THE GREAT EGG HARBOR RIVER WATERSHED MANAGEMENT AREA

A REPORT TO THE PINELANDS COMMISSION ON THE STATUS OF SELECTED AQUATIC AND WETLAND RESOURCES

Pinelands Commission
Long-term Environmental Monitoring Program
2005

Cover image is a 2002 color-infrared aerial photograph (by Keystone Aerial Surveys for NJDEP) showing developed, agricultural, and forested land within a portion of the Hospitality Brook drainage of the Great Egg Harbor River Watershed Management Area.

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BY ROBERT A. ZAMPELLA, JOHN F. BUNNELL,
KIM J. LAIDIG, AND NICHOLAS A. PROCOPIO

2005

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Long-term Environmental-monitoring Program
Pinelands Commission
P.O. Box 7
New Lisbon, NJ 08064

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Several land owners gave permission to access their property for biological surveys. The New Jersey Division of Parks and Forestry and the New Jersey Division of Fish and Wildlife authorized access to state lands. The Division of Fish and Wildlife provided the necessary fish and amphibian collection permits.

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INTRODUCTION

This report on the Pinelands National Reserve portion of the Great Egg Harbor River Watershed Management Area (WMA), which includes the Great Egg Harbor River, Tuckahoe River, Absecon Creek, and Patcong Creek basins (Figure 1), is the third watershed assessment completed by the Pinelands Commission as part of a long-term environmental-monitoring program initiated in 1990. A study of the Mullica River Basin, which was the initial focus of the monitoring program, demonstrated that changes in the composition of stream vegetation, fish assemblages, and anuran (frog and toad) assemblages were associated with increasing land-use intensity and water-quality degradation (Zampella et al. 2001). The presence of nonnative plants (disturbance indicators), fish, and anuran species characterized impacted stream sites.

Based on the results of the Mullica River Basin study, less intense biological-sampling protocols were used to conduct an assessment of the Rancocas Creek Basin (Zampella et al. 2003). Nonnative species, pH, and specific conductance were selected as the primary ecological indicators used to assess the status of surface waters in the Rancocas Creek Basin. Rather than completing multiple visits to 100-m stream reaches to inventory fish and vegetation as was done in the Mullica River Basin, Commission scientists targeted disturbance-indicator plants and nonnative fish in 20-m stream reaches located at road crossings. By targeting the late-breeding bullfrog, a nonnative species that was generally found at degraded Mullica River Basin sites, anuran-vocalization surveys were limited to the latter part of the anuran-breeding period.

The Rancocas Creek Basin sampling sites were co-located with New Jersey Department of Environmental Protection (NJDEP) ambient-biomonitoring-network (AMNET) sites. The NJDEP operates the AMNET program throughout the state. Benthic macroinvertebrate (aquatic insects and other macroscopic aquatic invertebrates) data collected through this program are used in the development of a federally required water-quality inventory and other watershed-based regulatory and planning programs.

In 2002, Commission scientists surveyed the streams in the Great Egg Harbor River WMA using the same ecological indicators, sampling protocols, and sampling-network strategy used in the Rancocas Creek Basin. The purpose of this report is to present the results of these surveys.

All water-quality and biological data collected during the study are included in appendices to this report. Chapter 1 describes the landscape of the Great Egg Harbor River WMA. Chapter 2 characterizes the status of the region's surface waters and relates water quality to land-use patterns. In Chapters 3 through 5, the composition of stream vegetation, fish assemblages, and anuran assemblages is described in relation to site-specific and regional drainage-basin characteristics.

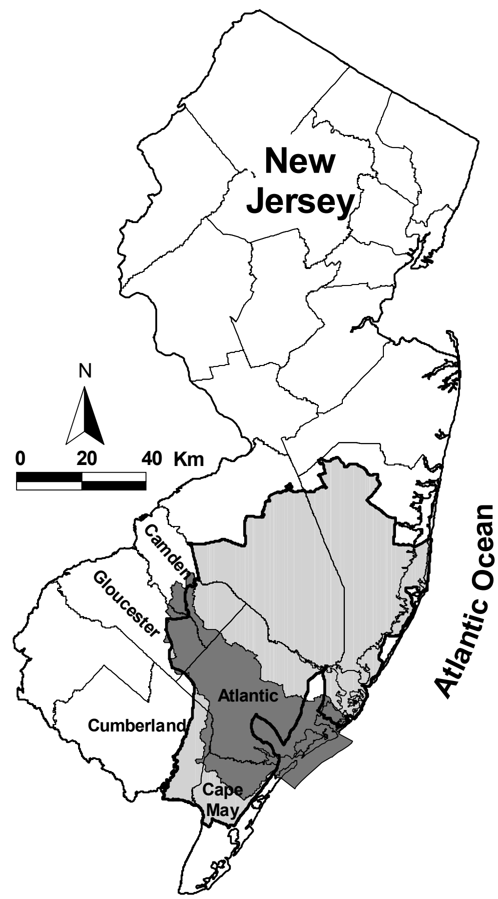

Figure 1. Regional location of the Great Egg Harbor River WMA (dark shading) in the Pinelands National Reserve (light shading).

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Zampella, R. A., J. F. Bunnell, K. J. Laidig, and N. A. Procopio. 2003. The Rancocas Creek Basin: A report to the Pinelands Commission on the status of selected aquatic and wetland resources. Pinelands Commission, New Lisbon, New Jersey, USA.

1 The Great Egg Harbor River Watershed Management Area Study Area

Introduction

Seventy-three percent of the 1,624 km^2 Great Egg Harbor River Watershed Management Area (WMA) lies within the Pinelands National Reserve (PNR). The PNR portion of the watershed drains 22 municipalities in Atlantic, Camden, Cape May, Cumberland, and Gloucester Counties (Figure 1.1). The Cohansey Sand underlies the entire study area (Figure 1.2). The Bridgeton Formation and Cape May Formation form a veneer over portions of the Cohansey, covering 11% and 29% of the study area, respectively.

In this report, the PNR portion of the Great Egg Harbor River WMA is divided into six study basins, including the Hospitality Branch, Upper Great Egg Harbor River, Middle Great Egg Harbor River, Lower Great Egg Harbor River, Atlantic Drainage basins (Absecon Creek and Patcong Creek), and Tuckahoe River (Figure 1.3). The land-use characteristics of each study basin and the management areas designated through the Pinelands Comprehensive Management Plan are summarized in this chapter.

Development of Land-use, Geologic, and Management-area Profiles

Drainage-basin Delineations

Drainage-basin boundaries used throughout this report were obtained from the New Jersey Department of Environmental Protection (NJDEP 1996) digital-hydrography data. Because basin boundaries were not available for some monitoring sites, drainage basins for these sites were delineated using digital-topographic maps, ArcView software, and on-screen digitizing.

Land-use Profiles

Land-use profiles were prepared for each monitoring site by summing the area of major land-use/land-cover classes (NJDEP, 1995/97 Land Use/Land Cover Update 2001) for the drainage area upstream from the site. The NJDEP data set describes land-use using both the general Anderson Level I classification and various subclasses (Anderson et al. 1976). Wetlands are classified according to Cowardin et al. (1979). The general classes include urban, agriculture, barren land, forest, wetlands, and water. A revised Pinelands terminology is used throughout this report (Table 1.1). Pinelands land-use types are developed land, upland agriculture (including orchards), wetland agriculture, barren land, upland forest, wetlands, and water. In this report, the combined area of upland forest, wetlands, and water is described as forest land. Upland agriculture and developed land are referred to as altered land.

Pinelands Management Areas

The Commission's regional-planning and land-allocation program divides the PNR into several management areas within which land uses of varying intensities are permitted (Pinelands Commission 1980, Collins and Russell 1988). In order of increasing permitted-development intensity, management areas in the Great Egg Harbor River WMA include the Forest Area, Agricultural Production Area, Rural Development Area, Pinelands Village, Pinelands Town, and Regional Growth Area (Figure 1.4).

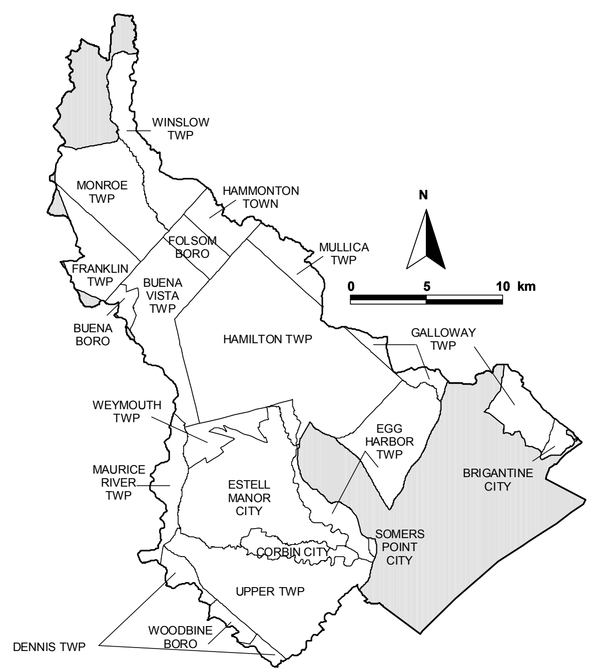

Figure 1.1. Municipalities in the Great Egg Harbor River WMA. Shaded areas are outside the Pinelands National Reserve. Berlin Township and Berlin Borough are not shown.

Table 1.1. New Jersey Department of Environmental Protection land-use/land-cover classes and the revised Pinelands terminology.

Pinelands classes	NJDEP classes	Code	Subclasses (NJDEP 95 Label)
Developed land	Urban	1110	Residential, high density, multiple dwelling
		1120	Residential, single unit, medium density
		1130	Residential, single unit, low density
		1140	Residential, rural, single unit
		1150	Mixed residential
		1200	Commercial/services
		1211	Military reservations
		1300	Industrial
		1400	Transportation/communications/utilities
		1600	Mixed urban or built-up land
		1700	Other urban or built-up land
		1800	Recreational land
		1804	Athletic fields (schools)
Upland agriculture	Agriculture	2100	Cropland and pastureland
		2300	Confined feeding operations
		2400	Other agriculture
		2200	Orchards/vineyards/nurseries/horticultural areas
Wetland agriculture	Wetlands	2140	Agricultural wetlands (modified)
Barren land	Barren land	7100	Beaches
		7300	Extractive mining
		7400	Altered lands
		7500	Transitional areas
		7600	Undifferentiated barren lands
Upland forest	Forest	4110	Deciduous forest (10-50% crown closure)
		4120	Deciduous forest (>50% crown closure)
		4210	Coniferous forest (10-50% crown closure)
		4220	Coniferous forest (>50% crown closure)
		4230	Plantation
		4311	Mixed forest (>50% coniferous with 10%-50% crown closure)
		4312	Mixed forest (>50% coniferous with >50% crown closure)
		4321	Mixed forest (>50% deciduous with 10-50% crown closure)
		4322	Mixed forest (>50% deciduous with >50% crown closure)
		4410	Old field (< 25% brush covered)
		4420	Deciduous brush/shrubland
		4430	Coniferous brush/shrubland
		4440	Mixed deciduous/coniferous brush/shrubland
		4500	Severe burned upland vegetation
Water	Water	5100	Streams and canals
		5200	Natural lakes
		5300	Artificial lakes
		5410	Tidal rivers, inland bays, and other tidal waters
		5420	Dredged lagoon
		5430	Atlantic ocean
Wetlands	Wetlands	1461	Wetland rights-of-way (modified)
		1750	Managed wetland in maintained lawn greenspace
		1850	Managed wetland in built-up maintained rec area
		2150	Former agricultural wetland (becoming shrubby, not built-up)
		6210	Deciduous wooded wetlands
		6220	Coniferous wooded wetlands
		6221	Atlantic white cedar swamp
		6231	Deciduous scrub/shrub wetlands
		6232	Coniferous scrub/shrub wetlands
		6233	Mixed scrub/shrub wetlands (deciduous dom.)
		6234	Mixed scrub/shrub wetlands (coniferous dom.)
		6240	Herbaceous wetlands
		6251	Mixed forested wetlands (deciduous dom.)
		6252	Mixed forested wetlands (coniferous dom.)
		6500	Severe burned wetlands
		7430	Disturbed wetlands (modified)
		6110	Saline marshes
		6120	Freshwater tidal marshes
		6130	Vegetated dune communities

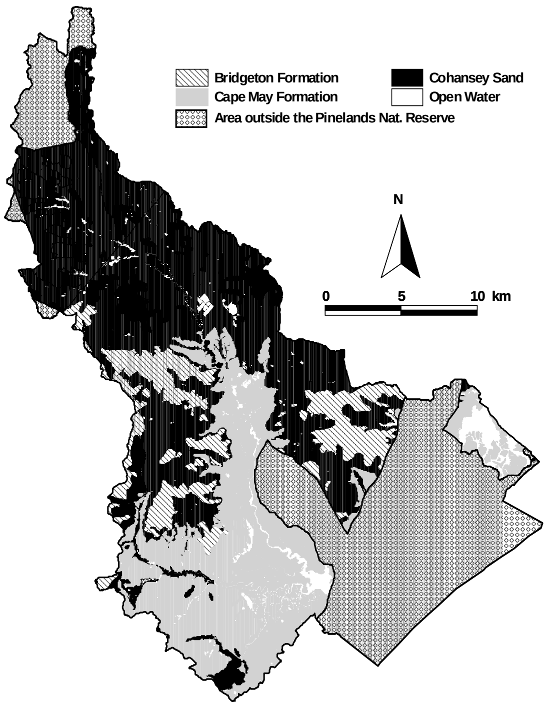

Figure 1.2. Surficial geology of the Pinelands National Reserve portion of the Great Egg Harbor River WMA.

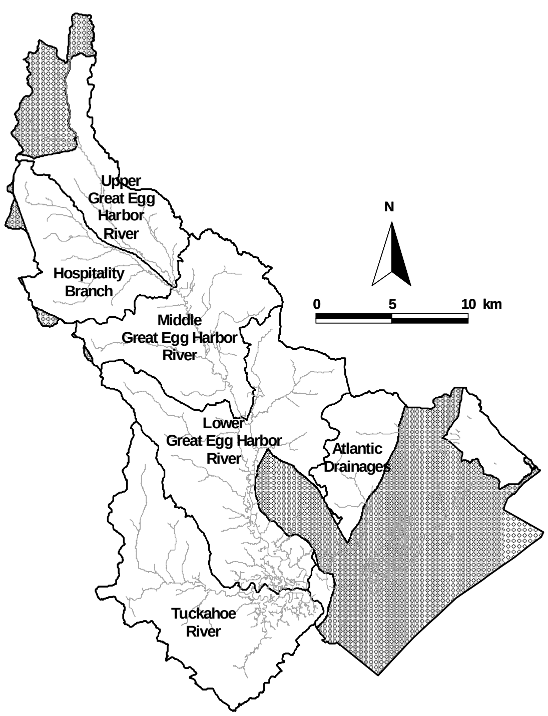

Figure 1.3. Six study basins in the Great Egg Harbor River WMA. Shaded areas are outside the Pinelands National Reserve.

Military and Federal Installation Area is also present in the Great Egg Harbor River WMA. The Preservation Area District and the associated Special Agricultural Production Area (blueberry and cranberry agriculture) are not found in the study area. Management-area profiles were prepared for each study basin using ArcView software and a management-area coverage (Pinelands Commission, Land Capability Map, November 1999).

