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1.0 INTRODUCTION

To address the potential effects of the proposed channel deepening on the tidal marshes of the Savannah National Wildlife Refuge (SNWR), an extensive ecological assessment was performed in October 1997. Due to the number of historical perturbations to this system, i.e., tide gate installation, it was imperative to establish a quantitative inventory of the existing plant associations occurring in the area. To attain this goal, a number of quantitative vegetation sampling quadrats were established. In addition, qualitative quadrats were placed in all areas of the SNWR that displayed unique signatures on aerial photography. Information obtained from this study was used to delineate plant community associations on multispectral SPOT satellite imagery.

To assess the potential effects of channel deepening requires that a general range in salinity changes be known and these changes then related to the potential change in the distributions of freshwater, brackish, and saline marshes within the tidally influenced areas of the Savannah River marsh system. The major concern of all regulatory and environmental entities is the displacement and reduction of areal extent of freshwater marsh, which, for the purposes of this study, is assumed to be all areas that have salinity values of less than 0.5 parts per thousand (ppt). To accurately predict possible changes to the system, it is imperative to delineate the existing extent of all plant associations and relate their distributions to existing in-situ salinity conditions and gradients. In addition, if the existing conditions could be compared to plant associations existing when the tide gate was operating, which was shown to dramatically increase salinities in the study area, then analysis of these changes could be used to reciprocally predict probable changes that would occur if salinity once again increased.

In October 1990, Pearlstine *et al.* (1990) documented the plant communities occurring in the tidal marsh areas of the Savannah River and related these associations to the elevated salinities present as a result of the operation of the tide gate. They presented a succession model that predicted a dramatic increase in freshwater marsh as salinities were reduced in response to the removal of the tide gate. Following re-sampling of the quadrat areas in 1993 and 1994, Latham and Kitchens (1996) reported gradual recovery of the marsh system in response to tide gate removal and dramatic reduction in surface water and sediment salinities in all study areas.

The purpose of the presently described ecological data is to compare the present distribution of vegetation to that found in 1986-1988 (Pearlstine *et al.*, 1990) and 1993-1994 (Latham and Kitchens, 1996). These data are further summarized in several other references to include Latham (1990), Latham *et al.* (1991), and Pearlstine *et al.* (1993). From these comparisons, probable future trends in plant distributions and succession patterns can be ascertained.

The assumption that must be made in making these comparisons and, thus, predicting change is as follows:

> ASSUMPTION 1: The period of time in which the tide gate was operating resulted in a worst case salinity condition as compared to the situation that would result from the proposed channel deepening.
>
> If this assumption is true, then the following hypotheses may apply to predicted vegetation changes:
>
> HYPOTHESIS 1: If plant community change has been dramatic since the tide gate was removed, then future increase in salinity could again potentially produce dramatic effects, hence, reducing extent of freshwater marshes.
>
> HYPOTHESIS 2: If change in vegetation since the tide gate removal has been minimal or comparably undetectable, then the range of salinity increase in response to dredging will fall in the natural salinity tolerance range of the existing plant community.
>
> HYPOTHESIS 3: If a change in predicted or existing communities has not occurred between 1988 and 1997, then salinity may not be the only factor controlling plant community change in this area of the river.

With this assumption and these hypotheses in mind, an ecological study was performed in October 1997 to facilitate comparisons of existing plant community structure and distribution with historic data and, hence, attempt to predict potential changes in response to the proposed project.

2.0 METHODOLOGY

2.1 QUANTITATIVE VEGETATION MONITORING

Ten (10) permanent quantitative vegetation quadrats were established in unimpounded tidal marsh areas of the SNWR and Lower Savannah River (Figure 1). The general purpose of the quantitative study is to accurately determine the plant species composition of the tidal marsh areas and describe the species abundance and population structure with respect to existing salinity gradients.

The vegetation quadrats were established in 10 discrete areas of the tidal marsh based upon existing river channel salinities. A permanent marker consisting of a 10-foot length concrete rebar and a 3/4-inch, schedule 40 PVC pole was placed at the beginning of the quadrat (0 pole) immediately adjacent to the river. A measuring tape was extended 500 or 600 feet marshward and each 100-foot length was permanently marked as described. Quadrat 3 is 600 feet long while all other quadrats are 500 feet in length. Herbaceous vegetation was quantified in a continuous 2-foot wide band extending the entire linear length of the quadrat.

Quadrats 8, 4, 3, and 2 are located in the areas described by Study Areas 1 (freshwater), 2 (intermediate), 3 (brackish), and 4 (subsaline), respectively, sampled by Pearlstine *et al.* (1990) and Latham and Kitchens (1996). All quadrat locations are shown in Figure 1. Existing surface water and sediment salinity data for each respective quadrat location is presented in Figure 2.

Salinity concentrations for the 50th and 90th percentile frequency distributions are presented for flows of 5,900, 8,200 and 9,500 cubic feet per second. Salinities given for each quadrat have been interpolated from data obtained from continuous monitoring stations located in close proximity to the quadrats. Flows given refer to specific periods occurring from July 9, 1997, through October 1, 1997. A flow of 8,200 cubic feet per second was the average flow for the period July 9, 1997, through October 1, 1997. For the period extending from September 1, 1997, through October 1, 1997, relatively low flows of 5,900 cubic feet per second were recorded. In contrast, the period from July 9, 1997, through September 1, 1997, higher flows of 9,500 cubic feet per second were present. This value was found to approximate the average growing season flow (April 1 through November 1) occurring in this system for the last 10 years. Maximum surface and bottom salinities at quadrat locations were interpolated from contours produced from the data recorded from July 9, 1997, through October 1, 1997. Sediment salinity and conductivity data for 1997 were taken from shallow

piezometers installed at the time of the vegetation study. Sediment salinity taken from 1985 to 1987 was taken from Pearlstine *et al*. (1990). These data were compiled to order the quadrats on a general salinity gradient for analysis and interpolation of vegetation distribution patterns.

2.1.1 Measurement of Herbaceous Size Class Vegetation

Herbaceous vegetation in each quadrat was monitored using the following modified line-intercept technique. The modified method incorporates the principle of the line-intercept method described by Phillips (1959); however, the width of the quadrat is extended to 2 feet so that an elongated sampling quadrat is formed and cover classifications and permanent frequency intervals are established.

The method consists of observations of plant species occurring along an elongated belt quadrat. Each quadrat is divided into continuous 10-foot intervals, each of which is 2 feet wide. The 10-foot intervals are further divided into 10, 1 foot x 2 foot intervals (Figure 3).

Individual species cover is determined on the basis of the percent cover occupied within each 10 x 2-foot cover interval. Seven cover categories have been assigned to estimate ranges of percent cover that are visually determined (Table 1). In addition, frequency is determined on the basis of occurrence within each 1 foot x 2 foot interval. Therefore, a maximum value of 10 is possible for each 10-foot interval. Data are tabulated in a raw data matrix consisting of numerical frequency and cover values for each species for each 10-foot interval and summarized by species, as follows:

> ***Total Frequency*** = the total number of 1 x 2 foot intervals where the species occurred. The maximum value is 500 for a 500-foot quadrat and 600 for a 600-foot quadrat.
>
> ***Relative Frequency (or Frequency Percent)*** = the total number of 1 x 2 foot intervals where the species occurred divided by the total number of 1 x 2 foot intervals in the quadrat (500 or 600).

Table 1

Cover Value Categories and Assigned Ranges (%)
for Each Cover Classification Used in
Quantitative Monitoring of Herbaceous Vegetation

Category	Range (%)	Mid-Point of Cover Ranges		% Range/ Category
0	0	0		
			---------->	1
1	<1	0.5		
			---------->	10
2	1-10	5		
			---------->	20
3	10-30	20		
			---------->	20
4	30-50	40		
			---------->	20
5	50-70	60		
			---------->	20
6	70-90	80		
			---------->	10
7	90-100	95		

Frequency Distribution of Cover Category Values Assigned = the total number of cover intervals in which the species was present in the designated cover range (i.e., 1 to 7). The maximum value that can be obtained is 50 for a 500-foot quadrat and 60 for a 600-foot quadrat.

Total Quadrat Area--Probable Percent Cover Range = the probable percent cover range of the species as calculated over the total quadrat area. The range is calculated as follows:

Total Percent Cover Range =
$\sum$ [(frequency in each cover range) x (minimum/average/maximum value for each range)]/total number of cover intervals in the quadrat.

Total Occurrence Area--Probable Percent Cover Range = the probable percent cover range of the species as calculated over the total cover interval area only where the species occurred. The range is calculated as follows:

Occurrence Percent Cover Range =
$\sum$ [(frequency in each cover range) x (minimum/average/maximum value for each range)]/total number of cover intervals where the species occurred.

Frequency Rank = the numerical rank of the species within the plot based on frequency of occurrence. A rank of 1 indicates the plant occurred more frequently than any other plant.

Cover Rank = the numerical rank of the species within the plot based on the percent cover displayed by the species. A rank of 1 indicates the plant covered more area than any other plant.

This sampling method was developed and is used for several reasons. First, and most important, is that it establishes an absolute measure of species occurrence by using defined frequency intervals. The use of small continuous frequency intervals allows the migration of existing vegetation to be accurately mapped and subsequent changes easily followed with time. In addition, because frequency data are based on species presence or absence, it is absolute

and no error is introduced by estimation by different individuals, which is required in determining

cover percentages. The method also estimates cover using several defined cover categories. Although estimates are not absolute and are somewhat variable when performed by different people, they serve as a suitable comparative mechanism when used to compare cover among several different quadrats. It should be noted that it is very easy to estimate coverages of less than 10 percent or greater than 80 percent by a single species in a given interval. However, it is very difficult to estimate cover of 10 to 20 species that totally occupy a given expanse of a cover interval. For this reason, larger ranges have been used to estimate cover in all categories except at the extreme low range and the extreme high range.

The occurrence of bare ground throughout the quadrats has been given the same consideration as plant species cover. Bare ground or non-vegetated surface is present in all systems and is not necessarily a definitive characteristic of newly reclaimed areas or disturbed systems. Bare ground is defined as all ground area not covered by some form of live vegetative structure as viewed from above. The analysis of bare ground allows for the determination of some form of vegetation stratification index. With bare ground considered, vegetation coverage of an area can never be greater than 100 percent; however, total percent coverages of all plant species within a quadrat are often totaled and equal greater than 100 percent cover. Analyses of natural systems indicate that a great degree of plant stratification occurs; however, the areas are most often not 100 percent covered by vegetation.

2.1.2 Classification of Existing Plant Communities

The classification and distribution of the existing plant communities was performed with the use of Geographic Information System (GIS) technology. Satellite imagery was obtained in the form of SPOT multispectral 20-m resolution imagery for the dates of August 22, 1997, and October 2, 1997. Supervised data classifications were performed using Imagine Software from ERDAS with a Sun Microsystems Ultra 2 Workstation. Images were rectified using a vector coverage of the river channels and secondary channels as digitized from USGS Quad sheets and aerial photography.

Supervised plant community classifications were generated based upon site specific quantitative and qualitative cover and frequency data. Each quantitative quadrat was divided into defined plant associations based on species abundance data. In addition, qualitative descriptions of plant associations were performed in 52 additional areas of the tidal marshes to

further differentiate and describe unique signatures. Locations of the qualitative plots are given in Figure 4. In each area, all plant species were recorded as well as coverage data based on the previously described ranges (Table 1).

2.1.3 Data Analysis

Data analysis strategies were directed toward describing 5 types of vegetation statistics, as follows:

1. Species-Area Curves

Species-area curves have been constructed to show the increase in the cumulative total number of species as each additional quadrat has been added to the data set. Species-area curves have traditionally been used to define the amount of sample area needed to accurately describe the plant populations being investigated. In general, the relation between the total number of species and total habitat area is described by the power function (Forman and Gordon, 1986): $S = CA^z$, in which S = the number of species, A = the sample or habitat area, z = the slope of the line relating species and area, and C = a constant measuring the number of species in a given unit area. As described by the generally accepted species-area curve methodology, an adequate sample area is established when (1) a 10 percent increase in sample area results in an increase in species equaling 10 percent or less of the total species present, or (2) the sampling is adequate when the curve becomes horizontal (linear) (Phillips, 1959). Species-area curves were constructed in 2 ways: first, with quadrat areas arranged in order of most saline to least saline, and, second, reciprocally, from the most freshwater site to the most saline. This analysis was performed not only to show the effect of sample area on total species found, but to show the relationship of total cumulative number of species with respect to salinity gradients. Salinity gradients were determined based on maximum surface water salinities measured from July 9, 1997, through October 1, 1997, at each respective location (Figure 2).

2. Species Composition

The species occurring in a given quadrat area are presented as a function of the relative frequency of each species present. Relative frequency is defined as the number of frequency intervals in which the species occurred divided by the total frequency of all species. This statistic, as presented, represents the probability of encountering a given species in a given area of the sample quadrat. These data are presented graphically in the form of pie charts so that dominance of given species as described by relative frequency is easily seen.

3. Population Structure

To analyze the general population structure of the 10 sample areas, species abundance versus species rank curves were generated. These curves are typically referred to as Whittaker plots in which the Y-axis corresponds to some form of abundance measure (Whittaker, 1972). For the present analysis, frequency percent was calculated, which equals the number of frequency intervals in which the species was found divided by the total number of frequency intervals present. The scale of the Y-axis is logarithmic ($\log_{10}$). The X-axis represents the rank of species "N" from 1 (most abundant species) to "N" (most rare species). The resulting plots typically give curves of geometric (straight line, steep slope), logarithmic (straight line, gradual slope), and lognormal (S-shaped) distributions. These curve forms relate abundance distribution patterns of species in sample areas contrasting distributions of rare versus very common species. Whittaker (1972) related the form of species abundance versus species rank curves to several resource utilization hypotheses describing the ability of a species to use different parts of a resource along a resource gradient. This ability of a species has been described generally as the occupation of the species, or niche. Where 2 species occupy the same niche, they are competitive with one another for the resource and the most competitive may completely exclude the other species. The geometric curve is correlated to a niche-preemption hypothesis by Whittaker (1992) and assumes that a dominant species occupies a given fraction of the resource. The second most dominant occupies a given fraction of the remaining resource and so on. The resulting curve is generally a straight line with a steep slope. This type of curve is

generally obtained in areas where species diversity is low and in which environmental conditions are relatively severe and a single environmental resource is extremely important, i.e., salinity.

The lognormal distribution is found in situations where the niche preemption and random niche-boundary hypothesis situations occur. The latter is described as the condition in which several unlimiting resources are present and species abundances are limited by competitive interaction at randomly located boundaries. The lognormal distribution is characteristic of a community in which a large number of species have intermediate importance and few rare or few dominant species are present. When the number of species (Y-axis) is plotted against a geometric (octave) scale (X-axis) of species abundance, the resulting distribution is described by the central limit theorem, e.g., a normal distribution around a central modal abundance class.

A third distribution described by Whittaker (1992) is the logarithmic series. This type of distribution implies that the number of rare species, or those with minimal distributions, is always maximized and that the number of species represented by a single individual is always maximal (Krebs, 1989). When the number of species is graphed (Y-axis) against the number of individuals found for each species (X-axis), the resulting curve is termed a “hollow curve”. This curve has an initial descending slope similar to the lognormal distribution; however, the slope becomes linear. Whittaker (1992) offers no theoretical justification for this type of distribution, indicating only weak inference can be made to the previously described niche-boundary hypothesis. The extensive analysis of species abundance and rank relationships was performed for several reasons: most importantly, to establish species richness and evenness relationships among the 10 quadrat areas as compared to existing salinity gradients.

4. Species Distribution Patterns

The frequency of all species for all areas of the quadrat are presented graphically. This procedure allows visual representation of species occurrence

patterns in relation to one another and also in relation to specific chemical or physical parameters such as salinity, distance from river channel, elevation, or sediment structure.

5. Plant Community Similarity

Plant community similarity indices were calculated for all possible pair-wise comparisons of the 10 quantitative quadrats. To calculate these statistics, 2 common similarity indices were used. The first is Sorensen's similarity coefficient (S_s), as follows:

$$S_s = 2A/(2A + B + C)$$

where,

A = number of species present in both samples A and B,

B = number of species occurring in sample B but absent in sample A, and

C = number of species occurring in sample A but absent in sample B.

This procedure was first used by Czekanowski in 1913, however, was re-introduced by Sorensen in 1948.

The second measure of similarity used is Jaccard's community coefficient (S_j), as follows:

$$S_j = A/(A + B + C)$$

where,

A, B, and C are as previously described.

The weaknesses of the uses of similarity indices to describe plant communities are well documented; however, for the intent and purposes of this report, they serve as a mechanism to compare the species composition based on the presence-absence data of the 10 quadrat areas and thus enable very general observations about the similarities of the species associations to be made.

3.0 RESULTS

3.1 PLANT SPECIES AND SPECIES-AREA CURVES

Species codes, botanical names, common names, and USACOE regional and national wetland indicators of all plant species observed at the SNWR are presented in Table 2. Plant species found in each individual quadrat are summarized in Table 3. The frequency and cover data matrix obtained for all species in all quadrat areas is summarized in Appendix Table A-1. Quadrat summary statistics for species cover and frequency are given in Table 4. Mean percent cover estimates for all species occurring in qualitative plots are tabulated in Tables 5 and 6.

The botanical names of several plant species detailed in this report are different than those indicated by Pearlstine *et al*. (1990). To prevent confusion in comparison with these data, a brief explanation of these differences is warranted. The most notable difference is the nomenclature of creeping spikerush (*Eleocharis fallax* Weatherby), which was referred to as sand spikerush (*Eleocharis montevidensis* Kunth) in their study. Sand spikerush (*Eleocharis montevidensis* Kunth), as described in Radford *et al*. (1968) and Beal (1977), occurs very rarely in North and South Carolina, whereas creeping spikerush (*Eleocharis fallax* Weatherby) is of common occurrence in brackish marshes throughout the intercoastal plain of North Carolina, South Carolina, and Georgia. These species are difficult to distinguish with both having thin, wiry stems originating from a thin, reddish rhizome. These species are distinguished vegetatively by creeping spikerush (*Eleocharis fallax* Weatherby) having a firm, collar-like summit of the leaf sheath being generally oblique without a mucro. By contrast, sand spikerush (*Eleocharis montevidensis* Kunth) has a truncate leaf sheath with a prominent mucro at the summit. Creeping spikerush (*Eleocharis fallax* Weatherby) is described as being larger, up to 70 cm tall, compared to a 40-cm height expected for sand spikerush (*Eleocharis montevidensis* Kunth). For comparative drawings, see Godfrey and Wooten (1979). All specimens found at the SNWR are larger than 40 cm, and, in no instance, has a mucro at the summit of the leaf sheath been observed. For these reasons, this species has tentatively been identified as creeping spikerush (*Eleocharis fallax* Weatherby). Comparison to herbarium specimens has been made and appear to indicate this is the species present. However, strict botanical protocol would suggest that this plant presently be referred to as spikerush (*Eleocharis* sp.). This approach was considered, but due to the importance of this species and the common

Table 2

Species Codes, Botanical Names, Common Names, FDEP (Chapter 63-340.450, FAC) Classifications, and USACOE Regional and National Wetland Indicators of All Plant Species Observed at the Savannah National Wildlife Refuge During October-November 1997

