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A Comparison of Vegetation in Restored and Natural Wetlands in the Nebraska Sandhills.

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A Comparison of Vegetation in Restored and Natural Wetlands in the Nebraska Sandhills

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By

Warren Thomas Weaver

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ABSTRACT

Plant composition was compared between 3 restored and 3 natural Nebraska Sandhill wetlands using plot data collected from each wetland in July and August of 1995 along five randomly placed, 25m transects. A total of 126 species were identified, of which 72 were found only in the natural area and 23 only in the restored area; the natural wetlands averaged 58 species and the restored 31. Cluster analysis of mean cover values, at a Euclidean Distance of 1000, identified five vegetative associations in the natural and three in the restored wetlands. In addition, cluster analysis of combined data indicated a complete separation of the restored and natural wetlands. Ordination of combined data showed a tight clustering of the restored area plots midway along the X-axis (xeric-hydric gradient; Eigenvalue 0.78) suggesting that the restored area represents only a portion of the total gradient of the natural area. Three basic patterns of species distribution were identified based on the natural area data. Type I species distributions were characterized by *Scirpus acutus* which increased in canopy cover from being absent in the xeric upland to 18% cover in the hydric lowland. This species, however, was ubiquitous throughout the restored area averaging 2% cover. *Eleocharis erythropoda* characterized Type II species of both natural and restored wetlands with the highest canopy in the central plots of the natural area transect (26%) and even higher (55%) in the restored area. *Dichanthelium acuminatum* var. *implicatum* typified Type III species with a decrease in cover from xeric (11%) to absent in the hydric sites. Type III species were either absent.

ANOVA and Student-Newman-Keuls multicomparison test of species with a frequency of at least 10% showed significant differences ($p<0.05$) among at least two of three restored or natural wetland plots for *Agrostis stolonifera, Ambrosia psilostachya, Eleocharis acicularis, Eleocharis erythropoda, Eleocharis palustris, Lysicmachia ciliata, Lythrum alatum, Scirpus acutus, Spartina pectinata, Suim suave, and Typha* spp..

Based on community-level and species level analyses, the present study suggests that the restored Sandhill wetlands evaluated are not, presently, similar to natural wetlands and that it would be premature to suggest that the restorations are successful. Further, the results of this study suggest that serious wetland restoration efforts must ensure that basic abiotic (e.g. topographic) heterogeneity is provided in restoration sites. The difficulties, and probable costs, involved in ensuring successful wetland restoration should invite more serious efforts to prevent destruction of this habitat.

INTRODUCTION

Since European settlement, wetlands of the continental United States have declined 53%, from 89 to 42 million ha (Mitsch and Gosselink 1993). Wetland loss by state varies considerably. In Nebraska, for example, wetlands declined from 1.2 million ha in the 1780's to 0.77 million ha by the mid 1980's. Of the remaining Nebraska wetlands, 0.57 million ha occur in the Sandhills region (Mitsch and Gosselink 1993). In general, the primary cause of the loss of wetlands has been draining for agricultural purposes (Kentula et al. 1992). As wetland loss increased, however, so did public interest in wetlands. Due in part to this interest, a "no-net-loss policy" was established by the United States government as mandated by Section 404 of the Clean Water Act of 1977. This legislation states that damage to wetlands is to be avoided and, when unavoidable, must be mitigated by replacement or improvement of a wetland elsewhere. One direct result of this legislation has been the establishment of mitigation projects across the United States. Generally, the intent of such mitigation is the re-establishment of the vegetation as well as the hydrological, geochemical, and ecological processes associated with wetlands (Simenstad and Thom 1996). While this intent is commendable, is it achievable?

Studies using abiotic factors to assess restoration success showed varying results. For example, 24 of 40 wetland projects in Florida were considered to be either incomplete or failures based primarily upon differences in hydrology (Mitsch and Wilson 1996). In Connecticut, Confer and Niering (1992) evaluated five restored and five natural wetland sites and found that the restored sites had significantly greater amounts of open water, water depth, and water depth fluctuation then did the natural sites. Since hydrology is the most important factor driving wetland development, these variations may explain why different communities were found in the natural and restored areas (Bedford 1996). In addition to hydrology, regional and local community composition is influenced by pH, soil, and nutrient availability (Kenkel 1987). Variations in these factors, in combination, may create unique conditions resulting in each wetland differing to some degree from all others. Restoration of this abiotic diversity is likely to be difficult.

While the restoration of abiotic conditions is essential, the success of wetland restoration studies has been based largely on studies of the vegetation, which is presumed to reflect abiotic conditions. In general, biotic evaluations consist of measures of species occurrence and diversity. In Massachusetts, six wetland restorations were considered successful after the establishment of at least 75% cover of native wetland vegetation within two growing seasons (Jarman et al. 1991). This dual criteria of cover and time represents Massachusetts's definition of wetland restoration success. In the prairie pothole wetlands of the north-central United States, however, success has been measured by comparing restored and natural wetlands (Galatowitsch and van der Valk 1996). The prairie pothole restoration was considered successful because species richness was the same as that in the natural wetland, even though species composition differed. The difference in composition may have been due either to the seed bank in the restored wetlands containing fewer propagules or fewer species or to the isolation of the restored wetlands making it difficult for species with poor dispersal mechanisms to reach these sites.

Wetland restoration also has been considered successful with the recolonization of hydric sites by wetland species (Bishop 1981, LaGrange and Dinsmore 1989). Such recolonization has most likely been the result of a diversity of long-lived seeds in the seed bank (van der Valk 1978) in those wetlands where the substrate has been only slightly altered. Where the topography and base hydrology have been more substantially altered, the degree to which pre-disturbance conditions, particularly ecosystem functions, were successfully re-established is less clear, perhaps because of differences in how success is measured (Bishop 1981, LaGrange and Dinsmore 1989, Kentula et al. 1992 and van der Valk 1978). Overall, the results of studies suggest that wetland restoration, at best, takes a considerable period of time (Galatowitsch and van der Valk 1996, Mitsch and Wilson 1996, Simenstad and Thom 1996) and, at worst, practically speaking, is not possible.

A truly successful wetland re-establishment replaces not just appropriate species but also ecosystem functions such as flood retention, ground-water recharge, and the maintenance of water quality (Dennison and Berry 1993). Time and economics, however, make the assessment of pre- and post-disturbance ecosystem functions impractical. Thus, most federal and state regulatory agencies use the restoration of vegetation type and certain hydrologic considerations, such as water regimes, as criteria to measure success. The underlying assumption is that, for wetlands, there is a direct relationship between plant species composition and ecosystem function (Galatowitsch and van der Valk 1994); the presence of hydric species infers the presence of appropriate ecosystem function. The present study is also based on this assumption and, like other studies, is a comparison between natural and restored wetlands. Specifically, this study tested the null hypothesis that there was no difference between restored and natural wetlands in either community composition or spatial distribution of individual species.

METHODS

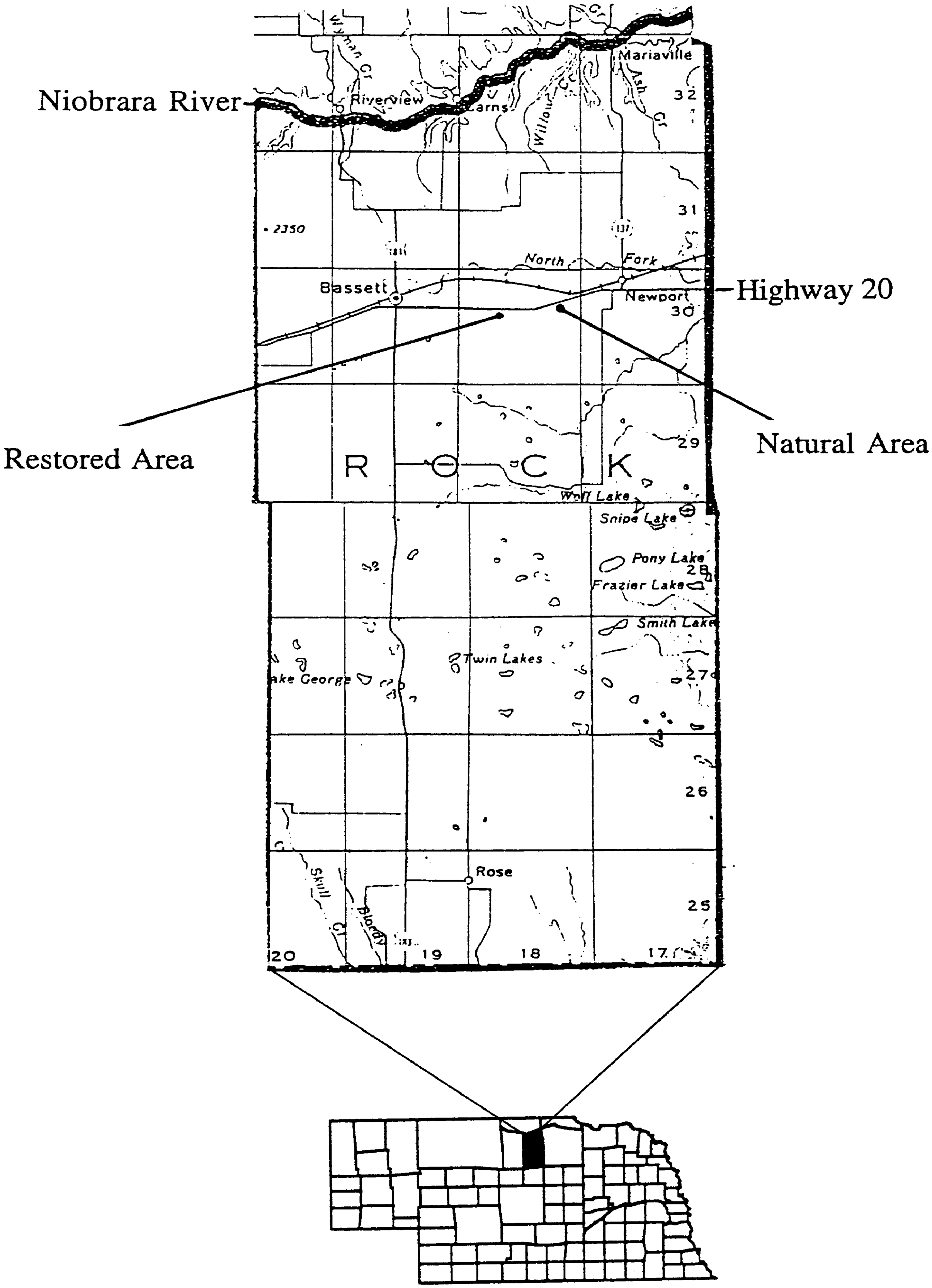
STUDY AREA

In 1993, the Wetlands Unit of the Nebraska Department of Roads restored 10 wetlands throughout the state for mitigation purposes. These restorations were accomplished first through manipulation of the land surface to achieve the proper topographic elevation and then through the reintroduction of vegetation using one of three procedures: (1) introducing a wetland seed mix, (2) planting seedlings, or (3) covering the substrate with hydric soils from natural wetlands that were presumed to contain seeds of wetland species.