THE GREAT EGG HARBOR RIVER WATERSHED MANAGEMENT AREA

Eighty-one percent of the PNR portion of the Great Egg Harbor River WMA is undeveloped forest land, including upland forest, wetlands, and water (Figures 1.5 and 1.6). Developed land and upland agriculture cover 11% and 6.4% of the area, respectively. About one percent is barren land. Less than one percent is wetland agriculture.

Fifty-six percent of the Great Egg Harbor River WMA is Forest Area (Figures 1.4 and 1.7). Agricultural Production Areas cover 6.7% of the area. Twelve percent is designated Regional Growth Area and 18.2% is classified as Rural Development Area. Pinelands Villages and Pinelands Towns represent a relatively small percentage of the basin area. The only Military and Federal Installation Area, the Naval Aviation Facilities Experimental Center (NAFEC) is located in the Atlantic Drainage portion of the study area.

Tuckahoe River

The 265-km^2 Tuckahoe River study basin lies entirely within the PNR within Atlantic, Cape May, and Cumberland Counties. The study basin comprises the Tuckahoe River and four tributaries, including Tarkiln Brook, McNeals Branch, Warners Mill Stream, and Mill Creek. Forest land, which covers 87.3% of the study area, dominates the basin (Figures 1.5 and 1.6). The predominance of forest land is reflected in the classification of 83.2% of the basin as Forest Area (Figures 1.4 and 1.7).

Lower Great Egg Harbor River

The 322-km^2 Lower Great Egg Harbor River study basin lies almost entirely within the PNR in Atlantic County. This study basin includes the Jack Pudding Branch, Babcock Creek, Watering Race Branch, Gravelly Run, Miry Run, South River, Cedar Brook,

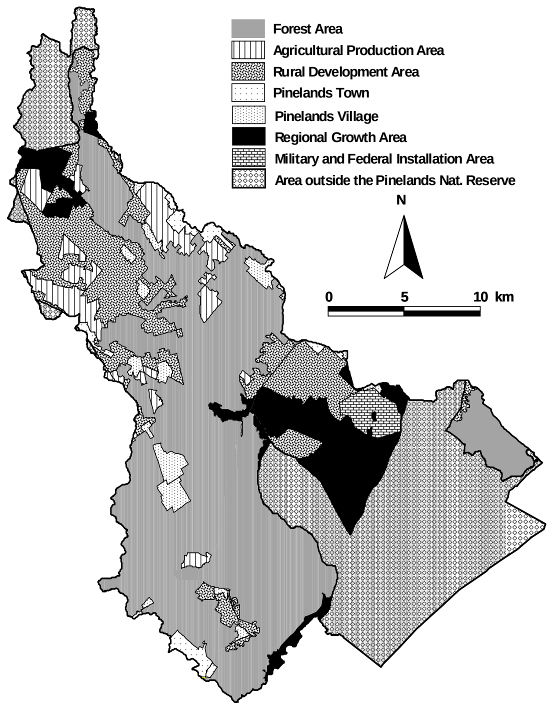

Figure 1.4. Pinelands management areas in the Great Egg Harbor River WMA.

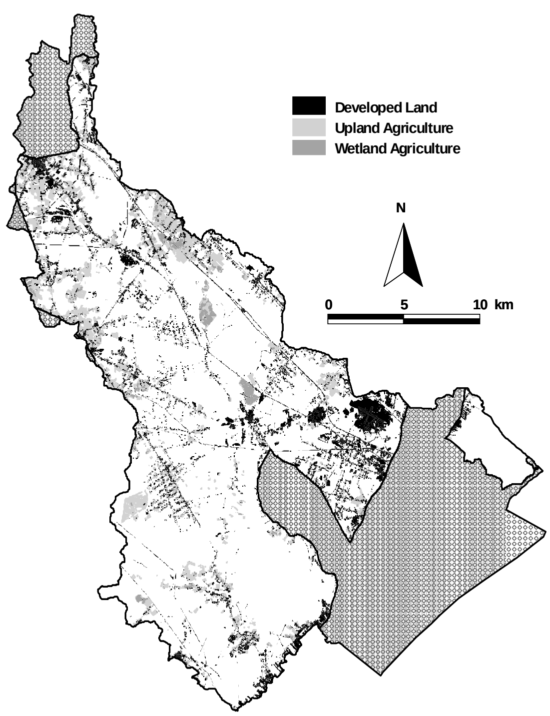

Figure 1.5. Developed land, upland agriculture, and wetland agriculture in the Pinelands National Reserve portion of the Great Egg Harbor River WMA. Unshaded areas represent forest lands (uplands, wetlands, and water) and barren lands.

Stephen Creek, and Gibson Creek. More than 85% of this study basin is forest land (Figures 1.5 and 1.6). Although a majority of the basin is designated as Forest Area, a relatively large percentage is classified as Regional Growth Area or Rural Development Area (Figures 1.4 and 1.7).

Middle Great Egg Harbor River

The Middle Great Egg Harbor River study basin is located in the central portion of the Great Egg Harbor River WMA and lies entirely within Atlantic County. This 204-km^2 study basin includes the main stem of the Great Egg Harbor River, Deep Run, Mare Run, and Makepeace Stream. With 83.6% of the area composed of forest land, the land use profile of the Middle Great Egg Harbor River study basin is similar to that of the Lower Great Egg Harbor River basin (Figures 1.5 and 1.6). Upland agriculture and developed land are concentrated in the Deep Run drainage, especially in the headwater areas. Both Mare Run and Makepeace Stream are relatively unaltered. More than two thirds of the area is designated as Forest Area, which reflects the higher percentage of forest land in the study basin (Figures 1.4 and 1.7).

Atlantic Drainages

The Atlantic Drainage study basin includes Absecon Creek and two tributaries of Patcong Creek. This 133-km^2 study basin drains portions of Atlantic County and a small area of Cape May County. Developed land is the dominant altered-land use, covering 24% of the study basin (Figures 1.5 and 1.6). A large portion of the developed-land area is associated with the NAFEC and the Atlantic City International Airport. The area classified as upland agriculture is negligible. Forest land covers 73.3% of the area. Forty-four percent of this study basin is designated as Regional Growth Area. Military and Federal Installation Area represents an additional 16.1% of the basin (Figures 1.4 and 1.7).

Hospitality Branch

The 134-km^2 Hospitality Branch study basin drains parts of Atlantic and Gloucester Counties. All but a small portion of the area lies within the PNR. The basin comprises several tributaries, including the Hospitality Branch, Faraway Branch, Marsh Lake Branch, Three Pond Branch, White Oak Branch, and Whitehall Branch. The Hospitality Branch basin is

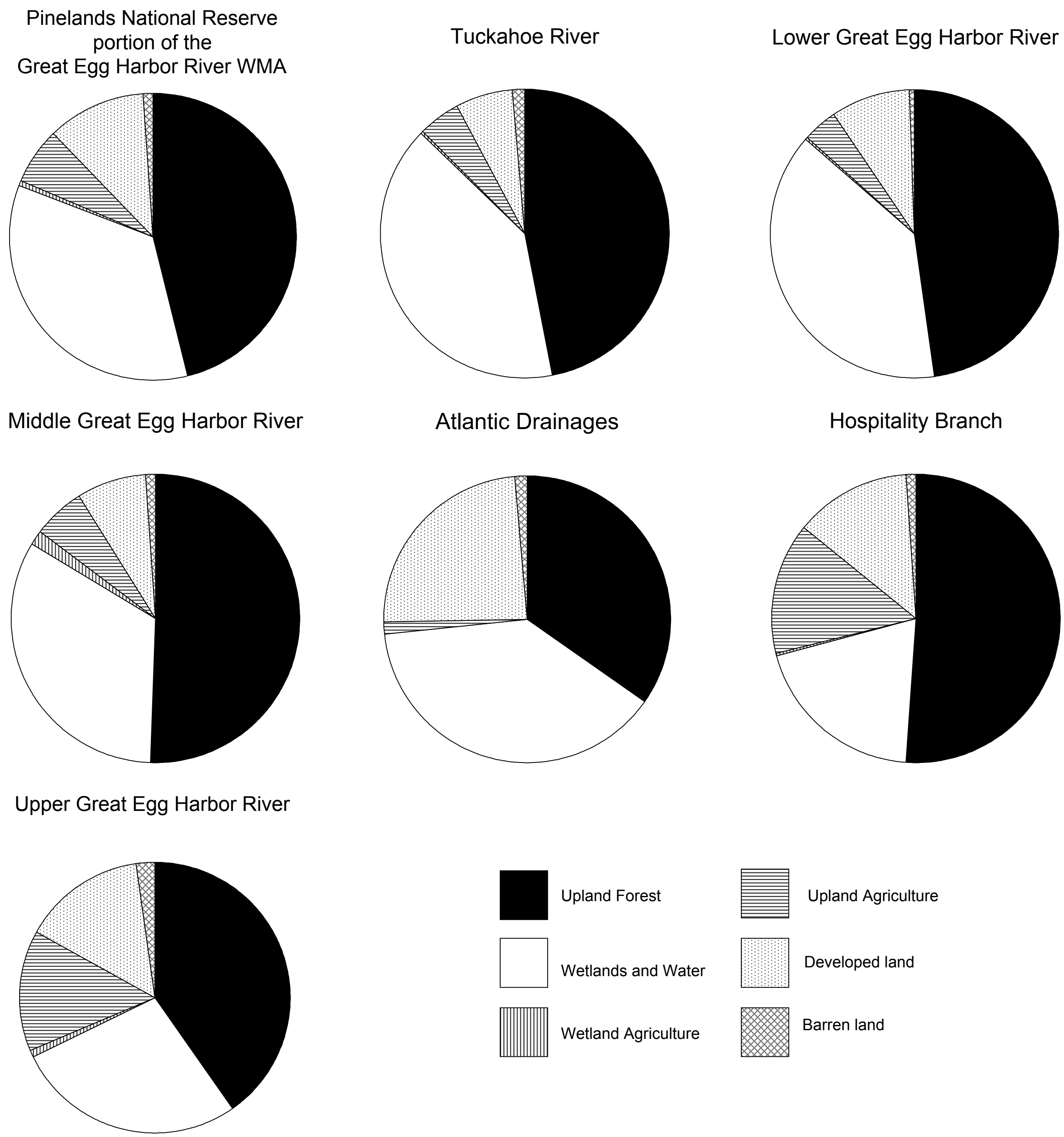

Figure 1.6. Land-use profiles for the Pinelands National Reserve portion of the Great Egg Harbor River WMA. Refer to Table 1.1 for descriptions of each land-use/land-cover class.

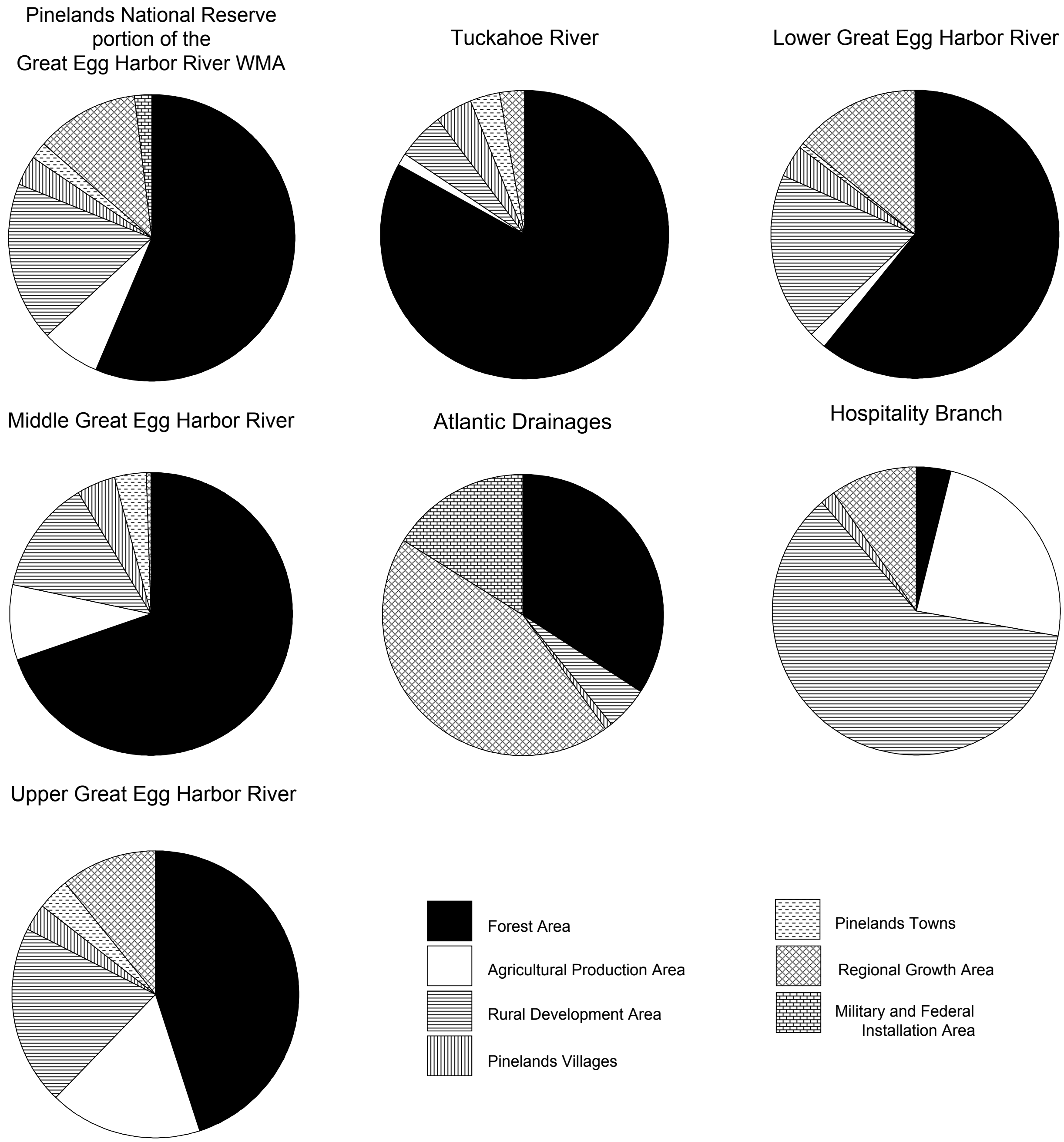

Figure 1.7. Management-area profiles for the Pinelands National Reserve portion of the Great Egg Harbor River WMA.

highly altered. Although 70.9% of the basin is forest land, 12.9% is developed and 14.7% is upland agriculture (Figures 1.5 and 1.6). Faraway Branch, Three Pond Branch, and White Oak Branch are among the least disturbed drainages in this study basin. More than 95% of the Hospitality Branch study basin is designated for development or agriculture, with Rural Development as the dominant Pinelands management area (Figures 1.4 and 1.7).

Upper Great Egg Harbor River

The 123-km^2 Upper Great Egg Harbor River study basin drains portions of Atlantic, Camden, and Gloucester Counties and includes the Great Egg Harbor River, Fourmile Branch, Squankum Branch, and Penny Pot Stream. The headwaters of the Great Egg Harbor River and the Fourmile Branch originate outside the Pinelands National Rerseve.

