

2003 Vegetation Monitoring in Mill River Freshwater Tidal Marshes

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Prepared by

**J. Lee Rogers
and
Penelope Sharp**

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As part of the ongoing evaluation of the lower Mill River corridor and the potential environmental effects of the Whitney Water Treatment Plant (WTP), the South Central Connecticut Regional Water Authority conducts annual monitoring of plant communities in the freshwater tidal marsh. This marsh, created in part by downstream tidegates belonging to the City of New Haven, is an unusual vegetation type that contributes significantly to the biological diversity and wildlife populations in the lower Mill River and East Rock Park.

The Water Authority's Environmental Evaluation Team, in its 1999 assessment of potential impacts of the proposed treatment plant, recommended that vegetation in the marsh be monitored annually or biennially, both prior to construction of the plant to provide baseline data and after the plant is placed in operation, which is expected to occur in late 2004. Data from these vegetation studies are to be evaluated, along with monitoring of soil salinity, river flow, and water quality in the lower Mill River, to evaluate environmental impacts of treatment plant operation and the possible need to implement management measures to mitigate any adverse effects.

Vegetation Sampling Method

In 2003, Penni Sharp and Vincent Kay conducted quantitative vegetation sampling of the Mill River marshes on September 25. Vegetation monitoring was conducted along two permanent transects also monitored in 1998 and in 2000-2002. Monitoring in 2002, 2001, and 1998 was performed at approximately the same time, in late September; 2000 monitoring was done about 5 weeks earlier, in August. Preliminary sampling in the area of the northern transect was also performed in September 1991. Soil water salinity measurements have been made in spring and late summer from three monitoring wells on each transect, installed in September 2000.

The upstream or northern transect, MR-N, is about 2,000 feet below the Whitney dam, just south of the East Rock Park footbridge and about 700 feet north of the East Rock Road bridge. This transect passes through one of the largest and most varied parts of the marsh. As surveyed, the transect is about 100 meters long; approximately 75 meters of this length passes through high marsh, a mosaic of shrubs and emergent marsh (primarily cattails), which is seasonally or occasionally flooded but not subject to daily tidal inundations. About 25 meters of low marsh bordering the river is alternately flooded and exposed as a result of daily tidal fluctuations in the river; portions of the low marsh are often inaccessible due to flooding by tidal action or high river flows.

The downstream transect, MR-S, passes through a narrower and less varied marsh community about 300 feet south of the East Rock Road bridge. This transect is about 55 meters long from upland edge to river. The high marsh, about 45 meters wide, consists primarily of cattail marsh, with shrub thickets on elevated hummocks. The remaining 10 meters of the transect is in low marsh bordering the river.

Permanent transects at both sites are approximately perpendicular to the river, with marker stakes placed every 5 meters. Maps of these transects, and a detailed description of the methodology, appear in the report by Lee Rogers included in the Water Authority's *Lake Whitney Water Treatment Plant Environmental Evaluation: Volume Two* (January 1999). Vegetation sampling is performed by extending 5-meter sampling chains to the south at right angles from each stake on the permanent transect. A dowel rod is inserted into the vegetation at 0.5 m. intervals along the sampling chain (for a total of 10 sampling points per chain), and all species touching the rod (or an imaginary upward extension of it) are recorded.

For transect MR-S, sampling begins at the origin of the permanent transect (stake 1) and extends through stake 12, for a total of 12 chains and 120 sampling points. On transect MR-N, sampling begins at the second stake, since the stake at the origin of the transect is located within a swale with little vegetation other than canopy trees overhanging from the adjacent upland forest. A total of 18 stakes are sampled, for a total of 18 chains and 180 sampling points; two additional stakes were installed and surveyed on the riverward end of this transect but are typically inundated and have not been accessible for sampling.

Results and Discussion

River and Soil Conditions

Growing-season conditions on the Mill River in 2003 were marked by substantially higher than normal rainfall in June, August, and September, while precipitation was well below normal in April and July. As shown in Table 1, although total annual precipitation at Lake Whitney in 2003 was less than an inch above average, rainfall during the growing season was above normal. From April through September, the area received 27.6 inches of precipitation, compared with about 23 inches in an average growing season. This was comparable to 28 inches during the growing season of 2000 and 26.2 inches in the 1998 growing season. In contrast, the area received only 16.3 inches of rain during the 1999 growing season, when no monitoring was performed. Rainfall was approximately normal during the growing seasons of 2002 (24.2 inches) and 2001 (20.3 inches); however, because of an extended dry period from October through December 2001, that year had the lowest total precipitation of the study period.

Soil water in the transect monitoring wells was sampled on April 16 and July 31, 2003, during both high and low tide conditions (Table 2). At both sampling times, salinity in the Mill River adjacent to the transects was 0.1 ppt (parts per thousand). Soil water salinity was 0.1 to 0.2 ppt in nearly all sampling wells, reaching 0.3 ppt in only one of the MR-S wells at high tide in April and at both high and low tide in July. Even though soil salinity was measured during the driest months of the 2003 growing season, these values were lower than the peak values observed in July 2001 and 2002. In 2002, also a dry July, soil salinities were as high as 0.7 ppt on transect MR-N and 0.4 ppt on MR-S. In 2001, with July precipitation higher but still below average, peak salinities of 0.4 ppt on MR-N and 0.5 ppt on MR-S were measured. Except for these July peaks observed in one well on each transect, salinity in the soil water of these transects has always measured well below the 0.5 ppt considered the limit of tolerance for freshwater marsh plants as an average annual salinity.

2003 Vegetation Monitoring

Vegetation monitoring results for 2003 are presented in Tables N and S, which show the data collected on the north and south transects, respectively. The data are presented for each sampling chain to show zonation in the marshes. These tables thus provide a profile of the two marsh areas. They have been subdivided into zones based on topography and vegetation, as described in the vegetation report in the Water Authority's *Lake Whitney Water Treatment Plant Environmental Evaluation: Volume Two* (Rogers 1999).