Restored sites selected for this study were limited to those using hydric soil replacement since, after a thorough search, only this procedure provided enough sites for any type of replication within the Sandhills soil types. Due to difficulties in finding similar but spatially separate replicate sites, the three restored wetlands for this study were selected from within a single, 10 ha unit located at 42°34'07" North by 99°27'01"East (Fig. 1). This unit had been restored in 1993. Natural wetlands within 6.4 km of the restored site were used for comparison (42°35'15" North by 99°21'40" East).

In addition to proximity, soil type was a consideration in site selection. Prior to elevation manipulation, the area containing the restored wetlands consisted of a complex soil association dominated by a mesic aquic ustipsamments (Els loamy sand) with patches

Fig. 1. Location of study sites in the Rock County, Nebraska.


Niobrara River
Highway 20
Restored Area
Natural Area
Mariaville
Riverview
Bassett
Newport
North
Fork
R
O
C
K
Wolf Lake
Snipe Lake
Pony Lake
Frazier Lake
Smith Lake
Twin Lakes
Rose
32
31
30
29
28
27
26
25
20
19
18
17

of a mixed, mesic typic psammaquents (Tyron loamy sand) and a mesic typic haplaquolls (Loup sand). Soils of the natural wetlands were more homogenous, consisting of a mixed mesic, typic ustipsamments (Valentine-Els fine sand) (Zink et al. 1985).

In 1994, four wetland types were identified by Duecker (1995) at the restored site based on National Wetland Inventory classifications (Cowardin et al. 1979): Palustrine Aquatic Bed (PAB), Palustrine Emergent Semipermanently flooded (PEMF), Palustrine Emergent Seasonally Flooded (PEMC), and Palustrine Emergent Temporarily Flooded (PEMA). The natural sites contained PAB, PEMC, and PEMA wetland types (U.S. Fish and Wildlife Service 1987).

METHODOLOGY

At each wetland, vegetation was evaluated along five, randomly located, 25-meter line transects selected to include all sides of each wetland. Transect length was the minimum distance required to span all visible vegetative zones as determined from measurements taken in the natural wetlands before the study was initiated. Each transect originated in an adjacent xeric upland and proceeded directly downslope into standing water. Since vegetative zonation was identifiable in the native but not in the restored wetlands, stratified sampling of zones was not conducted. Instead, to ensure similar sampling protocols for each of the natural and restored wetlands, thirteen, $0.5m^2$ rectangular plots were placed at 2m intervals along each 25m transect. Plot 1 was established at the xeric (upland) end and plot 13 at the hydric (lowland) end, in standing water. The restored sites, however, lacked the topographic variation of the natural wetlands since they did not contain xeric uplands. The hydrology of the restored site plots, therefore, is approximately equivalent to that of plots 5 - 13 in the natural sites.

Sampling was conducted between July 25th and August 9th, 1995 using a canopy cover procedure modified from Daubenmire (1959). Canopy cover categories used were 1 = < 1%, 2 = 1 - 5%, 3 = 5 - 25%, 4 = 25 - 50%, 5 = 50 - 75%, 6 = 75 - 95%, 7 = 95 - 99%, 8 = > 99% cover. Midpoint values were used for analysis. Extensive flooding of all study areas in the Spring of 1995 prevented a spring evaluation. Original data is available from the author upon request. Voucher specimens were collected and are located in the University of Nebraska at Omaha Herbarium (OMA), in Omaha, Nebraska. Nomenclature follows the Great Plains Flora Association (1986).

Community analyses were conducted using the PC-ORD (McCune and Mefford 1995) version of Detrended Correspondence Analysis as well as cluster analysis, using group averages (Kenkel 1987, Coetzee et al. 1994, Peinado et al. 1994). Mean values used in ordination and cluster analysis were calculated by combining all plots with the same numerical designation (1-13) from a single treatment (i.e. natural or restored) (n=15).

ANOVA and the Student-Newman-Keuls (SNK) multicomparison tests, using SAS, (SAS Institute Inc. 1985) were run on canopy cover for those species with a frequency of at least ten percent in either the natural or the restored area. Mean values used in the SNK tests were calculated by combining all plots with the same numerical designation (1-13) from a single wetland (n=5).

Results and Discussion

Community-Level Comparison.

Cluster analysis depicted a gradual change in community composition from xeric to hydric in both the natural and restored wetlands (Figs. 2 and 3). The analysis of natural wetlands first grouped plots into mesic and hydric community categories, then, within each grouping, further divided them by transect location along the presumed moisture gradient. Plots located in the hydric portion of the natural wetland were clustered into fewer community types than were those in the mesic portion (Fig. 2). The restored wetlands were similarly divided into mesic and hydric communities although even fewer wetland communities were differentiated (Fig. 3). This difference in community divisions may be seen at various points along the Euclidean Distance shown. A comparison of Figs. 2 and 3 at a Euclidean Distance of 1000, for example, indicates five associations in the natural area and only three in the restored area. This difference, between natural and restored wetland areas, is expected because of the absence of the xeric, upland communities in the restored area which reduces that area's topographic heterogeneity when compared to the natural area. In addition to the number of communities at each upper-level division (e.g. at a Euclidean Distance of 1000), there is a difference between restored and natural areas in the number of plots contained within each community division. Upper-level divisions of the natural area are generally characterized by fewer plots than those in the restored area suggesting that it consists of generally narrower zones of vegetation, each relatively distinct from the adjacent ones. The greater clustering of

Fig. 2. Cluster analysis of the natural wetland community using group averages with Euclidean Distances. n1 = Plot 1 (xeric upland); n13 = Plot 13 (hydric lowland).

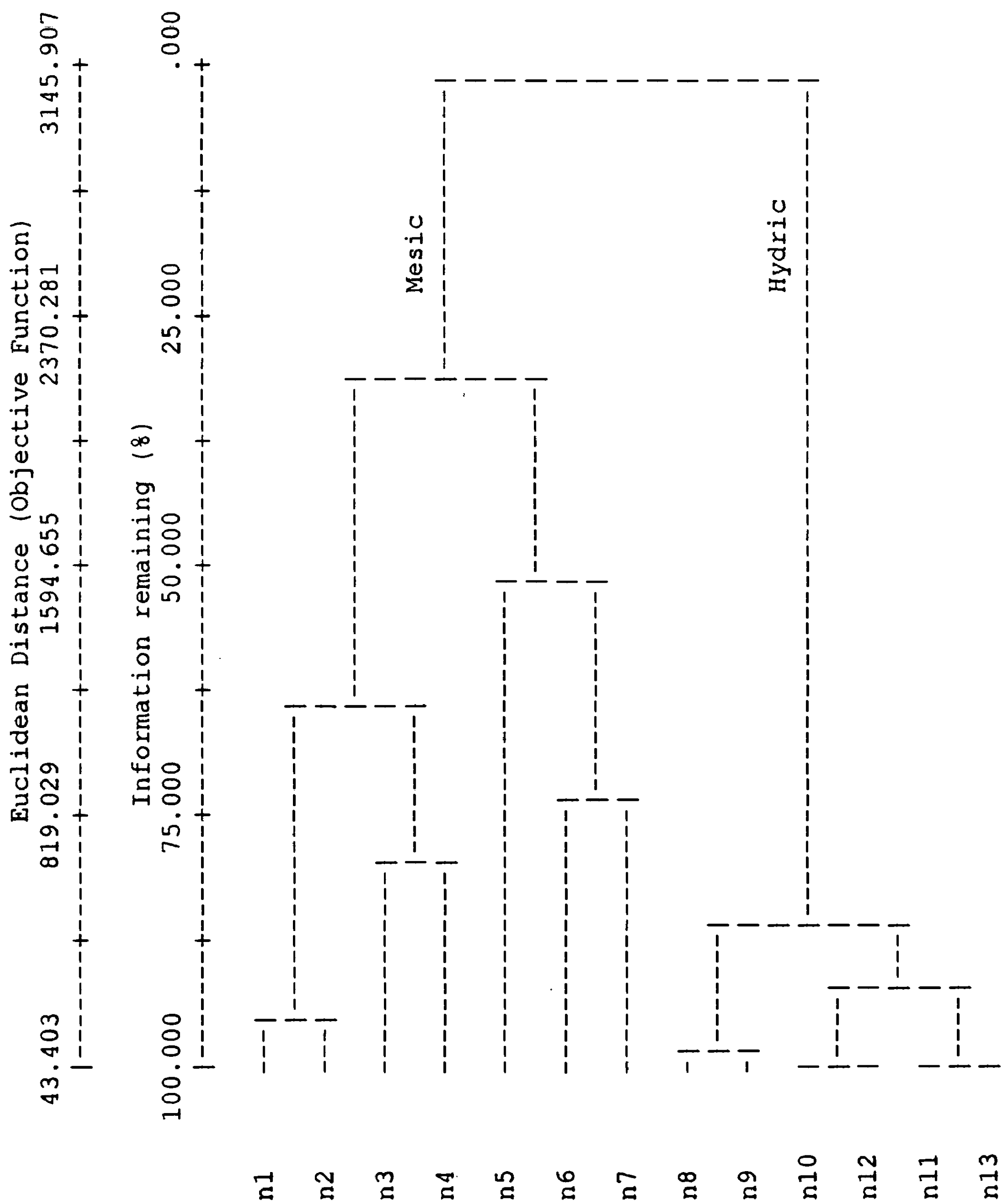
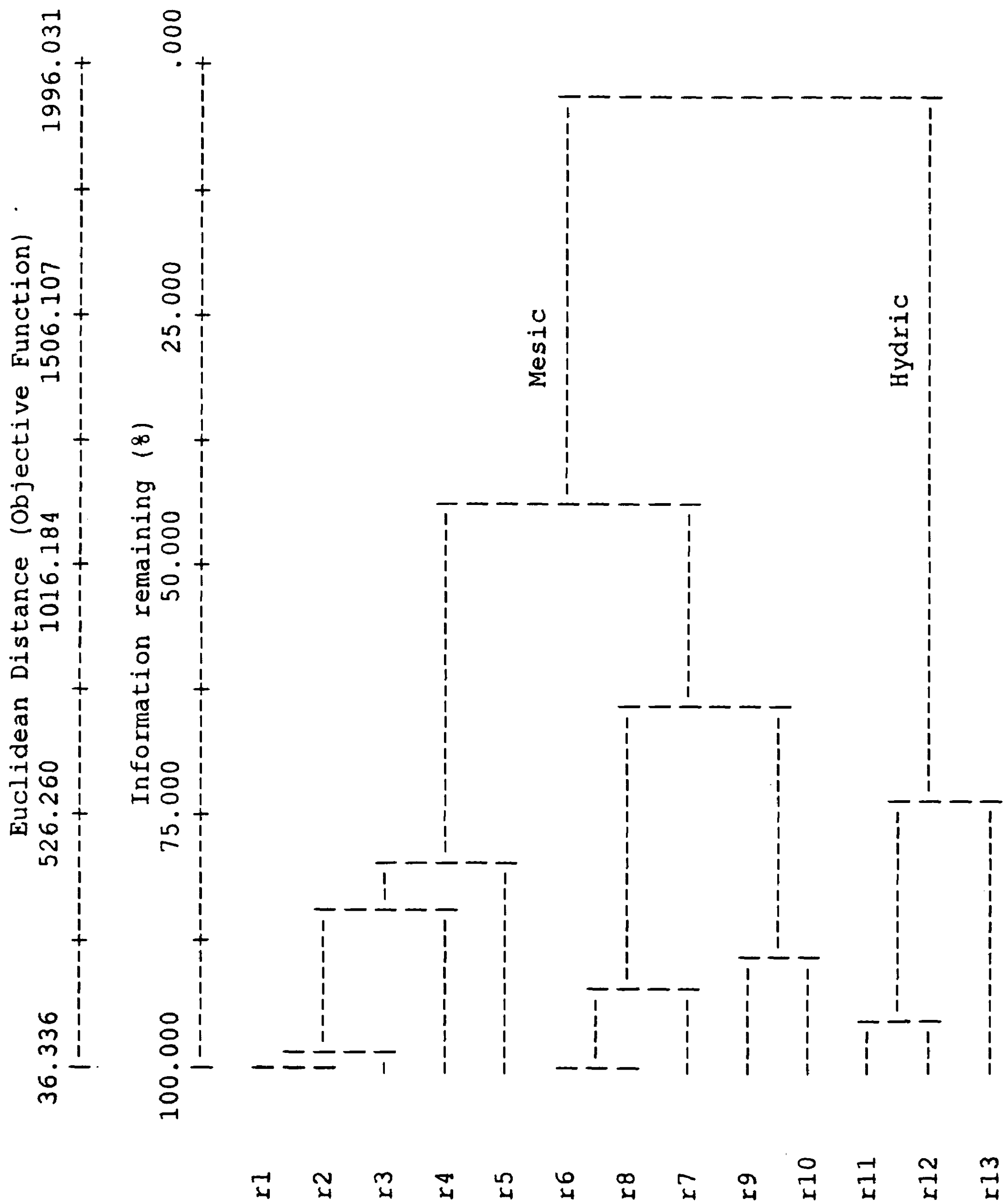