Species Code	Botanical Name	Common Name	FDEP Classification	USACOE Region 2 Indicator	USACOE National Indicator
ACE RUB	*Acer rubrum* L.	Red maple	FACW	FAC	FAC
AGA PUR	*Agalinis purpurea* (L.) Raf.	Large purple false-foxglove	FACW	FACW	FAC, FACW
ALN SER	*Alnus serrulata* (Ait.) Willd.	Brook-side alder	OBL	FACW+	FACW+, OBL
ALT PHI	*Alternanthera philoxeroides* (Mart.) Griseb.	Alligator weed	OBL	OBL	OBL
AMA CAN	*Amaranthus cannabinus* (L.) Sauer	Tidemarsh amaranthus	OBL	OBL	OBL
AMP ARB	*Ampelopsis arborea* (L.) Koehne	Pepper vine	NONE (Vine)	FAC+	FAC, FACW
AND GLO	*Andropogon glomeratus* (Walt.) BSP.	Bushy bluestem	FACW	FACW+	FACW, OBL
API AME	*Apios americana* Medic.	Ground nut	NONE (Vine)	FACW	FAC, FACW
ART HIS	*Arthraxon hispidus var. cryptatherus* (Hackel) Honda.	Joint-head arthraxon	UPL	FACU+	FACU+, FACW
AST ELL	*Aster elliottii* Torr. & Gray	Elliott's aster	OBL	OBL	OBL
AST SP.	*Aster species*	Aster	---	---	---
AST SUB	*Aster subulatus* Michx.	Annual saltmarsh aster	OBL	OBL	FACW, OBL
AST TEN	*Aster tenuifolius* L.	Perennial saltmarsh aster	OBL	OBL	OBL
BAC HAL	*Baccharis halimifolia* L.	Eastern false-willow	FAC	FAC	FAC, FACW
BET NIG	*Betula nigra* L.	River birch	OBL	FACW	FACW, OBL
BID LAE	*Bidens laevis* (L.) BSP.	Smooth beggar-ticks	OBL	OBL	OBL
BID MIT	*Bidens mitis* (Michx.) Sherff	Small-fruit beggar-ticks	OBL	OBL	OBL
BOE CYL	*Boehmeria cylindrica* (L.) Swartz.	Bog hemp	OBL	FACW+	FACW, OBL
BOL AST	*Boltonia asteroides* (L.) L'Her.	White boltonia	FACW	FACW	FACW, OBL
CAR ALB	*Carex albolutescens* Schweinitz	Greenish-white sedge	FACW	FAC+	FAC+, FACW
CAR AQU	*Carya aquatica* (Michx. F.) Nutt.	Water hickory	OBL	OBL	OBL
CAR SP.	*Carex species*	Sedge	---	---	---
CEP OCC	*Cephalanthus occidentalis* L.	Common buttonbush	OBL	OBL	OBL
CIC MEX	*Cicuta mexicana* Coult. & Rose	Mexican water hemlock	OBL	OBL	OBL
CIN ARU	*Cinna arundinacea* L.	Stout wood-reedgrass	NONE	FACW	FACW, FACW+
COR FOE	*Cornus foemina* Mill.	Stiff cornel	FACW	FACW-	FAC, FACW
CYP FLA	*Cyperus flavescens* L.	Yellow flatsedge	FACW	OBL	OBL
CYP HAS	*Cyperus haspan* L.	Sheathed flatsedge	OBL	OBL	OBL
CYP SP.	*Cyperus species*	Flatsedge	---	---	---
CYP STR	*Cyperus strigosus* L.	Straw-color flatsedge	FACW	FACW	FACW

Table 2
(continued)

Species Codes, Botanical Names, Common Names, FDEP (Chapter 63-340.450, FAC) Classifications, and USACOE Regional and National Wetland Indicators of All Plant Species Observed at the Savannah National Wildlife Refuge During October-November 1997

Species Code	Botanical Name	Common Name	FDEP Classification	USACOE Region 2 Indicator	USACOE National Indicator
Table 2, page 2 DES SP.		*Desmodium species*	Tick-trefoil	---	--- ---
DUL ARU	*Dulichium arundinaceum* (L.) Britton	Three-way sedge	OBL	OBL	OBL
ELE CEL	*Eleocharis cellulosa* Torr.	Gulf Coast spikerush	OBL	OBL	OBL
ELE ELO	*Eleocharis elongata* Chapm.	Slim spikerush	OBL	OBL	OBL
ELE GEN	*Eleocharis geniculata* (L.) Roem. & J. A. Schultes	Clustered spikerush	OBL	FACW+	FACW, OBL
ELE FAL	*Eleocharis fallax* Weatherby	Creeping spikerush	OBL	OBL	OBL
ELE GEN	*Eleocharis geniculata* (L.) Roem. & J. A. Schultes	Clustered spikerush	OBL	FACW+	FACW, OBL
ELE QUA	*Eleocharis quadrangulata* (Michx.) Roem. & J. A. Schultes	Square-stem spikerush	OBL	OBL	OBL
ERA REF	*Eragrostis refracta* (Chapm.) Scribn.	Meadow lovegrass	FAC	FACW	FACW
ERI GIG	*Erianthus giganteus* (Walt.) Muhl.	Sugarcane plumegrass	OBL	FACW	FACW, FACW+
EUP LEP	*Eupatorium leptophyllum* DC.	Fennel	OBL	FAC+	FAC+
EUT TEN	*Euthamia tenuifolia* (Pursh) Nutt.	Fragrant-golden-rod	FAC	---	---
FOR SEG	*Forestiera segregata* (Jacq.) Krug & Urban	Florida privet	FAC	---	---
FRA CAR	*Fraxinus caroliniana* Mill.	Carolina ash	OBL	OBL	OBL
FUI BRE	*Fuirena breviseta* (Coville) Coville	Saltmarsh umbrella-sedge	OBL	OBL	OBL
GAL TIN	*Galium tinctorium* L.	Stiff marsh bedstraw	FACW	FACW	FACW, OBL
GLE AQU	*Gleditsia aquatica* Marshall	Water-locust	OBL	OBL	OBL
HAB REP	*Habenaria repens** Nutt.	Water-spider orchid	FACW	OBL	OBL
HYD UMB	*Hydrocotyle umbellata* L.	Marsh pennywort	FACW	OBL	OBL
HYP HYP	*Hypericum hypericoides* (L.) Crantz	St. Andrew's cross	FAC	---	---
HYP MUT	*Hypericum mutilum* L.	Slender St. John's-wort	FACW	FACW	FACW, FACW+
ILE AMB	*Ilex ambigua** (Michx.) Torr.	Carolina holly	UPL	---	---
IMP CAP	*Impatiens capensis* Meerb.	Spotted touch-me-not	OBL	FACW	FACW, FACW+
IPO SAG	*Ipomoea sagittata* Poir.	Saltmarsh morning-glory	NONE (Vine)	FACW	FACW
IRI HEX	*Iris hexagona* Walter	Prairie iris	OBL	OBL	OBL
JUN EFF	*Juncus effusus* L.	Soft rush	OBL	FACW+	FACW+, OBL
JUN MAR	*Juncus marginatus* Rostk.	Grass-leaf rush	FACW	FACW	FACW, FACW+
JUN SCI	*Juncus scirpoides* Lam.	Needle-pod rush	OBL	FACW+	FACW, FACW+
JUN SIL	*Juniperus silicicola* (Small) Bailey	*Southern cedar*	*UPL*	*FAC*	*FAC, FACW*

Table 2,
(continued)

Species Codes, Botanical Names, Common Names, FDEP (Chapter 63-340.450, FAC) Classifications, and USACOE Regional and National Wetland Indicators of All Plant Species Observed at the Savannah National Wildlife Refuge During October-November 1997

Species Code	Botanical Name	Common Name	FDEP Classification	USACOE Region 2 Indicator	USACOE National Indicator
LEE HEX	*Leersia hexandra* Swartz	Club-head cutgrass	OBL	OBL	OBL
LEE ORY	*Leersia oryzoides* (L.) Swartz	Rice cutgrass	OBL	OBL	OBL
LIL CHI	*Lilaeopsis chinensis* (L.) Kuntze	Eastern lilaeopsis	OBL	OBL	OBL
LIQ STY	*Liquidambar styraciflua* L.	Sweetgum	FACW	FAC+	FAC, FACW
LOB GLA	*Lobelia glandulosa* Walter	Glandular lobelia	FACW	OBL	OBL
LON JAP	*Lonicera japonica* Thunb.	Japanese honeysuckle	UPL	FAC-	FACU, FAC+
LUD LEP	*Ludwigia leptocarpa* (Nutt.) Hara	River seedbox	OBL	OBL	OBL
LUD MIC	*Ludwigia microcarpa* Michx.	Small-fruit seedbox	OBL	OBL	OBL
LUD PAL	*Ludwigia palustris* (L.) Elliott	Marsh seedbox	OBL	OBL	OBL
LUD PIL	*Ludwigia pilosa* Walt.	Hairy seedbox	OBL	OBL	OBL
LUD REP	*Ludwigia repens* J. Forst.	Creeping seedbox	OBL	OBL	OBL
LUZ FLU	*Luziola fluitans* (Michx.) Terrell & H. Robinson	Luziola	OBL	OBL	OBL
LYC RUB	*Lycopus rubellus* Moench	Water hoarhound	OBL	OBL	OBL
MAG VIR	*Magnolia virginiana* L.	Sweetbay	OBL	FACW+	FACW+, OBL
MIK SCA	*Mikania scandens* (L.) Willd.	Climbing hempweed	NONE (Vine)	FACW+	FACW+, OBL
MUR KEI	*Murdannia keisak* (Hassk.) Hand.-Mazz.	Marsh dewflower	FAC	OBL	OBL
MYR CER	*Myrica cerifera* L.	Wax myrtle	FAC	FAC+	FAC, FAC+
NYS AQU	*Nyssa aquatica* L.	Water-tupelo	OBL	OBL	OBL
NYS BIF	*Nyssa sylvatica Marsh. var. biflora* (Walt.) Sarg.	Swamp black gum	OBL	OBL	FACW+, OBL
NYS OGE	*Nyssa ogeche* Bartr. ex Marsh.	Ogeechee-lime	OBL	OBL	OBL
ONO SEN	*Onoclea sensibilis** L.	Sensitive fern	FACW	FACW	FACW
OSM REG	*Osmunda regalis** L.	Royal fern	OBL	OBL	OBL
OXY FIL	*Oxypolis filiformis* (Walt.) Britt.	Water cowbane	OBL	FACW+	FACW, OBL
PAN HEM	*Panicum hemitomon* Schult.	Maidencane	OBL	OBL	FACW+, OBL
PAN RIG	*Panicum rigidulum* Bosc. ex Nees	Red-top panic grass	FACW	FACW	FAC, FACW+
PEL VIR	*Peltandra virginica* (L.) Kunth	Green arum	OBL	OBL	OBL
PER PAL	*Persea palustris* (Raf.) Sarg.	Swamp red-bay	OBL	FACW	FACW
PIN TAE	*Pinus taeda* L.	Loblolly pine	UPL	FAC	UPL, FAC
PLA OCC	*Platanus occidentalis* L.	American sycamore	FACW	FACW-	FAC, FACW

Table 2,
(continued)

Species Codes, Botanical Names, Common Names, FDEP (Chapter 63-340.450, FAC) Classifications, and USACOE Regional and National Wetland Indicators of All Plant Species Observed at the Savannah National Wildlife Refuge During October-November 1997

Species Code	Botanical Name	Common Name	FDEP Classification	USACOE Region 2 Indicator	USACOE National Indicator
PLU ODO	*Pluchea odorata* (L.) Cass.	Salt marsh fleabane	FACW	FACW	FACW
PLU ROS	*Pluchea rosea* Godfrey	Godfrey's fleabane	FACW	FACW	FACW
POL ARI	Polygonum arifolium L.	Halberd-leaf tearthumb	OBL	OBL	OBL
POL HYD	Polygonum hydropiperoides Michx.	Mild water-pepper	OBL	OBL	OBL
POL PUN	Polygonum punctatum Ell.	Dotted smartweed	OBL	FACW+	FACW, OBL
POL SAG	Polygonum sagittatum L.	Arrow-leaf tearthumb	OBL	OBL	OBL
PON COR	Pontederia cordata L.	Pickerelweed	OBL	OBL	OBL
PTI COS	Ptilimnium costatum (Elliott) Rad.	Ribbed mock bishop-weed	UPL	FACW	FACW, OBL
QUE LAU	Quercus laurifolia Michx.	Swamp laurel oak	FACW	FACW	FACW-, FACW
QUE LYR	Quercus lyrata Walter	Overcup oak	OBL	OBL	OBL
QUE NIG	Quercus nigra L.	Water oak	FACW	FAC	FAC, FACW
RHY COR	Rhynchospora corniculata (Lam.) Gray	Short-bristle beakrush	OBL	OBL	OBL
RHY MCC	Rhynchospora microcarpa Baldw. ex Gray	Small-fruited beakrush	OBL	FACW+	FACW+
ROS PAL	Rosa palustris Marsh.	Swamp rose	OBL	OBL	OBL
RUB BET	Rubus betulifolius Small	Blackberry	FAC	FAC	FAC
RUM VER	Rumex verticillatus L.	Swamp dock	FACW	FACW+	FACW, OBL
SAC STR	Sacciolepis striata (L.) Nash.	American cupscale	OBL	OBL	OBL
SAG GRA	Sagittaria graminea Michx.	Narrow-leaved arrow-head	OBL	OBL	OBL
SAG LAN	Sagittaria lancifolia L.	Bull-tongue arrow-head	OBL	OBL	OBL
SAG LAT	Sagittaria latifolia Willd.	Broad-leaf arrow-head	OBL	OBL	OBL
SAG STA	Sagittaria stagnorum Small	Water arrow-head	OBL	OBL	OBL
SAL CAR	Salix caroliniana Michx.	Coastal-plain willow	OBL	OBL	FACW+, OBL
SAM CAN	Sambucus canadensis L.	Elderberry	FAC	FACW-	UPL, FACW
SAP SEB	Sapium sebiferum (L.) Roxb.	Chinese tallow-tree	FAC	FAC	FACU+, FAC
SAU CER	Saururus cernuus L.	Lizard's tail	OBL	OBL	OBL
SCI CYP	Scirpus cyperinus (L.) Kunth	Woolgrass bulrush	OBL	OBL	FACW+, OBL
SCI PUN	Scirpus pungens Vahl	Three-square bulrush	OBL	OBL	FACW+, OBL
SCI ROB	Scirpus robustus Pursh	Alkali bulrush	OBL	OBL	OBL
SCI VAL	Scirpus validus Vahl	Soft-stem bulrush	OBL	OBL	OBL

Table 2,
(continued)

Species Codes, Botanical Names, Common Names, FDEP (Chapter 63-340.450, FAC) Classifications, and USACOE Regional and National Wetland Indicators of All Plant Species Observed at the Savannah National Wildlife Refuge During October-November 1997

Species Code	Botanical Name	Common Name	FDEP Classification	USACOE Region 2 Indicator	USACOE National Indicator
SES PUN	Sesbania punicea (Cav.) Benth.	Purple rattle-bush	FAC	FAC+	FAC+, FACW-
SOL SEM	Solidago sempervirens L.	Seaside golden-rod	FACW	FACW	FACW-, FACW
SOL STR	Solidago stricta Ait.	Willow-leaf golden-rod	FACW	OBL	FACW-, OBL
SPA ALT	Spartina alterniflora Loiseleur	Saltmarsh cordgrass	OBL	OBL	OBL
SPA BAK	Spartina bakeri Merrill	Sand cordgrass	FACW	FACW+	FACW+
SPA CYN	Spartina cynosuroides (L.) Roth	Big cordgrass	OBL	OBL	OBL
SPI CER	Spiranthes cernua (L.) L. C. Rich var. odorata* (Nutt.) Correll	Nodding ladies'-tresses	FACW	OBL	OBL
TAX DIS	Taxodium distichum (L.) L. C. Rich.	Bald cypress	OBL	OBL	OBL
TOX RAD	Toxicodendron radicans (L.) Kuntze	Poison ivy	NONE (Vine)	FAC	FACU, FACW
TYP ANG	Typha angustifolia L.	Narrow-leaved cattail	OBL	OBL	OBL
TYP DOM	Typha domingensis Pers.	Southern cattail	OBL	OBL	OBL
TYP LAT	Typha latifolia L.	Common cattail	OBL	OBL	OBL
UNK COMP	Unknown composite	-----	---	---	---
UNK HER	Unknown herb	-----	---	---	---
VIB DEN	Viburnum dentatum L.	Southern arrow-wood	FACW	FAC	FAC
VIB NUD	Viburnum nudum L.	Possum-haw viburnum	FACW	FACW+	FACW+, OBL
VIT ROT	Vitis rotundifolia Michx.	Muscadine grape	NONE (Vine)	FAC	FAC-, FACW
VIO PRI	Viola primulifolia L.	Primrose-leaf violet	FACW	FACW	FAC, FACW+
WIS FRU	Wisteria frutescens (L.) Poir.	American wisteria	NONE (Vine)	FACW	FACW-, FACW
XYR IRI	Xyris iridifolia Chapm.	Iris-leaf yellow-eyed-grass	OBL	OBL	OBL
XYR PLA	Xyris platylepis Chapm.	Tall yellow-eyed-grass	OBL	OBL	OBL
ZIZ AQU	Zizania aquatica L.	Annual wildrice	OBL	OBL	OBL
ZIZ MIL	Zizaniopsis miliacea (Michx.) Doell & Aschers.	Southern wildrice	OBL	OBL	OBL

Table 2,
(continued)

Species Codes, Botanical Names, Common Names, FDEP (Chapter 63-340.450, FAC) Classifications, and USACOE Regional and National Wetland Indicators of All Plant Species Observed at the Savannah National Wildlife Refuge During October-November 1997

Species Code	Botanical Name	Common Name	FDEP Classification	USACOE Region 2 Indicator	USACOE National Indicator

FDEP Classification:

OBL = Obligate Species; FACW = Facultative Wet Species; FAC = Facultative Species; UPL = Upland Species; NONE = Aquatic or Vine

USACOE Indicator Categories:

Obligate Wetland (OBL). Occur almost always (estimated probability >99%) under natural conditions in wetlands.

Facultative Wetland (FACW). Usually occur in wetlands (estimated probability 67%–99%), but occasionally found in nonwetlands.

Facultative (FAC). Equally likely to occur in wetlands or nonwetlands (estimated probability 34%–66%).

Facultative Upland (FACU). Usually occur in nonwetlands (estimated probability 67%–99%), but occasionally found in wetlands (estimated probability 1%–33%).

Obligate Upland (UPL). Occur in wetlands in another region, but occur almost always (estimated probability >99%) under natural conditions in nonwetlands in the region specified. If a species does not occur in wetlands in any region, it is not on the National List. A positive (+) or negative (-) sign was used with the Facultative Indicator categories to more specifically define the regional frequency of occurrence in wetlands. The positive sign indicates a frequency toward the higher end of the category (more frequently found in wetlands) and a negative sign indicates a frequency toward the lower end of the category (less frequently found in wetlands).

