661.9

SOIL VEGETATION CORRELATIONS ALONG A HYDROLOGIC GRADIENT IN THE PLATTE RIVER WET MEADOWS

copy

A Thesis

Presented to the

Graduate Faculty of the Biology Department

and the

Faculty of the Graduate College

University of Nebraska

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science

University of Nebraska at Kearney

by

Andrew Simpson

April, 2001

THESIS ACCEPTANCE

Acceptance for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree Master of Science, University of Nebraska at Kearney.

Supervisory Committee

Name	Department
Charles J. Bicak	Biology
Steve Rothenberger	Biology
Harold Nagel	Biology
Robert J. Henszey	Platte River Whooping Maintenance Trust

Harold G. Nagel

Supervisory Committee Chair

17 April 2001

Date

ABSTRACT

Much work has been done establishing the importance of specific soil characteristics and plant communities within wetland ecosystems. Even with this extensive amount of knowledge about wetland soils, and wetland plant communities, there is still a gap in this information when it comes to relating specific plant communities to specific soil characteristics. To better understand this relationship, soil-vegetation correlation's were determined for sixteen wet meadow sites located in the Big Bend Reach of the Platte River. These sites were subjected to three land treatment regimes; haying, grazing, and rest. Soil texture, organic matter content, macronutrient levels, pH, salinity, and soil moisture were determined along transects representing 15 cm. relative increases in elevation for each of the sites. Plant species composition was determined along these same transects. Hydroperiods were determined at each site by monitoring hydrology levels from wells placed on the ridge and in the swale of the meadow. Canonical correspondnece analysis (CCA), a form of direct gradient multivariate ordination analysis was performed to determine the relationship between plant communities and the environmental variables present at the sites. Hydrology, salinity, phosphorous, and organic matter were all positively correlated with plant community composition within the land treatment sites, while pH was negatively correlated. These environmental variables accounted for 39.9% of the variation in the hayed sites, 45.4% in the rested sites, and 39.2% of the variation found in the plant species communities of the grazed sites. The grazed and rested sites showed no deviation from this trend, while the hayed sites exhibited a decreased correlation with the hydrology variables. Overall, CCA analysis was most effective if performed on sites separated by land treatment. It was also determined that the hydrology was the underlying factor influencing the plant species composition of these complex ecosystems. CCA ordination curves were produced for all plant species occurring in more than fifty percent of the sites, comparing plant species abundance to the environmental axis 1 and 2.

ACKNOWLEDGEMENTS

I would like to extend my deepest gratitude to Dr. Robert Henszey and the Platte River Whooping Crane Habitat Maintenance Trust. for not only providing the study area, technical help, funding, and data for this study, but also for giving me an opportunity to be part of a larger project that will provide an in depth insight into these wet meadow ecosystems. I would also like to thank the Research Services Council, and the Biology Department at the University of Nebraska at Kearney for providing funding, laboratories, and a place to call home for two years. This project would have never reached completion without the help of a few dedicated field assistants Brian Peterson, Adam Mues, and Jody Elliott, thank you all. Lastly, I would like to thank Dr. Hal Nagel for all of his guidance, expertise, and most importantly moral support throughout this project and my graduate career. Thank you for truly embodying the definition of a mentor.

TABLE OF CONTENTS

Introduction
- Justification........1
- Purpose........6
- Objectives........8
- Definition of Ordination........8

Materials and Methods
- Study Area........13
- Soil........17
- Vegetation........19
- Hydrology........19
- Ordination Analysis........20

Results
- Soil Parameters on Gradient Zones........22
- Ordination
  - All Sites........24
  - Land Treatment........29
  - Intensively Sampled Sites........40
  - Individual Species Ordination........44

Discussion
- Effectiveness of Ordinations........94
- Conclusions........97

Literature Cited........101

Appendix
- Master Data
  - Soil........106
  - Vegetation........111
- All Sites
  - Transect Correlations........112
  - Species Correlations........117
- Grazed Sites
  - Transect Correlations........121
  - Species Correlations........123
- Hayed Sites
  - Transect Correlations........126
  - Species Correlations........128
- Rested Sites
  - Transect Correlations........130
  - Species Correlations........132
- Intensively Sampled Sites
  - Transect Correlations........134
  - Species Correlations........136

Tables

1. Designation of Study Name Representing Treatment and Replicate............15
2. DCA/CCA Eigenvalue Comparison, All Sites.......................................24
3. Cumulative Variation Explained, All Sites.......................................25
4. Monte Carlo Test, All Sites...26
5. Correlation Coefficents, All Sites..27
6. DCA/CCA Eigenvalue Comparison, Land Treatment Sites........................29
7. Cumulative Variation Explained, Land Treatment Sites..........................30
8. Monte Carlo Test, Land Treatment Sites..31
9. Correlation Coefficients, Grazed Sites...32
10. Correlation Coefficients, Hayed Sites...33
11. Correlation Coefficients, Rested Sites..34
12. DCA/CCA Eigenvalue Comparison, Intensively Sampled Sites.................41
13. Cumulative Variation Explained, Intensively Sampled Sites...................42
14. Monte Carlo Test, Intensively Sampled Sites...................................42
15. Correlation Coefficients, Intensively Sampled Sites............................43

Figures

1. Study Area Map...13
2. Ridge-Swale Complex..16
3. Soil Parameter Averages for Each Gradient Zone.................................22
4. Soil Parameter Averages Expressed Graphically..................................23
5. CCA All Sites Species Plot..28
6. CCA Grazed Sites Transect/Species Plot..35
7. Dicanthelium *oligosanthes* Side Scatterplot, Grazed Sites.......................37
8. Carex *craweii* Side Scatterplot, Grazed Sites.....................................38
9. Calamagrostis *stricta* Side Scatterplot, Grazed Sites.............................39
10. Polygonum *amphibium* Side Scatterplot, Grazed Sites..........................40
11. CCA Intensively Sampled Sites Transect/Species Plot...........................44

Individual Species CCA Ordination Plots

12. Agropyron *caninum*...45
13. Agrostis *stolonifera*...46
14. Ambrosia *psilotstachya*..47
15. Andropogon *gerardii*...48
16. Apocynum *cannabium*...49
17. Aster *ericoides*..50
18. Aster *simplex*...51
19. Bromus *inermis*...52
20. Callirhoe *involucrata*..53
21. Carex *emoryi*..54
22. Carex *granularis*..55
23. Carex *pellita*...56
24. Carex *tetanica*...57
25. Carex *vulpinoidea*..58

26. Cirsium *floodmanii*..........59
27. Eleocharis *elliptica*..........60
28. Eleocharis *palustris*..........61
29. Eqisetum *arvense*..........62
30. Eqisetum *laevigatum*..........63
31. Erigeron *strigosus*..........64
32. Glychrizza *lepidota*..........65
33. Helianthus *maximiliani*..........66
34. Hordeum *jubatum*..........67
35. Hypoxis *hirsuta*..........68
36. Juncus *dudleyi*..........69
37. Leersia *oryzoides*..........70
38. Lippia *lanceolata*..........71
39. Lycopus *americanus*..........72
40. Lycopus *asper*..........73
41. Lysmachia *thrysiflora*..........74
42. Medicago *lupulina*..........75
43. Oxalis *stricta*..........76
44. Panicum *virgatum*..........77
45. Poa *pratense*..........78
46. Rosa *woodsii*..........79
47. Schyzicharium *scoparium*..........80
48. Scirpus *pungens*..........81
49. Smilacina *stellata*..........82
50. Solidago *canadense*..........83
51. Sorghastrum *nutans*..........84
52. Spartina *pectinata*..........85
53. Sporobolus *asper*..........86
54. Sporobolus *cryptandrus*..........87
55. Taraxicum *officinale*..........88
56. Trifolium *repens*..........89
57. Trifolium *pratense*..........90
58. Verbena *stricta*..........91
59. Viola *practinola*..........92
60. Xanthium *strumarin*..........93

INTRODUCTION

Justification

In the past two decades we have realized the effects of drastic decreases in not only wetland quantity but also in wetland quality on the overall health of the environment. Primarily, human impacts on these ecosystems that has lead to this decrease. Agricultural conversions, urban encroachment, and other habitat modifications have decreased wetland acreage (Erickson and Leslie 1987). In fact, only 45 percent of the original wetland acreage in the United States remained in the mid-1970's (Tiner and Wilen 1983). Since this drastic decrease, wetlands have become the most politically prominent ecosystem type in the country (Ehrenfeld 1993). Legislation in many forms has since served to help protect these ecosystems. President George Bush Sr. established a goal of "no net loss" of wetlands. His successor President Bill Clinton went even further and set a goal for a net increase of wetlands in the range of 100,000 acres annually to begin in 2005 (Baker 1999). It is this recognition of wetland loss that has sent both the scientific community and the resource management community scrambling to find a prescription for the maintenance and restoration of these ecosystems to insure their future integrity.

Wetlands are among the most complex of ecosystems because they are the result of a myriad of interacting factors. Hydrology, geomorphology, water chemistry, soil quality, land treatment, and human activities are all combined in a wetland ecosystems to form an intricate balance of organisms and their environment. It is most certainly due to this high level of complexity that so many people are left with the question, what is a wetland? The United States Fish and Wildlife Service, defines wetlands as lands that are;

> Transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year... The upland limit of a wetland is designated as: (1) the boundary between land with predominantly mesophytic and xerophytic cover; (2) the boundary between soil that is predominately hydric and soil that is predominately nonhydric; or (3) in the case of wetlands without vegetation or soil, the boundary between land that is flooded or saturated at some time each year and land that is not (Cowardin et al. 1979)

This definition classifies wetlands systems by the vegetation, the specific soil characteristics supporting the vegetation, and the hydrology. Also with this definition it is possible to see that the key components which comprise the complexity of a wetland system are also the components which define the system.

To better understand this definition it is necessary to first understand the terminology utilized in it. Hydrophytic vegetation is defined as plants that grow in water or a substrate that is at least periodically deficient in oxygen during a growing season as a result of excessive water content (Soil Conservation Service 1986). Hydric soils are defined as soils that are formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the profile (Fed. Regist. 1994).

Although this definition does fit many different types of wetlands from arctic boreal systems to coastal wetlands, for the purpose of this study we will be looking at the wetland systems in the central Great Plains region. More specifically the wet meadow systems in the Big Bend reach of the Central Platte River are examined. These wet meadows may be inundated for a few weeks in the spring, and are very common along the outskirts of the river channel.

The Big Bend Reach of the Platte River extends close to ninety miles from Lexington NE. to Chapman NE. Historically the Platte River was a broad open prairie river with a braided channel and numerous saturated wet meadows adjacent to the river (LeGrange 1997). However, water development projects, such as reservoirs and diversion canals, in Colorado, Wyoming, and Nebraska have reduced stream flows in the Platte River system (Currier et al. 1985, U.S. Fish and Wildlife Service 1981, Van Derwalker 1988). These water development projects have been estimated to have diverted approximately 70% of the flow along the "Big Bend Reach" of the Platte River since the mid-nineteenth century (Williams 1978). This drastic decrease in flow has resulted in the channelization of the once braided river. Channelization is evident in the fact that since 1860, the Central Platte River has lost up to 73 percent of its active channel areas (Sidle et al. 1989). This loss of active channel, as a direct result of the reduction of scouring flows on the Platte has allowed the establishment of undesirable woody vegetation (Currier 1995). All of these factors combined have many adverse effects on the region, most notably for this project the fact that wet meadow acreage decreased an average of 45% between 1938-1982 (Sidle et al. 1989).

This loss of flow through the "Big Bend Reach" of the Platte, and the increase of woody vegetation, reducing the amount of open channels has had numerous detrimental effects. One such effect is the drastic reduction of waterfowl nesting success, roosting, courtship behaviors, and feeding habitats of some migrating birds, including threatened and endangered species (U.S. Fish and Wildlife Service 1981). Even with these decreases in wet meadows, open channel availability, wildlife habitat, and stream flow, the "Big Bend Reach" of the Central Platte River is still responsible for providing essential habitat for a vast array of wildlife. Nearly 450,000 sandhill cranes (*Grus canadensis*) spend 6-8 weeks roosting in the river and feeding on invertebrates in the wet meadows adjacent to the Platte (Sidle et al. 1989). Also six endangered or threatened species of birds are found in the region, including the whooping crane (*Grus americana*), least tern (*Sterna antillarum*), bald eagle (*Haliateetus leucocephalus*), peregrine falcon (*Falco peregrinus*), eskimo curlew (*Numenius borealis*), and the piping plover (*Charadrius melodus*) (Sidle et al. 1988, U.S. Fish and Wildlife Service 1988).

Within the Central Platte River region this loss of wet meadows, and consequently the loss of wildlife habitat has been recognized. With this recognition there has been a movement to restore many of the wet meadow ecosystems in the region. This restoration has been seen to be a long process and many aspects of the systems are difficult to define, thus making restoration difficult. Within these restorations, however, one underlying principle has emerged. That principle is the fact that the hydrology of the restored systems is vital to determining what plant species are established in the restored areas (Nagel & Peterson 1998-2001). Restored sites success is dependent on the frequency and the duration of the flooding regime applied to each site. Due to the channelization of the Platte River, and the decreased flows in many cases the only way to provide the restored areas with an ample supply of water is to pump it into the site (Nagel & Peterson 1998-2001). This is technically difficult, and in most cases is not a really effective method of maintaining the hydrological regime necessary to restore these sites to a healthy wet meadow system. Within the region plans have been implemented to create more wet meadows. However, without the proper native flooding regimes these efforts are long term and subject to many difficulties.

When considering all of the political factors involved with wetland restoration and delineation, it is necessary to produce studies which help to better understand every aspect of these very complex systems. One must also look at these systems from a scientific standpoint. From this standpoint it is necessary to fill in any gaps within the general knowledge of a living system. The relationship of specific soil characteristics to specific plant communities is still an unexplored aspect of these wet meadows. It is the compilation of the political urgency to restore and define wetlands and the scientific necessity to understand these complex systems are the basis of this study of ecosystem interactions.

Purpose

There has been much work done in defining exactly what a wetland is and the key components of that ecosystem. Vegetation, hydrology, and soils are accepted as the three most basic identifying features of a wetland. Hydrology is generally recognized as the driving force that maintains wetland conditions, but it is also the most difficult parameter to describe, due to seasonal, annual and longer-term fluctuations (Allen et al. 1989). The hydrologic regime that a particular wetland is subjected to is directly responsible for defining the plant composition of the site, and also for forming the soil characteristics of that site. Although much work has been done to determine the relationships between wetland vegetation and the hydrology regime, few studies have attempted to correlate all three parameters (Allen et al. 1989). It has been stated that " soil is one of the most important physical components of wetlands" (Cowardin et al. 1979). Why have so many studies in the past overlooked the importance of these wetland soils in determining the structure of the ecosystem?

By recognizing the importance of all of the key components in the development and maintenance of a productive wetland ecosystem, it is much easier to understand the complexity of these systems. Much knowledge has been gained in the recent studies of wetlands, and in particular wet meadows. However, there are still many unknowns within these systems. These unknowns can be attributed to the high level of diversity involved with the types of wetlands present. Little work has been done to determine the correlation between wetland soils and the plant community. It is thought that these correlations may lead to some insight into the definition of a "transition zone" within a wet meadow. This "transition zone" is defined as the zone extending from wetland into the adjoining upland where components of both communities can be found. However, the actual regulatory edge of the wetland is thought to lie somewhere within this zone (Allen et al. 1989). Again this "transition zone" has never really been looked at from a multi-parametric viewpoint, considering soils, vegetation, and hydrology of the system.

From a resource manager's point of view, this elusive zone is of the utmost importance. Section 404 of the Federal Water Pollution Control Act of 1972 and the "swampbuster" provisions of the Food Security Act of 1985 require identification and delineation of wetlands in accordance with the statutes provided by both acts (Adams et al. 1987). These acts serve in a protective role to wetlands, and state that anyone who attempts to produce an agricultural commodity on converted wetlands are ineligible for government price supports, loans, crop insurance, and other agricultural subsidies during that crop year (Adams et al. 1987). In the past, the definition of a wetland has been well established (e.g., Mausbach 1994, Michener 1983, Thompson and Bell 1996) The question is no longer what is a wetland? The question now is where does it stop? Since the implementation of these acts landowners and government regulatory commissions have been desperately in search of this wetland boundary. This boundary is essential to all interest groups involved, as it defines where the regulated wetland ends and the non regulated uplands begin (Adams et al. 1987).

Objectives

- This study will provide important scientific data to begin to explain in a multi-parametric manner the overall effect of all three key components of wetlands, soils, hydrology, and vegetation.
- This study will provide in depth analysis of the importance of wetland soils as they pertain to determining certain vegetation community patterns.
- This study will provide further exploration into the characteristics that comprise the "transition zone". This is vital to providing resource managers and landowners alike the knowledge necessary to work towards the improvement of the overall health of the wet meadows on the Platte River.

Ordinations

Ordinations are a widely used family of methods, which attempt to reveal the relationships between ecological communities. The plant and soil communities of the wet meadows will be analyzed utilizing this technique. Over the past century there has been a gradual evolution of ordinations. The roots of this statistical tool extend all the way back to 1901 when Pearson invented principal component analysis (PCA) as a regression technique. The term ordination however did not begin to be used widespread until Whitaker began to develop the theoretical foundations for gradient analysis during the 1970's (Gauch, 1982). Whittaker defined gradient analysis as the study of relations of populations and communities along environmental gradients (Whittaker 1951,1956). Once this idea of gradient analysis was introduced, ordinations were well on the way to becoming a very useful tool for ecologists to begin to inquire into species-environment relationships. Up until this time, many problems had plagued this process, the biggest one being that in order to draw these conclusions community composition data and the associated habitat measurements must be compared (Ter Braak 1986). This comparison was no easy task as the data was in two separate formats. Even the earliest of ordinations would make this task simpler.

Whittaker began working with these techniques and found them to be very useful when analyzing large landscape patterns. In 1965 he was able to show that the vegetation of the Santa Catalina Mountains in Arizona could be analyzed to show the relations of communities to elevation and topographic moisture gradients (Whittaker and Niering 1965). These same types of correlations also proved to be very effective in analyzing small-scale landscape patterns. In Poland, a was performed in 1968, to determine the significance on soil characteristics, and topography on the forest community composition. This study showed that ten community bands could be derived from the forest, all of which depicted a different species-environment relationship (Frydman and Whittaker 1968). These results lend support to the effectiveness of ordination analysis for use in this study.

There are two types of gradient analysis: direct, and indirect. Direct gradient analysis is the process by which species importance and measured environmental variables are compared to determine their importance along an environmental gradient. Indirect gradient analysis is the process by which the samples are ranked according to their species composition (Gauch et al. 1974). Each one of these types of analysis has provided very useful data. Direct gradient analysis shows that "species distributions show a rounded or bell-shaped form in most cases, overlap broadly, and have their centers and limits scattered along the gradient" (Whittaker 1956, McIntosh 1967). In contrast, indirect gradient analyses have been shown to give a linear representation of the community data (Bray and Curtis 1957).

All of these past discoveries and experimentation have lead to the development of the most widely used ordination techniques today (Palmer 1993). This technique is an extension of correspondence analysis, an example of indirect gradient analysis. This type of analysis is not constrained by the environmental variables present. However, the extension of correspondence analysis (CA) is constrained by multiple regression on its relationship to environmental variables and is an example of direct gradient analysis technique (McCune 1997). This extension is called canonical correspondence analysis (CCA). Canonical correspondence analysis is a multivariate direct gradient analysis that relates a set of environmental variables directly to the set of species being analyzed (Ter Braak 1986). This technique identifies an environmental basis for community ordination by detecting the patterns of variation in community composition that can best be explained by the environmental variables (Ter Braak 1986). Data being analyzed by CCA will thus show the influence of all of the environmental variables on the community, and it will also show where a specific community falls along the environmental gradient. CCA is a form of weighted averaging ordination, which provides it with the ability to simultaneously order sites and species, produce rapid computations, and have very good performance when species have nonlinear and unimodal relationships to environmental gradients. It has been shown that CCA performs well even with skewed species distributions, and extremely high noise levels (Palmer 1993).

Always a concern with any type of correlation analysis is the multicollinearity of some of the environmental variables. In other types of ordinations, this is a great concern. For example it has been shown that in the North Carolina piedmont, numerous environmental variables are correlated with soil pH (Christensen and Peet 1984). If you were analyzing this data in a previous type of ordination analysis you may have to perform separate tests on each variable to determine it's individual importance to not only the species composition, but also to each other environmental variable. This process is very time consuming and is no longer a practical application. This pre-processing of multicollinear data is unnecessary when utilizing CCA, due to the fact that CCA can reveal a second and even third meaningful axis even if the variables are intercorrelated (Palmer 1993). The more axis added to the anlaysis however, the more unstable the results for those individual axis do become. Leading to a decreased amount of variation being explained by these axis. It has been shown that the CCA ordination is not affected at all by high correlations between species or between environmental variables. "Such redundancy in the environmental data is probably actually beneficial, because some errors in measuring the environmental data may be averaged out" (Ter Braak 1987).

CCA has been used for numerous scientific studies ranging from the effects flooding and light availability on floodplain saplings (Hall and Harcombe 1998), the distribution of ectomycorrhizal-basidiomycete communities along a vegetation gradient

(Nantel and Neumann 1992), to the elucidation of plant and bird species distribution throughout a grid system in the United Kingdom (Hill 1991).

It is for all of these reasons that CCA is the best-suited ordination technique for this study. It is thought that CCA will be best suited to discern distinct differences between the upland and the wetland plant species and their relationships to the soil and hydrology. CCA will also provide a species specific analysis of all the plant species present, providing an insight into the environmental needs of each plant species, and more importantly where it belongs on the hydrology gradient present in the wet meadows along the Platte River. CCA will play an important role in answering the question of where the "transition zone" is in these wetlands, and what species comprise it.

Materials and Methods

Study Area

The Platte River Whooping Crane Maintenance Trust, National Audubon Society, and private landowners provided the land used for this study. The wet meadows utilized on this land were located within the Big Bend Reach of the Central Platte River (Fig. 1).

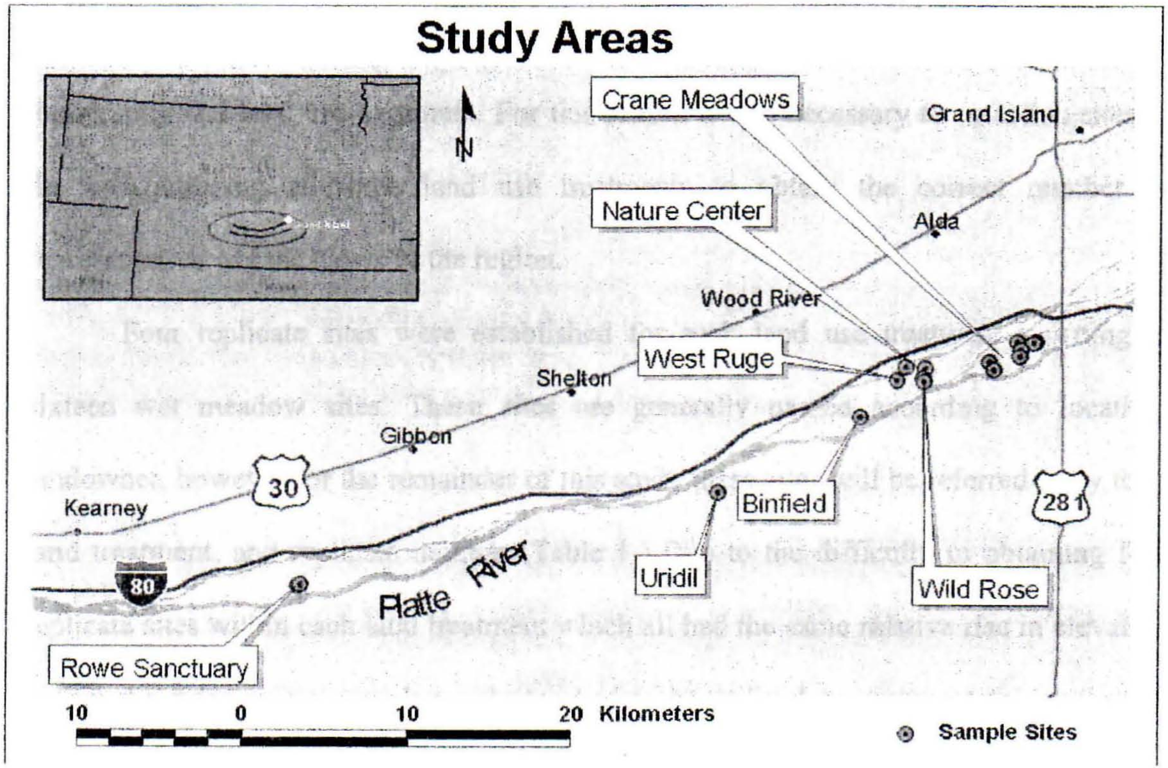

Figure 1. Map Representing Study Area, Location and General Name of Wet Meadow Sites Used

These wet meadows were selected as part of a larger project dealing with the effects of hydroperiods on wet meadow plant communities (Henszey et al. 1998).

Three land management treatments were determined for these wet meadow sites. Haying, grazing, and rested land treatments where all utilized for both this study and the hydrology study. These land treatments are mostly low intensity management, and include once yearly haying sites, long term rested sites (4-8 years), and low intensity rotational grazing consisting of approximately 0.8 AUM's per acre. On top of those treatments a prescribed burn rotation is incorporated onto all sites. All of these land treatments are managed by the Platte River Whooping Crane Maintenance Trust. These treatments must be considered when evaluating any land on the Platte River. Due to the diversity of land treatments on the Platte and the intense focus on agriculture in the area it is very difficult to acquire any large number of replicate sites with all of the same topography and land use treatment. For this reason it was necessary to establish sites in the area utilizing all three land use treatments to obtain the correct number of representative wet meadows in the region.

Four replicate sites were established for each land use treatment resulting in sixteen wet meadow sites. These sites are generally named according to location/ landowner, however for the remainder of this study these sites will be referred to by their land treatment, and replicate number (Table 1.) Due to the difficulty in obtaining four replicate sites within each land treatment which all had the same relative rise in elevation within the ridge-swale complex, subsites had to be utilized to represent this extension along the gradient. The denotation of a site "a" and a site "b" within a replicate (Table. 1) represent these extensions.

Table 1. Designation of study name representing treatment and replicate

GENERAL NAME		STUDY DESIGNATION
Crane Meadows Field	2 (Grazed, Replicate 1)	G1
Crane Meadows Field	10 (Grazed, Replicate 2)	G2
Crane Meadows Field	12 (Grazed, Replicate 3)	G3
Binfield	(Grazed, Replicate 4)	G4
Crane Meadows Field	6 (Hayed, Replicate 1a)	H1a
Uridil	(Hayed, Replicate 1b)	H1b
Crane Meadows Field	8 (Hayed, Replicate 2)	H2
Wild Rose North/South	(Hayed, Replicate 3)	H3a, H3b
Rowe Sanctuary	(Hayed, Replicate 4)	H4a, H4b
Crane Meadows Field	3 (Rested, Replicate 1)	R1
Crane Meadows Field	3 (Rested, R Replicate 2a)	R2a
W Ruge	(Rested Replicated 2b)	R2b
Nature Center NW	(Rested Replicate 3)	R3
Nature Center SE	(Rested Replicate 4)	R4

Each of these wet meadow sites represents a ridge-swale complex, along a hydrologic gradient. This gradient moves from an area subjected to often saturation with standing water in the swale, to an upland area representing a mesic, occasionally xeric environment. Observation wells were installed at the lowest point of each complex located within the swale, and at the highest point located on top of the ridge (Fig.2). These wells were installed at least five feet deeper that the expected maximum water table depth at each of the sixteen sites.

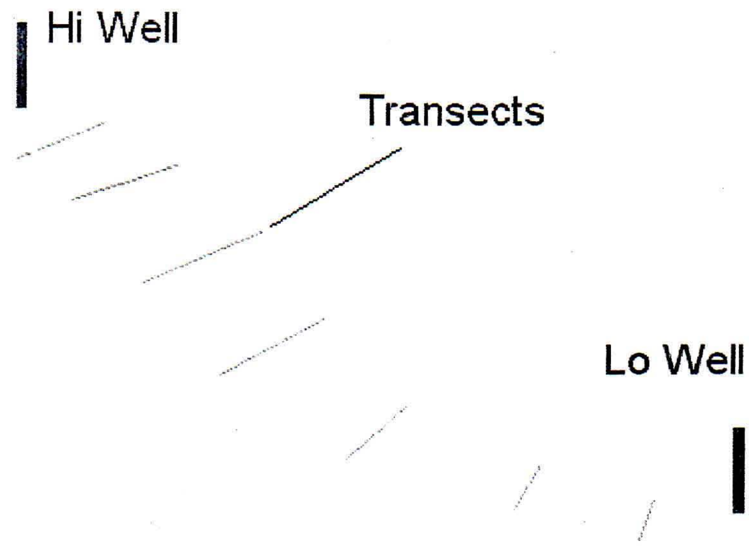

Figure 2. Representing Ridge-Swale Complex, Location of Wells at each Site and Transects

At each site a set of transects were also established to determine the plant communities present at each site. These transects were established to locate plant community bands at intervals representing 15 cm. steps in elevation along the gradient. These transects extend twelve meters on either side of a line between the wells.

The 15 cm. steps in elevation were determined with an auto level to determine the location of each transect. Each transect was marked by a permanent fire-proof line which followed the contours of the slope. These transects ran perpendicular to the ridge-swale gradient and were used for both the plant and soil community analyses in this study (Fig. 2).

Soil Sampling

Soil samples were collected using a 7.5 cm. diameter auger to 15-20 cm depths. Samples were collected at each transect. At each transect the soil samples were pooled at both ends, and approximately the middle. Resulting in subsamples being taken at different intervals along each transect. This pooling was done whenever possible, however, due to haying practices, the transects at those sites were destroyed making this impossible. Within these hayed sites, all soil sampling began at the end of each transect. All soil samples were placed in plastic bags, labeled, placed in a cooler and transported to the laboratory for analysis.

Initially this study was designed to only analyze the soil-plant relationships at three of the grazed wet meadows and one of the rested sites. This exploratory study was designed to look in depth into the effects of grazing on the soil-plant relationships of these meadows utilizing the one rested site as the control. These four sites were sampled in May, June and July of 2000. The samples from these sites were analyzed for texture, percent moisture, temperature, pH, salinity, and percolation rate.

It was later determined that all sixteen wet meadow sites should be analyzed for soil-plant relationships. Phosphorous, potassium, and nitrogen levels, pH, salinity, organic matter, and soil texture, where determined for all one hundred thirty one transects across all sixteen sites.

The sampling of these sites was conducted in the same manner, along the same transects, as the other four sites and occurred in August of 2000. Combined this exploratory part of the study, and the sampling of all of the sites, consequently lead to only four sites being sampled for soil moisture, soil temperature, and percolation rate extensively. These sites do in turn have extra soil characteristics sampled for. However, all of the sites were sampled evenly for nutrients and texture in August of 2000.

In total, 131 transects were sampled for macronutrients, organic matter, and texture. The analyses were performed by Ward Laboratories, Inc. Kearney NE. Soil pH was determined using a pH meter with the sample in a 1:1 soil water suspension (Brown and Rodiguez 1983). Soil salinity was determined using electrical conductivity with the sample in a 1:1 soil water suspension (Rhoades 1982). The nitrate present in the soil samples was determined via potassium chloride extract (Gelderman and Beegle 1998). Phosphorous was determined utilizing Bray P (Frank et al. 1998). Potassium was determined via ammonium acetate extract (Warncke and Brown 1998). Organic matter of the soils samples was determined by percent present via loss on ignitions technique (Combs and Nathan 1998). Texture of the soils is expressed as percent sand, silt, and clay and was determined utilizing the hydrometer method (Palmer and Frederick 1995). Soil temperature was determined at each transect by using a hand digital thermometer and soil probe. Percent moisture was determined by using the gravimetric weighing method (Singer and Munns 1996). Percolation rate was determined utilizing the double ring infiltrometer method (Klute 1986). This analysis was also only performed at the four intensive sites, and was conducted on the outside edge of each of the four sites at the end of each transect.

Vegetation Sampling

Vegetation sampling was performed along each of the designated transects to determine the plant communities present at each site. This vegetation sampling was performed at 200 points per transect by the Platte River Whooping Crane Maintenance Trust. Vegetation samples were taken along each plant community band utilizing the point-intercept method, and estimating basal cover of each species present (USDI Bureau of Land Management 1996). From this sampling technique the percent species composition for each transect at each site was determined. This vegetation sampling was conducted over a two-year period including the growing season of 1999 and 2000 (Henszey et al.1998). For the purpose of this study, only the 2000 data were analyzed to correspond with the 2000 soil data collected.