Euclidean Distance (Objective Function)
43.403
819.029
1594.655
2370.281
3145.907
Information remaining (%)
100.000
75.000
50.000
25.000
.000
Mesic
Hydric
n1
n2
n3
n4
n5
n6
n7
n8
n9
n10
n12
n11
n13

Fig. 3. Cluster analysis of the restored wetland community using group averages with Euclidean Distances. r1 = Plot 1 (xeric); r13 = Plot 13 (hydric).


Euclidean Distance (Objective Function)
36.336
526.260
1016.184
1506.107
1996.031
Information remaining (%)
100.000
75.000
50.000
25.000
.000
Mesic
Hydric
r1
r2
r3
r4
r5
r6
r8
r7
r9
r10
r11
r12
r13

plots in the restored area is consistent with the idea that zonation, if it occurs at all, occurs over a broader area than it does in the natural area. These results are consistent with the known physical differences where the restored area is topographically more homogeneous than the natural area.

Cluster analysis of combined data from the restored and natural areas exhibits complete separation of the restored and natural vegetative communities at a Euclidean Distance of approximately 3000 (Fig. 4). This aspect of the study, therefore shows that the restored area wetlands do not closely resemble any of communities that occur in the natural wetland. This differentiation between restored and natural wetlands is reflected also by ordination of the combined data from which a comparatively tight clustering of the restored area plots is shown roughly midway along the xeric-hydric gradient shown for the natural area (Fig. 5). This depiction also supports the previous conclusion of greater community homogeneity in the restored area whereas the distribution of the natural area plots along Axis 1 suggests both considerable community heterogeneity and narrow, relatively discrete vegetative zones.

Species-Level Comparison

A total of 126 species was found during this study of which 72 were found only in the natural area and 23 only in the restored area (Appendix Table A). Further, the average number of species for the natural area was 58 and that for the restored area was 31. In combination, these differences further support the previous conclusion of substantial differences between the natural and restored areas sampled.

Fig. 4. Cluster analysis of combined community data using group averages with Euclidean Distances. n1 - n13 = natural area (xeric to hydric) r1 - r13 = restored area (xeric to hydric).

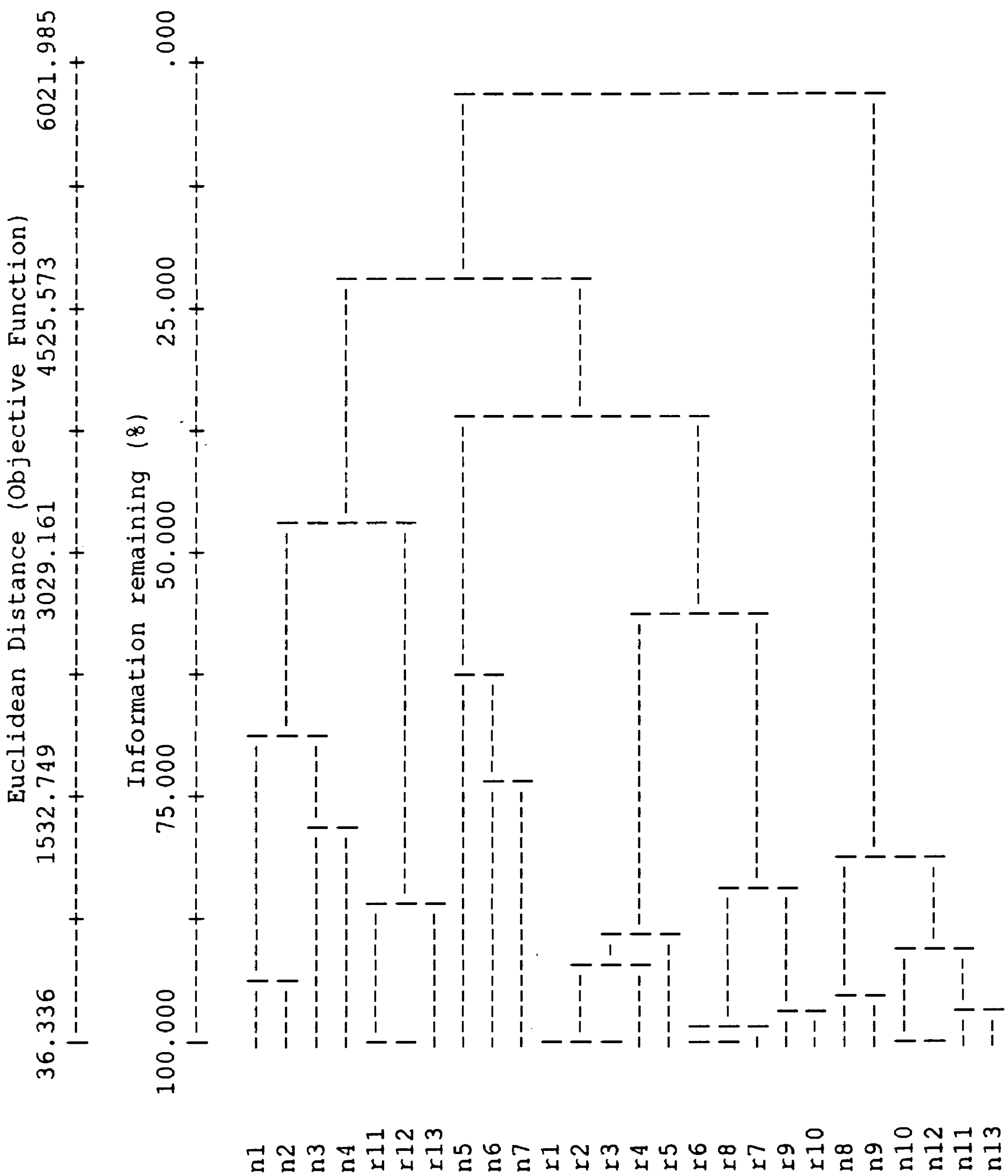
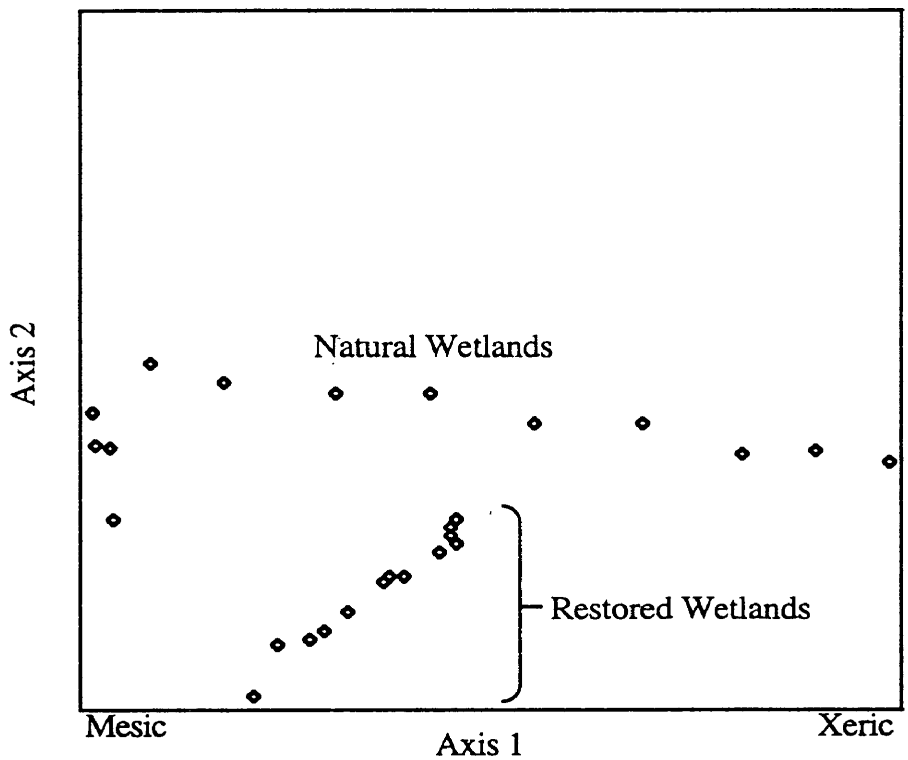

Euclidean Distance (Objective Function)
36.336
1532.749
3029.161
4525.573
6021.985
Information remaining (%)
100.000
75.000
50.000
25.000
.000
n1
n2
n3
n4
r11
r12
r13
n5
n6
n7
r1
r2
r3
r4
r5
r6
r8
r7
r9
r10
n8
n9
n10
n12
n11
n13

Fig. 5. Ordination of restored and natural area plots on the first two DCA axes. The Eigenvalue of Axis 1 is 0.7798; that of Axis 2 is 0.3014.