As shown in Table N, the upper marsh on transect MR-N is dominated by spotted jewelweed (*Impatiens capensis*), which gradually gives way to narrow-leaved cattail (*Typha angustifolia*), an emergent marsh plant tolerant of relatively high salinities. Cattail dominates the middle marsh, along with the climbing composite *Mikania scandens*. The transect then passes through a broad area where emergent marsh intermingles with shrub thickets, apparently depending on small changes in elevation; this area appears in Table N as three zones, "Shrub thicket," "Shrub/marsh" (the lowest area), and "Dogwood thicket." In the higher areas of this complex, silky dogwood (*Cornus amomum*) dominates, intermixed with several herbaceous species, including cattail, mikania, jewelweed, and goldenrod (*Solidago gigantea*). Swamp rosemallow (*Hibiscus moscheutos*) is also among the shrubs in this area. In the lower swale, northern arrowwood (*Viburnum dentatum* var. *recognitum*) is the dominant shrub; buttonbush (*Cephalanthus occidentalis*), a shrub highly tolerant of periodic inundation, appears in the lowest and wettest areas. Cattails (*T. angustifolia*) are absent in the low shrub/marsh, and jewelweed (*Impatiens capensis*) is the dominant herbaceous species. As the ground rises slightly on the riverward side, there is a dense thicket of silky dogwood (*C. amomum*), again intermixed with cattails as well as jewelweed. Below this rise, the substrate descends fairly rapidly toward the river. Silky dogwood is still common on higher ground, but cattails disappear in the low marsh, which is subject to frequent tidal inundation. *Mikania scandens*, purple loosestrife (*Lythrum salicaria*), and jewelweed occur among the dogwood, but give way to arrow arum (*Peltandra virginiana*), and then (beyond stake 18) to other species tolerant of regular submersion, including arrowhead (*Sagittaria* sp.), pickerel weed (*Pontederia* sp.), and white waterlily (*Nymphaea odorata*).

As shown in Table S, sampling at site MR-S, begins in an area of transition between upland forest and marsh, dominated by spicebush (*Lindera benzoin*), silky dogwood (*Cornus amomum*), and multiflora rose (*Rosa multiflora*); jewelweed is the dominant herb. In the upper marsh, narrow-leaved cattail (*Typha angustifolia*) and

jewelweed (*Impatiens capensis*) are dominant, while in the middle marsh, jewelweed becomes less common and cattails share dominance with *Mikania scandens*. The transect then crosses a small rise or hummock, where a few shrubs such as swamp rosemallow (*Hibiscus moscheutos*) intermix with the cattail community. Beyond this is low marsh, where cattails and jewelweed are replaced by arrow arum. The last sampling chain crosses part of a small levee adjacent to the river, where a large silver maple (*Acer saccharinum*) and other upland species occur.

Plant Community Baseline Variability, 1998 - 2003

Summary tables in the appendix compare the current data to those collected in previous years of monitoring. For each transect, the species recorded in the sample are shown by year. The first summary table for each transect lists species in order of their percent cover in the current (2003) sample; these are followed by alphabetical listings of all species recorded on each transect. Data from 1991 sampling in the MR-N area of the marsh have been omitted from this report because permanent transects had not yet been established, and sampling data from the transect used in 1991 cannot be compared directly to the later data. The 1991 data appear in the original Environmental Evaluation study (Rogers 1999) and in previous annual vegetation monitoring reports.

As shown in the appendix tables, total plant cover on the marsh transects was lower than in the two previous years and was similar to that in 2000, which was, like 2003, a wetter than normal growing season. Coverage by individual species, however, did not necessarily show the same pattern as in 2000, probably in part because sampling in that year was done several weeks earlier. It is likely there were also differences in the ability of seedlings to become established early in the growing season, since April 2000 had higher than normal rainfall, while that in April 2003 was well below normal. At MR-N, total cover for 2003 was 521 percent, between the high of 647 in 2001, when there was approximately normal precipitation during the growing season, and the low of 307 in 1998, another wet year in which precipitation in April and May was unusually high.. At MR-S, 2003 cover of 308 percent was between the 2002 high of 324 and the 1998 low of 274. The total percent coverage is obtained by added the percent cover for all species.

Species diversity in the Mill River marshes has generally been fairly consistent, despite changes in cover by non-dominant species. In 2003, 31 species were counted on the MR-N transect and 21 on MR-S. In three of the previous four years of this study, the number of species on MR-N ranged between 28 and 31, and the number of species on MR-S was between 17 and 23. Species diversity on both transects peaked in 2001, when the sample included 40 species on transect MR-N and 27 species on transect MR-S. Conditions during 2001 may have been unusually favorable for many species, since a relatively dry April could have permitted early germination and establishment of seedlings, while consistent rainfall through the remainder of the growing season minimized stress.

In the emergent marsh (mid-marsh), most of the dominant species, including cattails (*Typha angustifolia*), jewelweed (*Impatiens capensis*) and the vining composite *Mikania scandens*, showed a decrease in percent cover compared with the 2002 sample. Cattails, the most abundant species at both sites, have shown only minor variability from year to year. Mikania, a climbing composite found in close conjunction with the cattails, has varied substantially over the course of this study. Cover by this species at MR-N reached a high in 2002, although its peak at MR-S occurred in 1998. In the fall of 2001, the monitoring team observed a number of seedlings of this species at MR-N, and this apparently unusual fall germination may have contributed to the high Mikania cover there in 2002. Jewelweed (*I. capensis*) shows great year-to-year variability, both at the Mill River and other wetland sites. High water levels during the early part of the growing season appear to reduce or delay germination and result in reduced cover by this species.