Hydrology

The hydrology of these wet meadows was determined utilizing the wells at each ridge-swale complex. These wells were also monitored by the Platte River Whooping Crane Maintenance Trust . One well at each site was equipped with a continuous water level recorder and the other well was checked at least once a month. Regression analysis was later used to determine a continuous record for the periodically measured well. This data was then expressed as daily, weekly, 7 day running averages, 14 day running averages, and monthly means of hydroperiod levels, frequency and duration at each of the sites (Henszey et al. 1998). These 14 day running means for both the high and the low well sites that were be utilized for this study.

Ordinations

Using the software package PC-ORD two main ordinations were performed using a variety of different scenarios to best determine the soil-plant relationships. Canonical correspondence analysis (CCA), corresponding Monte Carlo tests, and detrended correspondence analysis (DCA) was performed on all sites together, the grazed, rested, and hayed sites separately within their respective land treatments, and on the four sites which had the intensive soil sampling performed.

Detrended correspondence analysis is a widely used technique which results in an indirect gradient analysis. This analysis was performed on each sample as a means of determining the total amount of variation that could be explained by ordination techniques unconstrained by the environmental variables (Hall and Harcombe 1998).
It has been shown that this step is vital to determining whether or not the results from the CCA can be trusted when attempting to explain the variation in the community data with the environmental variables (McCune 1997). If the eigenvalues for the DCA are similar to the eigenvalues of the CCA, then the CCA tests are considered valid.

The Monte Carlo test provided in PC-ORD was used to determine how often random permutations of the data would produce eigenvalues as large or larger than those actually obtained from our data (Ter Braak 1997). This test also serves as a significance tests for our data and provides validity to the species-environment correlation coefficients provided by the CCA (McCune 1997).

Canonical correspondence analysis was performed on each plant and soil sample to determine the overall effect the environmental variables had on the plant species community present at the wet meadows. This analysis allowed for the interpretation of the most important environmental variable on the plant species present, at different stages along the gradient.

Results

Averages for all soil parameters measured where determined for specific zones along the ridge-swale hydrology gradient. Zone one is representative of the upland ridge area of the complex, zone two and three are representative of the approximate beginning and end of the "transition zone" within the complex, and zone four represents the swale (Fig 3).

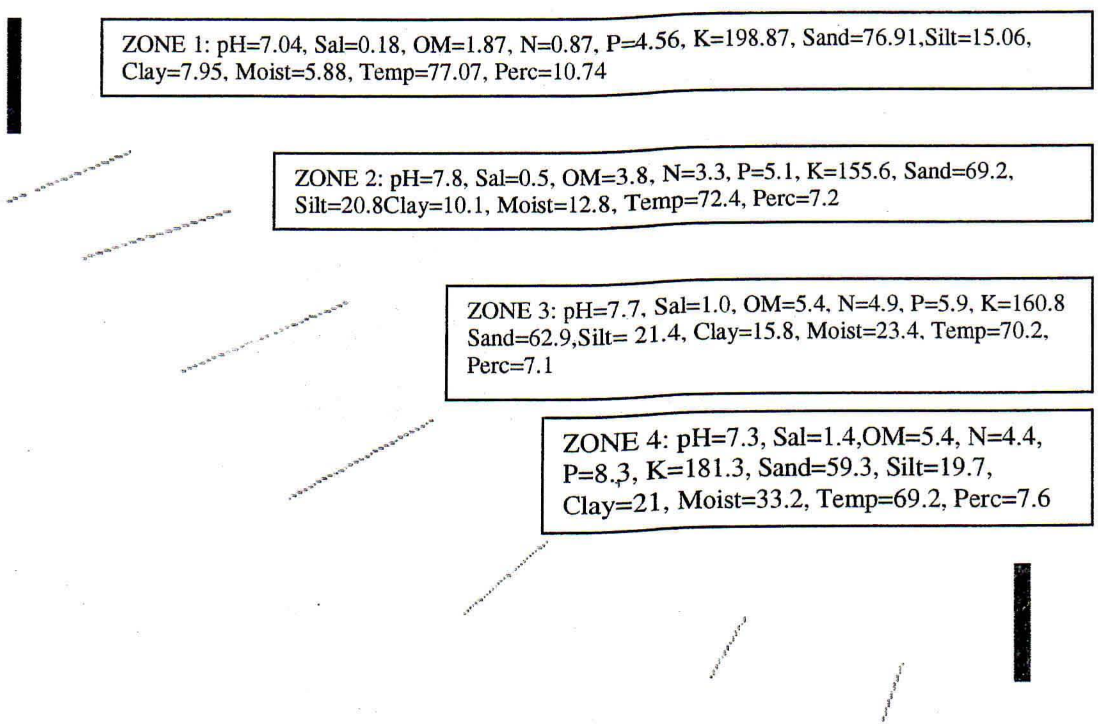

Figure 3. Soil parameter averages for each zone along ridge-swale gradient

The soil parameter averages when applied to zones along the hydrologic gradient are represented graphically (Fig. 4).

Individual Soil Parameter Averages for Gradient ZONES 1,2,3 and 4

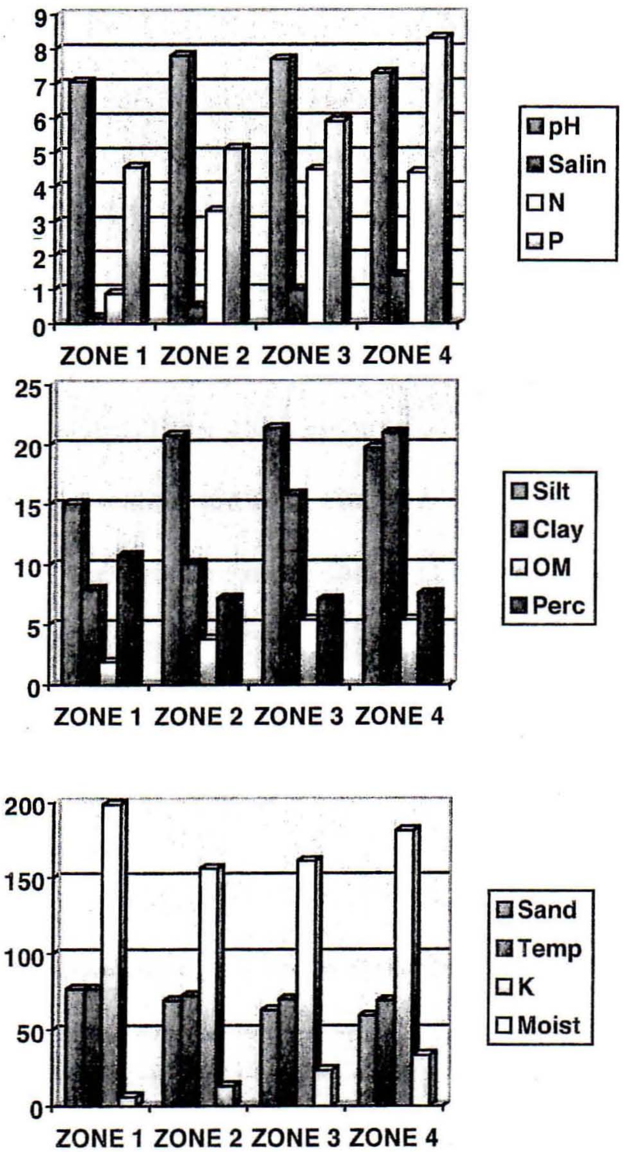

Figure 4. The effect of individual soil parameter averages within gradient ZONES 1,2,3 and 4

All Sites Ordinations

DCA analysis was performed on all sixteen replicate sites at once resulting in a total species variation (inertia) of 4.68. CCA was also performed on this grouping of wet meadow sites resulting in a total species variation of 6.56 (Table. 2). The relative distance between the DCA and the CCA inertia can be attributed to the noise from the environmental variables that constrain the CCA analysis.

Eigenvalues representing the percent of variance in the community data that is explained by each axis were also calculated (Table 2.) The eigenvalues for the DCA analysis should only be used for comparison to the CCA eigenvalues to determine the effectiveness of the CCA analysis. These DCA eigenvalues can be misleading when used alone due to the processes of rescaling and detrending which destroys the correspondence between the eigenvalue and the structure along that axis (McCune and Mefford 1999). When compared the eigenvalues for the DCA analysis do not deviate very much from the eigenvalues for the CCA analysis. With most of the species variance (66%) being explained by the first axis of the ordination, and the least amount (28%) explained by axis 3 (Table 2.).

Table 2. DCA CCA axis eigenvalues, and total inertia (variation) in the species data for all wet meadows analyzed.

	Eigenvalues			
	Axis 1	Axis 2	axis 3	Total inertia
DCA	0.67	0.31	0.22	4.68
CCA	0.66	0.41	0.28	6.56

CCA analysis for all sixteen sites also revealed the amount of variance in the species data that could be explained by the environmental variables applied to the data. In this case those environmental variables consisted of the soil characteristics measured at each transect, and the hydrological data collected from the associated wells at each site. This variance is expressed as percent explained by each axis of the analysis. The cumulative variance that could be explained by all axis for this analysis amounted to 20.7 percent (Table 3.). Also included in this portion of the analysis was the development of a correlation coefficient (Pearson Correlation) which represents the relationship between the species data and the sample scores that are linear combinations of the environmental variables (McCune and Mefford 1999). As seen from the environmental correlation coefficients, axis one is representing the hydrology of the site, and axis two is representing pH (Table 5). For axis one there was a strong correlation of 0.95, and a lesser correlation of 0.75 for axis 3 illustrating the fact that axis one is representative of more species variation attributed to environmental variables than axis two, and three (Table 3).

Table 3. Axis summary statistics depicting the amount of species composition that is explained by the environmental variables for all wet meadow sites

	Axis 1	Axis 2	Axis 3
Variance in species data			
% of variance explained	10.1	6.3	4.3
Cumulative % explained	10.1	16.4	20.7
Pearson Correlation, Spp-Envt*	0.95	0.86	0.75

***Correlation between sample scores for an axis derived from the species data and the sample scores that are linear combinations of the environmental variables.**

Monte Carlo tests were also run in conjunction with the CCA analysis to determine the significance of both the eigenvalues, and the species-environment correlation coefficients produced. Utilizing a random data analysis it was determined that the correlation coefficients, and eigenvalues derived from this analysis were significantly different than would be found be chance (Table 4). This significance test supports the validity of both the eigenvalues and the correlation coefficients for this portion of the study.

Table 4.Monte Carlo test results, including significance of both Eigenvalues and Species-environment correlation coefficients

		Randomized data			
	Real data	Monte Carlo test			
Axis	Spp-Envt Corr.	Mean	Minimum	Maximum	P
1	0.953	0.53	0.44	0.87	0.02
2	0.864	0.49	0.42	0.71	0.02
3	0.754	0.49	0.36	0.63	0.02
Axis	Eigenvalue				
1	0.66	0.14	0.09	0.4	0.02
2	0.41	0.1	0.06	0.2	0.02
3	0.28	0.08	0.05	0.1	0.02

P=proportion of randomized runs with species-environment correlation/Eigenvalue greater than or equal to the observed value

Correlations for each individual environmental variable, each transect at each replicate and each individual plant species were calculated in the CCA analysis. The correlation coefficients for the environmental variables are shown (Table 5), and the correlation coefficients for each plant species, and each site are presented (Appendix). Hydrology variables had the highest positive correlation with the first two axes, percent sand, and pH had the strongest negative correlation with axis one. pH had a strong positive correlation with axis two, with phosphorous having the largest negative impact on axis 2 (Table 5). These coefficients also reveal the influence of one environmental variable upon another. For instance, the percent sand and silt in the soil texture is negatively correlated with axis one which is strongly correlated with the hydrology. The percent clay and organic matter are strongly correlated with axis one (Table. 5). Axis three showed good trends in the variables as well, however should not be examined too closely due to its low eigenvalue (Table 3) , illustrating the fact that it does not represent much of the variation in the species data as explained by the environmental variables.

Table 5. All sites, correlation coefficients for each environmental variable in respect to each CCA axis

	Correlations*		
Variable	Axis 1	Axis 2	Axis 3
1 pH	-0.186	0.502	0.657
2 salinity	0.747	-0.276	0.421
3 OM	0.472	0.369	0.268
4 ppmN	0.362	0.316	0.151
5 ppm P	0.642	-0.367	0.110
6 ppm K	0.012	-0.025	-0.012
7 %sand	-0.403	0.156	-0.168
8 %silt	-0.115	0.315	0.307
9 %clay	0.417	0.246	-0.304
10 14-day H	0.886	0.355	0.103
11 14-day L	0.826	0.392	0.190
12 moisture	0.827	0.294	0.045

*** Correlations are "intraset correlations" of Ter Braak (1986)**

CCA All Sites Species Plot Ordination

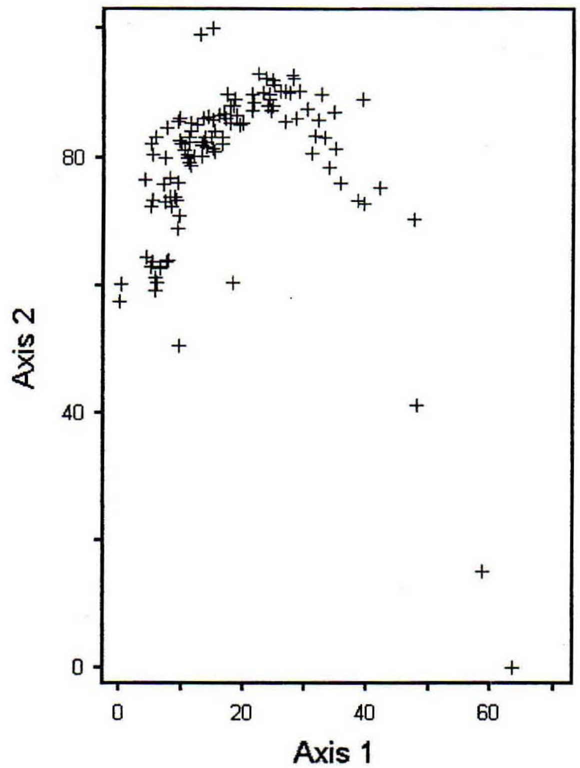

Figure 5. Depicting species distribution along CCA axis 1 and 2

+=individual species

Individual species relationships to each axis were also determined for all sixteen sites in the study. These plant relationships show a bell-shaped curve distribution along axis 1 and 2 (Figure 5). As shown by the axis correlation's axis one is mostly influenced by the hydrology present, so the further you travel out on axis one the wetter the environment becomes (Table 5). This increase in soil wetness, results in the exclusion of many plant species not adapted to such saturated condition, and thus fewer species can be found. Conversely, the same can be said about the mesic conditions represented at the beginning of axis one and the limited amount of species diversity present there (Figure 5). Axis two can thus be looked at as a pH gradient and species are limited by this parameter along the respective axis. The same inferences can be made for all soil parameters and the extent to which they positively or negatively effect the plant species distribution at all of the wet meadow sites (Table 5, Figure 5).

Land Treatments

DCA and CCA eigenvalues, and total variance (inertia) were also determined for the plant communities for the sites in each land treatment regime (Table. 6).

Table 6. DCA, CCA axis eigenvalues, and total inertia (variation) in the species data for all wet meadows analyzed

	Eigenvalues			
	Axis 1	Axis 2	Axis 3	Total inertia
GRAZED				
DCA	0.78	0.29	0.15	4.1
CCA	0.76	0.61	0.37	4.42
HAYED				
DCA	0.65	0.28	0.15	3.17
CCA	0.75	0.51	0.24	3.76
RESTED				
DCA	0.71	0.36	0.09	2.76
CCA	0.71	0.4	0.31	3.1

For each of the land treatments, the species diversity was determined by utilizing all plant species that occurred at all of the replicate sites more than 5% of the time (Appendix). From these plant community matrices and the DCA, CCA, analysis performed on it can be seen that for all of the regimes, the majority of the species variation can be explained by axis one of the ordination . This is shown by the CCA eigenvalues for axis 1 of 0.78 for the grazed sites, 0.75 for the hayed sites, and 0.71 for the rested sites (Table. 6). These eigenvalues are reduced for axis two representing the fact that although this axis is important in the ordination, it is secondary to axis one in the importance of explanation of species data by the environmental variables. DCA and CCA eigenvalues were very close for axis one with gaps being seen in axis two and distinct differences in axis three of this analysis. Leading to the lending of weight to axis one and two of the CCA analysis, and limited reliability of axis three, for the sites under their respective land treatment.

Table 7. Axis summary statistics depicting the amount of species composition that is explained by the environmental variables

	GRAZED			HAYED			RESTED		
Variance in species data	Axis 1	Axis 2	Axis3	Axis 1	Axis 2	Axis 3	Axis 1	Axis 2	Axis 3
% of variance explained	17.2	13.7	8.3	19.9	13.7	6.3	22.8	12.6	10
Cumulative % explained	17.2	30.9	39.2	19.9	33.6	39.9	22.8	35.4	45.4
Pearson Correlation, Spp-Envt*	0.98	0.94	0.79	0.97	0.93	0.86	0.976	0.921	0.846

***Correlation between sample scores for an axis derived from the species data and the sample scores that are linear combinations of the environmental variables.**

Overall, 39.2 percent of the plant community variation was explained by the environmental variables for the grazed sites, 39.9% for the hayed sites, and 45.4% for the rested sites (Table 7). The CCA analysis performed on the sites under a particular type of land treatment resulted in high Pearson species-environment correlation's for axis one and two with decreasing correlation on axis three (Table 7). Leading to inference of correlation of most the plant species variation to axis one and two of the ordination with decreasing variance attributed to axis three.

Monte Carlo Tests performed on the wet meadows within each land treatment regime lending weight to both the eigenvalues and the correlation's coefficients for each regime. With the randomized runs for both coefficients occurring less than or equal to 6 percent of the time (Table 8).

Table 8. Monte Carlo test results, including significance of both Eigenvalues and Spp-Envt correlation coefficients for all land treatments

			Randomized data			
		Real data	Monte Carlo test			
	Axis	Spp-Envt Corr.	Mean	Minimum	Maximum	P
	1	0.98	0.76	0.62	0.93	0.02
	2	0.94	0.68	0.56	0.79	0.02
	3	0.79	0.65	0.54	0.8	0.06
GRAZED SITES	Axis	Eigenvalue				
	1	0.76	0.4	0.24	0.65	0.02
	2	0.61	0.27	0.17	0.37	0.02
	3	0.37	0.18	0.12	0.28	0.02
	1	0.97	0.67	0.53	0.8	0.02
	2	0.93	0.65	0.53	0.79	0.02
	3	0.86	0.67	0.49	0.84	0.02
HAYED SITES	Axis	Eigenvalue				
	1	0.75	0.29	0.19	0.49	0.02
	2	0.51	0.19	0.13	0.26	0.02
	3	0.24	0.13	0.09	0.18	0.02
	1	0.98	0.7	0.53	0.86	0.02
	2	0.92	0.64	0.52	0.82	0.02
	3	0.85	0.62	0.41	0.8	0.02
RESTED SITES	Axis	Eigenvalue				
	1	0.71	0.29	0.17	0.42	0.02
	2	0.4	0.18	0.12	0.27	0.02
	3	0.31	0.11	0.07	0.17	0.02

P=proportion of randomized runs with species-environment correlation/Eigenvalue greater than or equal to the observed value

The CCA analysis for the grazed sites revealed strong positive correlation with hydrology, and the environmental variables associated with axis one, with a negative correlation with percent sand and percent silt soil texture (Table 9). This axis is responsible for 17.2 percent of the variance that can be explained by all the environmental variable (Table7). Axis two was most strongly correlated with pH, and negatively associated with salinity, Phosphorous, and Nitrogen (Table 9). Although this axis is responsible for 13.7percent of explained variance (Table 7). The DCA and CCA eigenvalues for the grazed sites axis two differ almost two fold (Table 6.), suggesting some environmental noise on this axis.

Table 9. Grazed sites, correlation coefficients for each environmental variable in respect to each CCA axis

	Correlations*		
Variable	Axis 1	Axis 2	Axis 3
1 pH	0.047	0.653	-0.397
2 salinity	0.795	-0.405	-0.201
3 OM	0.613	0.373	0.107
4 ppmN	0.433	0.323	0.132
6 ppm P	0.675	-0.323	0.106
7 ppm K	0.233	0.263	0.033
8 %sand	-0.387	0.328	0.172
9 %silt	- 0.120	0.282	0.061
10 %clay	0.200	0.328	0.251
11 14-day H	0.898	0.234	0.129
12 14-day L	0.816	0.286	0.146
13 moisture	0.836	0.285	0.124

*** Correlations are "intraset correlations" of Ter Braak (1986)**

CCA analysis for all hayed sites showed some variation from the other land treatment regimes with regards to the most important environmental variable in relationships to the species distribution along the ordination axis. For the hayed sites, axis one was most strongly positively correlated to phosphorous, salinity, and percent clay, and negatively correlated with pH and percent sand (Table 10). This axis was responsible for 19.9 percent of the total variance explained by environmental variables for all hayed sites (Table 7). Axis two was strongly correlated with the hydrology, and the associated variables, however, again data noise provided some influence (Table. 6). Even with this noise, the data supports the concept that the hayed community composition were influenced by the hydrology, however, other parameters in these situations may have just as strong a influence.

Table 10. Hayed sites, correlation coefficients for each environmental variable in respect to each CCA axis

Variable	Correlations* Axis 1	Axis 2	Axis 3
1 ph	-0.222	0.342	-0.610
2 salinity	0.524	0.612	-0.169
3 OM	0.148	0.512	-0.231
4 ppmN	0.019	0.501	-0.111
5 ppm P	0.920	-0.154	-0.003
6 ppm K	0.213	-0.293	0.187
7 %sand	-0.443	-0.302	0.560
8 %silt	0.160	0.351	-0.679
9 %clay	0.595	0.150	-0.232
10 14-day H	0.496	0.801	-0.221
11 14-day L	0.451	0.810	0.006
12 moisture	0.220	0.778	0.070

*** Correlations are "intraset correlations" of Ter Braak (1986)**

The Rested CCA analysis again shows hydrology as being the strongest influence on the plant species composition. The hydrology variables were strongly correlated to axis one (Table 11), which was responsible for 22.8 percent variation (Table 7). Overall pH was negatively correlated with both axis one and two in this analysis. Axis two for the rested sites shows little positive correlation for any environmental variable (Table 11). This axis is responsible for the explaining 12.6 percent of the plant community variance explained by the environmental variables (Table 7). Unlike the previous land treatments, axis two in the rested analysis has similar DCA and CCA eigenvalues (Table 6), lending more weight to this axis. Within these rested sites however 10 percent variation from environmental variables is explained by axis three (Table 7). This axis three was not supported by the DCA /CCA eigenvalue comparisons (Table 6.), suggesting data noise being produced by the environmental variables which constrained ordination on this axis.

Table 11. Rested sites, correlation coefficients for each environmental variable in respect to each CCA axis

	Correlations*		
Variable	Axis 1	Axis 2	Axis 3
1 pH	-0.445	-0.675	0.256
2 salinity	0.465	-0.394	-0.200
3 OM	0.532	-0.417	-0.295
4 ppmN	0.451	-0.223	-0.154
5 ppm P	0.453	-0.133	-0.242
6 ppm K	-0.326	0.103	0.074
7 %sand	-0.263	0.098	-0.445
8 %silt	-0.400	-0.341	0.207
9 %clay	0.604	0.195	0.285
10 14-day H	0.826	-0.392	0.276
11 14-day L	0.752	-0.551	0.252
12 moisture	0.878	-0.179	-0.084

*** Correlations are "intraset correlations" of Ter Braak (1986)**

CCA Grazed Sites Transect/Species Plot Ordination

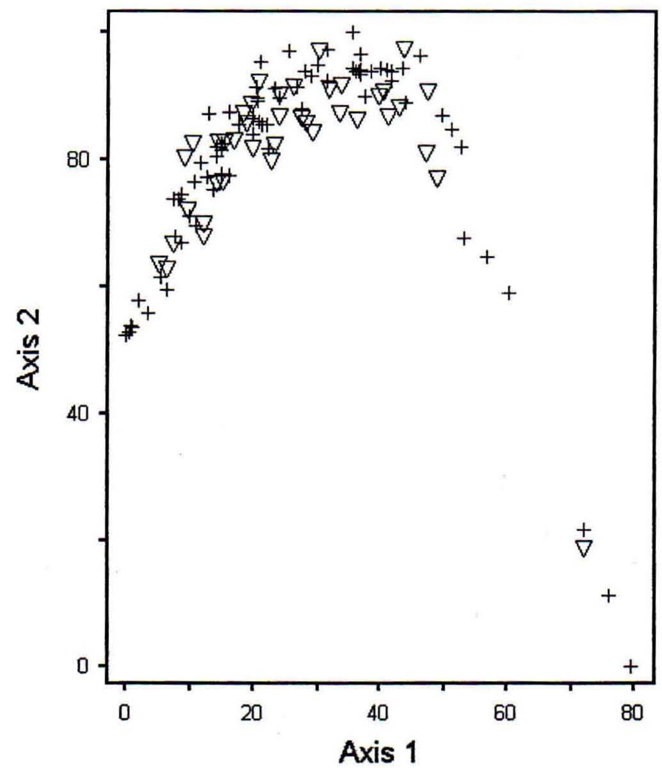

Figure 6. Depicting transect, and plant species distribution along CCA axis 1 and 2

+=species triangles=transects

Species distribution along axis one and two were overlaid with the position of the individual transects within the grazed regime and displayed (Figure 6).Displaying graphically the placement of these transect along a hydrologic gradient, representing a shift from a mesic to hydric environment. These transects within each individual site show the same bell-shaped curve that the species do. The transect and species distributions for the hayed and rested sites also exhibited this bell-shaped curve distribution.

CCA ordination allows for the plotting of not only an entire plant community against the environmental axis one and two but this analysis also allowed for the plotting of individual plant species as well. From this it was possible to get an approximate definition of where along the gradient a specific plant could be found, and more importantly how much it is affected by distinct environmental variables. All of this allowing for a determination of which plant species would be found in the upland, wetland, and transition zones of the wet meadows.

Dicanthelium oligosanthes Shult. is a perennial plant that is typically found in open prairie systems, or disturbed sites (McGregor et al. 1986). It can be seen that this plant is only found at the far left of axis one, and has a correlation coefficient of -0.480 with that axis. It is also strongly negatively correlated with axis two (Figure 7.). It has been shown that axis one of the grazed sites is strongly correlated with hydrology (Table 9). From this it is concluded that Dicanthelium *oligosanthes* is not an example of an hydrophytic plant and will be found on the upland ridges of the wet meadows. Also illustrated is the influence of pH and salinity represented by axis two on this plant species.

CCA GRAZED SITES INDIVIDUAL SPECIES DISTRIBUTION

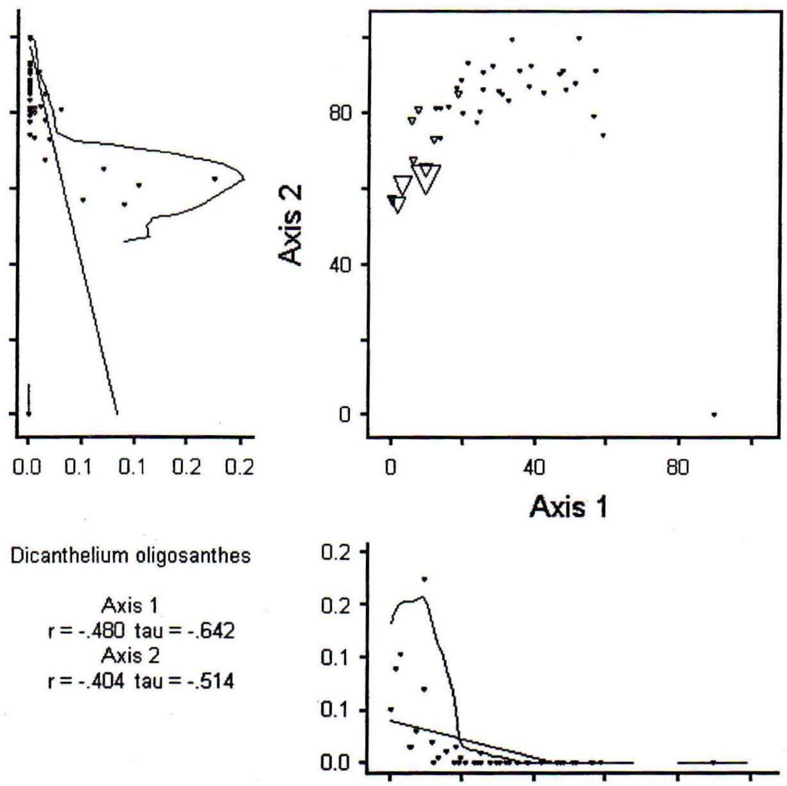

Figure 7. Depicting the distribution of *Dicanthelium oligosanthes* along CCA axis 1 and 2

Triangles=species abundance r=correlation coefficient

When looking at *Carex craweii* Dew. a plant that is found in wet ditches, meadows and prairie swales (McGregor et al. 1986), a much different conclusion can be drawn. This plant was found to have a correlation coefficient of -0.175 which still shows it to be negatively correlated with axis one, however not to the extent that *Dicanthelium* is. *Carex craweii* is also found further out on axis one showing its higher affinity to the hydrology variable that define that axis, placing it in the wetter regions of the wet meadow (Figure 8).