Axis 2
Natural Wetlands
Restored Wetlands
Mesic
Axis 1
Xeric

Species found only in the natural area, and with a cover value of at least 5% in any one of the sites, were *Amorpha canescens, Andropogon scoparius, Antennaria neglecta, Bromus japonicus, Bromus tectorum, Carex brevior, Carex pellita, Carex vulpinoidea, Cenchrus longispinus, Chenopodium pratericola, Cyperus* spp., *Cyperus strigosus, Dichanthelium acuminatum* var. *implicatum, Eleocharis palustris, Helianthus petiolaris, Hemicarpha micrantha, Hordeum jubatum, Juncus dudleyi, Juncus marginatus, Panicum virgatum, Phalaris arundinacea, Poa compressa, Polygonum convolvulus, Potamogeton* sp., *Sagittaria cuneata, Sisymbrium altissimun, Solidago missouriensis, Spartina pectinata,* and *Strophostyles leiosperma*. Some of these species reflect those of more xeric habitats which were absent from the restored sites. Species occurring in both restored and natural wetlands were *Agrostis stolonifera, Alisima triviale, Aster* sp., *Calamagrostis stricta, Carex* spp., *Eleocharis acicularis, Eleocharis erythropoda, Euthamia graminiifolia, Potamogeton nodosus, Scirpus acutus, and Typha* spp. Species that occurred only in the restored areas were *Bidens frondosa, Helianthus maximilianii, Helianthus* sp., *Leersia oryzoides, Ludwigia polycarpa, Lycopus asper, Lysimachia ciliata, Lythrum alatum, Salix exigua* subspecies *interior, Scirpus fluviatilis, Sium suave, and Sparganium eurycarpum.*

Individual Species Distributions

Assessment of the distribution of species along a topographic gradient, and presumably a soil-moisture gradient, was limited to those species with a frequency of at least 10% in either the natural or restored wetland. These species were classified into one of three groups based on their distribution in the natural wetlands: Type I species increase in canopy cover from xeric to hydric, Type II species have a maximum cover in the intermediate portion of the gradient, and Type III species decrease from xeric to mesic.

Scirpus acutus (Fig. 6) characterizes Type I species, which increase in cover along the presumed moisture gradient from the xeric upper slope to the hydric lowland. Other Type I species include *Eleocharis palustris, Typha* spp., *Alisima triviale, Potamogeton nodosus, Polygonum amphibium,* and *Urticularia vulgaris.* Three of these, *Eleocharis palustris, Typha* spp., and *Scirpus acutus,* are of special significance since their distribution along the gradient in the restored area differs substantially from that of their natural area cohort. In the restored area, *Scirpus acutus* is ubiquitous but its cover does not occur as a gradient as it does in the natural area (Fig. 6, Table 1) *Typha* spp. are also ubiquitous and in amounts exceeding that in the natural area, where they are absent except in the hydric plots. *Eleocharis palustris,* however, is absent in the restored area whereas it is ubiquitous in the natural area (Table 1).

Eleocharis erythropoda (Fig. 7) characterizes the Type II species, with highest canopy cover in central plots of the transect in the natural wetland area. Since, in the absence of xeric plots, the distribution shown for the restored area approximates that of the natural area from plots 5 through 13, the distribution of this species may be considered similar in both areas. Other Type II species with similar distributions in both the restored and natural wetlands include *Carex* spp., *Eleocharis acicularis, Calamagrostis stricta, Sagittaria cuneata, Spatina pectinata, Lycopus asper, Aster* spp., *Carex brevior, Juncus dudleyi, and Leersia oryzoides* (Table 1). *Eleocharis acicularis,* however is considerably

Fig. 6. Distribution of *Scirpus acutus* along sampling gradients in natural and restored wetland areas.

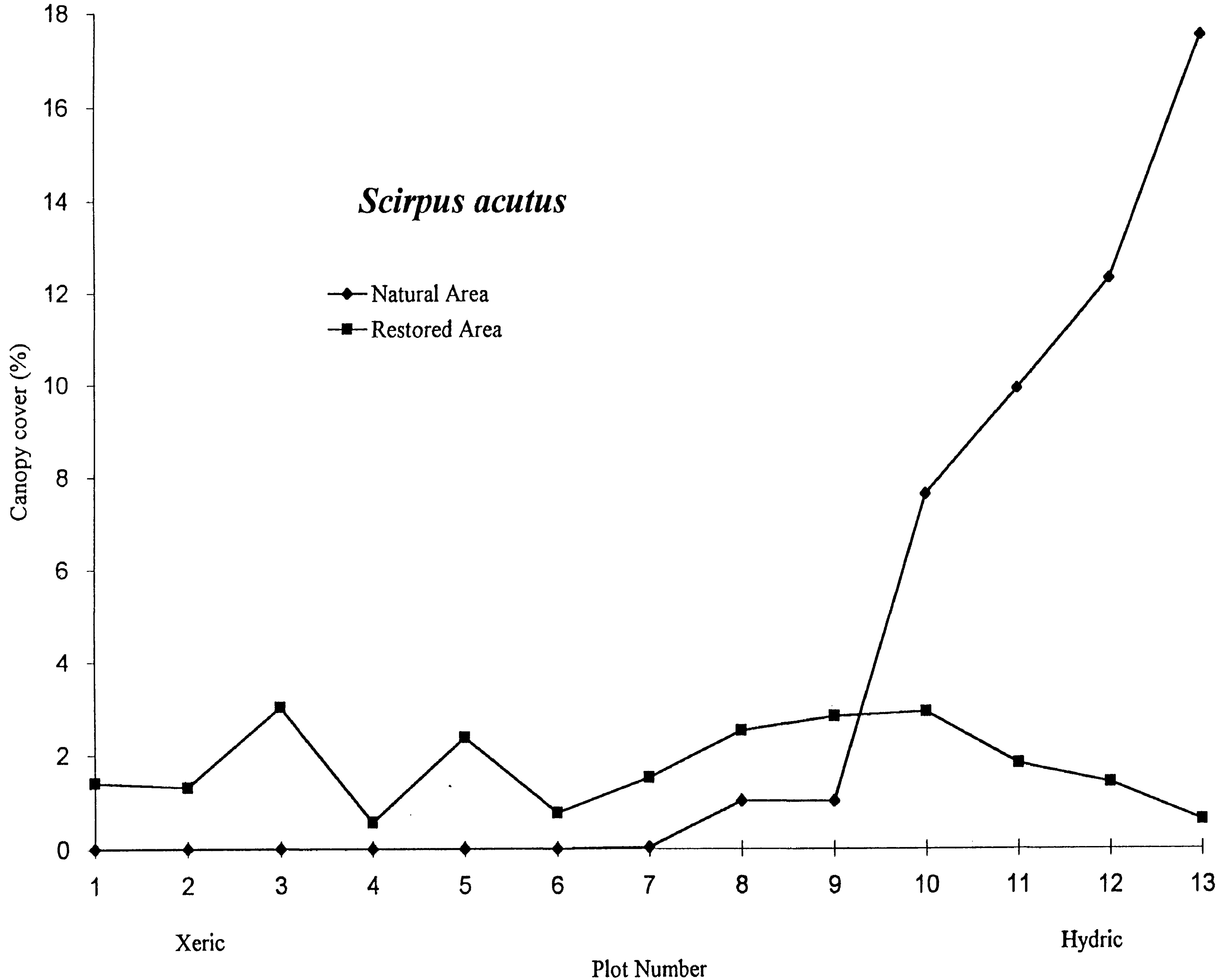

Scirpus acutus
Natural Area
Restored Area
Canopy cover (%)
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Xeric
Hydric
Plot Number

Table 1. Mean Canopy Cover of species with a frequency greater then 10%														
Species	**Study Area**	**Transect by plot**												
		Xeric												**Hydric**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Agrostis stolonifera	Natural	11	12	26	19	7	1	tr	0	0	0	0	0	0
	Restored	0	0	2	tr	tr	0	0	0	0	0	0	0	0
Alisma triviale	Natural	0	0	tr	tr	1	tr	1	3	2	1	4	1	1
	Restored	1	2	3	2	2	2	3	3	3	2	tr	3	1
Ambrosia psilostachya	Natural	3	3	1	1	tr	0	0	0	0	0	0	0	0
	Restored	0	tr	tr	tr	1	tr	tr	0	0	0	0	0	0
Artemisia ludoviciana	Natural	1	2	tr	tr	tr	0	0	0	0	0	0	0	0
	Restored	0	0	0	0	0	0	0	0	0	0	0	0	0
Aster spp.	Natural	0	tr	tr	1	5	2	tr	2	3	tr	0	0	0
	Restored	2	2	0	tr	tr	1	tr	tr	tr	0	0	0	0
Eleocharis acicularis	Natural	0	0	0	0	6	tr	12	8	1	0	0	0	0
	Restored	0	0	0	0	7	13	6	12	19	26	25	18	9
Eleocharis erythropoda	Natural	0	3	7	9	17	26	17	2	2	0	0	0	0
	Restored	44	47	48	55	42	32	31	35	27	18	8	3	tr
Eleocharis palustris	Natural	0	0	0	3	2	12	15	33	36	39	26	35	25
	Restored	0	0	0	0	0	0	0	0	0	0	0	0	0
Euthamia graminiifolia	Natural	6	8	4	2	1	3	tr	tr	0	0	0	0	0
	Restored	0	0	3	1	tr	0	0	tr	0	0	0	0	0
Calamagrostis stricta	Natural	1	tr	1	7	10	6	5	1	0	0	0	tr	0
	Restored	12	7	6	2	1	tr	5	tr	tr	0	0	0	0
Carex brevior	Natural	tr	tr	3	3	1	tr	0	0	0	0	0	0	0
	Restored	0	tr	0	0	0	0	0	0	0	0	0	0	0

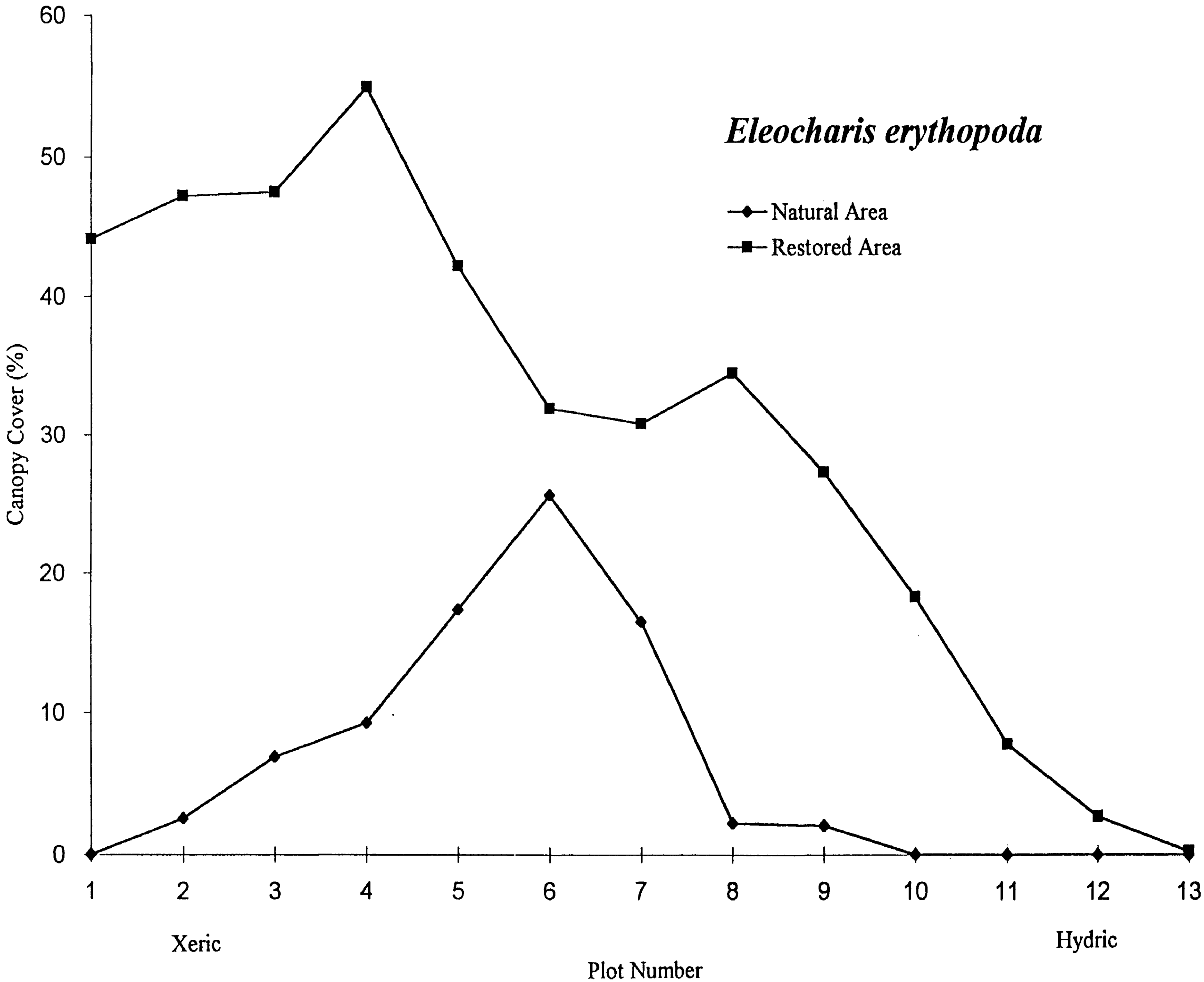
Table 1. Mean Canopy Cover of species with a frequency greater then 10%. Cont'd.

