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MANAGEMENT AND RESEARCH NEEDS

FOR ENDANGERED AND THREATENED PLANTS, SAND PRAIRIE

VEGETATION AND HABITAT-RESTRICTED ANIMAL SPECIES

AT THE SAVANNA ARMY DEPOT

CARROLL CO. & JO DAVIESS CO., IL

Report to the Savanna Army Depot

by

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SUMMARY

Study objectives

The Savanna Army Depot contains 7,000 acres of sand prairie and savanna that provide habitat for ten Illinois endangered or threatened plant species, at least eight species of obligate prairie birds, including the state endangered upland sandpiper, and at least seven small mammal species. Persistence of these species depends upon maintenance of their sand prairie ecosystem, which has been degraded by overgrazing and fire protection. In order to restore the original vegetation structure and species diversity of this vegetation, the Illinois Department of Natural Resources and the U.S. Fish & Wildlife Service requested the Savanna Army Depot to reduce grazing levels and reintroduce prescribed burning to the sand prairie ecosystem. Experimental monitoring is needed to understand how to regulate grazing and burning in order to insure that populations of endangered and threatened plants and animals increase or persist. This report quantifies the abundances of rare plant populations, sand prairie birds, and small mammals at the Depot. In relation, we examine the effects of grazing exclusion and late spring prescribed burning on vegetation, and assess the potential effects on rare plants and prairie birds and small mammals.

Plant species

There are at least 74 occurrences of ten endangered or threatened plant species among 35 stations at the Savanna Army Depot. The sizes and numbers of populations of these species are highly variable, and the expected responses of many to experimental management are unknown. In general, we expect that prescribed burning and reduced grazing will benefit populations of those species that usually occur in sand prairie habitat, such as bearded wheatgrass, shaved sedge, kittentails, and inland New Jersey Tea, or redroot. Others may require more specific monitoring, especially those that are rare on a regional or national basis or require special habitats. For example, Mohlenbrock's umbrella sedge is nearly endemic to Illinois and is restricted to sand blowouts; the false heather is also restricted to blowouts, but is more widespread; the fragile prickly pear cactus has a single Illinois population that is located at the Depot; fame flower, a species of blowouts and open sand prairie, is a candidate for federal listing. We found the umbrella sedge in only three stations at the Depot, with a single large population in a 15-acre area. Experimental grazing exclusions are needed to assess the potential impact of reduced grazing on this population. False heather is more frequent at the Depot. Reduced grazing should benefit this shrub because it is easily damaged by trampling from cattle. However, it appears sensitive to fire, and its population sizes may change with burning. The fragile prickly pear was found to be extremely abundant in a single large area, and may have spread because of unpalatability to cattle. Burning and reduced grazing effects on this population should be monitored. Fame flower was found to be abundant throughout a large part of the Depot, usually occurring as scattered individuals in sand prairie and in blowouts. As with the fragile prickly pear, burning and reduced grazing effects on these populations should be monitored.

Bird populations

The abundances of different obligate, or characteristic, prairie bird species at the Depot appear to be affected by grazing and by the presence of other competitive bird species. The two most abundant obligate prairie birds are the grasshopper sparrow and the western meadowlark, which prefer heavy to moderate grazing and intermediate vegetation density. The endangered upland sandpiper

prefers similar habitat but is less frequent and may need habitat improvement. Reduced grazing is expected to cause a shift in abundance among these and other species, with prescribed burning providing alternate habitat for some species. However, specific research on each species is needed. A far more serious problem at the Depot is the high numbers of non-grassland bird species, which negatively impact the prairie species. Introduced trees should be removed from sand prairies to reduce numbers of non-grassland birds and improve habitat for prairie bird species.

Small mammal populations

Small mammal populations in the Depot sand prairie include the short-tailed and masked shrews, the deer mouse, western harvest mouse, and white-footed mouse, and the prairie and meadow voles. The deer mouse is by far the most abundant species, the prairie vole is common, and the white-footed mouse and meadow vole are uncommon. Population sizes of these species can be expected to vary depending on each species' response to grazing and burning, and their cyclic population trends. For example, shrew species are three times as abundant in areas excluded from grazing, while deer mice are more abundant in grazed areas and are expected to increase in burned areas. Vole species appear to be negatively impacted by prescribed burning, which reduces habitat cover and causes direct mortality; but, they can quickly repopulate after burns. The western harvest mouse appears to be most common in areas of sand blowouts, but may also require areas with vegetation cover. Specific research is needed to understand habitat needs and vegetation management impacts on this species at the Depot.

Experimental grazing and burning effects on sand prairie

Over a three-year period, combinations of fire, grazing, and grazing exclusion treatments were found to significantly alter the structure of sand prairie and the abundances of some plant species. One of our primary objectives was to determine if the importance of alien cool-season bluegrasses could be reduced by fire while increasing cover of native cool-season and warm-season prairie grasses. Because of a wet, cool spring, bluegrasses increased in all treatments except burning without grazing, while cover of native grasses increased in all treatments except combined burning and grazing. In relation, the endangered shaved sedge, a cool-season species, was found to have its greatest increase in frequency and cover under the burning without grazing treatment. These very preliminary results suggest that:

- burning is the most preferred management treatment for increasing native grasses and sedges while controlling alien grasses
- reduced grazing is the second most preferable
- combined grazing and burning is not recommended

Other results of these experiments were less clear. For example, the numbers of perennial herbaceous species declined in all treatments, while annual and biennial species did not decline only in the non graze treatment. Many of the late-successional species that we expected to increase with burning appeared to show a positive response by increased flowering, but they remain so rare that monitoring of sampling plots did not detect significant changes. Thus, continued monitoring of fire and grazing effects is needed to assess long-term management effects on vegetation, and interactions with animal species.

TABLE OF CONTENTS	Page
INTRODUCTION	1
STUDY AREAS	2
Areas with rare species	2
METHODS	3
Endangered or threatened plant populations	3
Animal populations	4
Vegetation responses to grazing exclusion and prescribed burning	4
RESULTS AND DISCUSSION	5
Numbers of plant species and populations	5
Individual plant species	6
Bird populations	11
Small mammal populations	12
Effects of grazing and burning on sand prairie structure	13
MANAGEMENT RECOMMENDATIONS	14
Individual plant species	14
Grassland birds	17
Small mammals	18
Sand prairie vegetation.	19
ACKNOWLEDGMENTS	20
REFERENCES	21
TABLES	
1. Endangered, threatened, & rare vascular plants	5
2. <i>Cyperus grayioides</i> population characteristics	8
3. <i>Hudsonia tomentosa</i> population characteristics	9
4. <i>Opuntia fragilis</i> population characteristics	10
5. Relative abundance and frequency of bird species	12
6. Relative abundance and frequency of small mammal species	13
FIGURES	
1. Location of the Savanna Army Depot and study areas	
2. Savanna Army Depot Vegetation Transect Locations	
3. Effects of burning, grazing, and grazing exclusion on dominant plants	
4. Effects of burning, grazing, and grazing exclusion on species richness and vegetation structure	
Appendix I. List of latin and vernacular names for sand prairie species.	

INTRODUCTION

The Savanna Army Depot comprises 13,000 acres in Carroll Co. and Jo Daviess Co., IL, including more than 7,000 acres of sand prairie and sand savanna vegetation. This vegetation was first studied in 1908 by H.S. Pepon (1909) and by H.A. Gleason (1910), who reported such rare plant species as *Besseyia bullii*, *Bouteloua gracilis*, *Ceanothus ovatus*, *Hudsonia tomentosa*, *Opuntia fragilis*, and *Talinum rugospermum* (common and latin names for plant species are given in Appendix I). Conversion of the site to an Army Ammunition Depot in 1917 resulted in long-term protection, but led to its compartmentalization by unsurfaced roads that access bunkers and storage buildings, and maintenance by open grazing. Beginning in the 1970's, investigations by the Illinois Department of Conservation (now Dept. of Natural Resources), Illinois Nature Preserves Commission, and Illinois Natural Areas Inventory began to document the presence of rare plant species and important habitats found by historic studies. Despite a history of open grazing and fire protection, the sand prairie has maintained populations of many endangered plant species and a diverse flora, and is one of the Midwest's largest and most important natural areas (Bowles 1993).

At the request of the Illinois Department of Natural Resources and the U.S. Army, we began to survey and quantify populations of rare plant species (Bowles & Jones 1991), and to assess management needs of prairie vegetation at the Savanna Army Depot (Bowles 1993). In the absence of fire, cattle grazing has been the primary mechanism maintaining open prairie at the Depot. However, such grazing is known to reduce cover of native grasses and forbs, while maintaining disproportionately high levels of grazing-adapted unpalatable plants, including alien weeds (Curtis 1959, White 1978). In contrast, burning increases cover of native grasses and maintains high levels of native species diversity (Collins & Wallace 1990). Indeed, comparisons of sand prairie vegetation at the Depot with former ungrazed conditions (Gleason 1910) and with small (< .025 ha) experimental grazing exclosures demonstrated that grazing alters the structure of sand prairie and eliminates late-successional plant species (Bowles 1993). However, it is unknown how burning and reduced grazing may affect populations of rare plants and sand prairie animals that have survived long-term grazing and fire protection. Of particular concern are characteristic or obligate prairie bird species, which require native prairie habitat and are in need of conservation management (Herkert *et al.* 1993), and populations of small mammals that occupy sand prairie habitat.

In this report, we quantify populations of endangered or threatened plants at the Depot and propose management recommendations and research needs. We also compare vegetation response to experimental grazing exclosure and prescribed burning conducted at the Depot,

and assess the status of bird and small mammal species within this context. We expected grazing exclusion to increase abundance of perennial grasses and forbs that are selectively eaten by cattle, and to decrease abundance of annual and biennial plant species that increase with grazing (Bowles 1993). In relation, we expected spring burning to further decrease abundance of annual and biennial plants and the cool season exotic bluegrasses *Poa compressa* and *pratensis*. Similarly, there are several expected responses of animal species to grazing reduction and burning. Among prairie birds, those requiring extremely open sparse habitat would be expected to decline with reduced grazing, but some of these species may nest in burned ungrazed habitat (Herkert *et al.* 1993). Small mammals have variable responses to grazing and burning, depending upon their habitat requirements (Kaufman *et al.* 1990). As with birds, those mammals that require sparse vegetation may decline with grazing exclusion, but they may use burned grassland as alternate habitat. However, species such as meadow voles may be vulnerable to fire and require recolonization to maintain populations (Harty *et al.* 1991).

STUDY AREAS

Areas studied with concentrations of rare species populations

Specific locations of endangered and threatened plant populations at the Savanna Army Depot were provided in an earlier report by Bowles & Jones (1991). Many of these species were concentrated within six areas of relatively high quality sand prairie and sand savanna that are described below (Figure 1).

Dry-mesic sand savanna - located in NE1/4 Sec 14, SE1/4 Sec 11. This is one of two comparatively high quality sand savannas in the Depot. Past disturbances include road and bunker construction, and the area is currently grazed. *Quercus velutina* is the dominant woody species, common graminoid species include *Andropogon scoparius*, *Koeleria cristata*, *Carex muhlenbergii*, and *Cyperus schweinitzii*. At least four rare species occur in this area, primarily in blowouts and open sand. *Cyperus grayioides* is restricted to a single blowout in this area. *Hudsonia tomentosa*, *Talinum rugospermum*, and *Polanisia jamesii* occur throughout the area in blowout and open sand savanna habitat.