Table 3

Species List Detailing Presence (X) and Absence (--) of All Plants Found in 10 Quantitative Quadrats Established in the Savannah National Wildlife Refuge During October-November 1997

Species Name	Quadrat Number									
	2	10	5	3	4	7	1	6	8	9
Aster tenuifolius	X	X	X	--	X	--	--	--	--	--
Pluchea odorata	X	X	X	X	X	--	X	X	X	--
Scirpus robustus	X	X	--	--	--	X	--	--	--	--
Scirpus validus	X	X	X	X	X	X	X	X	X	X
Spartina alterniflora	X	X	X	X	--	X	--	--	--	--
Spartina cynosuroides	X	--	--	X	X	X	--	--	--	--
Typha angustifolia	X	X	X	X	--	X	X	X	X	--
Alternanthera philoxeroides	--	X	X	--	--	--	X	--	--	--
Amaranthus cannabinus	--	X	X	X	X	X	--	--	--	X
Bidens laevis	--	X	X	X	X	X	X	X	X	X
Cicuta mexicana	--	X	X	--	X	X	X	X	X	X
Eleocharis fallax	--	X	X	X	X	--	X	X	X	X
Iris hexagona	--	X	--	--	--	--	X	X	X	--
Peltandra virginica	--	X	--	X	--	X	--	--	--	--
Polygonum arifolium	--	X	X	--	--	--	X	--	X	X
Polygonum punctatum	--	X	X	X	X	X	X	X	X	X
Pontederia cordata	--	X	--	X	X	--	X	--	--	X
Sagittaria lancifolia	--	X	X	X	X	X	X	X	X	--
Zizaniopsis miliacea	--	X	X	X	X	X	X	X	X	X
Aster elliottii	--	--	X	--	X	X	X	X	X	X
Aster species	--	--	--	--	--	X	--	--	X	X
Boltonia asteroides	--	--	--	X	--	X	--	--	X	--
Eleocharis elongata	--	--	--	--	--	X	--	X	--	--
Lilaeopsis chinensis	--	--	X	X	--	X	--	--	--	--
Ptilimnium costatum	--	--	--	--	--	X	--	--	X	--
Baccharis halimifolia	--	--	X	--	--	--	--	X	X	X
Cyperus haspan	--	--	X	X	X	--	X	X	X	X
Euthamia tenuifolia	--	--	X	--	--	--	--	--	--	--
Hydrocotyle umbellata	--	--	X	--	--	--	X	X	--	--
Juncus effusus	--	--	X	--	--	--	--	X	--	--
Pluchea rosea	--	--	X	X	--	--	--	--	--	--
Zizania aquatica	--	--	X	--	--	--	X	X	--	X
Agalinis purpurea	--	--	--	--	--	--	X	--	X	X
Apios americana	--	--	--	X	--	--	X	--	X	--
Bidens mitis	--	--	--	--	--	--	X	--	--	--
Cyperus species	--	--	--	--	--	--	X	--	--	--
Eleocharis quadrangulata	--	--	--	--	X	--	X	X	--	--
Leersia oryzoides	--	--	--	X	--	--	X	X	X	--
Lobelia glandulosa	--	--	--	--	--	--	X	--	X	--
Ludwigia leptocarpa	--	--	--	--	--	--	X	--	--	--

Table 3

(continued)

Species List Detailing Presence (X) and Absence (--) of All Plants Found in 10 Quantitative Quadrats Established in the Savannah National Wildlife Refuge During October-November 1997

Species Name	Quadrat Number									
	2	10	5	3	4	7	1	6	8	9
Ludwigia microcarpa	--	--	--	--	--	--	X	--	X	X
Ludwigia palustris	--	--	--	--	--	--	X	--	--	--
Mikania scandens	--	--	--	--	--	--	X	X	X	X
Murdannia keisak	--	--	--	--	--	--	X	X	X	X
Polygonum sagittatum	--	--	--	--	--	--	X	--	X	--
Rhynchospora corniculata	--	--	--	--	--	--	X	--	X	X
Typha latifolia	--	--	--	--	--	--	X	--	--	--
Xyris iridifolia	--	--	--	--	--	--	X	X	X	--
Acer rubrum	--	--	--	--	--	--	--	X	--	X
Andropogon glomeratus	--	--	--	--	--	--	--	X	--	--
Carex albolutescens	--	--	--	--	--	--	--	X	--	--
Cinna arundinacea	--	--	--	--	--	--	--	X	--	--
Cyperus strigosus	--	--	--	--	X	--	--	X	X	--
Eleocharis cellulosa	--	--	--	X	X	--	--	X	X	--
Eupatorium leptophyllum	--	--	--	--	--	--	--	X	--	--
Hypericum hypericoides	--	--	--	--	--	--	--	X	--	--
Hypericum mutilum	--	--	--	--	--	--	--	X	X	--
Ipomoea sagittata	--	--	--	--	--	--	--	X	X	--
Juncus scirpoides	--	--	--	--	--	--	--	X	X	--
Luziola fluitans	--	--	--	--	--	--	--	X	--	--
Myrica cerifera	--	--	--	--	--	--	--	X	X	X
Osmunda regalis	--	--	--	--	--	--	--	X	X	X
Panicum rigidulum	--	--	--	--	--	--	--	X	X	--
Persea palustris	--	--	--	--	--	--	--	X	--	X
Rhynchospora microcarpa	--	--	--	--	--	--	--	X	X	--
Solidago sempervirens	--	--	--	--	--	--	--	X	--	--
Solidago stricta	--	--	--	--	--	--	--	X	--	--
Taxodium distichum	--	--	--	--	--	--	--	X	--	--
Unknown herb	--	--	--	--	--	--	--	X	--	--
Oxypolis filiformis	--	--	--	X	--	--	--	--	--	--
Scirpus pungens	--	--	--	X	--	--	--	--	--	--
Cephalanthus occidentalis	--	--	--	--	--	--	--	--	--	X
Cornus foemina	--	--	--	--	--	--	--	--	--	X
Forestiera segregata	--	--	--	--	--	--	--	--	--	X
Galium tinctorium	--	--	--	--	--	--	--	--	X	X
Lonicera japonica	--	--	--	--	--	--	--	--	--	X
Onoclea sensibilis	--	--	--	--	--	--	--	--	X	X
Rubus betulifolius	--	--	--	--	--	--	--	--	--	X
Rosa palustris	--	--	--	--	--	--	--	--	--	X
Salix caroliniana	--	--	--	--	--	--	--	--	--	X

Saururus cernuus	--	--	--	--	--	--	--	--	--	X

Table 3

(continued)

Species List Detailing Presence (X) and Absence (--) of All Plants
Found in 10 Quantitative Quadrats Established in the
Savannah National Wildlife Refuge During October-November 1997

Species Name	Quadrat Number									
	2	10	5	3	4	7	1	6	8	9
Scirpus cyperinus	--	--	--	--	--	--	--	--	X	X
Toxicodendron radicans	--	--	--	--	--	--	--	--	--	X
Wisteria frutescens	--	--	--	--	--	--	--	--	--	X
Panicum hemitomon	--	--	--	--	X	--	--	--	X	--
Alnus serrulata	--	--	--	--	--	--	--	--	X	--
Arthraxon hispidus var. cryptatherus	--	--	--	--	--	--	--	--	X	--
Aster subulatus	--	--	--	--	--	--	--	--	X	--
Cyperus flavescens	--	--	--	--	--	--	--	--	X	--
Desmodium species	--	--	--	--	--	--	--	--	X	--
Dulichium arundinaceum	--	--	--	--	--	--	--	--	X	--
Eragrostis refracta	--	--	--	--	--	--	--	--	X	--
Erianthus giganteus	--	--	--	--	--	--	--	--	X	--
Fuirena breviseta	--	--	--	--	--	--	--	--	X	--
Leersia hexandra	--	--	--	--	--	--	--	--	X	--
Lycopus rubellus	--	--	--	--	--	--	--	--	X	--
Sacciolepis striata	--	--	--	--	--	--	--	--	X	--
Sagittaria latifolia	--	--	--	--	--	--	--	--	X	--
Sagittaria stagnorum	--	--	--	--	--	--	--	--	X	--
Sesbania punicea	--	--	--	--	--	--	--	--	X	--
Unknown composite	--	--	--	--	--	--	--	--	X	--
Viburnum nudum	--	--	--	--	--	--	--	--	X	--
Viola primulifolia	--	--	--	--	--	--	--	--	X	--

Table 4

Savannah National Wildlife Refuge Herbaceous Quadrat Data: Summary Statistics for Herbaceous Vegetation Encountered in Quadrats 1 through 10 Monitored October 1997

Quad	Species	Total Freq	Freq %	Frequency of Cover Category Cover Category No./Range (%) 1 <1	2 1-10	3 10-30	4 30-50	5 50-70	6 70-90	7 >90	PROBABLE PERCENT COVER RANGE (%) Total Quadrat Area Min	Avg	Max	Total Occurrence Area Min	Avg	Max	Freq Rank	Cover Rank
1	*Bare ground*	215	43.0	0	18	7	0	0	0	0	1.8	4.6	7.8	3.5	9.2	15.6		
1	*Water*	425	85.0	0	0	0	0	1	0	42	76.6	81.0	85.4	89.1	94.2	99.3		
1	*% Vegetation Cover*	500	100.0	0	0	0	0	0	8	42	86.8	92.6	98.4	86.8	92.6	98.4		
1	*Agalinis purpurea*	36	7.2	0	11	0	0	0	0	0	0.2	1.1	2.2	1.0	5.0	10.0	13	11
1	*Alternanthera philoxeroides*	33	6.6	0	2	1	1	0	0	0	0.8	1.4	2.0	10.5	17.5	25.0	14	9
1	*Apios americana*	17	3.4	0	2	1	0	0	0	0	0.2	0.6	1.0	4.0	10.0	16.7	20	17
1	*Aster elliottii*	342	68.4	1	18	11	15	2	0	0	13.6	20.6	28.0	14.4	21.9	29.8	3	3
1	*Bidens laevis*	22	4.4	1	5	0	0	0	0	0	0.1	0.5	1.0	0.9	4.3	8.5	17	19
1	*Bidens mitis*	27	5.4	0	8	0	0	0	0	0	0.2	0.8	1.6	1.0	5.0	10.0	15	15
1	*Cicuta mexicana*	9	1.8	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	24	25
1	*Cyperus haspan*	50	10.0	1	10	0	0	0	0	0	0.2	1.0	2.0	0.9	4.6	9.2	10	12
1	*Cyperus species*	22	4.4	0	6	0	0	0	0	0	0.1	0.6	1.2	1.0	5.0	10.0	17	17
1	*Eleocharis fallax*	471	94.2	0	5	1	4	9	8	21	60.7	67.6	74.6	63.2	70.4	77.7	1	1
1	*Eleocharis quadrangulata*	68	13.6	1	9	1	0	0	0	0	0.4	1.3	2.4	1.7	6.0	11.0	8	10
1	*Hydrocotyle umbellata*	45	9.0	2	9	0	0	0	0	0	0.2	0.9	1.8	0.8	4.2	8.4	11	14
1	*Iris hexagona*	6	1.2	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	27	25
1	*Leersia oryzoides*	221	44.2	0	6	7	3	6	2	2	15.7	20.0	24.4	30.2	38.5	46.9	5	4
1	*Lobelia glandulosa*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	32	29
1	*Ludwigia leptocarpa*	110	22.0	0	18	4	0	0	0	0	1.2	3.4	6.0	2.6	7.7	13.6	7	7
1	*Ludwigia microcarpa*	6	1.2	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	27	29
1	*Ludwigia palustris*	6	1.2	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	27	29
1	*Mikania scandens*	10	2.0	1	1	1	0	0	0	0	0.2	0.5	0.8	3.7	8.5	13.7	22	19
1	*Murdannia keisak*	57	11.4	0	7	1	1	0	0	0	0.9	1.9	3.0	5.2	10.6	16.7	9	8
1	*Pluchea odorata*	6	1.2	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	27	27
1	*Polygonum arifolium*	8	1.6	0	0	1	0	0	0	0	0.2	0.4	0.6	10.0	20.0	30.0	25	22
1	*Polygonum punctatum*	213	42.6	0	13	9	5	2	0	0	7.1	11.3	15.8	12.2	19.5	27.2	6	5
1	*Polygonum sagittatum*	22	4.4	0	5	0	0	0	0	0	0.1	0.5	1.0	1.0	5.0	10.0	17	21
1	*Pontederia cordata*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	32	29
1	*Rhynchospora corniculata*	11	2.2	0	4	0	0	0	0	0	0.1	0.4	0.8	1.0	5.0	10.0	21	22
1	*Sagittaria lancifolia*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	31	29
1	*Scirpus validus*	236	47.2	8	26	7	1	0	0	0	2.5	6.3	10.6	3.0	7.5	12.6	4	6
1	*Typha angustifolia*	26	5.2	1	7	0	0	0	0	0	0.1	0.7	1.4	0.9	4.4	8.9	16	16
1	*Typha latifolia*	10	2.0	1	3	0	0	0	0	0	0.1	0.3	0.6	0.8	3.9	7.8	22	24
1	*Xyris iridifolia*	40	8.0	0	10	0	0	0	0	0	0.2	1.0	2.0	1.0	5.0	10.0	12	13
1	*Zizania aquatica*	8	1.6	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	25	27
1	*Zizaniopsis miliacea*	421	84.2	0	12	11	9	7	9	0	27.4	35.6	44.0	28.6	37.1	45.8	2	2
2	*Bare ground*	408	81.6	0	9	26	6	0	0	0	9.0	16.1	23.4	11.0	19.6	28.5		
2	*Water*	25	5.0	0	1	1	0	1	0	0	1.2	1.7	2.2	20.3	28.3	36.7		
2	*% Vegetation cover*	500	100.0	0	0	0	1	13	21	15	70.0	78.5	87.0	70.0	78.5	87.0		
2	*Aster tenuifolius*	169	33.8	2	17	2	2	0	0	0	1.9	4.1	6.6	4.2	9.0	14.4	5	6
2	*Pluchea odorata*	3	0.6	1	1	0	0	0	0	0	0.0	0.1	0.2	0.6	2.8	5.5	7	7
2	*Scirpus robustus*	321	64.2	0	15	15	4	1	0	0	6.7	11.9	17.4	9.6	17.0	24.9	2	4
2	*Scirpus validus*	292	58.4	2	9	11	7	1	3	0	11.8	16.9	22.2	17.9	25.6	33.7	3	2
2	*Spartina alterniflora*	262	52.4	0	5	12	10	3	0	0	11.5	16.9	22.4	19.2	28.2	37.3	4	3
2	*Spartina cynosuroides*	116	23.2	1	13	6	0	3	0	0	4.5	7.3	10.4	9.7	15.9	22.7	6	5
2	*Typha angustifolia*	395	79.0	0	6	11	5	5	7	11	39.9	47.1	54.4	44.4	52.3	60.4	1	1
3	*Bare ground*	578	96.3	0	3	31	22	2	0	0	17.9	27.3	36.7	18.5	28.2	37.9		
3	*Water*	501	83.5	0	7	5	30	5	4	0	24.8	32.6	40.5	29.2	38.3	47.6		
3	*% Vegetation cover*	600	100.0	0	0	0	8	18	28	6	60.7	70.2	79.7	60.7	70.2	79.7		
3	*Amaranthus cannabinus*	11	1.8	0	3	0	0	0	0	0	0.1	0.3	0.5	1.0	5.0	10.0	13	14
3	*Apios americana*	2	0.3	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	18	16
3	*Bidens laevis*	66	11.0	0	3	2	0	1	3	0	4.7	5.9	7.2	31.4	39.4	47.8	8	4
3	*Boltonia asteroides*	5	0.8	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	16	16
3	*Cyperus haspan*	1	0.2	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	22	16
3	*Eleocharis cellulosa*	102	17.0	0	5	4	3	1	0	0	3.1	4.8	6.5	14.2	21.9	30.0	5	6
3	*Eleocharis fallax*	26	4.3	0	2	1	0	0	1	0	1.4	1.8	2.3	20.5	27.5	35.0	10	9
3	*Leersia oryzoides*	5	0.8	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	16	16
3	*Lilaeopsis chinensis*	10	1.7	0	2	0	0	0	0	0	0.0	0.2	0.3	1.0	5.0	10.0	14	15
3	*Oxypolis filiformis*	2	0.3	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	18	16
3	*Peltandra virginica*	2	0.3	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	18	16
3	*Pluchea odorata*	16	2.7	0	8	0	0	0	0	0	0.1	0.7	1.3	1.0	5.0	10.0	11	11
3	*Pluchea rosea*	10	1.7	1	3	0	0	0	0	0	0.1	0.3	0.5	0.8	3.9	7.8	14	12
3	*Polygonum punctatum*	90	15.0	0	0	1	3	5	0	0	5.8	7.3	8.8	38.9	48.9	58.9	6	3
3	*Pontederia cordata*	2	0.3	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	18	16
3	*Sagittaria lancifolia*	107	17.8	4	25	1	0	0	0	0	0.6	2.5	4.7	1.2	4.9	9.5	4	8
3	*Scirpus pungens*	76	12.7	0	5	2	0	2	0	0	2.1	3.1	4.2	13.9	20.6	27.8	7	7
3	*Scirpus validus*	564	94.0	0	2	11	10	15	19	0	41.5	50.8	60.2	43.7	53.5	63.3	1	1
3	*Spartina alterniflora*	118	19.7	0	6	4	3	1	0	0	3.1	4.8	6.7	13.3	20.7	28.6	3	5
3	*Spartina cynosuroides*	29	4.8	0	1	4	0	0	0	0	0.7	1.4	2.2	8.2	17.0	26.0	9	10
3	*Typha angustifolia*	12	2.0	1	3	0	0	0	0	0	0.1	0.3	0.5	0.8	3.9	7.8	12	12
3	*Zizaniopsis miliacea*	193	32.2	4	15	4	7	4	2	0	10.1	14.0	18.1	16.8	23.3	30.1	2	2
4	*Bare ground*	485	97.0	0	9	21	13	5	1	0	18.6	27.3	36.2	19.0	27.9	36.9		
4	*Water*	410	82.0	0	0	3	1	0	0	37	67.8	72.3	76.8	82.7	88.2	93.7		
4	*% Vegetation cover*	500	100.0	0	0	2	4	13	21	10	63.2	72.2	81.2	63.2	72.2	81.2		

Table 4

(continued)

Savannah National Wildlife Refuge Herbaceous Quadrat Data: Summary Statistics for Herbaceous Vegetation Encountered in Quadrats 1 through 10 Monitored October 1997

Quad	Species	Total Freq	Freq %	Frequency of Cover Category Cover Category No./Range (%) 1 <1	2 1-10	3 10-30	4 30-50	5 50-70	6 70-90	7 >90	PROBABLE PERCENT COVER RANGE (%) Total Quadrat Area Min	Avg	Max	Total Occurrence Area Min	Avg	Max	Freq Rank	Cover Rank
4	*Amaranthus cannabinus*	3	0.6	1	1	0	0	0	0	0	0.0	0.1	0.2	0.6	2.8	5.5	12	11
4	*Aster elliottii*	187	37.4	4	13	8	6	2	1	0	8.9	13.3	18.1	13.0	19.6	26.6	4	3
4	*Aster tenuifolius*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	12	12
4	*Bidens laevis*	156	31.2	1	19	8	2	0	0	0	3.2	6.7	10.6	5.3	11.2	17.7	6	5
4	*Cicuta mexicana*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	16	12
4	*Cyperus haspan*	2	0.4	2	0	0	0	0	0	0	0.0	0.0	0.0	0.1	0.5	1.0	16	17
4	*Cyperus strigosus*	4	0.8	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	11	12
4	*Eleocharis cellulosa*	34	6.8	4	2	0	0	0	0	0	0.0	0.2	0.5	0.4	2.0	4.0	8	10
4	*Eleocharis fallax*	167	33.4	2	10	8	0	0	0	0	1.8	4.2	6.8	4.5	10.6	17.1	5	7
4	*Eleocharis quadrangulata*	26	5.2	0	5	0	0	0	0	0	0.1	0.5	1.0	1.0	5.0	10.0	9	8
4	*Panicum hemitomon*	54	10.8	0	4	1	1	0	2	0	3.7	4.8	6.0	23.0	30.0	37.5	7	6
4	*Pluchea odorata*	12	2.4	1	3	0	0	0	0	0	0.1	0.3	0.6	0.8	3.9	7.8	10	9
4	*Polygonum punctatum*	361	72.2	1	19	7	11	7	1	0	16.8	23.5	30.6	18.2	25.6	33.3	2	2
4	*Pontederia cordata*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	12	12
4	*Sagittaria lancifolia*	1	0.2	1	0	0	0	0	0	0	0.0	0.0	0.0	0.1	0.5	1.0	18	18
4	*Scirpus validus*	351	70.2	11	23	5	5	2	0	0	6.5	10.8	15.6	7.0	11.8	17.0	3	4
4	*Spartina cynosuroides*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	12	12
4	*Zizaniopsis miliacea*	446	89.2	0	5	10	11	13	11	0	37.1	46.5	56.0	37.1	46.5	56.0	1	1
5	*Bare ground*	483	96.6	0	16	22	9	1	1	0	12.5	20.4	28.6	12.8	20.8	29.2		
5	*Water*	445	89.0	0	2	2	18	1	3	19	50.6	57.5	64.4	56.3	63.9	71.6		
5	*% Vegetation cover*	500	100.0	0	0	0	1	10	22	17	72.0	80.3	88.6	72.0	80.3	88.6		
5	*Alternanthera philoxeroides*	22	4.4	0	2	1	0	0	0	0	0.2	0.6	1.0	4.0	10.0	16.7	11	11
5	*Amaranthus cannabinus*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	17	16
5	*Aster elliottii*	1	0.2	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	22	16
5	*Aster tenuifolius*	44	8.8	3	11	0	0	0	0	0	0.2	1.1	2.3	0.8	4.0	8.1	7	8
5	*Baccharis halimifolia*	15	3.0	0	1	1	0	1	0	0	1.2	1.7	2.2	20.3	28.3	36.7	13	7
5	*Bidens laevis*	45	9.0	1	8	1	0	1	1	0	2.8	4.0	5.4	11.5	16.7	22.6	6	4
5	*Cicuta mexicana*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	17	16
5	*Cyperus haspan*	1	0.2	1	0	0	0	0	0	0	0.0	0.0	0.0	0.1	0.5	1.0	22	23
5	*Eleocharis fallax*	300	60.0	1	1	0	2	7	8	12	41.0	45.7	50.4	66.2	73.7	81.3	2	1
5	*Euthamia tenuifolia*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	17	16
5	*Hydrocotyle umbellata*	41	8.2	9	0	0	0	0	0	0	0.0	0.1	0.2	0.1	0.5	1.0	9	22
5	*Juncus effusus*	4	0.8	1	1	0	0	0	0	0	0.0	0.1	0.2	0.6	2.8	5.5	16	15
5	*Lilaeopsis chinensis*	18	3.6	0	2	1	0	0	0	0	0.2	0.6	1.0	4.0	10.0	16.7	12	11
5	*Pluchea odorata*	74	14.8	3	19	0	0	0	0	0	0.4	1.9	3.9	0.9	4.4	8.8	4	6
5	*Pluchea rosea*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	17	16
5	*Polygonum arifolium*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	17	16
5	*Polygonum punctatum*	67	13.4	1	6	2	2	0	0	0	1.7	3.0	4.4	7.8	13.7	20.1	5	5
5	*Sagittaria lancifolia*	42	8.4	13	7	0	0	0	0	0	0.2	0.8	1.7	0.4	2.1	4.2	8	9
5	*Scirpus validus*	465	93.0	8	23	8	4	3	4	0	13.1	18.8	25.0	13.1	18.8	25.0	1	3
5	*Spartina alterniflora*	7	1.4	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	14	13
5	*Typha angustifolia*	37	7.4	5	6	0	0	0	0	0	0.1	0.7	1.3	0.6	3.0	5.9	10	10
5	*Zizania aquatica*	5	1.0	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	15	13
5	*Zizaniopsis miliacea*	174	34.8	0	1	1	4	4	5	3	19.0	22.2	25.4	52.8	61.7	70.6	3	2
6	*Bare ground*	330	66.0	0	15	14	4	1	1	0	7.9	13.1	18.6	11.3	18.7	26.6		
6	*Water*	498	99.6	0	0	0	1	0	2	47	88.0	93.3	98.6	88.0	93.3	98.6		
6	*% Vegetation cover*	499	99.8	0	0	1	0	6	17	26	76.8	84.2	91.6	76.8	84.2	91.6		
6	*Acer rubrum*	9	1.8	0	1	0	1	0	0	0	0.6	0.9	1.2	15.5	22.5	30.0	20	11
6	*Andropogon glomeratus*	7	1.4	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	22	23
6	*Aster elliottii*	175	35.0	1	13	10	1	2	0	0	4.9	8.5	12.4	9.0	15.8	23.0	4	3
6	*Baccharis halimifolia*	11	2.2	1	4	0	0	0	0	0	0.1	0.4	0.8	0.8	4.1	8.2	18	18
6	*Bidens laevis*	2	0.4	1	0	0	0	0	0	1	1.8	1.9	2.0	45.1	47.8	50.5	33	10
6	*Carex albolutescens*	7	1.4	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	22	23
6	*Cicuta mexicana*	1	0.2	1	0	0	0	0	0	0	0.0	0.0	0.0	0.1	0.5	1.0	43	43
6	*Cinna arundinacea*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	32
6	*Cyperus haspan*	18	3.6	3	4	0	0	0	0	0	0.1	0.4	0.9	0.6	3.1	6.1	13	17
6	*Cyperus strigosus*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	32
6	*Eleocharis cellulosa*	21	4.2	1	5	0	0	0	0	0	0.1	0.5	1.0	0.9	4.3	8.5	11	15
6	*Eleocharis elongata*	8	1.6	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	21	23
6	*Eleocharis fallax*	408	81.6	0	9	6	7	5	8	8	36.2	42.9	49.8	42.1	49.9	57.9	1	1
6	*Eleocharis quadrangulata*	7	1.4	1	0	1	0	0	0	0	0.2	0.4	0.6	5.1	10.3	15.5	22	18
6	*Eupatorium leptophyllum*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	32
6	*Hydrocotyle umbellata*	12	2.4	7	1	0	0	0	0	0	0.0	0.2	0.3	0.2	1.1	2.1	17	31
6	*Hypericum hypericoides*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	32
6	*Hypericum mutilum*	5	1.0	1	2	0	0	0	0	0	0.0	0.2	0.4	0.7	3.5	7.0	28	27
6	*Ipomoea sagittata*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	32
6	*Iris hexagona*	11	2.2	1	3	0	0	0	0	0	0.1	0.3	0.6	0.8	3.9	7.8	18	22
6	*Juncus effusus*	17	3.4	0	5	0	0	0	0	0	0.1	0.5	1.0	1.0	5.0	10.0	16	16
6	*Juncus scirpoides*	6	1.2	1	2	0	0	0	0	0	0.0	0.2	0.4	0.7	3.5	7.0	25	27
6	*Leersia oryzoides*	6	1.2	0	0	1	0	0	0	0	0.2	0.4	0.6	10.0	20.0	30.0	25	21
6	*Luziola fluitans*	25	5.0	0	1	0	0	0	0	2	3.6	3.9	4.2	60.3	65.0	70.0	10	7
6	*Mikania scandens*	19	3.8	0	3	1	0	0	0	0	0.3	0.7	1.2	3.3	8.8	15.0	12	13
6	*Murdannia keisak*	119	23.8	0	9	5	2	2	0	0	4.4	6.9	9.6	12.2	19.2	26.7	6	5
6	*Myrica cerifera*	40	8.0	0	3	2	3	1	0	0	3.3	4.7	6.2	18.1	26.1	34.4	8	6