Species	Study Area	Transect by plot: Xeric 1	2	3	4	5	6	7	8	9	10	11	12	Hydric 13
Carex spp.	Natural	tr	4	4	18	28	10	7	10	3	1	3	1	0
	Restored	2	1	1	5	5	1	tr	2	tr	tr	tr	tr	tr
Dichanthelium acumin-	Natural	8	11	11	7	1	0	0	0	0	0	0	0	0
atum var. *implicatum*	Restored	tr	1	tr	tr	1	tr	tr	tr	0	0	0	0	0
Juncus alpinoarticulatus	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
	Restored	tr	2	2	1	tr	1	1	tr	tr	0	0	0	0
Juncus dudleyi	Natural	1	3	8	7	1	tr	0	0	0	0	0	0	0
	Restored	tr	1	1	1	1	tr	tr	tr	tr	0	0	0	0
Juncus torreyi	Natural	tr	tr	1	tr	1	1	0	0	0	0	0	0	0
	Restored	1	tr	1	2	tr	1	1	tr	tr	0	tr	0	0
Leersia oryzoides	Natural	tr	0	0	0	2	tr	0	0	0	0	0	0	0
	Restored	2	2	1	tr	tr	4	1	tr	tr	tr	0	0	0
Lycopus asper	Natural	0	0	0	tr	tr	tr	tr	0	0	0	0	0	0
	Restored	2	4	3	4	7	4	1	3	3	0	0	0	0
Lysimachia ciliata	Natural	0	0	0	0	1	1	0	tr	0	0	0	0	0
	Restored	1	2	1	1	1	2	tr	2	tr	tr	1	0	0
Lythrum alatum	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
	Restored	6	5	8	6	10	7	2	1	1	tr	tr	0	0
Polygonum amphibium	Natural	0	0	0	0	0	0	0	tr	tr	2	1	1	1
	Restored	0	0	tr	tr	0	0	0	0	0	tr	tr	0	0
Potamogeton nodosus	Natural	0	0	0	0	tr	tr	1	tr	2	1	1	3	2
	Restored	0	0	0	0	0	1	3	1	1	1	2	2	3

Table 1. Mean Canopy Cover of species with a frequency greater then 10%. Cont'd.

Species	Study Area	Transect by plot												
		Xeric												Hydric
		1	2	3	4	5	6	7	8	9	10	11	12	13
Sagittaria cuneata	Natural	0	0	0	tr	1	tr	11	7	7	tr	tr	tr	tr
	Restored	tr	0	0	0	0	tr	tr	1	1	tr	tr	tr	tr
Scirpus acutus	Natural	0	0	0	0	0	0	tr	1	1	8	10	12	18
	Restored	1	1	3	1	2	1	2	3	3	3	2	1	1
Suim suave	Natural	0	0	0	0	0	0	0	0	0	0	0	0	1
	Restored	4	5	3	4	4	2	2	tr	tr	tr	tr	tr	0
Spartina pectinata	Natural	0	0	tr	0	tr	9	5	1	1	tr	tr	0	0
	Restored	tr	0	tr	1	tr	tr	0	0	0	0	0	0	0
Typha spp.	Natural	0	0	0	0	0	0	0	0	0	0	0	0	6
	Restored	3	3	3	2	1	2	5	5	7	10	7	5	5
Urticularia vulgaris	Natural	0	0	0	0	0	0	0	0	tr	tr	1	1	1
	Restored	0	0	0	0	0	0	0	0	0	0	0	tr	2

Fig. 7. Distribution of *Eleocharis erythropoda* along sampling gradients in natural and restored wetland areas.



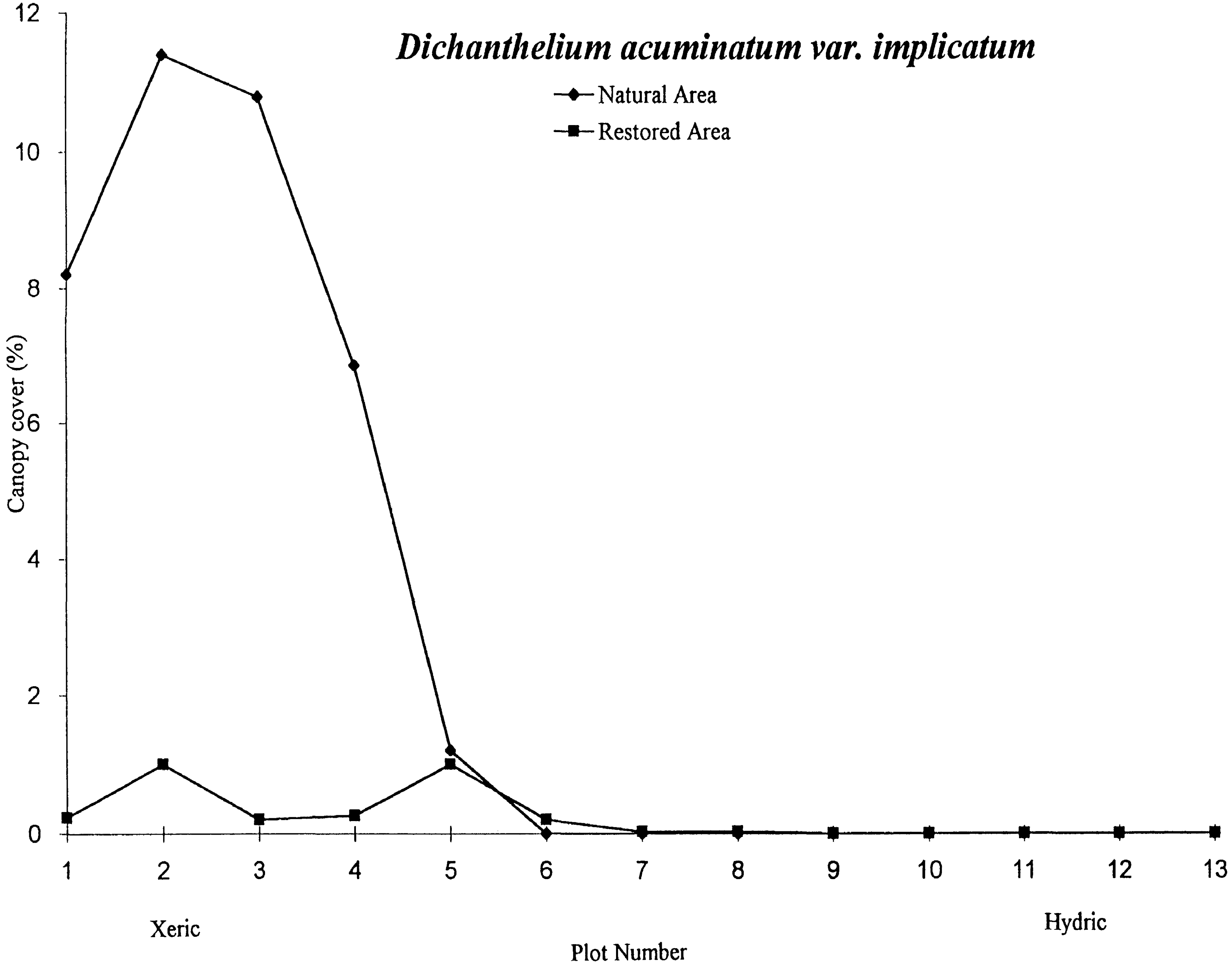
Eleocharis erythopoda
Natural Area
Restored Area
Canopy Cover (%)
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Xeric
Hydric
Plot Number

higher in cover in the restored area (26%) than in the natural wetlands (12%).

Dichanthelium acuminatum var. *implicatum* (Fig. 8) typifies Type III species by displaying an inverse relationship between cover and presumed soil-moisture as expected by plot location. Other Type III species include *Agrostis stolonifera, Artemisia ludoviciana, Ambrosia psilostachya, Euthamia graminiifolia, Juncus torreyi* and, in the restored area only, *Juncus alpinoarticulatus* (Table 1). Overall, Type III species, are absent or have very low average cover values in large.

These various trends provide support for the community-level conclusion that the natural and restored wetlands differ in plant composition. They do not consistently support any explanation for these differences, however, a possible explanation is that those species distributed similarly in the restored and the natural areas may more rapidly achieve their successional position than those whose distribution presently is dissimilar. It is not illogical to consider that some species reach a relative equilibrium canopy cover more quickly than others, perhaps because of the growth rate, reproduction success or dispersability. The data from the present study do not discount this explanation although only subsequent study can confirm it validity.

Fig. 8: Distribution of *Dichanthelium acuminatum* var. *implicatum* along sampling gradients in natural and restored wetland areas.



Dichanthelium acuminatum var. implicatum
Natural Area
Restored Area
Canopy cover (%)
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
9
10
11
12
13
Xeric
Hydric
Plot Number

BETWEEN-TREATMENT ANALYSIS

The similarity of restored and natural wetlands was also tested, by plot, using ANOVA and the Student-Newman-Keuls multicomparison test, for species with a frequency of at least 10% in either the natural or the restored areas. Significant differences ($p<0.05$) among or between at least two of three restored or natural wetland plots were found for *Agrostis stolonifera, Ambrosia psilostachya, Eleocharis acicularis, Eleocharis erythropoda, Eleocharis palustris, Lysimachia ciliata, Lythrum alatum, Scirpus acutus, Spartina pectinata, Suim suave,* and *Typha* spp. (Appendix Table B). The large number of statistically significant differences in species cover, both between and within wetlands, indicates that the distribution of individual species is not entirely consistent, whether in natural or in restored wetlands. Within-treatment differences make between-treatment differences difficult to explain. Nevertheless, the number of significant differences between natural and restored wetlands, in conjunction with other community-level and species-level data, support the overall conclusion that the restored areas in this study differ substantially from the natural areas, at least at the time of this study.