About two-thirds of the study basin is forest land. With more than a quarter of its area delineated as developed land and upland agriculture, this drainage is one of the most heavily altered of the six study basins (Figures 1.5 and 1.6). Squankum Branch is a highly urbanized watershed, whereas upland agriculture dominates the Penny Pot Stream basin. The Upper Great Egg Harbor River study basin contains all Pinelands management areas except Military and Federal Installation Areas (Figures 1.4 and 1.7).

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2 Water Quality

Introduction

Throughout the Pinelands, variations in stream-water quality are associated with the extent of land-use disturbance in a watershed (Morgan and Good 1988, Zampella 1994, Dow and Zampella 2000, Zampella et al. 2001, Zampella et al. 2003). Pinelands stream sites with extensive, upstream development and upland agriculture (altered land) tend to display higher pH and specific conductance values and higher concentrations of dissolved solids than those in basins with little altered land. Elevated pH in degraded streams appears to be related to enhanced primary productivity associated with nutrient enrichment (Morgan 1985) and increases in alkalinity. In most Pinelands waters, specific conductance, which is a measure of the ability of water to conduct an electrical current, is influenced by the presence of calcium, magnesium, sodium, potassium, chloride, and sulfate ions. The contribution of hydrogen ions to specific conductance becomes important at low pH values (Dow and Zampella 2000, Zampella et al. 2001).

In the Pinelands, water-quality degradation, represented by changes in pH and specific conductance, has ecological consequences. Variations in pH and specific conductance are associated with variations in other water-quality parameters, such as increased nutrient and ion concentrations (Zampella 1994, Zampella et al. 2001), and changes in the composition of biological communities (Morgan and Philipp 1986, Zampella and Laidig 1997, Zampella and Bunnell 1998, Zampella and Bunnell 2000, Zampella et al. 2001, Zampella et al. 2003).

In this chapter, the relationship between land use and pH and specific conductance is described for Great Egg Harbor River Watershed Management Area (WMA) water-quality monitoring sites. Nitrogen and phosphorus data collected through a cooperative Pinelands Commission-Atlantic County Utilities Authority ambient-water-quality program (Dow 1996) are also presented and summarized.

Methods

Field Measurements of pH and Specific Conductance

Between April 2002 and March 2003, Commission staff collected specific conductance and pH data monthly at 55 stream sites in the Pinelands National Reserve portion of the Great Egg Harbor River WMA (Table 2.1, Figure 2.1). At each monitoring site, grab samples were collected directly from the stream or lake outflow using a one-liter Nalgene plastic bottle that was rinsed three times with stream water. Most samples were collected under baseflow or near baseflow conditions.

An Orion model-250a pH meter with automatic temperature compensation and a ROSS combination electrode was used to measure pH. An Orion model-122 conductivity meter with temperature compensation was used to measure specific conductance. To ensure adequate stabilization of the pH meter, pH was measured in three separate 250 ml samples that were split from the grab sample, and the third measurement was recorded. The specific conductance of the third sample was also measured and recorded. Using two pH buffers (4.0 and 7.0) that bracket the expected pH range found in streams of the New Jersey Outer Coastal Plain, the pH meter was calibrated at the beginning of every sampling day and after every three hours of use. The conductance meter was checked monthly against two United States Geological Survey standards (50 μS cm^{-1} and 100 μS cm^{-1}). All calibration data were recorded.

Pinelands Commission-Atlantic County Utilities Authority Water-quality Data

Specific conductance, pH, nitrite plus nitrate as nitrogen, ammonia as nitrogen, and total phosphorus as phosphorus data collected at twelve Great Egg Harbor River WMA stream sites were also analyzed. All sites were sampled quarterly between March 1991 and August 1995. Sample collection and laboratory methods are described in Dow (1996).

Detection limits reported for each nutrient varied within and among the sites. Detection limits for nitrite plus nitrate as nitrogen (NO_x-N) ranged from 0.02 to 0.20 mg L^{-1}. When preparing summary statistics, the higher detection limit was applied to all censored (i.e., below detection limit) NO_x-N data. Detection limits for ammonia as nitrogen and total phosphorus as phosphorus also varied. Several ammonia and phosphorus samples reported as 0.10 mg L^{-1} were deleted prior to analysis. The next highest detection limit (0.05 mg L^{-1} for both parameters) was applied to all censored ammonia and total phosphorus data when preparing summary statistics.

Table 2.1 Water-quality monitoring sites in the Great Egg Harbor River WMA. Median pH and specific conductance (SC, $\mu S/cm^{-1}$) values for the 49 sites used in the water-quality analyses for the period April 2002 to March 2003. Altered land represents the combined percentage of developed land and upland agriculture. Refer to Figure 2.1 for site locations. Refer to Appendix 1 for full site descriptions and monthly water-quality data.

		Percentage Land Use					
Study Basin/Site Name	Site Code	Developed Land	Upland Agriculture	Altered Land	pH	SC	N
Tuckahoe River Study Basin							
McNeals Branch at Route 666	TMCNE666	4.9	0.5	5.4	4.4	51	11
Mill Creek at Route 557	TMILL557	3.6	1.5	5.1	4.4	80	11
Tarkiln Branch at Route 548	TTAR548S	2.1	5.6	7.8	4.8	61	9
Tuckahoe River at Route 49 near Head of River	TTU49HED	3.7	7.4	11.1	4.9	42	11
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	5.2	9.9	15.0	4.9	34	11
Tuckahoe River at Route 637	TTUCUMBS	9.1	7.0	16.1	5.4	38	11
Warners Mill Stream at Aetna Drive	TWAAETNA	1.4	3.6	5.0	4.2	66	8
Lower Great Egg Harbor River Study Basin							
Babcock Creek at Route 322	LBABC322	14.3	7.8	22.1	4.6	59	11
Gibson Creek at Route 50	LGIBSO50	6.4	1.7	8.1	4.3	43	11
Gravelly Run at Route 559	LGRAV559	14.4	1.5	15.8	4.5	75	11
Jack Pudding Branch at Leipzig Road	LJALEIPZ	14.1	14.3	28.5	6.3	78	9
South River at Estelle Avenue	LSOESTEL	13.0	19.4	32.4	4.8	102	11
South River at Forty Wire Road	LSOFORTY	9.1	8.4	17.5	5.5	54	11
South River at Route 552	LSOUT552	10.1	11.1	21.2	5.3	60	11
Stephen Creek at Eleventh Avenue	LSTELEVE	8.3	1.7	9.9	5.4	36	11
Stephen Creek at Route 50	LSTEP50S	9.1	3.0	12.2	5.5	33	11
Watering Race Branch at Route 50	LWATER50	7.9	4.5	12.4	4.1	94	11
Middle Great Egg Harbor River Study Basin							
Deep Run at Route 559	MDEEP559	9.3	7.8	17.1	4.8	63	11
Deep Run at Eighth Street	MDEPANCS	19.4	21.3	40.7	6.1	147	9
Great Egg Harbor River at Route 559	MGREA559	18.3	12.7	31.1	5.1	66	11
Great Egg Harbor River at Route 616	MGREA616	15.6	10.7	26.2	4.8	75	7
Mare Run at Route 559	MMARE559	4.6	2.2	6.9	4.6	41	11
Makepeace Stream at Route 623	MMKRT623	9.5	1.7	11.2	4.0	139	11
Atlantic Drainages Study Basin							
Maple Run at Route 662	AMAMILLR	41.0	0.7	41.7	5.7	100	11
Mill Branch at Route 684	AMILL684	27.4	1.8	29.3	5.0	44	11
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	51.5	0.2	51.7	5.5	100	11
Hospitality Branch Study Basin							
Faraway Branch at Jackson Road	HFAJACKS	11.4	7.5	19.0	5.0	40	11
Hospitality Branch at Route 633	HHOBLUEB	20.0	30.7	50.7	6.1	74	11
Hospitality Branch at Cain's Mill Road	HHOCAINS	18.0	15.4	33.4	5.5	58	9
Hospitality Branch at Sharps Road	HHODIAMO	21.0	18.2	39.2	5.8	61	9
Hospitality Branch at Eighth Street	HHOEIGHT	13.4	15.9	29.3	5.8	53	9
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	14.6	18.7	33.3	5.8	63	11
Hospitality Branch at Route 538	HHORT538	24.3	22.7	47.0	6.0	63	11
Hospitality Branch at Whitehall Road	HHOWHITE	22.7	28.0	50.7	6.0	72	9
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	6.9	25.8	32.7	5.5	48	11
Marsh Lake Branch at Jackson Road	HMAJACKS	7.0	27.6	34.6	5.1	50	9
Marsh Lake Branch at Piney Hollow Road	HMAPINEY	14.4	24.3	38.7	5.8	112	8
Marsh Lake Branch at Unexpected Road	HMAUNEXS	7.0	34.2	41.2	5.0	75	11
Whitehall Branch at Blue Bell Road	HWHBLUEB	24.9	21.1	45.9	6.0	57	11
Whitehall Branch at Whitehall Road	HWHWHITE	27.5	16.2	43.7	6.2	61	9
Upper Great Egg Harbor River Study Basin							
Four Mile Branch at Route 536	UFORT536	42.4	11.2	53.6	6.1	106	11
Great Egg Harbor River at Route 536 Spur	UGR536SP	40.0	7.6	47.6	6.2	83	11
Great Egg Harbor River at Route 536	UGREA536	35.9	7.9	43.8	5.9	87	9
Great Egg Harbor River at Route 54	UGRERT54	28.4	7.9	36.3	5.8	75	11
Great Egg Harbor River at Route 691	UGRRT691	72.9	6.7	79.7	6.1	177	11
Great Egg Harbor River at Route 723	UGRRT723	34.5	8.6	43.1	6.0	80	11
Penny Pot Stream at Eighth Street	UPENN8TH	15.0	33.5	48.5	5.9	134	11
Penny Pot Stream at Route 54	UPENNY54	16.5	31.4	47.9	5.2	114	9
Squankum Branch at Malaga Road	USQMALAG	61.5	6.0	67.5	6.2	115	9

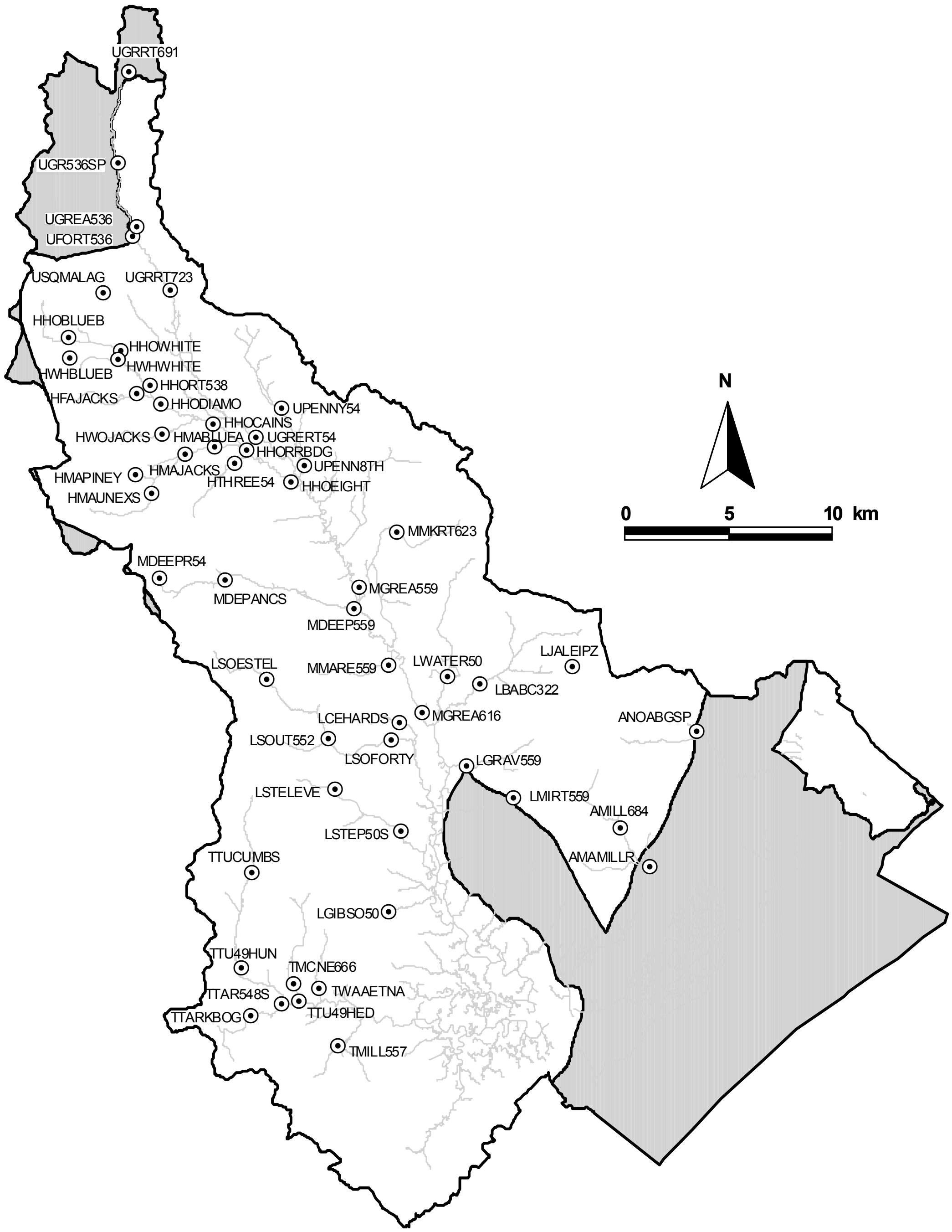

Figure 2.1. Location of 55 pH and specific conductance monitoring sites in the Pinelands National Reserve portion of the Great Egg Harbor River WMA. Refer to Table 2.1 for site descriptions. Stippling represents areas of the Great Egg Harbor River WMA that are outside the Pinelands National Reserve.

Data Analysis

With one exception, six sites with fewer than eight sampling points were deleted prior to analysis of the 2002-2003 pH and specific conductance data. Summary statistics (first, second, and third quartiles and 10th and 90th percentiles) were calculated for pH and specific conductance for 49 sites. The same summary statistics were calculated for the 1991-1995 Atlantic County data set.

Using forward stepwise-multiple regression, median pH and specific conductance values for the 2002-2003 period were related to the percentage of developed land and upland agriculture. Specific conductance values were log transformed prior to analysis. Simple linear regression was also used to relate both water-quality parameters to the percentage of altered land (combined percentage of developed land and upland agriculture). Spearman rank correlation was used to relate and compare median pH and specific conductance values for the 2002-2003 sampling period to those of the 1991-1995 sampling period. The relationship between the 1991-1995 nutrient data and the percentage of altered land was analyzed graphically. Regression and correlation analyses were completed using Statistica 5.5 (Statsoft Inc., Tulsa, OK, 1995). An alpha level of 0.05 was used to assess significance for all tests. For each monitoring site, land-use/land-cover profiles for 1995 were prepared from digital data obtained from the New Jersey Department of Environmental Protection (NJDEP, 1995/97 Land Use/Land Cover Update 2001, Chapter 1).

