DETERMINATION OF SEED BANK COMPOSITION FOR SITES OF AN ENDANGERED FLOODPLAIN SPECIES, *BOLTONIA DECURRENS*.

PROJECT #97043

FINAL REPORT SUBMITTED TO:

The Illinois Department of Natural Resources, Division of Natural Heritage and the Wildlife Preservation Fund Advisory Committee
1996 Small Project Program

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ABSTRACT

Boltonia decurrens (Asteraceae) or decurrent false aster, is a fugitive floodplain species that establishes in disturbed sites along the Illinois and Mississippi Rivers. Channelization of the rivers through an extensive series of levees, locks and dams has altered the dynamic nature of these systems, affecting timing, frequency and duration of flooding. The replacement of the natural river system with an artificially controlled one is partially responsible for the endangered status of this species. Historical observations suggest that unless there are subsequent disturbance events, *B. decurrens* is replaced by competing vegetation within three to five years. Although it is primarily restricted to the Illinois River Valley, there are known populations near the confluence of the Mississippi and Illinois Rivers. Following the 1993 floods, seed bank analysis was completed for all of the known Illinois sites. Seed bank analysis was completed again to assess the effects of the 1995 flood. Additionally, we examined the effects of different management practices undertaken at the Woodford County Conservation Area.

INTRODUCTION

Boltonia decurrens was placed on the national list of threatened species in 1988 by the United States Fish and Wildlife Service. It is currently listed as endangered in Missouri (Missouri Department of Conservation, 1992) and threatened in Illinois (Herkert, 1991). *B. decurrens* is a fugitive floodplain species that colonizes disturbed sites along the Illinois River and its confluence with the Mississippi River, but is primarily restricted to the Illinois River Valley. A plant that was once reported by the United States Army Corps of Engineers to be seen flowering profusely along the riverbanks of the Illinois River (Bellrose et al., 1979), it is now isolated in disjunct populations (Morgan, 1980). Current population sites range from Woodford County, north of Peoria, Illinois, to St. Charles County, Missouri. Alteration of normal hydrologic cycles has destroyed the floodplain habitat of the Illinois River system, a component of the upper Mississippi River system (Bellrose et al., 1979). The decline of *B. decurrens* is an indication of the grave problem posed by destruction of the wetland and floodplain habitats upon which many plant and animal species depend for survival. The flood of 1993 undermined the majority of the flood control structures placed along the rivers, providing prolonged inundation of the population sites of *B. decurrens* and creating potential sites for new populations to establish. Flooding in 1995 created the rare circumstance of two extreme hydrologic events occurring within a short time period.

During 1993, the extent and duration of the flood prevented individuals of *B. decurrens* from flowering and producing seed for the 1994 growing season (Smith, 1994). Soil core analysis of population sites in Illinois after the flood verified the persistence of a viable seed bank from 1992 to 1994. Of the 14 sites sampled, 7 sites had seeds present in the soil core that resulted in flowering populations in 1994. Of these seven sites, 5 had a minimum of 5,000 individuals of *B. decurrens* (Smith, 1995). Persistence of a viable seed bank can dictate if a population will survive through unfavorable conditions, such as those in 1993, until a time when conditions are favorable for re-establishment of this species. Soil core analysis has not been completed for the Illinois sites to determine the effects of the 1995 flood.

Depth of the seed bank is also crucial in predicting regeneration of populations. The seeds of *B. decurrens* do not germinate unless they are exposed to light; therefore, siltation of any amount will have a negative impact on regeneration of populations (Baskins and Baskins, 1988;

Smith, 1990; Smith et a.l, 1995). Approximately 96% of *B. decurrens* germinated from seed cores collected in 1994 were in the uppermost 4 cm of the soil cores and all *B.decurrens* sites with plants after the flood had seeds present in the upper 2 cm of the soil core (Smith, 1995).

The objectives of this study were as follows:

1. Determination of presence, size and depth of the seed bank of *Boltonia decurrens*
2. Determine composition of the vegetative seed bank.
3. Monitor *Boltonia decurrens* populations for fluctuations in size.

MATERIALS AND METHODS

In 1996, soil cores were collected from each of the following sites using a plastic tube inserted into a 1x7 cm stainless steel soil probe to maintain column integrity.

Site (# of cores)	Location
Anderson Lake (9)	Fulton County
Cooper Park (9)	Tazewell County
Gilbert Lake (9)	Jersey County
Horseshoe Lake (9)	Madison County
Rice Lake (9)	Fulton County
Woodford County Conservation Area (27)	Woodford County

The cores were transported to Southern Illinois Unviersity Edwardsville (SIUE) where germination tests were conducted. Each core was pushed out of the tube and sliced into four, 2-cm sections, mixed with water into a slurry and spread over Pro-mix commercial potting medium in 4x4x4 cm containers. The pots were transferred to flats in the SIUE greenhouse and kept moist until germination ceased. When germination appeared to cease for each container, the soil was disturbed with a stainless steel probe and observed another two weeks for additional germination. After sufficient growth, seedlings were transplanted to individual pots and grown until anthesis when species identification was made.

Seeds/m^2 was calculated for all sites sampled and specifically for *Boltonia decurrens*.

Vegetative composition of the seed bank for each site and for each treatment area at Woodford County (control, mow and burn) was compared by calculating diversity (Shannon-Weiner Index) and eveness using the PC-ORD program (McCune 1995). Additionally, a Bray-Curtis ordination, using Sorensen's Index (Barbour et al. 1980) as a measure of distance, was calculated to compare treatment areas at Woodford County and to assess changes over time (McCune 1995). Seed bank presence, depth and population size of *B. decurrens* at all study sites for 1996 were compared to 1994 and 1995.

RESULTS

Presence, size and depth of *Boltonia decurrens* seed bank

For 1996, 61.7% of *Boltonia decurrens* seeds were found in the upper 2 cm of the soil seed bank (Table 2). Rice Lake had the greatest number of seeds in the upper 2 cm of the seed bank, accounting for 59% of the *Boltonia decurrens* seeds at that population site (Table 1) and 47% of all seeds at that site prior to flooding in 1996. Gilbert Lake had the highest percentage of *Boltonia decurrens* seeds in the upper 2 cm of the seed bank pre-flood (75%)(Table 1). The sites of the smallest populations, Anderson Lake and Cooper Park, had no seeds found in the seed bank (Table 1). Gilbert, Horseshoe and Rice Lakes all had seeds present when sampled in 1996. All sites that had $\geq$1000 plants in 1996 had seeds in the upper 2 cm of the soil seed bank (Table 1 and 3).

In 1996, Woodford County had seeds present only in the control area. Although the mowed area had seeds present in 1995, there were no seeds found in 1996 samples. After application of the burn treatment in 1994, no seeds were germinated in samples taken through 1996 in the burned area (Table 1).