CONCLUSION

Evidence that the restored Nebraska Sandhill wetlands are not, or are not yet, similar to natural Sandhill wetlands is apparent from three sources, (a) community-level analysis and species-level analysis of both (b) canopy cover gradients and (c) significant differences between species common to both types of wetlands. While there are presently significant differences between restored and natural wetlands, the data do not discount the possibility that, with time, the restored areas may naturally succeed to a point when at least the vegetative composition is considerably more similar to the natural area than it is at present. Whether or not the ecosystem functions of the wetland follow the same progression toward establishment must be the focus of a different type of study.

Based on the present study, and particularly on the observed differences in topographic variability which also appear in the vegetative analysis, this study suggests that serious wetland restoration efforts should take particular care to ensure that topographic heterogeneity is provided in any such effort. In the absence of such heterogeneity, it appears that the biotic diversity may not be attainable. Further, this study suggests that successful mitigation (e.g. the replacement of destroyed wetlands) may be difficult. Whether such attainment is even possible requires additional time and a study expanded to consider evaluating abiotic conditions as well. The difficulties and probable costs involved in ensuring wetland restoration also should invite more serious efforts to prevent destruction of this habitat.

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Appendix

Appendix Table A. Species list and site in which located. N = species that occurred only in the natural wetlands; R = species that occurred only in the restored wetlands. No site is shown for species that occur in both natural and restored wetlands.

Site	Scientific and Common Name
N	*Achillea millefolium* L. (yarrow)
N	*Agropyron caninum* L. (wheatgrass)
N	*Agrostis hyemalis* Walt. (ticklegrass)
N	*Agrostis scabra* Willd. (ticklegrass)
	Agrostis stolonifera L. (redtop)
	Alisima triviale Pursh (water plantain)
R	*Alopecurus aequalis* Sobol (short-awn foxtail)
N	*Amaranthus arenicola* I. M. Johnst. (sandhills pigweed)
	Amaranthus rudis Sauer (water hemp)
	Ambrosia psilostachya DC (western ragweed)
	Ammannia spp.
N	*Amorpha canesens* Pursh (lead plant)
N	*Andropogon scoparius* Michx. (little blue stem)
N	*Antennaria neglecta* Greene (field pussy toes)
N	*Apocynum sibiricum* L. (indian hemp dogbane)
N	*Artemisia dracunculus* L. (silky wormwood)
N	*Artemisia ludoviciana* Nutt. (white sage)
N	*Aster ericoides* L. (white aster)
	Aster sp.
R	*Bidens cernua* L. (nodding beggar-ticks)
R	*Bidens frondosa* L. (beggar-ticks)
N	*Bromus inermis* Leyss. (smooth brome)
N	*Bromus japonicus* Thunb (japonese brome)
N	*Bromus tectorum* L. (downy brome)
	Calamagrostis stricta (Timm.) Koel. (reedgrass)
N	*Calamovilfa longifolia* Hook (prairie sandreed)
N	*Carex brevior* (Dewey) Mack. ex Lunell
	Carex pellita Muhl. (*C. lanuginosa* of older literature)
	Carex scoparia Schkuhr ex Willd. (group 1)
	Carex sp.
N	*Carex tribuloides* Wahl. (group 1)
	Carex vulpinoidea Michx. (group V)
N	*Cenchrus longispinus* (Hack.) Fern. (sandbur)
N	*Chenopodium pratericola* Rydb. (goosefoot)

Appendix Table A. Species list and site in which located. Continued

Site	Scientific and Common Name
	Chenopodium sp.
R	*Cicuta maculata* L. (common water hemlock)
N	*Cirsium canescens* Nutt. (platte thistle)
N	*Cirsium flodmanii* (Rydb.) Arthur (flodman's thistle)
N	*Cycloloma atriplicifolium* (Spreng.) Coult. (tumble ringweed)
N	*Cyperus aristatus* Rottb. (sedge)
N	*Cyperus schweinitzii* Torr. (sedge)
N	*Cyperus sp.*
N	*Cyperus strigosus* L. (sedge)
	Dichanthelium acuminatum var.implicatum (Scribn.) GouldandClark.
N	*Dichanthelium oligosanthes var.scribnerianum* (Nash) Gould
N	*Digitaria sp.*
	Eleocharis acicularis (L.) R.and S.
	Eleocharis erythropoda Steud.
N	*Eleocharis palustris* (L.) R.andS.
N	*Eriogonum annuum* Nutt. (annual eriogonum)
N	*Euphorbia sp.*
	Euthamia graminiifolia (L.) Nutt.
N	*Froelichia floridana* (Nutt.) Moq. (field snake cotton)
N	*Froelichia gracilis* (Hook.) Moq. (slender snake cotton)
R	*Galium trifidum* L. (small bedstraw)
R	*Glycyrrhiza lepidota* Pursh (wild licorice)
N	*Haplopappus spinulosus* (Pursh) DC (cutleaf ironplant)
R	*Helenium autumnale* L. (sneezeweed)
R	*Helianthus maximilianii* Schrad. (maximilian sunflower)
N	*Helianthus petiolaris* Nutt. (plains sunflower)
	Helianthus sp.
N	*Hemicarpha micrantha* (Vahl) Britt.
N	*Hordeum jubatum L.* (foxtail barley)
	Hypericum majus (A. Gray) Britt. (greater St.John's-wort)
R	*Juncus alpinoarticulatus* Chaix in Vill.
N	*Juncus balticus* Willd. (baltic rush)
	Juncus dudleyi Wieg. (dudley rush)
N	*Juncus marginatus* Rostk. (grassleaf rush)
N	*Juncus scirpoides* Lam.
	Juncus torreyi Cov. (Torreyi rush)

Appendix Table A. Species list and site in which located. Continued

Site	Scientific and Common Name
N	Lamiacea of unknown genus
	Leersia oryzoides (L.) Sw. (rice cutgrass)
N	*Lepidium densiflorum* Schrad. (peppergrass)
N	*Leptochola fascicularis* (Lam.) A. Gray (bearded sprangletop)
N	*Lespedeza capitata* Michx. (round-head lespedeza)
N	*Liatris squarrosa* (L.) Michx.
N	*Lotus purshianus* (Benth.) Clem. and Clem (prairie trefoil)
R	*Ludwigia polycarpa* Short and Peter (manyseed seedbox)
N	*Lycopus americanus* Muhl. *ex* Bart. (american bugleweed)
	Lycopus asper Greene
N	*Lycopus uniflorus* Michx. (one flower horehound)
R	*Lysimachia ciliata* L. (fringed loosestrife)
R	*Lythrum alatum* Pursh (winged loosestrife)
	Mentha arvensis L. (field mint)
N	*Oenothera villosa* Thunb. (common evening primrose)
N	*Panicum virgatum* L. (switchgrass)
N	*Paspalum setaceum* Michx. (tufted perennials)
N	*Phalaris arundinacea* L. (reed canary grass)
N	*Phleum pratense* L.
N	*Plantago patagonica* Jacq. (Patagonian plantain)
N	*Poa compressa* L. (Canada bluegrass)
R	*Poa pratensis* L. (Kentucky bluegrass)
N	*Polanisia jamesii* (T and G) Iltis (cristatella)
N	*Polygala sanguinea* L. (blood polygala)
	Polygonum amphibium L. *sens. lat.* (water smartweed)
N	*Polygonum convolvulus* L. (climbing or wild buckwheat)
N	*Polygonum persicaria* L. (lady's thumb)
R	*Populus deltoides* Marsch. (cottonwood)
N	*Potamogeton nodosus* Poir. (longleaf pondweed)
N	*Potentilla norvegica* L. (Morwegian cinquefoil)
	Potamogeton sp.
N	*Redfildia flexuosa* (Thurb.) Vasey (blowout grass)
N	*Rotala ramosior* (L.) Koehne (toothcup)
R	*Rumex crispus* L. (curly dock)
	Sagittaria cuneata Sheld. (arrowhead)
	Sagittaria graminea Michx.

Appendix Table A. Species list and site in which located. Continued

Site	Scientific and Common Name
R	*Salix exigua* subsp.. *interior* (Rowlee) Cronq.(sandbar willow)
N	*Salsola sp.*
	Scirpus acutus Muhl.
R	*Scirpus fluviatilis* (Torr.) A. Gray
R	*Scirpus pungens* Vahl.
N	*Sisymbrium altissimum* L. (tumbling mustard)
N	*Sisyrinchium montanum* Greene
R	*Sium suave* Walt. (water parsnip)
N	*Solidago missouriensis* Nutt. (prairie goldenrod)
N	*Solidago* spp.
N	*Sorghastrum nutans* (L.) Nash (Indian grass)
R	*Sparganium eurycarpum* Engelm.
	Spartina pectinata Link (prairie cordgrass)
R	*Sporobolus cryptandrus* (Torr.) A. Gray (sand dropseed)
R	*Stachys palustris (*Nutt.) Epling (hedge nettle)
N	*Strophostyles leiosperma* (T and G) Piper (slick-seed bean)
	Trifolium hybridum L. (alsike clover)
	Trifolium sp.
	Trifolium repens L. (White clover)
	Typha spp.
	Utricularia vulgaris L. (common bladderwort)
	Verbena hastata L. (blue vervain)
R	*Vernonia baldwinii* Torr. (western ironweed)

Appendix Table B. Mean cover values of all plant species with a frequency of at least 10 percent in either area. Nat. = natural area, Res. = restored area * = $P < 0.05$; ** = $P < 0.01$; NS = not significant ($p>0.05$). Trace (tr) species have a mean cover value of less then 0.5. Means of a species within a row that have the same superscript letter or that are missing superscripts do not differ significantly (Non-parametrical SNK's) ($p>0.05$)