Table 4

(continued)

Savannah National Wildlife Refuge Herbaceous Quadrat Data: Summary Statistics for Herbaceous Vegetation Encountered in Quadrats 1 through 10 Monitored October 1997

				Frequency of Cover Category Cover Category No./Range (%)							PROBABLE PERCENT COVER RANGE (%) Total Quadrat Area			Total Occurrence Area				
Quad	Species	Total Freq	Freq %	1 <1	2 1-10	3 10-30	4 30-50	5 50-70	6 70-90	7 >90	Min	Avg	Max	Min	Avg	Max	Freq Rank	Cover Rank
6	*Osmunda regalis*	42	8.4	0	3	0	3	1	0	0	2.9	3.9	5.0	20.4	27.9	35.7	7	7
6	*Panicum rigidulum*	18	3.6	0	6	0	0	0	0	0	0.1	0.6	1.2	1.0	5.0	10.0	13	14
6	*Persea palustris*	4	0.8	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	29	29
6	*Pluchea odorata*	6	1.2	2	2	0	0	0	0	0	0.0	0.2	0.4	0.6	2.8	5.5	25	26
6	*Polygonum punctatum*	144	28.8	0	35	0	0	0	0	0	0.7	3.5	7.0	1.0	5.0	10.0	5	9
6	*Rhynchospora microcarpa*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	31	32
6	*Sagittaria lancifolia*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	32
6	*Scirpus validus*	238	47.6	5	30	2	4	1	0	0	4.4	8.3	12.7	5.3	9.8	15.1	3	4
6	*Solidago sempervirens*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	32
6	*Solidago stricta*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	32
6	*Taxodium distichum*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	31	32
6	*Typha angustifolia*	4	0.8	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	29	29
6	*Unknown herb*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	32
6	*Xyris iridifolia*	18	3.6	1	4	0	0	0	0	0	0.1	0.4	0.8	0.8	4.1	8.2	13	18
6	*Zizania aquatica*	31	6.2	0	8	0	0	0	0	0	0.2	0.8	1.6	1.0	5.0	10.0	9	12
6	*Zizaniopsis miliacea*	369	73.8	0	4	9	13	3	7	5	31.5	38.7	46.0	38.4	47.2	56.1	2	2
7	*Bare ground*	395	79.0	0	11	23	3	0	3	0	10.8	17.5	24.4	13.5	21.9	30.5		
7	*Water*	232	46.4	0	6	8	0	5	4	2	15.9	20.0	24.2	31.8	40.0	48.4		
7	*% Vegetation cover*	500	100.0	0	0	2	1	4	24	19	72.8	80.9	89.0	72.8	80.9	89.0		
7	*Amaranthus cannabinus*	6	1.2	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	14	13
7	*Aster elliottii*	138	27.6	0	2	2	2	8	3	0	13.8	17.0	20.2	40.7	50.0	59.4	5	4
7	*Aster species*	33	6.6	0	1	2	1	0	1	0	2.4	3.3	4.2	24.2	33.0	42.0	8	8
7	*Bidens laevis*	382	76.4	0	5	10	10	11	6	2	31.1	39.1	47.2	35.3	44.4	53.6	1	1
7	*Boltonia asteroides*	2	0.4	1	0	0	0	0	0	0	0.0	0.0	0.0	0.1	0.5	1.0	15	17
7	*Cicuta mexicana*	33	6.6	0	2	1	1	0	1	0	2.2	3.0	3.8	22.4	30.0	38.0	8	9
7	*Eleocharis elongata*	26	5.2	0	1	1	0	0	2	0	3.0	3.7	4.4	37.8	46.3	55.0	10	7
7	*Lilaeopsis chinensis*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	15	15
7	*Peltandra virginica*	93	18.6	1	9	5	0	0	0	0	1.2	2.9	4.8	3.9	9.7	16.1	6	10
7	*Polygonum punctatum*	301	60.2	1	21	9	8	2	1	2	14.0	19.9	26.2	15.9	22.6	29.8	3	3
7	*Ptilimnium costatum*	17	3.4	0	6	0	0	0	0	0	0.1	0.6	1.2	1.0	5.0	10.0	12	12
7	*Sagittaria lancifolia*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	15	15
7	*Scirpus robustus*	11	2.2	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	13	13
7	*Scirpus validus*	271	54.2	1	19	9	3	2	2	0	8.8	13.5	18.6	12.2	18.8	25.9	4	5
7	*Spartina alterniflora*	2	0.4	1	0	0	0	0	0	0	0.0	0.0	0.0	0.1	0.5	1.0	15	17
7	*Spartina cynosuroides*	50	10.0	0	1	1	1	2	1	0	4.2	5.3	6.4	35.2	44.2	53.3	7	6
7	*Typha angustifolia*	22	4.4	2	7	0	0	0	0	0	0.1	0.7	1.4	0.8	4.0	8.0	11	11
7	*Zizaniopsis miliacea*	302	60.4	0	20	8	7	5	2	2	17.6	23.8	30.4	20.0	27.0	34.5	2	2
8	*Bare ground*	335	67.0	0	18	11	9	3	0	0	11.0	17.0	23.4	13.4	20.7	28.5		
8	*Water*	378	75.6	0	0	3	0	0	1	35	65.0	69.3	73.6	83.3	88.8	94.4		
8	*% Vegetation cover*	500	100.0	0	0	0	3	9	12	26	74.4	81.8	89.2	74.4	81.8	89.2		
8	*Agalinis purpurea*	150	30.0	3	24	0	0	0	0	0	0.5	2.4	4.9	0.9	4.5	9.0	4	8
8	*Alnus serrulata*	129	25.8	0	3	1	1	5	4	2	15.1	17.7	20.4	47.1	55.3	63.8	8	3
8	*Apios americana*	16	3.2	0	1	1	0	0	0	0	0.2	0.5	0.8	5.5	12.5	20.0	28	28
8	*Arthraxon hispidus var. cryptatherus*	12	2.4	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	31	32
8	*Aster elliottii*	130	26.0	0	29	4	0	0	0	0	1.4	4.5	8.2	2.1	6.8	12.4	7	5
8	*Aster species*	4	0.8	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	43	39
8	*Aster subulatus*	73	14.6	2	14	0	0	0	0	0	0.3	1.4	2.8	0.9	4.4	8.9	11	14
8	*Baccharis halimifolia*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	50	45
8	*Bidens laevis*	22	4.4	0	6	0	0	0	0	0	0.1	0.6	1.2	1.0	5.0	10.0	27	25
8	*Boltonia asteroides*	11	2.2	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	32	32
8	*Cicuta mexicana*	33	6.6	8	9	0	0	0	0	0	0.2	1.0	2.0	0.6	2.9	5.8	22	22
8	*Cyperus flavescens*	1	0.2	1	0	0	0	0	0	0	0.0	0.0	0.0	0.1	0.5	1.0	56	58
8	*Cyperus haspan*	98	19.6	2	19	0	0	0	0	0	0.4	1.9	3.8	0.9	4.6	9.1	10	12
8	*Cyperus strigosus*	35	7.0	1	10	0	0	0	0	0	0.2	1.0	2.0	0.9	4.6	9.2	20	19
8	*Desmodium species*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	45	45
8	*Dulichium arundinaceum*	105	21.0	1	16	2	1	0	0	0	1.3	3.2	5.4	3.3	8.0	13.6	9	6
8	*Eleocharis cellulosa*	29	5.8	0	5	0	0	0	0	0	0.1	0.5	1.0	1.0	5.0	10.0	26	28
8	*Eleocharis fallax*	317	63.4	3	4	2	1	7	3	16	41.1	45.6	50.3	57.1	63.4	69.8	1	1
8	*Eragrostis refracta*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	50	45
8	*Erianthus giganteus*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	50	45
8	*Fuirena breviseta*	7	1.4	1	2	0	0	0	0	0	0.0	0.2	0.4	0.7	3.5	7.0	36	38
8	*Galium tinctorium*	53	10.6	0	10	0	0	0	0	0	0.2	1.0	2.0	1.0	5.0	10.0	16	20
8	*Hypericum mutilum*	13	2.6	2	3	0	0	0	0	0	0.1	0.3	0.6	0.6	3.2	6.4	30	31
8	*Ipomoea saggitata*	133	26.6	2	18	0	0	0	0	0	0.4	1.8	3.6	0.9	4.6	9.1	6	13
8	*Iris hexagona*	43	8.6	3	9	0	0	0	0	0	0.2	0.9	1.9	0.8	3.9	7.8	18	23
8	*Juncus scirpoides*	3	0.6	1	1	0	0	0	0	0	0.0	0.1	0.2	0.6	2.8	5.5	45	43
8	*Leersia hexandra*	66	13.2	0	8	2	1	0	0	0	1.2	2.4	3.8	5.3	10.9	17.3	12	9
8	*Leersia oryzoides*	142	28.4	0	20	3	0	0	0	0	1.0	3.2	5.8	2.2	7.0	12.6	5	7
8	*Lobelia glandulosa*	1	0.2	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	56	45
8	*Ludwigia microcarpa*	7	1.4	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	36	39
8	*Lycopus rubellus*	8	1.6	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	35	32
8	*Mikania scandens*	10	2.0	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	33	32
8	*Murdannia keisak*	172	34.4	0	6	9	3	1	2	0	7.5	11.0	14.6	17.9	26.2	34.8	3	4

Table 4

(continued)

Savannah National Wildlife Refuge Herbaceous Quadrat Data: Summary Statistics for Herbaceous Vegetation Encountered in Quadrats 1 through 10 Monitored October 1997

				Frequency of Cover Category Cover Category No./Range (%)							PROBABLE PERCENT COVER RANGE (%)							
											Total Quadrat Area			Total Occurrence Area				
Quad	Species	Total Freq	Freq %	1 <1	2 1-10	3 10-30	4 30-50	5 50-70	6 70-90	7 >90	Min	Avg	Max	Min	Avg	Max	Freq Rank	Cover Rank
8	*Myrica cerifera*	6	1.2	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	39	39
8	*Onoclea sensibilis*	56	11.2	0	8	4	0	0	0	0	1.0	2.4	4.0	4.0	10.0	16.7	14	9
8	*Osmunda regalis*	31	6.2	0	4	1	0	1	0	0	1.3	2.0	2.8	10.7	16.7	23.3	24	11
8	*Panicum hemitomon*	10	2.0	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	33	32
8	*Panicum rigidulum*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	45	45
8	*Pluchea odorata*	14	2.8	0	6	0	0	0	0	0	0.1	0.6	1.2	1.0	5.0	10.0	29	25
8	*Polygonum arifolium*	32	6.4	0	4	1	0	0	0	0	0.3	0.8	1.4	2.8	8.0	14.0	23	24
8	*Polygonum punctatum*	51	10.2	0	9	1	0	0	0	0	0.4	1.3	2.4	1.9	6.5	12.0	17	17
8	*Polygonum sagittatum*	30	6.0	0	6	0	0	0	0	0	0.1	0.6	1.2	1.0	5.0	10.0	25	25
8	*Ptilimnium costatum*	63	12.6	2	12	0	0	0	0	0	0.2	1.2	2.4	0.9	4.4	8.7	13	18
8	*Rhynchospora corniculata*	34	6.8	2	9	1	0	0	0	0	0.4	1.3	2.4	1.6	5.5	10.2	21	15
8	*Rhynchospora microcarpa*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	50	45
8	*Sacciolepis striata*	6	1.2	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	39	39
8	*Sagittaria lancifolia*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	50	45
8	*Sagittaria latifolia*	3	0.6	1	1	0	0	0	0	0	0.0	0.1	0.2	0.6	2.8	5.5	45	43
8	*Sagittaria stagnorum*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	50	45
8	*Scirpus cyperinus*	4	0.8	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	43	45
8	*Scirpus validus*	6	1.2	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	39	45
8	*Sesbania punicea*	38	7.6	0	6	1	0	0	0	0	0.3	1.0	1.8	2.3	7.1	12.9	19	20
8	*Typha angustifolia*	1	0.2	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	56	45
8	*Unknown composite*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	45	45
8	*Viburnum nudum*	7	1.4	0	0	1	0	0	0	0	0.2	0.4	0.6	10.0	20.0	30.0	36	30
8	*Viola primulifolia*	6	1.2	2	2	0	0	0	0	0	0.0	0.2	0.4	0.6	2.8	5.5	39	37
8	*Xyris iridifolia*	54	10.8	2	13	0	0	0	0	0	0.3	1.3	2.6	0.9	4.4	8.8	15	15
8	*Zizaniopsis miliacea*	302	60.4	4	23	7	3	4	3	3	17.3	22.8	28.9	18.4	24.3	30.7	2	2
9	*Bare ground*	276	55.2	0	22	6	0	1	0	0	2.6	5.8	9.4	4.6	10.0	16.2		
9	*Water*	255	51.0	0	0	7	5	4	5	6	26.2	31.0	35.8	48.5	57.4	66.3		
9	*% Vegetation cover*	500	100.0	0	0	0	1	0	9	40	85.2	91.2	97.2	85.2	91.2	97.2		
9	*Acer rubrum*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	29
9	*Agalinis purpurea*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	29	29
9	*Amaranthus cannabinus*	5	1.0	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	25	20
9	*Aster elliottii*	136	27.2	0	14	4	2	2	0	1	6.1	8.9	12.0	13.2	19.3	26.1	3	2
9	*Aster species*	1	0.2	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	36	29
9	*Baccharis halimifolia*	13	2.6	0	3	1	0	0	0	0	0.3	0.7	1.2	3.3	8.8	15.0	14	12
9	*Bidens laevis*	25	5.0	0	4	1	0	0	0	0	0.3	0.8	1.4	2.8	8.0	14.0	9	11
9	*Cephalanthus occidentalis*	9	1.8	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	16	17
9	*Cicuta mexicana*	37	7.4	0	10	0	0	0	0	0	0.2	1.0	2.0	1.0	5.0	10.0	6	10
9	*Cornus foemina*	9	1.8	0	1	1	0	0	0	0	0.2	0.5	0.8	5.5	12.5	20.0	16	15
9	*Cyperus haspan*	7	1.4	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	20	20
9	*Eleocharis fallax*	19	3.8	0	1	1	1	0	0	0	0.8	1.3	1.8	13.7	21.7	30.0	10	8
9	*Forestiera segregata*	8	1.6	0	1	1	0	0	0	0	0.2	0.5	0.8	5.5	12.5	20.0	19	15
9	*Galium tinctorium*	9	1.8	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	16	20
9	*Lonicera japonica*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	29
9	*Ludwigia microcarpa*	6	1.2	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	22	20
9	*Mikania scandens*	5	1.0	1	2	0	0	0	0	0	0.0	0.2	0.4	0.7	3.5	7.0	25	19
9	*Murdannia keisak*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	29	29
9	*Myrica cerifera*	17	3.4	0	1	1	1	0	0	0	0.8	1.3	1.8	13.7	21.7	30.0	11	8
9	*Onoclea sensibilis*	134	26.8	1	16	4	0	1	0	0	2.1	4.4	7.0	4.8	10.0	16.0	4	5
9	*Osmunda regalis*	56	11.2	0	3	2	1	3	1	0	5.5	7.1	8.8	27.3	35.5	44.0	5	3
9	*Persea palustris*	15	3.0	0	2	1	0	0	0	0	0.2	0.6	1.0	4.0	10.0	16.7	13	14
9	*Polygonum arifolium*	37	7.4	0	6	0	0	1	0	0	1.1	1.8	2.6	8.0	12.9	18.6	6	6
9	*Polygonum punctatum*	148	29.6	1	22	2	2	0	0	0	2.0	4.6	7.6	3.8	8.5	14.1	2	4
9	*Pontederia cordata*	10	2.0	0	3	0	0	0	0	0	0.1	0.3	0.6	1.0	5.0	10.0	15	17
9	*Rubus betulifolius*	17	3.4	0	1	1	0	1	0	0	1.2	1.7	2.2	20.3	28.3	36.7	11	7
9	*Rhynchospora corniculata*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	29	29
9	*Rosa palustris*	6	1.2	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	22	20
9	*Salix caroliniana*	5	1.0	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	25	20
9	*Saururus cernuus*	28	5.6	0	7	0	0	0	0	0	0.1	0.7	1.4	1.0	5.0	10.0	8	12
9	*Scirpus cyperinus*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	33	29
9	*Scirpus validus*	5	1.0	1	1	0	0	0	0	0	0.0	0.1	0.2	0.6	2.8	5.5	25	28
9	*Toxicodendron radicans*	3	0.6	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	29	29
9	*Wisteria frutescens*	7	1.4	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	20	20
9	*Zizania aquatica*	6	1.2	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	22	20
9	*Zizaniopsis miliacea*	490	98.0	0	0	0	1	3	11	35	82.0	88.5	95.0	82.0	88.5	95.0	1	1
10	*Bare ground*	480	96.0	0	9	29	9	1	0	0	12.4	20.9	29.6	12.9	21.8	30.8		
10	*Water*	358	71.6	0	5	5	25	1	0	0	17.1	23.7	30.4	23.8	32.9	42.2		
10	*% Vegetation cover*	500	100.0	0	0	0	1	9	31	9	69.2	78.3	87.4	69.2	78.3	87.4		
10	*Alternanthera philoxeroides*	50	10.0	0	0	0	0	1	4	0	6.6	7.6	8.6	66.0	76.0	86.0	5	3
10	*Amaranthus cannabinus*	8	1.6	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	13	13
10	*Aster tenuifolius*	32	6.4	2	9	0	0	0	0	0	0.2	0.9	1.8	0.8	4.2	8.4	7	9
10	*Bidens laevis*	21	4.2	2	4	0	0	0	0	0	0.1	0.4	0.8	0.7	3.5	7.0	11	12
10	*Cicuta mexicana*	2	0.4	0	1	0	0	0	0	0	0.0	0.1	0.2	1.0	5.0	10.0	17	17
10	*Eleocharis fallax*	67	13.4	2	4	3	0	1	1	0	3.1	4.4	5.8	14.0	20.1	26.5	4	4
10	*Iris hexagona*	5	1.0	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	14	13