Composition of vegetative seed bank

Seed bank diversity ranged from .959 (Woodford County) to 2.043 (Gilbert Lake). For the three sites where disturbance was not examined (Anderson Lake, Cooper Park and Horseshoe Lake) diversty was greatest at Anderson Lake (Fig. 1b), the site with the smallest *Boltonia decurrens* population (Table 1). Conversely, Horseshoe Lake had the lowest seed bank diversity and the largest *B. decurrens* population (Fig.1b and Table 1). Flooding in 1996 initially lowered

diversity at Gilbert Lake and Rice Lake (Fig. 2b and 3b), but a second flood event increased both richness and diversity at Rice Lake (Fig. 3a and b).

Richness in the control plot at Woodford County has declined overall since 1995, with one sample showing an increase from 9 to 11 species present after the second flood event in 1996 (Fig. 4a). Diversity likewise decreased from 1.85 to 1.6 in the period spanning 9-95 to 12-96, although it showed a slight increase to 1.7 in 12-96. Sampling after flood events (7-96 and 8-96) showed decreases in diversity as a result of this type of disturbance (Fig. 4b).

Decreasing richness was more pronounced in the mowed and burned plots with the treatments and flood events markedly reducing the number of species present in the seed bank (Fig. 5a and Fig. 6a). Mowing reduced species richness in 1995 and 1996, with a greater magnitude of reduction in 1995 (Fig. 5a). Burning only slightly lowered species richness and had no effect on seed bank diversity in 1995 (Fig 6a and b). The burn treatment was not applied in 1996 due to lack of fuel and unfavorable weather conditions. Flood events in 1996 did lower richness and diversity in both the mowed and burned plots (Figs 5a and b, Figs. 6a and b).

Ordination plots of the treatment areas at Woodford County illustrate three dimensionally the relationship of the samples to each other. The greater the distance between the points, the less similar the samples are. Although there is slight similarity within samples taken in 1995, samples taken in 1996 of the control area are very dissimilar from each other and from 1995 (Fig. 7). The effects of treatment application are apparent in the mowed area with samples taken in 1995 being very different from each other and the same pattern repeated in 1996 (Fig. 8). Burning in 1995 had an effect on the community; however, flooding in 1996, when the burn was not applied, also had a marked effect with great dissimilarity between samples (Fig. 9). Overall, the composition and distribution of seeds in the seed bank noticeably changed from 1995 to 1996 in all three treatment areas. By 1996, the mowed area continued to be very similar to the control area with both areas being very dissimilar from the burned area (Fig. 10).

Complete lists of all species present in the soil seed bank samples are in Appendix 1 of this report.

Fluctuations in size of *Boltonia decurrens* populations

In 1996, 3 of the 6 population sites examined in this report had increases in population

size; Anderson Lake, Cooper Park and Rice Lake. Anderson Lake and Cooper Park both have less than 200 plants. The Rice Lake population increased from 25,000 to 30,000 plants. All other sites declined from 20 - 75%, with the number of plants declining by 31,391 overall or 19%. This was accompanied by a 36% decrease in total seed bank of *B. decurrens*, a loss of 27,613 seeds/m^2 (Table 3).

DISCUSSION

It is difficult, at best, for populations of *Boltonia decurrens* to have a strong recovery in favorable conditions without a substantial seed bank. Despite a significant and favorable disturbance event with the flood of 1993, Cooper Park and Anderson Lake did not experience population rebound with the magnitude witnessed at other population sites such as Gilbert Lake and Woodford County (Smith 1995). It appears that greater seeds/m^2 results in greater population recovery as long as conditions are favorable. As with standing vegetation (Smith et al 1996) it appears that higher diversity in the seed bank is detrimental to *B. decurrens* populations, although this may partially depend upon species composition.

The application of mow and burn treatments at Woodford County appears to have mixed results. The population there, which established after the flood of 1993, has continued to decline drastically. Burning appears to completely destroy the seed bank present, although this treatment is beneficial to rosette survival (Smith et al in review). No seeds have been found in samples from the burned area since the first treatment in 1994. The mowed area did have seeds in 1995, but not 1996 and has reduced rosette survival compared to the burned area. The control area continued to have a seed bank present throughout the study, but is reduced from 1995. This population site has become dominated by *Aster ontarionus* (Mettler-McClure, pers. obs.), a species that is a very strong competitor in dry and flooded conditions (Smith and Moss 1996). The dense overgrowth of this rhizomatous plant possibly affects germination of seeds by reducing light and moisture therefore reducing *Boltonia decurrens* germination (Smith 1990, Smith 1991, Smith et al. 1993, Smith et al. 1995).

Given the lack of a clear benefit to using mowing or burning as a management practice, the population at Rice Lake is the focus of a new study being initiated in cooperation with the Department of Natural Resources. This population is located next to a field that previously has been cultivated to provide food for waterfowl and has continued to be a fairly strong, persistent

population, possibly due to the disturbance provided by cultivation. This area was not cultivated in 1996 due to wet soil conditions. The entire field now has *Boltonia decurrens* throughout with preliminary population estimates placing the number of plants at 150,000, verifying the existence of a large seed bank in this area. A significant portion of this field has been put aside to study the effects of discing on population regeneration. At specified intervals, the IDNR has agreed to disc designated areas and leave one specified area as a control that receives no discing. Population size, seedling recruitment, rosette survival, vegetative composition and seed bank composition will be monitored throughout this study using methods previously used by our lab that resulted in successful data collection.