CCA GRAZED SITES INDIVIDUAL SPECIES DISTRIBUTION

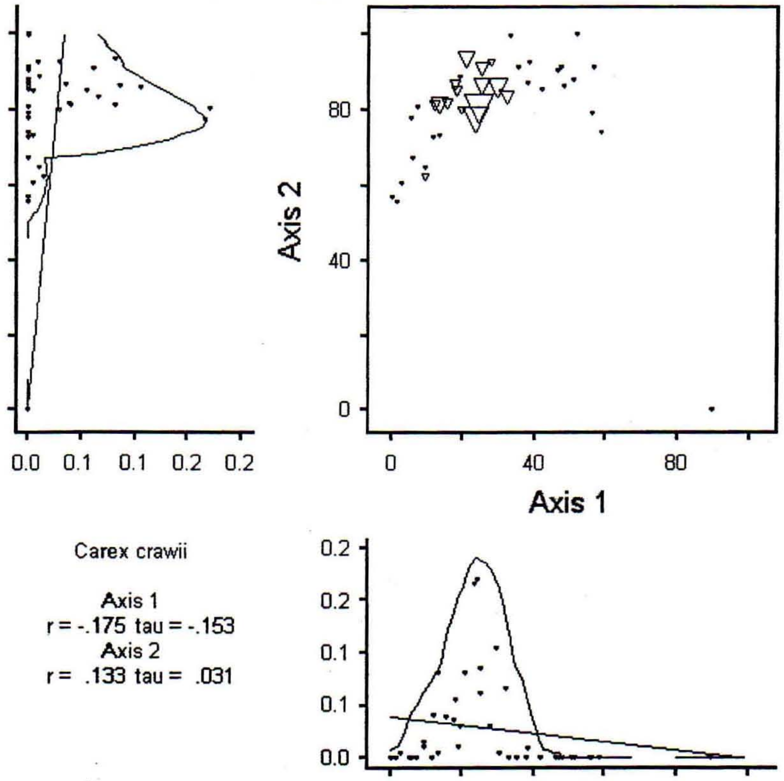

Figure 8. Depicting the distribution of *Carex craweii* along CCA axis 1 and 2

Triangles=species abundance   r=correlation coefficient

Calamagrostis stricta Timm. a plant that is defined as being found in wet places, stream banks, and marshes (McGregor et al. 1986) shows even more of a shift down the hydrology gradient. A positive correlation coefficient of 0.275 against axis one and 0.255 against axis two is observed for this plant species (Figure 9). The envelope lines for this species show it's position as being in the bottom portion of the gradient moving into the wettest portion which is represented by the end of axis one (Figure 9)

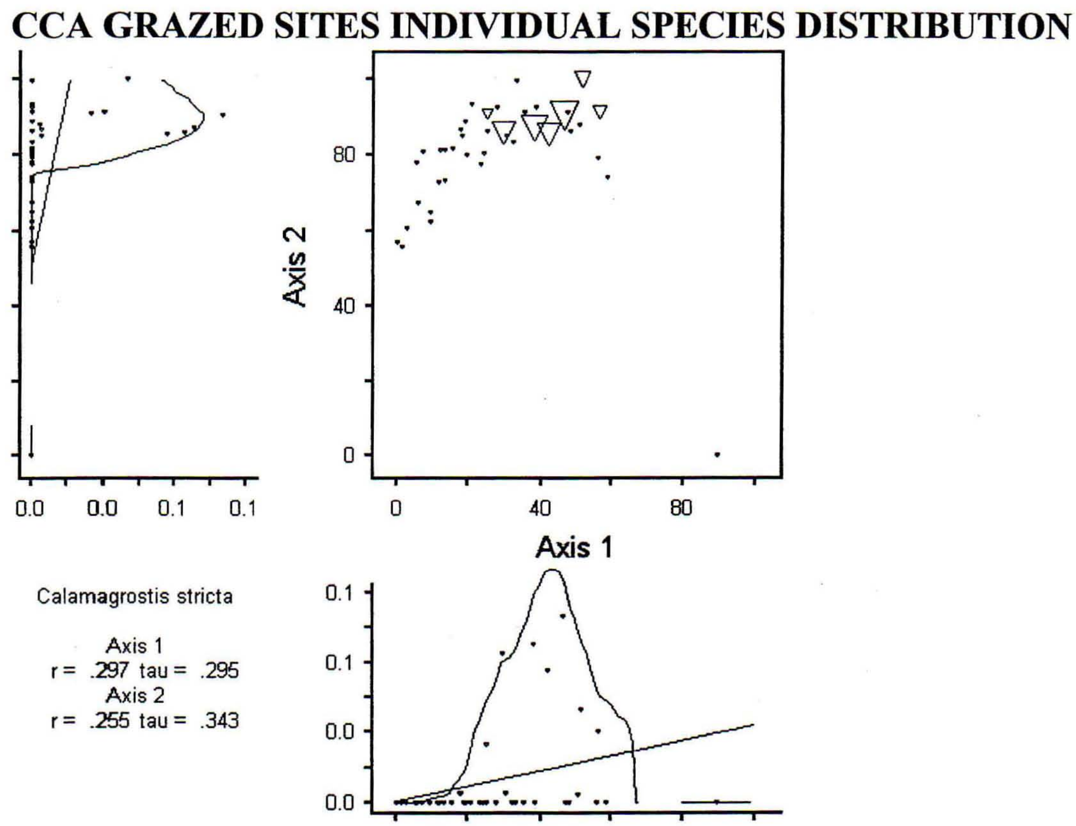

Figure 9. Depicting the distribution of *Calamagrostis stricta* along CCA axis 1 and 2

Triangles=species abundance r=correlation coefficient

Polygonum amphibium L. is commonly named water smartweed, and is indeed found primarily in shallow waters, shoreline marshes, and roadside ditches (McGregor et al.1986). The grazed sites sampled for this plant species show that it has a much higher correlation coefficient of 0.503 with axis one, however it shows no affinity for axis two at all (Figure 10). From this correlation it can be seen that this plant species would be found in the saturated lowland region of the swale, and would represent the wet end of the hydrology gradient

CCA GRAZED SITE INDIVIDUAL SPECIES DISTRIBUTION

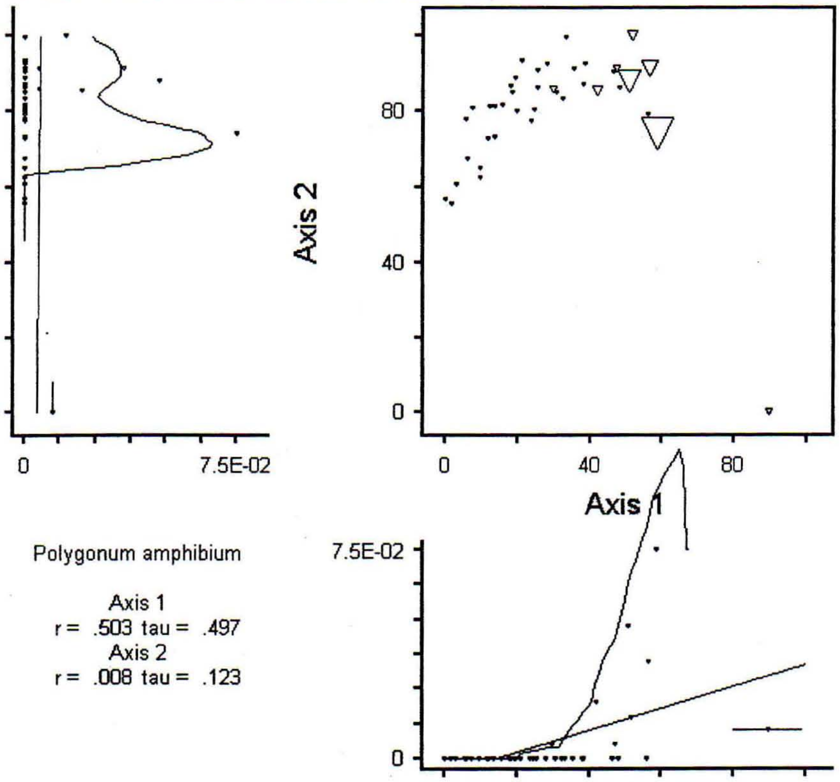

Figure 10. Depicting the distribution of Polygonum amphibium along CCA axis 1 and 2

Triangles=species abundance r=correlation coefficient

These analyses have allowed for the definition of a particular plant species at a particular point along the ridge-swale complex. Even by just taking the four plant species used in this example the full spectrum of the gradient can be observed graphically. This study has produced a correlation coefficient for each of the plant species, as well as every transect sampled for each CCA ordination performed (Appendix).

Intensive Soil Sampling Sites

G1,G2,G3, and R1 sites were all sampled for looking at three more soil parameters than the other twelve sites. These parameters included percolation rate, soil temperature, and gravimetric soil moisture content. When including these extra soil variables these sites had to be analyzed independent of the other fourteen sites due to the incompatibility of the base matrices and the inability of the software to run the analysis on incompatible matrices. From these analyses, however it can be determined what if any correlation these added variables had to the species composition the four samples sites.

With a total variance (inertia) of 4.0 for the DCA analysis of these sites, and 4.34 for the CCA analysis it is seen that the CCA analysis results can be supported (Table 12). The same can be said for the eigenvalues for axis one, but due to the distinct difference in the DCA, CCA eigenvalues. Axis two and three should not be weighted as heavily when considering influence of the variable associated to that axis and its effect on the plant community (Table 12).

Table 12. DCA, CCA axis eigenvalues, and total inertia (variation) in the species data for intensively sampled wet meadows analyzed for intensively sampled sites

	Eigenvalues			
	Axis 1	Axis 2	Axis 3	Total inertia
DCA	0.78	0.20	0.15	4.0
CCA	0.79	0.6	0.38	4.34

From the CCA analysis of these sites it was determined that axis one can explain 18.2 percent, axis two 13.8 percent and axis three 8.7 percent of the variation in the plant community that can be attributed to the environmental variables. The total amount of variation explained by these variables is 40.8 percent (Table 13). Axis one and two both exhibit high species-environment correlation coefficient with 0.99, and 0.96 respectively, and axis three has a slightly lower value at 0.82 (Table 13).

Table 13. Axis summary statistics depicting the amount of species composition that is explained by the environmental variables for intensively sampled sites

	Axis 1	Axis 2	Axis 3
Variance in species data			
% of variance explained	18.2	13.8	8.7
Cumulative % explained	18.2	32	40.8
Pearson Correlation, Spp-Envt*	0.99	0.96	0.82

***Correlation between sample scores for an axis derived from the species data and the sample scores that are linear combinations of the environmental variables.**

The Monte Carlo tests run on this set of data show that in all but one correlation coefficient the randomized runs would produce a p=0.02. Axis three could be reproduced 8 percent of the time showing that that axis should not be trusted when drawing species-environment correlation's within these sites (Table 14). None of the eigenvalues produced from the analysis of the intensively sampled sites could be reproduced more than 2 percent of the time, leading to the support of this data (Table 14).

Table 14.Monte Carlo test results, including significance of both Eigenvalues and Spp-Envt correlation coefficients for intensively sampled sites

	Real data	Randomized data Monte Carlo test			
Axis	Spp-Envt Corr.	Mean	Minimum	Maximum	P
1	0.99	0.80	0.69	0.95	0.02
2	0.96	0.72	0.62	0.87	0.02
3	0.82	0.69	0.55	0.87	0.08
Axis	Eigenvalue				
1	0.79	0.45	0.24	0.67	0.02
2	0.6	0.32	0.20	0.50	0.02
3	0.39	0.22	0.16	0.35	0.02

P=proportion of randomized runs with species-environment correlation/Eigenvalue greater than or equal to the observed value

For the intensively sampled sites axis one is most strongly positively correlated with soil temperature, percent sand, and percent silt, and is negatively correlated with virtually all other variables (Table 15). Axis two is strongly correlated with percent moisture, organic matter, and percent clay, and weakly correlated with macronutrients, and the hydrology variables (Table 15). This is in contrast to all the other ordinations performed for this study where the hydrology was strongly positively correlated with axis one, and the macronutrients, clay and organic matter were weakly correlated. Once again due to the poor performance in the Monte Carlo significance test, and the variation in DCA, CCA eigenvalues, axis three is not considered valid for any correlation's within these sites

Table 15. Intensively sampled sites, correlation coefficients for each environmental variable in respect to each CCA axis

	Correlations*		
Variable	Axis 1	Axis 2	Axis 3
1 %moist	-0.688	0.517	-0.293
2 soil temp	0.423	0.348	-0.388
3 perc.	0.085	-0.206	-0.082
4 pH	0.137	0.583	0.507
5 salinity	-0.751	-0.315	0.348
6 OM	-0.595	0.463	-0.055
7 ppmN	-0.373	0.324	0.016
9 ppm P	-0.755	-0.275	0.050
10 ppm K	-0.243	0.389	-0.074
11 %sand	0.535	0.160	-0.054
12 %silt	0.279	0.115	-0.121
13 %clay	-0.423	0.573	-0.392
14 14-day H	-0.865	0.303	0.030
15 14-day L	-0.790	0.306	-0.008
16 moisture	-0.861	0.253	-0.070

*** Correlations are "intraset correlations" of Ter Braak (1986)**

CCA Intensively Sampled Sites Transect/Species Plot Ordination

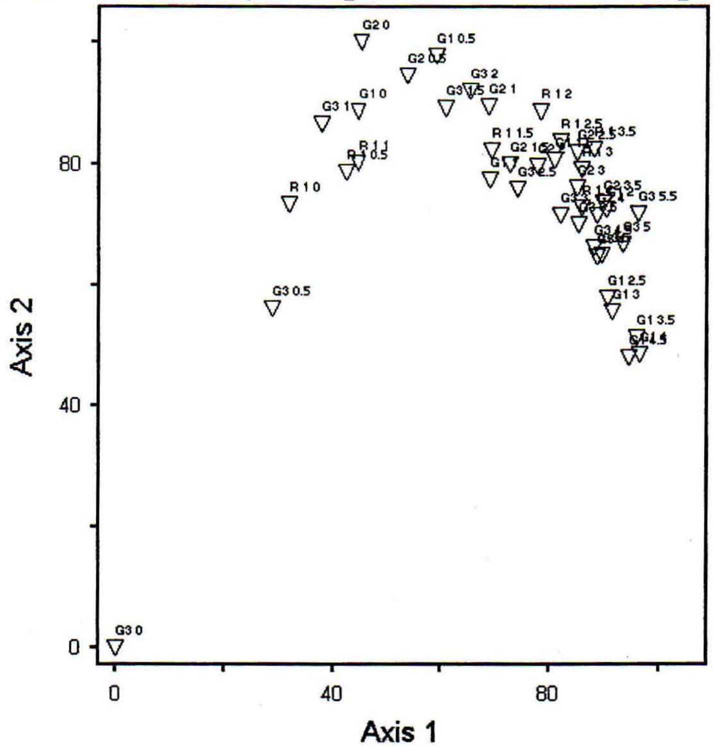

Figure 11. Depicting transect, and plant species distribution along CCA axis 1 and 2

+=species triangles=transects

These distinct differences can be seen clearly when the transect and species distribution is analyzed when plotted along CCA axis one and axis two (Figure 11). These distributions still exhibit the bell-shaped curve, however in this ordination the density of species/transect distribution is reversed, illustrating the influence of the upland environmental variables on this axis.

Individual Species Ordinations

Individual ordination curves where determined for each plant species occuring along over fifty percent of the transects within the wet meadow sites. Each of these curves compares the plant species abundance to axis one representing the hydrology, salinity, and "wet" environmental variables, and axis two which is representing pH and the "dry" environmental variables. These ordinations were taken from the CCA analysis comparing all of the sixteen wet meadow sites within the study. This analysis ultimately did not produce the larger explanation of variance for the gradient. However, this reduced variation explained has no bearing on the individual plant species response to the soil, and hydrology environmental variables.

CCA Individual Species Distribution of *Agropyron caninum*

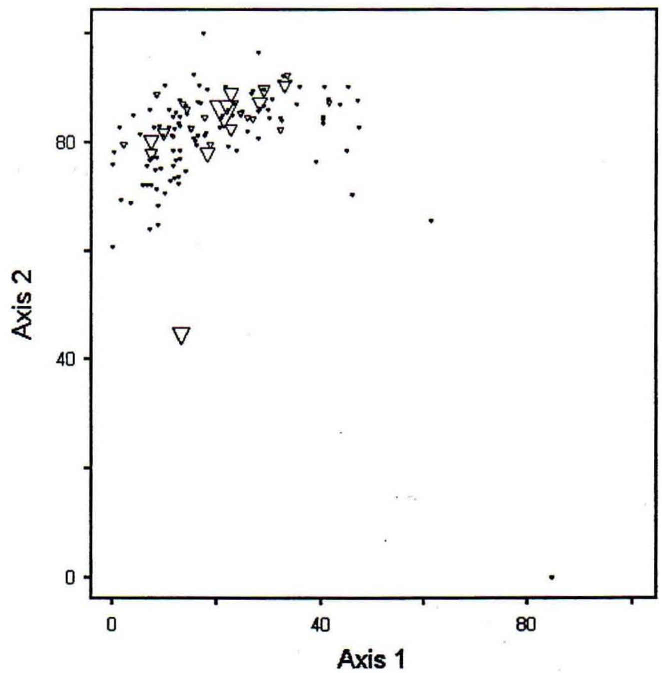

Figure 12. Depicting species distribution along CCA axis one and two triangles =species abundance

Agropyron caninum L. is a tufted perennial wheatgrass, which can be found in a variety of habitats, ranging from moist areas, to relatively dry areas (McGregor et al. 1986). This species can tolerate a variety of environmental conditions, and is found to have a strong correlation with both axis one and two in the CCA ordination (Fig 12).

CCA Individual Species Distribution of *Agrostis Stolonifera*

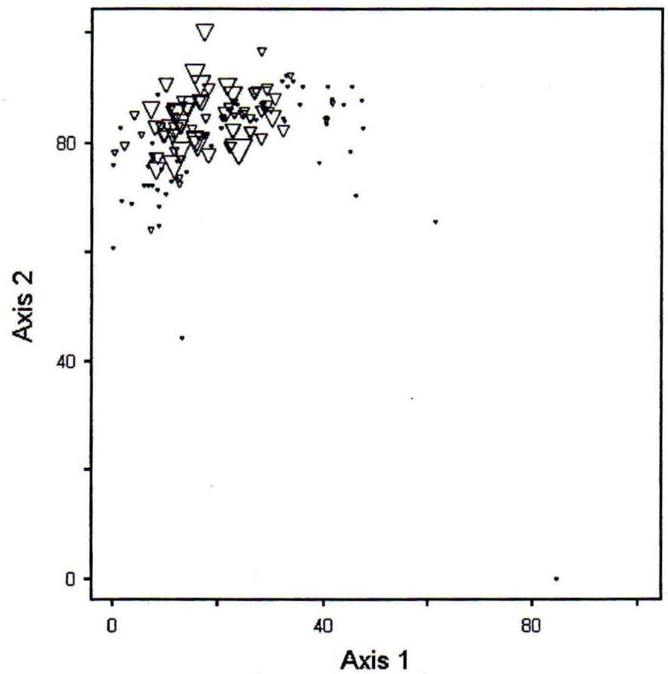

Figure 13. Depicting species distribution along CCA axis one and two triangles =species abundance

Agrostis stolonifera L. is a rhizomatous plant species commonly known as redtop. This plant species can generally be found in to be abundant in lowland moist areas (McGregor et al. 1986). Within the wet meadow sites examined for this study it was seen that redtop was strongly associated with axis one representing the hydrology present at the sites. It was also seen that this plant could be found in varying abundances within the "transition zone" along the hydrological gradient (Fig 13).

CCA Individual Species Distribution of *Ambrosia psilostachya*

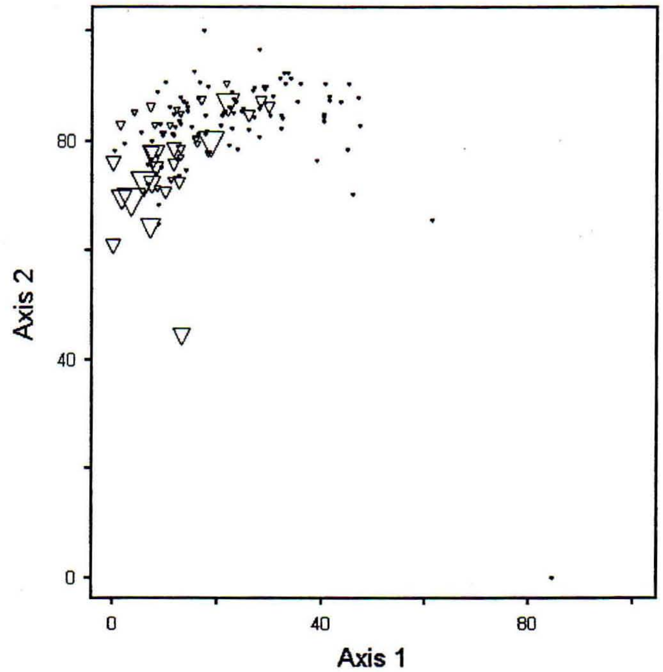

Figure 14. Depicting species distribution along CCA axis one and two triangles =species abundance

Ambrosia psilostachya DC. is a perennial herb commonly know as western ragweed. Western ragweed is an upland species and can be found in open prairies, and waste places (McGregor et al. 1986). This plant species is not positively correlated with axis one of the ordination. This is demonstrated by the fact that this species can be found in greatest abundance at the lower point of axis one (Fig 14). Western ragweed is limited by saturated moist soils, and is not an example of a hydrophytic plant. Instead it is better adapted to living in dry areas and establishing disturbed areas.

CCA Individual Species Distribution of *Andropogon gerardii*

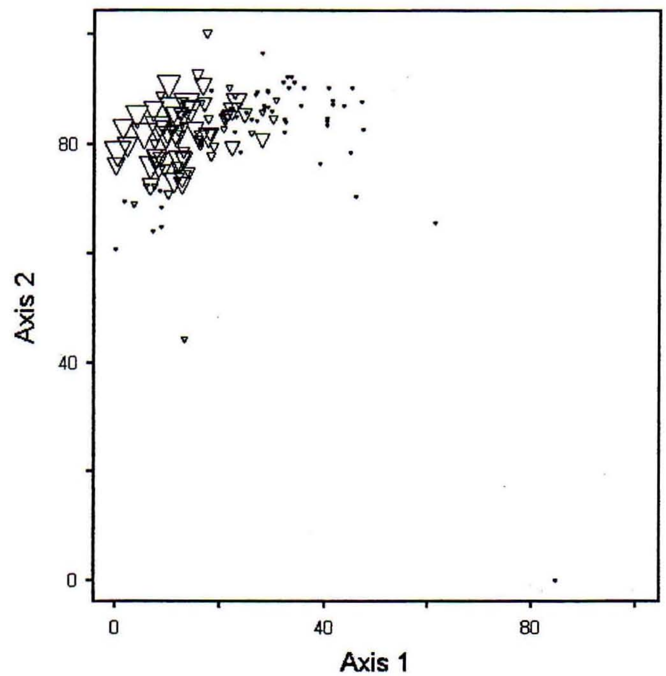

Figure 15. Depicting species distribution along CCA axis one and two triangles =species abundance

Andropogon gerardii Vitman. is an abundant perennial commonly known as big bluestem. This species is most commonly found in prairies, roadsides, and especially in lowland prairies (McGregor et al. 1986). Big bluestem is primarily found at the last points closest to zero on axis one of the CCA ordination (Fig 15). This placement along the hydrological gradient demonstrates the fact that this plant is most commonly found on the ridge of the wet meadow ecosystem.

CCA Individual Species Distribution of *Apocynum cannabnium*

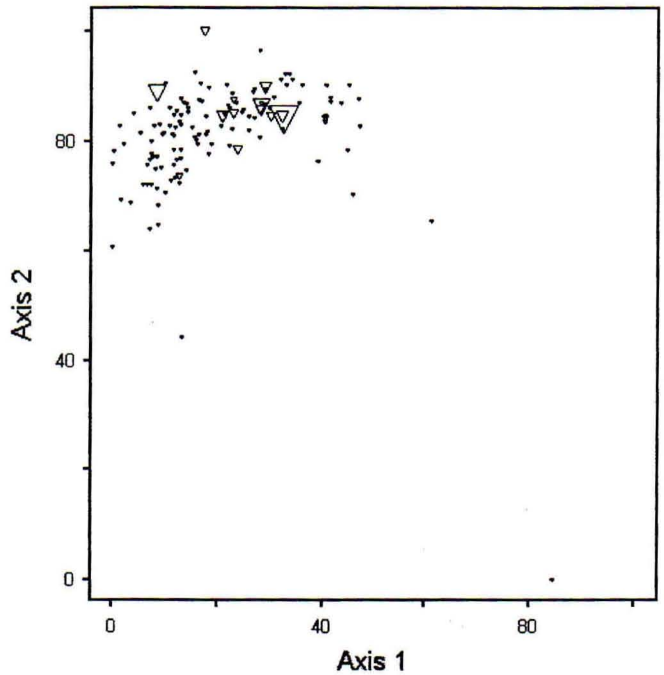

Figure 16. Depicting species distribution along CCA axis one and two triangles =species abundance

Apocynum cannabinum L. is a perennial herb commonly known as prairie dogbane. This plant species is commonly found in prairies, open or wooded waterways, or lakeshores, and disturbed roadways or fields (McGregor et al. 1986). *Apocynum cannabinum* was found to be associated with axis one of the CCA ordination. It was found in greatest abundance as you travel farther out along axis one (Fig 16). This species was also found in smaller abundance closer to zero along axis one of the ordination, and at varying locations along axis two, demonstrating it's wide ranging habitat preferences.

CCA Individual Species Distribution of *Aster ericoides*

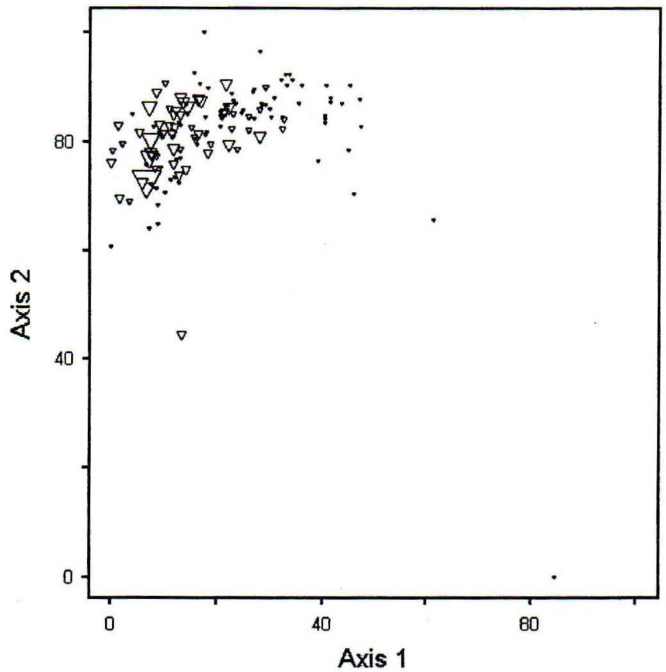

Figure 17. Depicting species distribution along CCA axis one and two triangles =species abundance

Aster ericoides L. is a colonial perennial herbacious plant which arises from a extensive system of rhizomes and stolons. Commonly known as white aster, *Aster ericoides*, is found most commonly in open upland prairies and plains (McGregor et al. 1986). In the wet meadows examined for this study the white aster plant communities were shown to be negatively correlated with both axis one and two (Fig 17).

CCA Individual Species Distribution of *Aster simplex*

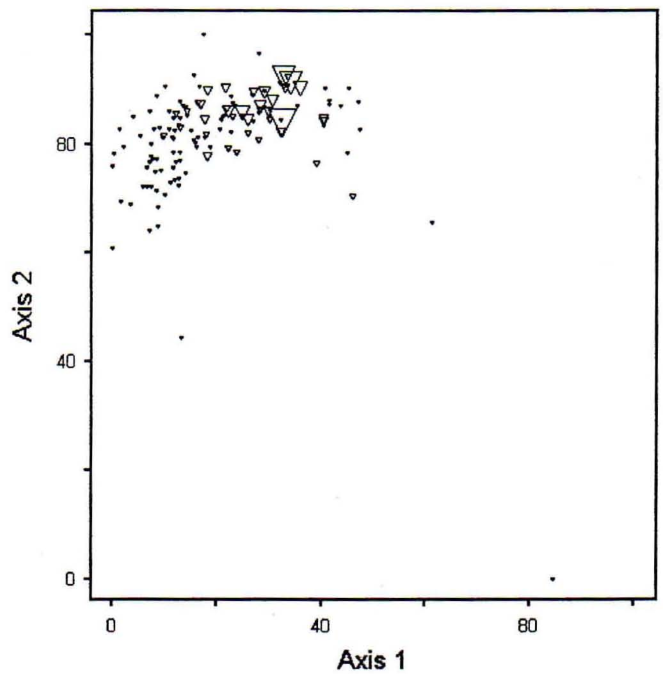

Figure 18. Depicting species distribution along CCA axis one and two triangles =species abundance

Aster simplex Wild. is commonly known as the panicled aster, and is found mostly in damp or drying meadows and other low sites (McGregor et al. 1986). In contrast to the white aster in the wet meadows, this rhizomatous perennial is positively correlated with both axis one and two of the CCA ordination analysis (Fig 18).

CCA Individual Species Distribution of *Bromus inermis*

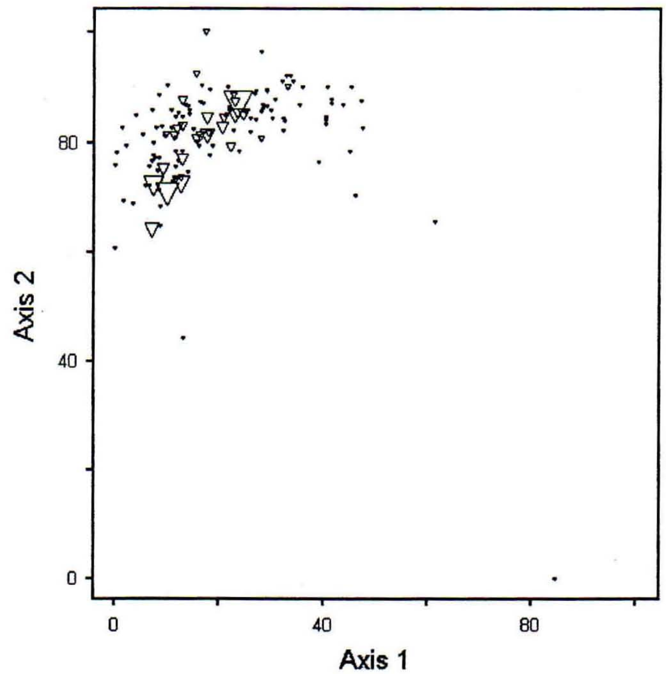

Figure 19. depicting species distribution along CCA axis one and two triangles =species abundance

Bromus inermis Leyss. is a strongly rhizomatous perennial that is found in a variety of habitats. This plant is most commonly used as a cover plant for roadways and pasture lands (McGregor et al. 1986). It can be seen in the Platte River wet meadows utilized for this study that this plant species had no real affinity for either axis one or two, and was found in varying abundances along the gradient (Fig 19).

CCA Individual Species Distribution of *Callirhoe involucrata*

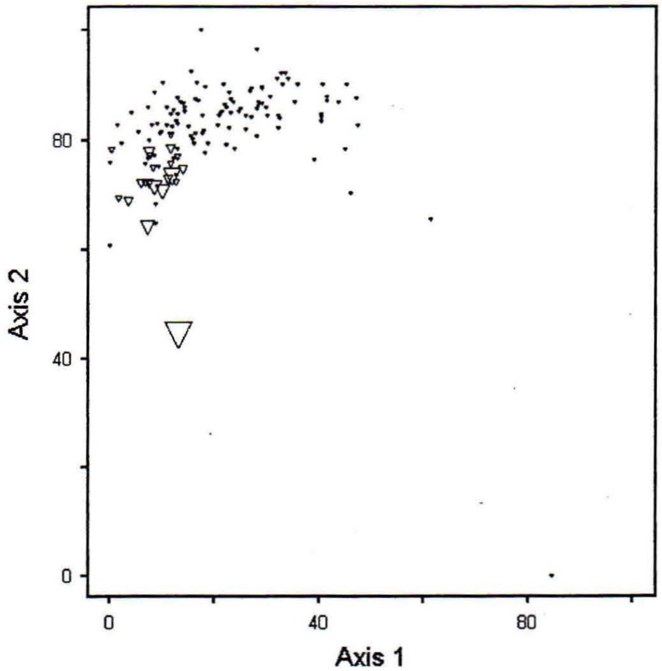

Figure 20. Depicting species distribution along CCA axis one and two triangles =species abundance

Callirhoe involucrata T.&G. is a perennial plant species commonly found in dry and often sandy soil in prairies, plains, and open woods (McGregor et al .1986). Commonly referred to as purple poppy mallow, this plant species had a negative correlation with both axis one and two, and was found in greatest abundances on the lower end of the CCA ordination axis (Fig 20).

CCA Individual Species Distribution of *Carex emoryi*

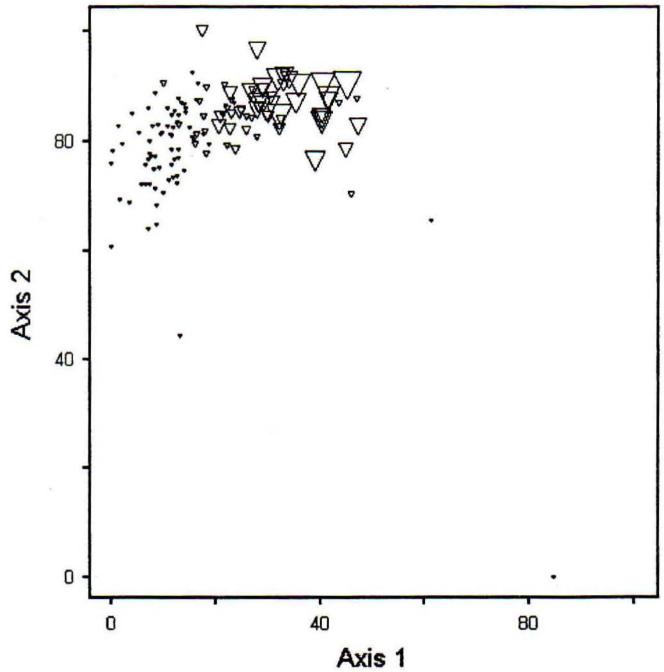

Figure 21. Depicting species distribution along CCA axis one and two triangles =species abundance

Carex emoryi Dew. is described as a rhozomatous perennial member of the sedge family, and can be found mostly in moist meadows, ditches and shores (McGregor et al. 1986). Within the sites examined for this study this plant species was found to be positively correlated with both axis one and two along the CCA ordination analysis (Fig 21).

CCA Individual Species Distribution of *Carex granularis*

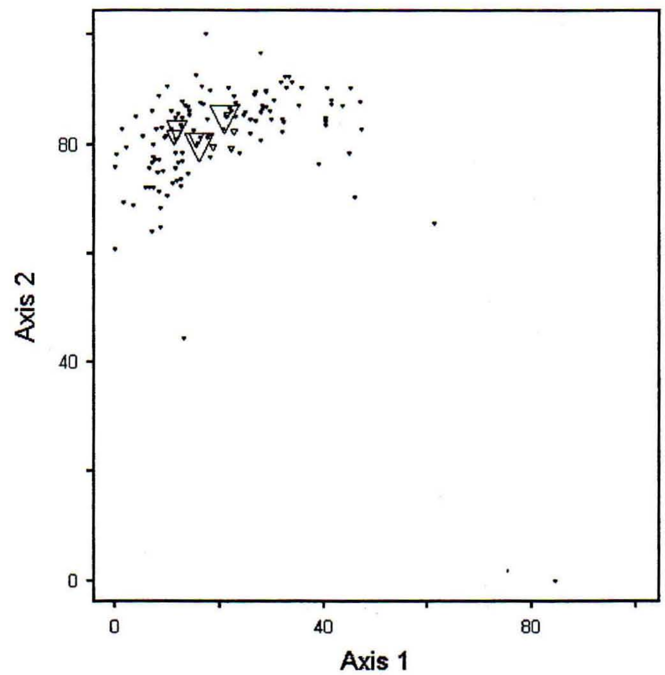

Figure 22. Depicting species distribution along CCA axis one and two triangles =species abundance

Carex granularis Muhl. is described as being a cespitose perennial sedge which is found mostly in ditches, swamps, and river bottom woods (McGregor et al.1986). Contrary to this description this plant species was found mostly in the upper region of the gradient and was not strongly correlated with either CCA ordination axis (Fig 22).