Dry sand savanna - Examples of this community occur in two areas: NW1/4 NE1/4 Sec 25 and SE1/4 NW1/4 SE1/4 Sec 14. The site in Sec 14 is currently grazed; it contains a small population of *Besseyia bullii* and larger numbers of *Polanisia jamesii*. Part of the second area has been fenced to exclude cattle grazing, and contains populations of *Cyperus grayioides* and *Hudsonia tomentosa*.

Dry-mesic sand prairie and sand savanna - N1/2 N1/2 S1/2 NE1/4 Sec 24. This area extends for about 1/2 mile along the north edge of an east-west road. It is dominated by *Quercus velutina*, *Carex muhlenbergii*, *Aristida tuberculosa*, and *Tephrosia virginiana*. Important plant species present include a large population of the formerly Illinois listed *Paspalum bushii*, a local colony of *Agropyron subsecundum*, a large population of *Ceanothus ovatus*, and a reported population of *Salvia azurea*.

Dry-mesic sand prairie - NE1/4 Sec 24 and adjacent S1/2 S1/2 Sec 13. This is one of the larger tracts of sand prairie that is unfragmented by road and bunker construction. Past overgrazing may have led to abundance of the endangered *Opuntia fragilis*. Other common species include *Andropogon scoparius*, *Panicum oligosanthes*, *Cyperus schweinitzii*, *Aristida tuberculosa*, *Tephrosia virginiana*, *Selaginella ruprestris*, & *Ambrosia psilostachya*.

Dry sand prairie - NE1/4 SW1/4 Sec 30, and the adjacent NW1/4 SW1/4 SE1/4 Sec 30. This area includes the Depot's largest contiguous populations of *Cyperus grayoides* and *Hudsonia tomentosa*. These plants, along with *Cyperus schweinitzii* and *Aristida tuberculosa*, are dominant over 10 acres of open sand prairie where grazing appears to enhance blowout conditions.

Dry mesic sand prairie - NE1/4 & NW1/4 of Sec 3. This area contains the largest high quality contiguous tract of sand prairie on the Army Depot. It extends along a continuum from level upland sand prairie down an east-facing slope to open sand and blowouts. Dominant species include *Ambrosia psilostachya*, *Andropogon scoparius*, & *Selaginella ruprestris*. Small populations of late-successional species such as *Aster linariifolius*, *Sporobolus heterolepis*, *Stipa spartea*, *Helianthus rigidus*, *Petalostemum purpureum* & *Amorpha canescens* still occur in this tract, especially on slopes. The uncommon *Geum triflorum* & *Carex meadii* are present, along with populations of *Besseyia bullii*, *Hudsonia tomentosa* & *Talinum rugospermum*.

METHODS

Endangered or threatened plant populations

Systematic field searches were conducted in 1990 to determine the presence and status of Illinois listed or rare vascular plant species at the Savanna Army Depot (Bowles & Jones 1991). Once these populations were located, a variety of sampling methods were used to measure the frequency, cover, density, or size of plants in multiple plots ranging from 1/4m² to 1m², or in larger single plots. More specific methods are provided for each species in association with data analysis in the following section. Additional data on rare species were

compiled in association with community sampling conducted in exclosures in 1993 & 1995.

Animal populations.

Sand prairie bird species populations are annually surveyed at the Savanna Army Depot by the Department of Natural Resources, recording numbers of individuals seen or heard at non-overlapping sample stations located throughout the Depot sand prairie (*sensu* Glass 1991). The status of these populations was assessed by analyzing a data set collected from 105 sample points in 1990 (Bowles 1993). For comparison in this report, additional bird census data were analyzed from a station within the 20-ha exclosure in Sec 3, which was sampled twice annually in June-July of 1993-1995. For small mammal species, snap trap abundance data were collected in 1993 and 1995, and field surveys made in 1995. Data were collected from the 20-ha exclosure in 1993 (100 trap-nights) and in 1994 (200 trap-nights each), and from a grazed control area with 200 trap-nights in 1994 (Anderson *et al.* 1994).

Vegetation response to grazing exclusion and prescribed burning

Several large grazing exclosures were established in 1993 to allow assessment of vegetation and animal responses to reduced grazing levels at the Depot. One exclosure fence was established around the sand savanna and blowout complex in the SE1/4 NW1/4 SE1/4 Sec 14. A second 20 hectare (50-acre) exclosure was established in the high quality sand prairie in the NE1/4 & NW1/4 of Sec 3. Half of the exclosure and adjacent grazed sand prairie were spring-burned in 1995.

Seven sampling transects containing 139 permanent half meter square (0.5m^2) plots were established within the 20-ha exclosure in Sec 3 in 1993, before the effects of grazing exclusion could take place (Figure 2). To allow comparison with ongoing grazing, 5 transects with 79 plots were also established outside the exclosure in 1993. Within each plot, the number of square decimeters ($.01\text{ m}^2$) occupied by each vascular plant species was counted in 1993. This measurement provides a cover abundance index that ranges from 1-50, which can be divided by 50 to estimate percent cover. T-tests or ANOVA can be used to determine significant variation in the mean number of square decimeters occupied per plot under different treatments.

As indicated, half of the exclosure and an adjacent plot area were burned in spring 1995. This burn encompassed transects 5-10, allowing comparison of grazing and non-grazing effects within burned and non-burned areas, and interactions between these treatments. The burn was conducted with a southwest wind, on 25 April. At this time, the exotic cool season

grasses *Poa compressa* & *P. pratensis* were growing, along with the native sedge *Carex tonsa*, and some annuals and biennials. To compare the effects of the burn treatment and grazing enclosure, 120 plots (30 per treatment) were re-sampled in 1995 and analyzed for changes by repeated ANOVA. A similar transect with thirteen permanent plots was also established in 1995 inside the enclosure constructed in Sec 14.

RESULTS AND DISCUSSION

Numbers of plant species and populations found

In addition to seven rare plant species originally listed from the Depot by Gleason (1910), five new species have been recorded (Table 1). *Bouteloua gracilis*, which was originally found by Pepon in 1908, has not been relocated and is considered extirpated from Illinois. The sedge *Carex tonsa*, which occurs throughout the site, was probably lumped by Gleason with *C. umbellata*. The grass *Paspalum bushii* may have been included with *P. setaceum* by Gleason. This species was discovered at the Depot in 1990, and has since been removed from Illinois listing because it has been found to be too common. There are at least 74 occurrences of the remaining ten species among at least 35 stations at the Depot (Bowles & Jones 1991). Three species (*Agropyron subsecundum*, *Mirabilis hirsuta*, & *Salvia azurea*) may occur at a single locality. *Besseyia bullii* was found at two sites, *Opuntia fragilis* at three sites, and *Cyperus grayioides* at four sites. Fifty-nine occurrences of *Ceanothus ovatus*, *Polanisia jamesii*, *Hudsonia tomentosa*, & *Talinum rugospermum* are shared among 31 stations.

Table 1. Illinois endangered and threatened or rare vascular plants of the Savanna Army Depot. Asterisks (*) indicate species discovered new since Gleason (1910).

<u>Species</u>	<u>Common name</u>	<u>Status</u>
* <i>Agropyron subsecundum</i>	Bearded wheatgrass	Illinois endangered
<i>Besseyia bullii</i>	Kittentails	Illinois threatened
<i>Bouteloua gracilis</i>	Gramma grass	Illinois extirpated
* <i>Carex tonsa</i>	Shaved sedge	Illinois endangered
<i>Ceanothus ovatus</i>	Redroot	Illinois endangered
<i>Polanisia jamesii</i>	James' clammyweed	Illinois endangered
* <i>Cyperus grayioides</i>	Molenbrock's umbrella sedge	Illinois threatened
<i>Hudsonia tomentosa</i>	False heather	Illinois endangered
* <i>Mirabilis hirsuta</i>	Hairy umbrella wort	Illinois endangered
<i>Opuntia fragilis</i>	Fragile prickly pear	Illinois endangered
* <i>Paspalum bushii</i>	Hairy beadgrass	formerly Illinois endangered, delisted
* <i>Salvia azurea</i> subsp. <i>pitcheri</i>	Blue sage	Illinois threatened
<i>Talinum rugospermum</i>	Fame flower	not Illinois listed, under federal review

Individual plant species status

***Agropyron subsecundum* (bearded wheat grass)**

This tufted perennial grass usually occurs in mesic sand prairies. It is essentially restricted to extreme northern Illinois, where most populations occur in the Chicago region. We found a single population in a 150m² area of degraded mesic sand prairie located to the northwest of the road intersection in the NW1/4 NW1/4 SW1/4 NW1/4 of Sec 19. This is adjacent to the locality in which J. Schwegman found *Salvia azurea*.

The habitat for *Agropyron subsecundum* is grazed; additional species include *Poa pratensis*, *Rhus aromatica*, *Physalis virginiana*, *Verbena stricta*, *Achillea millefolium*, *Andropogon gerardii*, & *Panicum virgatum*. It also had been invaded by red cedar (*Juniperus virginiana*) and honey locust (*Gleditsia triacanthos*). We sampled the *A. subsecundum* by counting the number of flowering culms per 1-meter square area along a 1 meter x 15 meter transect. Non-flowering plants were not recorded because they were indistinguishable from other grasses. This may under-represent actual population density. We counted 146 flowering culms in the 15m² transect area. Their average density was 9.87 culms/m² (± 7.25 sd).

***Besseyia bullii* (kittentails)**

This perennial herb spreads by vegetative offshoots. It occurs in gravel and sand prairies and savannas across northwestern Illinois. Plants appear to be sensitive to drought and often occur on north slopes or in partial shade of savanna. According to Gleason (1910) it occurred in savanna and in sand prairie, and single populations were found in each of these habitats. One is in sand savanna on the top of a high dune, 25m west and 75m south of the northwest corner of a "buried ammunition" fence in the SE1/4 NW1/4 SE1/4 of Sec 14. The second population occurs in sand prairie inside and outside of grazing exclosures located on the east side of the perimeter road in the Carroll Co. section of the Depot in the NE1/4 of Sec 3.

In the sand savanna population, ten individual plants were found within a 2m² area, in association with *Quercus velutina*, *Juniperus virginiana*, *Rhus aromatica* var. *arenaria*, *Poa pratensis*, *Euphorbia corollata*, & *Parthenocissus quinquefolia*. This savanna has a closed tree canopy due to fire protection. The second population occurs on level upland sand prairie, and along an adjacent east-facing slope. There are probably several hundred or more plants spread over a 100-acre area. When sampled by 218 1/2m² plots among 12 stratified random transects, this species occurred three times in two of the transects where it ranged from 2% to 8% cover. In these plots, its common associates include *Achillea millefolium*, *Ambrosia psilostachya*, *Andropogon scoparius*, *Poa pratensis*, *Panicum oligosanthes*, *Panicum villosissimum*, &

Selaginella rupestris. In 1995 plants appeared in two plots that were grazed, and disappeared from two burned plots. However, many flowering plants were observed in parts of the burned area that were not sampled. More detailed sampling from larger plots is needed to further quantify population characteristics and management effects on this species.