RESULTS

Field Measurements of pH and Specific Conductance

The drainage basins associated with the monitoring sites displayed a wide range of land-use conditions (Table 2.1). The percentage of altered land in these basins ranged from 5.0% to 80%. Both pH and specific conductance increased as the percentage of altered land in a watershed increased (Figures 2.2 and 2.3). Although land use within each study basin varied widely, land use in the Middle Great Egg Harbor River, Lower Great Egg Harbor River, and Tuckahoe River basin study basins was generally less intense than that of the Upper Great Egg Harbor River, Hospitality Branch, and Atlantic Drainage basins (Table 2.1). The contrasting land use profiles were reflected in the median pH values associated with streams in the three less-impacted basins. Differences in specific conductance between these two classes of study basins were less distinct, although values in the Upper Great Egg Harbor River and Atlantic

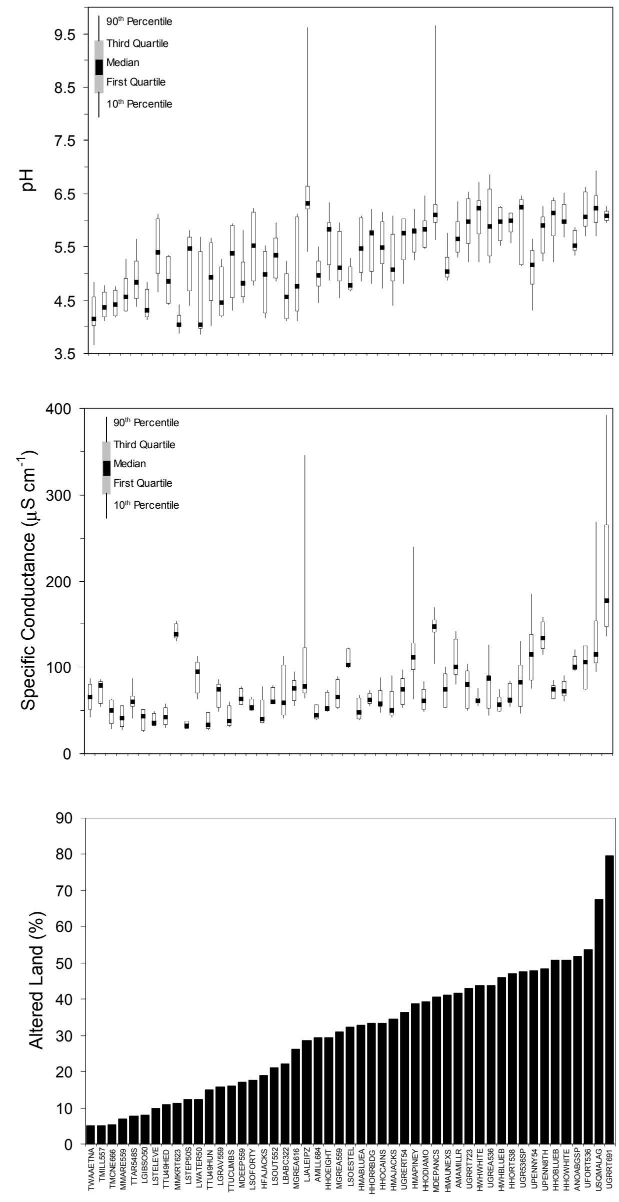

Figure 2.2. Great Egg Harbor River WMA surface-water-quality gradients. Sites are ordered along a watershed disturbance gradient represented by increasing altered-land use (developed and upland agriculture). Refer to Table 2.1 for site descriptions.

Drainage study basins were generally higher than in the other study basins.

Median pH for the 49 Great Egg Harbor River WMA sites sampled ranged from a minimum of 4.0 to a maximum of 6.3 (Table 2.1, Figure 2.4). Median specific conductance values ranged from 33-177 μS cm^{-1} (Figure 2.5). Altered-land values for the five least-altered sites, four of which were in the Tuckahoe River study basin, ranged from 5.0% to 7.8% with an overall median of 5.4%. The median pH and specific conductance for

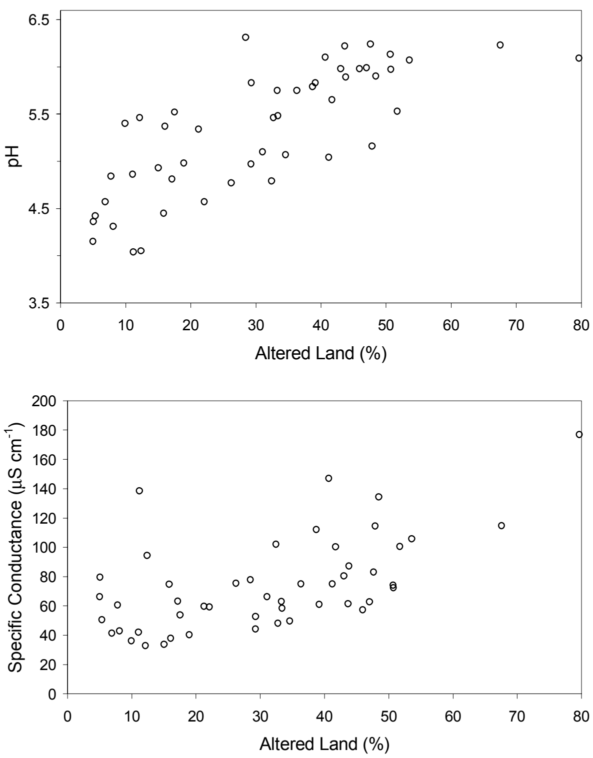

Figure 2.3. The relationship between pH and specific conductance (μS cm^{-1}) and the percentage of altered land (developed land and upland agriculture) in a drainage basin for 49 stream monitoring sites in the Great Egg Harbor River WMA.

these five sites was 4.4 (range = 4.2- 4.8) and 61 μS cm^{-1} (range = 41-80 μS cm^{-1}), respectively. These minimally disturbed Great Egg Harbor River WMA reference-stream sites provide a standard for comparing water quality at other sites. Altered-land values for the six sites in the most heavily altered basins ranged from 51% to 80% with a median of 53%. The median pH and specific conductance for these six sites was 6.1 (range = 5.5-6.2) and 103 μS cm^{-1} (range = 72-177 μS cm^{-1}), respectively. The median pH and specific conductance values calculated using the 2002-2003 data were generally similar to those based on the 1991-1995 data set (Table 2.2, Figure 2.6), although pH was slightly higher and specific conductance was slightly lower for the 1991-1995 period.

The results of the multiple regression analyses based on 49 sites revealed that developed land and upland agriculture explained 59.8% (R-square = 0.598) of the variability in pH and 36.8% (R-square = 0.368) of the variability in specific conductance. Developed land explained a greater portion of the variability in both water-quality variables (Table 2.3). The results revealed by the simple linear regression analysis relating altered land (combined cover of developed land and upland agriculture) to water quality were similar to those of the multiple regression analysis. Altered land explained 59.5% and 34.9% of the variability in pH and specific conductance, respectively.

The relationships between the two water-quality variables and land use was not as strong as those reported in other Commission studies (Dow and Zampella 2000, Zampella et al. 2001, Zampella et al. 2003). The specific conductance model was improved by removing Makepeace Stream, an acid-water stream with unusually high specific conductance readings.

Table 2.2. Pinelands Commission-Atlantic County Utilities Authority nutrient-monitoring sites in the Great Egg Harbor River WMA. Median nitrite plus nitrate as nitrogen, ammonia as nitrogen, and total phosphorus as phosphorus concentrations are expressed as mg L^{-1}. The number of samples (n) for each variable are shown in parentheses. All sites were sampled between March 1991 and August 1995. Percentage altered land includes developed land and upland agriculture. Two codes are given for each sampling site, including those used throughout this report, (e.g., UGRERT54), and those used by Dow (1996), e.g., (PCGE1).

			Median Values					
Study Basins and Site Codes		Site Descriptions	pH	Specific Conductance	Nitrite + Nitrate as N	Ammonia as N	Total P as P	% Altered Land
Tuckahoe River Study Basin								
TMCNE666	PCTU2	McNeals Branch at Route 666	4.4 (19)	37 (19)	<0.20 (19)	<0.05 (17)	<0.05 (19)	5.4
TTU49HUN	PCTU3	Tuckahoe River at Route 49 at Hunters Mill	5.4 (19)	28 (19)	<0.20 (19)	<0.05 (17)	<0.05 (19)	15.0
Lower Great Egg Harbor River Study Basin								
LBABC322	PCGE9	Babcock Creek at Route 322	4.7 (19)	52 (19)	0.43 (19)	<0.05 (17)	<0.05 (19)	22.1
LGRAV559	PCGE6	Gravelly Run at Route 559	4.3 (19)	51 (19)	<0.20 (19)	<0.05 (17)	<0.05 (18)	15.8
LSOFORTY	PCGE15	South River at Forty Wire Road	5.6 (19)	49 (19)	0.61 (19)	<0.05 (17)	<0.05 (19)	17.5
LSTEP50S	PCGE16	Stephen Creek at Route 50	5.9 (19)	29 (19)	0.30 (19)	<0.05 (17)	<0.05 (19)	12.2
LWATER50	PCGE11	Watering Race Branch at Route 50	4.2 (19)	60 (19)	<0.20 (19)	0.05 (18)	<0.05 (19)	12.4
Middle Great Egg Harbor River Study Basin								
MDEEP559	PCGE14	Deep Run at Route 559	4.9 (19)	57 (19)	0.22 (19)	<0.05 (19)	0.05 (19)	17.1
MMKRT623	PCGE4	Makepeace Stream at Route 623	4.0 (19)	91 (19)	<0.20 (19)	0.05 (17)	<0.05 (18)	11.2
Hospitality Branch Study Basin								
HHOEIGHT	PCGE2	Hospitality Branch at Eighth Street	5.7 (19)	45 (19)	0.29 (19)	0.05 (19)	<0.05 (18)	29.3
Upper Great Egg Harbor River Study Basin								
UGRERT54	PCGE1	Great Egg Harbor River at Route 54	5.8 (19)	58 (19)	0.60 (19)	0.12 (19)	<0.05 (19)	36.3
UPENN8TH	PCGE3	Penny Pot Stream at Eighth Street	5.9 (19)	91 (19)	1.26 (19)	0.09 (19)	<0.05 (18)	48.5

Table 2.3. Results of the multiple-regression analyses relating land use to pH, specific conductance (μS cm^{-1}), and a "hydrogen-ion-free" specific conductance value. All relationships are significant ($p < 0.05$).

	R-square values		
	pH	Specific Conductance	H^+ Free SC
Developed Land	0.371	0.300	0.392
Upland Agriculture	0.227	0.068	0.151
Total	0.598	0.368	0.543

The Makepeace Stream drainage basin is dominated by forest land, but includes a section of the Atlantic City Expressway and the Farley Plaza rest stop. Prior to 1992, the Farley Plaza package plant discharged treated wastewater to Makepeace Stream at a point upstream from the monitoring site (Frank Seney and Kathleen Kaufschneider, personal communication, 12 Feb. 2004). The expressway and rest stop may also be a source of dissolved solids such as road salt. Both road salt and wastewater can contribute to specific conductance. Removing this site from the analysis increased the percentage of variability in specific conductance explained by the land uses from 36.8% to 45.6%. Another factor complicating the relationship between specific conductance and land use is the effect of hydrogen ions on specific conductance at low pH (Figure 2.7). At low pH values, specific conductance increases due to a dramatic increase in hydrogen ion concentration To account for this effect, the estimated contribution of hydrogen to specific conductance was calculated for each median pH value (Standard Methods 1992), the calculated value was subtracted from the measured value, and a "hydrogen-ion-free" conductance value that reflects other dissolved solids was analyzed. This analysis yielded R-square values of 0.543 and 0.632, with and without Makepeace Stream included in the multiple regression analysis.

Nutrients

Nitrite + nitrate as nitrogen

Nitrite plus nitrate as nitrogen (NO_x-N) concentrations generally increased as the percentage of altered land in a basin increased (Table 2.2, Figure 2.8). Median NO_x-N values were at or below the detection limit for five of the twelve monitoring sites. The median percentage altered-land values for sites with median NO_x-N concentrations below and above the detection limit were 12% and 22%, respectively. The difference in land cover between these two detection-limit classes was significant (Mann-Whitney U Test, $p = 0.019$).

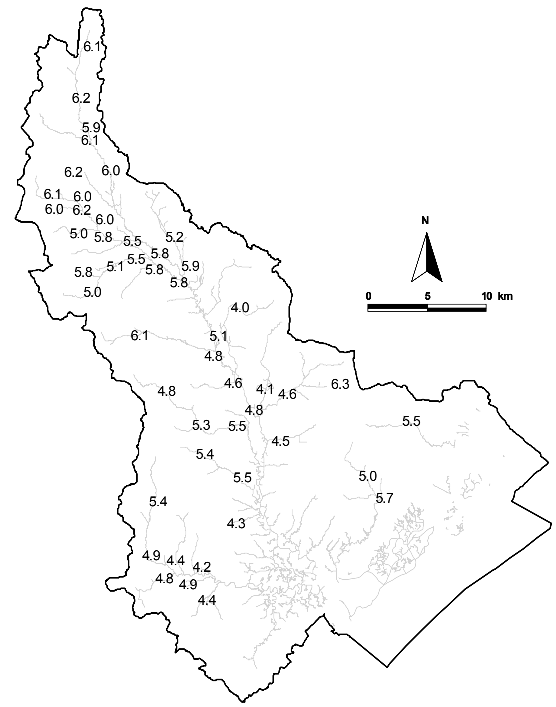

Figure 2.4. Median pH values for 49 stream-monitoring sites in the Great Egg Harbor River WMA.

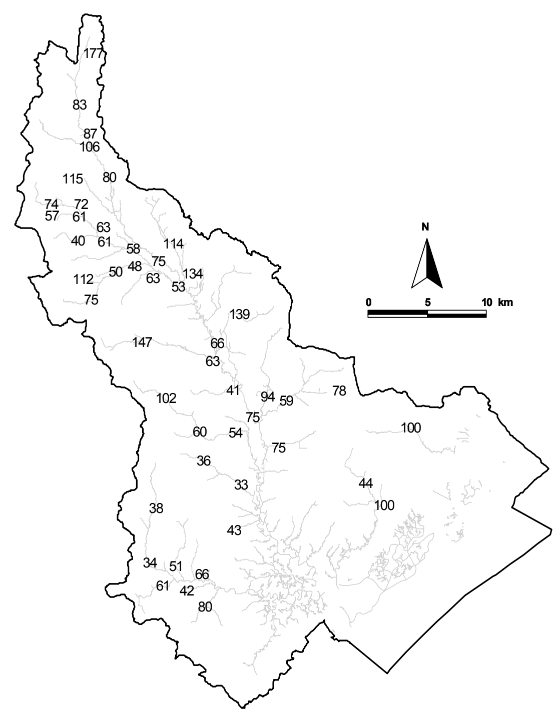

Figure 2.5. Median specific conductance (:S cm^{-1}) values for 49 stream-monitoring sites in the Great Egg Harbor River WMA.