Table 4

(continued)

Savannah National Wildlife Refuge Herbaceous Quadrat Data: Summary Statistics for Herbaceous Vegetation Encountered in Quadrats 1 through 10 Monitored October 1997

				Frequency of Cover Category Cover Category No./Range (%)							PROBABLE PERCENT COVER RANGE (%)							
											Total Quadrat Area			Total Occurrence Area				
Quad	Species	Total Freq	Freq %	1 <1	2 1-10	3 10-30	4 30-50	5 50-70	6 70-90	7 >90	Min	Avg	Max	Min	Avg	Max	Freq Rank	Cover Rank
10	*Peltandra virginica*	9	1.8	0	5	0	0	0	0	0	0.1	0.5	1.0	1.0	5.0	10.0	12	11
10	*Pluchea odorata*	22	4.4	1	10	0	0	0	0	0	0.2	1.0	2.0	0.9	4.6	9.2	10	8
10	*Polygonum arifolium*	24	4.8	0	1	2	0	0	0	0	0.4	0.9	1.4	7.0	15.0	23.3	8	10
10	*Polygonum punctatum*	44	8.8	0	7	1	0	0	0	0	0.3	1.1	2.0	2.1	6.9	12.5	6	7
10	*Pontederia cordata*	1	0.2	1	0	0	0	0	0	0	0.0	0.0	0.0	0.1	0.5	1.0	18	18
10	*Scirpus robustus*	5	1.0	0	2	0	0	0	0	0	0.0	0.2	0.4	1.0	5.0	10.0	14	13
10	*Sagittaria lancifolia*	5	1.0	2	1	0	0	0	0	0	0.0	0.1	0.2	0.4	2.0	4.0	14	16
10	*Scirpus validus*	463	92.6	0	2	6	11	8	20	0	43.8	53.0	62.2	46.6	56.4	66.2	1	1
10	*Spartina alterniflora*	24	4.8	0	3	1	1	0	0	0	0.9	1.5	2.2	8.6	15.0	22.0	8	6
10	*Typha angustifolia*	168	33.6	1	19	6	0	0	0	0	1.6	4.3	7.4	3.0	8.3	14.3	3	5
10	*Zizaniopsis miliacea*	337	67.4	2	7	14	12	6	2	1	20.7	28.2	35.8	23.6	32.1	40.7	2	2

Table 5

Mean Percent Cover Estimates for All Plant Species Found in Qualitative Quadrats Monitored in the Savannah National Wildlife Refuge During October-November 1997 Plots 1 through 25

Plant Species	Plot Number																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Bare ground	20	20	20	20	20	20	5	5	20	5	20	5	20	20	40	40	0	5	20	0	0	0	0	5	5
Acer rubrum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--
Agalinus purpurea	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	20	.5	5	5	.5	.5	--
Alnus serrulata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--
Alternanthera philoxeroides	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--	--
Amaranthus cannabinus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	5	--	--	.5	--	--	.5	--	--
Apios americana	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	5	--	--	--	--
Arthraxon hispidus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	40	60	--	--	--
Aster elliottii	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	20	20	--	5	.5	20	20	--
Aster species	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	.5	--	--	--	--
Aster tenuifolius	--	--	--	--	--	--	--	--	--	20	.5	80	--	--	--	--	--	--	--	--	--	--	--	--	--
Baccharis halimifolia	--	60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bidens laevis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	20	60	--	--	.5	20	.5	5	5	.5
Bidens mitis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	.5	--	20	5	--	--	--
Boehmeria cylindrica	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--	5
Boltonia asteroides	--	--	5	20	.5	--	.5	--	--	20	--	--	--	--	.5	.5	20	--	--	.5	--	--	--	--	--
Carex species	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--
Cicuta mexicana	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	.5	.5	--	--	5
Cyperus flavescens	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--
Cyperus haspan	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	20	--	5	.5	.5	5	.5
Cyperus strigosus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	5	.5	--	--	--
Dulichium arundinaceum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--
Eleocharis cellulosa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	40	5	--	--	--	--	--	--	--	--	--
Eleocharis geniculata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--
Eleocharis fallax	--	--	--	--	--	--	--	--	--	--	--	--	--	60	--	5	--	--	20	--	--	60	40	80	--

Table 5

(continued)

Mean Percent Cover Estimates for All Plant Species Found in Qualitative Quadrats Monitored in the Savannah National Wildlife Refuge During October-November 1997 Plots 1 through 25

	Plot Number																								
Plant Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Eleocharis quadrangulata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	20	.5	--	.5	--
Erianthus giganteus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	.5	--
Fuirena breviseta	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	.5	--	--	--
Habenaria repens	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--
Hydrocotyle umbellata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--
Hypericum mutilum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	5	.5	.5	--	--
Impatiens capensis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--
Ipomoea sagittata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--	--
Iris hexagona	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	.5	.5	--	--	--
Juncus effusus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--
Juncus marginatus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	.5	.5	--	--
Leersia hexandra	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	5	.5	--	--	--
Lilaeopsis chinensis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--
Lobelia glandulosa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	.5	--	.5	.5	--	.5	--
Ludwigia leptocarpa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--
Ludwigia palustris	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	20	--	--	.5	--	--	--
Ludwigia pilosa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	5	.5	--	--	--
Ludwigia repens	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--
Luziola fluitans	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--
Lycopus rubellus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--	--
Magnolia virginiana	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--
Mikania scandens	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	20	5	--	--	--	--
Murdannia keisak	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	80	80	40	5	--
Myrica cerifera	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	.5	--	.5	--
Nyssa ogeche	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--

Table 5

(continued)

Mean Percent Cover Estimates for All Plant Species Found in Qualitative Quadrats Monitored in the Savannah National Wildlife Refuge During October-November 1997 Plots 1 through 25

	Plot Number																								
Plant Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Nyssa sylvatica var. biflora	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--
Onoclea sensibilis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	.5	--	--	--
Oxypolis filiformis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--	--
Panicum hemitomon	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60	--	--
Pluchea odorata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--
Pluchea rosea	--	--	--	.5	.5	--	--	--	--	--	--	.5	.5	.5	.5	.5	--	--	--	--	--	--	--	--	--
Polygonum arifolium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	40	20	--	--	.5	--
Polygonum hydropiperoides	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	40	5	5	5	20	--	.5	5	20
Polygonum sagittatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	.5	--	--	--
Pontederia cordata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	.5	5	.5	--	--	--
Ptilimnium costatum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	.5	--	--	--
Rhynchospora corniculata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--		
Rumex verticullatus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--
Sacciolepis striata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	.5	--	--	--
Sagittaria graminea	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--
Sagittaria lancifolia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	.5	--	--	.5	--	--	5	--	--	--
Sagittaria latifolia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	5	--	--	--
Sambucus canadensis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--	--
Saururus cernuus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5
Scirpus cyperinus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--
Scirpus robustus	--	--	.5	20	.5	--	--	--	--	5	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--
Scirpus validus	5	--	--	20	5	5	80	20	20	--	20	20	40	20	--	5	5	5	40	--	5	.5	--	20	--
Spartina alterniflora	--	--	80	20	40	--	20	--	--	40	40	20	--	--	--	--	--	--	--	--	--	--	--	--	--
Spartina bakeri	80	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Spartina cynosuroides	5	20	20	20	--	40	--	80	60	20	--	--	--	--	--	20	--	--	--	--	--	--	--	--	--

Table 5

(continued)

Mean Percent Cover Estimates for All Plant Species Found in Qualitative Quadrats Monitored in the Savannah National Wildlife Refuge During October-November 1997 Plots 1 through 25

	Plot Number																								
Plant Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Spiranthes cernua	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--
Taxodium distichum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	.5	--
Typha angustifolia	--	--	5	20	20	40	--	--	--	--	60	--	--	--	.5	--	--	--	--	--	--	.5	--	--	--
Xyris iridifolia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	.5	.5	.5	--
Zizania aquatica	--	--	--	--	--	--	--	--	--	--	--	--	60	40	--	40	80	80	20	40	80	5	60	80	95

Table 6

Mean Percent Cover Estimates for All Plant Species Found in Qualitative Quadrats Monitored in the Savannah National Wildlife Refuge During October-November 1997 Plots 26 through 52

Plant Species	Plot Number																								
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Bare ground	20	5	--	--	--	5	5	5	5	5	40	20	5	5	5	.5	--	40	20	--	40	20	5	5	--	--	--
Agalinus purpurea	--	--	--	--	--	--	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Amaranthus cannabinus	20	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Andropogon glomeratus	40	95	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	20
Andropogon virginicus	.5	--	--	5	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aster elliottii	5	--	--	.5	.5	5	5	.5	40	80	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aster species	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Aster subulata	5	--	.5	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aster tenuifolius	--	--	--	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--
Baccharis halimifolia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		5
Bidens laevis	20	--	.5	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bidens mitis	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carex species	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	95	--
Cicuta mexicana	5	.5	--	5	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyperus erythrorhizos	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyperus haspan	5	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyperus strigosus	60	20	5	95	95	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eleocharis cellulosa	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eleocharis elongata	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eleocharis fallax	.5	.5	.5	.5	.5	20	20	80	40	5	5	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eleocharis quadrangulata	--	5	--	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Erianthus giganteus	--	.5	5	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Eupatorium capillifolium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Galium tinctorium	--	--	95	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hydrocotyle umbellata	--	--	40	--	--	.5	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 6
(continued)

Mean Percent Cover Estimates for All Plant Species Found in Qualitative Quadrats Monitored
in the Savannah National Wildlife Refuge During October-November 1997
Plots 26 through 52

Plant Species	Plot Number																												
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Hypericum mutilum	--	--	5	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Iris hexagona	--	--	5	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Juncus effusus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Juncus polycephalus	--	--	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Juncus scirpoides	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Leersia oryzoides	--	--	.5	--	--	60	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lilaeopsis chinensis	--	--	--	--	--	--	--	--	--	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lobelia glandulosa	--	--	.5	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ludwigia leptocarpa	--	--	.5	--	--	--	5	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Murdannia keisak	--	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Myrica cerifera	--	--	5	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.5
Nyssa sylvatica var. biflora	--	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Orontium aquaticum	--	--	.5	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Osmunda regalis	--	--	20	.5	.5	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Panicum rigidulum	--	--	.5	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Paspalum urvillei	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Peltandra virginica	--	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Persea palustris	--	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pluchea odorata	--	--	--	--	--	--	--	--	--	--	--	.5	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--
Polygonum arifolium	--	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polygonum punctatum	--	--	.5	.5	.5	20	--	20	40	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polygonum species	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Pontederia cordata	--	--	--	20	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rhynchospora corniculata	--	--	--	20	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rhynchospora microcarpa	--	--	--	5	5	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Sacciolepis striata	--	--	--	5	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 6
(continued)

Mean Percent Cover Estimates for All Plant Species Found in Qualitative Quadrats Monitored in the Savannah National Wildlife Refuge During October-November 1997
Plots 26 through 52

Plant Species	Plot Number																								
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Scirpus robustus	--	--	--	--	--	--	--	--	--	--	--	--	5	20	5	--	5	5	--	--	--	--	20	--	--	--	5
Scirpus validus	--	--	--	.5	.5	5	5	80	40	40	60	80	.5	60	--	95	80	60	60	60	--	80	40	80	--	--	--
Sesbania emerus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Sesbania punicea	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Smilax bononox	--	--	--	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Solidago stricta	--	--	--	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Spartina alterniflora	--	--	--	--	--	--	--	--	--	--	5	--	5	60	--	--	5	60	60	80	60	20	--	--	--	--	5
Spartina cynosuroides	--	--	--	--	--	--	--	--	--	--	5	--	20	5	40	--	80	5	--	5	--	5	80	20	--	--	5
Typha angustifolia	--	--	--	.5	.5	--	--	.5	--	.5	5	5	95	60	95	--	--	5	--	--	--	--	80	5	--	--	5
Typha domingensis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	95	--	--
Typhas species	--	--	--	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unknown grass	--	--	--	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Xyris iridifolia	--	--	--	.5	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Zizania aquatica	--	--	--	.5	.5	--	--	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Zizianopsis milliacea	--	--	--	5	20	95	95	5	95	--	40	--	--	--	--	--	--	--	--	--	--	--	--	80	80	--	--

occurrence of other spikerushes (*Eleocharis* sp.), we felt a general nomenclature may cause more confusion, especially with respect to the previous studies. This confusion will be resolved in spring or summer when fertile specimens of this species are present.

The plant names *Pluchea purpurascens* (Swartz) DC. and *Aneilema keisak* Hassk. described by Pearlstine *et al*. (1990) have been changed in the botanical literature to salt marsh fleabane (*Pluchea odorata* [L.] Cass.) and marsh dewflower (*Murdannia keisak* [Hassk.] Hand.-Mazz.), respectively, and are so referenced in the present report.

To simplify review of the data, descriptions of plant species composition and community structure will be given on a quadrat by quadrat basis in a general order from the most saline to least saline quadrat. Species-area curve plots are presented in Figure 5 for most saline to least saline distributions and Figure 6 for least saline to most saline distributions. A total of 103 species was found in all 10 quantitative quadrats ranging from a minimum of 7 species found in Quadrat 2 to a maximum of 58 species found in Quadrat 8. The form of the curves show 2 obvious trends. First, the total cumulative number of species increases incrementally if plotted from the most saline quadrat to the least saline quadrat. Second, if viewed in the reverse fashion, it is shown that only 2 additional species are added with the addition of the final 4 most saline quadrats. These results are obvious; however, they show a simple, very important trend in this system: *as salinity decreases, species diversity increases. This simple axiom serves as an important tool in comparing past and future succession trends within this system.*

3.2 EXISTING CONDITION OF QUADRAT 2--BACK RIVER

Quadrat 2 is the most saline of the study areas with maximum surface and bottom salinities exceeding 10 ppt (Table 2). Frequency distributions of 50 percent and 90 percent for salinity at this site equaled 1.71 and 3.86 ppt for a normal average growing season flow of 9,500 cubic feet per second. For a 50 percent frequency distribution, the salinity would be greater than or less than the given values 50 percent of the time. For a 90 percent frequency value as described, the salinity exceeds the given value only 10 percent of the time. Interstitial sediment water chemistry salinities along the quadrat ranged from 4.0 to 6.4 ppt as compared to a mean interstitial sediment salinity of 9.3 reported by Pearlstine *et al.* (1990) prior to tide gate removal. Presently, this system characteristically experiences salinity conditions ranging from oligohaline (0.5 to 5 ppt) to mesohaline (5 to 18 ppt).

The total number of species found in the sample area was 7, of which 57.1 percent occurred in greater than 50 percent of all frequency intervals (Figure 7 [A]). The most dominate species present was narrow-leaf cattail (*Typha angustifolia* L.), which occurred in 395 of 500 frequency intervals with average quadrat coverage equaling 47.1 percent (Table 4). The relative frequency (RF) of this species, or frequency in relation to total frequency of all other species present, was 25.35 percent (Figure 8). Although only 7 species were present, all species with the exception of salt marsh fleabane (*Pluchea odorata* [L.] Cass.) were relatively abundant. Saltmarsh bulrush (*Scirpus robustus* Pursh) (RF = 20.60 percent), soft-stem bulrush (*Scirpus validus* Vahl) (RF = 18.74 percent), saltmarsh cordgrass (*Spartina alterniflora* Loiseleur) (RF = 16.82 percent), perennial saltmarsh aster (*Aster tenuifolius* L.) (RF = 10.85 percent), and big cordgrass (*Spartina cynosuroides* [L.] Roth) (RF = 7.45 percent) all displayed comparatively high relative frequency values. Whittaker's plots of the species rank-abundance curve show a linear type plot characteristic of a geometric distribution (Figure 7 [B,C]).

The schematic of frequency distributions of all species (Figure 9) shows that narrow-leaf cattail (*Typha angustifolia* L.) was relatively abundant throughout the quadrat. Distributions of saltmarsh bulrush (*Scirpus robustus* Pursh), soft-stem bulrush (*Scirpus validus* Vahl), saltmarsh cordgrass (*Spartina alterniflora* Loiseleur), and perennial saltmarsh aster (*Aster tenuifolius* L.) displayed a definitive zonation, being absent in the approximately first 150 feet of quadrat distance, indicating a distinct gradient in relation to the river channel at this location. Big cordgrass (*Spartina cynosuroides* [L.] Roth) showed a more aggregated distribution pattern, being present in clumps within the beginning, central, and ending areas of the quadrat.

3.3 EXISTING CONDITION OF QUADRAT 10--MIDDLE RIVER

The maximum projected surface water and bottom salinities occurring at this location are approximately 10 ppt (Figure 2). The interstitial sediment water salinity ranged from 0.6 to 1.6 ppt, while 50 percent and 90 percent frequency distribution values at 9,500 cubic feet per second equal 0.20 and 1.40 ppt, respectively. Hence, the conditions at this location range from freshwater (less than 0.5 ppt) to oligohaline (0.5 to 5 ppt) with extreme events being in the mesohaline range (5 to 18 ppt). Based on these values, this area is subjected to a wide range of salinity conditions.

The total number of species found in the quadrat was 18 with only 2 species being found in greater than 50 percent of all frequency intervals (Figure 10). Although the distribution in geometric frequency classes gives the appearance of a normal distribution (Figure 10 [B]). The Whittaker plot is indicative of a geometric series (Figure 10 [C]). This indicates a relative similarity in number of species distributed in each size class, which ranges from 1 to 4 species. A typical lognormal distribution would show a greater relative proportion of the number of species in the modal, or central, frequency class.

The most dominant species occurring in the area was soft-stem bulrush (*Scirpus validus* Vahl) with a relative frequency of 35.98 percent (Figure 11) and average cover value of 53.0 percent. It occurred in 463 of 500 frequency plots (Table 4). Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) was the second most dominant species with a relative frequency of 26.18 percent (Figure 11) and average cover value of 28.2 percent (Table 4). Narrow-leaf cattail (*Typha angustifolia* L.) was very frequently encountered, being present in 168 of 500 intervals; however, coverage was only 4.3 percent of the area. The majority of the species present (61.1 percent) in this area occurred in less than 5 percent of the frequency intervals (Figure 10 [A]). The schematic of frequency distributions (Figure 12) shows that both soft-stem bulrush (*Scirpus validus* Vahl) and southern wildrice *(Zizaniopsis miliacea* [Michx.] Doell & Aschers.) were distributed throughout the quadrat, while narrow-leaf cattail (*Typha angustifolia* L.) occurred only at distances greater than 230 feet from the edge of the channel. The distribution of creeping spikerush (*Eleocharis fallax* Weatherby) almost invariably corresponded with areas of the quadrat in which the substrate is less consolidated or "shakes" to some degree when walking across the surface. Alligator-weed (*Alternanthera philoxeroides* [Mart.] Griseb.) and saltmarsh cordgrass (*Spartina alterniflora* Loiseleur) are restricted to the first 50 feet immediately adjacent to the Front River. The most notable observation in this area is with regard to the growth form of southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.), which is very short, or less vigorous, as compared to that found in more freshwater quadrats.