A few herbaceous marsh species showed increased cover in 2003. Among these was arrow arum (*Peltandra virginica*), a low-marsh emergent favored by wet conditions. The two fern species common at MR-N, marsh shield fern (*Thelypteris palustris*) and sensitive fern (*Onoclea sensibilis*), also had higher cover than in 2002. Both species of tearthumbs, the arrow-leaved (*Polygonum sagittatum*) and halberd-leaved (*P. arifolium*), showed increases over last year at both sites; in fact, their 2003 cover at MR-S, 5.8 and 12.5 percent, respectively, was the highest yet recorded at this site. At MR-N, however, both species had only about 2 percent cover, considerably less than the 2001 peak of 10.6 percent for *P. sagittatum*. The tearthumbs are highly variable wetland species, both in their absolute percent cover and relative to each other; they can be so abundant

as to present a hazard to the sampling team one year and absent from the next year's sample.

Two species of concern that occur in the Mill River marshes are the introduced invasives, purple loosestrife (*Lythrum salicarium*) and common reed (*Phragmites australis*). On the Mill River, *Phragmites* is found primarily in areas that have been disturbed by filling or other human activity. It does not occur in the area of the transects and has not been found in any of the samples to date. Purple loosestrife is a minor component of the marsh in both transect areas. On both transects, this species shows a substantial increase in cover since 1998, when a dry growing season may have helped to keep it in check, but has remained fairly stable over the last 3 years. In 2003, purple loosestrife at MR-S showed a small increase compared with 2002, from 10.8 to 14.2 percent cover, but remained below its 2001 peak of 15.8 percent. At MR-N, purple loosestrife decreased from its 2002 peak of 20.6 to 15.6 percent cover in 2003.

In the shrub marsh areas, silky dogwood (*Cornus amomum*) cover for 2003 decreased at MR-N, where it is a strong dominant, but increased at MR-S, where shrub marsh forms a much more limited part of the marsh community. Shrubs adapted to wetter conditions did not show this decrease: Northern arrowwood (*Viburnum dentatum*) cover remained approximately the same on both transects, while buttonbush (*Cephalanthus occidentalis*) and swamp rosemallow (*Hibiscus moscheutos*) on transect MR-N both increased in percent cover.

Conclusions

The results of repeated sampling along permanent transects at two sites in the lower Mill River marshes provide a range of baseline data that quantitatively describe the marsh community in terms of natural or successive changes and responses to high (2003, 2000, 1998), normal (2002), and slightly below normal (2001) precipitation conditions during the growing season. The vegetation sampling performed over this period indicates that the narrow-leaved cattails that dominate much of the marsh have remained relatively constant in their percent cover, while other herbaceous species, including jewelweed (*Impatiens capensis*), the climbing composite *Mikania scandens*, arrow-leaved tearthumb (*Polygonum sagittatum*), and ferns, are quite variable from year to year, presumably in response to precipitation and other environmental conditions. These changes are not clearly correlated with overall precipitation during the growing season and are probably related largely to conditions during the period of germination and seedling establishment.

Shrub cover on these marshes, primarily by silky dogwood (*Cornus amomum*) and arrowwood (*Viburnum dentatum*), varies somewhat from year to year, but has shown no marked directional trend that might indicate successional change or overall drying of the marsh. Shrub cover in the samples does appear to be influenced by year-to-year climatic differences. Buttonbush (*Cephalanthus occidentalis*) cover is directly correlated with growing-season precipitation, but changes in cover by *C. amomum* do not appear to correlate directly with rainfall; for example, in 2003, its percent cover was higher than in 2002 on transect MR-S, but slightly reduced at MR-N.

Evidence as to whether purple loosestrife (*Lythrum salicaria*) is invading these marshes is thus far inconclusive. Overall, there has been an increase in cover by this species, especially at site MR-N, but it does not appear to be moving into new areas of the marsh. Additionally, the growth of this plant appears to be substantially influenced by precipitation. A series of normal to wet growing seasons over the last four years may have provided favorable conditions for its growth. It is noteworthy that another introduced plant, *Phragmites australis*, has not invaded these essentially undisturbed sites, despite the presence of abundant sources in nearby disturbed areas.

The Whitney water treatment plant is expected to be brought on-line in late 2004, providing an opportunity for one additional year of baseline monitoring before the plant becomes operational. The RWA plans an extended drawdown of Lake Whitney during the late summer (July-September) of 2004, reaching lows of about 5.5 feet below spillway level, to complete intake modifications and other necessary work. During this period, water will be released downstream through the blowoff valve. Therefore, conditions in the Mill River marshes during 2004 vegetation monitoring will depend both on growing season precipitation and artificial modification of streamflow during the planned drawdown.

The extended period of annual baseline monitoring, which includes 6 of the 7 years from 1998 through

2004, will provide a valuable data base for comparison with vegetation monitoring results obtained once the water treatment plant is in operation. The baseline results indicate normal variability in the marshes in the absence of water supply withdrawals. Baseline data can also help to identify any long-term successional trends that may be affecting the plant communities of the marshes. Continued monitoring of river water and soil water salinity should indicate whether any future changes in marsh vegetation are the result of reductions in freshwater flows by treatment plant operations.