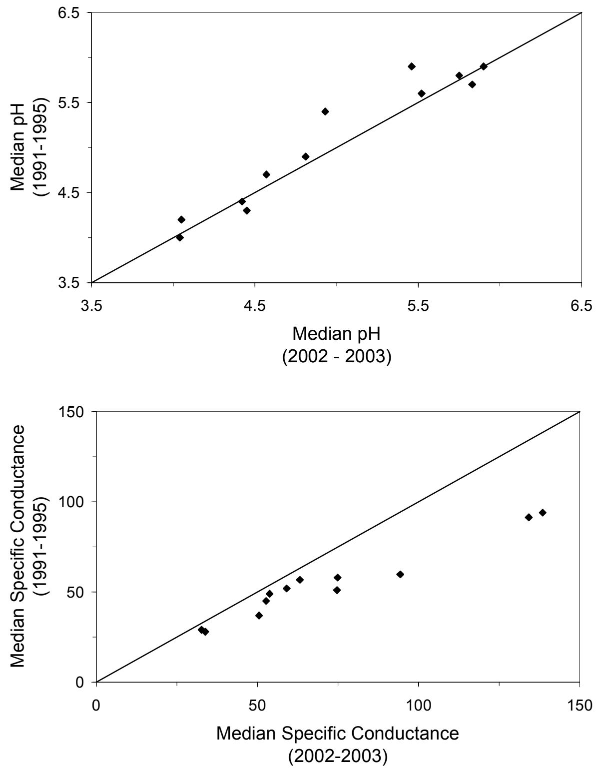

Figure 2.6. A comparison of median pH and specific conductance (μS cm^{-1}) values for 12 stream-monitoring sites based on data collected by the Commission from 1991-1995 and 2002-2003. The correlations between median pH and specific conductance over the two periods were significant ($p < 0.05$) with Spearman r values of 0.93 and 0.97, respectively.

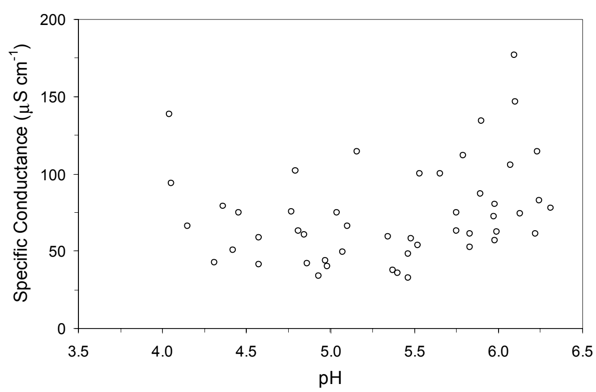

Figure 2.7. The relationship between pH and specific conductance for stream-monitoring sites in the Great Egg Harbor River WMA.

The highest median NO_x-N concentration was reported from Penny Pot Stream at Eighth Street (1.26 mg L^{-1}) (Table 2.2, Figure 2.8). Because reference streams typically have median NO_x-N concentrations below 0.05 mg L^{-1} (Zampella et al. 2001), the high detection limit (0.20 mg L^{-1}) used prevents a definite conclusion regarding the NO_x-N status of the least disturbed Great Egg Harbor River WMA streams.

Ammonia as nitrogen

Elevated ammonia levels were most apparent in the most heavily altered basins (Table 2.2, Figure 2.8). The median value equaled or exceeded the 0.05 mg L^{-1} detection limit at five of the twelve sites. The median percentage altered-land values for sites with median ammonia concentrations below and above the detection limit were 16% and 29%, respectively. The difference in altered-land use between these two detection-limit classes was not significant (Mann-Whitney U Test, p = 0.29). Differences in ammonia levels were more obvious when third-quartile (75th percentile) values were inspected. The highest third-quartile concentrations were reported for the Great Egg Harbor River at Route 54 (0.20 mg L^{-1}), Penny Pot Stream at Eighth Street (0.15 mg L^{-1}), and Hospitality Branch at Eighth Street (0.12 mg L^{-1}). The drainages associated with these sites were the most heavily altered of the twelve sites monitored.

Total phosphorus as phosphorous

There was no obvious relationship between total phosphorus concentrations and land use (Table 2.2, Figure 2.8). The median concentration of total phosphorus was below detection limit at eleven of the twelve nutrient-monitoring sites. The exception was Deep Run at Route 559, located a distance downstream from the Buena Borough Municipal Utilities Authority discharge, where a median phosphorus concentration of 0.05 mg L^{-1} was reported. Third quartile (75th percentile) values exceeded the detection limit at all sites except Hospitality Branch at Eighth Street. A peculiar trend was the occurrence of higher 90th percentile values for sites in the least-altered basins.

Study-basin Characterizations

Tuckahoe River

Specific conductance and pH were measured at seven monitoring sites in the Tuckahoe River study basin (Table 2.1, Figure 2.9). The study basin was the least altered of all Great Egg Harbor River WMA study basins, with altered land ranging from 5.0% to 16% in the drainages associated with the monitoring sites. Water quality reflected the low percentage of altered

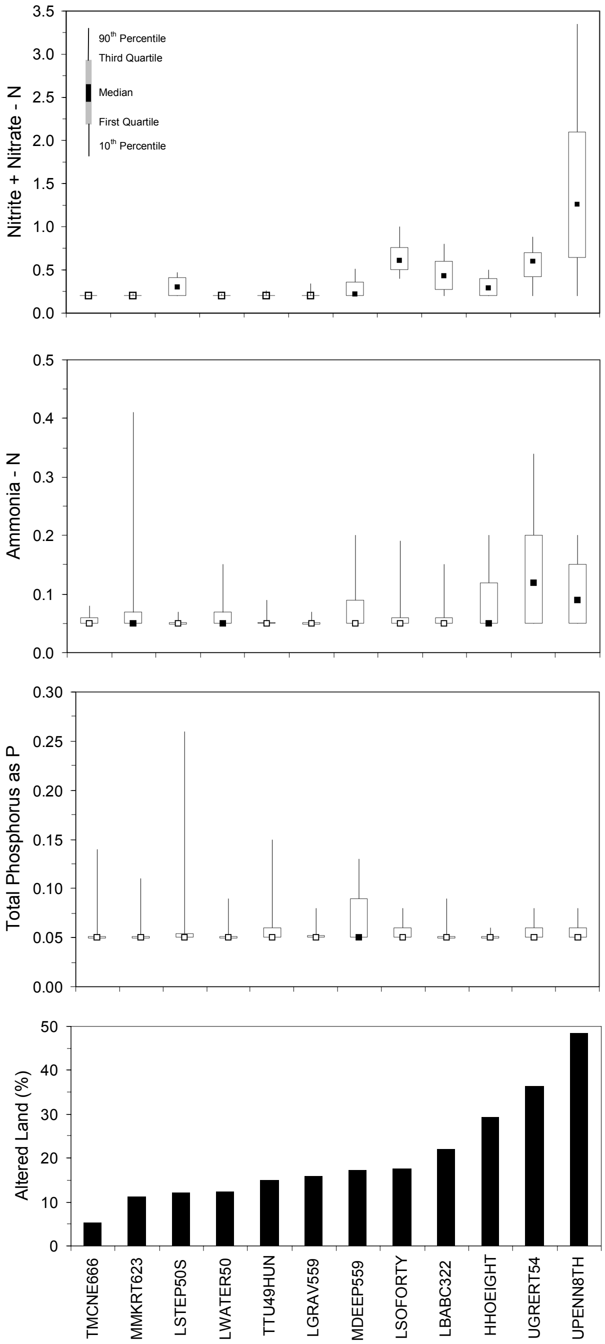

Figure 2.8. Great Egg Harbor River WMA surface-water-quality gradients. Sites are ordered along the watershed-disturbance gradient by increasing percentage of altered land (developed land and upland agriculture). Values below detection limit for nitrite + nitrate - N (0.20 mg L^{-1}), ammonia - N (0.05 mg L^{-1}), and total phosphorus as phosphorus (0.05 mg L^{-1}) are shown as open squares. The third quartile for nitrite + nitrate - N at site LGRAV559 was 0.2 mg L^{-1}. The third quartile for ammonia - N at site LSTEP50S was 0.05 mg L^{-1}. The third quartile for total phosphorus at sites TMCNE666, MMKRT623, LWATER50, and LBABC322 was 0.05 mg L^{-1}. Data were collected between 1991 and 1995. Stream station names and median values are given in Table 2.2.

land in the drainage basin. The Tuckahoe River study basin included four of the five Great Egg Harbor River WMA reference sites. Median pH values ranged from 4.2 at Warners Mill Stream at Aetna Drive to 5.4 at Tuckahoe River at Route 637, with an overall study-basin median value of 4.8. Specific conductance values ranged from 34 $\mu S\ cm^{-1}$ at Tuckahoe River at Route 49 at Hunters Mill to 80 $\mu S\ cm^{-1}$ at Mill Creek at Route 557, with an overall study-basin median of 51 $\mu S\ cm^{-1}$.

Nutrients were sampled at the Tuckahoe River at Route 49 at Hunters Mill site and at McNeals Branch at Route 666 site (Table 2.2, Figure 2.8). The median concentrations for all three nutrients were below detection limit, although the third quartile ammonia and phosphorus concentrations exceeded the 0.05 mg L^{-1} detection limit. About a quarter of the samples from the Tuckahoe River site exceeded the NO_x-N detection limit.

Lower Great Egg Harbor River

With altered land ranging from 8.1% to 32% in the basins associated with ten monitoring sites, the Lower Great Egg Harbor River study basin was the least altered of the three Great Egg Harbor River study basins (Upper, Middle, and Lower Great Egg Harbor River basins). Median pH values ranged from 4.1 at Watering Race Branch at Route 50 to 6.3 at Jack Pudding Branch at Leipzig Road, with an overall median value of 5.1 (Table 2.1, Figure 2.9). Specific conductance values ranged from 33 $\mu S\ cm^{-1}$ at Stephen Creek at Route 50 to 102 $\mu S\ cm^{-1}$ at South River at Estelle Avenue, with an overall median of 59 $\mu S\ cm^{-1}$. Specific conductance values in the Lower Great Egg Harbor River study basin were generally lower than all other study basins except the Tuckahoe River study basin.

Nutrients were sampled at five Lower Great Egg Harbor River sites (Table 2.2, Figure 2.8). With one exception, median ammonia and total phosphorus concentrations were below detection at all sites. The exception was Watering Race Branch at Route 50 where the median ammonia concentration was 0.05 mg L^{-1}. Median NO_x-N concentrations exceeding the 0.20 mg L^{-1} detection limit were reported for three of the five Lower Great Egg Harbor River sites. The median concentrations at these three sites, which included Babcock Creek at Route 322, South River at Forty Wire Road, and Stephen Creek at Route 50, ranged from 0.30 mg L^{-1} to 0.61 mg L^{-1}.

Middle Great Egg Harbor River

The Middle Great Egg Harbor River study basin was less altered and displayed better water quality in comparison to the Upper Great Egg Harbor River and Hospitality Branch study basins (Table 2.1, Figure 2.9). Altered-land cover at six monitoring sites ranged from 6.9% to 41%. Median pH at most sites was within the range of the five Great Egg Harbor River WMA reference sites. Values ranged from 4.0 at Makepeace Stream at Route 623 to 6.1 at Deep Run below Eighth Street, with an overall median value of 4.8. Specific conductance values ranged from 41 μS cm^{-1} at Mare Run to 147 μS cm^{-1} at Deep Run below Eighth Street, with an overall median of 71 μS cm^{-1}. The Deep Run site is located downstream from the Buena Borough Municipal Utilities Authority discharge. Specific conductance values ranging from 524 to 801 μS cm^{-1} at an upstream (MDEEPR54) site, located directly below the discharge, were excluded from the analyses (Appendix 1). The second highest median specific conductance value (139 μS cm^{-1}) was reported for Makepeace Stream. As previously mentioned, the Makepeace Stream basin includes a section of the Atlantic City Expressway and the Farley Plaza rest stop, which may be a source of dissolved solids from road salts or wastewater.

Nutrients were sampled at Makepeace Stream and Deep Run at 559 (Table 2.2, Figure 2.8). Elevated nutrient levels in the Pinelands streams are frequently associated with wastewater discharges (Zampella 1994). Both Makepeace Stream and Deep Run received wastewater discharges during the 1991-1995 monitoring period. NO_x-N concentrations were below detection limit at Makepeace Stream on 16 of 19 sampling dates. Detectable NO_x-N concentrations at Makepeace Stream ranged from 0.20 mg L^{-1} to 0.44 mg L^{-1}. The median NO_x-N at Deep Run was 0.22 mg L^{-1}. Ammonia was detected in Makepeace Stream samples on a majority of sampling dates. The median ammonia concentration at this site was 0.05 mg L^{-1}. Although the median ammonia concentration at Deep Run was below the detection limit, elevated concentrations were recorded on seven sampling dates. Deep Run was the only nutrient-monitoring site in the Great Egg Harbor River WMA where the median total phosphorus (0.05 mg L^{-1}) was within detectable limits. Total phosphorus was detected on seven of eighteen Makepeace Stream sampling dates. The median total phosphorus concentration at this site was < 0.05 mg L^{-1}.

Atlantic Drainages

Water quality was sampled at three Atlantic Drainage stream sites. All three were heavily altered, with the percentage of altered land ranging from 29% to 52% (Table 2.1, Figure 2.9). Median pH ranged from 5.0 at Mill Branch at Route 684 to 5.7 at Maple Run at Route 662. Median pH for the North Branch Absecon Creek at the Garden State Parkway was 5.5. Specific conductance varied with pH, ranging from 44 μS cm^{-1} at the Mill Branch site to 100 μS cm^{-1} at both Maple Run and North Branch Absecon Creek sites. Nutrients were not sampled in this study basin.

Hospitality Branch

The Hospitality Branch study basin was also highly altered, with altered-land values ranging from 19% to 51%. Median pH at fourteen monitoring sites ranged from 5.0 at Faraway Branch at Jackson Road and Marsh Lake Branch at Unexpected Road to 6.2 at Whitehall Branch at Whitehall Road, with an overall median value of 5.8 (Table 2.1, Figure 2.9). Specific conductance values, which ranged from 40 μS cm^{-1} at Faraway Branch at Jackson Road to 112 μS cm^{-1} at Marsh Lake Branch at Piney Hollow Road, with an overall median of 61 μS cm^{-1}, were lower than expected based on the high percentage of altered land associated with the monitoring sites. However, these values are high compared to those reported for the five Great Egg Harbor River WMA reference sites and reference sites in the Mullica River Basin (Zampella et al. 2001). Nitrogen and phosphorus were sampled at Hospitality Branch at Eighth Street (Table 2.2, Figure 2.8). Median NO_x-N (0.29 mg L^{-1}) and ammonia (0.05 mg L^{-1}) concentrations were high at this site.

Upper Great Egg Harbor River

The Upper Great Egg Harbor River study basin was in general the most highly altered study basin with some of the highest pH and specific conductance values reported for the Great Egg Harbor River WMA (Table 2.1, Figure 2.9). Median pH values reported for the nine monitoring sites ranged from 5.2 at Penny Pot Stream at Route 54 to 6.2 at Squankum Branch at Malaga Road and the Great Egg Harbor River at Route 536 Spur. Specific conductance ranged from 75 μS cm^{-1} at the Great Egg Harbor River at Route 54 to 177 μS cm^{-1} at the Great Egg Harbor River at Route 691. The overall median pH and specific conductance for the study basin was 6.0 and 106 μS cm^{-1}, respectively.

