mean density	13	9	13	23	32
ss27g	1	std dev	0	0	0	0	0
ss36g	1	mean density	93	98	111	108	99
ss36g	1	std dev	15	18	17	21	21
ss37g	1	mean density	76	91	84	83	71
ss37g	1	std dev	12	9	11	17	9
ss38g	1	mean density	80	79	76	79	77
ss38g	1	std dev	41	47	44	44	42

Table C-6. Frequency (%) and standard deviation in sandsage shrubland for 1999-2002 (2000-2002 for needle-and-thread).
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 100/plot.

Plot number	Grazed	Frequency plot size	Prickly pear 99	Prickly pear 00	Prickly pear 01	Prickly pear 02	Three-awn 99	Three-awn 00	Three-awn 01	Three-awn 02	Blue grama 99	Blue grama 00	Blue grama 01	Blue grama 02
ss08ug	0	.3 m x .3 m	2	2	1	1	8	6	2	3	30	31	30	26
ss08ug	0	1 m x 1 m	4	4	3	3	24	20	13	11	76	76	72	65
ss30ug	0	.3 m x .3 m	9	11	14	12	38	52	60	50	69	75	79	76
ss30ug	0	1 m x 1 m	29	31	32	30	86	88	88	86	94	98	99	99
ss31ug	0	.3 m x .3 m	3	6	3	5	9	18	14	10	46	42	39	39
ss31ug	0	1 m x 1 m	24	20	19	20	35	49	41	32	78	72	74	73
ss32ug	0	.3 m x .3 m	33	30	38	35	29	29	30	20	53	60	65	63
ss32ug	0	1 m x 1 m	69	71	73	72	84	87	84	76	94	91	91	90
ss39ug	0	.3 m x .3 m	14	8	9	10	3	3	0	2	22	29	36	35
ss39ug	0	1 m x 1 m	36	29	30	31	12	11	14	13	63	67	69	67
ss40ug	0	.3 m x .3 m	27	23	26	25	1	2	3	4	20	22	29	20
ss40ug	0	1 m x 1 m	57	56	55	57	5	10	10	10	46	52	54	49
ss21g	1	.3 m x .3 m	9	9	11	13	15	20	19	16	35	41	45	44
ss21g	1	1 m x 1 m	28	30	35	34	60	64	66	61	81	80	82	81
ss27g	1	.3 m x .3 m	17	17	18	26	50	61	65	43	9	12	8	10
ss27g	1	1 m x 1 m	54	51	51	54	97	96	93	89	27	31	24	23
ss36g	1	.3 m x .3 m	0	1	1	1	24	27	32	26	51	62	62	59
ss36g	1	1 m x 1 m	3	5	4	4	83	88	82	77	90	93	93	90
ss37g	1	.3 m x .3 m	1	2	2	2	9	5	6	6	54	64	61	58
ss37g	1	1 m x 1 m	10	5	6	9	27	30	23	22	93	90	95	94
ss38g	1	.3 m x .3 m	4	3	3	2	42	50	45	47	41	45	45	44
ss38g	1	1 m x 1 m	12	10	11	11	90	93	92	90	78	75	75	76

Table C-6. Frequency (%) and standard deviation in sandsage shrubland for 1999-2002 (2000-2002 for needle-and-thread).
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Sample size is 100/plot.