Appendix Tables

Table 1: Lake Whitney Precipitation, 1998 - 2003

Table 2: Mill River Freshwater Tidal Marsh Groundwater Monitoring Well Data, 2003

Table N: Mill River North (MR-N) Vegetation Frequency by Species and Zone, 2003

Table S: Mill River South (MR-S) Vegetation Frequency by Species and Zone, 2003

MR-N Transect - Alphabetical List of Species and Percent Cover, 1991-2003

MR-N Transect - Summary of Species by Percent Cover in 2002, 1991-2003

MR-S Transect - Alphabetical List of Species and Percent Cover, 1998-2003

MR-S Transect - Summary of Species by Percent Cover in 2002, 1998-2003

Table 1 - Lake Whitney Precipitation 1998-2003 (inches)*

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Total	Growing Season Apr.- Sept.
1998	5.00	4.69	5.59	3.98	5.51	8.30	1.11	4.92	2.36	3.23	1.81	0.95	47.45	26.18
1999	6.85	4.76	3.90	1.50	2.75	0.32	1.22	3.42	7.05	3.86	2.91	2.41	40.95	16.26
2000	2.44	1.89	4.14	4.68	3.31	5.95	7.04	2.72	4.29	0.44	4.45	2.41	43.76	27.99
2001	1.62	2.05	7.29	1.53	5.32	4.26	2.87	3.43	2.84	1.18	1.03	2.18	35.60	20.25
2002	1.67	1.27	4.09	3.45	5.56	3.35	1.90	3.16	6.73	4.20	4.15	4.06	43.59	24.15
2003	1.47	2.48	4.13	2.92	4.11	6.57	1.57	5.47	6.94	5.36	2.18	3.62	46.82	27.58
Average	3.65	3.27	4.39	4.10	3.97	3.61	3.64	3.98	3.72	3.59	4.03	3.98	45.93	23.02

*Source: RWA precipitation gauge data

**Table 2
Mill River Freshwater Tidal Marsh
Groundwater and River Salinity (ppt)**

Station	4/16/03 (spring)		7/31/03 (summer)	
	Low tide	High tide	Low tide	High tide
MRN - 1	0.2	0.2	0.2	0.2
MRN - 2	0.2	0.2	0.2	0.3
MRN - 3	0.2	0.3	0.3	0.2
River @ MRN	0.1	0.1	0.1	0.1
MRS - 1	0.1	0.1	0.2	0.2
MRS - 2	0.1	0.1	0.2	0.1
MRS - 3	0.2	0.1	0.2	0.1
River @MRS	0.1	0.1	0.1	0.1

Table N: MILL RIVER FRESHWATER TIDAL MARSH VEGETATION, NORTH SITE (MR-N) -- FREQUENCY BY SPECIES AND ZONE, 2003

Vegetation Zone: Species	Upper marsh		Mid.marsh		Shrub thicket		Shrub/marsh		Dogwood thicket		Low marsh		2003								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total	%Cover	
<i>Iris pseudacorus</i>	1																		1	0.6	
<i>Viburnum lentago</i>	4																		4	2.2	
<i>Bidens frondosa</i>	2																		2	1.1	
<i>Polygonum sagittatum</i>	1	1	1																3	1.7	
<i>Polygonum arifolium</i>	2																		2	1.1	
<i>Impatiens capensis</i>	6	8	7	3					6	6	4	8	8	3	5	6	3		73	40.6	
<i>Onoclea sensibilis</i>	1	9	2								3								15	8.3	
<i>Strophostylus helvola</i>		1																	1	0.6	
<i>Mikania scandens</i>			1	9	9	9	5	5	2	4			1	5	2	3			55	30.6	
<i>Typha angustifolia</i>		6	7	9	10	9	10	10	5	2			1	7	1	3			80	44.4	
<i>Lythrum salicaria</i>		2		3		2	3			1	7				3		4	2	1	28	15.6
<i>Toxicodendron radicans</i>		3	4																7	3.9	
<i>Thelypteris palustris</i>		4	8	10	7										1				30	16.7	
<i>Bohemeria cylindrica</i>					4	3		2	2						1				12	6.7	
<i>Cuscuta gronovii</i>									1				1		1	3	3		9	5.0	
<i>Hibiscus moscheutos</i>							7	6	1										14	7.8	
<i>Parthenocissus quinquefolia</i>							1			1	4	3	1						10	5.6	
<i>Vernonia novaboracensis</i>									1										1	0.6	
<i>Laportea sp.</i>									1										1	0.6	
<i>Aster simplex</i>										1		6	1						8	4.4	
<i>Cornus amomum</i>								2	10	8		6	10	1	10	8	10	8	73	40.6	
<i>Solidago gigantea</i>									2										2	1.1	
<i>Leersia oryzoides</i>										7	6			3	2		2		20	11.1	
<i>Viburnum dentatum</i>										3	10	4	7		1	6	2	3	36	20.0	
<i>Rorippa palustris</i>											1								1	0.6	
<i>Mimulus ringens</i>											1								1	0.6	
<i>Polygonum hydropiper</i>													1	2		1	3		7	3.9	
<i>Cephalanthus occidentalis</i>														6	4				10	5.6	
<i>Sium suave</i>																1			1	0.6	
<i>Eupatoriadelphus maculatus</i>																	1		1	0.6	
<i>Trifolium sp.</i>																			1	0.6	
<i>Peltandra virginiana</i>															2	3	2	4	11	6.1	
	TOTALS																		520	288.9	

Table S: MILL RIVER SOUTH (MR-S) VEGETATION FREQUENCY BY SPECIES AND ZONE, 2003

Vegetation Zone:	Trans.shrub		Upper marsh			Middle marsh			Hummock		Lower marsh		2003	
	1	2	3	4	5	6	7	8	9	10	11	12	Total	%Cover
<i>Lindera benzoin</i>	5												5	4.2
<i>Acer rubrum</i>	4	1											5	4.2
<i>Impatiens capensis</i>	2	1	3	6	8	9	4	3	10	10	10	2	68	56.7
<i>Chelone glabra</i>		3											3	2.5
<i>Polygonum arifolium</i>		4	3	3	4		1						15	12.5
<i>Viburnum dentatum</i>			7	7	1								15	12.5
<i>Cornus amomum</i>	1	8									2		11	9.2
<i>Rosa multiflora</i>		1											1	0.8
<i>Leersia oryzoides</i>		2	1										3	2.5
<i>Typha angustifolia</i>		6	9	5	10	10	10	10	10	10	10		90	75.0
<i>Mikania scandens</i>				2		7	9	8					26	21.7
<i>Lycopus americana</i>				1									1	0.8
<i>Geum lacinatedum</i>				2									2	1.7
<i>Peltandra virginica</i>											5	10	15	12.5
<i>Lythrum salicaria</i>			1	7	2						2	5	17	14.2
<i>Bohemeria cylindrica</i>					1	2	2				3		8	6.7
<i>Solanum dulcamara</i>					1								1	0.8
<i>Epilobium coloratum</i>				1									1	0.8
<i>Polygonum sagittatum</i>					7								7	5.8
<i>Hibiscus moscheutos</i>									4				4	3.3
<i>Acer saccharinum</i> *												10	10	8.3
TOTALS												308	256.7	