The two nutrient-monitoring sites were characterized by elevated NO_x-N and ammonia concentrations (Table 2.2, Figure 2.8). As previously mentioned, the highest median NO_x-N concentration (1.26 mg L^{-1}) was reported from Penny Pot Stream at Eighth Street. The median NO_x-N concentration for the Great Egg Harbor River at Route 54 site was 0.60 mg L^{-1}. Median ammonia levels at these two sites were the highest reported for the Great Egg Harbor River WMA.

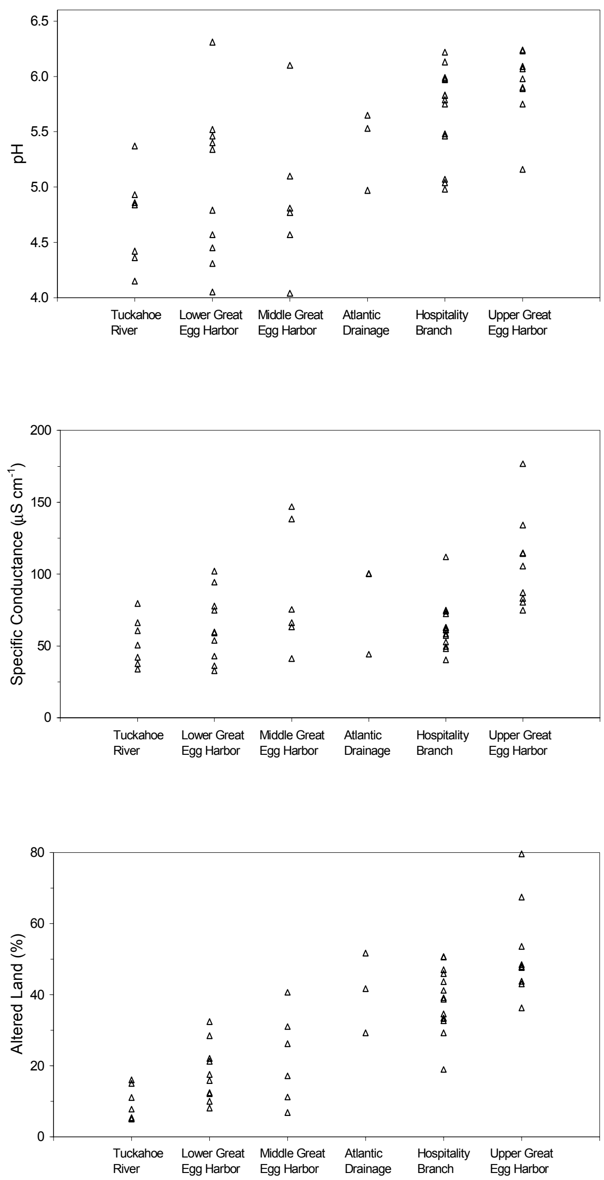

Figure 2.9. Comparison of median pH and specific conductance (μS cm^{-1}) and the percentage of altered land (developed land and upland agriculture) recorded for 49 stream-monitoring sites in the six study basins of the Great Egg Harbor River WMA.

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3 STREAM VEGETATION

INTRODUCTION

Commission stream-vegetation studies in the Mullica River and Rancocas Creek basins revealed that plant-species composition was associated with watershed-disturbance gradients characterized by increasing upland-agriculture and developed-land uses and increasing surface-water pH and specific conductance (Zampella and Laidig 1997, Zampella et al. 2001, 2003). Plant-species composition in streams associated with heavily farmed and developed watersheds was characterized by a high percentage of plants associated with the region to the north and west of the Pine Barrens, referred to by Stone (1911) as the Middle District. Stream sites in more heavily degraded watersheds also supported a higher percentage of a group of twenty-nine Middle District and exotic plants, referred to by Zampella and Laidig (1997) as disturbance-indicator species (Table 3.1). Plants of Stone's (1911) Pine Barrens District dominated the flora of streams in forested watersheds.

The relationship between land-use disturbance and disturbance-indicator plants in the Rancocas Creek Basin was complicated because, unlike the Mullica River Basin, a significant portion of the Rancocas Creek Basin is located within or near the approximate boundary of Stone's (1911) Middle District. It was unclear if a Middle District plant was present due to watershed disturbance or because an area falls within its natural range. Regardless, land use was the major factor affecting water quality in the Rancocas Creek Basin and Middle District plants were not generally associated with acid waters.

In 2002, Commission scientists surveyed aquatic and wetland vegetation at stream sites in the Great Egg Harbor River Watershed Management Area (WMA). These surveys and the evaluation methods developed in the Mullica River and Rancocas Creek studies were then used to assess the status of vegetation in the streams within the Great Egg Harbor River WMA. The results of this assessment are presented in this chapter.

Table 3.1. Disturbance-indicator plant species at Mullica River Basin stream sites (Zampella and Laidig 1997).

Scientific name	Common name
Asclepias incarnata	swamp milkweed
Bidens connata	purple-stemmed beggar ticks
Bidens frondosa	beggar ticks
Boehmeria cylindrica	false nettle
Callitriche heterophylla	larger water starwort
Carex lurida	sallow sedge
Cinna arundinacea	wood-reed
Cyperus strigosus	straw-colored cyperus
Dioscorea villosa	common wild yam
Echinochloa muricata	American barnyard grass
Erechtites hieracifolia	pilewort
Eupatorium dubium	eastern joe-pye weed
Galium tinctorium	stiff marsh bedstraw
Impatiens capensis	spotted touch-me-not
Lindernia dubia	short-stalked false pimpernel
Lobelia cardinalis	cardinal flower
Ludwigia palustris	water purslane
Microstegium vimineum	stiltgrass
Mikania scandens	climbing hempweed
Panicum clandestinum	deertongue grass
Polygonum arifolium	halberd-leaved tearthumb
Polygonum hydropiperoides	mild water pepper
Polygonum punctatum	dotted smartweed
Polygonum sagittatum	arrow-leaved tearthumb
Potamogeton epihydrus	Nuttall's pondweed
Potamogeton pusillus	small pondweed
Sambucus canadensis	common elder or elderberry
Thelypteris palustris	marsh fern
Typha latifolia	broad-leaved cattail

METHODS

Study Sites

Thirty-seven Great Egg Harbor River WMA stream sites were surveyed as part of the stream-vegetation monitoring program (Table 3.2). Many of the survey sites were located at New Jersey Department of Environmental Protection Ambient Biomonitoring Network (NJDEP AMNET) stations. A few of these sites were located near the approximate boundaries of Stone's (1911) Middle District and Coastal Strip regions. Criteria used to select additional survey stations were drainage-area land-use characteristics, accessibility, and suitability as plant-survey sites. Sites consisted of a 20-m length of stream divided into two 10-m sections located upstream and downstream of a bridge or road crossing or a single 20-m section located upstream or downstream of a crossing. The sampling area at each site included the channel and a two-meter wide belt transect along each bank. The location of each sampling station, which was determined using an NJDEP AMNET coverage or orthophotoquads and a geographic information system, is reported as latitude and longitude.

Table 3.2 Median pH and specific conductance values (μS cm^{-1}) and the percentage of upland agriculture, developed land, and altered land (developed and upland agriculture) in the basin for 37 Great Egg Harbor River WMA stream sites. Except for UGR8THST, where water quality was measured upstream at UGRERT54, stream-vegetation and water-quality sites are the same. Refer to Chapter 2 for details regarding water-quality monitoring.

Site Code	pH	SC	Upland Ag.	Developed	Altered Land
AMAMILLR	5.7	100	0.7	41.0	41.7
AMILL684	5.0	44	1.8	27.4	29.3
ANOABGSP	5.5	100	0.2	51.5	51.7
HHOBLUEB	6.1	74	30.7	20.0	50.7
HHORRBDG	5.8	63	18.7	14.6	33.3
HHORT538	6.0	63	22.7	24.3	47.0
HMABLUEA	5.5	48	25.8	6.9	32.7
HMAUNEXS	5.0	75	34.2	7.0	41.2
HTHREE54	4.3	121	1.9	7.4	9.4
HWHBLUEB	6.0	57	21.1	24.9	45.9
HWOJACKS	4.0	122	10.0	7.5	17.5
LBABC322	4.6	59	7.8	14.3	22.1
LGIBSO50	4.3	43	1.7	6.4	8.1
LGRAV559	4.5	75	1.5	14.4	15.8
LSOESTEL	4.8	102	19.4	13.0	32.4
LSOFORTY	5.5	54	8.4	9.1	17.5
LSOUT552	5.3	60	11.1	10.1	21.2
LSTELEVE	5.4	36	1.7	8.3	9.9
LSTEP50S	5.5	33	3.0	9.1	12.2
LWATER50	4.1	94	4.5	7.9	12.4
MDEEP559	4.8	63	7.8	9.3	17.1
MDEEPR54	6.5	695	50.4	26.7	77.1
MDEPANCS	6.1	147	21.3	19.4	40.7
MGREA559	5.1	66	12.7	18.3	31.1
MMARE559	4.6	41	2.2	4.6	6.9
TMCNE666	4.4	51	0.5	4.9	5.4
TMILL557	4.4	80	1.5	3.6	5.1
TTU49HED	4.9	42	7.4	3.7	11.1
TTU49HUN	4.9	34	9.9	5.2	15.0
TTUCUMBS	5.4	38	7.0	9.1	16.1
UFORT536	6.1	106	11.2	42.4	53.6
UGR536SP	6.2	83	7.6	40.0	47.6
UGR8THST	5.8	75	7.8	27.9	35.7
UGRRT691	6.1	177	6.7	72.9	79.7
UGRRT723	6.0	80	8.6	34.5	43.1
UPENN8TH	5.9	134	33.5	15.0	48.5
USQMALAG	6.2	115	6.0	61.5	67.5

Characterizing Stream Conditions

Several drainage-basin and local-habitat attributes were characterized at each stream site (Table 3.2). The variables included pH, specific conductance, upland agriculture, and developed land. Upstream land-use profiles were prepared using ArcView software and NJDEP 1995/1997 land-use data (Chapter 1). Specific conductance was measured with an Orion model-122 conductivity meter with temperature compensation and pH was measured with an Orion model-250a pH meter with automatic temperature compensation and a ROSS combination electrode (Chapter 2).

Plant-species Surveys

Plant-survey methods were the same as those used in the Rancocas Creek Basin study (Zampella et al. 2003). Channel and bank plants were surveyed on a single occasion during each of two time periods (July-August and September-October) in 2002. Two of the sites were surveyed during only one of the two time periods. Following Stone (1911), all plants were classified as either a Pine Barrens District species, Middle District species, or species found in both the Pine Barrens District and the Middle District. The latter are referred to as wide-ranging species. Southern New Jersey plants not included in Stone's biogeographic lists, but described in his individual species accounts as uncharacteristic of the Pine Barrens District, were assigned to the Middle District category. Using Gleason and Cronquist (1991), species that are not native to North America were classified as exotic. Both Middle District and exotic species represent non-Pinelands species.

The complete plant-survey data set and distribution maps for species that were found at two or more sites are presented in Appendix 2. Taxonomic nomenclature follows Gleason and Cronquist (1991). Both scientific and common names are given in Appendix 2. The appendix also describes the location of each site, including latitude and longitude. The Commission maintains a herbarium collection that includes voucher specimens for many of the plant species encountered during the Great Egg Harbor River WMA stream surveys.

Stream-vegetation Gradients

Detrended correspondence analysis (DCA, Hill 1979a, Hill and Gauch 1980) and TWINSPAN (Hill 1979b) were used to ordinate and classify plant species and sampling sites based on presence/absence data. These analyses were completed using PC-ORD, Version 4 (McCune and Mefford 1999).

With DCA, sites are ordered along axes based on species-composition data. TWINSPAN is a classification technique which groups sites based on species composition. The use of both methods in the Commission's monitoring program is more fully described in Zampella et al. (2001). To limit the effect of rare species on the ordinations, only species occurring at two or more sites were included in the analyses. Plant specimens that were identified only to genus were eliminated from the analyses if the genus was represented by known species. Excluding these plants from the analyses had very little effect on the results.

Spearman rank correlation and graphical analysis were used to determine if species composition, represented by the DCA axes, varied in relation to environmental factors. The environmental factors included the percentage of upland agriculture, developed land, and altered land (upland agriculture and developed land) in a basin, pH, and specific conductance. Selection of these variables was based on the results of previous Commission stream-vegetation studies (Zampella and Laidig 1997, Zampella et al. 2001, 2003). An alpha level of 0.05 was used to identify significant relationships revealed by the correlation analyses.

Differences in biogeography and watershed conditions between the TWINSPAN-derived site classes were evaluated using Mann-Whitney U tests. The percentage of native and nonnative species, pH, specific conductance, and the percentage of altered land (developed land and upland agriculture) were compared between the first two site classes.

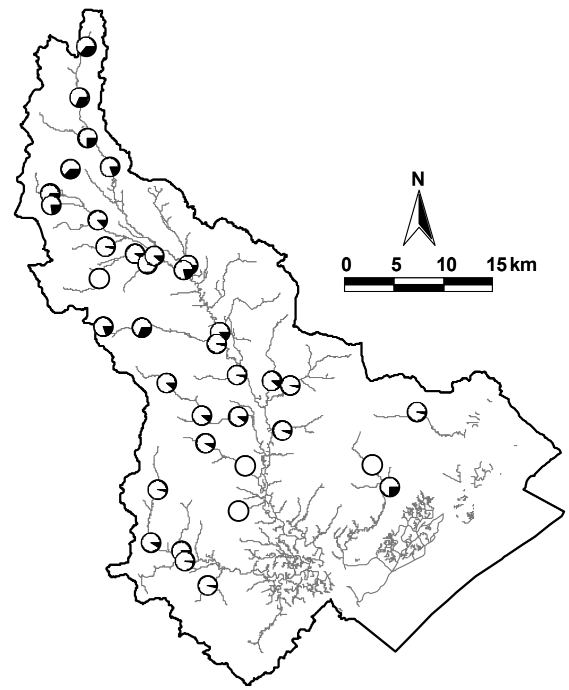

Figure 3.1 Pie charts showing as black the percentage of disturbance-indicator species found at 37 Great Egg Harbor River WMA stream sites.

RESULTS

Plant-species Surveys

A total of 216 vascular plant species, including 160 herbaceous and 56 woody species, were found at the 37 Great Egg Harbor River WMA stream sites. Total and herbaceous plant-species richness ranged from 13 to 66 and 2 to 50, respectively. The mean (± 1 SD) number of species found at the 37 sites was 34 ± 11. Median species richness was 33.

Twenty-seven disturbance-indicator species (Table 3.1) were found during the plant surveys. Thirty-three of the 37 survey sites supported one or more disturbance-indicator species (Figure 3.1). Indicator plants that occurred at more than one quarter of the sites were *Ludwigia palustris, Panicum clandestinum, Polygonum hydropiperoides, Galium tinctorium, and Boehmeria cylindrica*. The remaining disturbance indicators occurred at one to nine study sites.