***Carex tonsa* (shaved sedge)**

This perennial cespitose sedge is restricted to sand deposits in the northern half of Illinois. *Carex tonsa* occupies open sand prairie in at least four localities at the Army Depot. A large population occurs throughout the sand prairie inside and outside of grazing exclosures located on the east side of the perimeter road in the Carroll Co. section of the Depot in the NE1/4 of Sec 3. In this area, *C. tonsa* occurred in 22 out of 218 1/2m² plots (10.1% frequency) in 1993. In these plots, its common associates include *Achillea millefolium*, *Ambrosia psilostachya*, *Andropogon scoparius*, *Poa pratensis*, *Panicum oligosanthos*, *Panicum villosissimum*, & *Selaginella rupestris*. In 1995, plants dropped from 30% to 10% frequency and from 4.7% to 3.35 cover in the no burn/no graze treatment. But positive responses occurred in all other treatments. In the no burn/graze treatment, frequency increased from 3.3% to 10%, and in the burn/graze and burn/no graze treatments, plants increased from under 15% frequency to greater than 20% frequency. There were similar increases in cover in these treatments, with the greatest increase from 1.5% to 10.3% in the burn/no graze treatment.

***Ceanothus ovatus* (inland New Jersey tea, redroot)**

This shrub occurs in sandy or gravel prairies and savannas across northern Illinois. Gleason (1910) recorded it from savanna and from sand prairie. It is now widespread at the Army Depot, with at least eight stations. It forms large colonies in grazed dry-mesic sand prairie throughout Sec 32 and the NE1/2 of Sec 31. It also occurs in the S1/2 of S30, the NE1/4 of Sec 25, the SE1/4 of Sec 24, the SW1/4 Sec 29, and the SW 1/4 Sec 33.

In Sec 24, we censused 46 plants in a 200m²-meter circular plot, which is the equivalent of 1 plant/4.65m². By measuring the crown radius, we estimated crown surface area by $A = 3.1416 (r^2)$. Average crown area was .491 ($\pm .448sd$) m², and ranged from .0314-2.27m². The most common species occurring with *C. ovatus* in this plot were *Opuntia humifusa*, *Rhus aromatica* var. *arenaria*, *Cyperus schweinitzii*, *Carex muhlenbergii*, & *Selaginella rupestris*.

Cyperus grayioides (Mohlenbrock's umbrella sedge)

This perennial sedge is restricted to sand deposits along the Illinois and Mississippi Rivers. Its optimum habitat appears to be natural sand blowouts in excessively dry sand prairie and sand savanna, where it often occurs with *Hudsonia tomentosa*. We found three stations for this species at the Army Depot. One population occurs within a 300m² area between bunkers 907 & 908 in the SE1/4 NW1/4 NE1/4 of Sec 14. A second site consists of three small colonies located in sand savanna in the NW1/4 NE1/4 of Sec 25. The only large population occurs in a series of blowouts in about 15 acres of dry-sand prairie located in the NE1/4 SW1/4 of Sec 30, and the adjacent NW1/4 NW1/4 SE1/4 of Sec 30.

We sampled the *Cyperus grayioides* populations by recording the frequency and density of plant stems (ramets) in 1m² plots along four stratified random transects through three populations. At the first site, the most frequent associates were *Hudsonia tomentosa* (100% frequency) and *Panicum villosissimum* (67% frequency), while *C. grayioides* occurred at 50% plot frequency. At the second site, *C. grayioides* occurred at 41% frequency. At the third site, the most frequent plants in the first transect were *C. grayioides* (72% frequency), *C. schweinitzii* (52% frequency), *Hudsonia tomentosa* (35% frequency) & *Aristida tuberculosa* (32% frequency). *Cyperus grayioides* also occurred at 72% frequency in the second transect at the third site. Among the four transects, we sampled a total of 385 ramets within a total 84m² sampling area, within which *C. grayioides* plot density ranged from 0 to 26 plants/m² (Table 2). Average density was not highly variable, ranging from 2.88 (\pm 2.77 sd) to 7.24 (\pm 11.53 sd) ramets/m² across the three sites. Both the highest and lowest plot densities for this species occurred in transects where it had highest plot frequencies.

Table 2. Characteristics of three *Cyperus grayioides* populations at the Savanna Army Depot

Population & Plot No.	No. of plots	Plot frequency	Total ramets sampled	Density range/m ²	Average ramet density/m ²
1	12 1m ²	50%	24	0-6	3.00 (\pm 1.69 sd)
2	22 1m ²	41%	93	0-22	4.22 (\pm 6.92 sd)
3a	25 1m ²	72%	196	0-26	7.24 (\pm 11.53 sd)
3b	25 1m ²	72%	72	0-10	2.88 (\pm 2.77 sd)

Hudsonia tomentosa (false heather)

This shrub is a low mat-forming colonizer of sand blowouts in northwestern Illinois. There are at least 19 population occurrences throughout the depot, where it is restricted to open sand of natural blowouts in dry sand prairie and sand savanna.

We sampled *Hudsonia tomentosa* by recording its plot frequency and either the percent

cover or density of plants in 1m² plots along stratified random transects through three populations that contained *Cyperus grayioides*. At these sites, *H. tomentosa* frequency ranged from 36% to 100%. At the site with 36% *H. tomentosa* frequency, *Cyperus grayioides*, *C. schweinitzii*, & *Aristida tuberculosa* occurred at 72%, 52%, and 32% frequency, respectively. Where *H. tomentosa* occurred with 100% frequency, *Panicum villosissimum* & *Cyperus grayioides* were subdominant at 67% frequency.

When *H. tomentosa* density was measured, it ranged from 0-3 plants/m², with an average of 0.92 (± 0.954 sd) plants/m², and 14 plants occurred within a 25m² sampling area at 56% frequency. When *H. tomentosa* cover was measured, it ranged from 0% to 50%, averaging 7.24% (± 11.53 sd)/m² when frequency was 36%, and 22.08% (± 1.69 sd)/m² when frequency was 100%. We also encountered *Hudsonia tomentosa* rarely in community sampling plots. Here, this species occurred in three 1/m² plots among three transects out of a total of 218 plots among 12 transects. In these plots, it ranged from 4% to 14% cover, and common associates included *Panicum villosissimum*, *Polygonella articulata*, *Ambrosia psilostachya* & *Festuca octoflora*.

Table 3. Sampling data for *Hudsonia tomentosa* in sites that also support *Cyperus grayioides* populations at the Savanna Army Depot.

Plot No.	No. of plots	Plot frequency	% cover range/m ²	Density range/m ²	Average % cover or density/m ²
1	12 1m ²	100%	5-50%	-----	22.08% (± 1.69)
2	25 1m ²	56%	-----	0-3/m ²	0.92 (± 0.954)
3	25 1m ²	36%	0-50%	-----	7.24% (± 11.53)

***Mirabilis hirsuta* (hairy umbrella-wort)**

Only two native Illinois stations are known for this perennial herb, one at the Army Depot and a second at the adjacent Hanover Bluff Nature Preserve, Jo Daviess Co. A few plants were found by John Schwegman in dry-mesic sand prairie in the NW1/4 NW1/4 of Sec 10. We observed these plants in 1990, but an adjacent wildlife food plot may have destroyed most of the population.

***Opuntia fragilis* (fragile prickly pear)**

This cactus occurs in Illinois only in sand prairie at the Savanna Army Depot, where it was discovered by Gleason. Unlike the common prickly pear (*Opuntia humifusa*), which is widespread at the Depot, there are as few as three stations for *O. fragilis*, and only one large population. This species is most abundant within the NE1/4 of Sec 24 and the adjacent S1/2

S1/2 of Sec 13, where thousands of plants occur at extremely high densities in overgrazed prairie. This site is a low basin that may differ ecologically from other Depot habitats.

We sampled the largest population with two separate transects, one with 25 plots through low, mesic sand prairie, and the second with 15 plots through higher, dry-mesic sand prairie. In these transects, we recorded frequencies of all species in 1/4m² plots and the numbers of *O. fragilis* plants in 0.4m² subplots. In the mesic prairie transect, *Ambrosia psilostachya* was the most common species, occurring at 84% frequency; *O. fragilis* and *Panicum oligosanthos* were the second most abundant plant species, at 76% frequency, while *Tephrosia virginiana* occurred at 68% frequency and *Cyperus schweinitzii* at 64% frequency. In this transect, 80 *O. fragilis* plants occurred in the total 10m² total sampling area, with a average density of 2.84 (± 3.21 sd) plants/0.4m², or, approximately 7.1 plants/m². In the dry-mesic transect, *Opuntia fragilis* occurred at 100% frequency, *Ambrosia psilostachya* at 67% frequency, and *Tephrosia virginiana* occurred at 53% frequency. Here, 62 *O. fragilis* plants occurred in the total 6m² sampling area, with a average density of 4.13 (± 2.87) plants/0.4m², or, approximately 10.325 plants/m².

Table 4. Sampling data for *Opuntia fragilis* at the Savanna Army Depot.

Plot	No. of 1/4m ² plots	Plot frequency	Average density/0.4m ²
mesic	25	76%	2.84 (± 3.21 sd)
dry-mesic	15	100%	4.13 (± 2.87 sd)

***Polanisia jamesii* - (James' clammyweed)**

This annual herb is an obligate colonizer of open sand blowouts and disturbances. It may occur in Illinois only in JoDaviess County, with the largest population at the Savanna Army Depot. Here, there are thousands of plants in at least 23 stations, primarily in artificial disturbances along roadsides and to a lesser degree in natural blowouts. We sampled one roadside population with a 1m x 20m transect, in which *Polanisia jamesii* plants were quantified by their number per 1/m². There were 201 plants in the 20m² sampling area, with an average of 10.05 (± 6.38 sd) plants/m². *Polanisia jamesii* was also the most abundant plant species, occurring at 100% frequency. *Diodera teres* occurred at 85% frequency, while *Panicum villosissimum* and *Bromus tectorum* occurred at 50% frequency.

***Salvia azurea* subsp. *pitcheri* (blue sage)**

This perennial herb occurs rarely as native populations in southern, western, and

northwestern Illinois, usually in dry habitats. One station was found in the Army Depot by John Schwegman. It was located southwest of a road intersection in the NW1/4 NW1/4 SW1/4 NW1/4 of Sec 19. This is adjacent to the locality for *Agropyron subsecundem*, but the *Salvia azurea* was not relocated.

***Talinum rugospermum* (fame flower)**

This perennial herb occurs in most Illinois sand deposits, but is usually rare. At the Savanna Army Depot, it occurs in at least nine stations, including blowout openings in dry-mesic sand savanna and in open sand prairie. It occasionally occurs with *Hudsonia tomentosa*. It is frequent in the SE1/4 of Sec 11, and in the adjacent NE 1/4 of Sec 14, and also occurs inside and outside the grazing enclosure in the NE1/4 of Sec 3. In the grazing enclosure study, *T. rugospermum* occurred in five out of a total of 218 1/m² plots in three out of the 12 transects. In these plots it always occurred at less than 2% cover, and was associated with *Ambrosia psilostachya*, *Andropogon scoparius*, *Cyperus filiculmis*, *Lepidium virginicum*, *Oenothera rhombipetala*, *Panicum villosissimum*, & *Selaginella rupestris*. Based on a frequency of five out of 218 plots, it is difficult to estimate the population size, but Robertson *et al.* (1993) estimated that over 300 plants occurred in the enclosure area.