Plot number	Grazed	Frequency plot size	Sand dropseed 99	Sand dropseed 00	Sand dropseed 01	Sand dropseed 02	Needle- and -thread 00	Needle- and -thread 01	Needle- and -thread 02	Russian thistle 99	Russian thistle 00	Russian thistle 01	Russian thistle 02
ss08ug	0	.3 m x .3 m	21	17	16	15	48	49	46	71	25	18	0
ss08ug	0	1 m x 1 m	65	64	58	53	85	90	89	90	56	55	0
ss30ug	0	.3 m x .3 m	42	44	45	45	0	0	0	1	1	1	0
ss30ug	0	1 m x 1 m	85	86	87	86	1	1	1	4	1	4	0
ss31ug	0	.3 m x .3 m	24	13	16	15	54	61	52	7	0	1	0
ss31ug	0	1 m x 1 m	65	58	62	67	98	99	97	26	3	11	0
ss32ug	0	.3 m x .3 m	35	32	39	28	2	4	2	0	1	0	0
ss32ug	0	1 m x 1 m	90	88	89	82	11	13	12	2	1	0	0
ss39ug	0	.3 m x .3 m	13	13	16	13	42	55	49	45	35	27	2
ss39ug	0	1 m x 1 m	51	64	69	58	93	98	97	81	72	74	18
ss40ug	0	.3 m x .3 m	31	32	33	28	35	50	40	29	6	10	0
ss40ug	0	1 m x 1 m	77	83	83	78	79	85	81	62	19	33	0
ss21g	1	.3 m x .3 m	57	61	62	58	3	6	5	0	0	5	0
ss21g	1	1 m x 1 m	98	98	97	96	18	23	18	3	1	17	0
ss27g	1	.3 m x .3 m	39	50	57	41	2	3	3	0	0	0	0
ss27g	1	1 m x 1 m	90	92	98	97	5	16	13	0	0	1	0
ss36g	1	.3 m x .3 m	49	52	47	38	0	0	0	7	0	1	0
ss36g	1	1 m x 1 m	97	96	96	89	0	0	0	32	1	18	1
ss37g	1	.3 m x .3 m	65	61	65	59	4	4	9	38	6	8	0
ss37g	1	1 m x 1 m	99	97	99	99	23	24	29	82	13	21	0
ss38g	1	.3 m x .3 m	62	77	79	64	0	0	0	18	12	12	1
ss38g	1	1 m x 1 m	98	99	100	100	0	0	0	52	51	42	6

Table C-7. Mean canopy cover (%) and standard deviation in shortgrass prairie for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Prairie dogs: 0 = prairie dogs absent, 1 = prairie dogs present. Sample size is 32 microplots/plot.

Plot number	Grazed	Prairie Dogs	Mean Std dev	Three-awn 98	Three-awn 99	Three-awn 00	Three-awn 01	Three-awn 02	Blue grama 98	Blue grama 99	Blue grama 00	Blue grama 01	Blue grama 02	Galleta grass 98	Galleta grass 99	Galleta grass 00
sg61ug	0	1	mean	17	29	20	25	0	11	14	12	18	0	0	0	0
sg61ug	0	1	std dev	6	9	4	13	0	6	5	4	7	0	0	0	0
sg63ug	0	0	mean	1	1	0	0	0	3	4	1	2	0	28	37	9
sg63ug	0	0	std dev	1	1	0	0	0	3	4	1	3	0	10	10	1
sg68ug	0	0	mean	0	0	0	0	0	39	42	42	39	1	6	7	5
sg68ug	0	0	std dev	0	0	0	0	0	4	2	6	2	1	5	6	5
sg69ug	0	0	mean		9	3	3	0		50	23	28	0		0	0
sg69ug	0	0	std dev		7	2	2	0		10	4	4	0		0	0
sg74ug	0	0	mean		9	9	8	4		31	24	27	10		0	0
sg74ug	0	0	std dev		4	5	3	2		5	7	7	5		0	0
sg80ug	0	1	mean				14	0				0	0			
sg80ug	0	1	std dev				20	0				0	0			
sg81ug	0	1	mean				13	1				16	0			
sg81ug	0	1	std dev				4	1				12	0			
sg64g	1	0	mean		0	0	0	0		32	18	26	1		13	4
sg64g	1	0	std dev		0	0	0	0		11	9	8	0		6	2
sg65g	1	0	mean		0	0	0	0		18	5	15	0		0	0
sg65g	1	0	std dev		0	0	0	0		11	2	10	0		1	0
sg67g	1	0	mean	0	0	0	0	0	39	48	40	38	0	0	1	1
sg67g	1	0	std dev	0	0	0	0	0	8	8	7	8	0	1	1	1
sg70g	1	1	mean	8	10	8	6	0	21	24	26	29	2	2	6	4
sg70g	1	1	std dev	7	8	6	5	0	6	11	13	14	1	4	7	5
sg77g	1	1	mean	0	1	1	2	0	36	40	34	34	0	1	2	1
sg77g	1	1	std dev	1	2	1	2	0	4	5	5	6	0	2	3	1
sg78g	1	1	mean	10	12	11	12	0	24	15	22	25	1	0	0	0
sg78g	1	1	std dev	6	7	3	4	0	4	6	6	6	1	0	0	0
sg79g	1	0	mean	1	2	2	2	0	16	18	18	20	1	1	1	2
sg79g	1	0	std dev	2	2	2	2	0	9	6	8	8	1	1	2	3

Table C-7. Mean canopy cover (%) and standard deviation in shortgrass prairie for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Prairie dogs: 0 = prairie dogs absent, 1 = prairie dogs present. Sample size is 32 microplots/plot.