3.4 EXISTING CONDITION OF QUADRAT 5--MIDDLE RIVER

The maximum surface water and bottom salinities found for this area are approximately 7.5 ppt (Figure 2). Interstitial sediment salinities ranged from 0.7 to 1.7 ppt, while 50 percent and 90 percent salinity values at 9,500 cubic feet per second equal 0.18 and 1.22 ppt, respectively. Similar to the Quadrat 10 location, these values range from freshwater (less than 0.5 ppt) to oligohaline (0.5 to 5 ppt) to mesohaline (5 to 18 ppt) conditions.

A total of 23 species was found in Quadrat 5 with only 2 species occurring in greater than 50 percent of all intervals, while 13 species (56.5 percent) occurred in less than 5 percent of all intervals (Figure 13). The species rank-abundance plots show a bimodal distribution of species (when plotted geometrically) (Figure 13 [B]) and a Whittaker plot typical of a geometric series (Figure 13 [C]).

Three dominant species were present in this quadrat area. The most dominant species based on relative frequency is soft-stem bulrush (*Scirpus validus* Vahl), having a relative frequency of 33.89 percent (Figure 14). This species occurred in 465 of 500 frequency plots with an average cover of 18.8 percent. The relative frequency of creeping spikerush (*Eleocharis fallax* Weatherby) was 21.87 percent (Figure 14) being present in 300 of 500 frequency intervals, however, with an average cover of 45.7 percent, exceeding that of soft-stem bulrush (*Scirpus validus* Vahl). The relative frequency of southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell &

Aschers.) equals 12.68 percent (Figure 14) being present in 174 of 500 intervals with an average cover of 22.2 percent (Table 4).

The frequency distribution schematic (Figure 15) shows a very distinct zonation in the distribution of several species, most notably that of creeping spikerush (*Eleocharis fallax* Weatherby) and southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.). At 180 feet from the Middle River edge, southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) disappears and creeping spikerush (*Eleocharis fallax* Weatherby) becomes a very dominant species. This transition is visually very abrupt and directly corresponds to the occurrence of the unconsolidated substrate, better known as “trembling earth” or “floating islands”. This situation is typical of many areas located in the central marsh regions lying between the Back and Middle Rivers north of Rifle Cut and the Middle and Front Rivers north of Steamboat River. These areas apparently do not flood as frequently as adjacent areas with consolidated sediments because the mat appears to rise and fall to some degree with high tide events.

3.5 EXISTING CONDITION OF QUADRAT 3--LITTLE BACK RIVER

The maximum surface water and bottom salinities interpolated for this quadrat area are approximately 3 and 6 ppt, respectively (Figure 2). The interstitial sediment water salinity measured ranged from 0.2 to 2.0 ppt as compared to a mean value of 4.7 ppt reported by Pearlstine *et al.* (1990). Frequency distribution of 50 percent and 90 percent salinity values for

9,500 cubic feet per second flows for this area are 0.17 and 1.45 ppt, respectively. Based on these values, salinity ranges in this area vary from freshwater (less than 0.5 ppt) to mesohaline (5 to 18 ppt) conditions.

A total of 22 species was found in this quadrat with 12 species (54.5 percent) occurring in less than 5 percent of the intervals, while only 2 species occurred in greater than 50 percent of all intervals (Figure 16 [A]). The resulting species rank-abundance plots approximate a geometric series distribution (Figure 16 [B]). The most dominant species is soft-stem bulrush (*Scirpus validus* Vahl), which has a relative frequency of 38.92 percent (Figure 17) and was present in 564 of 600 cover intervals with an average cover of 50.8 percent (Table 4). Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) was the second most abundant species with a relative frequency of 13.32 percent (Figure 17) being present in 193 of 600 intervals with an average cover of 14.0 percent. Bull-tongue arrow-head (*Sagittaria lancifolia* L.) was the only other species distributed frequently throughout the quadrat, being present in 107 of 600 intervals, however, having an average cover of only 2.5 percent (Table 4). Several other species were found in dense aggregated populations (Figure 18). Saltmarsh cordgrass (*Spartina alterniflora* Loiseleur) only occurred in the last 100 feet of the quadrat while dotted smartweed (*Polygonum punctatum* Ell.), smooth beggar-ticks (*Bidens laevis* [L.] BSP.), and big cordgrass (*Spartina cynosuroides* [L.] Roth) were densely clumped in the area of the quadrat directly adjacent to the Back River. Creeping spikerush (*Eleocharis fallax* Weatherby) and Gulf Coast spikerush (*Eleocharis cellulosa* Torr.) occur from 140 to 270 feet along the quadrat length. There exists a distinct zonation in the distribution of southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) and saltmarsh cordgrass (*Spartina alterniflora* Loiseleur) within this quadrat.

3.6 EXISTING CONDITION OF QUADRAT 4--LITTLE BACK RIVER

The maximum interpolated salinities for surface water and bottom locations are 1.5 and 4.0 ppt, respectively, for this area (Figure 2). Interstitial sediment water salinities ranged from 0 to 0.2 ppt as compared with a mean value of 2.1 ppt reported by Pearlstine *et al.* (1990). The 50 percent frequency distribution for salinity equals 0.11 ppt as compared to 0.96 ppt for the 90 percentile as calculated for flows of 9,500 cubic feet per second. These values indicate this area is subjected to freshwater (less than 0.5 ppt) and oligohaline (0.5 to 5 ppt) salinity conditions.

A total of 18 species was observed in this quadrat with 4 species being present in greater than 50 percent of the intervals and 9 species (50 percent) being present in less than 5 percent of the intervals (Figure 19 [A]). The species rank- abundance curve is indicative of a geometric series with various numbers of species generally ranging from 1 to 3, with 1 exception, being distributed over a wide range of geometric frequency classes (Figures 19 [B,C]).

Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) was the most dominant species occurring in 446 of 500 frequency intervals with an average cover of 46.5 percent (Table 4). Dotted smartweed (*Polygonum punctatum* Ell.) and soft-stem bulrush (*Scirpus validus* Vahl) were co-dominant being found in 361 and 351 of 500 frequency intervals, respectively. Dotted smartweed (*Polygonum punctatum* Ell.) displayed the greatest cover of the 2 species being 23.5 percent as compared to 10.8 percent for soft-stem bulrush (*Scirpus validus* Vahl). Relative frequency distributions were 24.57 percent for southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.), 19.89 percent for dotted smartweed (*Polygonum punctatum* Ell.), and 19.34 percent for soft-stem bulrush (*Scirpus validus* Vahl). Elliott's aster (*Aster elliottii* Torr. & Gray), creeping spikerush (*Eleocharis fallax* Weatherby), and smooth beggar-ticks (*Bidens laevis* [L.] BSP.) were also common with relative frequency values of 10.30 percent, 9.20 percent, and 8.60 percent, respectively (Figure 20).

The frequency distribution diagrams indicate the most common species are distributed throughout all areas of the quadrat (Figure 21). The exceptions are the 3 *Eleocharis* species, which display a more aggregated distribution pattern.

3.7 EXISTING CONDITION OF QUADRAT 7--FRONT RIVER

Although the maximum bottom and surface salinities found in this area exceed 10 ppt, the 50 percent and 90 percent frequency distribution values of 0.10 and 0.98 ppt, respectively, were lower than those found for the Quadrat 3 location (Figure 2). The sediment salinities ranged from 0.1 to 1.0 ppt. The total number of species found was 18 with 4 species occurring in greater than 50 percent of intervals and 8 species being present in less than 5 percent of all intervals (Figure 22 [A]). The resulting species rank-abundance curves were characteristic of a geometric series being essentially linear with a steep slope (Figures 22 [B,C]).

Unlike preceding quadrat areas, Quadrat 7 was dominated by smooth beggar-ticks (*Bidens laevis* [L.] BSP.), which is a perennial herbaceous species. The relative frequency of smooth beggar-ticks (*Bidens laevis* [L.] BSP.) equaled 22.56 percent (Figure 23) and the species was present in 382 of 500 frequency intervals with an average cover of 39.1 percent (Table 4). Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.), dotted smartweed (*Polygonum punctatum* Ell.), and soft-stem bulrush (*Scirpus validus* Vahl) had relative frequency values of 17.84 percent, 17.78 percent, and 16.01 percent, respectively (Figure 23).

The frequency distributions show that smooth beggar-ticks (*Bidens laevis* [L.] BSP.), southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.), and dotted smartweed (*Polygonum punctatum* Ell.) were common throughout the quadrat (Figure 24). Soft-stem bulrush (*Scirpus validus* Vahl) was absent in the central area of the quadrat, while Elliott's aster (*Aster elliottii* Torr. & Gray) and green arum (*Peltandra virginica* [L.] Kunth) were most abundant in the 320 to 500 foot area. All areas of the quadrat were characterized as having firm, consolidated sediments with no "trembling earth" encountered.

3.8 EXISTING CONDITION OF QUADRAT 1--FRONT RIVER

Maximum surface and bottom salinities for this area are in the range of 7.0 and 7.5 ppt, respectively (Figure 2). The interstitial sediment salinities range from 0.1 to 0.8 ppt, while at flows of 9,500 cubic feet per second, 50 percent and 90 percent frequency distribution values equal 0.04 and 0.98 ppt, respectively. Based on these data, this site experiences conditions ranging from freshwater (less than 0.5 ppt) to mesohaline (5 to 18 ppt) conditions.

A total of 33 species was encountered with only 3 species occurring in greater than 50 percent of the intervals and 17 species occurring in less than 5 percent of the intervals (Figure 25 [A]). Species rank-abundance plots indicate a greater tendency toward a lognormal distribution with the greatest number of species being present in the intermediate geometric frequency classes (Figures 25 [B,C]).

The 2 most dominant species present in this area are creeping spikerush (*Eleocharis fallax* Weatherby) and southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.). Creeping spikerush (*Eleocharis fallax* Weatherby) has a relative frequency of 18.36 percent (Figure 26), occurred in 471 of 500 frequency intervals, and has an average cover value of 67.6 percent (Table 4). Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) has a relative frequency value of 16.41 percent, occurred in 421 of 500 frequency intervals, and has an

average cover value of 35.6 percent. Elliott's aster (*Aster elliottii* Torr. & Gray), which is a perennial herbaceous species, was present in 342 of 500 frequency intervals, covering 20.6 percent of the quadrat area.

Along Quadrat 1 there is a marked difference in the consolidation of the sediment occurring at the 300-foot location. At this point, the "trembling earth" begins and sediments consist primarily of organic matter dispersed throughout a dense root mat. Although, as evidenced by the frequency distribution schematic (Figure 27), southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) and creeping spikerush (*Eleocharis fallax* Weatherby) occur along all intervals of the quadrat, the average coverage of these species changes dramatically at this point. From 300 to 500 feet, although southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) frequently occurs, the coverage drops dramatically. At the same line, coverage of creeping spikerush (*Eleocharis fallax* Weatherby) is complete, occupying greater than 90 percent of all available space. This distribution is not evident in Figure 27, but can be seen in the cover data matrix contained in Appendix Table A-1. This is a typical situation in areas where the floating mat occurs. Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) frequently occurs; however, it does not cover extensive ground area. It appears that the low density substrate often cannot support the weight of the tall leaves; hence, they fall over, restricting establishment of dense stands under these substrate conditions. Creeping spikerush (*Eleocharis fallax* Weatherby), on the other hand, is a wiry, low-growing spikerush in which the majority of the biomass is located either very close to the ground or below it.

3.9 EXISTING CONDITION OF QUADRAT 6--MIDDLE RIVER

Maximum surface and bottom salinities interpolated for the Quadrat 6 area are approximately 5.5 and 6.0 ppt, respectively (Figure 2). The 50 percent and 90 percent frequencies for salinities are 0.14 ppt and 0.84 ppt, respectively, at 9,500 cubic feet per second. Sediment salinity values measured during the field survey range from 0.2 to 0.4 ppt. These values indicate that the vegetation in this region typically experiences freshwater (less than 0.5 ppt) to oligohaline (0.5 to 5.0 ppt) conditions with extreme events being in the mesohaline (5 to 18 ppt) range.

A total of 43 species was found in Quadrat 6 with only 2 species being present in greater than 50 percent of the intervals and 34 species (79.1 percent) occur (Figure 28 [A]) in less than 5 percent of the frequency intervals. The species rank-abundance curves (Whittaker Plot: Figure 28 [C]) resembles a lognormal type distribution. The linear and geometric plots of species abundance (Figure 18 [A,B]) indicate trends of logarithmic distributions with maximum species occurring as very rare occurrences.

The 2 most dominant species are creeping spikerush (*Eleocharis fallax* Weatherby) and southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.), which have relative frequencies of 22.27 percent and 20.14 percent, respectively (Figure 29). Creeping spikerush (*Eleocharis fallax* Weatherby) is much more frequently

encountered than southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) occurring in 408 of 500 frequency intervals as compared to 369 of 500 frequency intervals (Table 4). However, average coverages are essentially equal being 42.9 percent for creeping spikerush (*Eleocharis fallax* Weatherby) and 38.7 percent for southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.). Soft-stem bulrush (*Scirpus validus* Vahl) (RF = 12.99 percent), Elliott's aster (*Aster elliottii* Torr. & Gray) (RF = 9.55 percent), dotted smartweed (*Polygonum punctatum* Ell.) (RF = 7.86 percent), and marsh dewflower (*Murdannia keisak* [Hassk.] Hand.-Mazz.) (RF = 6.50 percent) are also commonly encountered in this quadrat.

The frequency distribution schematic (Figure 30) shows that a change in the distribution of vegetation occurs at the 100-foot distance in the quadrat. The "floating mat" or "trembling earth" begins in this area, where a subsequent marked increase in creeping spikerush (*Eleocharis fallax* Weatherby), Elliott's aster (*Aster elliottii* Torr. & Gray), dotted smartweed (*Polygonum punctatum* Ell.), and marsh dewflower (*Murdannia keisak* [Hassk.] Hand.-Mazz.) occurs, which is consistent with previously described observations. The most remarkable difference between this quadrat and others described by more saline conditions is the number of very rarely occurring species, which is a direct result of the number of highly variable habitats available, due to the structure of the "trembling earth".

3.10 EXISTING CONDITION OF QUADRAT 8--LITTLE BACK RIVER

Quadrat 8 is located in the same area as that described as the freshwater site by Pearlstine *et al.* (1990). Maximum surface and bottom salinities for the Little Back River in this area equal 0.6 and 2.0 ppt, respectively (Figure 2). Interstitial sediment salinities were found to range from 0 to 0.2 ppt during this study as compared to 0.5 ppt for the period reported by Pearlstine *et al.* (1990). These data indicate that this plant community is presently exposed to conditions ranging from freshwater to oligohaline.

A total of 58 species was recorded in this area, which was the highest found of any quadrat (Figure 31 [A]). Of the total, only 2 species occurred in greater than 50 percent of quadrat intervals, while 32, or 55.2 percent, occurred in less than 5 percent of all intervals. The species rank-abundance plots depict essentially a straight line plot indicative of a logarithmic series. Further evidence of this type distribution is the maximization of rare species and the hollow curve plot obtained by these data (Figure 31 [A]) as described by Krebs (1989).

The most dominant species occurring in the site were creeping spikerush (*Eleocharis fallax* Weatherby) and southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.), which had relative frequency values of 12.20 percent and 11.62 percent, respectively (Figure 32). As can be seen in Figure 32, this quadrat is characterized by a dominance of 2 species, with 24 common species with relative frequencies ranging from 1.2 percent to 6.62 percent and 32 species being very rare.

The frequency distribution of all species (Figure 33) shows a much different distribution pattern than any previously described. Only 2 species, southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) and Elliott's aster (*Aster elliottii* Torr. & Gray), are found dispersed throughout most areas of the quadrat. Most common species showed a clumped or aggregate distribution pattern, being dominant in certain areas of the quadrat while being absent in others. The rare species are randomly dispersed throughout the quadrat.

Several factors are possibly responsible for the general distribution patterns noted. The substrate is consolidated for the first 130 feet of this quadrat, which results in a very dense, almost impenetrable wall of very tall, robust southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) and halberd-leaf tearthumb (*Polygonum arifolium* L.). The sediments are unconsolidated for the remaining 370 feet of quadrat length with varying degrees of "liquidity" of the sediments being present. In many areas, especially those dominated by brook-side alder (*Alnus serrulata* [Ait.] Willd.), the density of the floating mat is reduced to the point that even the "lightest and frailest" of the field grunts drop quickly out of sight in a flailing motion in which all body parts twist in a contorted manner as the desperately sinking individual grasps for any twig that will salvage him from the immediate peril of the rapidly rising water.

The structure of the mat itself gives rise to a number of habitats not present in other areas. Hummocks are formed from dead and decaying vegetation, which are colonized by a host of opportunistic species. In addition, the extensive hog activity in these areas has dramatically altered the sediment structure and distribution of the vegetation.

3.11 EXISTING CONDITION OF QUADRAT 9--MIDDLE RIVER

Maximum surface and bottom salinities projected for the Quadrat 9 area are approximately 2.5 ppt (Figure 2). Frequency distributions for surface salinities interpolated at this area indicate that 50 percent of the time the values are 0.10 ppt or less and 90 percent of the time the values are less than 0.5 ppt at 9,500 cubic feet per second. Sediment salinities measured during the study were 0 ppt, while conductivity values ranged from 160 to 300 μmhos/cm.

A total of 36 species was documented in this quadrat with only 1 species occurring in greater than 50 percent of the frequency intervals and 28, or 77.7 percent, present in less than 5 percent of the frequency intervals (Figure 34 [A]). The species rank-abundance plots show a curve indicative of a lognormal distribution (Figures 34 [B,C]).

Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) is by far the most dominant species occurring in the area having a relative frequency of 38.04 percent (Figure 35). This was the highest relative frequency value obtained for any species in all quadrat areas. Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) occurred in 490 of 500 frequency intervals with an average cover value of 88.5 percent. Dotted smartweed (*Polygonum punctatum* Ell.) and Elliott's aster (*Aster elliottii* Torr. & Gray) were also common species having relative frequencies of 11.49 percent and 10.56 percent, respectively (Figure 35).

Unique to this area was the common occurrence of sensitive fern (*Onoclea sensibilis* L.) (RF = 10.40 percent) and royal fern (*Osmunda regalis** L.) (RF = 4.35 percent) and the presence of several vine and shrub species not encountered in other areas. These include blackberry (*Rubus betulifolius* Small) (RF = 1.32 percent), stiff cornel (*Cornus foemina* Mill.) (RF = 0.70 percent), Florida privet (*Forestiera segregata* [Jacq.] Krug & Urban) (RF = 0.62 percent), American wisteria (*Wisteria frutescens* [L.] Poir.) (RF = 0.54 percent), and swamp rose (*Rosa palustris* Marsh.) (RF = 0.47 percent).

The frequency distribution schematic (Figure 36) shows southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) was the only species present in all areas of the quadrat. The occurrence of southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) was unique in the area, being extremely robust and very tall, forming a very dense stand. Unlike other areas within the predominately freshwater area, the sediments

throughout the quadrat length were consolidated with no sizable areas of “trembling earth” being present. This would explain the relative paucity of species as compared to the situation existing in the Quadrat 8 area.

3.12 COMPARISON OF COMMON PLANT SPECIES OCCURRING AMONG QUADRAT LOCATIONS

The comparison of the frequency distributions of the most common species encountered in the 10 quantitative quadrats is presented in Figure 37. In all 10 quadrat areas, a total quadrat length of 5,100 feet was established. Hence, the total number of frequency intervals present equals 5,100. Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) was the most common species encountered, occurring in 3,034 (59.5 percent) of the intervals. This species was found in all areas except the Quadrat 2 location, which experiences the highest salinities. The distribution of southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) also indicated a trend for greater frequencies to be found in the more freshwater areas, i.e., moving from south to north in the SNWR. In addition, the growth form of southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) becomes more vigorous, e.g., taller, denser stands, as salinity decreases. Quadrat 8 was the exception to this observation. In this area, as previously described, the “floating mats” somewhat restricts the distribution of this species.