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Figure 1

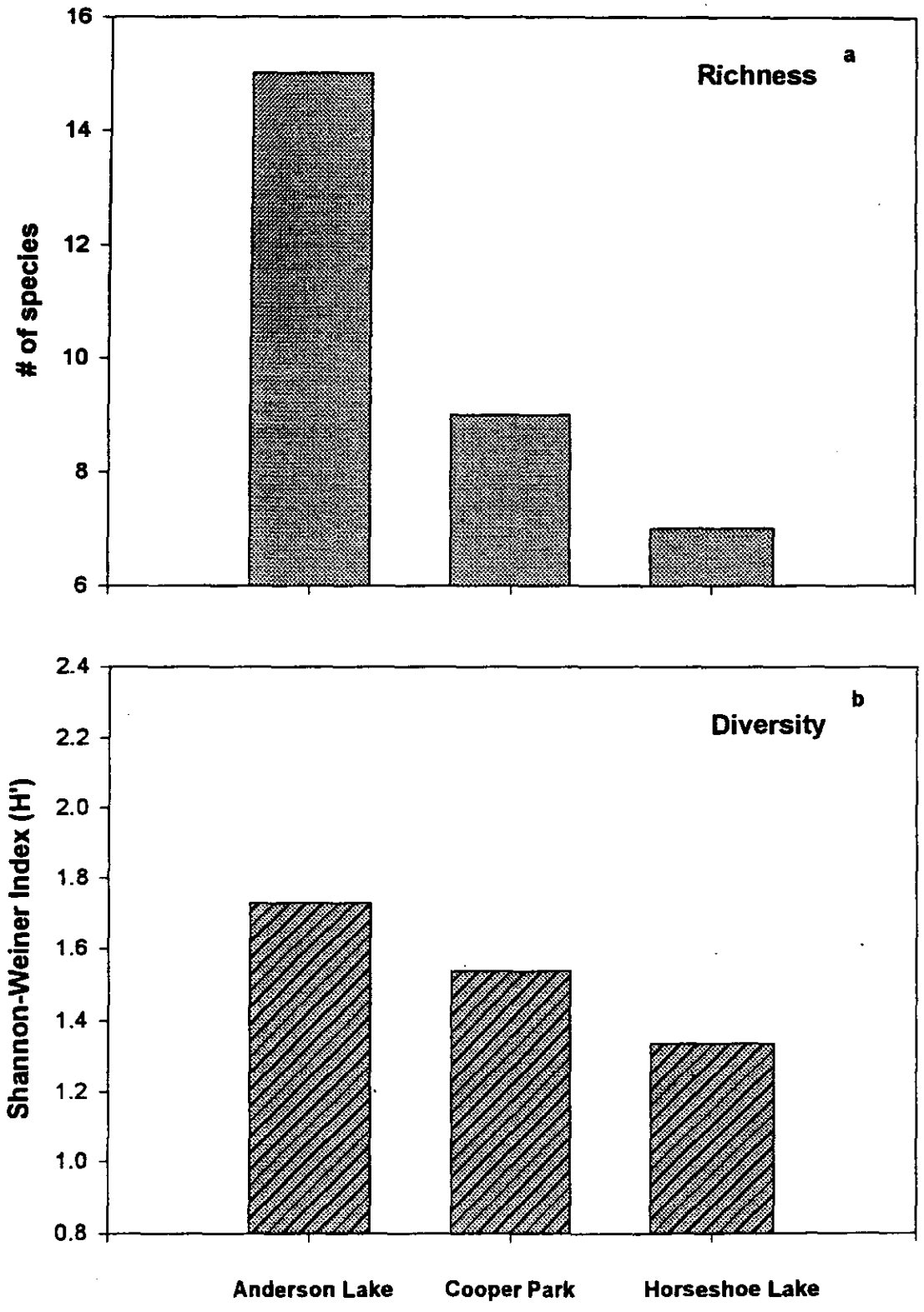
16
14
12
10
8
6
# of species
Richness
a
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
Shannon-Weiner Index (H')
Diversity
b
Anderson Lake
Cooper Park
Horseshoe Lake