Plot number	Grazed	Prairie Dogs	Mean Std dev	Galleta grass 01	Galleta grass 02	Alkali sacaton 98	Alkali sacaton 99	Alkali sacaton 00	Alkali sacaton 01	Alkali sacaton 02	Sand dropseed 98	Sand dropseed 99	Sand dropseed 00
sg61ug	0	1	mean	0	0	0	0	0	0	0	2	3	2
sg61ug	0	1	std dev	0	0	0	0	0	0	0	1	1	1
sg63ug	0	0	mean	27	0	0	0	0	0	0	3	3	1
sg63ug	0	0	std dev	3	0	0	0	0	0	0	3	3	1
sg68ug	0	0	mean	5	0	0	0	0	0	0	0	0	0
sg68ug	0	0	std dev	4	0	0	0	0	0	0	0	0	0
sg69ug	0	0	mean	0	0		0	0	0	0		4	1
sg69ug	0	0	std dev	0	0		0	0	0	0		2	1
sg74ug	0	0	mean	0	0		0	0	0	0		5	3
sg74ug	0	0	std dev	0	0		0	0	0	0		4	2
sg80ug	0	1	mean	0	0				0	0			
sg80ug	0	1	std dev	0	0				0	0			
sg81ug	0	1	mean	2	0				0	0			
sg81ug	0	1	std dev	4	0				0	0			
sg64g	1	0	mean	6	1		2	1	1	0		0	0
sg64g	1	0	std dev	3	1		1	1	2	0		0	0
sg65g	1	0	mean	0	0		31	9	23	5		0	0
sg65g	1	0	std dev	1	0		12	3	10	2		0	0
sg67g	1	0	mean	1	0	0	1	0	1	0	0	0	0
sg67g	1	0	std dev	1	0	1	1	0	1	0	0	0	0
sg70g	1	1	mean	5	1	0	0	2	1	0	2	3	3
sg70g	1	1	std dev	7	1	0	0	3	3	0	2	3	1
sg77g	1	1	mean	0	0	0	0	0	0	0	0	0	0
sg77g	1	1	std dev	1	0	1	1	0	0	0	0	0	1
sg78g	1	1	mean	0	0	1	0	0	0	0	1	0	1
sg78g	1	1	std dev	0	0	2	0	0	0	0	1	0	1
sg79g	1	0	mean	1	0	5	7	6	7	1	7	7	5
sg79g	1	0	std dev	1	0	4	5	3	3	1	5	4	5

Table C-7. Mean canopy cover (%) and standard deviation in shortgrass prairie for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Prairie dogs: 0 = prairie dogs absent, 1 = prairie dogs present. Sample size is 32 microplots/plot.

Plot number	Grazed	Prairie Dogs	Mean Std dev	Sand dropseed 01	Sand dropseed 02	Kochia 98	Kochia 99	Kochia 00	Kochia 01	Kochia 02	Russian thistle 98	Russian thistle 99	Russian thistle 00	Russian thistle 01
sg61ug	0	1	mean	2	0	2	1	0	0	0	0	3	0	0
sg61ug	0	1	std dev	1	0	2	1	0	1	0	1	2	0	0
sg63ug	0	0	mean	1	0	0	0	0	0	0	0	0	0	0
sg63ug	0	0	std dev	2	0	0	0	0	0	0	0	0	0	0
sg68ug	0	0	mean	0	0	0	0	0	0	0	0	0	0	0
sg68ug	0	0	std dev	0	0	0	0	0	0	0	0	0	0	0
sg69ug	0	0	mean	0	0		0	0	0	0		0	0	0
sg69ug	0	0	std dev	0	0		0	0	0	0		0	0	0
sg74ug	0	0	mean	3	1		0	0	0	0		0	0	0
sg74ug	0	0	std dev	2	0		0	0	0	0		1	0	0
sg80ug	0	1	mean	2	0				2	0				0
sg80ug	0	1	std dev	4	0				2	1				0
sg81ug	0	1	mean	1	0				0	0				0
sg81ug	0	1	std dev	1	0				0	0				0
sg64g	1	0	mean	0	0		0	0	0	0		0	0	0
sg64g	1	0	std dev	0	0		0	0	0	0		0	0	0
sg65g	1	0	mean	0	0		0	0	0	0		0	0	0
sg65g	1	0	std dev	0	0		0	0	0	0		0	0	0
sg67g	1	0	mean	0	0	0	0	0	0	0	0	0	0	0
sg67g	1	0	std dev	1	0	0	0	0	0	0	0	0	0	0
sg70g	1	1	mean	3	1	1	3	0	0	0	0	4	1	0
sg70g	1	1	std dev	2	1	1	3	0	0	0	0	8	2	0
sg77g	1	1	mean	0	0	0	0	0	0	0	0	0	0	0
sg77g	1	1	std dev	1	0	0	0	0	0	0	0	0	0	0
sg78g	1	1	mean	1	0	0	16	0	0	0	0	0	0	0
sg78g	1	1	std dev	1	0	0	9	1	0	0	0	0	0	0
sg79g	1	0	mean	4	0	0	0	0	0	0	0	0	0	1
sg79g	1	0	std dev	4	1	0	0	0	0	0	0	0	0	2