Soft-stem bulrush (*Scirpus validus* Vahl) was the second most frequently encountered species occurring in 2,891 (56.7 percent) frequency intervals (Figure 37). This species was the only species to occur in all quadrat areas, but was infrequently encountered in the most freshwater sites denoted as Quadrats 8 and 9. Soft-stem bulrush (*Scirpus validus* Vahl) was most frequently encountered in the Quadrat 10, 5, and 3 areas where 50th percentile salinity values ranged from 0.17 to 0.20 ppt and sediment salinities ranged from 0.2 to 2.0 ppt. A reduction in the frequency distribution was apparent in the most saline area (Quadrat 2) and Quadrats 7, 1, and 6 located on the Front and Middle Rivers.

It should be noted that since sampling for this study was conducted in October 1977, some seasonal dieback of soft-stem bulrush (*Scirpus validus* Vahl) had occurred. This dieback affects total cover of the observed soft-stem bulrush (*Scirpus validus* Vahl) populations. Frequency estimates are less sensitive to these changes; however, greater frequency of soft-stem bulrush (*Scirpus validus* Vahl) would probably have been found in August or September, but these differences should be relative among quadrat areas. Frequencies and cover estimates of southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) would be relatively unaffected by sampling dates during this period.

Creeping spikerush (*Eleocharis fallax* Weatherby) was the third most frequent species, occurring in 1,775 (34.8 percent) frequency intervals (Figure 37). This species was absent in Quadrats 2 and 7 and showed a very limited distribution in Quadrats 3 and 9. This species, as has been previously described, has dominance

restricted to areas that are characterized by “trembling earth”, where it thrives. In areas of compact, consolidated substrates, this species is of restricted distribution.

Elliott’s aster (*Aster elliottii* Torr. & Gray) and smooth beggar-ticks (*Bidens laevis* [L.] BSP.) are 2 very common herbaceous perennial species occurring throughout the SNWR, but often not receiving much consideration as being dominant species within the marsh. Elliott’s aster (*Aster elliottii* Torr. & Gray) occurred in 1,109 (21.7 percent) frequency intervals. However, this species was absent from quadrats located south of US-17 (Port Wentworth), showing an obvious intolerance of higher salinity conditions. This species may serve as a good indicator of expansion or decline of the general freshwater boundary in this system.

Smooth beggar-ticks (*Bidens laevis* [L.] BSP.) occurred in 741 (14.5 percent) frequency intervals (Figure 37). This species is very dominant in the Quadrat 7 area and adjacent areas and gives a unique signature on false color infrareds and SPOT satellite imagery, especially in the area bound between the Front and Middle Rivers north of US-17 extending to Steamboat River. This species occurred in all quadrats, except Quadrat 2, which shows a tolerance from a wide range of freshwater to brackish conditions.

Three species are present that show a preference for more saline conditions. Saltmarsh cordgrass (*Spartina alterniflora* Loiseleur) is most common in Quadrat 2, as might be expected, and is distributed just north of the Quadrat 5 location in the Middle River. A fairly extensive stand of saltmarsh cordgrass (*Spartina alterniflora* Loiseleur) is present in the Quadrat 3 area of the Little Back River just south of US-17. Saltmarsh bulrush (*Scirpus robustus* Pursh) and the herbaceous perennial saltmarsh aster (*Aster tenuifolius* L.) are 2 other salt-tolerant species that are common in the most saline Quadrat 2 area, but have infrequent distributions elsewhere (Figure 37). However, perennial saltmarsh aster (*Aster tenuifolius* L.) was encountered as far north as Quadrats 4 and 5, located on Argyle Island just north of Rifle Cut.

The species of greatest interest in the SNWR may presently be narrow-leaf cattail (*Typha angustifolia* L.). Narrow-leaf cattail (*Typha angustifolia* L.) occurred in only 665 (13.0 percent) frequency intervals, but was the most dominant species occurring in the more saline Quadrat 2 area (Figure 37). This species is encountered less frequently as salinity decreases, being absent from the freshwater Quadrat 9 area and occurring in only 1 interval in Quadrat 8.

Pearlstine *et al.* (1990) reported narrow-leaf cattail (*Typha angustifolia* L.) as having equal dominance at the brackish sites to soft-stem bulrush (*Scirpus validus* Vahl). This site corresponds with Quadrat 3 in the present study, where narrow-leaf cattail (*Typha angustifolia* L.) was found in only 2 percent (72/600) of the frequency intervals. In the intermediate marsh, which corresponds to Quadrat 4 of their study, narrow-leaf cattail (*Typha angustifolia L*.) occupied 22 percent of the study plots, whereas, this species was presently not recorded in this

area. In addition, they found no narrow-leaf cattail (*Typha angustifolia* L.) at the subsaline plots, whereas, presently, it is the dominant species in Quadrat 2, which is in the same location (Figure 37).

In review of 1994 false color infrared aerial photographs, it is apparent that there has been a dramatic increase in the population of narrow-leaf cattail (*Typha angustifolia* L.) south of US-17 since the removal of the tide gate. This has been accompanied by an apparent decrease in the occurrence of this species north of US-17 based on the historic data.

3.13 COMPARISON OF SPECIES COMPOSITION BETWEEN DIFFERENT QUADRAT AREAS

The results of all similarity coefficient calculations are presented in Figure 38. Both Sorensen and Jaccard similarity coefficients have been calculated for all possible pair-wise quadrat comparisons. Both indices are presented for completeness; however, further discussion is limited to use of the Sorensen coefficient. Both coefficients describe similar relationships between quadrats, but values of the Sorensen coefficient are slightly higher. A selection of this coefficient for discussion purposes is, however, totally arbitrary.

For easier review, the similarity coefficient matrix has been presented graphically (Figure 39). The quadrats have been grouped into 4 groups based on relative similarity trends. Group 1 (green) is composed of Quadrat 2 only, which is the area of highest measured salinities. This quadrat was most similar in species composition to quadrats of Group 2 (red), which, in general, tends to be quadrats of salinities intermediate between fresh and saline. However, this trend is not without exception. For example, Quadrat 4 has been placed within this group, but salinity values alone would place this quadrat in a gradient position between Quadrats 6 and 8 although species composition similarities to these areas were substantially lower.

Group 3 (yellow) consists of only Quadrat 1, which was placed in this position due to having intermediate similarities between the 3 most freshwater quadrats (Quadrats 6, 8, and 9), which are designated as Group 4 (blue). In general, it can be seen that Quadrat 2 has very low similarity with Quadrats 1, 6, 8, and 9 and higher similarities, however below 0.50, with Group 2 and, in general, these groups correspond with salinity gradients ranging from mesohaline to freshwater. A second point of significant consequence to the present study is that Group 2 is still somewhat unique and dissimilar to quadrats of Group 4, the freshwater areas, which somewhat addresses the status of the projected recovery of these systems to freshwater marsh as described by Pearlstine *et al.* (1990). In general, based upon percent similarity of plant species, the freshwater sites, which are areas of greatest species diversity, are confined north of the east-west line drawn across the northernmost ox-bow of Steamboat River east through the ox-bow of the Little Back River where the USF&W dock is located. North of this line is also where the majority of the “trembling earth” occurs. The exception is the area of Quadrat 9 that is found on consolidated sediments, however, exhibits a diverse array of freshwater species. In this discussion of similarities between sites, there has been an intentional minimization of relationships of species occurrence to well-defined salinity contours. This is because of the wide range of salinity conditions to which these sites are subjected. For example, the Group 2 quadrats would primarily be considered freshwater systems based on 50 percentile salinity concentrations ranging from 0.10 ppt at Quadrat 7 to 0.20 ppt at Quadrat 10 (Table 2). Sediment salinities were found to range from 0 ppt at Quadrat 4 to 2.0 ppt at Quadrat 3. Peak surface salinities range from 1.5 ppt to 10 ppt. This indicates that the plant species that occur in this group are tolerant of a wide range of salinities, and the concentrations that control the plant distribution in these areas are not evident. Neither is the extent to whether it is average

surface water salinity, average sediment salinity, or peak salinity events that control distribution of these species. If average surface water salinity were the controlling factor, we would expect a somewhat different distribution of species within this system.

3.14 COMPARISON OF PLANT COMMUNITY STRUCTURE

A summary of the Whittaker plots constructed for each quadrat is presented in Figure 40. The purpose of plotting species rank-abundance curves is to obtain some idea of the structure of the plant community and, hence, gain insight into the resource utilization strategy of the existing community. Simply stated, these plots present information on the diversity of the community, or number of species present and the degree to which dominant or rare species influence the plant community structure. The species rank-abundance plots show, as did the similarity indices, that the quadrats can be grouped based on similar structure. If we simply first examine slope of the resulting plots, it is shown that the steepest slope is found in Quadrat 2, while Quadrats 1, 6, 8, and 9 show more shallow, gradual slopes, which indicates greater species diversity. Quadrats 10, 5, 3, 4, and 7 show slopes intermediate between the freshwater and saline areas. This type of analysis was performed to establish an existing condition of community structure in this area to which all future changes can be compared.

To attempt a comparative analysis to historic data presented by Pearlstine *et al.* (1990), species rank-abundance plots are compared for all common quadrat areas (Figure 41). Plots presented in their report are of a different form than those in the present study. Their measure of species abundance is in the format of importance values, which is a measure of relative density and biomass data. In addition, they plotted abundance on an arithmetic scale. For comparison purposes, the plots of the present quadrats were changed to reflect the arithmetic scale they employed (Figure 41). Although the abundance measure is different, being frequency percent in the present case, curve forms should not be greatly changed. From these plots (Figure 41), it can be seen that plots of different slope were found in each area with species diversity increasing from freshwater to subsaline areas. The plots in the present study show the same trend and similar structure to that previously found. However, the current plots show a greater number of species, which reflects our use of contiguous versus discrete sampling plots and increased sample area. Two points should be stressed from these comparisons. First, is that community structure in these areas has not dramatically changed since 1986-1988. Second, there still exists a dramatic difference in the structure of Quadrats 2, 3, and 4 (intermediate,

brackish, and subsaline) and no shift has occurred that would increase similarity of these sites with Quadrat 8 or the freshwater site. This indicates that a dramatic change has not occurred in these systems in the time frame that was predicted.

4.0 DISCUSSION

The intent of the present vegetation study is to establish an existing condition of the plant species composition and plant community structure of the unimpounded marshes of the SNWR. In addition, some evaluation is needed addressing the plant community changes occurring since the removal of the tide gate. The study performed by Pearlstine *et al.* (1990) and others previously referenced provided a valuable tool with which to achieve this goal. Without their study, any conclusions based upon the present study regarding plant succession would be entirely speculative.

Pearlstine *et al.* (1990) presented a habitat succession model that predicted the change in the areal extent of freshwater marsh in response to salinity reduction due to the removal of the tide gate. Their model considered the boundary of freshwater communities to coincide with the 0.5 ppt salinity contour. The model predicted that the freshwater marsh would extend downstream to the southern tip of Argyle Island, resulting in a 340 percent increase in area over the existing freshwater marsh. The period of time expected for this change to occur was 2 years.

The present study indicates that, although changes have occurred in the distribution of several plant species in the marsh system, a wide-spread change in the distribution of the freshwater marsh system as defined by species diversity and population structure (not in-situ salinity) has not occurred to date. The question arises as to whether a continual, subtle change may proceed in the future, eventually realizing the extent of the model-predicted boundary. This question can only be answered with more questions and assumptions. It is very difficult to predict plant community change when so may factors affect the distribution of these species.

Pearlstine *et al.* (1990) predicted the dramatic expansion of the freshwater marsh system. They described this freshwater system as being a marsh dominated by sand spikerush (*Eleocharis montevidensis* Kunth) with a mixed component of freshwater species. The problem with this prediction is that salinity was the major factor presumed to control succession. In the present study, it is shown that this particular plant association is restricted to areas in which the sediments are unconsolidated, have higher concentrations of organic matter, and tend to be less inundated than other areas due to the ability to rise with higher water levels. This type of substrate is restricted in distribution to the northern areas of the study site, thereby imposing a geographical limitation to the expansion of this community type.

Marsh areas within the SNWR located south of US-17 tend to have firm, consolidated sediments that flood to greater depths and, thus, are additionally subjected to greater tidal energy and longer inundation periods. These factors will additionally affect succession of plant communities in these areas. A predictive succession model will need to address not only the chemical constraints of this system, but will also have to develop the geographical and physical constraints that also control species abundance and composition.

4.1 RESULTS: CLASSIFICATION OF EXISTING PLANT COMMUNITIES

Unclassified SPOT images of the SNWR for August 22, 1997, and October 2, 1997, are presented in Figures 42 and 43, respectively. The classified SPOT image showing the major plant communities in the SNWR and adjacent areas is presented in Figure 44 and was produced from classification of the August 22, 1997, image. The classification resulted in the delineation of 28 distinct plant classes or associations that give unique, discernable signatures on SPOT satellite imagery.

The plant associations that are given may reflect dominance of several species, in which case, the first species given is the most dominant in a relative sequence. The dominant species is the plant considered to be most responsible for the resulting signature on the image. The plant associations are described below in order of occurrence in the legend in Figure 44. No intended relationship to salinity is implied in this order.

4.1.1 Class Names

1. Exposed mud-unvegetated shoreline.

2. Creeping spikerush (*Eleocharis fallax* Weatherby)-soft-stem bulrush (*Scirpus validus* Vahl).

3. Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)-soft-stem bulrush (*Scirpus validus* Vahl)-dotted smartweed (*Polygonum punctatum* Ell.)-Elliott's aster (*Aster elliottii* Torr. & Gray)-smooth beggar-ticks (*Bidens laevis* [L.] BSP.).

4. Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)-creeping spikerush (*Eleocharis fallax* Weatherby).

5. Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.).

6. Creeping spikerush (*Eleocharis fallax* Weatherby)-freshwater mix.

7. Forested wetland.

8. Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)-soft-stem bulrush (*Scirpus validus* Vahl).

9. Mixed shrubs.

10. Creeping spikerush (*Eleocharis fallax* Weatherby)-freshwater mix-mixed shrubs.

11. Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)-creeping spikerush (*Eleocharis fallax* Weatherby)-freshwater mix.

12. Cypress-*Nyssa* swamp.

13. Soft-stem bulrush (*Scirpus validus* Vahl).

14. Soft-stem bulrush (*Scirpus validus* Vahl)-southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)-dotted smartweed (*Polygonum punctatum* Ell.)-smooth beggar-ticks (*Bidens laevis* [L.] BSP.).

15. Smooth beggar-ticks (*Bidens laevis* [L.] BSP.)-dotted smartweed (*Polygonum punctatum* Ell.)-Elliott's aster (*Aster elliottii* Torr. & Gray)-southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)-soft-stem bulrush (*Scirpus validus* Vahl).

16. Soft-stem bulrush (*Scirpus validus* Vahl)-southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)--three-square bulrush (*Scirpus pungens* Vahl.)-spikerush (*Eleocharis* sp.).

17. Disturbed bare ground.

18. Mixed evergreen vegetation.

19. Big cordgrass (*Spartina cynosuroides* [L.] Roth)-saltmarsh cordgrass (*Spartina alterniflora* Loiseleur)-narrow-leaf cattail (*Typha angustifolia* L.)-soft-stem bulrush (*Scirpus validus* Vahl).

20. Soft-stem bulrush (*Scirpus validus* Vahl)-saltmarsh bulrush (*Scirpus robustus* Pursh)-saltmarsh cordgrass (*Spartina alterniflora* Loiseleur)-perennial saltmarsh aster (*Aster tenuifolius* L.).

21. Narrow-leaf cattail (*Typha angustifolia* L.)-saltmarsh bulrush (*Scirpus robustus* Pursh)-saltmarsh cordgrass (*Spartina alterniflora* Loiseleur)-perennial saltmarsh aster (*Aster tenuifolius* L.).

22. Narrow-leaf cattail (*Typha angustifolia* L.)-big cordgrass (*Spartina cynosuroides* [L.] Roth).

23. Narrow-leaf cattail (*Typha angustifolia* L.)-big cordgrass (*Spartina cynosuroides* [L.] Roth)-soft-stem bulrush (*Scirpus validus* Vahl)-saltmarsh bulrush (*Scirpus robustus* Pursh).

24. Narrow-leaf cattail (*Typha angustifolia* L.)-southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.).

25. Big cordgrass (*Spartina cynosuroides* [L.] Roth)-southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.).

26. Big cordgrass (*Spartina cynosuroides* [L.] Roth).

27. Smooth beggar-ticks (*Bidens laevis* [L.] BSP.)-soft-stem bulrush (*Scirpus validus* Vahl)-dotted smartweed (*Polygonum punctatum* Ell.).

28. Saltmarsh cordgrass (*Spartina alterniflora* Loiseleur).

As was previously described, the division of the plant associations into 28 classes was possible from use of GPS in the areas of the quantitative vegetation quadrats and qualitative plots. The combination of these techniques allowed very detailed delineations, based on changes in dominance of several key species, to be made.

Examples of each type of community have generally been explained in the descriptions of each quadrat and the examination of the species frequency distribution diagrams. However, a few classes require brief explanations for clarity.

Exposed mud is exposed shoreline typically sparsely colonized by, for example, saltmarsh cordgrass (*Spartina alterniflora* Loiseleur) in the saline areas and annual wildrice (*Zizania aquatica* L.) in the freshwater areas. Mixed shrubs is typically a freshwater assemblage containing individuals of wax myrtle (*Myrica cerifera* L.), brook-side alder (*Alnus serrulata* [Ait.] Willd.), arrow-wood (*Viburnum dentatum* L.), red maple (*Acer rubrum* L.), and swamp red-bay (*Persea palustris* [Raf.] Sarg.). Mixed evergreen vegetation is generally restricted to berms or fill areas where oaks and pines persist. Forested wetland is a mixed assemblage of bald cypress (*Taxodium distichum* L. C. Rich.), swamp black gum (*Nyssa sylvatica* Marsh. var. *biflora* [Walt.] Sarg.), mixed shrubs and a component of bays, whereas, Cypress-*Nyssa* swamps are forested areas densely dominated by bald cypress (*Taxodium distichum* L. C. Rich.) and swamp black gum (*Nyssa sylvatica* Marsh. var. *biflora* [Walt.] Sarg.) and other deciduous hardwood species. As can be seen from the class names described, dominance of the *marshes* of the SNWR are typically divided among the following 11 species:

- Elliott's aster (*Aster elliottii* Torr. & Gray)
- perennial saltmarsh aster (*Aster tenuifolius* L.)
- smooth beggar-ticks (*Bidens laevis* [L.] BSP.)
- creeping spikerush (*Eleocharis fallax* Weatherby)
- dotted smartweed (*Polygonum punctatum* Ell.)
- alkali bulrush (*Scirpus robustus* Pursh)
- soft-stem bulrush (Scirpus validus Vahl)
- saltmarsh cordgrass (Spartina alterniflora Loiseleur)

- big cordgrass (Spartina cynosuroides [L.] Roth)
- narrow-leaf cattail (Typha angustifolia L.)
- southern wildrice (Zizaniopsis miliacea [Michx.] Doell & Aschers.)

The problems encountered with classification were that several plant associations gave very similar signatures on the SPOT image and were assigned the same value during classification. For example, the software was unable to differentiate between certain areas dominated by big cordgrass (*Spartina cynosuroides* [L.] Roth), narrow-leaf cattail (*Typha angustifolia* L.), and southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.), which in late summer appear very similar, even at close proximity on the ground. The differences between areas dominated by southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) and annual wildrice (*Zizania aquatica* L.) cannot be differentiated and thus annual wildrice (*Zizania aquatica* L.) dominated areas are incorporated in southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) associations in the present classification. Areas dominated by soft-stem bulrush (*Scirpus validus* Vahl) and saltmarsh cordgrass (*Spartina alterniflora* Loiseleur) are commonly confused as well as areas in which soft-stem bulrush (*Scirpus validus* Vahl) and creeping spikerush (*Eleocharis fallax* Weatherby) are present. In addition, and what proved to be particulary troublesome, was that areas dominated by smooth beggar-ticks (*Bidens laevis* [L.] BSP.) were consistently confused with creeping spikerush (*Eleocharis fallax* Weatherby)-freshwater mix areas. These regions are almost indistinguishable on the SPOT image.

To compensate for this problem, the study areas was divided into distinct groups based, in general, on north-south position within the River system. The first area, which included 2 sections, included areas north of Steamboat River and River Cut. This area was subdivided into separate areas predominately dominated by shrubs and trees and marshes. The second area included all areas between the Front and Little Back Rivers north of New Cut. The third area included all areas east of the Back River south of New Cut. The final group consisted of the north part of Hutchinson Island immediately south of New Cut.