	Agrostis stolonifera								*Alisma triviale*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	17^b	1^b	14^a	0^b	0^b	0^b	NS	1	0^b	0^b	0^b	2^a	0^b	tr^b	**
2	8^b	3^b	25^a	0^b	0^b	0^b	*	2	0	0	0	4	0	1	NS
3	8^{ab}	30^{ab}	41^a	0^b	6^{ab}	0^b	*	3	0^b	0^b	tr^b	9^a	1^b	0^b	**
4	36^a	14^{ab}	6^{cb}	0^c	1^c	0^c	**	4	0	1	0	7	tr	tr	*
5	19^a	1^b	tr^b	0^b	0^b	tr^b	**	5	0^b	4^{ab}	0^b	7^a	0^b	tr^b	NS
6	3	tr	1	0	0	0	NS	6	tr	1	0	3	0	3	NS
7	tr	0	0	0	0	0	NS	7	tr	4	0	8	1	1	NS
8	0	0	0	0	0	0	NS	8	8	0	1	6	1	2	NS
9	0	0	0	0	0	0	NS	9	4	0	1	1	6	1	NS
10	0	0	0	0	0	0	NS	10	4	0	0	tr	3	2	NS
11	0	0	0	0	0	0	NS	11	11	0	0	0	tr	tr	NS
12	0	0	0	0	0	0	NS	12	3^a	0^c	0^c	0^c	8^b	tr^c	NS
13	0	0	0	0	0	0	NS	13	4^{ab}	0^b	0^b	tr^{ab}	2^a	tr^{ab}	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Ambrosia psilostachya								*Artemisia ludoviciana*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	4^a	4^a	2^{ab}	0^b	0^b	0^b	NS	1	0^b	0^b	4^a	0^b	0^b	0^b	NS
2	4	4	tr	0	tr	0	NS	2	tr^b	4^{ab}	1^a	0^b	0^b	0^b	NS
3	1	1	tr	0	1	0	NS	3	0^b	0^b	1^a	0^b	0^b	0^b	**
4	3	1	0	0	1	0	NS	4	1	tr	1	0	0	0	NS
5	tr	0	0	0	3	0	NS	5	tr	tr	0	0	0	0	NS
6	0	0	0	0	tr	0	NS	6	0	0	0	0	0	0	NS
7	0	0	0	0	tr	0	NS	7	0	0	0	0	0	0	NS
8	0	0	0	0	0	0	NS	8	0	0	0	0	0	0	NS
9	0	0	0	0	0	0	NS	9	0	0	0	0	0	0	NS
10	0	0	0	0	0	0	NS	10	0	0	0	0	0	0	NS
11	0	0	0	0	0	0	NS	11	0	0	0	0	0	0	NS
12	0	0	0	0	0	0	NS	12	0	0	0	0	0	0	NS
13	0	0	0	0	0	0	NS	13	0	0	0	0	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Aster species								*Calamagrostis stricta*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0	0	0	0	6	1	NS	1	0^{b}	1^{ab}	3^{ab}	tr^{ab}	33^{a}	3^{ab}	*
2	0^{b}	1^{b}	0^{b}	0^{b}	7^{a}	tr^{b}	*	2	0^{b}	1^{b}	tr^{b}	tr^{b}	19^{a}	1^{b}	*
3	0	1	0	0	0	0	NS	3	0	1	3	0	17	1	NS
4	0	4	0	0	tr	1	NS	4	0^{b}	6^{ab}	14^{a}	0^{b}	4^{ab}	3^{ab}	NS
5	0^{b}	14^{a}	tr^{b}	0^{b}	1^{b}	tr^{b}	**	5	3	13	16	0	3	1	NS
6	0^{b}	7^{a}	tr^{b}	0^{b}	3^{b}	1^{b}	NS	6	17	0	2	0	1	tr	NS
7	0	1	1	0	1	0	NS	7	8	0	8	0	15	0	NS
8	0	3	3	0	0	tr	NS	8	2	0	tr	0	1	0	*
9	0	0	8	0	tr	1	NS	9	0	0	0	0	tr	0	NS
10	0	0	1	0	0	0	NS	10	0	0	0	0	0	0	NS
11	0	0	0	0	0	0	NS	11	0	0	0	0	0	0	NS
12	0	0	0	0	0	0	NS	12	1	0	0	0	0	0	NS
13	0	0	0	0	0	0	NS	13	0	0	0	0	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Carex brevior								*Carex spp.*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0	0	1	0	0	0	NS	1	0	0	tr	3	3	tr	NS
2	tr	0	1	0	tr	0	NS	2	8	3	1	3	1	tr	NS
3	6	0	4	0	0	0	NS	3	8	1	3	3	1	1	NS
4	6	3	1	0	0	0	NS	4	28	4	22	1	13	1	NS
5	2^{a}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	**	5	28^{ab}	11^{ab}	45^{a}	0^{b}	15^{ab}	tr^{ab}	*
6	1^{a}	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	NS	6	18^{ab}	4^{ab}	10^{a}	1^{ab}	0^{b}	1^{b}	NS
7	0	0	0	0	0	0	NS	7	11^{ab}	3^{b}	7^{a}	tr^{b}	tr^{b}	tr^{b}	NS
8	0	0	0	0	0	0	NS	8	8	4	18	0	7	1	NS
9	0	0	0	0	0	0	NS	9	tr	0	8	0	0	tr	NS
10	0	0	0	0	0	0	NS	10	0^{b}	0^{b}	4^{a}	0^{b}	0^{b}	tr^{b}	NS
11	0	0	0	0	0	0	NS	11	0^{b}	0^{b}	9^{a}	0^{b}	0^{b}	1^{ab}	**
12	0	0	0	0	0	0	NS	12	0	0	3	0	0	1	NS
13	0	0	0	0	0	0	NS	13	0	0	0	0	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Dichanthelium acuminatum var. implicatum								*Eleocharis acicularis*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0^b	4^b	21^a	0^b	1^b	0^b	**	1	0	0	0	0	0	0	NS
2	0^b	3^b	31^a	0^b	3^b	0^b	**	2	0	0	0	0	0	0	NS
3	0^c	13^b	19^a	0^c	1^c	0^c	NS	3	0	0	0	0	0	0	NS
4	0	4	17	0	1	0	NS	4	0	0	0	0	0	0	NS
5	0	1	3	0	3	0	NS	5	0	17	0	20	0	0	NS
6	0	0	0	0	1	0	NS	6	0^b	0^b	tr^b	40^a	0^b	0^b	**
7	0	0	0	0	tr	0	NS	7	0	15	21	8	0	0	NS
8	0	0	0	0	tr	0	NS	8	0^b	3^b	20^b	36^a	0^b	0^b	*
9	0	0	0	0	0	0	NS	9	0^b	0^b	3^b	58^a	0^b	0^b	**
10	0	0	0	0	0	0	NS	10	0^c	0^c	0^c	69^a	7^b	1^c	**
11	0	0	0	0	0	0	NS	11	0^b	0^b	0^b	40^a	35^a	1^b	*
12	0	0	0	0	0	0	NS	12	0^b	0^b	0^b	45^a	9^{ab}	1^b	**
13	0	0	0	0	0	0	NS	13	0	0	0	22	1	3	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Eleocharis erythropoda								*Eleocharis palustris*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0^{c}	0^{c}	0^{c}	57^{a}	25^{b}	50^{a}	**	1	0	0	0	0	0	0	NS
2	0^{c}	8^{c}	0^{c}	58^{a}	20^{b}	64^{a}	**	2	0	0	0	0	0	0	NS
3	0^{c}	21^{b}	0^{c}	59^{a}	31^{ab}	52^{a}	**	3	0	0	0	0	0	0	NS
4	1^{c}	18^{b}	9^{cb}	76^{a}	49^{ab}	40^{ab}	**	4	8	0	0	0	0	0	NS
5	18^{ab}	34^{a}	1^{b}	57^{a}	36^{a}	34^{a}	*	5	3	0	0	0	0	0	NS
6	23	45	9	34	31	31	NS	6	17	3	0	0	0	0	NS
7	16	19	15	26	34	34	NS	7	23	19	1	0	0	0	NS
8	tr^{b}	4^{b}	3^{b}	23^{a}	38^{a}	43^{a}	**	8	57^{a}	20^{bc}	23^{ab}	0^{c}	0^{c}	0^{c}	**
9	tr^{b}	0^{b}	6^{b}	13^{a}	21^{a}	48^{a}	**	9	54^{a}	31^{a}	24^{a}	0^{b}	0^{b}	0^{b}	**
10	0^{b}	0^{b}	0^{b}	4^{a}	23^{a}	28^{a}	NS	10	45^{a}	35^{a}	37^{a}	0^{b}	0^{b}	0^{b}	*
11	0^{b}	0^{b}	0^{b}	0^{b}	tr^{b}	23^{a}	*	11	26^{a}	21^{ab}	33^{a}	0^{b}	0^{b}	0^{b}	NS
12	0^{b}	0^{b}	0^{b}	0^{b}	tr	7	*	12	24^{a}	25^{ab}	55^{a}	0^{b}	0^{b}	0^{b}	*
13	0	0	0	0	tr	1	NS	13	36^{a}	17^{b}	23^{ab}	0^{b}	0^{b}	0^{b}	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Euthamia graminiifolia								*Juncus alpinoarticulatus*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	3^b	tr^b	14^a	0^b	0^b	0^b	*	1	0	0	0	tr	0	tr	NS
2	8^a	6^{ab}	11^{ab}	0^b	0^b	0^b	NS	2	0	0	0	3	0	3	NS
3	6^{ab}	1^{ab}	4^a	0^b	9^a	0^b	NS	3	0^b	0^b	0^b	1^b	0^b	4^a	NS
4	6	0	1	0	3	0	NS	4	0^b	0^b	0^b	0^b	0^b	4^a	NS
5	tr	tr	3	0	1	0	NS	5	0^b	0^b	0^b	0^b	0^b	1^a	*
6	6	tr	3	0	0	0	NS	6	0^b	0^b	0^b	3^{ab}	0^b	1^a	NS
7	tr	0	0	0	0	0	NS	7	0	0	0	1	tr	3	NS
8	1	0	0	0	tr	0	NS	8	0	0	0	0	0	1	NS
9	0	0	0	0	0	0	NS	9	0^b	0^b	0^b	0^b	0^b	1^a	NS
10	0	0	0	0	0	0	NS	10	0	0	0	0	0	0	NS
11	0	0	0	0	0	0	NS	11	0	0	0	0	0	0	NS
12	0	0	0	0	0	0	NS	12	0	0	0	0	0	0	NS
13	0	0	0	0	0	0	NS	13	0	0	0	0	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