* Overhanging canopy of tree rooted on adjacent levee

MR-N Transect - Alphabetical List of Species and Percent Cover
1998* - 2003

Species	1998		2000		2001		2002		2003	
	Total	%Cover	Total	%Cover	Total	%Cover	Total	%Cover	Total	%Cover
<i>Acer rubrum</i> **	0	0.0	15	8.3	11	6.1	0	0.0	0	0.0
<i>Apios americana</i>	0	0.0	3	1.7	4	2.2	0	0.0	0	0.0
<i>Aster simplex</i>	0	0.0	0	0.0	13	7.2	20	11.1	8	4.4
<i>Aster umbellatus</i>	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Bidens connata</i>	6	3.3	0	0.0	1	0.6	0	0.0	0	0.0
<i>Bidens frondosa</i>	0	0.0	0	0.0	6	3.3	0	0.0	2	1.1
<i>Bohemeria cylindrica</i>	15	8.3	9	5.0	19	10.6	10	5.6	12	6.7
<i>Cephalanthus occidentalis</i>	3	1.7	6	3.3	9	5.0	5	2.8	10	5.6
<i>Chelone glabra</i> ***	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Cinna latifolia</i>	6	3.3	0	0.0	0	0.0	2	1.1	0	0.0
<i>Clethra alnifolia</i> **	0	0.0	5	2.8	8	4.4	0	0.0	0	0.0
<i>Cornus amomum</i>	74	41.1	85	47.2	68	37.8	82	45.6	73	40.6
<i>C. amomum</i> SDLG ***	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Cuscuta gronovii</i>	0	0.0	0	0.0	7	3.9	2	1.1	9	5.0
<i>Eupatorium maculatum</i>	4	2.2	1	0.6	1	0.6	3	1.7	1	0.6
<i>Eupatorium perfoliatum</i>	0	0.0	0	0.0	2	1.1	0	0.0	0	0.0
<i>Geum lacinatedum</i>	4	2.2	1	0.6	0	0.0	1	0.6	0	0.0
<i>Helenium autumnale</i>	0	0.0	0	0.0	8	4.4	3	1.7	0	0.0
<i>Hibiscus moscheutos</i>	5	2.8	9	5.0	9	5.0	9	5.0	14	7.8
<i>Ilex verticillata</i> **	0	0.0	4	2.2	4	2.2	0	0.0	0	0.0
<i>Impatiens capensis</i>	25	13.9	42	23.3	77	42.8	81	45.0	73	40.6
<i>Iris pseudacorus</i>	6	3.3	5	2.8	7	3.9	7	3.9	1	0.6
<i>Laportea</i> sp.	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
<i>Leersia oryzoides</i>	4	2.2	6	3.3	21	11.7	16	8.9	20	11.1
<i>Lobelia cardinalis</i>	0	0.0	6	3.3	6	3.3	0	0.0	0	0.0
<i>Lycopus uniflorus</i> ***	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Lythrum salicaria</i>	13	7.2	32	17.8	31	17.2	37	20.6	28	15.6
<i>Mikania scandens</i>	56	31.1	39	21.7	52	28.9	87	48.3	55	30.6
<i>Mimulus ringens</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
<i>Nymphaea odorata</i>	8	4.4	0	0.0	0	0.0	0	0.0	0	0.0
<i>Onoclea sensibilis</i>	4	2.2	13	7.2	13	7.2	10	5.6	15	8.3
<i>Panicum clandestinum</i> ***	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Parthenocissus quinquefolia</i>	11	6.1	13	7.2	12	6.7	0	0.0	10	5.6
<i>Peltandra virginica</i>	4	2.2	6	3.3	7	3.9	5	2.8	11	6.1
<i>Pilea pumila</i>	2	1.1	0	0.0	0	0.0	0	0.0	0	0.0
<i>Polygonum anifolium</i>	3	1.7	6	3.3	5	2.8	1	0.6	4	2.2
<i>Polygonum hydropiper</i>	0	0.0	0	0.0	8	4.4	7	3.9	7	3.9
<i>Polygonum sagittatum</i>	0	0.0	0	0.0	19	10.6	0	0.0	3	1.7
<i>Polygonum scandens</i> ***	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Quercus</i> sp SDLG	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0
<i>Rorippa palustris</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
<i>Rosa multiflora</i>	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Sagittaria rigida</i>	7	3.9	4	2.2	4	2.2	0	0.0	0	0.0
<i>Scutellaria lateriflora</i>	0	0.0	0	0.0	1	0.6	0	0.0	0	0.0
<i>Sium suave</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
<i>Smilax rotundifolia</i> **	0	0.0	5	2.8	6	3.3	0	0.0	0	0.0
<i>Solanum dulcamara</i>	0	0.0	0	0.0	0	0.0	2	1.1	0	0.0
<i>Solidago gigantea</i>	3	1.7	9	5.0	9	5.0	13	7.2	2	1.1
<i>Solidago uliginosa</i>	1	0.6	0	0.0	0	0.0	3	1.7	0	0.0
<i>Strophostyles helvola</i>	2	1.1	0	0.0	15	8.3	0	0.0	1	0.6
<i>Symplocarpus foetidus</i>	0	0.0	1	0.6	1	0.6	0	0.0	0	0.0
<i>Thelypteris palustris</i>	0	0.0	20	11.1	32	17.8	24	13.3	30	16.7
<i>Toxicodendron radicans</i>	4	2.2	0	0.0	4	2.2	10	5.6	7	3.9
<i>Trifolium</i> sp.	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
<i>Typha angustifolia</i>	81	45.0	84	46.7	93	51.7	85	47.2	80	44.4
<i>Verbena hastata</i>	1	0.6	0	0.0	1	0.6	0	0.0	0	0.0
<i>Verbena urticifolia</i>	0	0.0	0	0.0	0	0.0	1	0.6	0	0.0
<i>Vernonia novaboracensis</i>	0	0.0	1	0.6	1	0.6	0	0.0	1	0.6
<i>Viburnum lentago</i>	7	3.9	5	2.8	4	2.2	5	2.8	4	2.2
<i>Viburnum dentatum</i>	28	15.6	32	17.8	46	25.6	36	20.0	36	20.0
<i>Viburnum dentatum</i> SDLG	0	0.0	0	0.0	2	1.1	0	0.0	0	0.0
TOTALS	388	215.6	467	259.4	647	359.4	567	315.0	522	290.0
Number of Species	31		29		40		28		31	