Table C-7. Mean canopy cover (%) and standard deviation in shortgrass prairie for 1998-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Prairie dogs: 0 = prairie dogs absent, 1 = prairie dogs present. Sample size is 32 microplots/plot.

Plot number	Grazed	Prairie Dogs	Mean Std dev	Russian thistle 02	Bare ground 98	Bare ground 99	Bare ground 00	Bare ground 01	Bare ground 02	Litter 98	Litter 99	Litter 00	Litter 01	Litter 02
sg61ug	0	1	mean	0	35	18	11	12	21	19	22	54	39	79
sg61ug	0	1	std dev	0	4	5	2	5	9	5	7	4	3	9
sg63ug	0	0	mean	0	38	30	24	27	31	23	24	65	42	68
sg63ug	0	0	std dev	0	14	11	12	9	7	5	9	13	10	6
sg68ug	0	0	mean	0	40	34	29	25	24	12	14	23	28	74
sg68ug	0	0	std dev	0	8	7	7	4	6	3	4	6	4	6
sg69ug	0	0	mean	0		16	13	15	17		19	59	53	82
sg69ug	0	0	std dev	0		2	3	3	4		2	4	8	4
sg74ug	0	0	mean	0		29	27	30	31		22	36	30	54
sg74ug	0	0	std dev	0		4	7	9	5		2	5	7	5
sg80ug	0	1	mean	0				19	39				51	45
sg80ug	0	1	std dev	0				6	13				8	11
sg81ug	0	1	mean	1				23	53				41	43
sg81ug	0	1	std dev	1				7	7				4	8
sg64g	1	0	mean	0		39	35	35	34		12	42	32	64
sg64g	1	0	std dev	0		10	9	15	8		3	6	10	9
sg65g	1	0	mean	0		49	50	62	59		9	38	8	38
sg65g	1	0	std dev	0		16	22	14	17		5	20	3	15
sg67g	1	0	mean	0	53	38	33	34	40	7	11	26	26	59
sg67g	1	0	std dev	0	9	6	10	11	16	3	1	2	5	16
sg70g	1	1	mean	0	57	40	35	31	63	2	10	23	24	32
sg70g	1	1	std dev	0	6	8	16	12	7	3	5	13	13	9
sg77g	1	1	mean	0	51	45	37	40	50	12	11	27	23	50
sg77g	1	1	std dev	0	5	5	7	4	16	1	3	5	3	16
sg78g	1	1	mean	0	49	28	41	39	27	11	20	24	21	71
sg78g	1	1	std dev	0	7	15	11	8	9	3	6	11	6	10
sg79g	1	0	mean	0	67	53	47	46	39	1	13	19	19	58
sg79g	1	0	std dev	0	4	13	9	11	6	1	7	7	7	5

Table C-8. Frequency (%) and standard deviation in shortgrass prairie for 1999-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Prairie dogs: 0 = prairie dogs absent, 1 = prairie dogs present. Sample size is 100/plot.