		Juncus dudleyi									*Juncus torreyi*				
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0	0	4	1	tr	0	NS	1	0^{b}	0^{b}	tr^{b}	3^{a}	0^{b}	1^{b}	NS
2	3	tr	7	0	3	0	NS	2	0	0	1	1	0	tr	NS
3	3^{ab}	11^{ab}	10^{a}	0^{b}	2^{ab}	0^{b}	NS	3	0	0	4	tr	0	3	NS
4	9	8	4	0	1	1	NS	4	0	0	1	3	0	2	NS
5	3	0	tr	0	3	0	NS	5	0	tr	3	tr	0	1	NS
6	0	tr	0	0	tr	0	NS	6	0	0	3	tr	0	4	NS
7	0	0	0	0	1	0	NS	7	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	2^{a}	**
8	0	0	0	0	1	0	NS	8	0^{b}	0^{b}	0^{b}	0^{b}	0^{b}	tr^{a}	**
9	0	0	0	0	1	0	NS	9	0	0	0	0	0	tr	NS
10	0	0	0	0	0	0	NS	10	0	0	0	0	0	0	NS
11	0	0	0	0	0	0	NS	11	0	0	0	0	0	1	NS
12	0	0	0	0	0	0	NS	12	0	0	0	0	0	0	NS
13	0	0	0	0	0	0	NS	13	0	0	0	0	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Leersia oryzoides								*Ludwigia polycarpa*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0^b	0^b	1^b	1^{ab}	0^b	4^a	NS	1	0	0	0	1	0	1	NS
2	0^b	0^b	0^b	1^b	0^b	4^a	NS	2	0	0	0	0	0	3	NS
3	0^b	0^b	0^b	1^{ab}	0^b	1^a	NS	3	0^b	0^b	0^b	1^b	0^b	3^a	NS
4	0	0	0	1	0	1	NS	4	0^b	0^b	0^b	0^b	0^b	7^a	*
5	0	3	3	1	0	1	NS	5	0	0	0	0	0	4	NS
6	0	1	0	0	11	tr	NS	6	0	0	0	tr	0	tr	NS
7	0^b	0^b	0^b	0^b	3^{ab}	1^{ab}	NS	7	0^b	0^b	0^b	0^b	0^b	1^a	NS
8	0	0	0	0	0	1	NS	8	0	0	0	0	0	3	NS
9	0	0	0	0	0	tr	NS	9	0	0	0	0	0	0	NS
10	0	0	0	0	0	tr	NS	10	0	0	0	0	0	0	NS
11	0	0	0	0	0	0	NS	11	0	0	0	0	0	tr	NS
12	0	0	0	0	0	0	NS	12	0	0	0	0	0	0	NS
13	0	0	0	0	0	0	NS	13	0	0	0	0	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Lycopus asper								*Lysimachia ciliata*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0^b	0^b	0^b	0^b	4^a	3^b	NS	1	0^b	0^b	0^b	2^a	0^b	1^a	**
2	0^b	0^b	0^b	1^b	13^a	tr^b	**	2	0	0	0	1	1	4	NS
3	0	0	0	tr	7	1	*	3	0^b	0^b	0^b	tr^b	0^b	4^a	NS
4	0	0	tr	3	4	4	NS	4	0^b	0^b	0^b	0^b	0^b	4^a	NS
5	0	0	1	3	14	4	NS	5	0^b	3^b	tr^b	0^b	0^b	2^a	NS
6	0	tr	1	tr	6	6	NS	6	0	0	3	0	1	6	NS
7	0	1	0	0	1	3	NS	7	0^b	0^b	0^b	0^b	tr^b	tr^a	*
8	0	0	0	0	8	0	NS	8	0^b	tr^b	0^b	0^b	1^{ab}	4^a	NS
9	0	0	0	0	8	0	NS	9	0^b	0^b	0^b	0^b	0^b	tr^a	**
10	0	0	0	0	0	0	NS	10	0	0	0	0	0	1	NS
11	0	0	0	0	0	0	NS	11	0	0	0	0	0	4	NS
12	0	0	0	0	0	0	NS	12	0	0	0	0	0	0	NS
13	0	0	0	0	0	0	NS	13	0	0	0	0	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Lythrum alatum								*Polygonum amphibium*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0^{b}	0^{b}	0^{b}	11^{a}	1^{b}	5^{a}	NS	1	0	0	0	0	0	0	NS
2	0	0	0	11	4	1	NS	2	0	0	0	0	0	0	NS
3	0^{b}	0^{b}	0^{b}	8^{ab}	4^{ab}	12^{a}	**	3	0	0	0	0	0	1	NS
4	0^{c}	0^{c}	0^{c}	1^{bc}	14^{b}	13^{a}	**	4	0	0	0	tr	0	tr	NS
5	0^{b}	0^{b}	0^{b}	3^{b}	8^{b}	13^{a}	NS	5	0	0	0	0	0	0	NS
6	0^{b}	0^{b}	0^{b}	1^{b}	tr^{b}	12^{a}	**	6	0	0	0	0	0	0	NS
7	0	0	0	0	1	7	NS	7	0	0	0	0	0	0	NS
8	0	0	0	0	3	3	NS	8	0	0	1	0	0	0	NS
9	0	0	0	0	0	0	NS	9	tr	1	0	0	0	0	NS
10	0	0	0	0	0	1	NS	10	3	3	1	0	0	tr	NS
11	0	0	0	0	0	1	NS	11	1	1	tr	0	0	tr	NS
12	0	0	0	0	0	0	NS	12	1	1	tr	0	0	0	NS
13	0	0	0	0	0	0	NS	13	0	1	4	0	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Potamogeton nodosus								*Sagittaria cuneata*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0	0	0	0	0	0	NS	1	0	0	0	0	1	0	NS
2	0	0	0	0	0	0	NS	2	0	0	0	0	0	0	NS
3	0	0	0	0	0	0	NS	3	0	0	0	0	0	0	NS
4	0	0	0	0	0	0	NS	4	0	tr	0	0	0	0	NS
5	0	1	0	0	0	0	NS	5	0	3	0	0	0	0	NS
6	0	1	0	3	0	0	NS	6	0	1	0	1	0	0	NS
7	0	4	0	8	0	0	NS	7	0^{b}	33^{a}	0^{b}	1^{b}	0^{b}	0^{b}	*
8	0	1	0	4	0	0	NS	8	0	20	0	3	0	0	NS
9	0^{b}	7^{a}	1^{b}	4^{b}	0^{b}	0^{b}	NS	9	0	20	0	3	0	0	NS
10	0	4	tr	3	0	0	NS	10	tr	1	0	1	0	0	NS
11	1	1	1	5	tr	tr	NS	11	tr	1	0	1	0	0	NS
12	3	3	4	7	tr	tr	NS	12	0	1	0	1	0	0	NS
13	3^{ab}	1^{ab}	1^{ab}	7^{a}	1^{ab}	0^{b}	NS	13	0	1	0	tr	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Scirpus acutus								*Scirpus fluviatilis*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0^{b}	0^{b}	0^{b}	1^{ab}	3^{ab}	tr^{a}	NS	1	0	0	0	0	tr	0	NS
2	0	0	0	tr	3	1	NS	2	0	0	0	1	1	0	NS
3	0	0	0	1	8	tr	NS	3	0	0	0	3	0	0	NS
4	0	0	0	1	tr	1	NS	4	0^{b}	0^{b}	0^{b}	4^{a}	1^{b}	0^{b}	NS
5	0	0	0	6	1	tr	NS	5	0^{b}	0^{b}	0^{b}	3^{a}	tr^{b}	0^{b}	NS
6	0	0	0	tr	1	1	NS	6	0	0	0	3	tr	0	NS
7	tr	0	0	4	tr	1	NS	7	0	0	0	6	tr	0	*
8	0^{c}	3^{bc}	0^{c}	1^{ab}	1^{bc}	5^{a}	NS	8	0	0	0	0	tr	0	NS
9	0^{b}	3^{ab}	0^{b}	6^{a}	1^{ab}	1^{a}	NS	9	0	0	0	0	0	0	NS
10	0^{c}	23^{ab}	0^{c}	4^{abc}	tr^{bc}	5^{a}	NS	10	0	0	0	0	0	0	NS
11	tr^{b}	30^{ab}	0^{b}	1^{b}	1^{b}	4^{a}	NS	11	0	0	.0	1	0	0	NS
12	0^{c}	37^{abc}	0^{c}	1^{bc}	1^{ab}	3^{a}	**	12	0	0	0	0	0	0	NS
13	1	25	28	0	1	1	NS	13	0	0	0	0	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Sium suave								*Sparganium eurycarpum*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0^b	0^b	0^b	7^a	0^b	6^{ab}	*	1	0	0	0	0	0	tr	*
2	0^b	0^b	0^b	12^a	0^b	4^a	**	2	0	0	0	1	0	tr	NS
3	0^b	0^b	0^b	7^a	0^b	1^a	*	3	0	0	0	0	0	tr	NS
4	0^b	0^b	0^b	7^a	0^b	4^a	*	4	0	0	0	0	3	tr	NS
5	0^b	0^b	0^b	7^a	1^{ab}	4^{ab}	NS	5	0	0	0	tr	3	tr	NS
6	0	0	0	4	tr	1	NS	6	0^b	0^b	0^b	7^a	1^b	0^b	**
7	0	0	0	3	0	4	NS	7	0	0	0	9	7	1	*
8	0	0	0	1	0	1	NS	8	0^b	0^b	0^b	11^{ab}	2^{ab}	tr^b	NS
9	0	0	0	1	0	1	NS	9	0^b	0^b	0^b	9^a	6^{ab}	1^{ab}	*
10	0	0	0	0	1	0	NS	10	0^b	0^b	0^b	7^a	1^{ab}	1^{ab}	*
11	0	0	0	tr	tr	1	NS	11	0^b	0^b	0^b	7^a	0^b	tr^b	*
12	0	0	0	0	0	1	NS	12	0^b	0^b	0^b	4^a	0^b	0^b	NS
13	3	0	0	0	0	0	NS	13	0	0	0	11	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

	Spartina pectinata								*Strophostyles leiosperma*						
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0	0	0	0	1	0	NS	1	0	0	4	0	0	0	NS
2	0	0	0	0	0	0	NS	2	1	1	11	0	0	0	NS
3	tr	0	0	0	1	0	NS	3	4	3	1	0	0	0	NS
4	0	0	0	0	3	0	NS	4	tr	1	tr	0	0	0	NS
5	1	tr	0	tr	0	0	*	5	3	1	0	0	0	0	NS
6	3	3	20	0	1	0	NS	6	tr	tr	0	0	0	0	NS
7	2[a]	7[a]	8[a]	0[b]	0[b]	0[b]	NS	7	0	0	0	0	0	0	NS
8	1	4	tr	0	0	0	NS	8	0	0	0	0	0	0	NS
9	1	3	1	0	0	0	NS	9	0	0	0	0	0	0	NS
10	0	0	1	0	0	0	NS	10	0	0	0	0	0	0	NS
11	tr	0	0	0	0	0	NS	11	0	0	0	0	0	0	NS
12	0	0	0	0	0	0	NS	12	0	0	0	0	0	0	NS
13	0	0	0	0	0	0	NS	13	0	0	0	0	0	0	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

Trifolium spp.								*Typha species*							
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA	Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	tr	0	0	tr	0	1	NS	1	0^{b}	0^{b}	0^{b}	8^{a}	0^{b}	0^{b}	NS
2	0	1	0	4	0	0	NS	2	0	0	0	8	0	1	NS
3	tr	3	0	0	0	0	NS	3	0	0	0	8	0	0	NS
4	0	0	0	1	0	0	NS	4	0^{b}	0^{b}	0^{b}	3^{a}	3^{ab}	0^{b}	NS
5	3	0	0	3	0	tr	NS	5	0	0	0	3	0	tr	NS
6	0	0	0	3	0	tr	NS	6	0	0	0	3	4	tr	NS
7	0	0	0	1	0	0	NS	7	0	0	0	0	13	3	NS
8	0	0	0	4	1	tr	NS	8	0	0	0	1	11	4	NS
9	0	0	0	3	0	tr	NS	9	0^{b}	0^{b}	0^{b}	1^{b}	17^{a}	10^{a}	*
10	0	0	0	0	1	3	NS	10	0^{b}	0^{b}	0^{b}	8^{ab}	10^{a}	12^{a}	NS
11	0	0	0	0	1	0	NS	11	0^{b}	0^{b}	0^{b}	1^{b}	9^{ab}	11^{a}	NS
12	0	0	0	0	0	0	NS	12	0	0	0	0	6	9	*
13	0	0	0	tr	0	1	NS	13	0	0	19	3	9	4	NS

Appendix Table B Mean cover values of all plant species with a frequency of 10 percent or greater (n=5 for all sites). Continued

Utricularia vulgaris							
Plot	Nat. 1	Nat. 2	Nat. 3	Res. 1	Res. 2	Res. 3	ANOVA
1	0	0	0	0	0	0	NS
2	0	0	0	0	0	0	NS
3	0	0	0	0	0	0	NS
4	0	0	0	0	0	0	NS
5	0	0	0	0	0	0	NS
6	0	0	0	0	0	0	NS
7	0	0	0	0	0	0	NS
8	0	0	0	0	0	0	NS
9	0	tr	0	0	0	0	NS
10	0	tr	1	0	0	0	NS
11	0^{b}	2^{a}	tr^{ab}	0^{b}	0^{b}	0^{b}	**
12	tr^{b}	2^{a}	0^{b}	tr^{b}	0^{b}	0^{b}	**
13	0^{b}	1^{a}	tr^{ab}	4^{a}	tr^{ab}	0^{b}	NS