* A slightly different transect in this area was also sampled in 1991; the 1991 results are available in previous reports.

** These species occur in an overhanging canopy and were sampled in 2000 and 2001 only.

*** Occurred in 1991 sample only

MR-N Transect - Summary of Species by Percent Cover
1998* - 2003

Species	1998		2000		2001		2002		2003	
	Total	%Cover	Total	%Cover	Total	%Cover	Total	%Cover	Total	%Cover
<i>Typha angustifolia</i>	81	45.0	84	46.7	93	51.7	85	47.2	80	44.4
<i>Cornus amomum</i>	74	41.1	85	47.2	68	37.8	82	45.6	73	40.6
<i>Impatiens capensis</i>	25	13.9	42	23.3	77	42.8	81	45.0	73	40.6
<i>Mikania scandens</i>	56	31.1	39	21.7	52	28.9	87	48.3	55	30.6
<i>Viburnum dentatum</i>	28	15.6	32	17.8	46	25.6	36	20.0	36	20.0
<i>Thelypteris paulustris</i>	0	0.0	20	11.1	32	17.8	24	13.3	30	16.7
<i>Lythrum salicaria</i>	13	7.2	32	17.8	31	17.2	37	20.6	28	15.6
<i>Leersia oryzoides</i>	4	2.2	6	3.3	21	11.7	16	8.9	20	11.1
<i>Onoclea sensibilis</i>	4	2.2	13	7.2	13	7.2	10	5.6	15	8.3
<i>Hibiscus moscheutos</i>	5	2.8	9	5.0	9	5.0	9	5.0	14	7.8
<i>Bohemeria cylindrica</i>	15	8.3	9	5.0	19	10.6	10	5.6	12	6.7
<i>Peltandra virginica</i>	4	2.2	6	3.3	7	3.9	5	2.8	11	6.1
<i>Cephalanthus occidentalis</i>	3	1.7	6	3.3	9	5.0	5	2.8	10	5.6
<i>Parthenocissus quinquefolia</i>	11	6.1	13	7.2	12	6.7	0	0.0	10	5.6
<i>Cuscuta granovii</i>	0	0.0	0	0.0	7	3.9	2	1.1	9	5.0
<i>Aster simplex</i>	0	0.0	0	0.0	13	7.2	20	11.1	8	4.4
<i>Polygonum hydropiper</i>	0	0.0	0	0.0	8	4.4	7	3.9	7	3.9
<i>Todxocodendron radicans</i>	4	2.2	0	0.0	4	2.2	10	5.6	7	3.9
<i>Polygonum arifolium</i>	3	1.7	6	3.3	5	2.8	1	0.6	4	2.2
<i>Viburnum lentago</i>	7	3.9	5	2.8	4	2.2	5	2.8	4	2.2
<i>Polygonum sagittatum</i>	0	0.0	0	0.0	19	10.6	0	0.0	3	1.7
<i>Bidens frondosa</i>	0	0.0	0	0.0	6	3.3	0	0.0	2	1.1
<i>Solidago gigantea</i>	3	1.7	9	5.0	9	5.0	13	7.2	2	1.1
<i>Eupatorium maculatum</i>	4	2.2	1	0.6	1	0.6	3	1.7	1	0.6
<i>Iris pseudacorus</i>	6	3.3	5	2.8	7	3.9	7	3.9	1	0.6
<i>Laportea sp.</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
<i>Mimulus ringens</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
<i>Rorippa palustris</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
<i>Sium suave</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
<i>Strophostylus helvola</i>	2	1.1	0	0.0	15	8.3	0	0.0	1	0.6
<i>Trifolium sp.</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
<i>Vernonia novaboracensis</i>	0	0.0	1	0.6	1	0.6	0	0.0	1	0.6
<i>Acer rubrum</i> **	0	0.0	15	8.3	11	6.1	0	0.0	0	0.0
<i>Apios americana</i>	0	0.0	3	1.7	4	2.2	0	0.0	0	0.0
<i>Aster umbellatus</i>	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Bidens connata</i>	6	3.3	0	0.0	1	0.6	0	0.0	0	0.0
<i>C. amomum</i> SDLG ***	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Chelone glabra</i> ***	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Cinna latifolia</i>	6	3.3	0	0.0	0	0.0	2	1.1	0	0.0
<i>Clethra alnifolia</i> **	0	0.0	5	2.8	8	4.4	0	0.0	0	0.0
<i>Eupatorium perfoliatum</i>	0	0.0	0	0.0	2	1.1	0	0.0	0	0.0
<i>Geum lacinatedum</i>	4	2.2	1	0.6	0	0.0	1	0.6	0	0.0
<i>Helenium autumnale</i>	0	0.0	0	0.0	8	4.4	3	1.7	0	0.0
<i>Ilex verticillata</i> **	0	0.0	4	2.2	4	2.2	0	0.0	0	0.0
<i>Lobelia cardinalis</i>	0	0.0	6	3.3	6	3.3	0	0.0	0	0.0
<i>Lycopus uniflorus</i> ***	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Nymphaea odorata</i>	8	4.4	0	0.0	0	0.0	0	0.0	0	0.0
<i>Panicum clandestinum</i> ***	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Pilea pumila</i>	2	1.1	0	0.0	0	0.0	0	0.0	0	0.0
<i>Polygonum scandens</i> ***	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Quercus sp</i> SDLG	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0
<i>Rosa multiflora</i>	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<i>Sagittaria rigida</i>	7	3.9	4	2.2	4	2.2	0	0.0	0	0.0
<i>Scutellaria lateriflora</i>	0	0.0	0	0.0	1	0.6	0	0.0	0	0.0
<i>Smilax rotundifolia</i> **	0	0.0	5	2.8	6	3.3	0	0.0	0	0.0
<i>Solanum dulcamara</i>	0	0.0	0	0.0	0	0.0	2	1.1	0	0.0
<i>Solidago uliginosa</i>	1	0.6	0	0.0	0	0.0	3	1.7	0	0.0
<i>Symplocarpus foetidus</i>	0	0.0	1	0.6	1	0.6	0	0.0	0	0.0
<i>Verbena hastata</i>	1	0.6	0	0.0	1	0.6	0	0.0	0	0.0
<i>Verbena urticifolia</i>	0	0.0	0	0.0	0	0.0	1	0.6	0	0.0
<i>Viburnum dentatum</i> SDLG	0	0.0	0	0.0	2	1.1	0	0.0	0	0.0
TOTALS	388	215.6	467	259.4	647	359.4	567	315.0	522	290.0
Number of Species	31		29		40		28		31	