Figure 2
Gilbert Lake

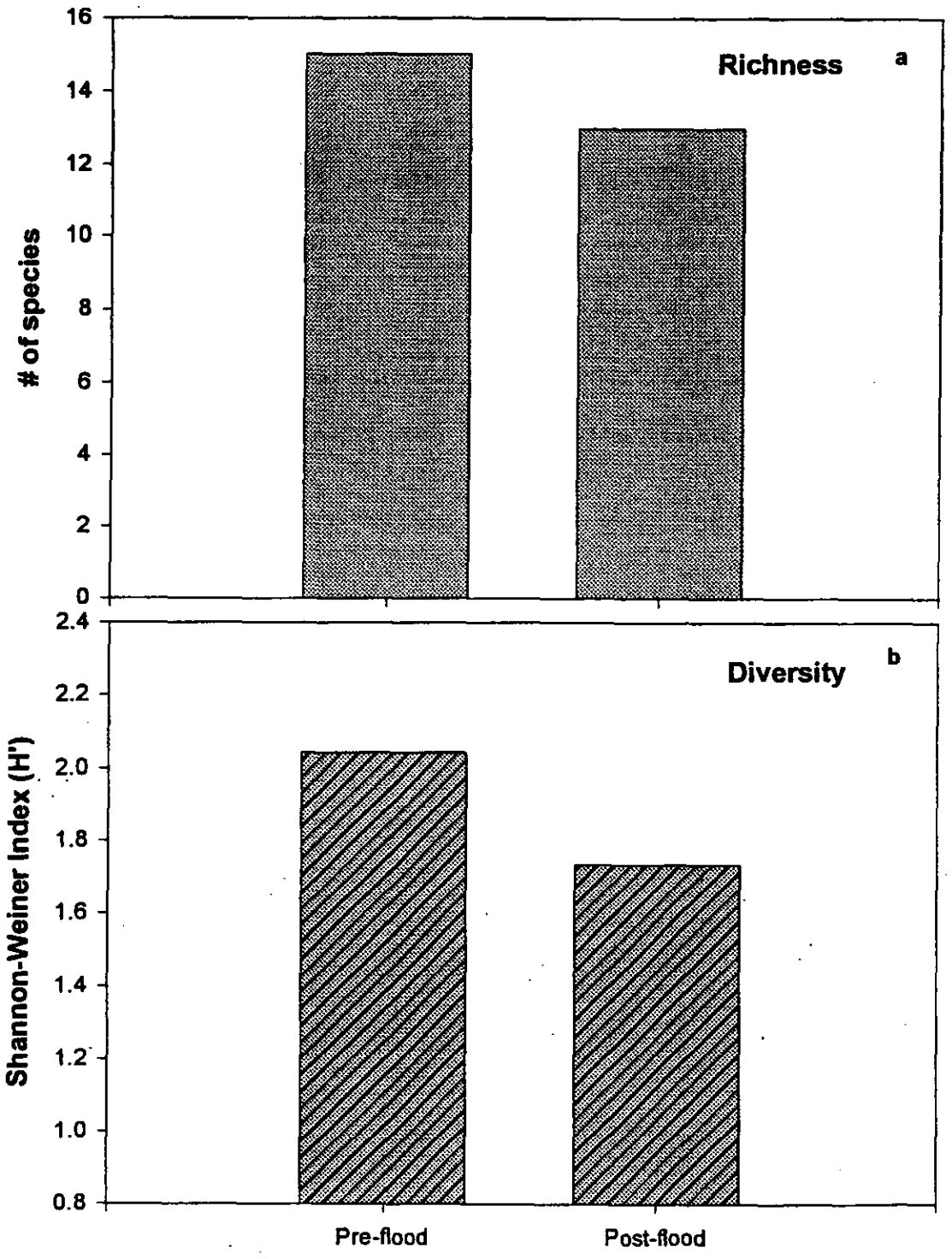

Figure 3
Rice Lake

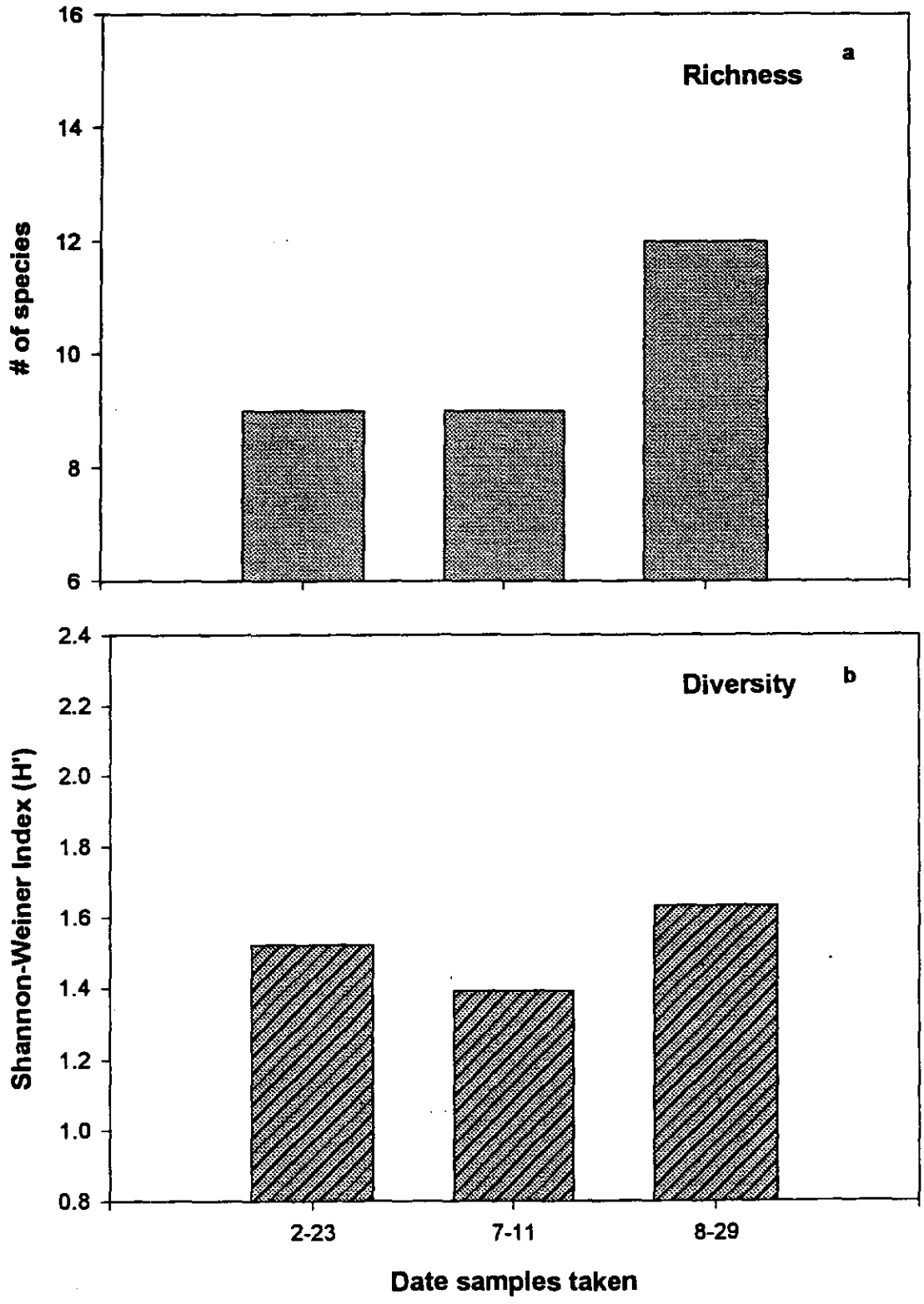

Figure 4
Woodford County Conservation Area
Control Plot

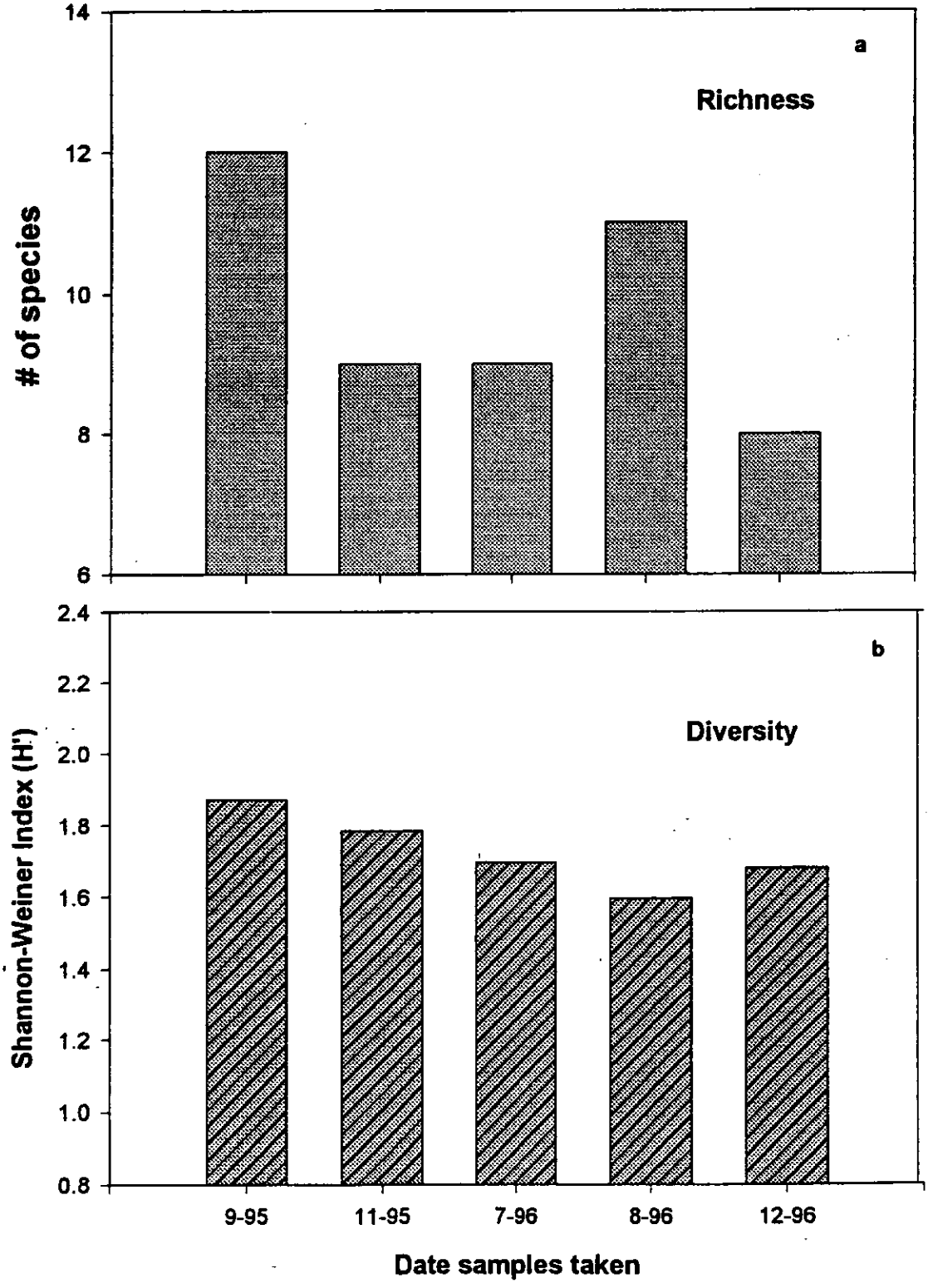

Figure 5
Woodford County Conservation Area
Mowed Plot

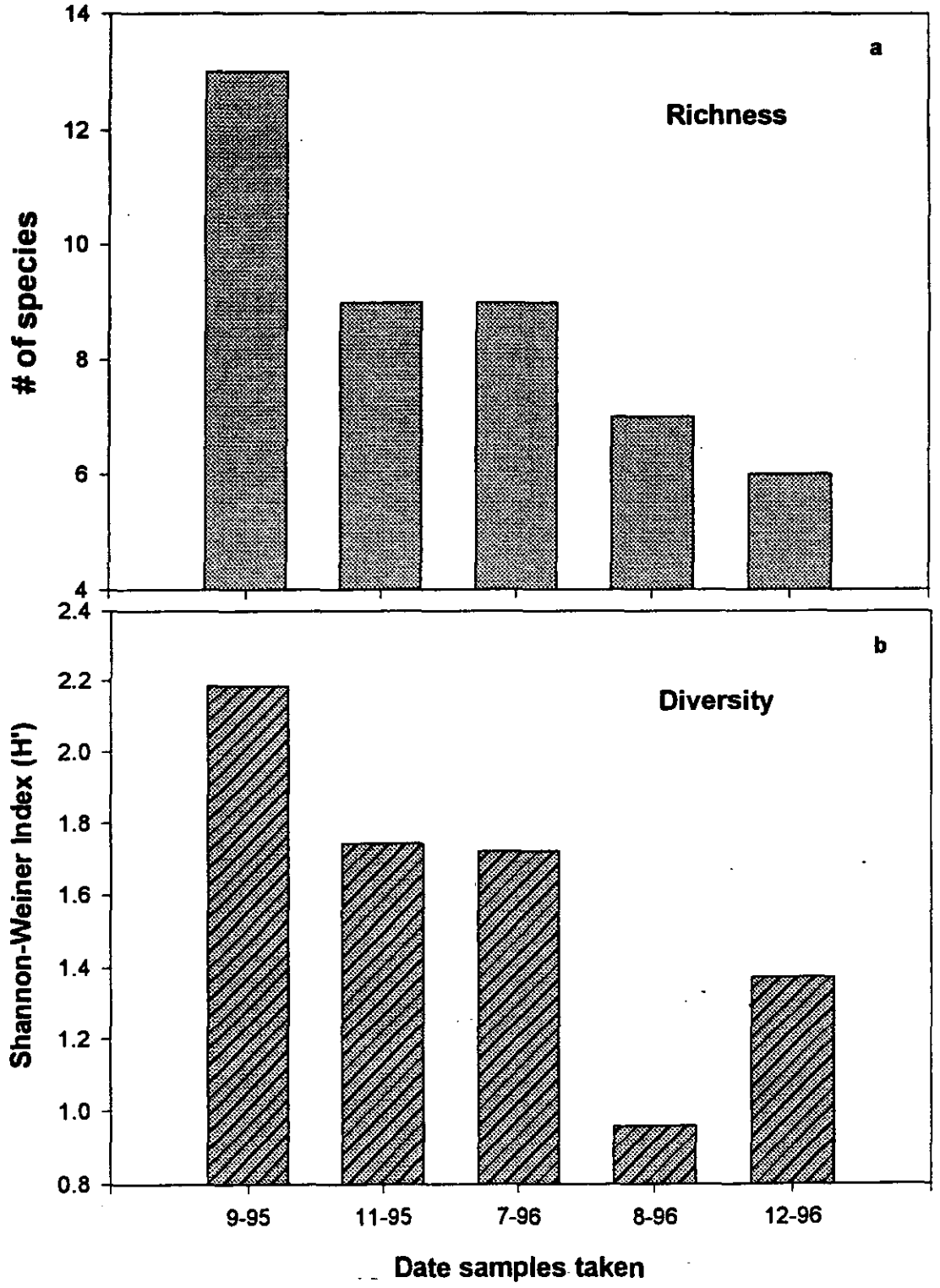

Figure 6
Woodford County Conservation Area
Burn Plot

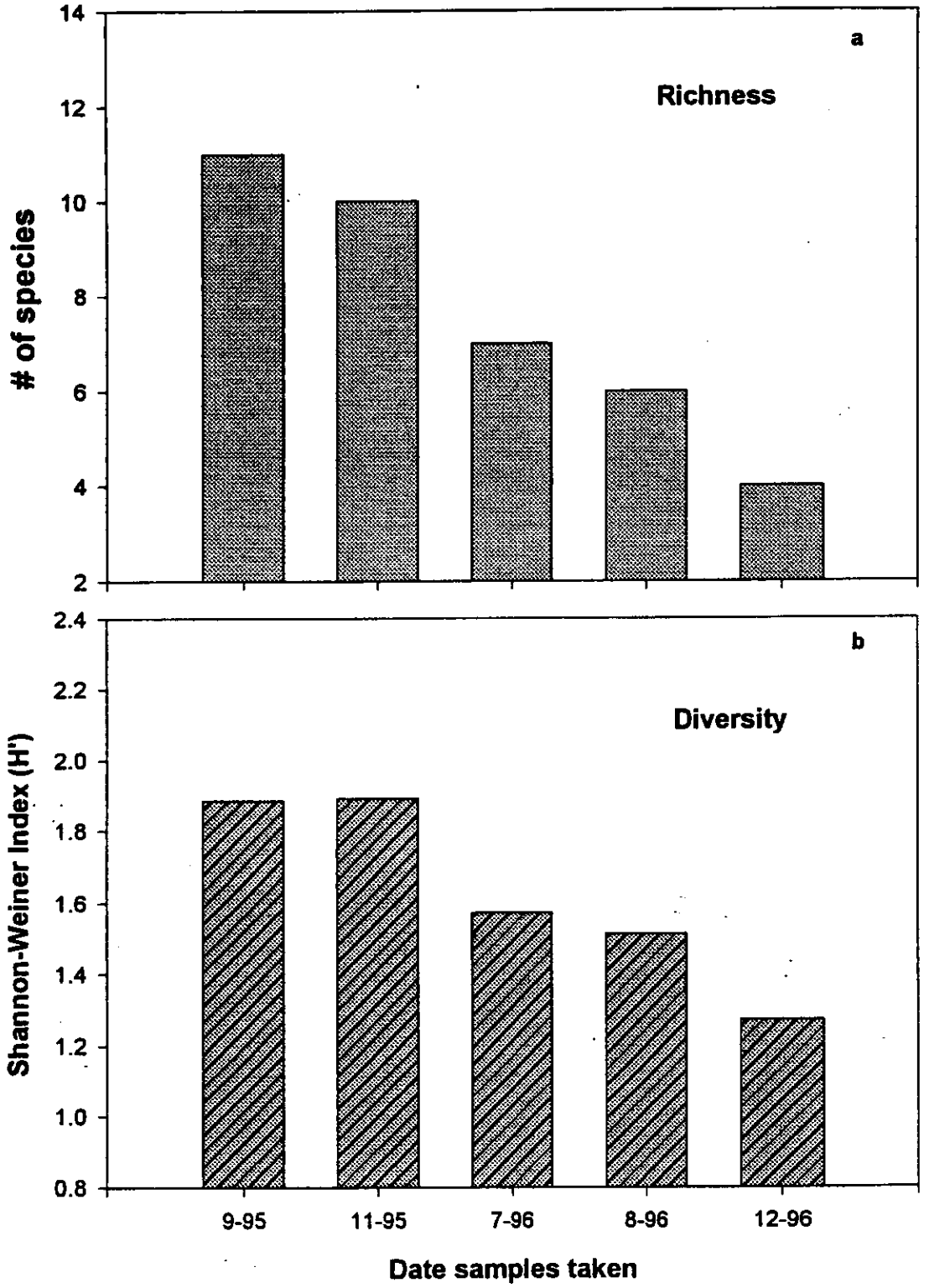