Bird populations

Bird species sampled at the grazing enclosure station (Table 5) are representative of samples made in sand prairie throughout the Depot, in which the western meadowlark and grasshopper sparrow are the most frequent species (Bowles 1993). For example, of the eight characteristic prairie species found at the Depot, only the upland sandpiper and horned lark were not sampled at the enclosure, and the grasshopper sparrow and western meadowlark were the most abundant and frequent species found at the enclosure. Further, the four most important grassland species found throughout the Depot also occurred at the enclosure station with the same rank abundance, with the field sparrow as the most important species. As elsewhere, however, non-grassland bird species were abundant, with a total of seven species sampled at a frequency greater than all grassland birds. This abundance of non-grassland species indicates the negative influence of trees and shrubs at the Depot, which allow persistence and competition of non-grassland birds with true prairie species (Bowles 1993).

Table 5. Relative abundance (percent of total individuals sampled) and frequency (presence at sample points over time) of birds censused from a 20-ha grazing enclosure at the Savanna Army Depot. Data from a single sample point censused twice annually during May-July 1993-1995. Species organized by prairie, grassland, or non-grassland guilds (*sensu* Herkert *et al.* 1993).

	<u>Rel. abundance</u>	<u>Frequency over time</u>
Prairie birds	47.9%	
Grasshopper sparrow	20.8%	100%
Western meadowlark	10.4%	100%
Eastern meadowlark	6.2%	50%
Savannah sparrow	5.2%	33%
Vesper sparrow	3.1%	16.7%
Dickcissel	2.1%	16.7%
Grassland birds	14.6%	
Field sparrow	5.2%	66.7%
Lark sparrow	4.2%	50%
Mourning dove	4.2%	50%
Redwinged blackbird	1.0%	16.7%
Nongrassland birds (7 species)	33.3%	
Exotic species	4.2%	
European starling	4.2%	16.7%

Small mammal populations

Small mammal populations within the grazing enclosure (Table 6) appear to be representative of the Depot sand prairie in general (Anderson *et al.* 1994), with the deer mouse the most abundant species and prairie vole a subdominant species, especially in grazed habitat. The western harvest mouse was also locally abundant, occurring in areas with blowout habitat (Anderson *et al.* 1994, R.W. Nyboer, pers.comm.). Although they were not common, short-tailed and masked shrews were three times as abundant in the grazing enclosure as in the grazed area, while the western harvest mouse was absent from the grazed area. The lower abundance of shrews and harvest mice might be expected, as these species use litter for foraging and nesting, respectively, while deer mice prefer the open habitat of burned and grazed sites for seed foraging (Kaufman *et al.* 1990). As a result, deer mouse had greater relative abundance in the grazed prairie.

Table 6. Relative abundance (percent of total individuals sampled) and total frequency (percent of trap-nights per transect) for small mammals trapped from transects sampled in a 20-ha grazing exclosure at the Savanna Army Depot, and in a grazed area (G). Sample size (n) is number of trap nights. Species organization follows Kaufman *et al.* (1990).

	Relative abundance			Total frequency		
	n=100	n=200	n=200	n=100	n=200	n=200
	1993	1994	1994 (G)	1993	1994	1994 (G)
Shrews						
Short-tailed shrew	-----	7.4%	1.8%	-----	2.5%	0.5%
Masked shrew	-----	4.4%	1.8%	-----	1.5%	0.5%
Cricetine rodents						
Deer mouse	30.6%	52.9%	70.9%	11%	18%	19.5%
Western harvest mouse	11.1%	7.4%	0%	4%	2.5%	0%
White-footed mouse	-----	1.5%	0%	-----	0.5%	0%
Microtine rodents						
Prairie vole	8.3%	22.1%	23.6%	3%	7.5%	6.5%
Meadow vole	-----	-----	1.8%	0%	0%	0.5%
Sciurid rodents						
13-lined ground squirrel	-----	4.4%	0%	-----	1.5%	0%
Other						
	50%	-----	-----	18%	-----	-----
	Total individuals			Total frequencies		
	36	68	55	36%	34%	27.5%

Effects of grazing and burning treatments on sand prairie vegetation structure

Changes in species and species richness

There were few clear differences among management treatments for changes in dominant species (Figure 3). The dominant native grass was little bluestem (*Andropogon scoparius*). This species increased in percent cover in all treatments but exceeded 30% cover only in the non-burn treatments. Indian grass (*Sorghastrum nutans*) increased to over 10% cover only in the burn treatment. Grazing adapted forbs were dominant in all treatments, including the rhizomatous *Ambrosia psilostachya*, *Rumex acetosella* and *Selaginella rupestris* and the annual/biennial *Plantago purshii*, *Lepidium virginicum*, & *Festuca octoflora*. All of these species declined in cover in all treatments, except for moderate increases of *Plantago purshii* & *Festuca octoflora* in the non-burn/graze treatment. *Selaginella rupestris* underwent its greatest decline in the burn/no graze treatment.

Overall, average plot species richness for native species declined significantly ($P < .0000$) from 12.1 species per plot in 1993 to 9.1 species per plot in 1995 (Figure 4a). Native plot species richness also varied significantly per plot ($P = .0001$) over time between grazing and burning treatments, declining for all treatments except no burn/graze, the historic management treatment (Figure 4a). Plot richness of alien species did not change over time when averaged across all treatments ($P = .09$); but, it differed between treatments over time

($P = .05$), with an increase only for the no burn/graze treatment (Figure 4a). Overall, there were 68 rare species, including seven aliens, that either appeared or disappeared from treatments between 1993 and 1995. Only in the non-burn/no graze plots was there an equal gain and loss of these species, with 12 species appearing and 12 species disappearing. Elsewhere, 25 species disappeared from the non-burn/no graze treatment, 21 species disappeared from the burn/graze treatment, and 18 species disappeared from the burn/no graze treatment.

Changes in vegetation structure

The total cover abundance of native perennial grasses increased significantly over time ($P < .0000$). But, this change differed among treatments ($P = .0005$), with perennial grasses not increasing in the burn/graze treatment (Figure 4b). Native perennial forbs behaved differently (Figure 4b). These species also declined over time across all treatments ($P = .01$), with no differences among treatments ($P = .92$). However, only in the burn/graze treatment did forbs decline without an associated increase in native forbs. Cover abundance of the alien bluegrasses *Poa pratensis* and *P. compressa* increased significantly over time by a factor of almost three ($P < .000$). This increase differed among treatments ($P = .0004$), with bluegrasses not increasing in the burn/no graze treatment (Figure 4c). In contrast, annual and biennial species decreased over time by a factor of two when averaged across treatments ($P < .0000$), and differed among treatments ($P = .01$). Here, annual and biennial species did not decrease only in the no burn/graze treatment (Figure 4c).

MANAGEMENT AND RESEARCH RECOMMENDATIONS

Individual plant species

Agropyron subsecundum

This perennial grass appears to be adapted to fire, and could be expected to increase with burning. However, its palatability and resistance to cattle grazing is unknown, and its response to grazing reduction is not clear. A positive response to burning or reduced grazing could be indicated by either an increase in size of the original 150m² area occupied, or an increase in the average culm density above the 9.87 culms/m² that was originally measured in the populations. There is an immediate need to eliminate juniper (*Juniperus canadensis*) and honey locust (*Gleditsia triacanthos*) from the habitat of this grass. These woody species should be cut and removed, and herbicide applied to the honey locust stumps.

Besseyia bullii

This species appears to be fire-tolerant, and also resistant to light grazing. But, no studies have specifically addressed the effects of reduced grazing and prescribed burning on this species, and our plot samples were too infrequent for conclusive data. If plants are fire- and grazing-tolerant, their populations may remain stable with management. Because these plants are infrequent and widely dispersed in sand prairie, additional sampling from large-scale plots is needed to characterize their population structure and reactions to management treatments. In the dry-mesic savanna, responses of kittentails to management to open the savanna canopy should be carefully monitored.

Carex tonsa

This species appears to be fire-adapted, and had its greatest increase in frequency and cover in the burn/no graze treatment. The palatability and resistance of this species to grazing is unknown, but plants also increased in frequency and cover under continued grazing, with or without fire. Our data indicate that spring burning without grazing may have the greatest positive effect on frequency and cover of this species. However, its early flowering period may cause susceptibility to late spring burning, which could prevent seed production and limit population spread.

Ceanothus ovatus

This species is eaten by deer (R. Nyboer, pers. comm.) and probably cattle, but specific effects of grazing are unknown. However, the large population size at the Depot suggests that it may be grazing resistant. This shrub appears to be fire-adapted by resprouting, as in *Ceanothus americanus*. A positive response to fire in Sec 24 could be indicated by an increase above the estimated density of 1 plant /4.65m². Burning should be expected to reduce the crown size of plants below the sample estimate of ~0.5m², and could be experimentally compared to a control area to assess effects on subsequent flowering and seed production.

Cyperus grayioides

Habitat requirements, and thus management recommendations, for this species are not fully understood. For example, although *Cyperus grayioides* is clearly adapted to sand blowouts, which are common at the Depot, only three populations were found. The largest population also occurs in habitat disturbed by cattle grazing, which occurs throughout the Depot. It is also unknown if this perennial species, like *Cyperus schweinitzii*, is unpalatable to cattle, or if it has a persistent seed bank. This is often a characteristic of disturbance-adapted annual species,

allowing them to survive and recolonize after disturbance. Several generalizations and recommendations emerge from these observations. This species' restriction to open sand suggests that it is sensitive to competition. But, it is unknown if it can tolerate frequent disturbance. The reaction of populations to altered disturbance patterns could be experimentally treated with a partial grazing exclosure to determine if plant density changes in relation to reduced grazing. To determine its ability to colonize habitats, seed production should be monitored, and seeds and seedlings should be introduced to apparently similar and different natural and artificially disturbed blowout habitats.

Hudsonia tomentosa

As with *Cyperus grayioides*, this species is restricted to open blowouts, but is far more common. Because *H. tomentosa* is woody, it is highly sensitive to fire. Fire protection and reduced grazing may allow fuel buildup, after which infrequent fires could eliminate this species. Thus, it should be determined if burning at certain frequencies can help maintain habitat for this species, and if it declines in unburned grazing exclosures. Cattle grazing may promote this species by stimulating blowout formation, but trampling damages and may kill individual plants. Because of the high number of populations, critical management for this species appears unnecessary, but populations should be monitored for changes in plant cover or density.

Mirabilis hirsuta

No information is available on the palatability or grazing resistance of this species, nor on its reaction to prescribed burning. It may never have been common, as it was not located by Gleason (1910). Experimental management is needed to assess methods for maintaining this species. Important research needs are to determine why it is rare and to identify its requirements for seed production and seedling establishment.

Opuntia fragilis

This cactus is unpalatable, and now apparently persists at an unnaturally large population size due to past grazing. However, plants appear to be essentially restricted to only a few areas and are abundant only at one station. Grazing should be experimentally reduced in part of the habitat occupied by this species. This may reduce the population size, and the effects on plant density should be carefully monitored. Its resistance to prescribed burning is unknown. If burning negatively impacts plants and selects for higher grass cover, it should also cause a decline in abundance.

Polanisia jamesii

This abundant annual herb does not appear to be in need of management at the Savanna Army Depot. Because it is disturbance-adapted, it may undergo a decrease in population size and plant frequency or density with reduced grazing. However, because of the extremely large number of individuals, any moderate reduction should not be critical to the persistence of this species at the Depot.

Salvia azurea subsp. *pitcheri*

No information is available on the palatability or grazing resistance of this species, nor on its reaction to prescribed burning. It may never have been common, as it was not located by Gleason (1910). Experimental management is needed to assess methods for maintaining this species. Important research needs are to determine why it is rare and to identify its requirements for seed production and seedling establishment.