* A slightly different transect in this area was also sampled in 1991; the 1991 results are available in previous reports.

** These species occur in an overhanging canopy and were sampled in 2000 and 2001 only.

*** Occurred in 1991 sample only

MR-S Transect - Alphabetical List of Species and Percent Cover
1998 - 2003

Species	1998		2000		2001		2002		2003	
	Total	%Cover	Total	%Cover	Total	%Cover	Total	%Cover	Total	%Cover
<i>Acer rubrum</i>	0	0.0	0	0.0	4	3.3	4	3.3	5	4.2
<i>Acer saccharinum</i> *	10	8.3	10	8.3	10	8.3	10	8.3	10	8.3
<i>Apios americana</i>	0	0.0	1	0.8	1	0.8	0	0.0	0	0.0
<i>Aster umbellatus</i>	0	0.0	0	0.0	0	0.0	1	0.8	0	0.0
<i>Bidens frondosa</i>	0	0.0	0	0.0	3	2.5	0	0.0	0	0.0
<i>Bohemeria cylindrica</i>	2	1.7	7	5.8	7	5.8	7	5.8	8	6.7
<i>Carex crinata</i>	0	0.0	0	0.0	0	0.0	1	0.8	0	0.0
<i>Chelone glabra</i>	0	0.0	0	0.0	2	1.7	1	0.8	3	2.5
<i>Cinna latifolia</i>	3	2.5	0	0.0	2	1.7	0	0.0	0	0.0
<i>Cornus amomum</i>	7	5.8	10	8.3	10	8.3	6	5.0	11	9.2
<i>Cornus amomum</i> SDLG	0	0.0	1	0.8	1	0.8	2	1.7	0	0.0
<i>Cuscuta gronovii</i>	4	3.3	0	0.0	10	8.3	5	4.2	0	0.0
<i>Epilobium coloratum</i>	0	0.0	1	0.8	0	0.0	2	1.7	1	0.8
<i>Geum laciniatum</i>	1	0.8	0	0.0	0	0.0	0	0.0	2	1.7
<i>Helenium autumnale</i>	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0
<i>Hibiscus moscheutos</i>	3	2.5	5	4.2	5	4.2	6	5.0	4	3.3
<i>Impatiens capensis</i>	39	32.5	51	42.5	51	42.5	83	69.2	68	56.7
<i>Leersia oryzoides</i>	4	3.3	10	8.3	3	2.5	1	0.8	3	2.5
<i>Lindera benzoin</i>	7	5.8	9	7.5	5	4.2	5	4.2	5	4.2
<i>Lobelia cardinalis</i>	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0
<i>Lonicera morowii</i>	0	0.0	0	0.0	0	0.0	4	3.3	0	0.0
<i>Lycopus americana</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.8
<i>Lythrum salicaria</i>	1	0.8	8	6.7	19	15.8	13	10.8	17	14.2
<i>Mentha arvensis</i>	2	1.7	0	0.0	0	0.0	0	0.0	0	0.0
<i>Mikania scandens</i>	78	65.0	43	35.8	34	28.3	38	31.7	26	21.7
<i>Onoclea sensibilis</i>	1	0.8	2	1.7	6	5.0	0	0.0	0	0.0
<i>Parthenocissus quinquefolia</i>	2	1.7	0	0.0	0	0.0	0	0.0	0	0.0
<i>Peltandra virginica</i>	2	1.7	13	10.8	10	8.3	10	8.3	15	12.5
<i>Polygonum arifolium</i>	11	9.2	0	0.0	10	8.3	0	0.0	15	12.5
<i>Polygonum sagittatum</i>	0	0.0	5	4.2	3	2.5	3	2.5	7	5.8
<i>Rosa multiflora</i>	2	1.7	5	4.2	1	0.8	5	4.2	1	0.8
<i>Sambucus canadensis</i>	1	0.8	0	0.0	1	0.8	0	0.0	0	0.0
<i>Solanum dulcamara</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.8
<i>Solidago uliginosa</i>	2	1.7	0	0.0	0	0.0	0	0.0	0	0.0
<i>Strophostylus helvola</i>	2	1.7	1	0.8	0	0.0	1	0.8	0	0.0
<i>Symplocarpus foetidus</i>	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0
<i>Toxicodendron radicans</i>	0	0.0	0	0.0	0	0.0	2	1.7	0	0.0
<i>Typha angustifolia</i>	80	66.7	94	78.3	96	80.0	98	81.7	90	75.0
<i>Vernonia novaboracensis</i>	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0
<i>Viburnum dentatum</i>	10	8.3	17	14.2	12	10.0	14	11.7	15	12.5
<i>V. dentatum</i> SDLG	0	0.0	0	0.0	0	0.0	2	1.7	0	0.0
TOTALS	274	228.3	293	244.2	310	258.3	324	270.0	308	256.7
Number of Species	23		17		27		23		21	