CCA Individual Species Distribution of *Carex pellita*

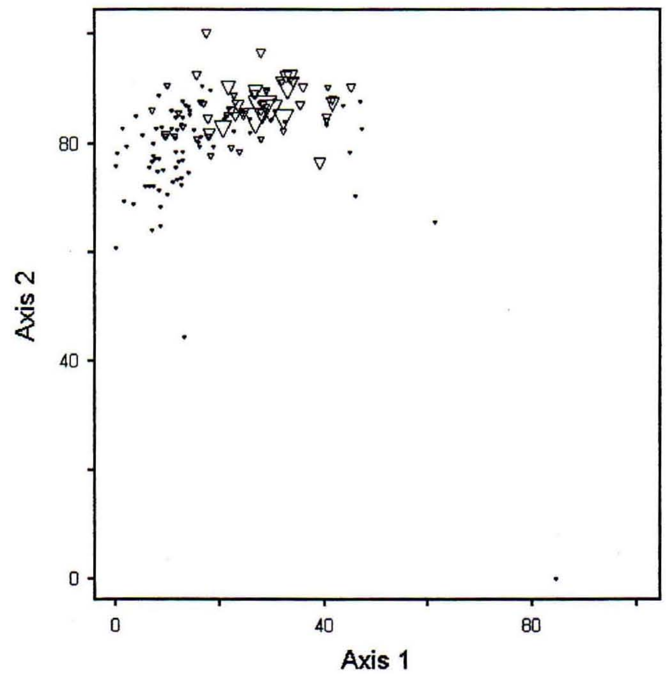

Figure 23. Depicting species distribution along CCA axis one and two triangles =species abundance

Carex pellita Muhl.ex Wild. a member of the sedge family is positively correlated with both axis one and axis two of the CCA analysis (Fig 23). Much like many other species that are found within the "transition zone" of these wet meadow complexes this plant is limited by habitats that are too wet, and habitats that are too dry, but has a wide range of habitat preferences within these two extremes.

CCA Individual Species Distribution of *Carex tetanica*

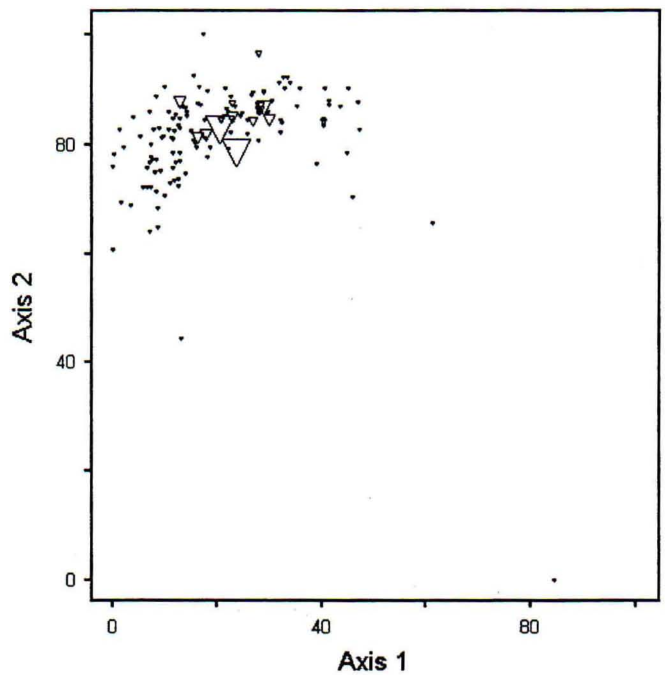

Figure 24. Depicting species distribution along CCA axis one and two triangles =species abundance

Carex tetanica Schkuhr. a cespitose perennial member of the sedge family, is most commonly found in swamps, wet meadows and ditches (McGregor et al. 1986). *Carex tetanica* is moderately correlated with both axis one and two of the CCA ordination analysis, this is displayed by its location along the gradient (Fig 24).

CCA Individual Species Distribution of *Carex vulpinoidea*

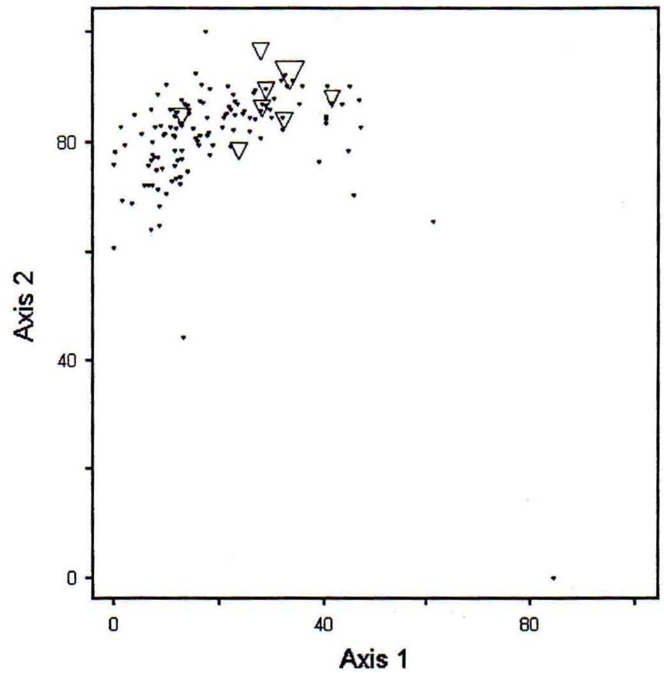

Figure 25. Depicting species distribution along CCA axis one and two triangles =species abundance

Carex vulpinoidea Michx. a cespitose perennial member of the sedge family is commonly found on hillsides, ravines, swampy areas, shores of ponds, lakes, and ditches (McGregor et al. 1986). From this description it is seen that this plant can inhabit a variety of different regions. This is demonstrated within the wet meadow complexes, by the fact that *Carex vulpinoidea* is found spread out along both axis. However, it is mainly a "transition zone" plant within the wet meadow systems (Fig 25).

CCA Individual Species Distribution of *Cirsium floodmanii*

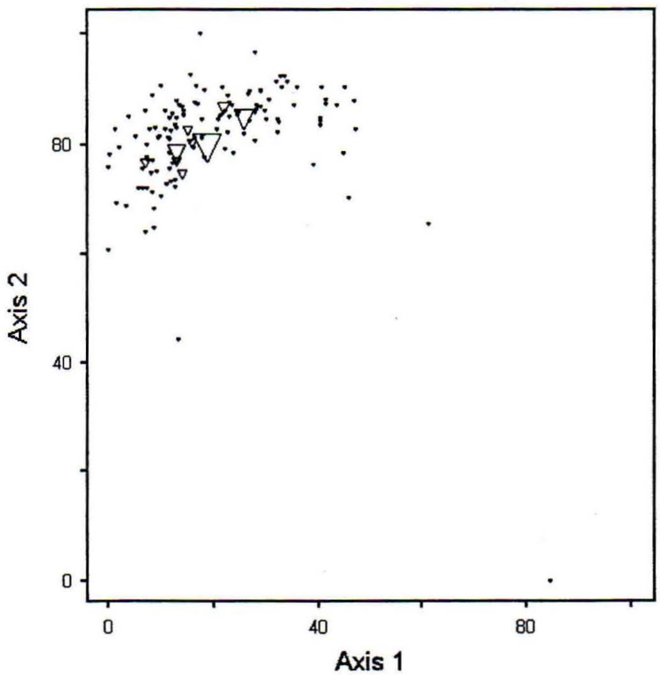

Figure 26. Depicting species distribution along CCA axis one and two triangles =species abundance

Cirsium floodmanii Rydb. is a cosmopolitan perennial commonly known as Floodman's thistle. This plant species is most commonly found in open sites, meadows, pastures, and waste places (McGregor et al. 1986). Floodman's thistle is moderately negatively correlated with both axis one and two suggesting it to be a more of a upland species within the wet meadow complexes (Fig 26).

CCA Individual Species Distribution of *Eleocharis elliptica*

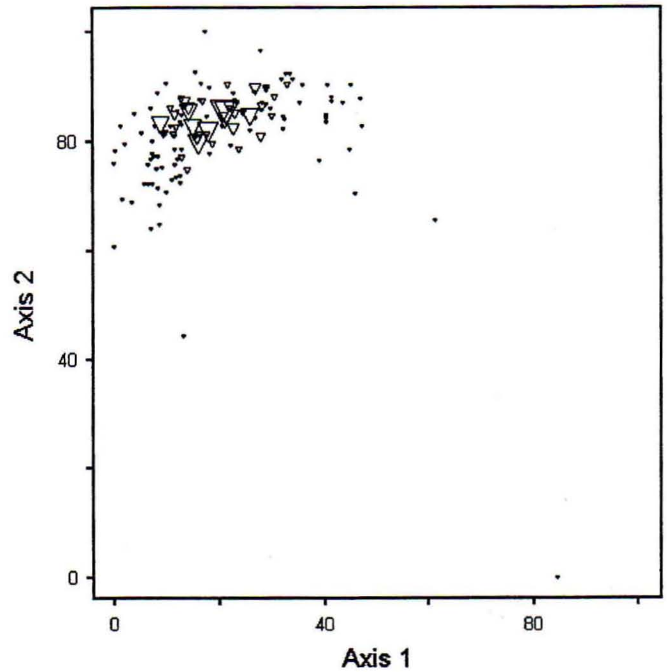

Figure 27. Depicting species distribution along CCA axis one and two triangles =species abundance

This member of the sedge family is commonly known as a spikerush (McGregor et al.1986). *Eleocharis elliptica* Kunth. is strongly correlated with axis one and moderately correlated with axis two of the CCA ordination analysis. This plant is found in high abundance within the wet meadow systems, and is a good example of a "transition zone" species (Fig 27).

CCA Individual Species Distribution of *Eleocharus palustris*

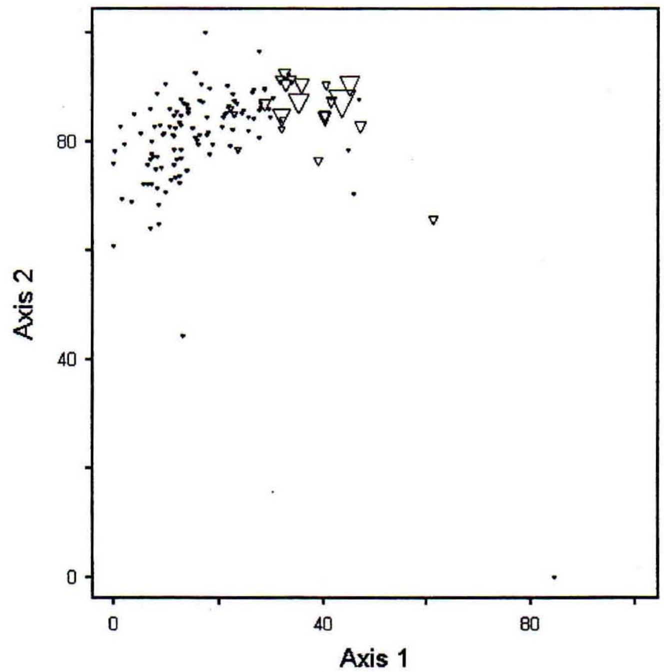

Figure 28. Depicting species distribution along CCA axis one and two triangles =species abundance

Eleocharis palustris (L.) R.& S. is a spikerush commonly found in standing water of road ditches, shores, and marshy meadows throughout the Great Plains region (McGregor et al. 1986). This plant species is found to be strongly correlated with axis one of the CCA ordination analysis, and negatively correlated with axis two of the ordination. This is displayed by the location of this plant species along the hydrologic gradient, determining this plant species to be a submerged vegetation type within the wet meadows (Fig 28).

CCA Individual Species Distribution of *Equisetum arvense*

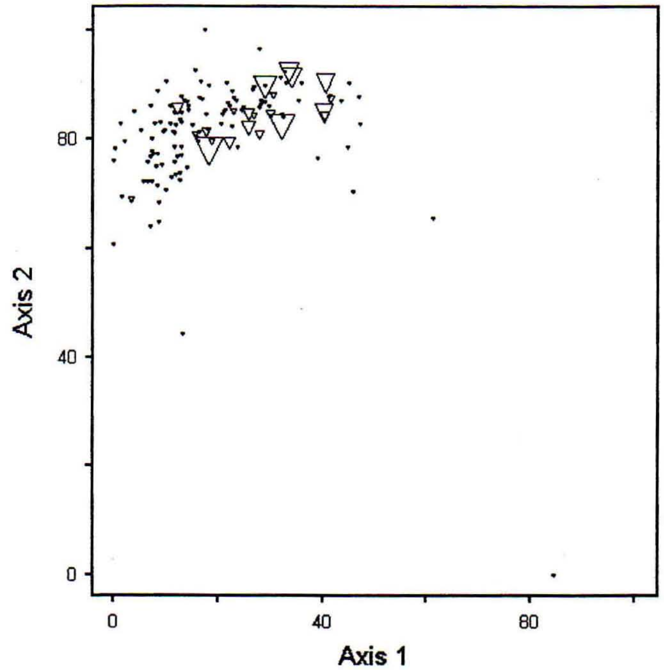

Figure 29. Depicting species distribution along CCA axis one and two triangles =species abundance

Equisetum arvense L. commonly known as field horsetail is a hydrophytic annual plant that is found in moist soils along lakeshores and streams, in low pastures, meadows and woodland thickets, and disturbed areas (McGregor et al. 1986). Field horsetail is a common plant species in the wet meadows examined for this study which shows a strong correlation with axis one, and a moderate correlation with axis two of the CCA ordination analysis (Fig 29). This positioning along the hydrologic gradient, and it's high abundance shows this plant to be a key component of the "transtion zone" plant species communities.

CCA Individual Species Distribution of *Equisetum laevigatum*

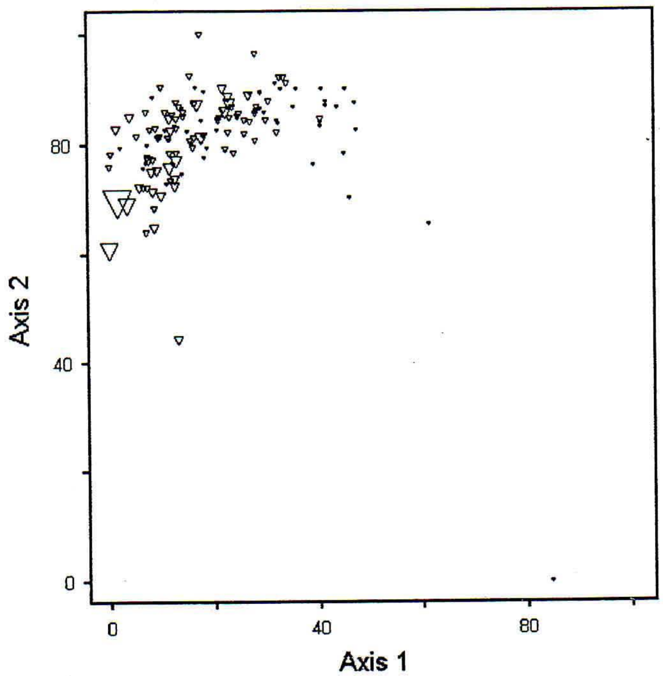

Figure 30. Depicting species distribution along CCA axis one and two triangles =species abundance

Equisetum laevigatum A.Br. is an annual horsetail commonly referred to as smooth scouring rush. This plant is commonly found on sandy riverbanks or streams, lakeshores, meadows, pastures, and upland prairies (McGregor et al. 1986). In contrast to *Equisetum arvense*, the smooth scouring rush is negatively correlated with axis one, and two of the CCA ordination analysis (Fig 30). This plant species is found in the upland sandy regions along the rigde of the wet meadow complexes examined for this study.

CCA Individual Species Distribution of *Erigeron strigosus*

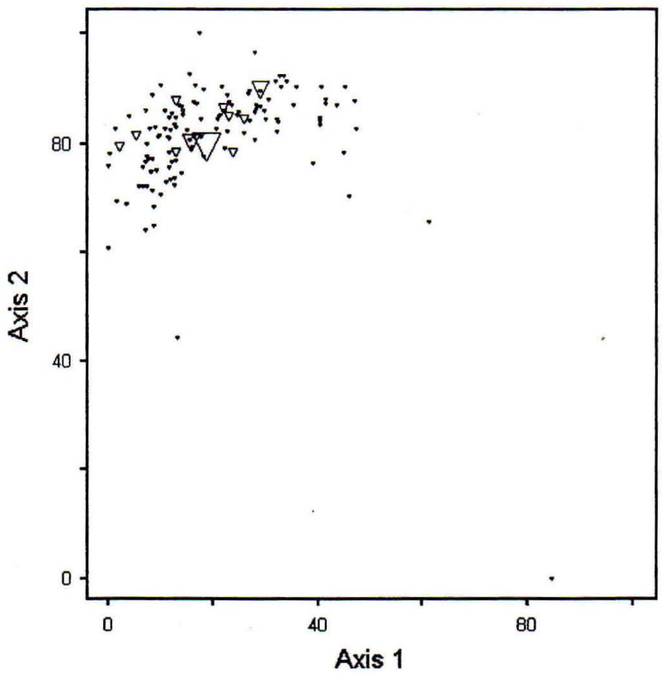

Figure 31. Depicting species distribution along CCA axis one and two triangles =species abundance

Erigeron strigosus Muhl. is described by as being an annual or rarely biennial herb of the sunflower family, and is commonly referred to as daisy fleabane. Daisy fleabane is commonly found in open moist or dry prairies and disturbed sites, and is often considered to be a weedy species (McGregor et al. 1986). Daisy fleabane is negatively correlated with axis one and positively correlated with axis two of the CCA ordination analysis. This correlation is demonstrated by the positioning of this plant species along the hydrologic gradient (Fig 31).

CCA Individual Species Distribution of *Glychrriza lepidota*

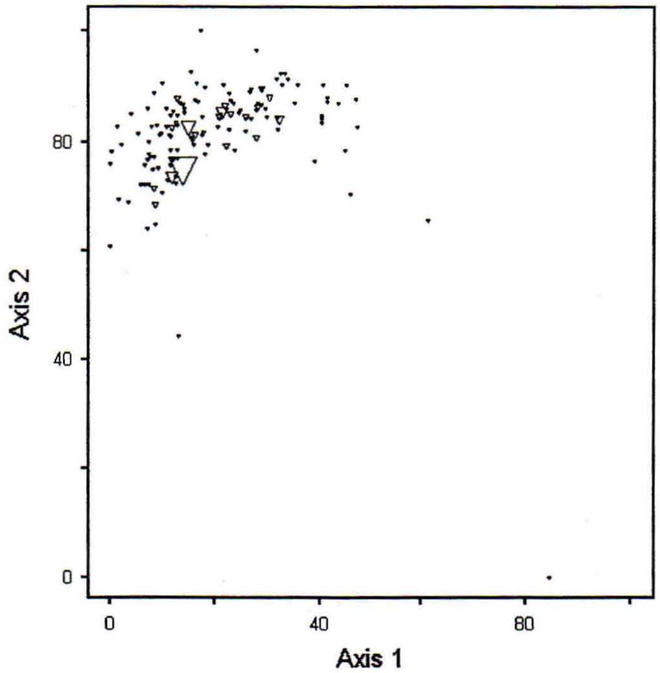

Figure 32. Depicting species distribution along CCA axis one and two triangles =species abundance

Glycyrrhiza lepidota Pursh. is a herbacious perennial plant commonly referred to as wild licorice. Wild licorice is infrequent to locally abundant in prairie ravines, stream valleys, lakeshores, moist areas, and roadsides (McGregor et al. 1986). Wild licorice is moderately negatively correlated with both axis one and two of the CCA ordination analysis (Fig 32).

CCA Individual Species Distribution of *Helianthus maximiliani*

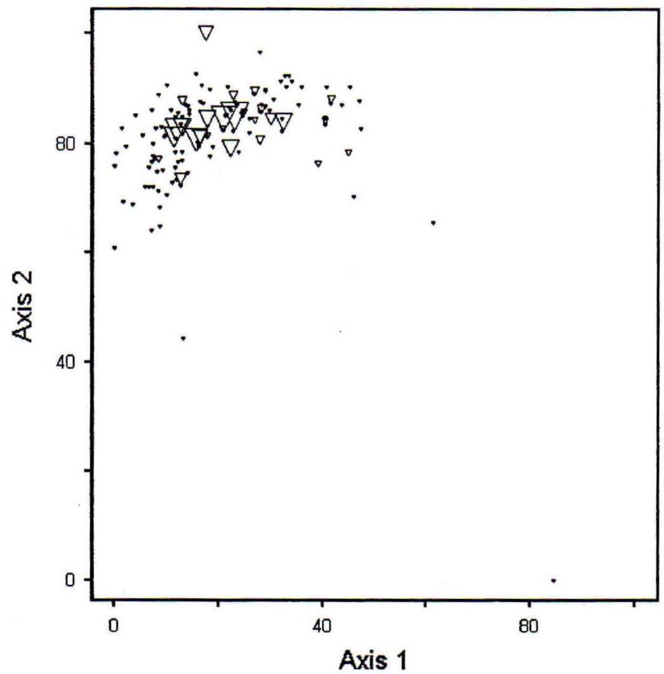

Figure 33. Depicting species distribution along CCA axis one and two triangles =species abundance

Helianthus maximiliani Schrad. is a perennial rhizomatous member of the sunflower family, commonly referred to as the maximilian sunflower. This plant species can be found in dry or damp open prairies, waste ground, and often in sandy sites (McGregor et al. 1986). Maximilian sunflower is moderately correlated with axis two, and weakly correlated with axis one of the CCA ordination analysis. This analysis shows this plant species to inhabit a moderately upland region of the wet meadow complexes (Fig 33).

CCA Individual Species Distribution of *Hordeum jubatum*

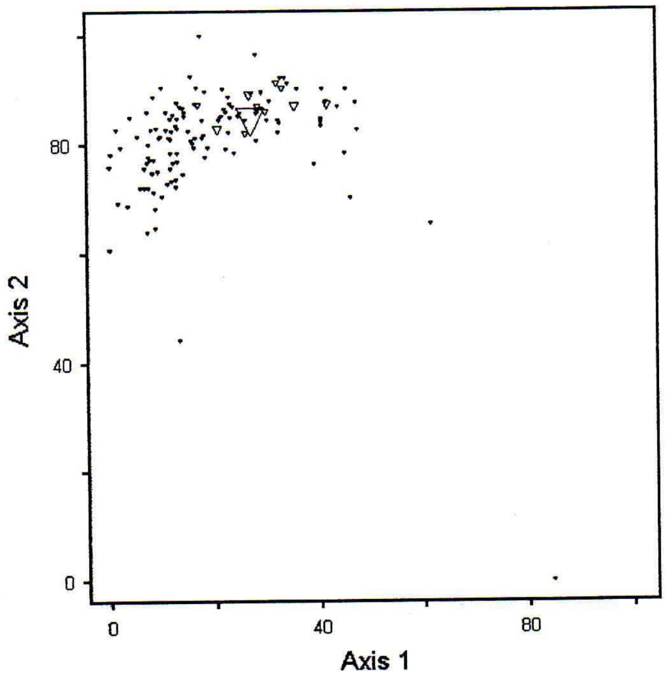

Figure 34. Depicting species distribution along CCA axis one and two triangles =species abundance

Hordeum jubatum L. is a tufted perennial member of the grass family commonly referred to as foxtail barley. Foxtail barley is found in roadsides, pastures, and waste ground of the Great Plains region (McGregor et al. 1986). This plant species is found in lower abundance in the wet meadow complexes and is moderately correlated with both axis one and axis two of the CCA ordination analysis (Fig 34).

CCA Individual Species Distribution of *Hypoxis hirsuta*

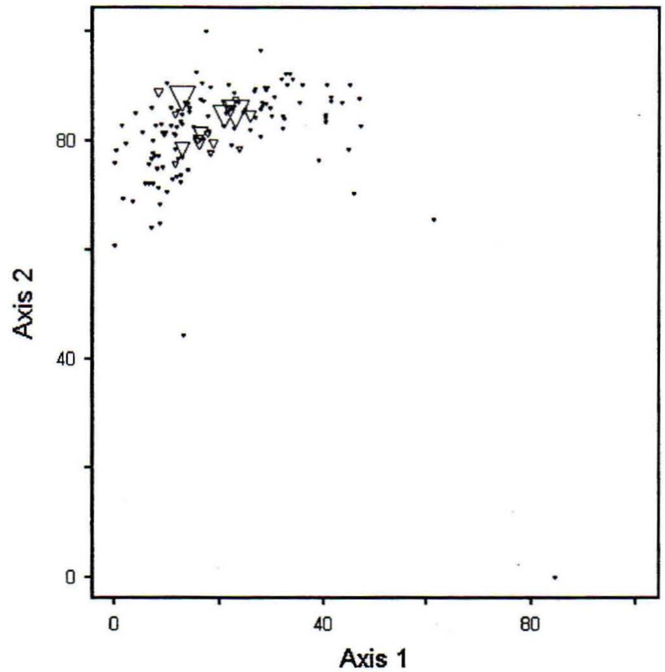

Figure 35. Depicting species distribution along CCA axis one and two triangles =species abundance

Hypoxis hirusta L. is a perennial herb of the lily family commonly referred to as yellow stargrass. This plant species is found in moist to dry prairies and occasionally in open deciduous woods (McGregor et al. 1986). Yellow stargrass is weakly correlated with both axis one and two of the CCA ordination analysis. This plant species is found in the upper part of the upland ridge in the wet meadow complexes (Fig 35).

CCA Individual Species Distribution of *Juncus dudleyi*

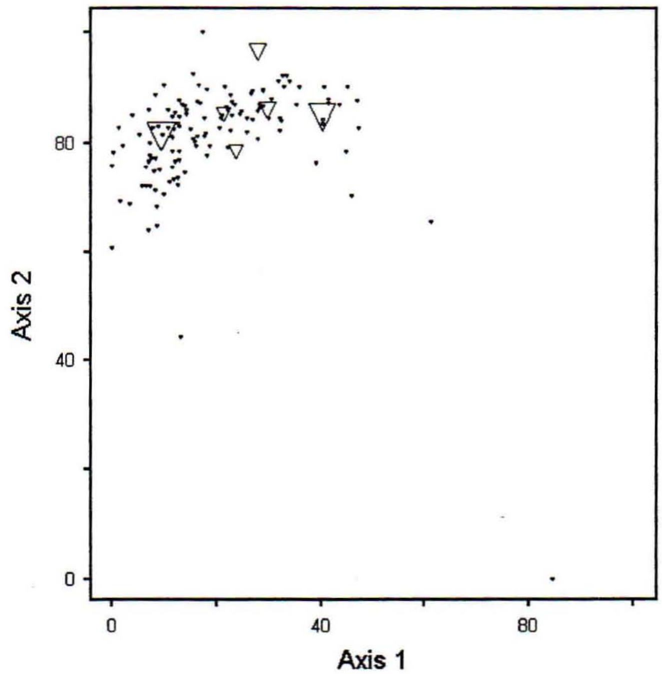

Figure 36. Depicting species distribution along CCA axis one and two triangles =species abundance

Juncus dudleyi Wieg. is a cespitose member of the rush family commonly referred to as Dudley rush. Dudley rush is found on lake and stream marshes, meadows and wet prairies (McGregor et al. 1986). This plant species is moderately correlated with both axis one and two of the CCA ordination analysis. This plant is found in substantial abundance at many locations along the gradient (Fig 36).

CCA Individual Species Distribution of *Leersia oryzoides*

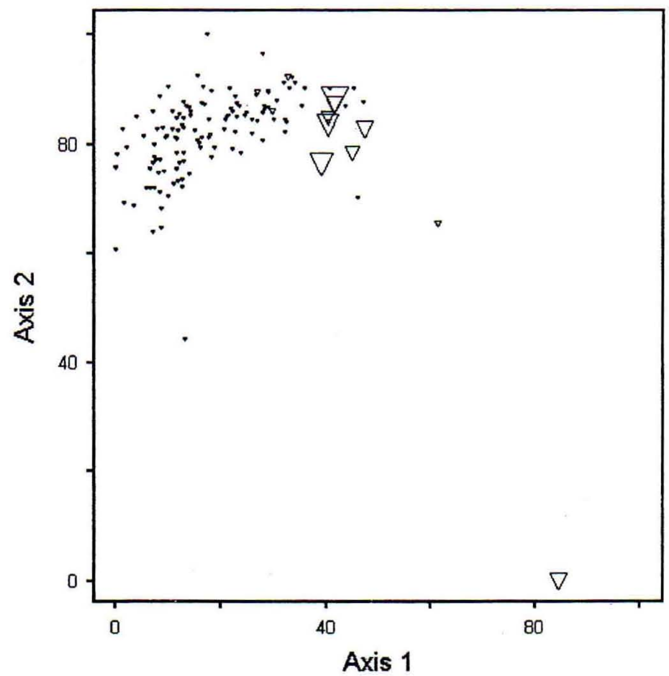

Figure 37. Depicting species distribution along CCA axis one and two triangles =species abundance

Leersia oryzoides L. is a tufted perennial belonging to the grass family and is commonly referred to as rice cutgrass. This plant species is found along ditches, streams, ponds, lakes, and marshes (McGregor et al. 1986). Rice cutgrass is strongly correlated with axis one of the CCA ordination analysis, and is located mostly within the swale of the wet meadow complex (Fig 37).

CCA Individual Species Distribution of *Lippia lanceolata*

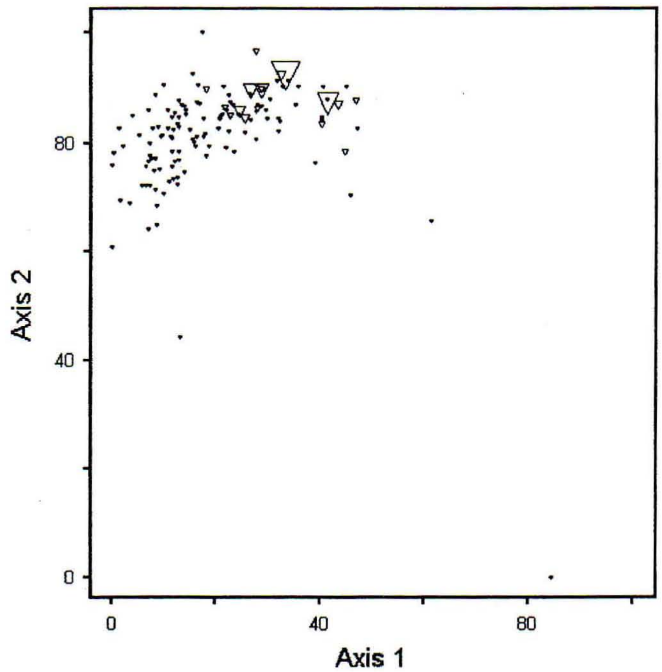

Figure 38. Depicting species distribution along CCA axis one and two triangles =species abundance

Lippia lanceolata Michx. is a perennial herb belonging to the vervain family, and is commonly referred to as northern fog-fruit. This plant species is frequent along margins of streams, ponds, lakes, prairie swales, ditches, and low woodlands (McGregor et al. 1986). This plant is strongly correlated with both axis one and two of the CCA ordination analysis (Fig 38).

CCA Individual Species Distribution of *Lycopus americanus*

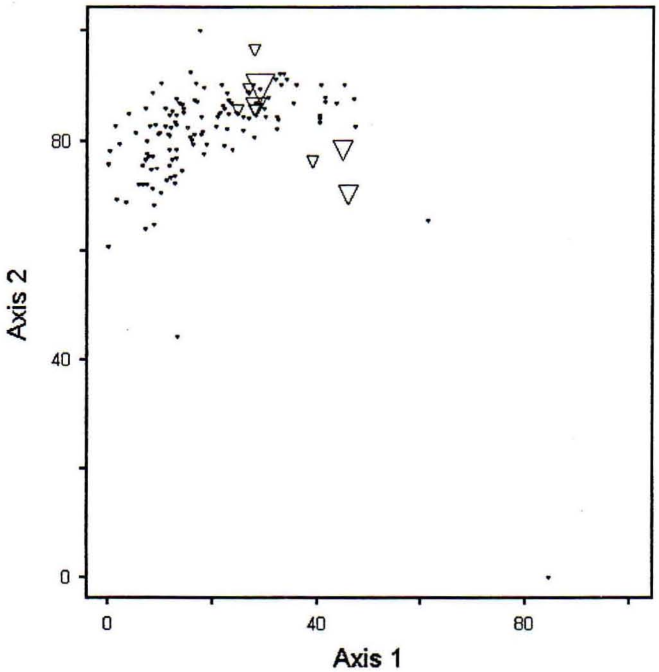

Figure 39. Depicting species distribution along CCA axis one and two triangles =species abundance

Lycopus americanus Muhl. a perennial plant, is a member of the mint family commonly referred to as american bugleweed. American bugleweed is commonly found in moist or wet soil, stream banks, lakeshores, sloughs, ditches, and exposed sites of the Great Plains region (McGregor et al. 1986). This plant species is strongly correlated with axis one and moderately correlated with axis two of the CCA ordination analysis (Fig 39).