Talinum rugospermum

This disturbance-adapted species occupies blowouts and small open patches in sand prairie. It does not maintain a persistent seed bank and relies upon seed dispersal to colonize disturbance patches (Pavlovic 1994). Although no information is available on the palatability or grazing resistance of this species, it may be promoted by moderate grazing, as it is widespread in parts of the sand prairie. However, it is easily damaged by trampling, which separates the plant from its taproot. This can be especially damaging to populations in savannas, where cattle collect during hot weather. It is probably most negatively impacted by grass competition, especially from sod-forming species such as bluegrass. Because of its wide dispersal and abundance at the Depot, no specific management is needed. However, monitoring for changes in population numbers and plant density should accompany reduced grazing and burning management.

Grassland bird management

Management needs are not clear for individual prairie bird species at the Savanna Army Depot because little information is known about their specific status or response to the current level of grazing. The primary management goal should be to maintain or increase population levels of characteristic prairie bird species, as this group is most vulnerable and sensitive to habitat loss (Herkert *et al.* 1993) and is apparently well-represented at the Depot. Management should focus on two objectives that can most easily affect status of these birds at the Depot: 1) reduction of non-grassland birds' use of prairie habitat, and 2) manipulation of habitat structure by grazing and burning. Non-grassland bird use of prairie can be reduced by removing trees and buildings

from open prairie. Buildings that cannot be removed could be repaired to prevent use by cavity-nesting birds such as starlings.

Experimentation is needed to understand how to best manage for bird species by using different grazing and burning intensities. Management experiments should be applied to blocks of at least 250 acres (100 ha) to overcome effects of small habitat size on bird use (Herkert *et al.* 1993). Blocks selected for management also should be as free as possible of trees, bunkers, and buildings to avoid attracting non-grassland birds. The primary effect of reduced grazing on vegetation is expected to be increased grass and litter cover and decreased sand cover (Bowles 1993). With total grazing exclusion, grass and litter cover should reach over 40% with sand cover less than 20%. These changes could select for increased frequencies of tallgrass prairie birds such as the dickcissel, eastern meadowlark, and savannah sparrow, but may decrease frequencies of the more common western meadowlark, grasshopper sparrow, and horned lark. However, dormant season burning might balance against effects of decreased grazing and allow maintenance of mixed-grass species under a reduced grazing regime. Such burning decreases early-season vegetation cover and depth and favors nesting by short grass species such as upland sandpipers and vesper sparrows (Plypec 1992, Skinner *et al.* 1984). Application of burning and grazing on a rotational basis should also be considered. For example, three-year burn rotations may also favor savannah sparrows (Skinner *et al.* 1984).

Even with reduced grazing, the dry-mesic sand soils at the Depot should prevent vegetation from attaining tallgrass conditions (Bowles 1993). For example, grass canopy heights measured in grazing exclosures at the Depot were under 25-cm, the canopy height for optimum habitat use by tallgrass prairie birds found in Missouri (Skinner *et al.* 1984). Thus, populations of these birds could be marginal and may not increase excessively with reduced grazing. If horizontal vegetation cover and litter are increased below 25 cm, and open sand cover is reduced but not eliminated, some mixed-grass species still may be favored.

Small mammal management

The primary management goal for small mammals at the Army Depot should be to maintain high levels of diversity among species now present, primarily by maintaining habitat conditions for less common species. As with birds, management prescriptions could be developed and tested based on mammal species' responses to changes in vegetation structure caused by altered grazing and prescribed burning. Because these processes remove litter and cover, they appear to select for deer mice, which forage for seeds, while decreasing habitat for shrews, western harvest mice, and voles (Kaufman *et al.* 1990). For the western harvest mouse, which was sampled more frequently near blowouts, this conclusion appears contradictory and needs

experimental testing. However, in general, reduced grazing would appear to increase habitat availability for more species, and help maintain species richness. Prescribed burning should have a balancing effect by reducing cover initially, but post-burn growth should quickly increase cover and seed production to equal or exceed pre-burn levels. Burning also has potential for reducing population sizes of some species, such as voles, but recovery by immigration can quickly reach pre-burn levels (Harty *et al.* 1991). If exotic cool season grasses such as *Poa pratensis* and *compressa* increase habitat for meadow voles, as proposed by Bixler & Kaufman (1995), they may also decline to former population levels as burning and reduced grazing select against these grasses.

Sand prairie vegetation management

Interpreting fire and grazing treatment effects

Fire and grazing treatments significantly affected sand prairie vegetation structure in 1995, apparently interacting with the heavy rainfall and cool temperatures during the spring 1995 growing conditions. The large increase in the cool season bluegrasses *Poa compressa* and *P. pratensis* is probably a response to the cool wet spring. An increased competitive effect from these exotic grasses may have contributed to the overall declines in richness and cover of native species. The late spring burn was able to depress, but not decrease, bluegrasses only in the burn/no graze treatment. Even though native species richness and perennial forbs still declined with the burn/no graze treatment, this was the only treatment in which native grass cover increased without an increase in bluegrasses. In contrast, the combined burn/graze treatment caused a decline in native richness and cover for all variables except bluegrass cover, which increased. We attribute this to an attraction of cattle to the burned area, in which they showed a preference for native grasses over bluegrasses. The no burn/graze treatment apparently did not cause a decline in native species richness because the ongoing grazing prevented a decline in annuals and biennials. However, this treatment allowed an undesirable increase in alien species richness and cover of bluegrasses.

It is unknown why the burn/no graze treatment resulted in a decline in native perennial forb cover, even though bluegrass did not increase in this plot. However, the short three-year study period must be considered when interpreting these results. Because of the extremely low abundance or absence of late-successional species due to past overgrazing (Bowles 1993), these species could not demonstrate an immediate demographic response to burning. However, we observed flowering of *Sporobolus heterolepis*, *Coreopsis palmata*, *Petalostemum purpureum*, *Helianthus rigidus*, & *Amorpha canescens* in the burn/no graze area. If seed production and

establishment occur, these species should increase over time. Such changes may require more than one decade to become evident (R.F. Betz, pers. comm.)

Summary and prairie management recommendations

As expected, our preliminary results indicate that reduced grazing increases abundance of native perennial grasses, but it also allowed an increase in abundance of exotic bluegrass species. Also as expected, burning prevented an increase in bluegrass while increasing native grass cover. Only with the combined grazing and burning treatment did native grasses fail to increase, while bluegrasses increased. It is unknown why species richness and abundance of native forbs declined under all treatments. This may reflect natural population cycles in relation to the short time period of the study and the degraded condition of the prairie. Because forb dominance is shared by a few early-successional rhizomatous species, and because late-successional species are extremely rare, a much longer time period may be needed to detect successional change.

Based on these preliminary results, we recommend that 1) burning should be the most preferred management treatment for increasing native grasses and sedges while controlling alien grasses, 2) reduced grazing should be the second most preferable management treatment, and 3) combined grazing and burning should not be used because of its potentially detrimental effects. These recommendations should be treated with caution because of the short time period of this study. Continued monitoring of fire and grazing effects is needed to assess long term management effects on vegetation, and interactions with animal species.

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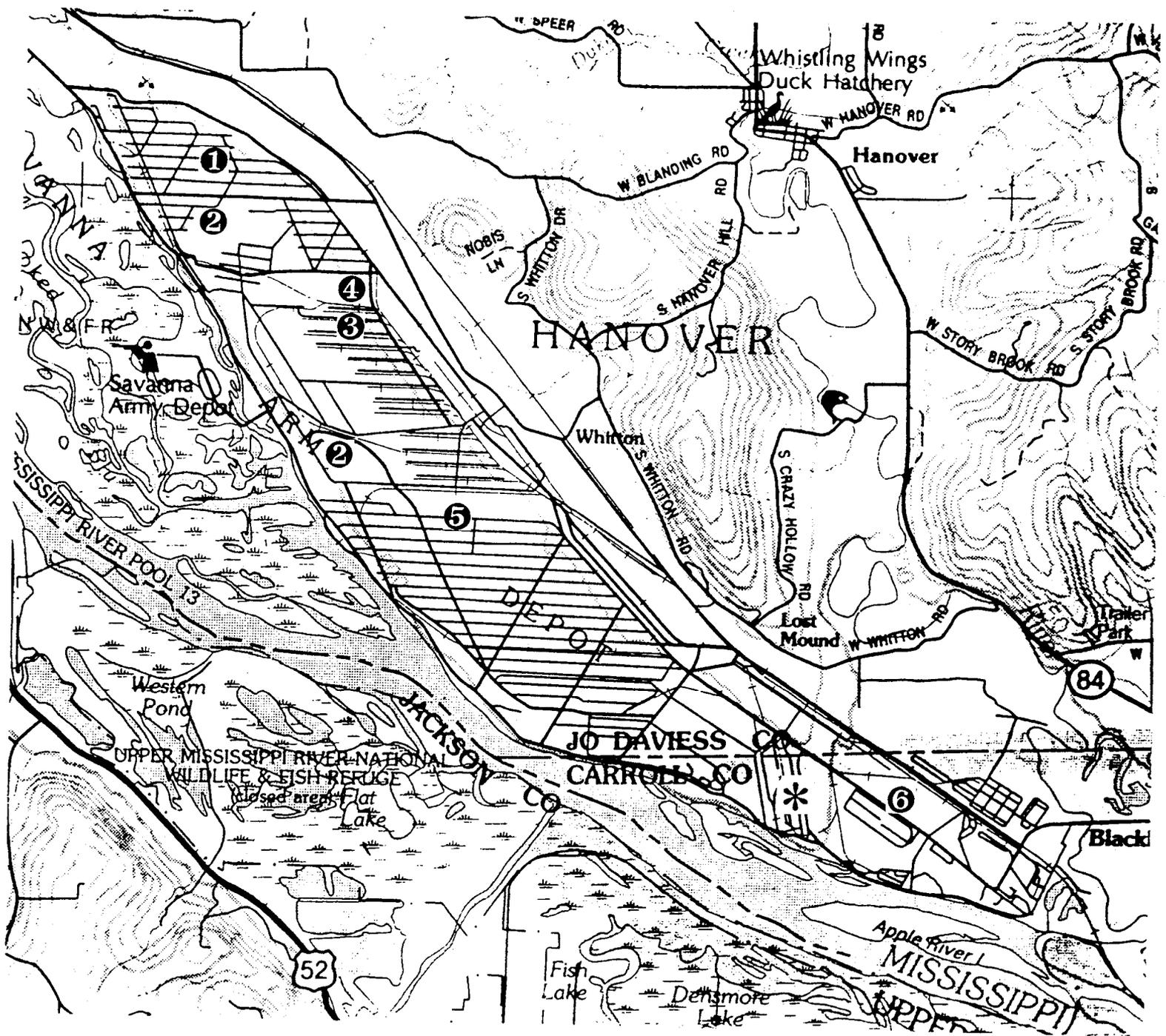


Figure 1. Location of principal concentrations of endangered and threatened plant species at the Savannah Army Depot, Carroll & Jo Daviess counties, Illinois. See Study Area section for descriptions of following areas.