Plot number	Grazed	Prairie Dogs	Frequency plot size	Prickly pear 99	Prickly pear 00	Prickly pear 01	Prickly pear 02	Three-awn 99	Three-awn 00	Three-awn 01	Three-awn 02	Blue grama 99	Blue grama 00	Blue grama 01	Blue grama 02
sg61ug	0	1	.3 m x .3 m	0	0	0	0	68	75	78	71	58	68	69	57
sg61ug	0	1	1 m x 1 m	1	0	1	0	99	97	98	98	92	94	93	87
sg63ug	0	0	.3 m x .3 m	24	24	22	21	10	7	4	4	16	13	11	11
sg63ug	0	0	1 m x 1 m	65	66	60	61	29	30	28	27	35	34	33	30
sg68ug	0	0	.3 m x .3 m	11	13	12	14	4	6	4	4	93	94	93	91
sg68ug	0	0	1 m x 1 m	59	57	51	56	9	11	11	11	99	99	98	97
sg69ug	0	0	.3 m x .3 m	22	23	23	20	19	20	20	19	88	90	90	89
sg69ug	0	0	1 m x 1 m	77	72	67	67	40	47	42	41	96	95	96	97
sg74ug	0	0	.3 m x .3 m	4	4	6	7	53	60	53	55	78	80	81	79
sg74ug	0	0	1 m x 1 m	33	32	32	31	97	98	96	96	97	96	95	94
sg80ug	0	1	.3 m x .3 m			0	0			8	4			0	0
sg80ug	0	1	1 m x 1 m			0	0			17	15			2	0
sg81ug	0	1	.3 m x .3 m			0	0			52	49			60	52
sg81ug	0	1	1 m x 1 m			0	0			86	88			75	74
sg64g	1	0	.3 m x .3 m	9	7	6	5	2	2	1	1	69	66	66	60
sg64g	1	0	1 m x 1 m	39	39	35	35	10	5	3	3	92	92	91	89
sg65g	1	0	.3 m x .3 m	6	7	7	7	0	0	0	0	43	44	48	49
sg65g	1	0	1 m x 1 m	48	43	46	45	1	0	0	0	67	67	69	70
sg67g	1	0	.3 m x .3 m	25	21	23	26	4	3	3	4	96	96	96	94
sg67g	1	0	1 m x 1 m	80	75	83	82	7	9	12	11	100	100	100	100
sg70g	1	1	.3 m x .3 m	1	1	2	0	51	48	45	24	64	74	74	69
sg70g	1	1	1 m x 1 m	6	5	5	4	84	85	81	46	88	89	94	91
sg77g	1	1	.3 m x .3 m	6	3	3	1	10	10	10	8	96	97	98	61
sg77g	1	1	1 m x 1 m	15	16	11	4	50	52	53	48	100	100	100	76
sg78g	1	1	.3 m x .3 m	1	2	4	3	75	84	84	84	84	92	91	93
sg78g	1	1	1 m x 1 m	6	8	9	9	98	99	99	99	99	100	100	100
sg79g	1	0	.3 m x .3 m	3	2	1	2	6	4	3	6	56	55	57	59
sg79g	1	0	1 m x 1 m	20	21	17	23	33	34	28	25	84	84	82	81

Table C-8. Frequency (%) and standard deviation in shortgrass prairie for 1999-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Prairie dogs: 0 = prairie dogs absent, 1 = prairie dogs present. Sample size is 100/plot.

Plot number	Grazed	Prairie Dogs	Frequency plot size	Galleta grass 99	Galleta grass 00	Galleta grass 01	Galleta grass 02	Alkali sacaton 99	Alkali sacaton 00	Alkali sacaton 01	Alkali sacaton 02	Sand dropseed 99	Sand dropseed 00	Sand dropseed 01
sg61ug	0	1	.3 m x .3 m	0	0	0	0	0	0	0	0	11	23	17
sg61ug	0	1	1 m x 1 m	2	2	2	0	0	0	0	0	57	70	66
sg63ug	0	0	.3 m x .3 m	95	98	96	99	3	3	3	3	11	12	11
sg63ug	0	0	1 m x 1 m	100	100	97	100	7	6	6	5	25	27	24
sg68ug	0	0	.3 m x .3 m	23	26	26	27	0	0	0	0	3	1	3
sg68ug	0	0	1 m x 1 m	46	51	46	50	0	0	0	0	12	12	12
sg69ug	0	0	.3 m x .3 m	0	0	0	0	0	0	0	0	18	21	17
sg69ug	0	0	1 m x 1 m	0	0	0	0	0	0	0	0	48	49	41
sg74ug	0	0	.3 m x .3 m	0	0	0	0	0	0	0	0	44	45	55
sg74ug	0	0	1 m x 1 m	0	0	0	0	0	0	0	0	83	85	93
sg80ug	0	1	.3 m x .3 m			0	0			0	0			1
sg80ug	0	1	1 m x 1 m			0	0			0	0			6
sg81ug	0	1	.3 m x .3 m			4	2			0	0			36
sg81ug	0	1	1 m x 1 m			6	5			0	0			71
sg64g	1	0	.3 m x .3 m	43	44	45	52	29	36	33	37	1	1	0
sg64g	1	0	1 m x 1 m	80	74	70	71	50	61	55	62	7	9	6
sg65g	1	0	.3 m x .3 m	7	8	9	9	58	64	71	72	0	1	0
sg65g	1	0	1 m x 1 m	13	12	15	14	87	90	91	95	3	2	1
sg67g	1	0	.3 m x .3 m	5	6	6	7	15	16	13	13	4	6	5
sg67g	1	0	1 m x 1 m	17	17	17	16	27	30	27	24	14	17	15
sg70g	1	1	.3 m x .3 m	8	12	12	10	0	0	0	0	21	48	50
sg70g	1	1	1 m x 1 m	15	16	16	13	0	1	1	1	63	88	88
sg77g	1	1	.3 m x .3 m	8	10	9	8	0	0	0	0	1	1	1
sg77g	1	1	1 m x 1 m	17	16	15	15	3	1	0	0	1	4	2
sg78g	1	1	.3 m x .3 m	7	7	9	9	0	0	0	0	16	45	45
sg78g	1	1	1 m x 1 m	16	17	16	16	0	0	0	0	30	75	76
sg79g	1	0	.3 m x .3 m	6	7	7	7	28	28	25	22	56	60	56
sg79g	1	0	1 m x 1 m	15	17	18	16	47	47	47	48	82	85	83