CCA Individual Species Distribution of *Lycopus asper*

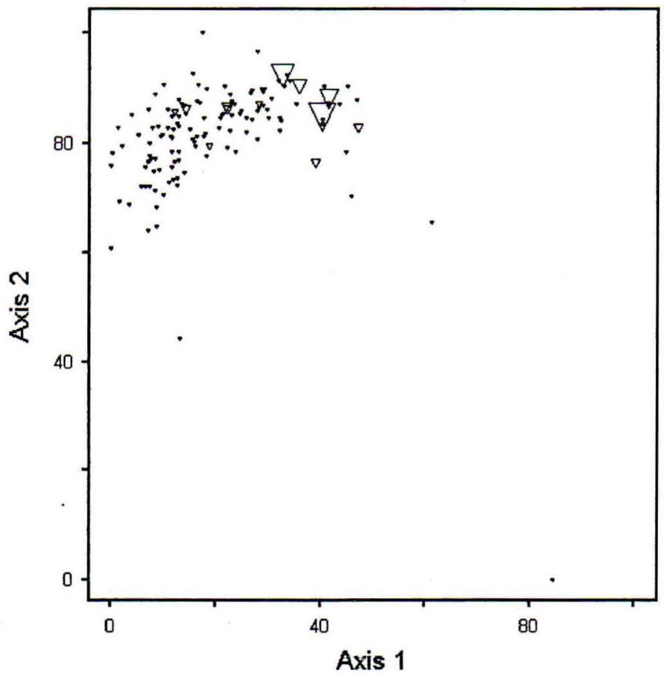

Figure 40. Depicting species distribution along CCA axis one and two triangles =species abundance

Lycopus asper Greene. is a perennial member of the mint family commonly referred to as rough bugleweed. Rough bugleweed is found in moist or wet soil, stream banks, sloughs, marshes, lakeshores, around springs, and usually disturbed sites (Mcgregor et al. 1986). Rough bugleweed is is strongly correlated with axis one and two of the CCA ordination analysis (Fig 40). American bugleweed, and rough bugleweed, are located at approximately the same positon along the gradient with the exception of the higher affinity of the rough bugleweed for axis two.

CCA Individual Species Distribution of *Lysmachia thrysiflora*

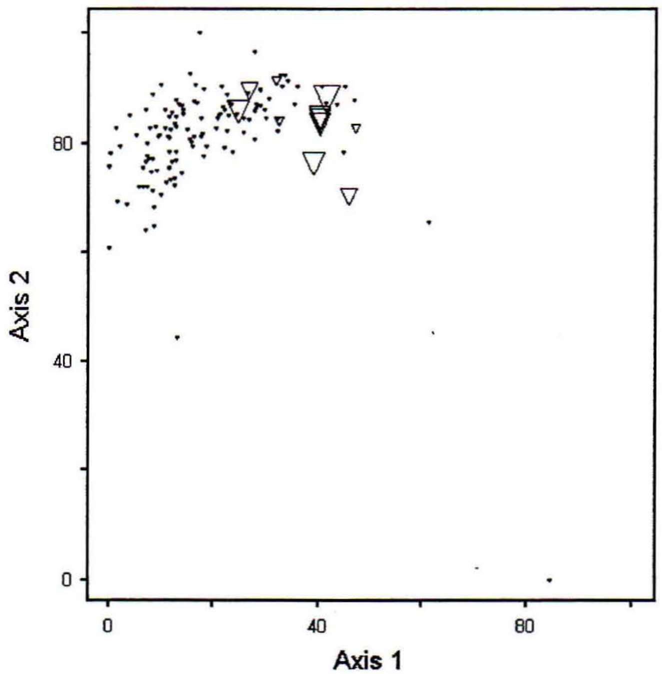

Figure 41. Depicting species distribution along CCA axis one and two triangles =species abundance

Lysimachia thyrsiflora L. is a erect perennial belonging to the primrose family commonly referred to as tufted loosestrife. Tufted loosestrife is found in fens, bogs, springs, marshes, wet meadows, shores, and is usually growing in fresh shallow water (McGregor et al. 1986). This plant species is strongly correlated with axis one of the CCA ordination analysis and is predominantly found in the swale region of the wet meadow complex (Fig 41).

CCA Individual Species Distribution of *Medicago lupulina*

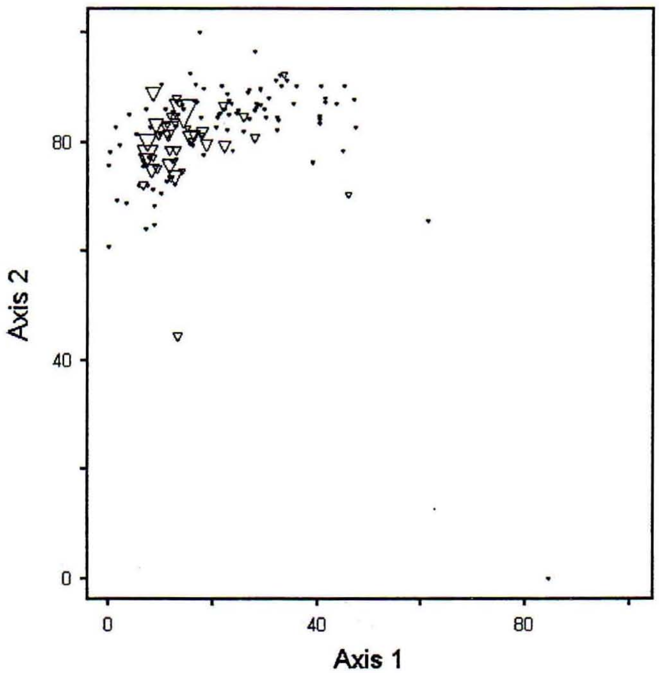

Figure 42. Depicting species distribution along CCA axis one and two triangles =species abundance

Medicago lupulina L. is an annual member of the bean family commonly referred to as black medick. Black medick is rather common in lawns, pastures, fields, stream valleys, prairie ravines, roadsides, and waste places (McGregor et al. 1986). This plant species is negatively correlated with both axis one and two of the CCA ordination analysis (Fig 42).

CCA Individual Species Distribution of *Oxalis stricta*

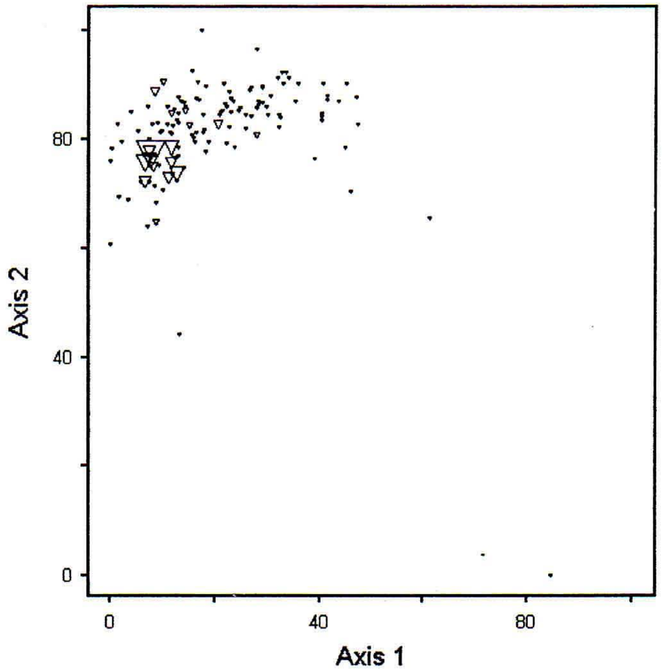

Figure 43. Depicting species distribution along CCA axis one and two triangles =species abundance

Oxalis stricta L. a perennial member of the wood sorrel family is commonly referred to as yellow wood sorrel. This plant species is found in open woods, prairie ravines, stream banks, gardens waste places, and is becoming uncommon to absent within the Great Plains region (McGregor et al. 1986). Yellow wood sorrel is negatively correlated with both axis one and two of the CCA ordination analysis. This plant is located in the upland region of the wet meadow complex (Fig 43).

CCA Individual Species Distribution of *Panicum virgatum*

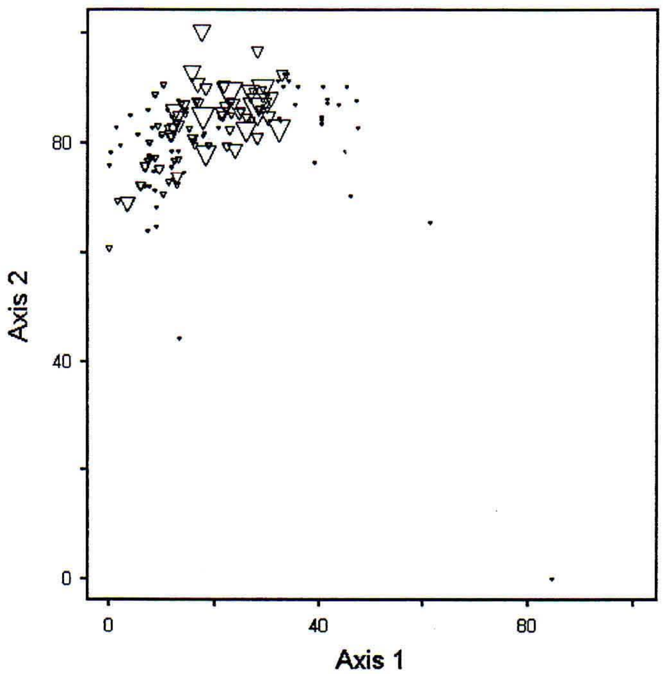

Figure 44. Depicting species distribution along CCA axis one and two triangles =species abundance

Panicum virgatum L. is a strongly rhizomatous perennial member of the grass family commonly referred to as switchgrass. Switchgrass is found in moist lowland prairies and other moist areas of the Great Plains region (McGregor et al. 1986). This plant species is negatively correlated with axis one and positively correlated with axis two of the CCA ordination analysis. Switchgrass is a abundant species within the wet meadow complex, located within the "transition zone" (Fig 44).

CCA Individual Species Distribution of *Poa pratensis*

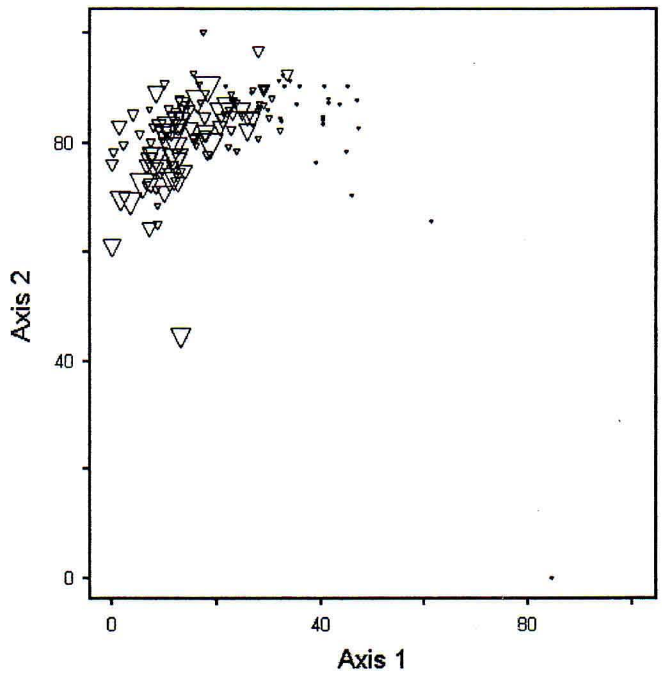

Figure 45. Depicting species distribution along CCA axis one and two triangles =species abundance

Poa pratensis L. is a strongly rhizomatous, mat-forming perennial of the grass family commonly referred to as Kentucky bluegrass. Kentucky bluegrass is very common in a variety of habitats throughout the Great Plains region (McGregor et al. 1986). This variation of habitat is clearly seen within the wet meadows examined for this site (Fig 45). Kentucky bluegrass is negatively correlated with axis one and two of the CCA ordination analysis. This plant species is found in abundance throughout the gradient, however, it is predominant in the upland regions.

CCA Individual Species Distribution of *Rosa woodsii*

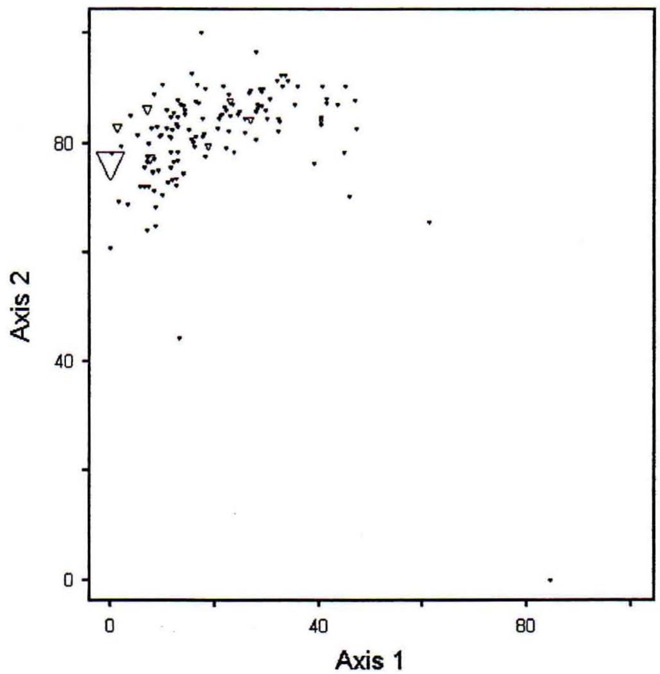

Figure 46. Depicting species distribution along CCA axis one and two triangles =species abundance

Rosa woodsii Lindl. commonly referred to as western wild rose, is a much branched shrub found in rocky prairie ravines, open woodlands, roadsides, and stream valleys (McGregor et al. 1986). The western wild rose is negatively correlated with both axis one and two of the CCA ordination analysis. This plant species was not found in a variety of sites, however when found it was located in the extreme "dry" upland regions of the wet meadow complex (Fig 46).

CCA Individual Species Distribution of *Schyzachrium scoparium*

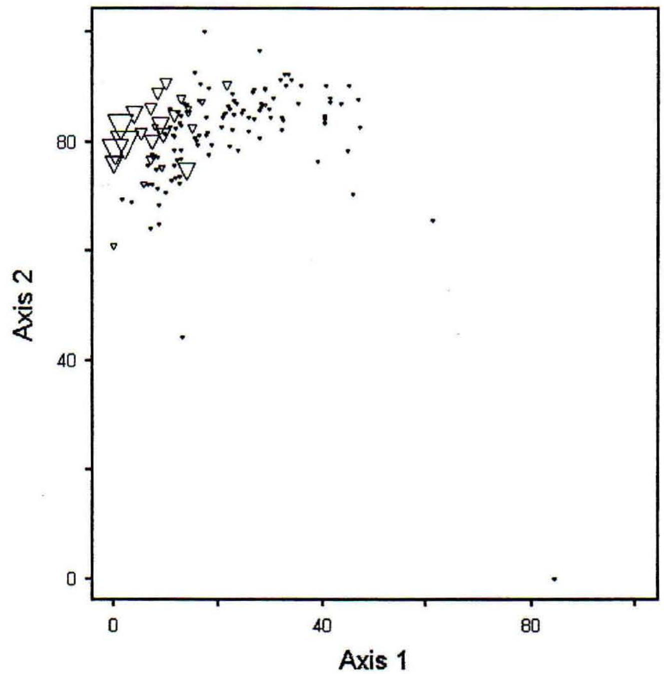

Figure 47. Depicting species distribution along CCA axis one and two triangles =species abundance

Schyzachrium scoparium Michx. is a cespitose perennial belonging to the grass family, and is often a dominant or co-dominant species of prairie ecosystems (McGregor et al. 1986). This plant species is negatively correlated with both axis one and two of the CCA ordination analysis. *Schyzachrium scoparium* is a abundant plant species found predominately in the upland ridge regions of the wet meadow complex (Fig 47).

CCA Individual Species Distribution of *Scirpus pungens*

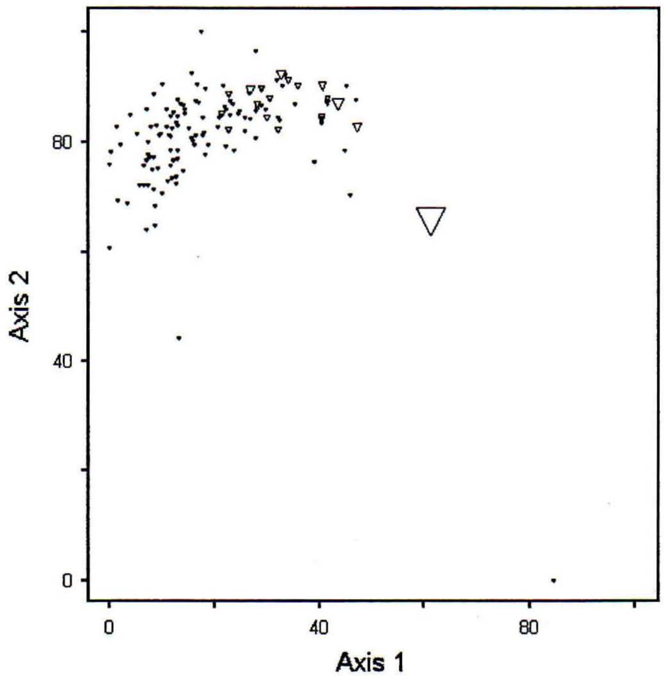

Figure 48. Depicting species distribution along CCA axis one and two triangles =species abundance

Scirpus pungens Vahl. is a perennial belonging to the sedge family originating from long creeping, reddish brown, rhizomes. *Scirpus pungens* is found in marshes, sloughs, and wet areas throughout the Great Plains region (McGregor et al. 1986). This plant species is strongly correlated with both axis one and two of the CCA ordination analysis. Although found in small abundance when present this sedge is found primarily within the swale "wet" region of the wet meadow complexes (Fig 48).

CCA Individual Species Distribution of *Smilacina stellata*

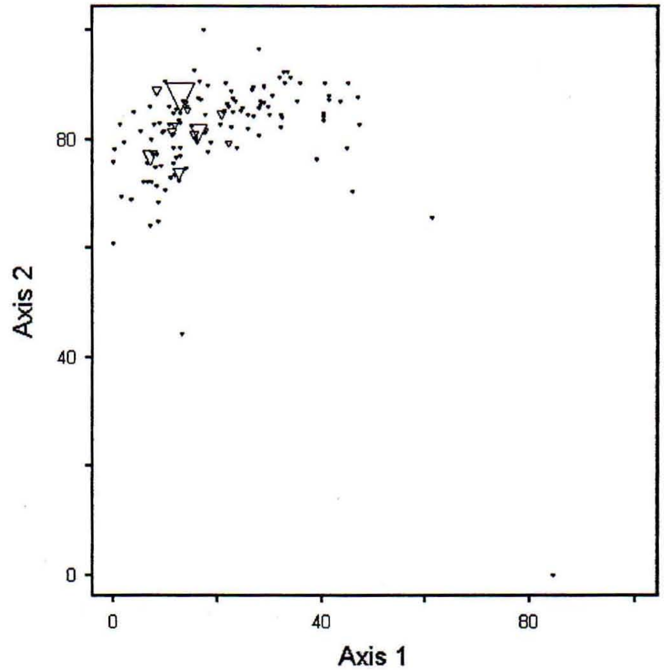

Figure 49. Depicting species distribution along CCA axis one and two triangles =species abundance

Smilacina stellata (L.) Desf. is a perennial member of the lily family commonly referred to as spikenard. Spikenard is found in moist to dry coniferous or deciduous woods, meadows, and is frequent along streams and rivers (McGregor et al. 1986). This plant species is negatively correlated with axis one and positively correlated with axis two of the CCA ordination analysis (Fig 49).

CCA Individual Species Distribution of *Solidago canadensis*

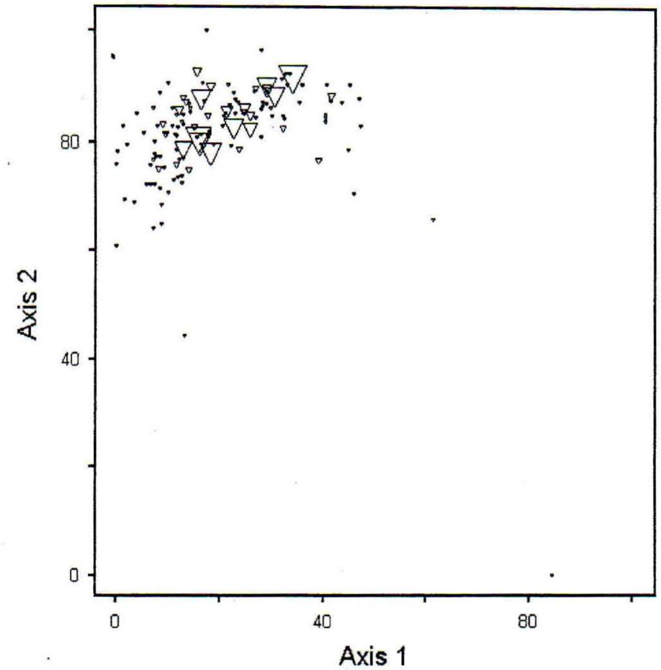

Figure 50. Depicting species distribution along CCA axis one and two triangles =species abundance

Solidago canadensis L. is a perennial herb belonging to the sunflower family commonly referred to as Canada goldenrod. Canada goldenrod is found in damp or drying open places, often in loose soils, and in clearings in wooded regions (McGregor et al. 1986). This plant species is weakly correlated with both axis one and two of the CCA ordination analysis. Canada goldenrod is dispersed throughout the wet meadow complex, predominately within the "transition zone" (Fig 50).

CCA Individual Species Distribution of *Sorghastrum nutans*

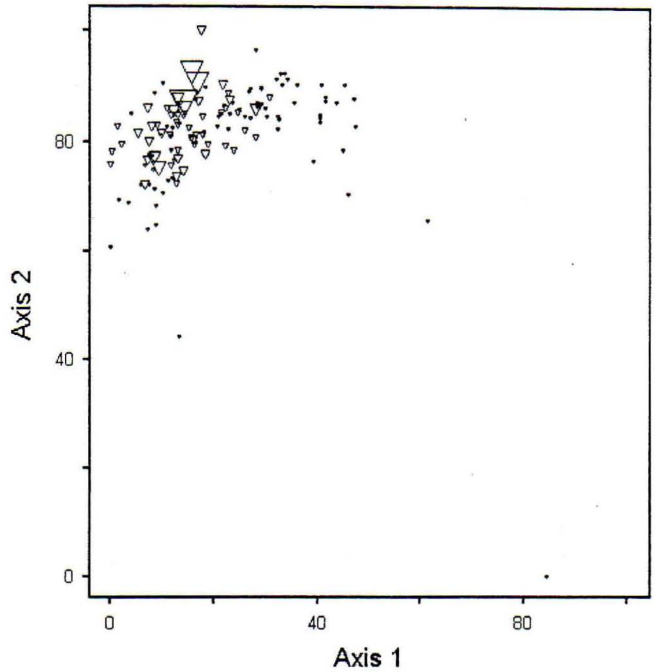

Figure 51. Depicting species distribution along CCA axis one and two triangles =species abundance

Sorghastrum nutans L. a short-rhizomatous perennial member of the grass family is commonly referred to as indian grass. Indian grass is found in open prairies, where it is often a dominant or co-dominant species (McGregor et al. 1986). This plant species is negatively correlated with axis one and positively correlated with axis two of the CCA ordination analysis (Fig 51).

CCA Individual Species Distribution of *Spartina pectinata*

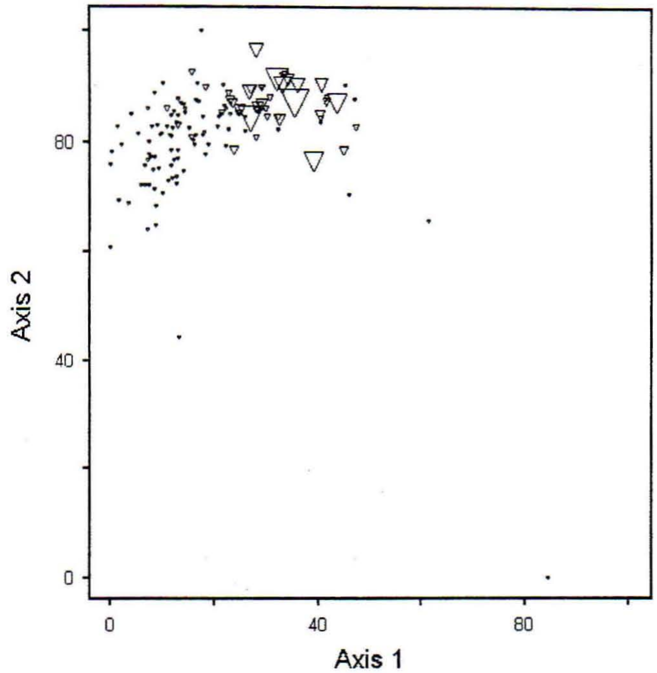

Figure 52. Depicting species distribution along CCA axis one and two triangles =species abundance

Spartina pectinata Link. is a perennial member of the grass family commonly referred to as prairie cordgrass. Prairie cordgrass is found in swales, ditches and wet prairies (McGregor et al. 1986). This plant species is strongly correlated with both axis one and two of the CCA ordination analysis. Prairie cordgrass is a abundant plant in the wet meadow complexes, located primarily in the "wet" swale region (Fig 52).

CCA Individual Species Distribution of *Sporobolus asper*

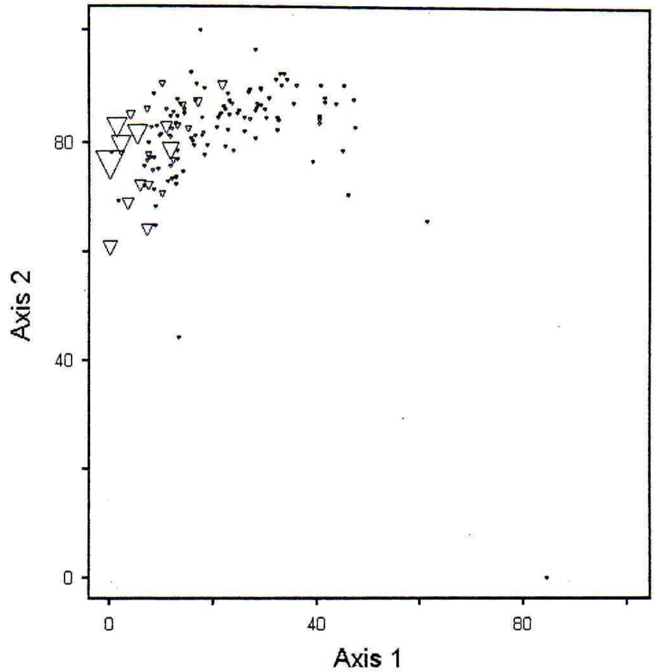

Figure 53. Depicting species distribution along CCA axis one and two triangles =species abundance

Sporobolus asper Michx. is a cespitose to solitary stemmed perennial member of the grass family commonly referred to as rough dropseed. Rough dropseed is found in prairies, roadsides, and a variety of other habitats (McGregor et al. 1986). This plant species is strongly positively correlated with axis one of the CCA ordination analysis, and is a very good example of an upland plant species (Fig 53).

CCA Individual Species Distribution of *Sporobolus cryptandrus*

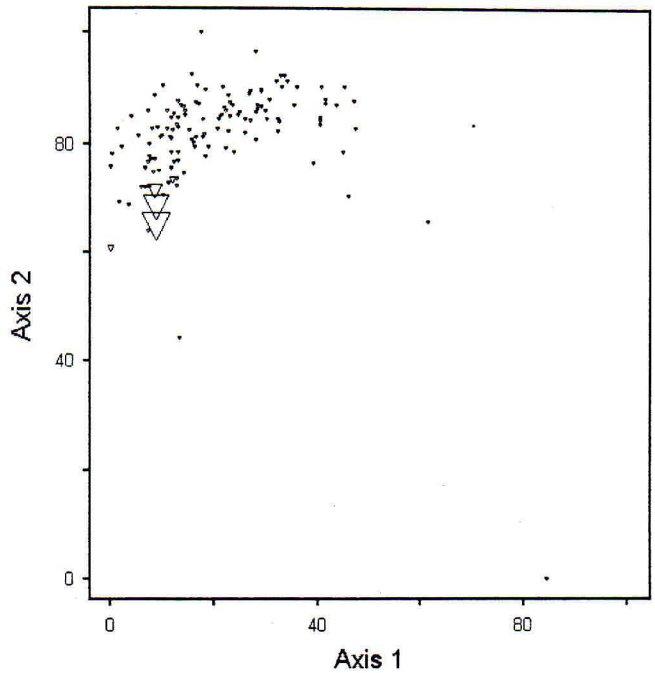

Figure 54. Depicting species distribution along CCA axis one and two triangles =species abundance

Sporobolus cryptandrus Torr. is a cespitose perennial member of the grass family commonly referred to as sand dropseed. Sand dropseed is found along roadsides, in pastures, and often in sandy soils (McGregor et al. 1986). This plant species was not found to be correlated with either axis one and two of the CCA ordination analysis, and is found in greatest abundance along the upland ridge of the wet meadow complex (Fig 54).

CCA Individual Species Distribution of *Taraxicum officinale*

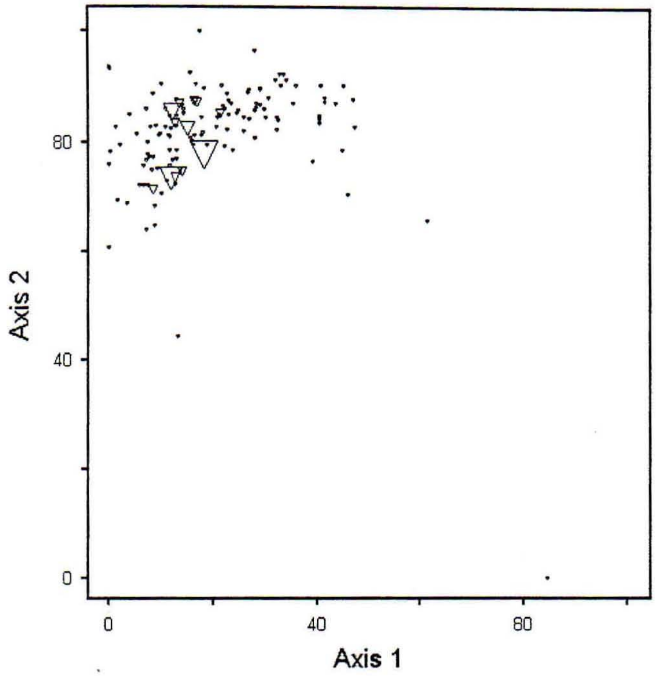

Figure 55. Depicting species distribution along CCA axis one and two triangles =species abundance

Taraxicum officinale Weber. is a taprooted herbaceous perennial member of the sunflower family commonly referred to as the common dandelion. The common dandelion is a common weed found in waste and disturbed sites,notably in lawns throughout the Great Plains region (McGregor et al. 1986). This plant species is negatively correlated with both axis one and two of the CCA ordination analysis (Fig 55). This ordination analysis illustrates the fact that this common weed has a low affinity for wet areas.