- (1) Dry-mesic sand savanna - NE1/4 Sec 15, SE1/4 Sec 11
- (2) Dry sand savanna - NW1/4 NE1/4 Sec 25 & SE1/4 NW1/4 SE1/4 Sec 14
- (3) Dry-mesic sand prairie and sand savanna - N1/2 N1/2 S1/2 NE1/4 Sec 24
- (4) Dry-mesic sand prairie - NE1/4 Sec 24 & S1/2 S1/2 Sec 13
- (5) Dry sand prairie - NE1/4 SW1/4 Sec 30 & NW1/4 NW1/4 SE1/4 Sec 30
- (6) Dry mesic sand prairie - NE1/4 & NW1/4 of Sec 3



1000-acre tract to be inventoried for endangered and threatened species.

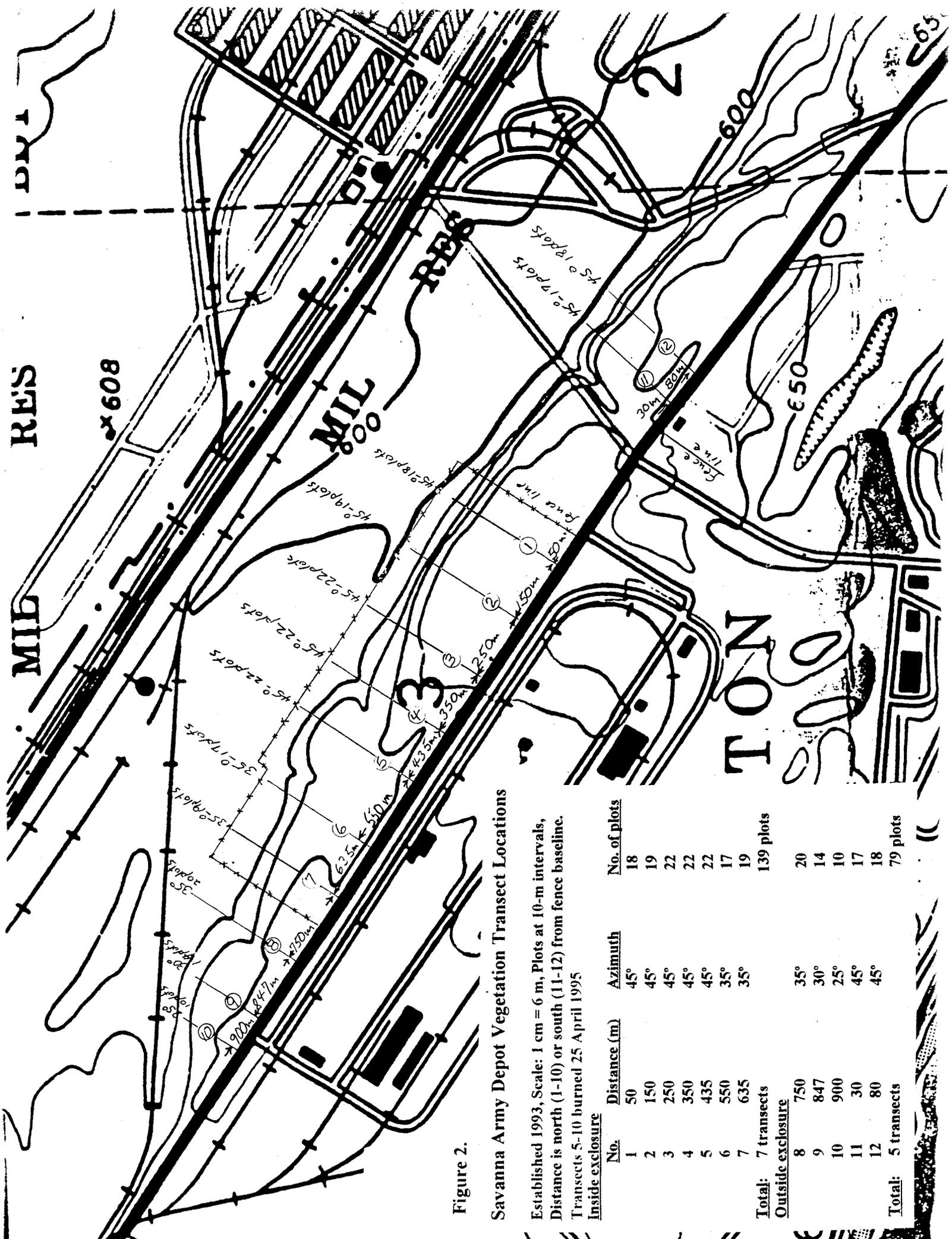


Figure 2.
Savanna Army Depot Vegetation Transect Locations

Established 1993, Scale: 1 cm = 6 m, Plots at 10-m intervals,
Distance is north (1-10) or south (11-12) from fence baseline.
Transects 5-10 burned 25 April 1995

No.	Distance (m)	Azimuth	No. of plots
1	50	45°	18
2	150	45°	19
3	250	45°	22
4	350	45°	22
5	435	45°	22
6	550	35°	17
7	635	35°	19
Total:	7 transects		139 plots
Outside enclosure			
8	750	35°	20
9	847	30°	14
10	900	25°	10
11	30	45°	17
12	80	45°	18
Total:	5 transects		79 plots

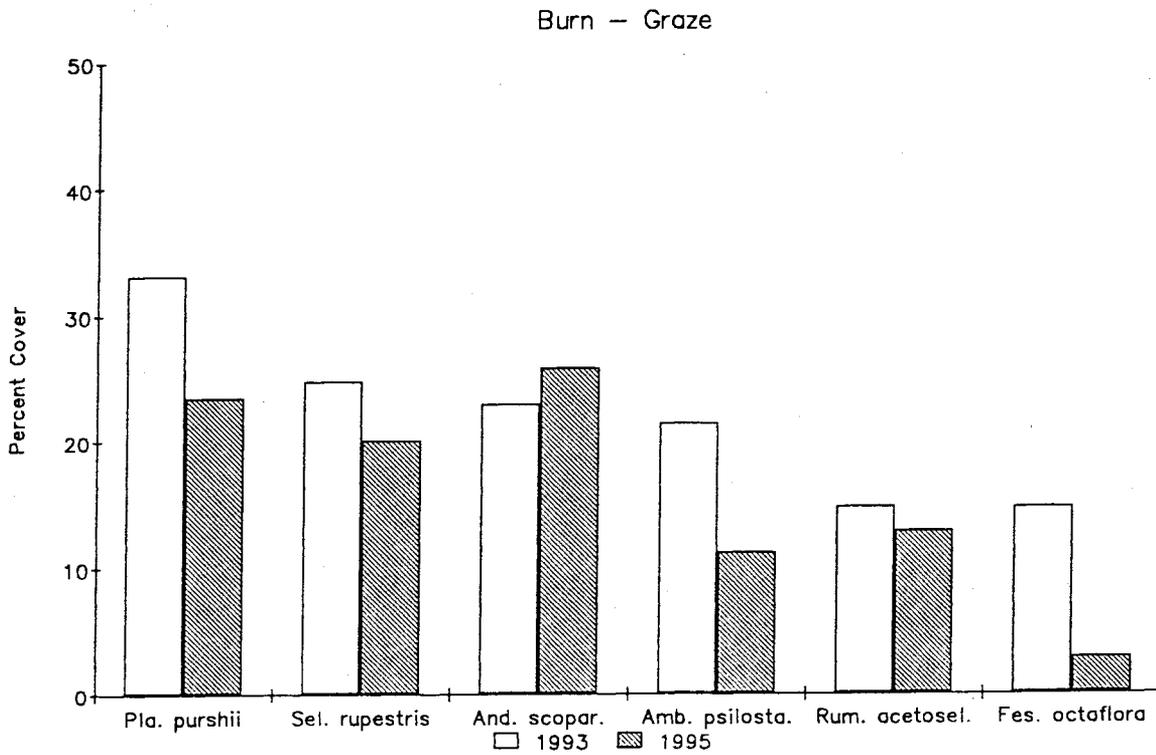
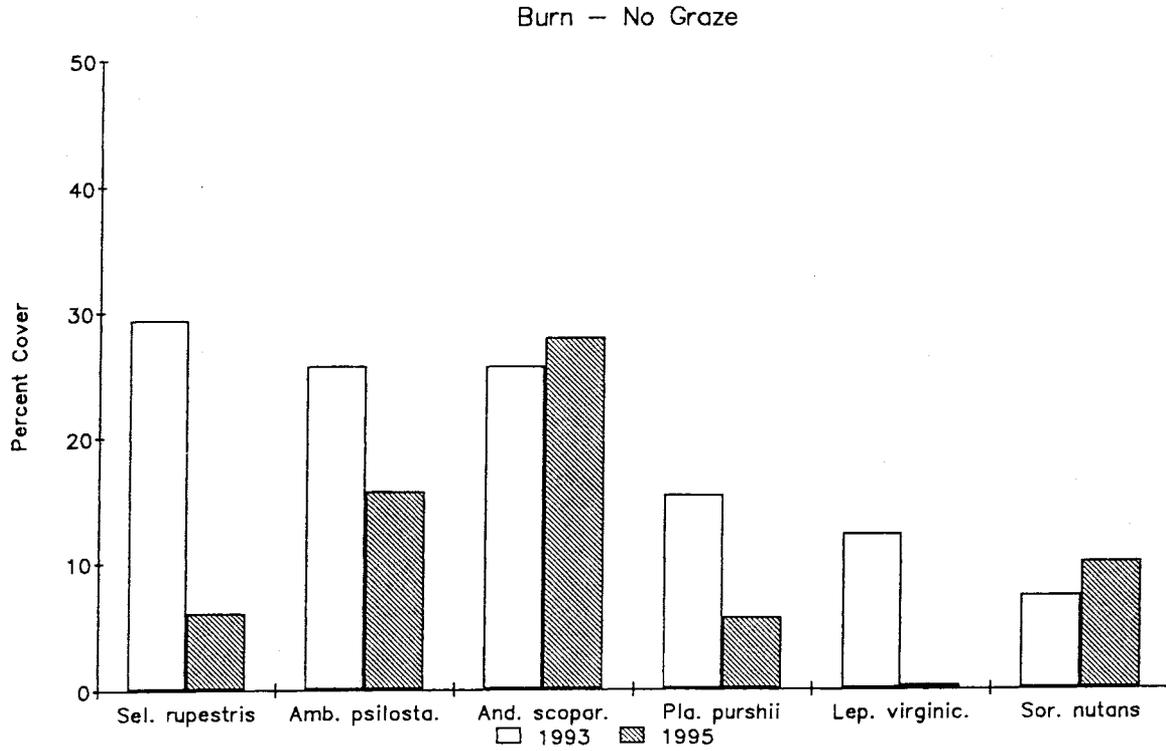


Figure 3a. Effects of grazing and grazing exclusion over time on percent cover of dominant plants in burned sand prairie at the Savanna Army Depot. See Figure 4c for *Poa pratensis* & *compressa*.