Table C-8. Frequency (%) and standard deviation in shortgrass prairie for 1999-2002.
Grazed: 0 = Ungrazed since 1942, 1 = Grazed until 1998. Prairie dogs: 0 = prairie dogs absent, 1 = prairie dogs present. Sample size is 100/plot.

Plot number	Grazed	Prairie Dogs	Frequency plot size	Sand dropseed 02	Kochia 99	Kochia 00	Kochia 01	Kochia 02	Russian thistle 99	Russian thistle 00	Russian thistle 01	Russian thistle 02
sg61ug	0	1	.3 m x .3 m	11	20	5	9	0	25	4	2	0
sg61ug	0	1	1 m x 1 m	60	58	16	23	0	72	11	10	0
sg63ug	0	0	.3 m x .3 m	7	1	0	0	0	1	0	0	0
sg63ug	0	0	1 m x 1 m	15	2	0	0	0	2	0	2	0
sg68ug	0	0	.3 m x .3 m	1	4	0	2	0	3	0	0	0
sg68ug	0	0	1 m x 1 m	8	5	0	3	1	9	1	2	0
sg69ug	0	0	.3 m x .3 m	16	5	2	0	0	6	1	1	0
sg69ug	0	0	1 m x 1 m	43	12	7	3	0	22	4	4	0
sg74ug	0	0	.3 m x .3 m	45	1	0	1	0	2	1	1	0
sg74ug	0	0	1 m x 1 m	89	6	1	2	0	15	5	14	0
sg80ug	0	1	.3 m x .3 m	0			25	22			1	0
sg80ug	0	1	1 m x 1 m	0			25	24			5	0
sg81ug	0	1	.3 m x .3 m	3			0	0			13	9
sg81ug	0	1	1 m x 1 m	24			0	0			56	33
sg64g	1	0	.3 m x .3 m	0	0	0	0	0	0	0	0	0
sg64g	1	0	1 m x 1 m	5	0	0	0	0	2	0	0	0
sg65g	1	0	.3 m x .3 m	0	0	0	0	0	1	0	0	0
sg65g	1	0	1 m x 1 m	1	0	0	0	0	7	0	0	0
sg67g	1	0	.3 m x .3 m	4	0	0	0	0	0	0	0	0
sg67g	1	0	1 m x 1 m	13	1	0	0	0	4	0	0	0
sg70g	1	1	.3 m x .3 m	28	0	0	0	0	6	12	5	0
sg70g	1	1	1 m x 1 m	80	1	0	0	0	28	19	12	0
sg77g	1	1	.3 m x .3 m	0	0	0	0	0	1	0	0	0
sg77g	1	1	1 m x 1 m	0	1	0	0	0	2	2	0	0
sg78g	1	1	.3 m x .3 m	41	0	0	0	0	1	9	5	0
sg78g	1	1	1 m x 1 m	75	0	0	0	0	9	28	13	1
sg79g	1	0	.3 m x .3 m	39	0	0	0	0	0	1	2	0
sg79g	1	0	1 m x 1 m	83	0	0	0	0	3	5	7	1