* Overhanging branches of tree rooted on adjacent levee

MR-S Transect - Summary of Species by Percent Cover in 2003
1998 - 2003

Species	1998		2000		2001		2002		2003	
	Total	%Cover	Total	%Cover	Total	%Cover	Total	%Cover	Total	%Cover
<i>Typha angustifolia</i>	80	66.7	94	78.3	96	80.0	98	81.7	90	75.0
<i>Impatiens capensis</i>	39	32.5	51	42.5	51	42.5	83	69.2	68	56.7
<i>Mikania scandens</i>	78	65.0	43	35.8	34	28.3	38	31.7	26	21.7
<i>Lythrum salicaria</i>	1	0.8	8	6.7	19	15.8	13	10.8	17	14.2
<i>Peltandra virginica</i>	2	1.7	13	10.8	10	8.3	10	8.3	15	12.5
<i>Polygonum arifolium</i>	11	9.2	0	0.0	10	8.3	0	0.0	15	12.5
<i>Viburnum dentatum</i>	10	8.3	17	14.2	12	10.0	14	11.7	15	12.5
<i>Cornus amomum</i>	7	5.8	10	8.3	10	8.3	6	5.0	11	9.2
<i>Acer saccharinum</i> *	10	8.3	10	8.3	10	8.3	10	8.3	10	8.3
<i>Bohemeria cylindrica</i>	2	1.7	7	5.8	7	5.8	7	5.8	8	6.7
<i>Polygonum sagittatum</i>	0	0.0	5	4.2	3	2.5	3	2.5	7	5.8
<i>Acer rubrum</i>	0	0.0	0	0.0	4	3.3	4	3.3	5	4.2
<i>Lindera benzoin</i>	7	5.8	9	7.5	5	4.2	5	4.2	5	4.2
<i>Hibiscus moscheutos</i>	3	2.5	5	4.2	5	4.2	6	5.0	4	3.3
<i>Chelone glabra</i>	0	0.0	0	0.0	2	1.7	1	0.8	3	2.5
<i>Leersia oryzoides</i>	4	3.3	10	8.3	3	2.5	1	0.8	3	2.5
<i>Geum lacinatedum</i>	1	0.8	0	0.0	0	0.0	0	0.0	2	1.7
<i>Epilobium coloratum</i>	0	0.0	1	0.8	0	0.0	2	1.7	1	0.8
<i>Lycopus americana</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.8
<i>Rosa multiflora</i>	2	1.7	5	4.2	1	0.8	5	4.2	1	0.8
<i>Solanum dulcamara</i>	0	0.0	0	0.0	0	0.0	0	0.0	1	0.8
<i>Apios americana</i>	0	0.0	1	0.8	1	0.8	0	0.0	0	0.0
<i>Aster umbellatus</i>	0	0.0	0	0.0	0	0.0	1	0.8	0	0.0
<i>Bidens frondosa</i>	0	0.0	0	0.0	3	2.5	0	0.0	0	0.0
<i>Carex crinata</i>	0	0.0	0	0.0	0	0.0	1	0.8	0	0.0
<i>Cinna latifolia</i>	3	2.5	0	0.0	2	1.7	0	0.0	0	0.0
<i>Cornus amomum</i> SDLG	0	0.0	1	0.8	1	0.8	2	1.7	0	0.0
<i>Cuscuta gronovii</i>	4	3.3	0	0.0	10	8.3	5	4.2	0	0.0
<i>Helenium autumnale</i>	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0
<i>Lobelia cardinalis</i>	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0
<i>Lonicera morowii</i>	0	0.0	0	0.0	0	0.0	4	3.3	0	0.0
<i>Mentha arvensis</i>	2	1.7	0	0.0	0	0.0	0	0.0	0	0.0
<i>Onoclea sensibilis</i>	1	0.8	2	1.7	6	5.0	0	0.0	0	0.0
<i>Parthenocissus quinquefolia</i>	2	1.7	0	0.0	0	0.0	0	0.0	0	0.0
<i>Sambucus canadensis</i>	1	0.8	0	0.0	1	0.8	0	0.0	0	0.0
<i>Solidago uliginosa</i>	2	1.7	0	0.0	0	0.0	0	0.0	0	0.0
<i>Strophostylus helvola</i>	2	1.7	1	0.8	0	0.0	1	0.8	0	0.0
<i>Symplocarpus foetidus</i>	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0
<i>Toxicodendron radicans</i>	0	0.0	0	0.0	0	0.0	2	1.7	0	0.0
<i>Vernonia novaboracensis</i>	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0
<i>V. dentatum</i> SDLG	0	0.0	0	0.0	0	0.0	2	1.7	0	0.0
TOTALS	274	228.3	293	244.2	310	258.3	324	270.0	308	256.7
Number of Species	23		17		27		23		21	

* Overhanging branches of tree rooted on adjacent levee