CCA Individual Species Distribution of *Trifolium repens*

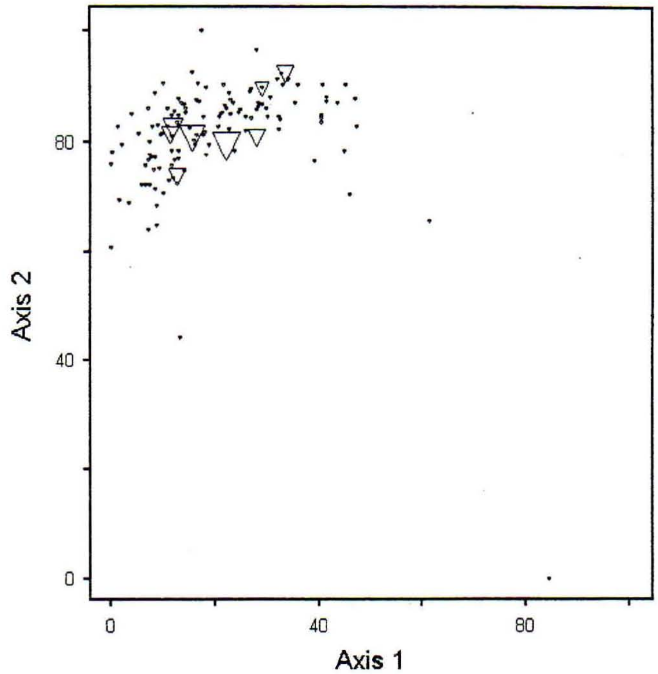

Figure 56. Depicting species distribution along CCA axis one and two triangles =species abundance

Trifolium repens L. is a taprooted perennial herb belonging to the bean family commonly referred to as white clover. White clover can be found in fields, roadsides, and waste places (McGregor et al. 1986). This plant species is negatively correlated with both axis one and two of the CCA ordination analysis. White clover is found at varying positions along the hydrologic gradient (Fig 56).

CCA Individual Species Distribution of *Trifolium pratense*

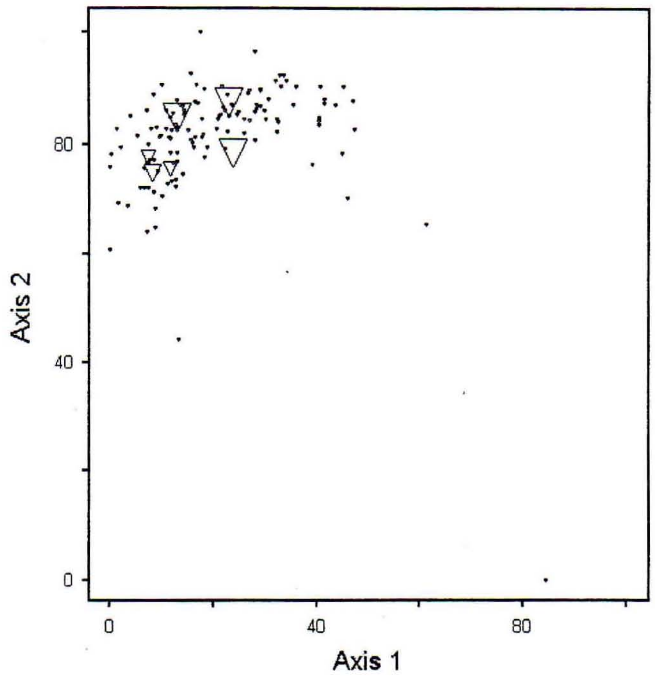

Figure 57. Depicting species distribution along CCA axis one and two triangles =species abundance

Trifolium pratense L. a cespitose short-lived perennial herb of the bean family is commonly referred to as red clover. Red clover is found in fields, pastures, roadsides, and waste places (McGregor et al. 1986). Red clover is negatively correlated with axis one, and positively correlated with axis two of the CCA ordination analysis (Fig 57).

CCA Individual Species Distribution of *Verbena stricta*

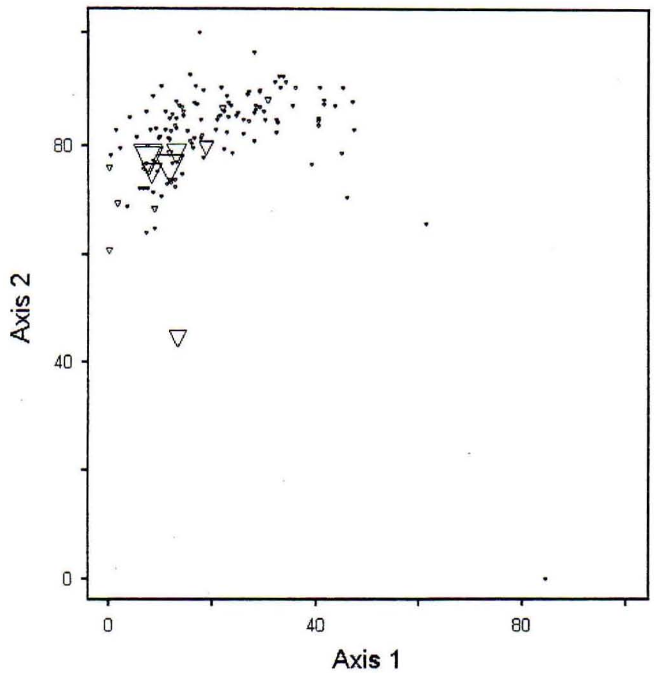

Figure 58. Depicting species distribution along CCA axis one and two triangles =species abundance

Verbena stricta Vent. is a perennial herb belonging to the vervain family of plants commonly referred to as hoary vervain. Hoary vervain is common in pastures, prairies, thickets, roadsides, and waste areas of the Great Plains region (McGregor et al. 1986). This plant species is negatively correlated with both axis one and two of the CCA ordination analysis (Fig 58).

CCA Individual Species Distribution of *Viola pratincola*

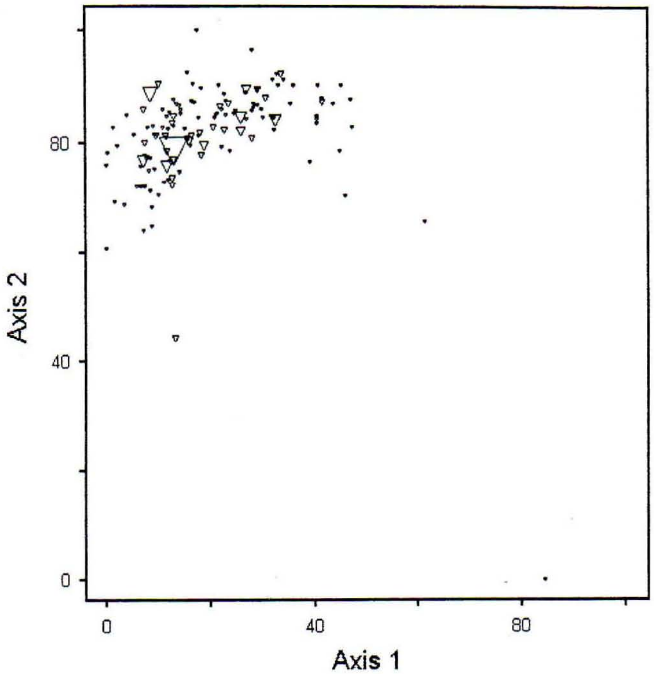

Figure 59. Depicting species distribution along CCA axis one and two triangles =species abundance

Viola pratincola Greene. a member of the violet family is a perennial acaulescent herb commonly referred to as blue prairie violet. Blue prairie violet is found in open woodlands, stream valleys, prairie hillsides and canyons, roadsides, pastures, and waste places in the Great Plains region (McGregor et al. 1986). This plant species is negatively correlated with axis one and positively correlated with axis two of the CCA ordination analysis (Fig 59).

CCA Individual Species Distribution of *Xanthium strumarium*

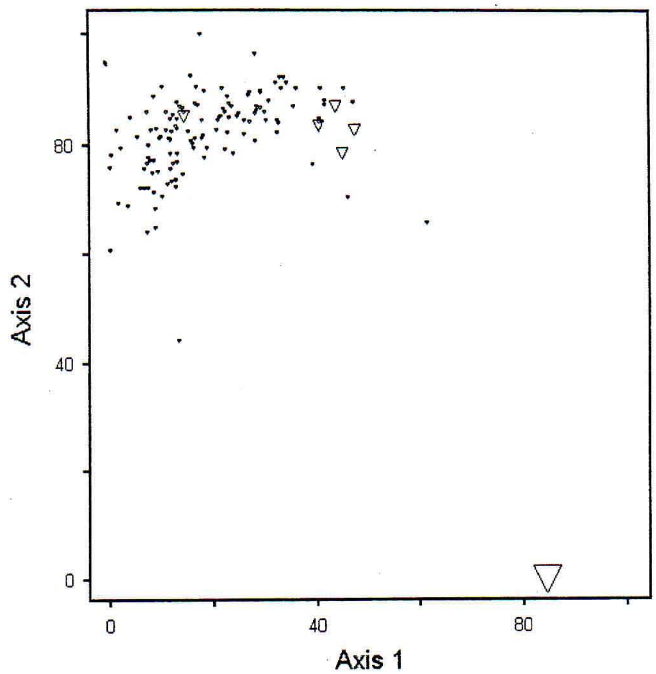

Figure 60. Depicting species distribution along CCA axis one and two triangles =species abundance

Xanthium strumarium L.)is a taprooted annual belonging to the sunflower family and is commonly referred to as cocklebur. Cocklebur is found in fertile, and disturbed soils of waste places (McGregor et al. 1986). This plant species is strongly correlated with axis one and strongly negatively correlated with axis two of the CCA ordination analysis (Fig 60).

Discussion

Effectiveness of ordinations

When considering the effectiveness of CCA ordinations in meeting the goals of this study, it must first be determined which ordination scenario produced sound results, helping the most in depicting the ecological structuring of the wet meadows involved. When examining the results from the CCA ordination which utilized all sixteen sites, it is found that 20.7 percent of the species diversity for those sites was explained by all of the environmental variables analyzed (Table 3). When examining the land treatment sites a much different conclusion is drawn. A cumulative 39.2 percent of the variation for the grazed sites, 39.9 percent of the species variation for the hayed sites, 45.4 percent of the species variation for the rested, and 40.8 percent variation for the intensively sampled sites could be explained by the environmental variables (Tables 7 and 13). This is approximately a two-fold increase from the CCA analysis examining all of the sites combined. This drastic increase may be due to extra noise in the data from autocorrelation of the hydrology, soil parameter, and even species data. Due to the fact that a much larger data matrix had to be constructed containing many similar types of data, this analysis could in fact be subjected to an increased risk of auto correlation. The data from this analysis was supported by the CCA/DCA comparison, and the Monte Carlo tests. Suggesting that it may be other unforeseen factors accounting for this difference, and not noisy data. The CCA analysis for the land treatment sites, and the intensively sampled sites was also supported by the same means, so it can also be used to give a description of these variables and their effect on the species community data in the wet meadows. None of these accounted for even half of the species variation within these sites. This leaves a large portion left unexplained. Some possible explanations could include past land use practices and the establishment of plant species during those uses.

Depending upon the variables and landscape being considered, each of these analyses is an effective tool. When considering larger landscape ecological concepts it may be more effective to in fact lump all of the data into one CCA analysis. When the smaller scale micro-topographic analysis is desired this idea of land treatment or small scale CCA ordination analysis may be more suitable. For this study, each ordination provided some useful insight into this complex ecosystem.

When considering all of the CCA analyses together it is seen that the hydrology variables are the most important environmental variable in regards to the impact on the plant species composition. Only the hayed sites showed any deviation from this conclusion, with a decreased affinity for the hydrology variables being represented by axis one. When examining the CCA ordination dealing with only the sites that were hayed it was determined that phosphorous, clay and salinity did in fact show a stronger correlation than the environmental variables. This difference in the correlation may be directly attributed to the land management practice. Haying is a mechanized agricultural technique and is not usually practiced on lands which are saturated most of the time, or have distinct differences in topography. Although each of the sites in this study represented the same shifts in elevation the shifts on the hayed sites were extended across a long distance and in some cases broken up into two sites. This gradual shift in elevation could result in a decrease in the depth of the swale from some of the sites. This decrease in depth of swale may result in a smaller "wetted zone" of the complex, thus causing a shift in the ordination results. This decrease in saturation could also be attributed to adjacent land management practices. Either way it is possible that the hayed sites plant community composition is influenced more by the soil conditions than by the hydrology.

It is important to note the close relationship of those soil conditions with hydrology, which drives the plant composition in the hayed sites. The total amount of phosphorous present in a system can be directly attributed to the total amount of organic matter present in a soil (Hausenbuiller 1972). In these wet meadows, transects which exhibited the highest amount of organic matter present were located directly in the bottom of the swale (Appendix). These regions which are saturated most of the time and this saturation leads to the soils forming in an anoxic environment. This anoxic soil environment is one of the driving factors in increasing the amount of organic matter in a wetland soil complex. These deep swales in the wet meadows, can act as chemical transformers, producing a dominant effect of transforming substances from inorganic nutrients to soluble and particulate organic compounds (Horne &Goldman, 1994). This leads to the underlying factor of the amount of macronutrients, organic matter, and texture being directly driven by the hydrology present in a wetland. To conclude that the hayed sites were not directly influenced by the hydrology present in the wet meadow would be a mistake. However, it is those sites which allow for a closer insight into how which of these soil parameters do have the biggest impact along a hydrologic gradient which is of an altered hydroperiod.

The CCA ordinations for this study have allowed for the designation of the hydrology variables, and the soil parameters associated with them as having the most influence on the plant species community composition in the wet meadows of the Central Platte River. These ordinations have also provided some insight as to how much impact each of these variables have in depicting where a particular species can be found along this hydrology gradient. The CCA ordinations for these wet meadow sites has also provided valuable insight into where along this gradient a specific plant species can be found, and in turn this reveals which environmental variable has the biggest influence on it (Appendix). When cosidering the study goal of defining an exact "transition zone", it can be seen that this study has provided this information for the specific wet meadow sites analyses. However, due to the complexity of the wet meadow ecosystem in general and the differential land use treatments in practice, it is not appropriate to state that a general definition can be assigned to this zone.

Due to the accuracy of this analysis technique, in pinpointing the needs of specific plant species, for this study CCA has proven to be a very valuable ordination technique. It may also be said that this technique could and should be applied to other areas outside of ecology, including planning agriculturally related management practices for land, and possibly even landscaping applications

Conclusions

When considering the overall picture of the wet meadows along the Central Platte River there is no doubt of their importance to the region. They provide vital habitat for many organisms, they are ecological sinks for industrial and agricultural wastes, and they help to maintain the overall aesthetic value of the river system. For this reason it is of the utmost importance to determine what it is that makes them function. For this, one must consider all components of these very complex systems. A range of plants from hydrophytic to xeric, soils under anoxic, and dry situations, topography, and hydrology were the main components examined in this study. It was found that the hydrology of these sites is the driving ecological factor in determining the plant community composition of these meadows. This was expected as it is this hydrology in conjunction with topography that is the source of the gradient present. What the ordination analysis of these variables did do for this study was to determine what effect this hydrology had on the soil characteristics present, and then in turn what effect those soil characteristics had on the plant communities. It was found that the soil variables that were dependent upon saturated conditions to develop, were in fact the secondary limiting variable along this gradient. These variables included; organic matter, macronutrients, and moist soil texture. pH and the drier soil texture did show a negative correlation with these variables, supporting the fact that they are not strongly influenced by the hydrology present, and thus did not impact the plant community composition to the extent of the other associated variables.

This study has also provided a correlation coefficient for each plant species present in the wet meadows. This value can enable resource managers to determine not only the importance of that species to the system as a whole, but also it provides insight into what extent it is associated with these distinct soil variables.

From these CCA ordinations, a type of "recipe" could be compiled to direct resource managers in the restoration of these slowly depleting wet meadows. It has been shown that in recently restored great plains wet meadows, only 0-2 wet prairie species can be found, as compared to the undisturbed meadows 1-22 species. Also 0-9 sedge species, as compared to 7-49 undisturbed species, and 1-8 restored shallow to emergent species as compared to the 7-19 shallow to emergent species found in the undisturbed meadow can be found (Galatowitch 1998). These numbers are disturbingly low and could hopefully be improved upon if the necessary topography, and accounting for specific soil properties were applied to these restoration sites

Overall the goals of determining the specific soil characteristics along the gradient, and gaining an overall better understanding of how these complex systems work have been met. Plant species correlations to the environmental variables present at the sites were determined meeting the specific goal of better understanding these relationships. The variation of the soils present along the hydrological gradient was also determined. And finally, ordination curves were developed for the most frequently occurring plant species providing an outline of exactly where it is along this gradient that the plants were found. These curves will be a useful tool for future restorations projects by determining what steps need to be taken to obtain the desired level of diversity with in a wet meadow.

Things to consider in the future of soil analysis of these wet meadow sites would be a more intensive sampling procedure at each transect, not just a few sites. This procedure would not necessarily consist of more soil parameters, but deeper soil cores, taken at closer increments along each transect. It would also be beneficial to examine some of the soil water capacity of these sites; including capillary fringe effects on plants, and soil water tension.

Literature Cited

Adams, D.A., M.A. Buford, and D.M. Dumond. 1987. In search of the wetland Boundary. *Wetlands* 7:59-70.

Allen, S.D., F.C. Golet, and A. F. Davis. 1989. Soil-vegetation correlations in Transition zones of Rhode Island red maple swamps. U.S. Fish Wildl. Serv. Biological Report 89(8).

Baker, B. 1999. Government regulation of wetlands is under siege from all sides *Bioscience* 49(11):869.

Bray, J.R. and J.T. Curtis. 1957. An ordination of upland forest communities of southern Wisconsin. *Ecol. Mono.* 27:325-349.

Brown, J.R., & R.R. Rodiguez. 1983. Determination of neutralizable acidity (NA). New Woodruff buffer method. p.29-30. *In* Soil Testing in Missouri. Missouri Coop. Ext. Service EC923.

Christensen, N.L., and R.K. Peet. 1984. Convergence during secondary forest succession. *J. Ecology* 72:25-36.

Combs, S.M., & M.V. Nathan. 1998. Soil organic matter. p. 53-58. *In* J.R. Brown et al. (ed.), Recommended soil test procedures for the North Central Region (revised). North Central Regional Publication 221. Missouri Agricultural Station Bull. 1001.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and deepwater habitats of the United States. U.S. Fish Wildl. Serv. FWS/OBS-79/31. 103pp.

Currier, P.J., G.R. Lingle, & J.G. VanDerwalker. 1985. Migratory bird habitat on the Platte and North Platte Rivers in Nebraska. Platte River Whooping Crane Critical Habitat Maintenance Trust, Grand Island, NE 177 pp.

Currier, P.J. 1995. Woody vegetation expansion and continuing declines in open channel habitat on the Platte River in Nebraska. Platte River Whooping Crane Critical Habitat Maintenance Trust. Grand Island, NE 19pp.

Ehrenfeld, J.G. 1993.The scientific basis for preserving wetlands. The Philadephia Society for Promoting Agriculture, Proc.

Erickson, N.E., & L.M. Leslie. 1987. Soil-vegetation correlations in the sandhills and Rainwater basin wetlands of Nebraska.U.S. Fish Wildl. Serv. Biological Report 87(11).

Frank, K., D. Beegle, and J.Denning. 1998. Phosphorous. p. 21-29. *In* J.R. Brown et al. (ed.), Recommended soil test procedures for the North Central Region (revised). North Central Regional Publication 221. Missouri Agricultural Station Bull. 1001 (revised).

Federal Register. 1994. Changes in hydric soils of the United States. U.S. Gov. Print Office, Washington, DC.

Frydman, I., & R.H. Whittaker 1968. Forest association of southeast Lublin province, Poland. *Ecology* 49(5):896-908.

Galatwotisch, S.M. 1998. A functional assessment of restored prairie wetlands and Implications for restoration programs. United States Geologic Survey, Northern Prairie Wildlife Research Center. Wetland Symposium, Proc.

Gauch, H.G., jr., G.B. Chase, & R.H. Whittaker. 1974. Ordination of vegetation Samples by Gaussian species distributions. *Ecology* 55-1382-1390.

Gauch, H.G., jr. 1982. Multivariate analysis in community structure. Cambridge University Press, Cambridge. MA.

Gelderman, R.H. and D. Beegle. 1998. Nitrate-Nitrogen. p.17-20. *In* J.R. Brown et al. (ed.), Recommended soil test procedures for the North Central Region (revised). North Central Regional Publication 221. Missouri Agricultural Station Bull. 1001 (revised).

Hall, R.B.W., and P.A. Harcombe. 1998. Flooding alters apparent position of floodplain saplings on a light gradient. *Ecology* 79(3)847-849.

Hausenbuiller, R.L. 1972. Soil Science; principles and practices. Wm. C. Brown Publishers, Dubuque, IA.

Henszey, R.J., J. Keough, and R. Swanson. 1998. Relationships between hydrology and biotic communities of riparian grasslands in the Central Platte River flood plain; project proposal. U.S. Geologic Survey Biological Resources Division Northern Prairie Wildlife Research Center, Jamestown, ND.

Hill, M.O. 1991. Patterns of species distribution in Britain elucidated by canonical correspondence analysis. *Journal of Biogeography*18:247-255.

Horne, A.J., and C.R. Goldman. 1994. Limnology second ed. McGraw-Hill, Inc. New York, NY.

Klute, A. 1986. Methods of soil analysis; Part 1, physical and mineralogical methods second ed. American Society of Agronomy.

LaGrange, T. 1997. Guide to Nebraska's wetlands; and their conservation needs. Nebraska Game and Parks Commision. Lincoln, NE.

Mausbach, M.J. 1994. Classification of wetland soils for wetland identification *Soil Survey Horizons* (spring):17-24.

McCune, B., and M.J. Mefford. 1999. PC-ORD. Multivariate analysis of ecological data, ver. 4. MjM Software Design, Glenden Beach, OR.

McCune, B. 1997. Influence of noisy environmental data on Canonical Correspondence Analysis. *Ecology* 78(8)261-77.

Michener, M.C. 1983. Wetland site index for summarizing botanical studies. *Wetlands* 3:180-191.

McIntosh, R.P. 1967. The continuum concept of vegetation. *Bot. Review* 33:130-187.

McGregor, R.L., T.M. Barkley, R.E. Brooks, & E.K. Schofield. Ed. 1986. Flora of the Great Plains. University Press of Kansas. Lawrence, KS.

Nagel, H., and B. Peterson. 1998-01. Alternative methods to maintain and/or enhance wet meadow habitat in and along the Platte River, Nebraska. Central Platte Natural Resources District, Nebraska Public Power District, Nebraska Game and Parks Commission.(unpublished research report).

Nantel, P., and P. Neumann. 1992. Ecology of ectomycorrhizal-basidiomycetecommunities on a local vegetation gradient. *Ecology* 73(1):99-119.

Palmer, M.W. 1993. Putting things in even better order: the advantages of Canonical Correspondence Analysis. *Ecology* 74(8). 2215-2230.

Palmer, R.G. and R.T. Frederick. 1995. Introductory Soil Science; laboratory manual. Oxford Univesity Press. New York, NY.

Rhoades, J.D. 1982. Soluble Salts. p. 167-179. *In* A.L. Page et al. (ed.), Methods of soil analysis. Part 2. second ed. Agronomy Monogr. 9. ASA and SSSA, Madison, WI.

Sidle, J.G., J.J. Dinan, M.P. Dryer, J.P. Rumancik, and J.W. Smith. 1988. Distribution Of the Least Tern in interior North America. *Am. Birds* 42:195-200.

Sidle, J.G., E.D. Miller, and P.J. Currier. 1989. Changing habitats in the Platte River Valley of Nebraska. *Prairie Nat.* 21(2):91-104.

Singer, M.J., and D.N. Munns. 1996. Soils; and introduction. third ed. Prentice-Hall, Inc. Upper Saddle River, NJ.

Soil Conservation Service. 1986. Wetland conservation provision of the Food Security Act of 1985 (draft). U.S. Dept. Agric., Soil Conserv. Serv., Washington, D.C.

Ter Braak, C.J.F. 1986. Canonical Correspondence Analysis: a new eigenvector Technique for multivariate direct gradient analysis. *Ecology* 67(5):1167-1179.

Ter Braak, C.J.F., and C.W.N. Looman. 1987. Regression. Pages 29-77 *in* R.H.G. Jongman, C.J.F. Ter Braak, and O.F.R. Van Tongeren, ed. Data analysis in community and landscape ecology. Pudoc, Wageningen, The Netherlands.

Ter Braak, C.J.F. 1997. CANOCO: a FORTRAN program for canonical Community ordination by (partial) (detrended)(canonical) correspondence Analysis. Principal components analysis, and redundancy analysis (ver. 2.1) Agriculture mathematics group. Wageningen, The Netherlands.

Tiner, R.W., and B.O. Wilen. 1983. The U.S. Fish and Wildlife Service's National Wetland Inventory project. Poster session, N. Am. Wildl. Nat. Resour. Conf. 48.

Thompson, J.A., and J.C. Bell. 1996. Color index for idenifying hydric conditions for Seasonally saturated mollisols in Minnesota. *Soil Sci. Soc. Am. J.* 60:1979-1988.

USDI Bureau of Land Management. 1996. Sampling vegetation attributes: interagency technical reference. BLM/RS/ST-96/002+1730.

U.S. Fish and Wildlife Service. 1981. The Platte River ecology study: special Research report. Northern Prairie Wildlife Research Center, Jamestown, ND.

U.S. Fish and Wildlife Service. 1988. Great Lakes and northern Great Plains Piping Plover recovery plan. U.S. Fish and Wildlife Service, Twin Cities, MN.

Van Derwalker, J. G. 1988. Preserving the Platte. The ICF Bugle 14(1)1-3. International Crane Foundation Quaterly Newsletter.

Warncke, D., and J.R. Brown. 1998. Potassium and other base cations. p. 31-33. *In* J.R. Brown et al. (ed.), Recommended soil test procedures for the North Central Region (revised). North Central Regional Publication 221. Missouri Agricultural Station Bull. 1001.

Whittaker, R.H. 1951. A criticism of the plant association and climatic climax Concepts. *Northwest Sci.* 25:17-31.

Whittaker, R.H. 1956. Vegetation of the Great Smoky Mountains. *Ecol. Monographs* 26:1-80.

Whittaker, R.H., & W.A. Niering. 1965. Vegetation of the Santa Catalina Moutains, Arizona: a gradient analysis of the south slope. *Ecology* 46(4):429-452.

Whittaker, R.H. 1967. Gradient analysis of vegetation. *Biol. Review* 42:207-26.

Williams, G.P. 1978. The case of the shrinking channels-North Platte and Platte Rivers in Nebraska. U.S. Geol. Surv. Circ. No. 781.

Appendix

Preface

This appendix provides the raw data used for all analyses for this study. The master data matrix is provided for both the soil and plant data. These matrices show specific plant species abundance at each site, and at each transect within that site. They also display the values for specific soil and environmental variables for each site and each transect within each site.

Also provided by this appendix is a detailed listing of all of the correlation coefficients for all of the plant species for each set of CCA analyses performed, and also for each transect analyzed for this study.

1a. Master data matrix for all soil parameters

Area Name	Yr.	Management Practice	Replicate	Relative Elevation	14-day High	14-day Low	Late season surface moisture (%)	ph	Salinity	Excess lime	OM	ppm N	lbs N/A	Ppm P	ppm K	Avg %sand	avg %silt	avg %clay	avg texture	%moist	avg. soil temp F	avg. perc. Vert cm. H20/10min
MICM, Field 2	00	G	1	0.0	0.25	-2.07	41	7.0	1.09	None	9.7	5.0	12	6	219	79	2	20	sl	31	71.2	0.33
	00	G	1	0.5	-0.22	-2.57	42	7.0	0.93	None	9.1	2.8	7	4	195	41	11	49	c	34	72.2	1.96
	00	G	1	1.0	-0.72	-3.07	40	7.6	1.04	High	5.1	4.1	10	4	158	50	9	41	c	26	75.2	0.03
	00	G	1	1.5	-1.22	-3.57	15	7.9	2.05	High	4.0	2.8	7	4	289	59	14	26	c	14	73.8	3.76
	00	G	1	2.0	-1.72	-4.07	2.3	7.1	0.21	None	1.7	0.2	1	4	154	63	10	27	scl	8	75.3	14.30
	00	G	1	2.5	-2.22	-4.57	-1	6.3	0.06	none	1.2	0.4	1	4	116	62	14	24	scl	7	78.3	9.86
	00	G	1	3.0	-2.72	-5.08	-1	6.2	0.08	none	2.0	0.6	2	4	75	66	20	14	sl	5	79.8	7.60
	00	G	1	3.5	-3.22	-5.58	-2	6.4	0.05	none	1.2	0.8	2	3	85	76	10	13	sl	5	80.1	11.56
	00	G	1	4.0	-3.72	-6.08	-2	6.2	0.05	none	0.8	0.5	1	4	134	76	10	14	sl	5	81.0	17.66
	00	G	1	4.5	-4.22	-6.58	-1	6.5	0.06	none	0.7	0.5	1	7	130	76	11	13	sl	4	81.6	7.06
MICM, Field 10	00	G	2	0.0	0.46	-1.77	37	6.9	1.31	none	6.3	1.8	4	10	445	40	7	54	c	32	69.3	1.96
	00	G	2	0.5	-0.04	-2.25	28	6.7	1.24	none	6.1	1.6	4	11	351	41	10	49	c	23	69.0	5.96
	00	G	2	1.0	-0.40	-2.72	25	7.6	1.40	none	6.8	3.6	9	8	192	50	9	41	c	21	69.2	19.90
	00	G	2	1.5	-0.87	-3.12	20	7.8	0.90	low	4.7	3.1	7	5	180	59	14	26	c	19	70.2	11.37
	00	G	2	2.0	-1.22	-2.91	14	8.0	0.63	low	4.3	3.3	8	5	118	63	10	27	scl	23	68.5	8.06
	00	G	2	2.5	-1.72	-3.41	8.2	8.4	0.38	high	4.6	3.1	7	6	112	62	14	24	scl	18	70.0	2.53
	00	G	2	3.0	-2.22	-3.90	6.5	8.2	0.27	high	3.1	1.4	3	4	83	66	20	14	sl	17	70.1	3.70
	00	G	2	3.5	-2.72	-4.39	2.2	7.9	0.31	none	2.7	0.4	1	5	102	76	10	13	sl	10	71.0	4.77
	00	G	2	4.0	-3.21	-4.85	0.8	6.8	0.31	none	2.7	0.6	2	5	180	76	10	14	sl	9	71.8	8.60
MICM, Field	00	G	3	0.0	0.99	-1.79	42	5.6	6.70	none	5.9	4.1	10	25	155							

12																						
	00	G	3	0.5	0.49	-2.29	31	7.0	1.07	none	3.0	0.6	1	10	142	63	11	25	scl	46	72.0	34.03
	00	G	3	1.0	-0.01	-2.79	43	7.6	1.69	low	6.6	5.9	14	8	250	57	16	28	cl	37	68.0	0.63
	00	G	3	1.5	-0.48	-3.29	21	7.9	1.17	low	3.1	3.7	9	5	175	70	12	25	scl	20	69.2	1.50
	00	G	3	2.0	-1.00	-3.78	18	7.2	1.01	none	12.4	17.7	43	12	279	81	5	14	sl	22	70.4	5.56
	00	G	3	2.5	-1.50	-4.28	16	7.9	1.14	high	4.3	4.7	11	6	176	78	9	13	sl	12	72.4	7.03
	00	G	3	3.0	-2.00	-4.78	10	8.0	0.98	high	2.3	2.6	6	4	114	78	9	13	sl	9	71.6	10.13
	00	G	3	3.5	-2.50	-5.28	11	7.6	0.32	none	1.5	0.5	1	4	155	79	8	13	sl	7	74.0	24.26
	00	G	3	4.0	-3.00	-5.78	5.6	7.2	0.14	none	1.2	0.3	1	4	157	83	8	9	ls	6	77.9	12.93
	00	G	3	4.5	-3.50	-6.28	2.2	6.5	0.10	none	1.7	0.7	2	4	198	83	8	9	ls	5	77.2	10.60
	00	G	3	5.0	-4.00	-6.78	1.6	6.5	0.12	none	2.1	1.4	3	3	239	79	10	10	ls	5	79.0	4.90
	00	G	3	5.5	-4.50	-7.28	1.9	6.6	0.09	none	1.9	0.7	2	4	319	80	10	11	ls	4	81.4	3.97
	00	G	3	6.0	-5.00	-7.78	0.8	7.0	0.10	none	1.5	1.9	4	4	383							
Binfield	00	G	4	0.0	0.99	-1.05	31	7.8	2.72	high	3.7	15.1	36	27	211	72	21	7	sl			
	00	G	4	0.5	0.49	-1.51	45	8.0	1.12	high	3.2	6.4	15	8	123	75	17	8	sl			
	00	G	4	1.0	-0.08	-2.00	45	6.8	0.79	none	6.6	5.3	13	6	139	81	15	4	ls			
	00	G	4	1.5	-0.58	-2.50	42	7.5	1.20	none	9.4	9.5	23	5	189	73	22	4	sl			
	00	G	4	2.0	-1.09	-2.99	38	8.0	0.82	high	4.9	7.8	19	5	116	69	25	6	sl			
	00	G	4	2.5	-1.59	-3.49	35	8.2	0.64	high	3.0	5.5	13	5	86	76	19	5	ls			
	00	G	4	3.0	-2.09	-3.98	30	8.2	0.49	high	2.8	5.4	13	5	146	77	19	5	ls			
	00	G	4	3.5	-2.59	-4.47	16	7.6	0.65	high	3.7	5.4	13	8	184	66	26	8	sl			
MICM-F6/Uridil	00	H	1a	0.0	0.10	-2.77	14	6.8	1.39	none	5.2	2.3	6	6	329	60	18	22	scl			
	00	H	1a	0.5	-0.39	-3.28	17	7.8	1.96	none	4.1	1.8	4	5	220	40	42	18	l			
	00	H	1a	1.0	-0.89	-3.78	14	7.9	1.70	high	5.8	6.7	16	6	136	41	42	17	l			
	00	H	1a	1.5	-1.38	-4.28	14	8.0	1.35	high	5.1	3.5	9	6	106	49	37	14	l			
	00	H	1a	2.0	-1.88	-4.78	8.1	8.2	0.91	high	3.4	1.6	4	5	74	69	25	5	sl			
	00	H	1a	2.5	-2.37	-5.29	3.6	8.3	0.27	low	2.5	0.8	2	5	205	70	25	5	sl			
	00	H	1b	0.0	-0.91	-3.11	24	7.6	0.89	none	6.0	7.5	18	8	124	45	29	26	l			
	00	H	1b	0.5	-1.41	-3.61	22	8.0	1.35	none	5.3	7.4	18	6	77	43	32	25	l			
	00	H	1b	1.0	-1.91	-4.11	16	7.9	1.25	high	6.4	6.5	16	7	104	50	35	15	l			
	00	H	1b	1.5	-2.44	-4.61	11	7.9	0.38	high	6.3	1.6	4	7	185	42	38	20	l			
	00	H	1b	2.0	-2.94	-5.11	9.3	8.0	0.35	high	7.4	7.3	18	6	178	47	39	15	l			