The number of plant species classified by Stone (1911) as Pine Barrens District plants represented 21% of the total species inventory for the 37 sites. Nearly 30% of the species were wide-ranging plants. Approximately half of the species inventory consisted of plants characteristic of Stone's Middle District or other non-Pinelands biogeographic regions. Twelve plant species were exotics. *Microstegium vimineum, Polygonum cespitosum, Rosa multiflora,* and *Lonicera japonica* occurred at seven or more sites. The other exotic species each occurred at a single site. Non-Pinelands species (exotic and Middle District plants) comprised the majority of species found at nearly one third of the sites (Figure 3.2). For plants that occurred at ten or more study sites, one-third of the woody species and nearly one-half of the herbaceous species consisted of non-Pinelands plants (Table 3.3).

Stream-vegetation Gradients

The gradient analysis was limited to 138 species occurring at two or more sites. One site, Deep Run at Route 54 (MDEEPR54), was excluded from the ordination because it was located immediately downstream from a wastewater point discharge.

The first DCA axis produced by ordinating 36 stream sites contrasted sites with a high percentage of Pine Barrens District and wide-ranging species with those sites supporting a high percentage of non-Pinelands (Middle District and exotic) species (Figure 3.3, Table 3.4). Three general trends, representing a decrease in the

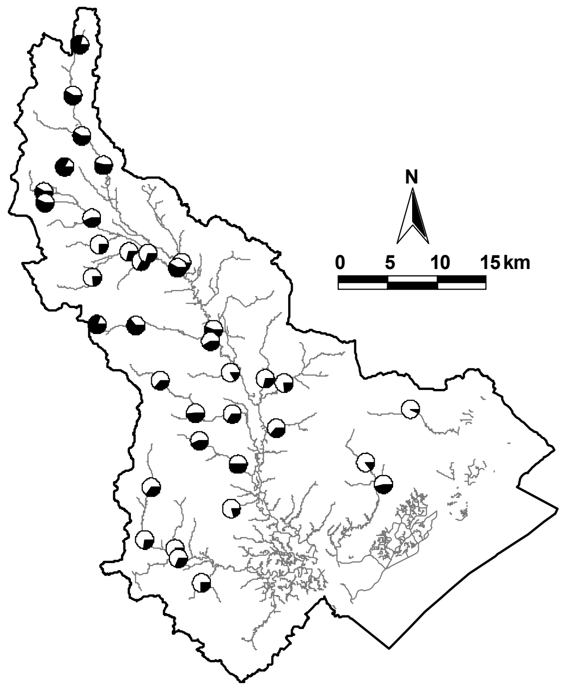

Figure 3.2 Pie charts showing as black the percentage of non-Pinelands species found at 37 Great Egg Harbor River WMA stream sites.

Table 3.3. Biogeography of plants found at ten or more sites in the Great Egg Harbor River WMA. Codes refer to Stone's (1911) Pine Barrens District (PB) and Middle District (M). Plants characteristic of both districts are listed as PB & M. Classification of a species as exotic is based on Gleason and Cronquist (1991). Middle District and exotic species represent non-Pinelands species.

Species	Biogeography	Number of Sites
Herbaceous species:		
Leersia oryzoides	M	29
Sparganium americanum	PB	26
Juncus effusus	PB & M	24
Peltandra virginica	M	22
Triadenum virginicum	PB & M	19
Woodwardia areolata	PB & M	17
Decodon verticillatus	PB & M	16
Ludwigia palustris	M	15
Lycopus virginicus	M	15
Lysimachia terrestris	PB & M	15
Panicum dichotomum	Not classified	15
Onoclea sensibilis	M	14
Panicum clandestinum	M	14
Lycopus uniflorus	Not classified	14
Polygonum hydropiperoides	M	13
Glyceria obtusa	PB & M	13
Osmunda cinnamomea	PB & M	13
Galium tinctorium	M	12
Iris versicolor	M	11
Juncus canadensis	PB & M	11
Scirpus cyperinus	PB & M	11
Hypericum mutilum	M	10
Boehmeria cylindrica	M	10
Nuphar variegata	PB	10
Osmunda regalis	PB & M	10
Woody species:		
Acer rubrum	PB	36
Clethra alnifolia	PB & M	35
Vaccinium corymbosum	PB	30
Smilax rotundifolia	PB & M	29
Eubotrys racemosa	PB & M	27
Rhododendron viscosum	PB	20
Magnolia virginiana	PB & M	19
Parthenocissus quinquefolia	M	17
Chamaecyparis thyoides	PB	17
Nyssa sylvatica	PB & M	16
Lonicera japonica	Exotic	14
Aronia arbutifolia	PB & M	14
Rubus hispidus	PB & M	14
Vitis labrusca	M	13
Cephalanthus occidentalis	PB & M	13
Ilex opaca	M	12
Toxicodendron radicans	M	12
Rosa multiflora	Exotic	11

percentage of Pine Barrens District species, an increase in the percentage of non-Pinelands species, and an increase in the percentage of disturbance-indicator plant species, were evident along this stream-community gradient (Figures 3.4 and 3.5). These trends were related to differences in the range of pH, specific conductance, and the percentage of altered land (upland agriculture and developed land) associated with each plant species (Figure 3.6, Table 3.5).

First-axis stream-site scores produced by the DCA site ordination were associated with increasing pH ($r = 0.73$, $p < 0.001$) and the percentage of altered land ($r = 0.61$, $p < 0.001$), developed land ($r = 0.64$, $p < 0.001$), and upland agriculture ($r = 0.33$, $p = 0.049$, Figure 3.7). The relationship between the community gradient and specific conductance was not significant, although conductance increased towards the nonnative-species end of the gradient. The ordering of sites along the second DCA axis was not related to plant biogeography or environmental factors.

A decrease in the percentage of native species was associated with increasing pH ($r = -0.75$, $p < 0.001$), specific conductance ($r = -0.35$, $p = 0.039$), and the percentage of developed land ($r = -0.63$, $p < 0.001$) and altered land in a basin ($r = -0.57$, $p < 0.001$). The relationship between the percentage of native species and upland agriculture was not significant. Opposite trends were observed for nonnative species.

The TWINSPAN classification revealed patterns similar to those obtained using DCA. The first

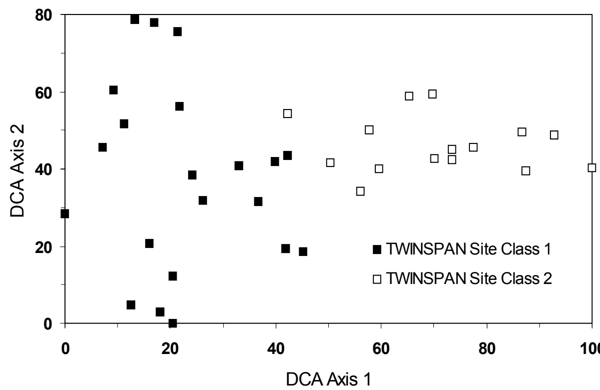

Figure 3.3. DCA ordination diagram and TWINSPAN classification for 36 Great Egg Harbor River WMA stream sites. Refer to Table 3.4 for site names ordered by DCA axis 1 scores.

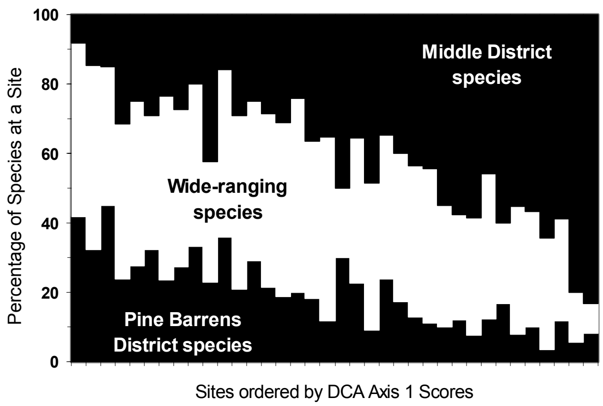

Figure 3.4 Biogeography of plants found at 36 Great Egg Harbor River WMA stream sites. Wide-ranging species are native to both the Pine Barrens District and the Middle District. Middle District species include exotic plants and are considered non-Pinelands species. Refer to Table 3.4 for site names ordered by DCA axis 1 scores.

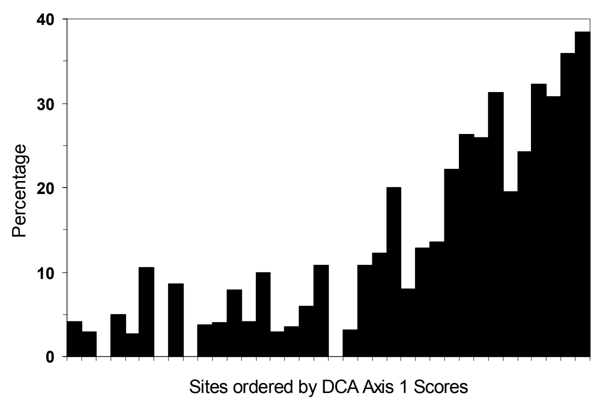

Figure 3.5 Percentage of indicator species at 36 Great Egg Harbor River WMA stream sites. Refer to Table 3.4 for site names ordered by DCA axis 1 scores.

TWINSPAN division separated a group of 21 sites with a higher percentage of native Pine Barrens District and wide-ranging plants (Site Class 1) from 15 sites characterized by a lower percentage of native plants and a higher percentage of disturbance-indicator species (Site Class 2, Figure 3.8). The relatively low percentage of native species at a few of the sites and the presence of disturbance-indicator species at all but four of the sites included in the first site class suggested that this class included some moderately degraded streams. The two site classes were also distinguished by contrasting pH, specific conductance, and the percentage of altered land (Figure 3.8). Based on Mann-Whitney U tests, there was a significant difference in the percentage of native and nonnative species ($p < 0.001$), pH ($p < 0.001$), specific conductance ($p = 0.008$), and altered land ($p < 0.001$) between the two site classes.

Study-basin Characterizations

Tuckahoe River

With the exception of Tuckahoe River at Route 637, sites in the Tuckahoe River study basin were generally associated with the end of the stream-vegetation community gradient characterized by a relatively high percentage of Pine Barrens District species and a low percentage of non-Pinelands species (Table 3.4, Figures 3.9 and 3.10). McNeals Branch at Route 666 and Mill Creek at Route 557 supported the highest percentage of Pine Barrens District plants in the study basin and each supported only a single disturbance indicator. As a group, Tuckahoe River study-basin sites supported the lowest number of disturbance-indicator species of all the other study basins in the Great Egg Harbor River WMA.

Lower Great Egg Harbor River

The nine sites in the Lower Great Egg Harbor River study basin occupied a transitional position along the stream-vegetation community gradient (Table 3.4, Figure 3.9). The percentage of Pine Barrens District species and non-Pinelands plants found at sites in this study basin ranged from 9 to 33 and 20 to 50, respectively (Figure 3.10). The number of disturbance-indicator species found at sites in the Lower Great Egg Harbor River study basin ranged from zero to six. Gibson Creek at Route 50 supported the highest percentage of Pine Barrens District species in the study basin. No disturbance indicators were found at this site.

Middle Great Egg Harbor River

The vegetation composition of the four sites in the

Table 3.4. Raw DCA axis 1 and axis 2 site scores for 36 stream-vegetation monitoring sites in the Great Egg Harbor River WMA based on an ordination of species presence/absence data. Sites are ordered by axis 1 scores. Refer to Appendix 2 for additional information on each site.

Study Basin	Site Name	Site Code	Axis 1	Axis 2
Atlantic	North Branch Absecon Creek at Garden State Parkway	ANOABGSP	0	70
Tuckahoe River	McNeals Branch at Route 666	TMCNE666	18	113
Atlantic	Mill Branch at Route 684	AMILL684	23	150
Hospitality Branch	Three Pond Branch at Route 54	HTHREE54	28	128
Tuckahoe River	Mill Creek at Route 557	TMILL557	31	12
Hospitality Branch	Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	33	195
Hospitality Branch	Marsh Lake Branch at Unexpected Road	HMAUNEXS	40	51
Tuckahoe River	Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	42	193
Lower Great Egg Harbor River	Gibson Creek at Route 50	LGIBSO50	45	7
Middle Great Egg Harbor River	Deep Run at Route 559	MDEEP559	51	0
Middle Great Egg Harbor River	Mare Run at Route 559	MMARE559	51	30
Hospitality Branch	Marsh Lake Branch at Blue Anchor Road	HMABLUEA	53	187
Hospitality Branch	White Oak Branch at Jackson Road	HWOJACKS	54	139
Lower Great Egg Harbor River	Watering Race Branch at Route 50	LWATER50	60	95
Tuckahoe River	Tuckahoe River at Route 49 near Head Of River	TTU49HED	65	79
Lower Great Egg Harbor River	Babcock Creek at Route 322	LBABC322	82	101
Lower Great Egg Harbor River	Gravelly Run at Route 559	LGRAV559	91	78
Lower Great Egg Harbor River	South River at Forty Wire Road	LSOFORTY	99	104
Lower Great Egg Harbor River	Stephen Creek at Route 50	LSTEP50S	104	48
Tuckahoe River	Tuckahoe River at Route 637	TTUCUMBS	105	108
Lower Great Egg Harbor River	South River at Estelle Avenue	LSOESTEL	105	135
Lower Great Egg Harbor River	South River at Route 552	LSOUT552	112	46
Upper Great Egg Harbor River	Penny Pot Stream at Eighth Street	UPENN8TH	125	103
Lower Great Egg Harbor River	Stephen Creek at Eleventh Avenue	LSTELEVE	139	85
Hospitality Branch	Hospitality Branch at Route 538	HHORT538	143	124
Middle Great Egg Harbor River	Great Egg Harbor River at Route 559	MGREA559	148	99
Upper Great Egg Harbor River	Great Egg Harbor River at Eighth Street	UGR8THST	162	146
Upper Great Egg Harbor River	Four Mile Branch at Route 536	UFORT536	173	147
Atlantic	Maple Run at Route 662	AMAMILLR	174	106
Hospitality Branch	Hospitality Branch at Route 633	HHOBLUEB	182	105
Upper Great Egg Harbor River	Great Egg Harbor River at Route 723	UGRRT723	182	112
Hospitality Branch	Whitehall Branch at Blue Bell Road	HWHBLUEB	192	113
Middle Great Egg Harbor River	Deep Run at Eighth Street	MDEPANCS	215	123
Upper Great Egg Harbor River	Great Egg Harbor River Route 536 Spur	UGR536SP	217	98
Upper Great Egg Harbor River	Great Egg Harbor River at Route 691	UGRRT691	230	121
Upper Great Egg Harbor River	Squankum Branch at Malaga Road	USQMALAG	248	100

Table 3.5. Raw DCA axis 1 and axis 2 species scores for 138 plants included in the stream-vegetation analysis based on an ordination of species presence/absence data. Species are ordered by axis 1 scores.