Figure 7
Woodford County Control Area
Ordination of species present in seed bank

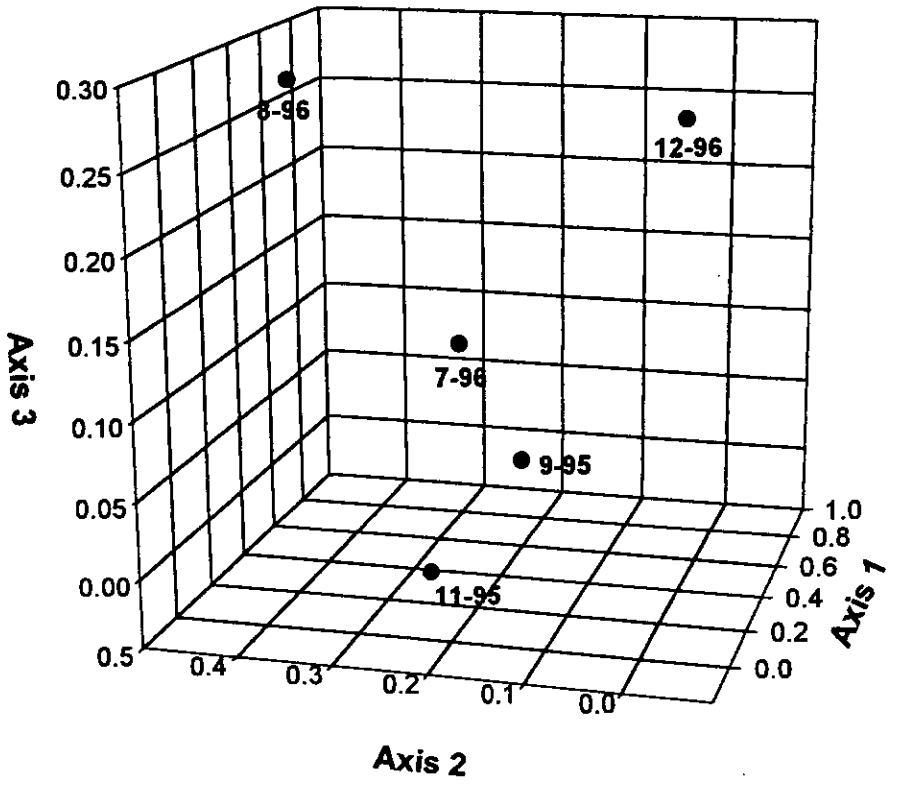

Figure 8
Woodford County Mowed Area
Ordination of species present in seed bank

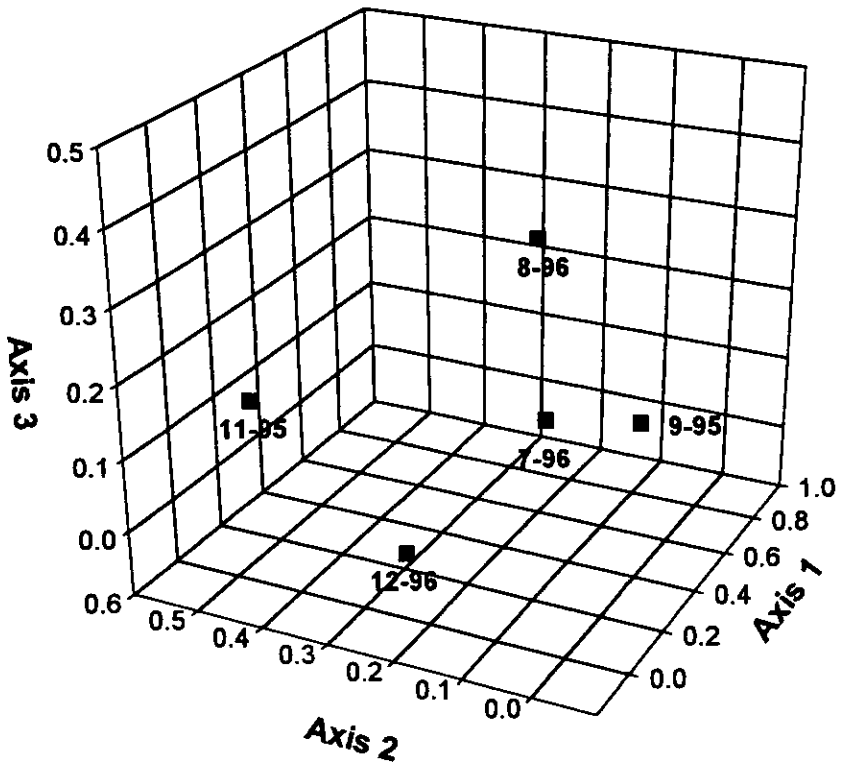

Figure 9
Woodford County Burned Area
Ordination of species present in seed bank

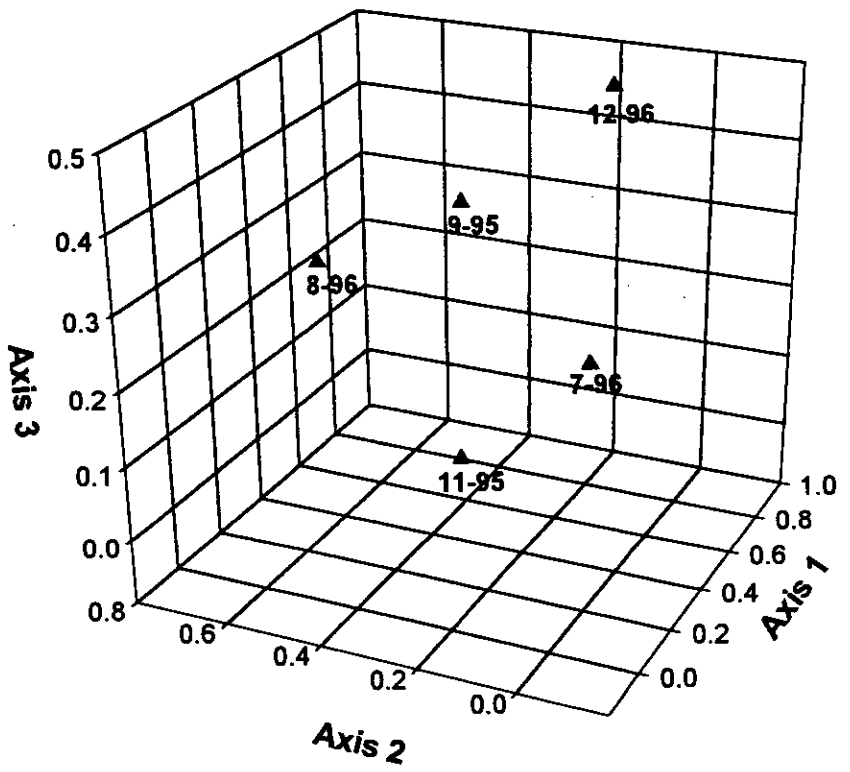

Figure 10
Woodford County