	00	H	1b	2.5	-3.44	-5.61	10	8.1	0.28	high	4.3	3.8	9	5	94	60	31	9	sl
	00	H	1b	3.0	-3.94	-6.11	7.9	7.7	0.22	low	4.1	2.5	6	6	136	60	31	8	sl
	00	H	1b	3.5	-4.44	-6.61	6.4	6.7	0.10	none	2.0	0.8	2	4	152	69	25	6	sl
MICM, Field 8	00	H	2	0.0	0.35	-2.32	16	6.6	2.03	none	5.1	1.8	4	17	258	30	32	37	cl
	00	H	2	0.5	-0.17	-2.84	14	6.5	1.61	none	8.4	2.1	5	8	278	35	36	29	cl
	00	H	2	1.0	-0.69	-3.39	19	7.0	1.40	none	6.9	1.0	2	6	148	33	37	30	cl
	00	H	2	1.5	-1.19	-3.89	13	7.7	1.65	high	4.8	1.3	3	5	102	57	30	13	sl
	00	H	2	2.0	-1.69	-4.40	6.3	8.1	0.86	high	3.9	1.8	4	5	71	62	27	11	sl
	00	H	2	2.5	-2.19	-4.90	1.8	8.1	0.19	none	3.6	0.9	2	5	81	69	25	6	sl
	00	H	2	3.0	-2.64	-5.35	0.6	7.5	0.21	none	3.7	1.0	3	5	102	72	25	3	sl
	00	H	2	3.5	-3.14	-5.85	1.8	6.2	0.21	none	2.9	0.1	1	4	84	72	24	4	sl
Wild Rose	00	H	3a	0.0	-1.52	-2.90	22	7.7	0.73	none	6.1	4.0	9	7	297	63	18	20	sl
	00	H	3a	0.5	-1.92	-3.31	30	8.2	0.60	none	3.9	0.6	1	5	225	53	35	11	sl
	00	H	3a	1.0	-2.36	-3.79	20	7.9	0.27	none	4.7	1.3	3	6	116	75	19	7	sl
	00	H	3a	1.5	-2.84	-4.26	12	7.3	0.22	none	2.5	8.0	19	5	117	87	9	3	ls
	00	H	3a	2.0	-3.25	-4.68	4.9	6.3	0.05	none	2.0	0.1	1	5	127	86	12	2	ls
	00	H	3a	2.5	-3.81	-5.24	4.3	6.4	0.06	none	1.7	0.3	1	5	154	86	12	3	ls
	00	H	3a	3.0	-4.32	-5.75	2.8	6.4	0.07	none	1.9	0.2	1	5	222	87	11	3	ls
	00	H	3a	3.5	-4.82	-6.26	2.4	6.3	0.13	none	1.8	0.8	2	7	178	86	11	3	ls
	00	H	3b	0.0	-0.31	-1.98	33	8.0	0.78	none	1.7	0.2	1	5	34	74	20	5	sl
	00	H	3b	0.5	-0.66	-2.33	33	8.3	1.00	none	4.2	2.9	7	5	74	69	27	4	sl
	00	H	3b	1.0	-1.24	-2.90	23	7.9	1.85	none	2.8	4.0	10	5	48	60	38	2	sl
Rowe Sanctuary	00	H	4a	0.0	0.26	-1.77	31	7.4	1.66	none	14.5	12.0	29	7	94	51	41	8	l
	00	H	4a	0.5	-0.24	-2.28	25	8.2	1.22	high	4.9	13.4	32	6	97	67	23	10	sl
	00	H	4a	1.0	-0.69	-2.85	17	7.5	0.81	none	9.6	8.8	21	6	110	53	34	13	sl
	00	H	4a	1.5	-1.19	-3.35	18	7.9	0.52	low	13.1	20.3	49	7	215	58	33	9	sl
	00	H	4a	2.0	-1.69	-3.85	18	8.1	1.11	high	11.9	16.9	41	7	132	51	42	7	l
	00	H	4a	2.5	-2.19	-4.35	16	8.2	0.57	high	6.3	4.7	11	6	264	52	35	13	l
	00	H	4a	3.0	-2.69	-4.86	14	8.1	0.31	high	4.6	4.1	10	6	192	61	33	6	sl
	00	H	4a	3.5	-3.25	-5.53	8.2	7.9	0.20	low	2.8	1.1	3	6	175	77	19	4	ls

	00	H	4a	4.0	-3.75	-6.03	6.7	7.1	0.20	none	2.9	0.9	2	6	238	76	21	3	ls			
	00	H	4a	4.5	-4.25	-6.53	6.4	6.7	0.10	none	2.8	0.5	1	6	233	74	22	3	ls			
	00	H	4a	5.0	-4.75	-7.03	5.6	7.0	0.13	none	2.1	2.6	6	5	290	74	22	3	ls			
	00	H	4b	0.0	0.03	-2.19	36	7.6	1.46	none	9.7	11.7	28	8	84	58	30	12	sl			
	00	H	4b	0.5	-0.46	-2.66	40	7.9	1.12	none	11.1	17.3	42	5	55	45	46	9	l			
	00	H	4b	0.9	-0.83	-3.02	30	7.9	1.54	low	5.6	8.4	20	6	149	52	30	18	l			
MICM, Field 3	00	R	1	0.0	0.96	-2.16	37	6.0	?	none	3.3	4.8	11	6	151	63	9	28	scl	30	65.2	7.67
	00	R	1	0.5	0.46	-2.67	39	7.2	1.25	none	2.0	1.5	3	5	137	35	12	52	c	36	65.7	1.37
	00	R	1	1.0	-0.11	-3.19	13	7.0	1.21	none	7.4	8.8	21	17	225	55	11	35	cl	30	67.8	12.46
	00	R	1	1.5	-0.66	-3.73	9.8	7.7	1.41	high	5.5	10.8	26	8	218	67	9	25	scl	19	67.9	7.13
	00	R	1	2.0	-1.16	-4.23	7.2	8.1	0.45	high	3.9	5.4	13	5	185	75	4	21	scl	15	69.2	6.26
	00	R	1	2.5	-1.67	-4.73	6.1	8.1	0.32	high	3.0	4.2	10	5	175	75	10	16	sl	11	71.2	6.83
	00	R	1	3.0	-2.17	-5.23	4.4	8.1	0.39	low	1.8	1.1	3	4	109	75	10	15	sl	8	72.7	5.06
	00	R	1	3.5	-2.67	-5.73	2.1	8.0	0.21	none	1.5	0.4	1	4	154	75	13	12	sl	6	71.5	10.00
	00	R	1	4.0	-3.24	-6.30	0.6	6.5	0.16	none	0.9	0.2	1	3	208	74	14	12	sl	6	74.5	9.56
MICM-F3/W Ruge	00	R	2a	0.0	0.58	-2.24	40	6.3	0.84	none	4.3	0.4	1	6	104	79	14	7	ls			
	00	R	2a	0.5	0.11	-2.71	39	6.5	0.96	none	7.3	0.2	1	4	51	69	21	10	sl			
	00	R	2a	1.0	-0.37	-3.20	24	6.6	1.24	none	8.4	0.7	2	4	75	73	21	6	sl			
	00	R	2a	1.5	-0.87	-3.70	22	7.8	1.37	high	5.6	3.5	8	4	69	74	19	7	sl			
	00	R	2a	2.0	-1.37	-4.20	8.5	7.8	2.37	high	6.5	2.9	7	4	105	65	26	9	sl			
	00	R	2a	2.5	-1.87	-4.70	5.6	8.4	0.83	high	5.0	9.3	22	5	105	67	23	10	sl			
	00	R	2a	3.0	-2.36	-5.20	4.2	8.2	0.78	high	2.8	2.7	6	4	234	76	18	5	ls			
	00	R	2b	0.0	-1.54	-3.40	16	7.5	0.30	none	3.4	0.4	1	4	163	81	13	6	ls			
	00	R	2b	0.5	-2.05	-3.91	11	8.2	0.24	high	2.9	0.3	1	4	123	58	33	9	sl			
	00	R	2b	1.0	-2.55	-4.41	9.9	8.3	0.20	high	2.0	0.4	1	4	149	80	17	4	ls			
	00	R	2b	1.5	-3.05	-4.91	8.4	8.2	0.17	high	2.1	0.7	2	4	151	82	14	4	ls			
	00	R	2b	2.0	-3.56	-5.42	14	8.1	0.23	high	2.7	1.3	3	5	163	56	36	8	sl			
	00	R	2b	2.5	-4.07	-5.93	13	7.8	0.24	low	3.0	1.2	3	5	151	75	19	7	sl			
	00	R	2b	3.0	-4.58	-6.43	4.9	6.7	0.06	none	2.0	0.4	1	4	199	82	15	3	ls			
	00	R	2b	3.5	-5.08	-6.94	4	6.6	0.05	none	1.5	0.4	1	4	187	83	14	3	ls			

	00	R	2b	4.0	-5.58	-7.44	4	6.9	0.08	none	1.9	0.4	1	5	230	83	14	3	ls
	00	R	2b	4.5	-6.08	-7.94	4.2	6.5	0.17	none	1.8	0.5	1	5	134	82	15	3	ls
Nature Center, NW	00	R	3	0.0	-0.21	-1.77	45	8.0	0.97	high	5.6	6.2	15	5	132	83	12	4	sl
	00	R	3	0.5	-0.71	-2.27	41	8.2	0.97	high	5.2	7.1	17	6	216	72	20	8	ls
	00	R	3	1.0	-1.21	-2.77	19	8.3	0.35	high	2.0	0.5	1	5	150	81	13	5	sl
	00	R	3	1.5	-1.71	-3.27	7.7	8.3	0.26	high	1.7	0.4	1	4	147	80	14	6	ls
	00	R	3	2.0	-2.21	-3.77	7.2	8.3	0.21	high	2.5	0.7	2	4	142	72	20	8	ls
	00	R	3	2.5	-2.71	-4.27	4	8.3	0.19	high	2.2	0.6	1	4	158	70	24	6	sl
	00	R	3	3.0	-3.22	-4.77	2.2	8.3	0.17	high	1.8	0.5	1	4	156	69	27	3	sl
	00	R	3	3.5	-3.72	-5.27	0.1	8.2	0.21	high	1.6	0.3	1	4	143	75	21	4	ls
	00	R	3	4.0	-4.22	-5.77	-1	8.0	0.56	high	1.8	0.1	1	4	172	68	29	3	sl
Nature Center, SE	00	R	4	0.0	-0.68	-2.08	33	8.1	0.45	none	1.6	1.5	4	5	78	90	6	4	ls
	00	R	4	0.5	-1.18	-2.58	36	8.2	0.40	high	4.4	6.4	15	7	125	66	23	11	sl
	00	R	4	1.0	-1.68	-3.08	27	8.5	0.39	high	2.5	2.0	5	5	186	66	26	8	sl
	00	R	4	1.5	-2.18	-3.58	18	8.4	0.41	high	2.5	1.0	2	5	222	62	32	6	sl
	00	R	4	2.0	-2.67	-4.08	6.6	8.4	0.31	high	2.8	1.1	3	5	299	62	31	6	sl
	00	R	4	2.5	-3.17	-4.58	3.3	8.3	0.21	high	2.7	0.9	2	5	276	69	27	4	Sl
	00	R	4	3.0	-3.67	-5.08	2.3	8.2	0.18	high	2.9	1.6	4	5	265	70	26	5	Sl
	00	R	4	3.5	-4.17	-5.58	1.3	8.4	0.17	high	1.8	0.7	2	5	241	69	28	3	Sl
	00	R	4	4.0	-4.67	-6.09	1.2	8.1	0.27	high	2.0	0.6	1	5	223	70	26	4	Sl

1b. Master Vegetation Data Matrix

To obtain a copy of a Master Vegetation Data Matrix, please contact;

Andrew Simpson, Bob Henszey, or Hal Nagel

2a. Transect correlations for CCA utilizing all sites

	Axis 1	Axis 2	Axis 3	Totals
1 G1 0	1.248829	0.625460	-0.053594	1.0000
2 G1 0.5	1.053379	0.634863	0.066650	1.0000
3 G1 1	0.328218	0.414838	0.251911	1.0000
4 G1 1.5	-0.103057	0.243070	0.413989	1.0000
5 G1 2	-0.546767	-0.002296	0.262428	1.0000
6 G1 2.5	-0.707049	-0.339136	-0.336242	1.0000
7 G1 3	-0.787156	-0.806948	-1.111816	1.0000
8 G1 3.5	-1.018589	-1.472613	-2.162021	0.9756
9 G1 4	-1.100005	-1.713590	-2.631493	0.9813
10 G1 4.5	-1.053874	-1.598661	-2.510509	0.9900
11 G2 0	1.224848	0.695081	-0.177491	1.0000
12 G2 0.5	1.144959	0.633482	-0.099992	0.9324
13 G2 1	0.212690	0.361406	0.328429	0.9950
14 G2 1.5	-0.023043	0.264656	0.274851	1.0000
15 G2 2	-0.109393	0.195168	0.268566	1.0000
16 G2 2.5	-0.235419	0.119269	0.264558	0.9949
17 G2 3	-0.450741	0.029729	0.256807	1.0000
18 G2 3.5	-0.587454	-0.051405	0.231886	1.0000
19 G2 4	-0.586340	-0.132595	0.105714	0.9950
20 G3 0	4.230290	-6.936183	2.776056	0.8465
21 G3 0.5	2.442065	-1.971374	0.068320	0.9749
22 G3 1	1.524548	0.162021	-0.392977	0.9904
23 G3 1.5	0.788142	0.457757	0.114754	1.0000
24 G3 2	0.674026	0.482979	0.140475	1.0000
25 G3 2.5	0.254029	0.348607	0.282793	1.0000
26 G3 3	-0.221358	0.209166	0.414760	1.0000
27 G3 3.5	-0.358808	0.092178	0.215938	0.9950
28 G3 4	-0.475319	-0.050707	0.055633	1.0000
29 G3 4.5	-0.538008	-0.164477	-0.029639	1.0000

30 G3 5	-0.618926	-0.291845	-0.168504	1.0000
31 G3 5.5	-0.689400	-0.447647	-0.281876	1.0000
32 G3 6	-0.631304	-1.114400	-0.442760	1.0000
33 G4 0	1.760246	0.054579	0.014371	0.9150
34 G4 0.5	1.508935	0.521781	-0.080493	0.9948
35 G4 1	1.179294	0.600488	-0.080701	0.9951
36 G4 1.5	0.497944	0.449608	0.048054	0.9953
37 G4 2	0.279141	0.407928	0.177629	1.0000
38 G4 2.5	-0.078968	0.188920	0.133779	1.0000
39 G4 3	-0.351614	-0.024415	0.055775	0.9858
40 G4 3.5	-0.556790	-0.206684	-0.061241	0.9951
41 H1a 0	0.957590	0.737508	0.089620	0.9950
42 H1a 0.5	0.668380	0.638913	0.227525	0.9900
43 H1a 1	0.070278	0.176897	0.091026	0.9950
44 H1a 1.5	-0.109507	0.168533	0.227040	0.9950
45 H1a 2	-0.360141	0.069158	0.282277	1.0000
46 H1a 2.5	-0.532670	-0.019382	0.345197	1.0000
47 H1b 0	0.403304	0.433589	0.042139	0.9950
48 H1b 0.5	0.157106	0.243306	0.071225	1.0000
49 H1b 1	-0.254369	0.075461	0.196512	1.0000
50 H1b 1.5	-0.527347	-0.065921	0.225347	1.0000
51 H1b 2	-0.592222	-0.049378	0.212910	1.0000
52 H1b 2.5	-0.645103	-0.033012	0.296801	0.9902
53 H1b 3	-0.620770	-0.140060	0.089803	0.9648
54 H1b 3.5	-0.725950	-0.254313	-0.079735	0.9747
55 H2 0	2.091516	-0.632894	-1.604797	0.9903
56 H2 0.5	0.980613	0.424476	-0.175384	0.9455
57 H2 1	-0.140939	0.181819	0.324191	1.0000
58 H2 1.5	-0.287923	0.140453	0.348627	1.0000
59 H2 2	-0.351252	0.100155	0.338361	1.0000
60 H2 2.5	-0.398781	0.071091	0.346384	0.9949
61 H2 3	-0.409788	0.062803	0.316909	1.0000
62 H2 3.5	-0.533092	-0.045254	0.201058	0.9950

63 H3a 0	-0.169804	0.036199	0.090634	0.9850
64 H3a 0.5	-0.304287	0.134604	0.324334	1.0000
65 H3a 1	-0.481732	-0.047882	0.222535	0.9951
66 H3a 1.5	-0.567115	-0.107078	0.183352	0.9950
67 H3a 2	-0.589734	-0.174201	0.123730	1.0000
68 H3a 2.5	-0.597296	-0.432292	-0.241071	1.0000
69 H3a 3	-0.731183	-0.724197	-0.614009	1.0000
70 H3a 3.5	-0.785142	-0.893365	-0.864646	0.9952
71 H3b 0	1.162060	0.780410	-0.052522	0.8850
72 H3b 0.5	0.779631	0.581653	0.046844	0.8000
73 H3b 1	0.242591	0.405603	0.341723	0.9900
74 H4a 0	1.080654	0.819108	0.062413	1.0000
75 H4a 0.5	0.618858	0.645702	0.247198	1.0000
76 H4a 1	0.269422	0.410856	0.299887	1.0000
77 H4a 1.5	0.033326	0.468594	0.383831	1.0000
78 H4a 2	-0.264065	0.334191	0.465968	0.9950
79 H4a 2.5	-0.452144	0.204820	0.506519	1.0000
80 H4a 3	-0.502248	0.154955	0.471044	1.0000
81 H4a 3.5	-0.628786	-0.178742	0.056315	0.9569
82 H4a 4	-0.661992	-0.150935	0.128137	1.0000
83 H4a 4.5	-0.674237	-0.229879	-0.043670	0.9700
84 H4a 5	-0.655291	-0.142801	-0.051291	0.9898
85 H4b 0	1.186069	0.786136	-0.057865	0.9950
86 H4b 0.5	0.479409	0.505746	0.093308	1.0000
87 H4b 0.9	0.199167	0.452249	0.294659	1.0000
88 R 1 0	2.357029	0.289448	-4.466584	1.0000
89 R 1 0.5	1.753562	0.362534	-1.924175	0.9619
90 R 1 1	1.261601	0.553320	-0.185045	1.0000
91 R 1 1.5	0.394820	0.372689	0.035535	1.0000
92 R 1 2	-0.131204	0.125447	0.087117	1.0000
93 R 1 2.5	-0.293698	0.058190	0.133196	1.0000
94 R 1 3	-0.428588	-0.027344	-0.021732	0.9953
95 R 1 3.5	-0.550420	-0.107860	-0.032657	1.0000

96 R 1 4	-0.633004	-0.293642	-0.376019	0.9850
97 R2a 0	1.846009	-0.118220	-0.793708	0.9600
98 R2a 0.5	1.215486	0.568209	-0.007077	0.9750
99 R2a 1	0.495605	0.453882	0.277288	0.9950
100 R2a 1.5	0.033083	0.196458	0.224040	0.9550
101 R2a 2	-0.111176	0.229611	0.388760	1.0000
102 R2a 2.5	-0.279090	0.183837	0.404746	0.9899
103 R2a 3	-0.461614	0.115549	0.401109	1.0000
104 R2b 0	-0.451092	-0.051219	0.139404	1.0000
105 R2b 0.5	-0.540882	-0.008721	0.305786	1.0000
106 R2b 1	-0.632983	-0.041725	0.313403	1.0000
107 R2b 1.5	-0.614225	-0.057997	0.297967	0.9950
108 R2b 2	-0.617152	-0.011297	0.364630	1.0000
109 R2b 2.5	-0.705927	-0.369294	0.053701	0.9850
110 R2b 3	-0.772182	-0.609627	-0.446370	0.9900
111 R2b 3.5	-0.716386	-0.603238	-0.450576	0.9950
112 R2b 4	-0.817024	-0.834460	-0.848546	1.0000
113 R2b 4.5	-0.990466	-1.161535	-1.150730	1.0000
114 R3 0	1.153977	0.755542	0.009751	1.0000
115 R3 0.5	1.099133	0.582583	0.084365	1.0000
116 R3 1	-0.017625	0.273773	0.348328	1.0000
117 R3 1.5	-0.393672	0.162255	0.479268	1.0000
118 R3 2	-0.484442	0.095820	0.438306	1.0000
119 R3 2.5	-0.560359	0.077135	0.452333	0.9949
120 R3 3	-0.737671	-0.029559	0.479874	0.9950
121 R3 3.5	-0.815596	-0.075884	0.491129	1.0000
122 R3 4	-0.773775	-0.061919	0.472206	1.0000
123 R4 0	0.847425	0.527596	0.075156	0.9948
124 R4 0.5	0.631907	0.527855	0.156690	1.0000
125 R4 1	-0.000232	0.370890	0.435452	1.0000
126 R4 2.5	-0.227055	0.189770	0.344235	1.0000
127 R4 2.5	-0.477505	0.108661	0.431159	1.0000
128 R4 2.5	-0.586214	0.041555	0.422969	1.0000

129 R4 3	-0.686912	-0.052825	0.378957	1.0000
130 R4 3.5	-0.808609	-0.165095	0.326673	1.0000
131 R4 4	-0.820065	-0.238535	0.212568	1.0000

2b. Species correlations for CCA utilizing all sites

	Axis 1	Axis 2	Axis 3	Totals
1 Agropyro	-0.015270	-0.085523	0.793670	0.2416
2 Agropyro	-0.405314	1.791339	0.481399	0.1052
3 Agropyro	-0.186388	1.860638	0.722738	0.0651
4 Agrostis	-0.276384	0.374532	0.633514	8.8592
5 Allium c	0.586640	1.032427	-0.096363	0.0514
6 Ambrosia	0.746301	0.598483	0.319744	0.0849
7 Ambrosia	-0.830556	-0.929193	-0.656509	1.2868
8 Andropog	-0.735261	-0.006136	0.507917	20.2623
9 Antennar	-1.191922	-0.948368	-1.416818	0.1103
10 Apocynum	0.521049	0.583583	0.315295	0.1295
11 Asclepia	-0.559016	0.222847	1.640409	0.0448
12 Asclepia	-1.751172	-2.289447	-1.291161	0.0250
13 Aster er	-0.668137	-0.170076	0.187556	1.6220
14 Aster si	0.780518	0.764442	0.216282	1.7562
15 Bidens f	1.795771	-0.339457	-1.561298	0.0532
16 Boutelou	-1.227936	-1.067685	-0.666199	0.0901
17 Boutelou	-1.076334	-1.855694	-3.516215	0.3139
18 Boutelou	-1.138508	-2.538045	-1.283181	0.0543
19 Bromus i	-0.376413	-0.233664	-0.012876	4.0204
20 Bromus j	-0.561224	-0.321918	-1.204167	0.2155
21 Calamagr	0.841676	0.915075	0.440230	2.3039
22 Calamovi	-1.301631	-1.857677	-2.096045	0.8553
23 Callirho	-0.971492	-0.342210	0.518248	0.0549
24 Callirho	-0.969412	-2.011734	-1.662087	0.6460
25 Carex br	-0.743904	-3.508642	0.348716	0.1504
26 Carex cr	-0.455792	0.247892	0.455219	2.3346
27 Carex el	-1.247325	-1.952471	-2.693238	1.5241
28 Carex em	1.127306	0.795586	-0.076478	13.0194
29 Carex gr	-0.304100	-0.020870	1.031837	0.1296
30 Carex gr	1.577783	0.093515	-1.786029	0.2001

31 Carex me	0.971999	0.792117	0.637399	0.0453
32 Carex mo	-0.772223	-0.620666	-1.649815	0.0352
33 Carex pe	0.672434	0.777028	0.340576	3.2941
34 Carex pr	0.171908	-2.465246	0.130616	0.2008
35 Carex te	0.323650	0.202487	0.741873	0.3400
36 Carex vu	0.839464	0.982300	0.708990	0.0441
37 Cicuta m	1.037607	0.434554	-0.382879	0.0593
38 Cirsium	-0.177533	-0.111728	-0.834729	0.0990
39 Cyperus	-1.212605	-1.882635	-2.582643	0.2486
40 Dalea pu	-1.138760	0.030852	1.240990	0.0685
41 Desmanth	-0.333540	0.314416	1.170232	0.0445
42 Dicanthe	-0.915233	-0.906624	-1.448955	1.4341
43 Dichanth	-0.724742	0.229256	1.185494	0.0742
44 Eleochar	-0.079450	0.371293	0.701571	2.4572
45 Eleochar	1.670545	0.760371	-0.322323	2.6803
46 Eleochar	3.246987	-1.338820	-0.305501	0.0301
47 Eleochar	1.178185	1.042368	0.096002	0.3181
48 Equisetu	0.795332	0.492767	0.736017	0.3521
49 Equisetu	-0.580944	-0.346511	-0.105705	2.2702
50 Eragrost	-0.759682	-1.146842	-4.004278	0.1241
51 Eragrost	-1.142047	-2.228069	-1.852761	0.0781
52 Erigeron	-0.161109	0.107612	0.226392	0.0797
53 Festuca	0.170532	0.806768	1.014531	0.0780
54 Glycyrrh	-0.154409	-0.166211	-1.612814	0.2275
55 Helenium	0.722435	0.968025	-0.321918	0.0458
56 Helianth	0.017489	0.345865	0.653093	0.8330
57 Hordeum	0.782396	0.712709	-0.336868	0.1201
58 Hypoxis	-0.169010	0.270637	0.637620	0.2985
59 Juncus b	-0.786737	0.436787	1.504252	0.0250
60 Juncus d	0.500315	0.403135	0.220231	0.0399
61 Juncus t	1.988663	-0.758456	0.260813	0.0453
62 Leersia	2.406671	-1.063277	-0.736410	0.6629
63 Liatris	-0.342543	-0.169824	1.786450	0.0050

64 Lippia l	1.210149	1.005930	-0.094113	0.6201
65 Lithospe	-0.934044	-1.925982	-1.503008	0.0500
66 Lobelia	0.122106	0.529655	-0.104580	0.0293
67 Lotus co	-0.789740	-0.963701	-1.552437	0.4916
68 Ludwigia	4.938227	-9.274987	4.442635	0.5706
69 Lycopus	1.263212	0.402468	-0.377032	0.0701
70 Lycopus	1.297951	0.795002	-0.040875	0.1872
71 Lysimach	0.124232	0.173530	0.451062	0.0500
72 Lysimach	1.627394	0.367789	-1.177954	0.1274
73 Medicago	-0.622182	-0.267336	-0.205107	1.3520
74 Melilotu	-0.719870	-0.161480	-1.252899	0.4609
75 Mentha a	1.433083	0.535836	-1.210785	0.0300
76 Muhlenbe	0.060813	0.775180	1.108877	0.3381
77 Oxalis s	-0.891340	-0.639899	-1.252176	0.1651
78 Panicum	-0.008717	0.457077	0.537022	5.5228
79 Paspalum	-1.128819	-2.207325	-2.768023	0.0389
80 Phalaris	1.518228	-0.090575	-0.669521	0.2453
81 Poa prat	-0.606561	-0.302167	-0.217686	20.4667
82 Polygonu	2.661449	-0.554323	-3.631100	0.6056
83 Polygonu	2.293950	-0.850083	-1.868548	1.2299
84 Prunella	-0.304001	-0.129531	-0.733310	0.1739
85 Pycnanth	-0.602673	0.026485	0.994968	0.0299
86 Ranuncul	1.904735	0.048801	-2.272588	0.0446
87 Ratibida	-0.769397	-1.362623	-2.975579	0.0501
88 Rosa woo	-1.203004	-0.202174	1.314193	0.0897
89 Rudbecki	-0.570059	0.015239	0.259756	0.1540
90 Schizach	-1.225929	-0.147665	0.889430	2.2880
91 Scirpus	1.726718	0.039354	0.067042	3.5788
92 Scirpus	2.348598	1.080319	-6.324679	0.9044
93 Scutella	1.875708	0.552008	-0.940668	0.0686
94 Senecio	-0.989805	-0.992310	-1.459736	0.0452
95 Smilacin	-0.565604	0.049926	0.622375	0.3895
96 Solidago	0.212066	0.407623	0.366427	0.8286

97 Solidago	0.156875	0.548652	0.581124	0.2847
98 Solidago	-1.005116	-0.721407	-1.268441	0.0549
99 Solidago	-0.959331	0.148409	1.413937	0.1032
100 Sorghast	-0.550666	0.289176	0.662798	3.6257
101 Spargani	4.412408	-7.507234	3.139739	0.4468
102 Spartina	1.048862	0.830806	0.106475	4.0097
103 Sporobol	-1.337974	-0.652406	0.222297	0.3881
104 Sporobol	-1.076832	-1.915478	-3.334332	0.8249
105 Stipa co	-1.771982	-2.536896	-1.519485	0.1600
106 Taraxacu	-0.504931	-0.279790	0.009434	0.1093
107 Teucrium	0.824688	0.650790	-1.488879	0.0144
108 Toxicode	0.276997	0.243363	-0.436918	0.0301
109 Trifoliu	-0.366207	-0.030532	0.199516	0.0445
110 Trifoliu	-0.024452	0.067407	0.461605	0.1830
111 Verbena	-0.874612	-1.122086	-1.338638	0.1994
112 Vernonia	0.486819	0.732587	0.177850	0.0946
113 Viola pr	-0.203521	0.021935	-0.190791	0.4186
114 Xanthium	3.291460	-4.613932	1.538396	0.0397

3a. Grazed sites CCA transect correlations

	Axis 1	Axis 2	Axis 3	Totals
1 G1 0	1.339079	0.556264	0.388013	1.0000
2 G1 0.5	0.663182	0.272228	0.388076	1.0000
3 G1 1	0.099337	0.289457	0.546196	1.0000
4 G1 1.5	-0.105387	0.525760	-1.106043	0.9953
5 G1 2	-0.433589	0.249033	-0.380724	0.9950
6 G1 2.5	-0.842358	-0.734516	1.019040	1.0000
7 G1 3	-0.837086	-0.849133	0.103725	1.0000
8 G1 3.5	-1.137155	-0.938394	0.809703	0.9756
9 G1 4	-1.272770	-1.125246	1.284350	0.9766
10 G1 4.5	-1.193874	-1.170532	0.763289	0.9900
11 G2 0	1.112825	0.968005	1.054504	0.9420
12 G2 0.5	0.866609	0.501675	0.459339	0.8502
13 G2 1	0.495568	0.343060	-0.468971	0.9650
14 G2 1.5	0.145366	0.237694	0.086276	1.0000
15 G2 2	-0.388374	0.432030	-0.092437	1.0000
16 G2 2.5	-0.454669	0.329149	-0.291457	0.9949
17 G2 3	-0.643396	0.065083	-0.553394	1.0000
18 G2 3.5	-0.705521	0.059521	-0.725165	0.9798
19 G2 4	-1.020204	-0.095727	-0.086507	0.9850
20 G3 0	2.879872	-3.909536	-1.023898	0.8465
21 G3 0.5	1.435485	-0.290400	0.385607	0.9548
22 G3 1	1.076724	0.394429	-0.080402	0.9809
23 G3 1.5	0.374663	0.557958	-0.593778	0.9845
24 G3 2	0.273041	0.946363	0.478492	0.9897
25 G3 2.5	0.216058	0.154592	-0.534300	1.0000
26 G3 3	-0.176525	-0.120023	-0.723029	1.0000
27 G3 3.5	-0.150219	0.024456	-0.567792	0.9950
28 G3 4	-0.363998	0.004158	-0.781031	1.0000
29 G3 4.5	-0.656350	-0.317897	-0.132421	1.0000
30 G3 5	-1.000524	-0.601808	0.664401	1.0000