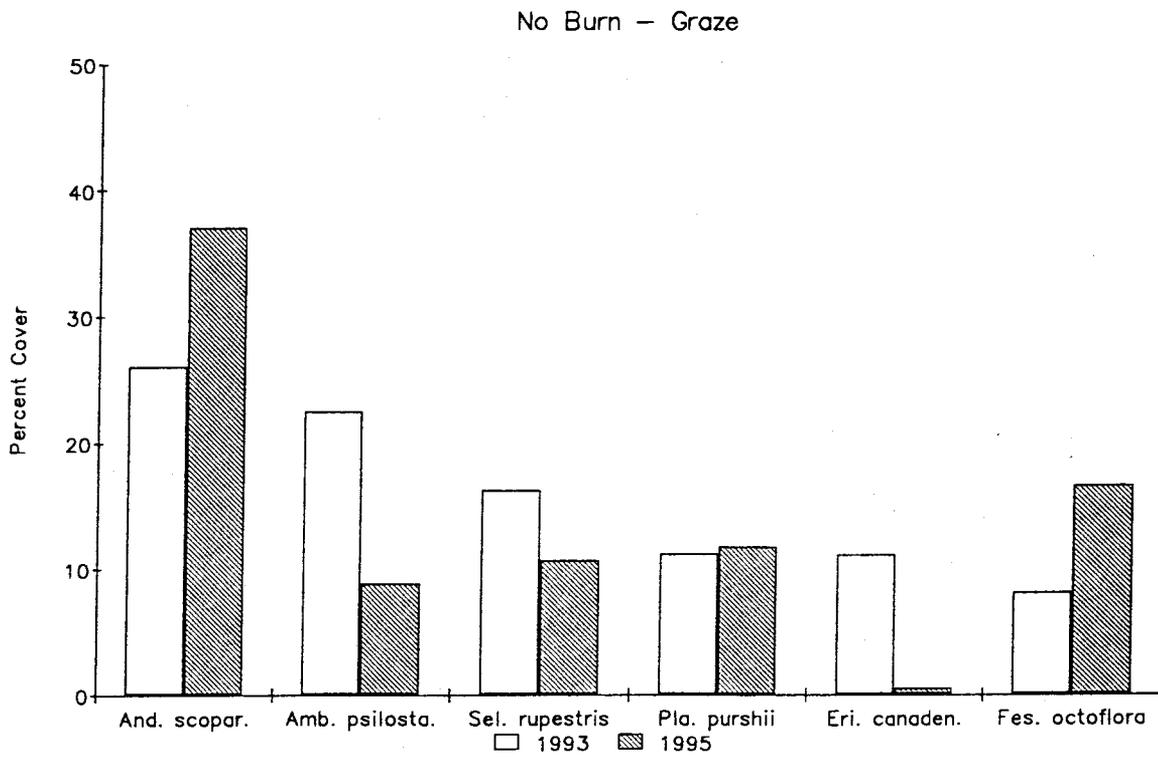
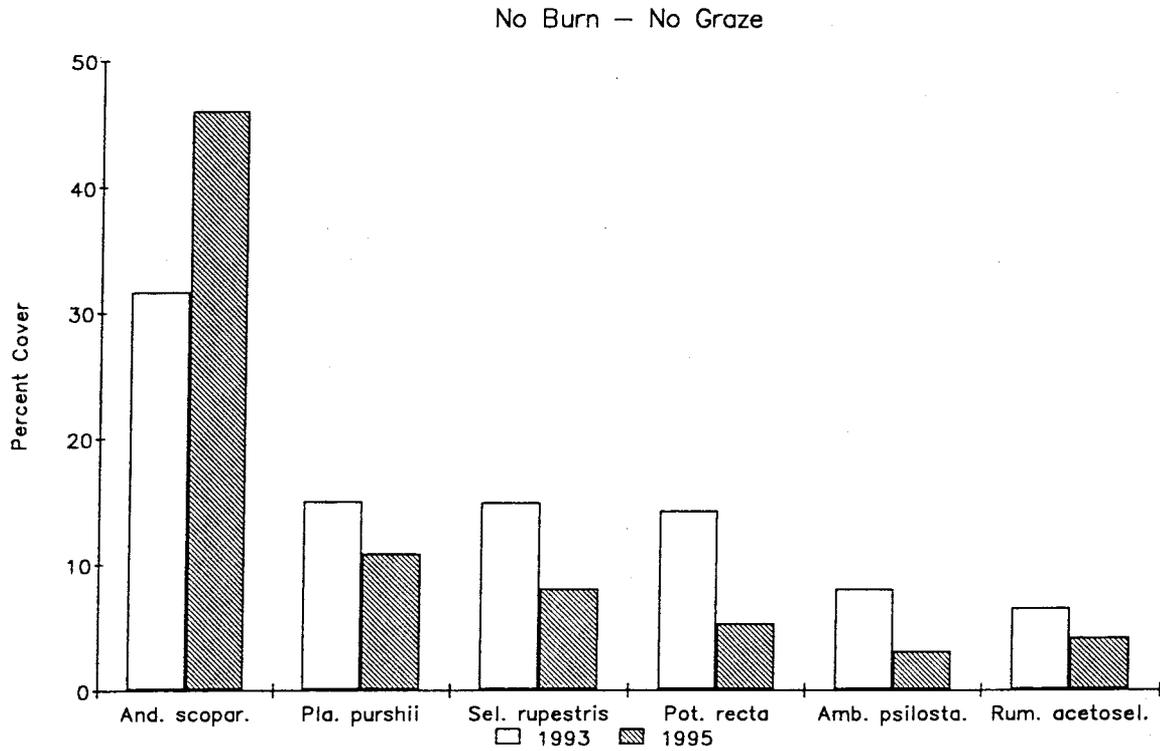


Figure 3b. Effects of grazing and grazing exclusion over time on percent cover of dominant plants in unburned sand prairie at the Savanna Army Depot. See Figure 4c for *Poa pratensis* & *compressa*.

Management Effects on Species Richness

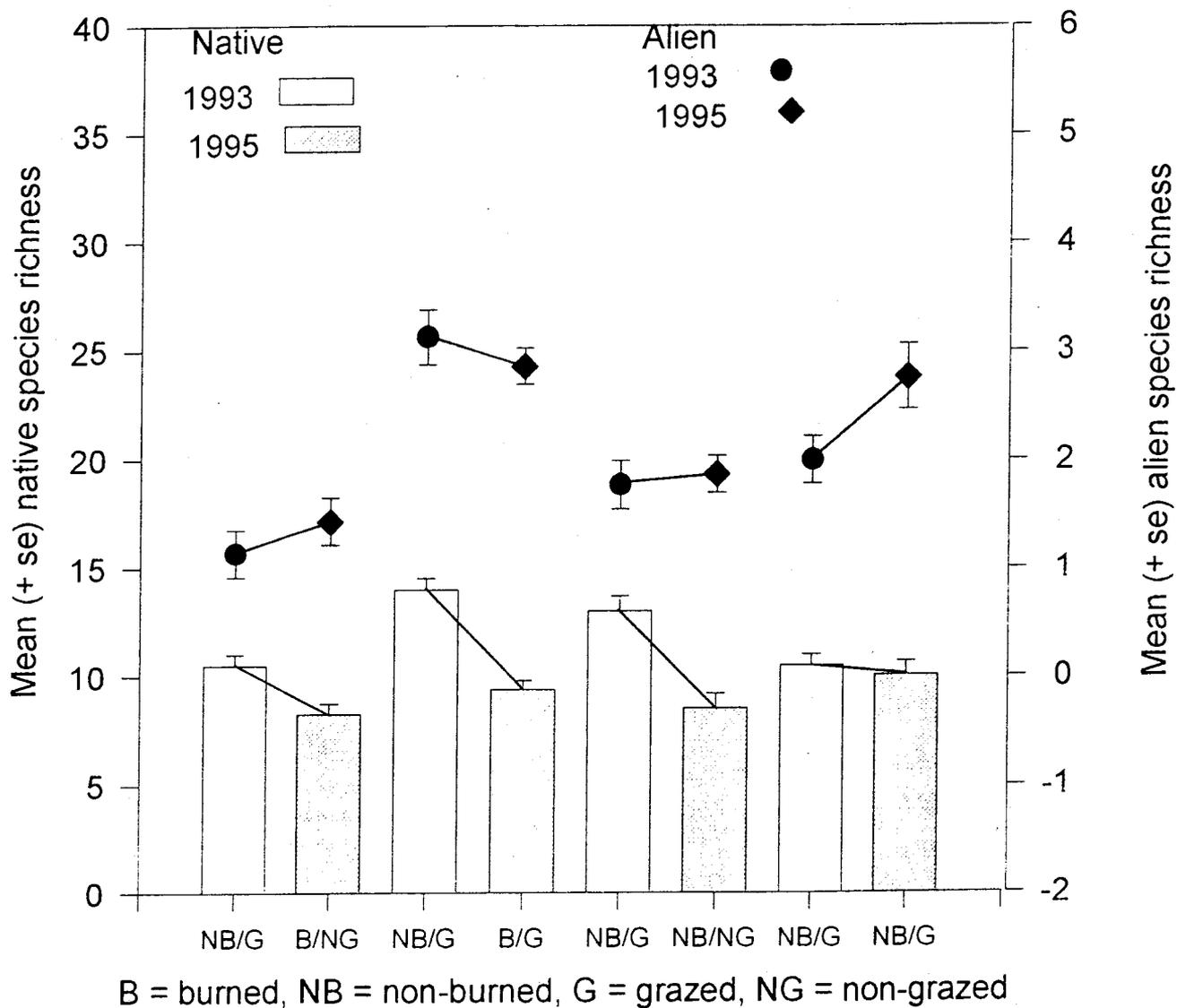


Figure 4a. Effects of burning, grazing, and grazing exclusion over time on native and alien species richness at the Savanna Army Depot.