Ordination of all treatments

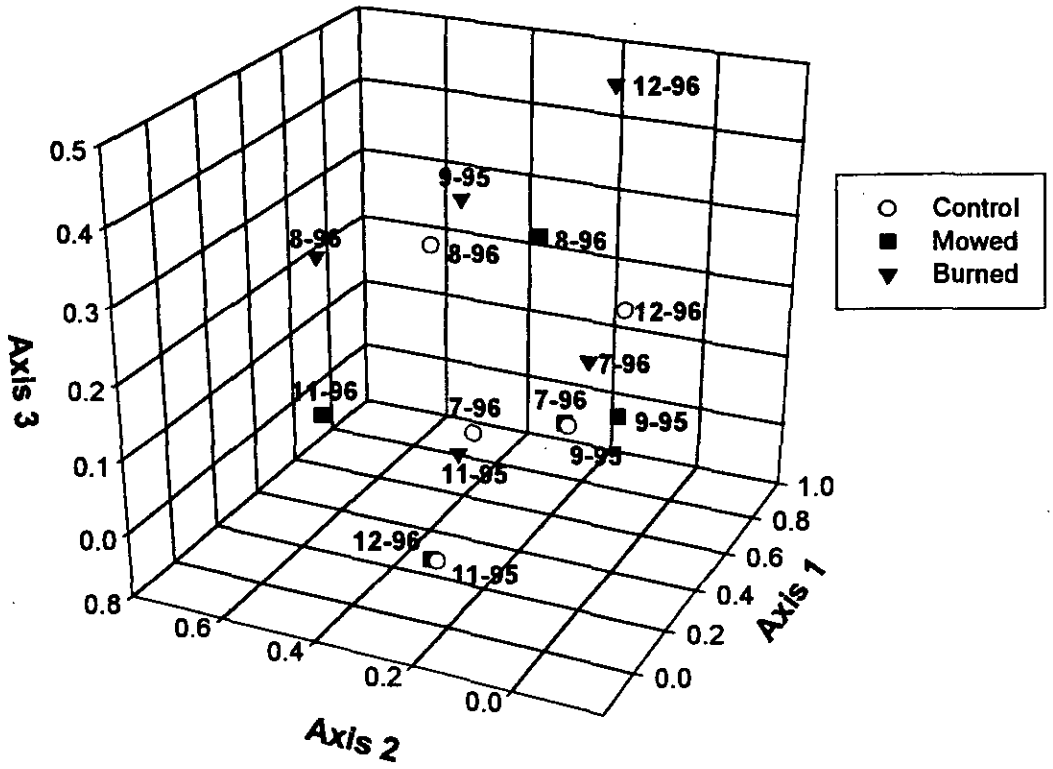

Table 1. Depth of *Boltonia decurrens* seed bank

Site (date core taken)	0-2 cm	2-4 cm	4-6 cm	6-8 cm
Anderson Lake (2-96)	0	0	0	0
Cooper Park (2-96)	0	0	0	0
Gilbert Lake (3-96)	15	4	1	0
Gilbert Lake (7-96)	7	2	0	2
Horseshoe Lake (7-96)	5	2	0	1
Rice Lake (2-96)	42	10	19	0
Rice Lake (7-96)	1	2	0	1
Rice Lake (8-96)	6	1	2	0
WCCA-Control (9-95)	10	1	1	0
WCCA-Control (11-95)	1	0	0	0
WCCA-Control (7-96)	0	1	0	0
WCCA-Control (8-96)	2	2	1	0
WCCA-Control (12-96)	1	0	0	0
WCCA-Mow (9-95)	2	2	0	2
WCCA-Mow (11-95)	3	1	0	0
WCCA-Mow (7-96)	0	0	0	0
WCCA-Mow (8-96)	0	0	0	0
WCCA-Mow (12-96)	0	0	0	0
WCCA-Burn (9-95)	0	0	0	0
WCCA-Burn (11-95)	0	0	0	0
WCCA-Burn (7-96)	0	0	0	0
WCCA-Burn (8-96)	0	0	0	0
WCCA-Burn (12-96)	0	0	0	0
Total	**79**	**24**	**23**	**4**