31 G3 5.5	-0.942334	0.040105	-0.432892	0.9850
32 G3 6	-0.724491	-0.339413	-0.855283	0.9045
33 G4 0	1.323574	-0.047147	0.840508	0.9150
34 G4 0.5	0.913544	0.552089	0.535949	0.9948
35 G4 1	0.958680	0.307793	0.533163	0.9852
36 G4 1.5	0.503382	0.618267	-0.019605	0.9718
37 G4 2	0.024740	0.601082	-0.265804	0.9800
38 G4 2.5	-0.107244	0.299863	0.008265	1.0000
39 G4 3	-0.308193	0.646068	-0.359733	0.9763
40 G4 3.5	-0.549725	0.082057	-0.302730	0.9803

3b. Grazed site CCA plant species correlation's

	Axis 1	Axis 2	Axis 3	Totals
1 Agropyro	-0.327895	0.456032	-1.488706	0.1419
2 Agrostis	-0.273914	0.229806	-0.846219	2.8048
3 Allium c	0.369965	0.969244	-1.147879	0.0463
4 Ambrosia	0.740552	0.511063	-0.479829	0.0652
5 Ambrosia	-0.717495	0.020519	-0.713894	0.4396
6 Andropog	-0.634268	0.045895	-0.718028	3.4894
7 Apocynum	0.618337	1.137138	0.648151	0.0201
8 Aster er	-0.667153	-0.022841	-0.715444	0.2787
9 Aster si	0.357615	0.661822	0.170484	0.5606
10 Boutelou	-1.592159	-1.817808	2.676047	0.3139
11 Bromus i	-0.592704	0.347033	-0.384078	0.6002
12 Bromus j	0.634870	0.742470	0.293715	0.0435
13 Calamagr	0.798244	0.743160	0.617171	0.5023
14 Calamovi	-1.374503	-1.601026	2.003887	0.2348
15 Callirho	-1.117046	-0.854952	-0.294282	0.3190
16 Carex cr	-0.298921	0.260150	-1.047616	1.1024
17 Carex el	-1.544424	-1.728335	2.465810	0.9533
18 Carex em	0.950471	0.769046	0.758227	4.6308
19 Carex gr	-0.218178	0.001414	-1.895237	0.0448
20 Carex pe	0.612370	0.780187	0.170832	0.7209
21 Carex pr	-0.600244	-0.257695	-1.610211	0.1250
22 Carex vu	0.684552	0.920488	-0.269488	0.0192
23 Cirsium	-0.500134	0.227689	-0.721158	0.0889
24 Cyperus	-1.520446	-1.742125	2.399006	0.1255
25 Dicanthe	-1.250645	-1.245773	1.141905	0.6171
26 Eleochar	-0.112676	0.494347	-1.244264	1.0336
27 Eleochar	1.268967	0.897411	1.633343	1.1146
28 Eleochar	1.566316	0.187526	2.009356	0.0301
29 Eleochar	0.985924	0.753978	-0.467956	0.1484
30 Equisetu	0.677738	0.749095	0.288803	0.1625

31 Equisetu	-0.670747	-0.249134	-0.034336	0.5309
32 Eragrost	-1.197177	-1.382556	1.635704	0.1241
33 Erigeron	-0.320376	0.487094	-0.612740	0.0547
34 Glycyrrh	-0.751128	-0.392345	0.675633	0.1678
35 Helenium	0.260478	0.803064	-0.256100	0.0458
36 Helianth	0.054613	0.594738	-0.635035	0.1948
37 Hypoxis	-0.364707	0.291628	-1.208809	0.0988
38 Juncus t	1.697469	-0.869521	0.010915	0.0303
39 Leersia	1.928371	-1.058760	-0.150012	0.3335
40 Lippia l	0.692230	0.759672	0.068415	0.4622
41 Lithospe	-1.047941	-0.448445	-0.208638	0.0399
42 Lobelia	-0.289397	0.847662	-0.843343	0.0244
43 Lotus co	-0.816087	-0.275882	-0.827285	0.4916
44 Ludwigia	3.337904	-5.066086	-1.934586	0.5261
45 Lycopus	0.881650	0.783080	0.725709	0.0306
46 Lycopus	0.692943	0.715195	-0.483189	0.0481
47 Lysimach	1.105149	0.772577	-0.064046	0.0440
48 Medicago	-0.867642	-0.130200	-0.545044	0.4127
49 Muhlenbe	0.140671	0.753138	-0.238163	0.0588
50 Oxalis s	-1.092078	-0.489675	-0.031385	0.0350
51 Panicum	-0.158349	0.580878	-0.679064	1.3479
52 Paspalum	-1.461075	-1.486657	1.888752	0.0339
53 Poa prat	-0.719186	-0.074124	-0.432719	5.6753
54 Polygonu	2.136397	-1.408642	-0.067802	0.2924
55 Polygonu	1.663417	0.011712	0.731957	0.2128
56 Prunella	-0.371492	0.135070	-1.472916	0.1541
57 Ratibida	-1.058000	-0.915291	0.881939	0.0501
58 Rudbecki	-0.335442	0.593510	-0.429530	0.0394
59 Schizach	-0.983253	-0.651305	1.141945	0.2247
60 Scirpus	1.126802	0.440836	0.930240	2.2981
61 Scutella	1.488175	0.316259	0.398619	0.0539
62 Solidago	0.101853	0.381936	-0.456271	0.5542
63 Solidago	0.204278	0.703649	-0.421317	0.1819

64 Sorghast	-0.672856	0.052294	-0.642021	0.7428
65 Spargani	3.115113	-4.366458	-1.497245	0.3926
66 Spartina	0.999130	0.657272	0.709745	1.0293
67 Sporobol	-0.800084	0.340703	-1.002244	0.0151
68 Sporobol	-1.554329	-1.786865	2.436197	0.7758
69 Taraxacu	-0.921669	-0.748168	0.127567	0.0445
70 Trifoliu	-1.137580	-0.485438	0.095699	0.0151
71 Verbena	-0.927092	-0.323312	-0.528025	0.1494
72 Vernonia	-0.014904	0.954379	-0.353207	0.0448
73 Viola pr	-0.228302	0.224439	-1.036303	0.2092
74 Xanthium	2.867377	-3.735547	-1.142787	0.0250

4a.Hayed site CCA transect correlation's

	Axis 1	Axis 2	Axis 3	Totals
1 H1a 0	0.393664	1.251623	0.541068	0.9900
2 H1a 0.5	0.235997	0.699101	-0.464754	0.9801
3 H1a 1	0.283110	0.236924	-0.629931	0.9950
4 H1a 1.5	0.049949	0.172621	-0.439406	0.9950
5 H1a 2	-0.384621	0.099766	-0.512575	0.9950
6 H1a 2.5	-0.333987	-0.235946	-0.664836	0.9899
7 H1b 0	0.758437	0.050678	-0.101987	0.9849
8 H1b 0.5	-0.380473	0.121553	-0.066385	1.0000
9 H1b 1	0.082528	-0.250069	-0.121684	1.0000
10 H1b 1.5	0.038767	-0.796062	-0.690879	0.9950
11 H1b 2	-0.618587	-0.719234	-0.491255	0.9899
12 H1b 2.5	-0.878600	-0.763000	-0.442034	0.9854
13 H1b 3	-0.385812	-1.059507	-0.427289	0.9497
14 H1b 3.5	-0.868230	-0.787914	0.212518	0.9141
15 H2 0	5.261567	-1.247024	-0.097890	0.9614
16 H2 0.5	1.116253	0.363949	0.001549	0.8762
17 H2 1	0.093433	0.346485	-0.254623	0.9804
18 H2 1.5	-0.367878	0.405067	-0.028180	1.0000
19 H2 2	-0.423815	-0.153367	-0.594199	1.0000
20 H2 2.5	-0.366825	-0.427592	-0.825757	0.9949
21 H2 3	-0.288585	-0.360165	-0.454451	1.0000
22 H2 3.5	-0.337213	-0.204402	0.029614	0.9703
23 H3a 0	-0.131514	0.106533	0.801055	0.9750
24 H3a 0.5	-0.261861	0.350862	-0.118446	0.9809
25 H3a 1	-0.418387	-0.143421	0.551854	0.9951
26 H3a 1.5	-0.441791	-0.081665	0.541757	0.9900
27 H3a 2	-0.163438	-0.345980	0.809606	1.0000
28 H3a 2.5	-0.402441	-0.689246	0.973887	0.9949
29 H3a 3	-0.667254	-0.769020	1.187190	0.9606
30 H3a 3.5	0.099141	-1.413797	1.057255	0.9275

31 H3b 0	0.330527	1.271474	0.262965	0.8850
32 H3b 0.5	-0.087231	1.082061	0.290619	0.7900
33 H3b 1	0.249076	0.504746	0.170177	0.9650
34 H4a 0	0.237433	1.373182	0.279660	1.0000
35 H4a 0.5	0.315790	0.917426	0.085102	0.9902
36 H4a 1	0.014060	0.507671	-0.337502	1.0000
37 H4a 1.5	-0.162958	0.540965	-0.216652	1.0000
38 H4a 2	-0.161291	0.161928	-0.295708	0.9950
39 H4a 2.5	-0.287175	-0.159456	-0.391067	1.0000
40 H4a 3	-0.061880	-0.380855	-0.407387	1.0000
41 H4a 3.5	-0.325647	-0.537428	0.100359	0.9569
42 H4a 4	-0.062944	-0.703050	0.281497	1.0000
43 H4a 4.5	0.009400	-0.852401	0.217394	0.9700
44 H4a 5	-0.595279	-0.845693	0.242532	0.9898
45 H4b 0	0.848174	1.144807	0.475478	0.9950
46 H4b 0.5	-0.307988	1.524328	-0.148131	0.9950
47 H4b 0.9	-0.030808	0.800716	0.325737	1.0000

4b. Hayed sites CCA species correlation's

	Axis 1	Axis 2	Axis 3	Totals
1 Agropyro	-0.214378	0.222170	-0.778664	0.0498
2 Agropyro	-0.272338	0.375756	-0.574948	0.1052
3 Agropyro	-0.177434	0.756552	-0.937238	0.0651
4 Agrostis	-0.182862	0.340025	-0.784504	2.8072
5 Ambrosia	-0.341883	-1.627296	3.874678	0.1972
6 Andropog	-0.392460	-0.576743	-0.028276	7.7230
7 Antennar	-1.124508	-1.559279	0.451422	0.0905
8 Apocynum	0.365103	0.639744	-0.705877	0.1094
9 Aster er	-0.550661	-0.720300	-0.997858	0.5787
10 Aster si	1.223693	0.692543	-0.088632	0.3766
11 Bromus i	-0.302836	-0.417886	1.399899	3.4202
12 Bromus j	-0.518906	-1.496588	0.884793	0.1721
13 Calamagr	0.406936	1.888662	0.113038	0.8046
14 Calamovi	-0.397017	-2.012062	4.655615	0.2256
15 Callirho	-0.596436	-1.143609	-2.095226	0.0348
16 Callirho	-0.404648	-1.610043	3.087449	0.2082
17 Carex cr	-0.631316	-1.009538	-2.113781	0.9732
18 Carex el	-0.414044	-2.009511	4.706742	0.1908
19 Carex em	0.261021	1.600292	0.279960	4.5528
20 Carex gr	-0.288863	-0.209315	-2.276390	0.0848
21 Carex pe	0.221086	1.126229	0.026319	1.6483
22 Carex te	-0.035997	0.617700	-0.550593	0.2903
23 Carex vu	0.427985	1.510143	-0.467098	0.0200
24 Dicanthe	-0.368703	-1.121971	-0.020355	0.5028
25 Dichanth	0.077985	-1.072960	-1.844644	0.0450
26 Eleochar	-0.007993	-0.110674	-1.279740	0.7134
27 Eleochar	0.681226	2.099973	1.298832	0.8640
28 Eleochar	0.435537	1.940666	0.411225	0.1597
29 Equisetu	-0.150465	0.343097	-0.349016	0.0496
30 Equisetu	-0.236017	-0.023599	0.189274	0.7647

31 Eragrost	-0.126439	-2.322480	4.483354	0.0781
32 Erigeron	0.087280	0.327125	-1.591360	0.0150
33 Festuca	-0.362818	0.412726	0.635430	0.0780
34 Glycyrrh	0.238564	0.401157	-1.535018	0.0597
35 Helianth	-0.074271	0.172871	-1.787146	0.6283
36 Hordeum	0.687415	0.877481	0.098906	0.0901
37 Hypoxis	-0.121524	0.071693	-2.152139	0.1847
38 Lippia l	0.148064	1.541178	-1.808005	0.0400
39 Lycopus	2.318360	0.431993	-0.670333	0.0296
40 Lysimach	-0.063870	-0.101182	-0.402677	0.0453
41 Lysimach	3.916228	-0.335870	0.099477	0.0196
42 Medicago	-0.335144	-0.806073	-1.598364	0.7266
43 Melilotu	-0.266646	-0.435948	-1.008972	0.0298
44 Muhlenbe	0.253901	1.622555	-0.644470	0.0496
45 Oxalis s	-0.516343	-1.114586	-0.065702	0.0751
46 Panicum	-0.175742	0.347167	-0.429327	2.2977
47 Phalaris	3.202112	-0.358238	-0.485130	0.2260
48 Poa prat	-0.291110	-0.687571	0.304068	6.9914
49 Polygonu	6.598201	-2.182184	-0.369722	0.8518
50 Prunella	-0.101603	0.416481	-1.815888	0.0197
51 Pycnanth	-0.509955	-0.546125	-2.752074	0.0299
52 Rudbecki	-0.598751	-1.162581	-1.754582	0.1147
53 Schizach	-0.708745	-1.258617	-1.561296	0.4271
54 Scirpus	0.099641	1.056322	-0.517231	0.2396
55 Smilacin	-0.442872	-0.515090	-2.061425	0.3795
56 Solidago	-0.071428	0.408210	-0.857780	0.0300
57 Solidago	-0.982980	-1.498239	0.213736	0.0403
58 Sorghast	-0.341352	-0.244183	-0.831940	1.7755
59 Spartina	0.462244	1.518355	0.529400	2.1302
60 Sporobol	-0.287761	-1.885965	3.644253	0.0492
61 Toxicode	0.252564	0.160653	-0.669715	0.0301
62 Trifoliu	-0.405178	-0.073059	-1.503637	0.1493
63 Viola pr	-0.168771	-0.558205	-0.823170	0.144

5a. Rested site CCA transect correlation's

	Axis 1	Axis 2	Axis 3	Totals
1 R 1 0	2.905156	2.794492	3.004101	0.7295
2 R 1 0.5	2.155795	0.834173	0.817777	0.8810
3 R 1 1	1.562998	-0.634192	-0.810162	0.9360
4 R 1 1.5	0.538168	-0.234645	-0.387953	0.9804
5 R 1 2	-0.037513	0.058855	-0.159506	1.0000
6 R 1 2.5	-0.229238	0.046725	0.037114	1.0000
7 R 1 3	-0.371025	0.274258	0.228235	0.9953
8 R 1 3.5	-0.462479	0.343902	0.281063	1.0000
9 R 1 4	-0.483462	0.765616	0.106389	0.9800
10 R2a 0	1.930808	0.221952	0.162597	0.9250
11 R2a 0.5	1.371824	-0.727218	-0.812763	0.9700
12 R2a 1	0.568781	-0.521062	-0.366200	0.9801
13 R2a 1.5	0.092385	-0.178202	-0.119936	0.9550
14 R2a 2	-0.091672	-0.410931	0.029692	1.0000
15 R2a 2.5	-0.256413	-0.336525	0.207435	0.9799
16 R2a 3	-0.467774	-0.214603	0.390370	0.9752
17 R2b 0	-0.422655	0.136708	0.158223	0.9850
18 R2b 0.5	-0.510038	-0.152854	0.364154	1.0000
19 R2b 1	-0.597666	-0.147453	0.351444	1.0000
20 R2b 1.5	-0.573698	-0.079483	0.295181	0.9900
21 R2b 2	-0.580044	-0.231629	0.345204	1.0000
22 R2b 2.5	-0.594416	0.274280	-0.106146	0.9850
23 R2b 3	-0.527200	1.057864	-0.726650	0.9900
24 R2b 3.5	-0.484543	0.957212	-0.724302	0.9650
25 R2b 4	-0.542229	1.448415	-1.238501	0.9700
26 R2b 4.5	-0.618281	1.950039	-1.810238	0.9850
27 R3 0	1.431565	-0.769184	-0.864757	1.0000
28 R3 0.5	1.210587	-0.714363	-0.685345	0.9800
29 R3 1	0.032344	-0.483955	0.028967	1.0000
30 R3 1.5	-0.378445	-0.440375	0.411720	0.9904

31 R3 2	-0.467313	-0.380675	0.398797	1.0000
32 R3 2.5	-0.544746	-0.333199	0.459451	0.9949
33 R3 3	-0.687230	-0.261333	0.472673	0.9900
34 R3 3.5	-0.734452	-0.206785	0.346387	0.9950
35 R3 4	-0.707803	-0.243447	0.357161	0.9955
36 R4 0	1.152702	-0.623782	-0.591176	0.9948
37 R4 0.5	0.849959	-0.473592	-0.507739	0.9849
38 R4 1	0.055328	-0.538725	-0.017349	1.0000
39 R4 2.5	-0.179749	-0.331630	0.118925	1.0000
40 R4 2.5	-0.442704	-0.334454	0.355419	1.0000
41 R4 2.5	-0.556568	-0.265686	0.389763	1.0000
42 R4 3	-0.622534	-0.149075	0.290889	0.9800
43 R4 3.5	-0.707452	-0.001583	0.193294	1.0000
44 R4 4	-0.710828	0.131089	0.071547	1.0000

5b. Rested site CCA species correlation's

	Axis 1	Axis 2	Axis 3	Totals
1 Agropyro	0.204671	-1.265519	-0.215086	0.0498
2 Agrostis	-0.393054	-0.472489	0.691352	3.2472
3 Ambrosia	0.122581	-0.084133	0.130997	0.0146
4 Ambrosia	-0.500656	1.467131	-1.161473	0.6500
5 Andropog	-0.741777	-0.458584	0.656414	9.0499
6 Antennar	-0.713904	-0.401329	0.619586	0.0198
7 Asclepia	-0.442594	-0.697322	0.123274	0.0348
8 Asclepia	-0.787119	3.413731	-3.652270	0.0250
9 Aster er	-0.496918	0.044753	0.378559	0.7645
10 Aster si	0.935706	-1.087998	-0.801410	0.8191
11 Bidens f	2.027748	1.245458	1.304207	0.0193
12 Boutelou	-0.579420	1.998128	-1.648604	0.0850
13 Calamagr	0.768719	-1.022515	-0.468996	0.9970
14 Calamovi	-0.725906	3.262049	-3.067776	0.3950
15 Callirho	-0.637962	2.338545	-1.146428	0.1189
16 Carex br	-0.678449	1.225927	-2.286571	0.0450
17 Carex cr	-0.558617	-0.498548	0.924940	0.2590
18 Carex el	-0.805665	3.406187	-3.687088	0.3800
19 Carex em	1.591466	-0.473589	-0.544475	3.8358
20 Carex pe	0.904006	-1.190625	-0.753347	0.9249
21 Carex pr	0.996417	-1.124619	-0.899121	0.0610
22 Dalea pu	-0.922217	-0.449200	1.093016	0.0588
23 Desmanth	-0.322396	-0.790464	0.704166	0.0297
24 Dicanthe	-0.807713	0.646645	-0.281326	0.3142
25 Eleochar	-0.263072	-0.500793	0.756710	0.7103
26 Eleochar	1.832206	-0.882902	-1.384734	0.7017
27 Equisetu	0.405910	-1.124586	-0.905636	0.1399
28 Equisetu	-0.479978	0.895158	-0.865139	0.9746
29 Helianth	1.667757	-0.774790	-1.546473	0.0098
30 Hordeum	0.761908	-0.966866	-0.053494	0.0202

31 Hypoxis	-0.514964	-0.876591	0.238357	0.0150
32 Juncus d	0.751766	-0.554887	-0.486128	0.0252
33 Leersia	2.403117	0.308545	-0.055496	0.3294
34 Lippia l	1.558225	0.123569	0.063048	0.1179
35 Lycopus	1.507781	-1.081015	-1.296889	0.1391
36 Lysimach	2.067634	0.145882	-0.259071	0.0638
37 Medicago	-0.655324	0.302765	0.541764	0.2127
38 Melilotu	-0.475792	1.587634	1.210449	0.4211
39 Mentha a	1.615560	0.194257	0.217991	0.0200
40 Muhlenbe	-0.018834	-0.955077	0.552161	0.2298
41 Oxalis s	-0.555424	1.054968	-0.542204	0.0550
42 Panicum	0.146478	-0.355079	-0.408504	1.8772
43 Poa prat	-0.467392	0.695567	-0.166306	7.7999
44 Polygonu	2.984665	2.580964	2.756639	0.1653
45 Rosa woo	-1.208608	0.297460	-0.541007	0.0700
46 Schizach	-1.023823	-0.335897	0.081361	1.6362
47 Scirpus	1.254656	-0.761475	-0.651833	1.0411
48 Scirpus	3.152104	3.451020	3.722295	0.9044
49 Solidago	0.045823	-0.802840	-0.064713	0.2444
50 Solidago	0.050932	-0.012912	0.291050	0.1028
51 Solidago	-0.716302	-0.706021	0.916088	0.0983
52 Sorghast	-0.580078	-0.603920	0.647203	1.1074
53 Spargani	2.608691	1.583101	1.735946	0.0542
54 Spartina	1.441464	-1.009335	-1.535422	0.8502
55 Sporobol	-0.911715	0.907910	-0.165292	0.3238
56 Sporobol	-0.768902	2.690720	-3.051455	0.0395
57 Stipa co	-0.746927	3.657811	-3.703261	0.1600
58 Taraxacu	-0.351663	-1.205733	0.359030	0.0598
59 Verbena	-0.737963	1.430449	-2.078262	0.0500
60 Vernonia	0.062172	-0.161378	0.161696	0.0299
61 Viola pr	-0.388723	-0.349770	0.445501	0.0647

6a. CCA transect correaltion's for intensively sampled sites

	Axis 1	Axis 2	Axis 3	Totals
1 G1 0	-1.214777	0.673572	-0.217404	1.0000
2 G1 0.5	-0.608079	1.095634	-0.583762	1.0000
3 G1 1	-0.201740	0.169096	-0.446974	1.0000
4 G1 1.5	0.288832	0.318112	0.880322	0.9953
5 G1 2	0.689845	-0.058204	0.239225	0.9950
6 G1 2.5	0.701631	-0.740659	-0.852410	1.0000
7 G1 3	0.739048	-0.834314	-0.251196	1.0000
8 G1 3.5	0.921599	-1.039381	-0.751873	0.9756
9 G1 4	0.945027	-1.168715	-1.085576	0.9766
10 G1 4.5	0.864491	-1.190948	-1.159558	0.9900
11 G2 0	-1.194145	1.197548	-0.838200	0.9903
12 G2 0.5	-0.826359	0.945603	-0.371239	0.9130
13 G2 1	-0.215427	0.711490	0.383429	0.9650
14 G2 1.5	-0.042527	0.283675	0.052847	1.0000
15 G2 2	0.158740	0.271308	0.204082	1.0000
16 G2 2.5	0.466513	0.372660	-0.081690	0.9899
17 G2 3	0.471270	0.100698	0.329643	1.0000
18 G2 3.5	0.670478	-0.012191	0.370188	0.9798
19 G2 4	0.620249	-0.110024	0.218996	0.9900
20 G3 0	-3.058572	-3.423069	1.393963	0.8465
21 G3 0.5	-1.864704	-0.815275	-0.362525	0.9749
22 G3 1	-1.497536	0.584674	0.186266	0.8947
23 G3 1.5	-0.536414	0.696769	0.792570	0.9326
24 G3 2	-0.350458	0.830918	-0.189625	0.9897
25 G3 2.5	0.016941	0.090577	0.385898	1.0000
26 G3 3	0.338427	-0.109018	0.555543	1.0000
27 G3 3.5	0.478873	-0.177092	0.478732	0.9950
28 G3 4	0.614892	-0.418204	0.298278	1.0000
29 G3 4.5	0.598014	-0.352870	-0.091212	1.0000
30 G3 5	0.820082	-0.329919	-0.820242	1.0000

6a. CCA transect correaltion's for intensively sampled sites

	Axis 1	Axis 2	Axis 3	Totals
1 G1 0	-1.214777	0.673572	-0.217404	1.0000
2 G1 0.5	-0.608079	1.095634	-0.583762	1.0000
3 G1 1	-0.201740	0.169096	-0.446974	1.0000
4 G1 1.5	0.288832	0.318112	0.880322	0.9953
5 G1 2	0.689845	-0.058204	0.239225	0.9950
6 G1 2.5	0.701631	-0.740659	-0.852410	1.0000
7 G1 3	0.739048	-0.834314	-0.251196	1.0000
8 G1 3.5	0.921599	-1.039381	-0.751873	0.9756
9 G1 4	0.945027	-1.168715	-1.085576	0.9766
10 G1 4.5	0.864491	-1.190948	-1.159558	0.9900
11 G2 0	-1.194145	1.197548	-0.838200	0.9903
12 G2 0.5	-0.826359	0.945603	-0.371239	0.9130
13 G2 1	-0.215427	0.711490	0.383429	0.9650
14 G2 1.5	-0.042527	0.283675	0.052847	1.0000
15 G2 2	0.158740	0.271308	0.204082	1.0000
16 G2 2.5	0.466513	0.372660	-0.081690	0.9899
17 G2 3	0.471270	0.100698	0.329643	1.0000
18 G2 3.5	0.670478	-0.012191	0.370188	0.9798
19 G2 4	0.620249	-0.110024	0.218996	0.9900
20 G3 0	-3.058572	-3.423069	1.393963	0.8465
21 G3 0.5	-1.864704	-0.815275	-0.362525	0.9749
22 G3 1	-1.497536	0.584674	0.186266	0.8947
23 G3 1.5	-0.536414	0.696769	0.792570	0.9326
24 G3 2	-0.350458	0.830918	-0.189625	0.9897
25 G3 2.5	0.016941	0.090577	0.385898	1.0000
26 G3 3	0.338427	-0.109018	0.555543	1.0000
27 G3 3.5	0.478873	-0.177092	0.478732	0.9950
28 G3 4	0.614892	-0.418204	0.298278	1.0000
29 G3 4.5	0.598014	-0.352870	-0.091212	1.0000
30 G3 5	0.820082	-0.329919	-0.820242	1.0000

31 G3 5.5	0.933890	-0.092864	-0.221362	0.9900
32 G3 6	0.647973	-0.407268	0.485299	0.9045
33 R 1 0	-1.736353	-0.021420	-1.101997	0.4444
34 R 1 0.5	-1.312325	0.218953	-0.957114	0.7333
35 R 1 1	-1.214522	0.286212	-0.805118	0.9901
36 R 1 1.5	-0.190353	0.383267	0.113902	0.9902
37 R 1 2	0.187785	0.677142	0.437829	1.0000
38 R 1 2.5	0.337697	0.457830	0.537863	0.9900
39 R 1 3	0.504779	0.239263	0.937021	0.9953
40 R 1 3.5	0.589767	0.396273	0.922891	0.9902
41 R 1 4	0.502085	-0.049879	0.391040	0.9800

6b. CCA species correlation's for intensively sampled sites

	Axis 1	Axis 2	Axis 3	Totals
1 Agropyro	0.527555	0.098201	1.246446	0.0982
2 Agrostis	0.408548	0.209338	0.745473	3.2952
3 Allium c	-0.559821	1.110686	1.642462	0.0463
4 Ambrosia	-0.625344	0.455155	0.703326	0.0799
5 Ambrosia	0.830866	-0.404699	0.176372	0.3048
6 Andropog	0.620821	-0.008096	0.398375	3.6253
7 Apocynum	-0.546777	1.381791	-0.239774	0.0201
8 Aster er	0.664721	-0.054219	0.498988	0.3483
9 Aster si	-0.417313	1.019178	-0.206662	0.5614
10 Bidens f	-1.131958	0.597439	-0.779563	0.0241
11 Boutelou	1.152747	-1.915753	-2.753436	0.3139
12 Bromus i	0.395261	0.310985	0.356872	0.6002
13 Calamagr	-0.573559	1.139127	-0.352527	0.6411
14 Calamovi	1.051403	-1.656949	-2.051711	0.2348
15 Callirho	0.935124	-0.892895	-0.265859	0.3390
16 Carex cr	0.451614	0.000269	0.843428	0.9127
17 Carex el	1.142117	-1.837685	-2.472287	0.9533
18 Carex em	-1.098751	0.887928	-0.837147	4.7464
19 Carex gr	0.370485	-0.055769	1.514606	0.0399
20 Carex gr	-1.319764	1.295118	-1.673905	0.1751
21 Carex pe	-0.661839	0.965423	-0.079726	0.6662
22 Carex pr	0.523061	-0.232301	0.850888	0.1298
23 Cirsium	0.784950	-0.619829	0.335165	0.0300
24 Cyperus	1.126612	-1.827113	-2.396301	0.1255
25 Dicanthe	0.996388	-1.297318	-1.354285	0.6271
26 Eleochar	0.247589	0.311626	1.232951	0.7891
27 Eleochar	-1.296489	1.491398	-1.573766	0.6453
28 Equisetu	-0.963069	1.369490	-0.779882	0.0747
29 Equisetu	0.587633	-0.319981	-0.316410	0.5078
30 Eragrost	0.971577	-1.425440	-1.597332	0.1241

31 Erigeron	0.214269	0.307644	0.453815	0.0253
32 Glycyrrh	0.767936	-0.737724	-0.812515	0.1483
33 Helenium	-0.527979	0.948317	0.810234	0.0359
34 Helianth	-0.173048	0.697280	0.419267	0.2047
35 Hypoxis	0.637438	-0.450913	0.986145	0.0501
36 Juncus t	-1.998820	-1.174257	0.398400	0.0303
37 Leersia	-2.113528	-0.609366	-0.363802	0.4386
38 Lippia l	-0.862007	0.569085	0.572056	0.1759
39 Lithospe	0.957865	-0.536182	-0.684689	0.0352
40 Lotus co	0.844117	-0.411109	-0.044774	0.4916
41 Ludwigia	-3.487970	-4.547628	2.503036	0.5406
42 Lycopus	-1.060344	0.473602	-0.383321	0.0404
43 Lysimach	-1.237802	0.856939	-0.527306	0.0878
44 Medicago	0.865251	-0.269013	0.167115	0.4034
45 Melilotu	0.657221	0.289331	1.766909	0.4311
46 Muhlenbe	0.255493	0.730192	0.550186	0.0352
47 Oxalis s	0.880436	-0.436200	-0.315912	0.0500
48 Panicum	0.211013	0.485540	0.747521	1.2463
49 Paspalum	1.125097	-1.636110	-1.746656	0.0339
50 Poa prat	0.631956	-0.018688	0.505291	6.7965
51 Polygonu	-2.311667	-0.783718	-1.291646	0.6056
52 Polygonu	-1.927226	0.041082	-1.279893	0.3229
53 Prunella	0.705602	-0.532632	0.890572	0.1200
54 Ranuncul	-1.921672	-0.512171	-0.934290	0.0348
55 Ratibida	0.878322	-0.862996	-1.121763	0.0501
56 Schizach	0.867206	-0.767281	-0.925004	0.2296
57 Scirpus	-0.619162	0.862607	0.341045	1.2294
58 Scutella	-1.911792	0.161937	-0.336553	0.0587
59 Solidago	0.023604	0.466978	0.338513	0.6187
60 Solidago	0.059230	0.609519	0.793643	0.2847
61 Sorghast	0.604922	-0.072328	0.500436	0.7472
62 Spargani	-3.279253	-3.952038	1.896584	0.4118
63 Spartina	-0.969425	0.760535	-0.598384	1.0642

64 Sporobol	0.727410	0.190132	1.204961	0.0646
65 Sporobol	1.126148	-1.847908	-2.545329	0.7853
66 Taraxacu	0.819363	-0.646657	0.036389	0.0542
67 Trifoliu	0.994058	-0.431475	-1.002584	0.0151
68 Verbena	0.884954	-0.538233	-0.377683	0.1349
69 Vernonia	-0.006513	0.983438	0.589458	0.0200
70 Viola pr	0.532179	-0.317767	0.821538	0.1453
71 Xanthium	-3.140935	-3.646836	1.537435	0.0246