A very general classification of plant communities can be made based on salinity gradients by these groupings. The area north of Steamboat River and Rifle Cut is typically dominated by freshwater associations. From this boundary south to New Cut are typically brackish plant associations, and south of New Cut are typically plant associations common to more saline environments. To allow comparisons of the existing classifications, the classified SPOT image prepared by Pearlstine *et al*. (1990) has been included as Figure 45. In general, these maps are very similar, especially with respect to the general geographic plant associations just described.

The extent of the freshwater vegetation associations as described by them are not appreciably different from the present study. There are some differences that need to be clarified to better understand the 2 images. The freshwater mix as described by Pearlstine *et al.* (1990) would, in part, encompass the following classes in the present study:

- Mixed shrubs
- Creeping spikerush (*Eleocharis fallax* Weatherby)-freshwater mix
- Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)-creeping spikerush (*Eleocharis fallax* Weatherby)-freshwater mix

Their *Zizaniopsis* class would correspond to the following associations in the present study, as follows:

- Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)
- Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)-creeping spikerush (*Eleocharis fallax* Weatherby)
- Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)-soft-stem bulrush (*Scirpus validus* Vahl)-dotted smartweed (*Polygonum punctatum* Ell.)-Elliott's aster (*Aster elliottii* Torr. & Gray)-smooth beggar-ticks (*Bidens laevis* [L.] BSP.)
- Southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.)-creeping spikerush (*Eleocharis fallax* Weatherby)-freshwater mix

It is important to note that in the present study, there is a distinction given between creeping spikerush (*Eleocharis fallax* Weatherby) and creeping spikerush (*Eleocharis fallax* Weatherby)-freshwater mix dominated habitats. Creeping spikerush (*Eleocharis fallax* Weatherby) is common in both freshwater and brackish areas of

the SNWR. However, the freshwater mix association contains a very diverse species array to specifically include the following species:

- Prairie iris (*Iris hexagona* Walt.)
- Iris-leaf yellow-eyed grass (*Xyris iridifolia* Chapm.)
- Glandular lobelia (*Lobelia glandulosa* Walter)
- Water-spider orchid (*Habenaria repens** Nutt.)
- Marsh dewflower (*Murdannia keisak* [Hassk.] Hand.-Mazz.)
- Joint-head arthraxon (*Arthraxon hispidus* var. *cryptatherus* [Hackel] Honda.)
- Sensitive fern (*Onoclea sensibilis* L.)
- Royal fern (*Osmunda regalis** L.)
- Others

These species are typically absent in areas south of a line drawn from Quadrat 1 north of Quadrats 5 and 4 as shown in Figure 1. This association is typically restricted to floating mat areas of the SNWR.

The major difference in the 2 images is seen in the northernmost area of Hutchinson Island bounded by US-17 at Port Wentworth and Steamboat River (between Front and Middle Rivers). They show a relatively large expanse of forested wetlands and freshwater mix, which was found to be dominated by smooth beggar-ticks (*Bidens laevis* [L.] BSP.) in the present study. This species gives a signature on the SPOT image that is very similar to these 2 “confused” plant associations.

In summary, the 2 SPOT image classifications performed approximately 10 years apart show very similar distributions of the plant associations.

4.2 EXISTING SALINITY CONTOURS AND PROJECTED CHANGES

The quantitative plant community study showed that the existing boundary of the diverse freshwater plant community has not changed dramatically since that reported by Pearlstine *et al*. (1990). In addition, extensive modeling of projected salinity changes in relation to the proposed deepening of the channel indicate that projected changes in salinities, especially along the Little Back River, will be minimal and not approach the dramatic levels as that experienced during operation of the tide gate. From these set of conditions, it can reasonably be asserted that the existing plant communities in the area of interest in the SNWR are tolerant of the salinity conditions that existed with the tide gate, the present conditions, and, hence, the conditions that are expected to occur as a result of the proposed project.

The question as to whether a gradual increase in the extent of the freshwater marsh characterized by a diverse array of species will expand in the future over some time period of "X" years has been raised. Based upon the present degree of understanding of this system, no legitimate argument can be made as to whether this will or will not happen. Therefore, an exercise was performed to delineate the area that most probably could be affected by an increase in salinity in relation to the proposed project.

To facilitate the delineation of the area of greatest potential impact, salinity contours for the existing conditions and the post-deepening conditions were generated. Since it has been established that the 0.5 ppt contour determines the extent of the freshwater system, the change in the physical location of the 0.5 ppt was determined. The area between the existing 0.5 ppt and the projected 0.5 ppt was calculated and used as a basis for determining an equitable mitigation measure to compensate for the probability that this system could change.

Existing condition contours were determined for flows of 5,900 cubic feet per second, 8,200 cubic feet per second, and 9,500 cubic feet per second. Salinity concentrations for the incremental percentile groups are shown for all continuous monitoring stations in Tables 7, 8, and 9 for the respective flows and are presented graphically in Figures 46, 47, and 48.

Salinity contours were determined for the 8,200 cubic feet per second for the post-project conditions since this flow was suggested in interagency negotiations (Figure 49). The projected salinity changes for this flow regime are presented in Table 10 and the post-deepening contours

Table 7

Salinity Data for High Tide
Day 244 to Day 270: Flow Average = 5,900 cfs

Station	River Mile	Mean (ppt)	Minimum (ppt)	Maximum (ppt)	50th Percentile (ppt)	90th Percentile (ppt)
GPA-01 (M)	-3.5	31.1	27.8	32.5	31.5	31.9
GPA-02 (B)	4.5	27.7	21.6	33.2	28.2	29.9
GPA-02 (S)	4.5	23.0	19.0	26.5	23.2	25.7
GPA-03 (B)	4.0	19.6	12.6	23.5	19.6	22.4
GPA-04 (B)	10.4	19.5	12.6	24.9	19.2	22.1
GPA-04 (S)	10.4	16.0	10.0	20.7	16.1	19.1
GPA-05 (B)	14.5	10.7	5.8	16.4	10.8	14.8
GPA-05 (S)	14.5	10.2	5.3	15.9	10.3	14.3
GPA-06 (B)	16.6	13.8	8.1	20.1	14.2	17.8
GPA-06 (S)	16.6	6.7	2.8	11.9	6.6	8.9
GPA-07 (B)	18.9	5.3	0.9	11.0	5.1	8.6
GPA-07 (S)	18.9	4.9	0.5	10.6	4.7	8.2
GPA-08 (B)	20.5	6.7	1.2	15.4	5.9	11.7
GPA-08 (S)	20.5	5.9	1.2	13.2	5.4	10.1
GPA-09 (B)	21.7	4.9	0.7	13.0	3.9	9.4
GPA-09 (S)	21.7	3.5	0.7	11.6	2.5	8.0
GPA-10 (B)	21.5	2.1	0.6	9.4	2.9	7.1
GPA-10 (S)	21.5	1.0	0.1	8.0	1.5	5.7
GPA-11 (B)	24.4	0.9	0.1	5.2	0.7	2.6
GPA-11 (S)	24.4	1.3	0.1	5.1	0.6	2.5
GPA-12 (B)	24.0	1.2	0.2	5.5	0.9	2.6
GPA-12 (S)	24.0	1.2	0.1	5.4	0.8	2.5
GPA-13 (B)	26.3	0.6	0.1	1.6	0.3	1.4
GPA-13 (S)	26.3	0.6	0.1	1.6	0.3	1.4
US17 Front River (B)	21.7	5.0	0.7	13.8	3.9	9.9
USF&W Dock (B)	22.3	0.4	0.0	2.4	0.2	1.0
USF&W Dock (S)	22.3	0.4	0.0	2.4	0.2	1.0
Lucknow Canal (B)	24.2	0.2	0.0	0.8	0.1	0.5
Lucknow Canal (S)	24.2	0.2	0.0	0.8	0.1	0.5

Notes: 1. S = Surface, M = Mid-Depth, B = Bottom

2. Surface values for GPA-05, 07, 09, 10, 11, 12, 13, USF&W Dock, and Lucknow Canal were extrapolated using discrete sampling data.

Table 8

Salinity Data for High Tide
Day 182 to Day 270: Flow Average = 8,200 cfs

Station	River Mile	Mean (ppt)	Minimum (ppt)	Maximum (ppt)	50th Percentile (ppt)	90th Percentile (ppt)
GPA-01 (M)	-3.5	31.7	27.4	33.9	31.7	32.8
GPA-02 (B)	4.5	26.6	20.3	33.2	26.6	29.3
GPA-02 (S)	4.5	21.2	12.1	27.5	21.9	25.4
GPA-03 (B)	4.0	15.8	8.5	23.5	15.5	20.7
GPA-04 (B)	10.4	18.6	10.9	25.0	18.6	22.0
GPA-04 (S)	10.4	13.7	5.6	20.7	13.6	18.0
GPA-05 (B)	14.5	8.8	3.8	16.4	8.1	13.1
GPA-05 (S)	14.5	8.5	3.5	16.2	7.9	12.9
GPA-06 (B)	16.6	11.0	3.8	21.1	10.6	16.2
GPA-06 (S)	16.6	5.6	1.3	14.1	5.4	8.6
GPA-07 (B)	18.9	3.3	0.0	11.0	2.7	7.8
GPA-07 (S)	18.9	3.1	0.0	10.8	2.5	7.6
GPA-08 (B)	20.5	4.5	0.1	15.4	4.2	10.7
GPA-08 (S)	20.5	2.9	0.1	13.2	1.7	7.5
GPA-09 (B)	21.7	3.2	0.1	13.0	2.6	8.2
GPA-09 (S)	21.7	1.7	0.1	11.6	1.1	6.7
GPA-10 (B)	21.5	1.9	0.0	9.4	1.1	4.5
GPA-10 (S)	21.5	1.8	0.0	9.3	1.0	4.4
GPA-11 (B)	24.4	0.3	0.0	5.2	0.1	1.0
GPA-11 (S)	24.4	0.2	0.0	5.1	0.0	0.9
GPA-12 (B)	24.0	0.7	0.0	5.5	0.4	1.7
GPA-12 (S)	24.0	0.6	0.0	5.4	0.3	1.6
GPA-13 (B)	26.3	0.2	0.0	1.6	0.1	0.3
GPA-13 (S)	26.3	0.2	0.0	1.6	0.1	0.3
US17 Front River (B)	21.7	3.0	0.0	13.8	2.1	7.5
USF&W Dock (B)	22.3	0.2	0.0	2.4	0.1	0.6
USF&W Dock (S)	22.3	0.2	0.0	2.4	0.1	0.6
Lucknow Canal (B)	24.2	0.1	0.0	0.8	0.0	0.3
Lucknow Canal (S)	24.2	0.1	0.0	0.8	0.0	0.3

Notes: 1. S = Surface, M = Mid-Depth, B = Bottom

2. Surface values for GPA-05, 07, 09, 10, 11, 12, 13, USF&W Dock, and Lucknow Canal were extrapolated using discrete sampling data.

Table 9

Salinity Data for High Tide
Day 182 to Day 243: Flow Average = 9,500 cfs

Station	River Mile	Mean (ppt)	Minimum (ppt)	Maximum (ppt)	50th Percentile (ppt)	90th Percentile (ppt)
GPA-01 (M)	-3.5	32.0	27.4	33.9	32.2	33.2
GPA-02 (B)	4.5	25.5	20.3	29.4	25.6	27.6
GPA-02 (S)	4.5	20.8	12.1	27.0	21.4	25.3
GPA-03 (B)	4.0	14.3	8.5	22.2	14.1	17.9
GPA-04 (B)	10.4	17.9	10.9	25.0	17.9	21.9
GPA-04 (S)	10.4	11.8	5.6	17.7	11.8	15.2
GPA-05 (B)	14.5	7.9	3.8	13.3	7.7	10.5
GPA-05 (S)	14.5	7.4	3.3	12.8	7.2	10.0
GPA-06 (B)	16.6	10.1	3.8	21.1	9.6	14.5
GPA-06 (S)	16.6	5.4	1.3	14.1	4.8	8.6
GPA-07 (B)	18.9	1.6	0.0	9.0	0.9	4.0
GPA-07 (S)	18.9	1.6	0.0	9.0	0.9	4.0
GPA-08 (B)	20.5	3.1	0.1	12.1	1.6	8.6
GPA-08 (S)	20.5	1.7	0.1	8.8	0.9	5.3
GPA-09 (B)	21.7	1.3	0.1	11.6	0.5	3.8
GPA-09 (S)	21.7	1.3	0.1	11.6	0.5	3.8
GPA-10 (B)	21.5	1.1	0.0	5.0	0.6	3.2
GPA-10 (S)	21.5	1.1	0.0	5.0	0.6	3.2
GPA-11 (B)	24.4	0.1	0.0	2.5	0.0	0.2
GPA-11 (S)	24.4	0.1	0.0	2.5	0.0	0.2
GPA-12 (B)	24.0	0.3	0.0	2.7	0.2	0.7
GPA-12 (S)	24.0	0.3	0.0	2.7	0.2	0.7
GPA-13 (B)	26.3	0.1	0.0	0.7	0.1	0.1
GPA-13 (S)	26.3	0.1	0.0	0.7	0.1	0.1
US17 Front River (B)	21.7	1.8	0.0	11.0	0.5	6.0
USF&W Dock (B)	22.3	0.0	0.0	0.7	0.0	0.1
USF&W Dock (S)	22.3	0.0	0.0	0.7	0.0	0.1
Lucknow Canal (B)	24.2	0.0	0.0	0.2	0.0	0.0
Lucknow Canal (S)	24.2	0.0	0.0	0.2	0.0	0.0

Notes: 1. S = Surface, M = Mid-Depth, B = Bottom

2. Surface values for GPA-05, 07, 09, 10, 11, 12, 13, USF&W Dock, and Lucknow Canal were extrapolated using discrete sampling data.

Table 10

High Tide Surface Salinity Impacts at 8,200 cfs

Station	Percentile (ppt)								
	10th	20th	30th	40th	50th	60th	70th	80th	90th
GPA-04	0.3	0.0	-0.1	-0.1	-0.3	-0.2	-0.2	-0.3	-0.6
GPA-05	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
GPA-06	0.4	0.4	0.5	0.5	0.4	0.4	0.5	0.5	0.5
GPA-07	0.1	0.2	0.2	0.4	0.4	0.4	0.4	0.3	0.3
GPA-08	0.2	0.5	0.6	0.8	0.9	1.0	1.1	1.2	1.3
GPA-09	0.1	0.4	0.6	0.7	0.8	0.8	0.9	0.9	0.9
GPA-10	0.1	0.3	0.6	0.8	0.9	0.9	1.0	1.0	1.0
GPA-11	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.4	0.4
GPA-12	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.6
GPA-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
GPA-15	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.5
USF&W	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Lucknow	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1

are shown in Figure 49. The comparison in the existing condition 0.5 ppt contour and the projected upstream movement of this contour is shown in Figure 50. The area shown to be affected by this movement of the 0.5 ppt boundary equals approximately 1,170 acres.

It must be emphasized that the existing condition contours and the projected change in these contours represent a worst-case scenario. Existing salinity contours were calculated for stages that exceed 4.5 feet, which is the lowest minimum elevation at which the marshes in the potential impact area flood. Based on analysis of historic stage data for 1994, this elevation is only exceeded 21.4 percent of the time during the year. In addition, salinities when tides are at this stage are substantially higher than the average salinities calculated for all tides and stages. For example, at station GPA-09 in the Front River, the 50 percentile salinity concentration for all stages is 0.3 ppt as compared to 1.1 ppt for stages exceeding 4.5 feet and flows of 8,200 cubic feet per second.

4.3 HISTORIC AERIAL PHOTOGRAPHY OF SPECIFIC QUADRAT AREAS

For completeness, a number of figures are presented showing how the 10 vegetation quadrat areas appeared in 1974, 1980, and 1994 aerial photography as compared to the August 22, 1997, SPOT image (Figures 51 to 60). The quadrat locations are presented on the photographs and each dot represents a corresponding 100-foot pole along the quadrat length. Although extensive analysis of likeness and difference between the images is not given, it can be seen, for example, the very similar appearance of signatures present in the more freshwater Quadrats 6, 8, and 9 locations (Figures 58, 59, and 60), which have shown little change since 1974. Interpretation of signatures in the more brackish and saline areas is more difficult, being more dependent on river stage, which dramatically affects the signature.

4.4 APPARENT EFFECT OF THE TIDE GATE ON THE MIDDLE RIVER

The apparent effect of the tide gate on the vegetation of the SNWR is not well documented partially due to the paucity of information existing prior to the construction of the tide gate. There are some apparent effects that may be attributed to the tide gate, which are seen on aerial photography. However, these effects are primarily restricted to the Middle River with no noticeable changes being apparent in the Little Back River. To show the area of impact, historic photographs for 1974, 1980, and 1994 (Figure 61) are presented. These photos represent periods prior to the installation of the tide gate (1974), during the operation of the tide gate (1980), and after the tide gate was decommissioned (1994). Area "A" represents the region in which a dramatic die-off of woody vegetation, trees, and shrubs occurred; however, changes in marsh vegetation in these areas are difficult to discern. It should be noted that these photos are all false-color infrared images, however, film types were obviously different and the 1974 photo was taken in spring after vegetation had begun to grow, which accounts for the very reddish image. The Area "B," which includes Area "A," depicts a unique marsh signature that has been present since 1974.

The SPOT image classification for this region is shown in Figure 62 to show the plant communities present. These areas were very pronounced in the classified SPOT image developed by Pearlstine *et al*. (1990) (Figure 45). These areas are, in addition, remarkably outlined by the salinity contours found in Figures 46, 47, and 48, and it is this region where the potential impact area for the deepening project could occur, as shown in Figure 50. This is a unique area of this system that has been consistently unique even prior to installation of the tide gate. To truly understand the complexities of salinity effects within the SNWR, further investigation in this area is warranted.

It should be noted that there is a presumption that die-back noted in this area is related to tide gate operation; however, McCoys Cut was dredged at this time, which could have contributed to this response.

4.5 VEGETATION CHANGES RELATED TO NEW CUT

A pronounced change in the vegetation at New Cut has taken place since 1974. In 1974, the area appears to have been dominated by soft-stem bulrush (Scirpus validus Vahl) and saltmarsh cordgrass (*Spartina alterniflora* Loiseleur) or some variety of this plant association. However, as shown in 1980 (Figure 63), as denoted in Area "A," a change in vegetation has occurred. This association is more freshwater in appearance, being dominated by southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) with a large population of smooth beggar-ticks (*Bidens laevis* [L.] BSP.). This population presently exists even after the closing of New Cut. This southern wildrice (*Zizaniopsis miliacea* [Michx.] Doell & Aschers.) dominated assemblage in the area of the cut is bounded to the north by soft-stem bulrush (*Scirpus validus* Vahl) dominated areas and to the south by soft-stem bulrush (*Scirpus validus* Vahl)-saltmarsh cordgrass (*Spartina alterniflora* Loiseleur) communities. This change is unique in this area and the development of a more freshwater community around the cut is contrary to the predicted effects with the tide gate operating.

A field review of the species occurring on the filled portion of New Cut 26 January 1998 showed the following species to be present:

- Narrow-leaf cattail (*Typha angustifolia* L.)
- Saltmarsh cordgrass (*Spartina alterniflora* Loiseleur)
- Purple rattle-bush (*Sesbania punicea* [Cav.] Benth.)
- Dangle-pod (*Sesbania emerus* [Aubl.] Urban)
- Small dog-fennel thorough-wort (*Eupatorium capillifolium* [Lam.] Small)
- Eastern false-willow (*Baccharis halimifolia* L.)
- Big cordgrass (*Spartina cynosuroides* [L.] Roth)
- Vasey grass (*Paspalum urvillei* Steud.)
- Soft rush (*Juncus effusus* L.)
- Sugarcane plumegrass (*Erianthus giganteus* [Walt.] Muhl.)
- Alkali bulrush (*Scirpus robustus* Pursh)
- Aster (Aster species)
- Smartweed (Polygonum species)
- Bushy bluestem (Andropogon glomeratus [Walt.] BSP)
- Wax myrtle (Myrica cerifera L.)

The most dominant species present was narrow-leaf cattail (*Typha angustifolia* L.).

5.0 SUMMARY

The intent of this ecological study was to define the existing conditions of the SNWR and potentially assess the potential problems associated with the proposed deepening project. To address, in depth, the successional patterns since the tide gate would require examination of historic photos or satellite imagery on a year by year basis. We have, however, established a significant database to which future change can be compared.

6.0 REFERENCES

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