Table 2. Relationship between soil depth and seeds
All sites for 1996

Depth	% of total seeds
0-2 cm	61.7
2-4 cm	18.5
4-6 cm	17.7
6-8 cm	3.1

Table 3. Seed Bank and Population Size of *Boltonia decurrens*

	1994 **Seeds/m² (Population Size)**	1995 **Seeds m² (Population Size)** % change*	1996 **Seeds m² (Population Size)** % change*
Anderson Lake	**0 (100)**	**0 (50)** 0 (-50%)	**0 (132)** 0 (+164%)
Cooper Park	**2643 (104)**	**25 (125)** -99.9% (+20%)	**0 (152)** 0 (+22%)
Gilbert Lake	**13,215 (20,000)**	**42,095 (10,000)** +219% (-50%)	**9,790 (2,500)** -78% (-75%)
Horseshoe Lake	**NA**	**17,988 (125,000)**	**3,916 (100,000)** -78% (-20%)
Rice Lake	**17,621 (50,000)**	**16,642 (25,000)** -5% (-50%)	**34,753 (30,000)** +109% (+25%)
Woodford County	**26,431 (60,000)**	**489 (5,000)** -98% (-92%)	**1,142 (1,000)** +134% (-80%)
Total	59,910 (130,204)	77,235 (165,175) -1.1% (-69%)**	49,601 (133,784) -36% (-19%)

*Percent change is calculated from previous year

**These data exclude the new population at Horseshoe Lake

Appendix I. 1996 seed bank species

Anderson Lake

Species	Frequency	
Cyperus aristatus Rottb.	.03	
Cyperus diandrus Torr.	.01	
Cyperus strigosus L.	.06	
Echinochloa colonum (L.)Link	<.01	
Eleocharis spp.	.31	
Eragrostis hypnoides (Lam.)BSP	.01	
Eupatorium serotinum Michx.	<.01	
Euphorbia humistrata Engelm.	.04	Total seeds=284
Iva ciliata Willd.	<.01	Seeds/m^2=139,011
Lindernia anagallidea (Michx.) Pennell	.24	
Panicum virgatum L.	<.01	
Penthorum sedoides L.	<.01	
Phyla lanceolata Michx.	.01	
Phytolacca americana L.	<.01	
Rotala ramosior (L.) Koehne	.27	

Cooper Park

Species	Frequency	
Conobea multifida (Michx.)Nutt.	.14	
Eragrostis hypnoides (Lam.)BSP	.03	
Lindernia anagallidea (Michx.) Pennell	.54	
Mimulus ringens L.	.02	Total seeds=37
Penthorum sedoides L.	.02	Seeds/m^2=18,110
Phyla lanceolata Michx.	.02	
Rorripa sinuata (Nutt.) Hitchc.	.02	
Rotala ramosior (L.) Koehne	.08	
Veronica peregrina L.	.11	

Horseshoe Lake

Species	Frequency	
Boltonia decurrens (Torrey & Gray)Wood	.05	
Cyperus aristatus Rottb.	.52	
Cyperus compresus L.	.01	Total seeds=162
Cyperus rivularis Kunth.	.06	Seeds/m^2= 79,295
Eleocharis spp.	.04	
Lindernia anagallidea (Michx.) Pennell	.10	
Rotala ramosior (L.) Koehne	.25	

Gilbert Lake

Species	Frequency Pre-flood	Post-flood
Acalypha rhamboidea Raf.	.00	<.01
Boltonia decurrens (Torrey & Gray)Wood	.02	.06
Cassia fasiculata Michx.	.00	<.01
Conobea multifida (Michx.)Nutt	.05	.08
Cyperus aristatus Rottb.	<.01	.00
Cyperus strigosus L.	.02	.00
Eleocharis spp.	.13	.06
Eragrostis hypnoides (Lam.)BSP	.01	.00
Leersia oryzoides(L.) Sw.	<.01	.10
Lindernia anagallidea (Michx.) Pennell	.06	.02
Mentha arvensis L.	<.01	.00
Panicum virgatum L.	<.01	.00
Penthorum sedoides L.	.01	.00
Phyla lanceolata Michx.	.02	.00
Polygonum lapathifolium L.	.00	<.01
Rorripa sessiliflora (Nutt.) Hitchc.	.00	.02
Rorripa sinuata (Nutt.) Hitchc.	<.01	.00
Rorripa sylvestris (L.) Bess.	.00	.17
Rotala ramosior (L.) Koehne	.05	.46
Samolus parviflorus Raf.	.14	.02
Veronica peregrina L.	.00	<.01
Total seeds	814	190
Seeds/m^2	398,434	93,000

Rice Lake

Species	Pre-flood	Frequency Post-flood*	Post-flood*
Abutilon theophrasti Medic	.00	.01	.03
Acalypha rhaamboidea Raf.	.00	.00	.01
Amaranthus rudis	.00	.03	.00
Boltonia decurrens (Torrey & Gray)Wood	.47	.03	.10
Chenopodium album L.	.00	.00	.01
Cyperus aristatus Rottb.	.13	.01	.00
Cyperus rivularis Kunth.	.00	.03	.00
Cyperus strigosus L.	.01	.00	.00
Eleocharis spp.	.00	.00	.55
Lindernia anagallidea (Michx.) Pennell	.17	.57	.09
Lindernia dubia (L.) Pennell	.00	.00	.02
Phyla lanceolata Michx.	.01	.00	.00
Phyllanthus caroliniensis Walt.	.00	.00	.01
Phytolacca americana L.	.01	.00	.00
Rorripa sessiliflora (Nutt.) Hitchc.	.00	.03	.02
Rorripa sinuata (Nutt.) Hitchc.	.01	.00	.00
Rorripa sylvestris (L.) Bess.	.06	.12	.10
Rotala ramosior (L.) Koehne	.14	.00	.02
Veronica peregrina L.	.00	.16	.04
Total seeds	152	124	93
Seeds/m^2	74,400	60,695	45,521

Woodford County Conservation Area

Species	Frequency			
	Control	Mow	Burn	
Aster ontarionis Wieg.	.01	<.01	<.01	
Boltonia decurrens (Torrey & Gray) Wood	.03	.02	0	
Chenopodium dessicatum A. Nelson	<.01	<.01	0	
Conobea multifida (Michx.)Nutt.	.10	.06	.30	
Conyza canadensis (L.) Cron.	.01	<.01	<.01	
Euphorbia dentata Michx	<.01	0	0	
Euphorbia supina Raf.	0	<.01	0	
Erigeron philadelphicus L.	0	<.01	.01	
Fragaria virginiana Duchesne	0	0	<.01	
Lindernia dubia (L.) Pennell	.18	.13	.26	
Medicago lupulina L.	.01	.04	.05	
Myosurus minimus L.	.03	.02	.05	
Phyla lancelota(Michx.) Greene	.01	.08	.04	
Plantago major L.	.23	.07	.10	
Polygonum aviculare L.	<.01	<.01	0	
Polygonum pensylvanicum L.	<.01	.02	0	
Portulaca oleraceae L.	0	0	<.01	
Ranunculus micranthus Nutt.	<.01	.02	.02	
Rotala ramosior (L.) Koehne	.08	.16	.08	
Rumex crispus L.	0	.03	.03	
Veronica peregrina L.	.30	.37	.04	
Total seeds	594	455	322	1371
seeds/m^2	290,748	222,711	157,611	223,691