Management Effects on Vegetation Structure

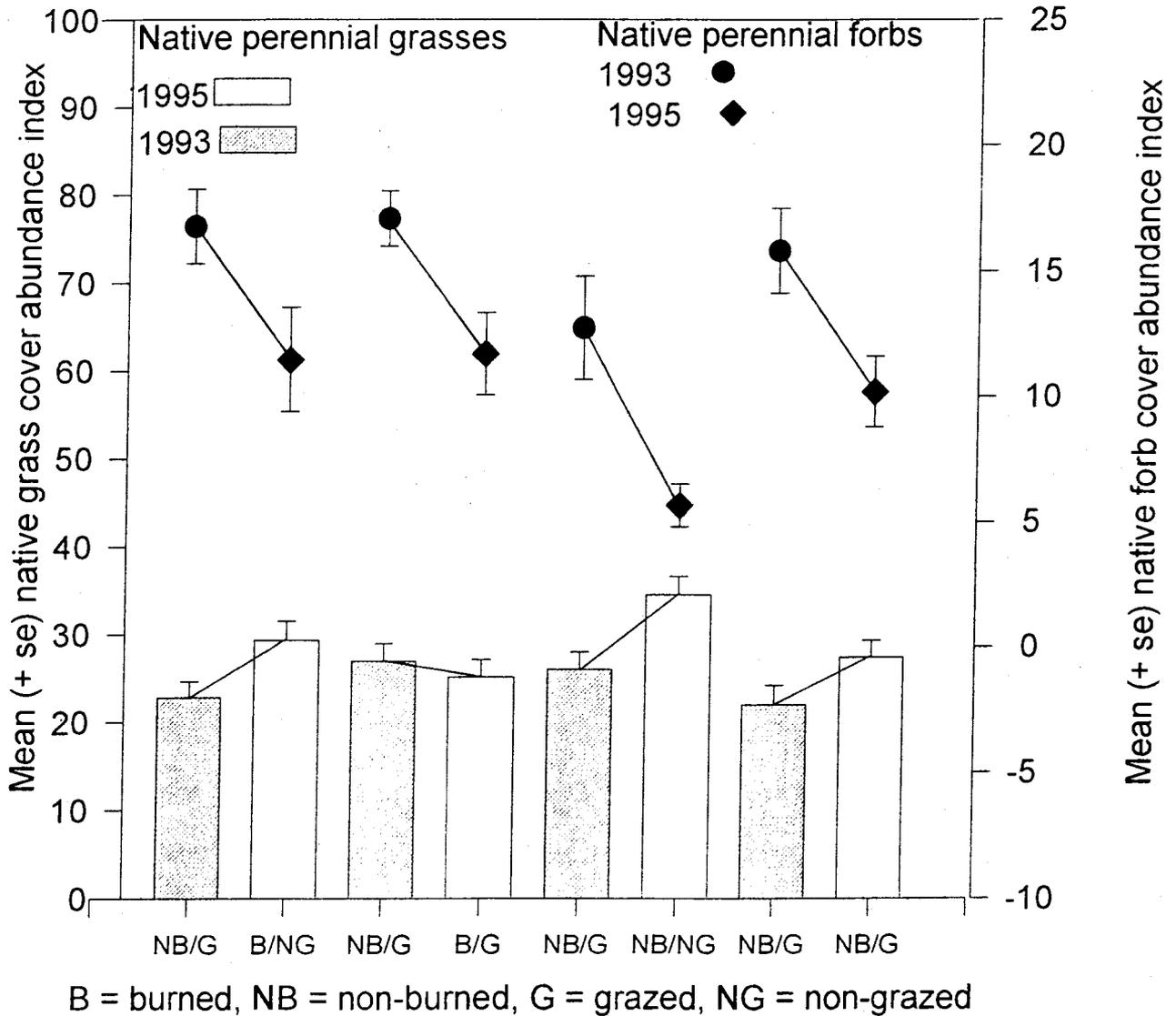


Figure 4b. Effects of burning, grazing, and grazing exclusion over time on cover abundance of native perennial grasses and forbs at the Savanna Army Depot. Divide each mean index value by 50 to estimate percent cover.

Management Effects on Vegetation Structure

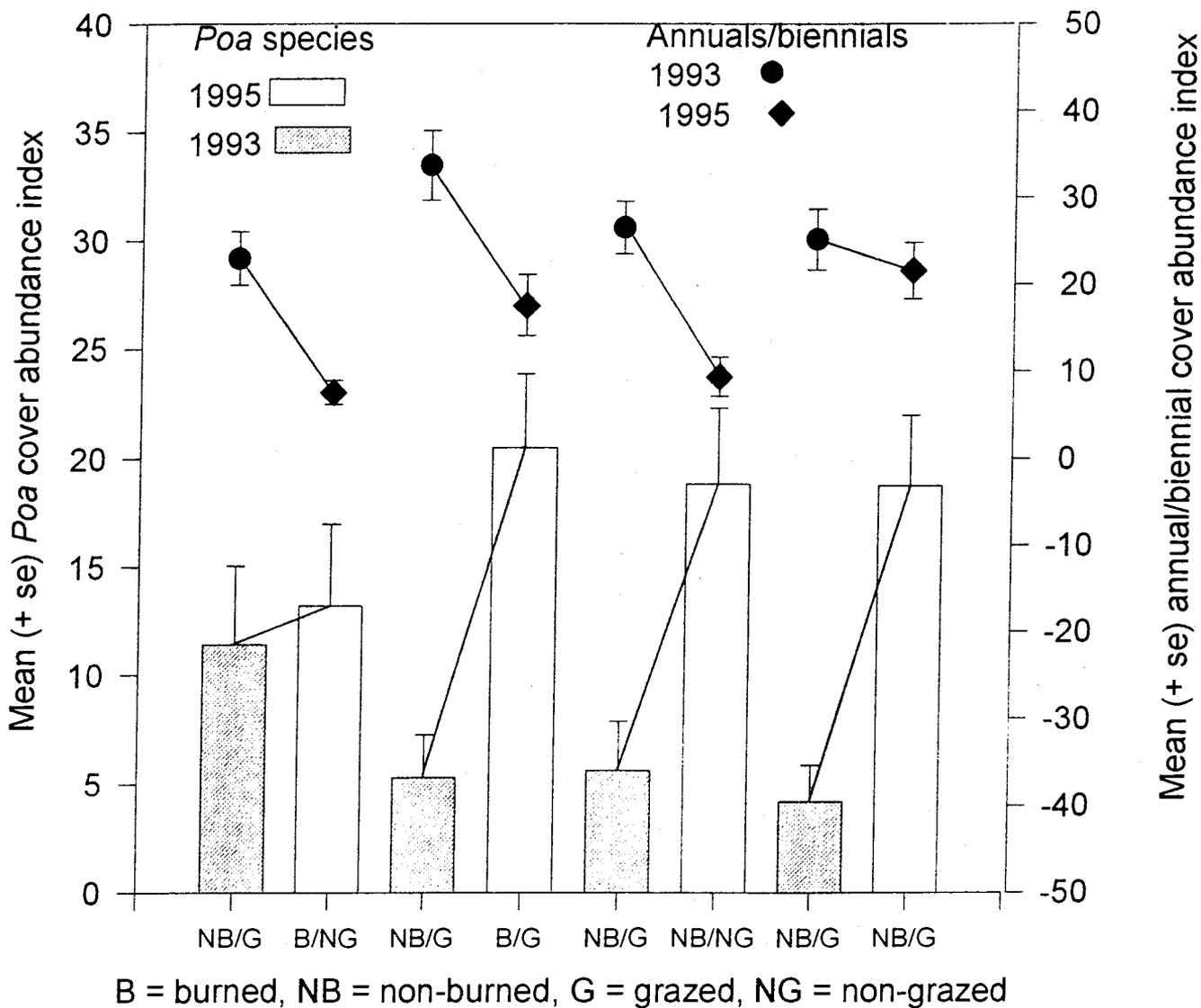


Figure 4c. Effects of burning, grazing, and grazing exclusion over time on cover abundance of *Poa compressa* & *P. pratensis* and annuals & biennials at the Savanna Army Depot. Divide each mean index value by 50 to estimate percent cover.

Appendix I. List of latin and vernacular names for characteristic sand prairie plants at the Savanna Army Depot. List derived from Gleason (1910) and Bowles (1993). See Table 1 for threatened and endangered plants.

<i>Achillea millefolium</i> (common yarrow)	<i>Kuhnia eupatorioides</i> (false boneset)
<i>Andropogon gerardi</i> (big bluestem grass)	<i>Lactuca canadensis</i> (wild lettuce)
<i>Andropogon scoparius</i> (little bluestem grass)	<i>Liatris aspera</i> (rough blazing-star)
<i>Ambrosia psilostachya</i> (western ragweed)	<i>Liatris cylindracea</i> (blazing-star)
<i>Amorpha canescens</i> (lead plant)	<i>Linaria canadensis</i> (blue toadflax)
<i>Anemone cylindrica</i> (thimbleweed)	<i>Linum sulcatum</i> (wild flax)
<i>Antennaria</i> sp. (pussytoes)	<i>Lithospermum croceum</i> (hairy puccoon)
<i>Arabis lyrata</i> (sand cress)	<i>Lepidium virginicum</i> (common peppergrass)
<i>Aristida tuberculosa</i> (needle grass)	<i>Leptoloma cognatum</i> (fall witch grass)
<i>Artemisia caudata</i> (beach wormwood)	<i>Lespedeza capitata</i> (round-headed bush clover)
<i>Asclepias viridiflora</i> (green milkweed)	<i>Mollugo verticillata</i> (carpetweed)
<i>Aster linariifolius</i> (flax-leaved aster)	<i>Monarda punctata</i> (horsemint)
<i>Aster ericoides</i> (heath aster)	<i>Oenothera rhombipetala</i> (sand primrose)
<i>Aster sericeus</i> (silky aster)	<i>Opuntia humifusa</i> (prickly-pear)
<i>Bouteloua hirsuta</i> (grama grass)	<i>Orobanche fasciculata</i> (clustered broomrape)
<i>Bulbostylis capillaris</i> (hair sedge)	<i>Panicum perlongum/depauperatum</i> (panic grass)
<i>Callirhoe triangulata</i> (poppy mallow)	<i>Panicum villosissimum</i> (hairy panic grass)
<i>Carex festucacea</i> (sedge)	<i>Panicum oligosanthes</i> (panic grass)
<i>Carex muhlenbergii</i> (sand sedge)	<i>Panicum virgatum</i> (switch grass)
<i>Carex umbellata</i> (sedge)	<i>Paspalum setaceum</i> (bead grass)
<i>Cassia fasciculata</i> (partridge pea)	<i>Penstemon hirsutus</i> (hairy beard-tongue)
<i>Ceanothus americanus</i> (New Jersey tea)	<i>Petalostemum candidum</i> (white prairie clover)
<i>Ceanothus ovatus</i> (inland New Jersey tea)	<i>Petalostemum purpureum</i> (purple prairie clover)
<i>Chenopodium album</i> (lamb's quarters)	<i>Physalis heterophylla</i> (ground cherry)
<i>Chrysopsis camporum</i> (golden aster)	<i>Physalis virginiana</i> (ground cherry)
<i>Coreopsis palmata</i> (prairie coreopsis)	<i>Plantago purshii</i> (salt-and-pepper plant)
<i>Croton glandulosus</i> (sand croton)	<i>Poa pratensis</i> (Kentucky bluegrass)
<i>Cyperus schweinitzii</i> (sedge)	<i>Polygala polygama</i> (purple milkwort)
<i>Cyperus filiculmis</i> (sedge)	<i>Polygala verticillata</i> (whorled milkwort)
<i>Echinacea pallida</i> (pale coneflower)	<i>Polygonum tenue</i> (slender knotweed)
<i>Equisetum hyemale</i> (scouring rush)	<i>Rhus aromatica</i> (fragrant sumac)
<i>Erigeron canadensis</i> (horseweed)	<i>Selaginella rupestris</i> (rock spikemoss)
<i>Erigeron strigosus</i> (daisy fleabane)	<i>Silene antirrhina</i> (sleepy catchfly)
<i>Eragrostis spectabilis</i> (tumble-grass)	<i>Sisyrinchium</i> sp. (blue-eyed grass)
<i>Euphorbia corollata</i> (flowering spurge)	<i>Solidago nemoralis</i> (field goldenrod)
<i>Euphorbia geyeri</i> (spurge)	<i>Solidago rigida</i> (rigid goldenrod)
<i>Festuca octoflora</i> (six-weeks fescue)	<i>Solidago speciosa</i> (showy goldenrod)
<i>Gnaphalium obtusifolium</i> (sweet everlasting)	<i>Solidago missouriensis</i> (Missouri goldenrod)
<i>Hedeoma hispida</i> (rough pennyroyal)	<i>Sorghastrum nutans</i> (Indian grass)
<i>Helianthemum bicknellii</i> (frostweed)	<i>Specularia perfoliata</i> (Venus' looking-glass)
<i>Helianthus occidentalis</i> (western sunflower)	<i>Stipa spartea</i> (porcupine grass)
<i>Helianthus rigidus</i> (prairie sunflower)	<i>Talinum rugospermum</i> (fame flower)
<i>Koeleria cristata</i> (June grass)	<i>Tephrosia virginiana</i> (goat's-rue)
	<i>Tradescantia ohiensis</i> (spiderwort)
	<i>Verbena bracteata</i> (creeping vervain)
	<i>Verbena stricta</i> (hoary vervain)
	<i>Viola pedata</i> (birdfoot violet)