Species	Axis 1	Axis 2	Species	Axis 1	Axis 2	Species	Axis 1	Axis 2
Myrica pensylvanica	-169	-242	*Liquidambar styraciflua*	9	-60	*Salix sp.*	165	267
Carex bullata	-165	297	*Glyceria obtusa*	9	205	*Phragmites australis*	166	291
Juncus militaris	-165	297	*Apios americana*	10	102	*Nyssa sylvatica*	168	43
Drosera intermedia	-158	-142	*Juncus pelocarpus*	10	222	*Panicum clandestinum*	178	138
Eleocharis flavescens var. olivacea	-156	280	*Carex atlantica*	12	-18	*Rubus hispidus*	179	33
Ilex glabra	-151	-194	*Aster novi-belgii*	18	32	*Vitis labrusca*	183	55
Pinus rigida	-140	-199	*Mitchella repens*	27	-135	*Lonicera japonica*	184	-56
Gaylussacia frondosa	-132	-208	*Ilex verticillata*	27	77	*Viola sp.*	185	-15
Lachnanthes caroliniana	-129	435	*Aronia arbutifolia*	31	-23	*Thelypteris palustris*	188	258
Amelanchier canadensis	-127	-85	*Viola lanceolata*	34	251	*Ludwigia alternifolia*	191	279
Eleocharis robbinsii	-127	344	*Cephalanthus occidentalis*	40	228	*Polygonum hydropiperoides*	193	231
Oxypolis rigidior	-125	40	*Sagittaria engelmanniana*	43	126	*Osmunda cinnamomea*	197	-35
Potamogeton oakesianus	-125	390	*Vaccinium corymbosum*	47	85	*Viburnum dentatum*	202	138
Smilax walteri	-124	97	*Peltandra virginica*	48	104	*Onoclea sensibilis*	203	145
Rhynchospora macrostachya	-113	434	*Parthenocissus quinquefolia*	49	71	*Polygonum punctatum*	203	158
Eupatorium resinosum	-111	425	*Iris versicolor*	51	114	*Ludwigia palustris*	217	206
Alnus serrulata	-106	186	*Carex collinsii*	57	223	*Cyperus strigosus*	226	27
Chamaedaphne calyculata	-94	205	*Eubotrys racemosa*	59	9	*Toxicodendron radicans*	227	87
Viburnum nudum var. nudum	-79	185	*Scirpus cyperinus*	59	183	*Phalaris arundinacea*	238	228
Chamaecyparis thyoides	-76	27	*Prunus serotina*	59	342	*Galium tinctorium*	242	169
Potamogeton confervoides	-72	-27	*Quercus phellos*	63	-111	*Cuscuta sp.*	256	226
Potamogeton epihydrus	-68	360	*Lobelia cardinalis*	69	186	*Aster vimineus*	261	156
Nymphaea odorata	-66	300	*Triadenum virginicum*	71	225	*Lycopus virginicus*	264	145
Carex stricta	-56	-133	*Ilex opaca*	85	-14	*Agrostis perennans*	265	176
Panicum verrucosum	-56	258	*Juniperus virginiana*	86	18	*Rosa multiflora*	265	204
Hypericum canadense	-55	160	*Itea virginica*	90	-75	*Juncus tenuis*	272	64
Euthamia tenuifolia	-55	276	*Carex atlantica var. capillacea*	90	-7	*Carex lurida*	273	80
Scirpus subterminalis	-51	186	*Rhexia virginica*	90	212	*Bidens frondosa*	275	191
Eriocaulon aquaticum	-47	144	*Juncus canadensis*	91	216	*Carex albolutescens*	278	114
Woodwardia virginica	-47	215	*Cardamine sp.*	94	42	*Polygonum cespitosum*	279	106
Kalmia angustifolia	-37	-124	*Lyonia ligustrina*	103	36	*Hypericum mutilum*	284	210
Pontederia cordata	-31	275	*Spiraea tomentosa*	109	322	*Scutellaria lateriflora*	289	152
Utricularia fibrosa	-29	313	*Acer rubrum*	112	61	*Typha latifolia*	295	218
Rhododendron viscosum	-22	48	*Decodon verticillatus*	118	125	*Dioscorea villosa*	300	-32
Nuphar variegata	-22	139	*Panicum dichotomum*	121	-5	*Microstegium vimineum*	311	98
Dulichium arundinaceum	-17	276	*Clethra alnifolia*	126	51	*Mikania scandens*	314	160
Eleocharis acicularis	-15	368	*Eupatorium dubium*	130	70	*Polygonum sagittatum*	321	143
Smilax glauca	-13	-207	*Smilax rotundifolia*	138	72	*Boehmeria cylindrica*	325	165
Magnolia virginiana	-6	84	*Woodwardia areolata*	143	21	*Callitriche heterophylla*	346	95
Carex folliculata	-1	23	*Sparganium americanum*	144	71	*Sambucus canadensis*	346	182
Oxalis stricta	0	122	*Panicum virgatum*	145	-29	*Impatiens capensis*	368	97
Carex crinita	2	-234	*Solidago rugosa*	147	330	*Bidens connata*	371	116
Eleocharis tenuis	6	335	*Leersia oryzoides*	156	101	*Ceratophyllum echinatum*	374	99
Osmunda regalis	8	119	*Juncus effusus*	160	140	*Rubus sp.*	383	72
Lysimachia terrestris	8	140	*Lycopus uniflorus*	161	147	*Polygonum arifolium*	404	76
Sabatia difformis	8	291	*Utricularia geminiscapa*	163	199	*Lemna sp.*	412	133

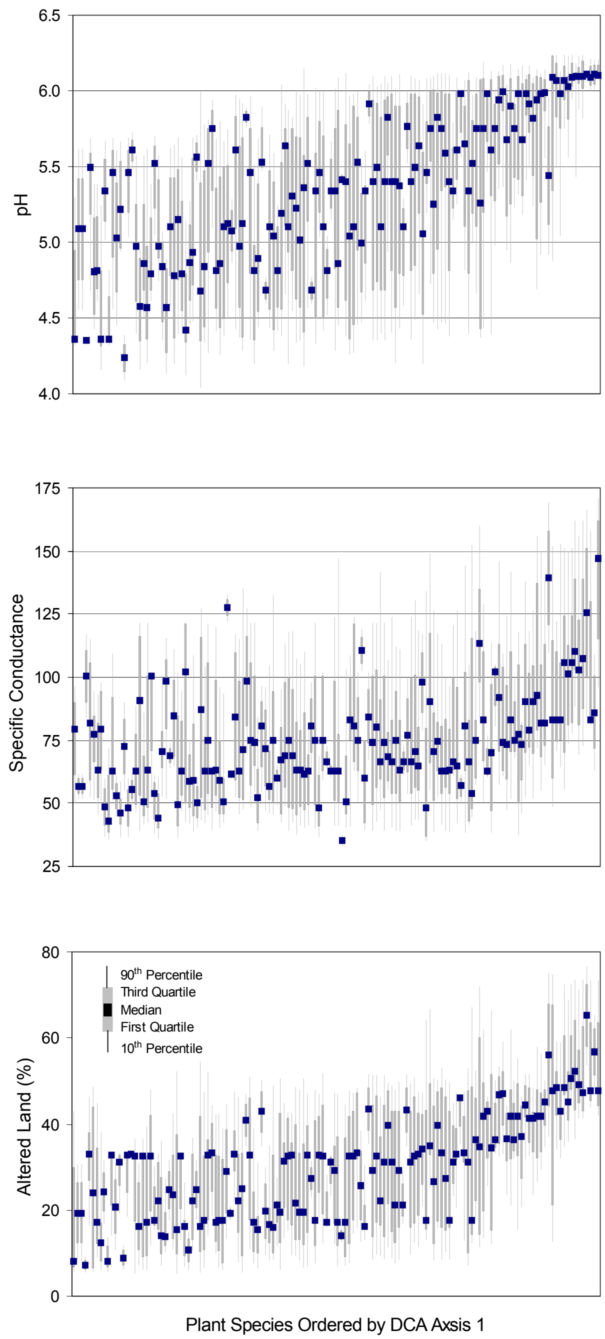

Figure 3.6. The pH, specific conductance (μS cm^{-1}) and percentage of altered land (developed land and upland agriculture) associated with plant species found at 36 stream sites. Refer to Table 3.5 for species names ordered by DCA axis 1 scores.

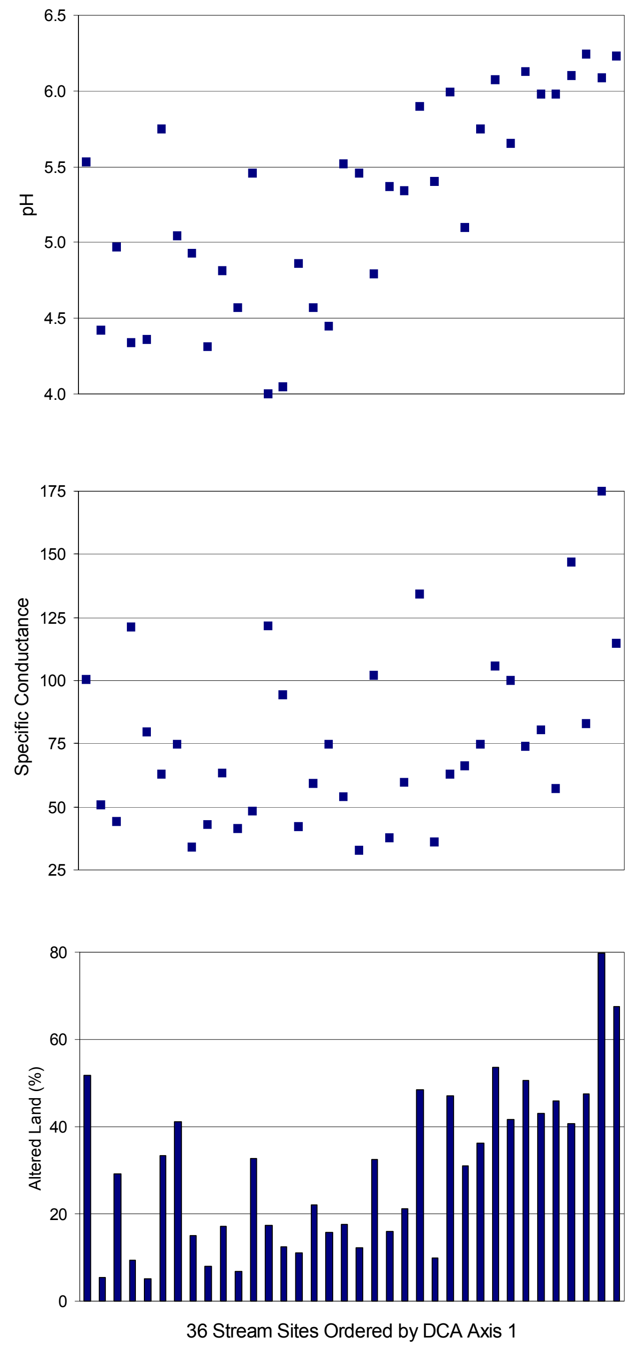

Figure 3.7. The pH, specific conductance (μS cm^{-1}) and percentage of altered land (developed land and upland agriculture) for 36 Great Egg Harbor River WMA stream sites. DCA axis 1 represents a stream-vegetation community gradient. Refer to Table 3.4 for site names ordered by DCA axis 1 scores.

Middle Great Egg Harbor River study basin, represented by DCA axis 1 scores, was highly variable (Table 3.4, Figure 3.9). The percentage of Pine Barrens District species ranged from a low of 4 (Deep Run at Eighth Street) to a maximum of 36 (Mare Run at Route 559) at sites in this study basin (Figure 3.10). Non-Pinelands species comprised over half of the species present at two of the sites. From one to ten disturbance-indicator species were found at sites in this study basin.

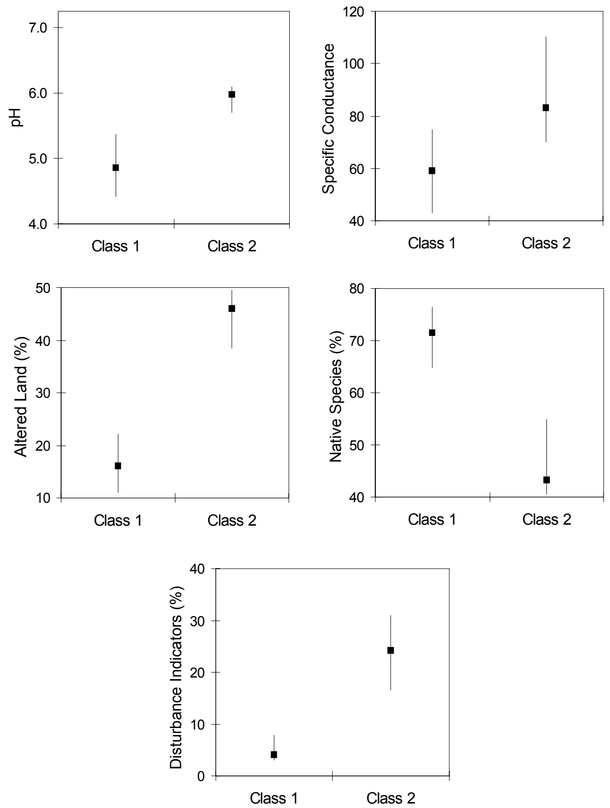

Figure 3.8. Median and first and third quartile specific conductance (μS cm^{-1}), pH, percentage of altered land (developed land and upland agriculture), percentage of native species (Pine Barrens District and wide-ranging species), and percentage of disturbance-indicator species for two TWINSPAN-derived site classes for 36 Great Egg Harbor River WMA stream sites.

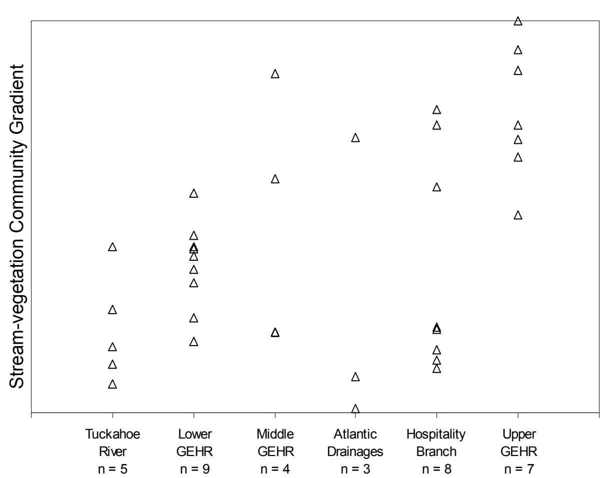

Figure 3.9. Position of stream-vegetation survey sites along the stream-vegetation community gradient, represented by DCA axis 1 site scores, in six Great Egg Harbor River WMA study basins. Refer to Table 3.4 for site names ordered by DCA axis 1 scores.

Hospitality Branch

The vegetation composition of the eight sites in the Hospitality Branch study basin was highly variable, with sites clustering at opposite ends of the stream-vegetation community gradient (Table 3.4, Figure 3.9). A group of five sites was associated with the end of the community gradient characterized by a relatively high percentage of Pine Barrens District species and a relatively low percentage of non-Pinelands species when compared with the three sites at the other end of the gradient (Figure 3.10). Disturbance-indicator species were present at all but one of the sites in this basin. Hospitality Branch at the Pennsylvania/Reading Railroad Bridge had the highest species richness (66 species) of all the study sites in the Great Egg Harbor River WMA.

Upper Great Egg Harbor River

All Upper Great Egg Harbor River study-basin sites were located toward the end of the community gradient characterized by a low percentage of Pine Barrens district species and a high percentage non-Pinelands species (Table 3.4, Figures 3.9 and 3.10). The percentage of Pine Barrens district species for several sites in this basin was among the lowest of all the study sites in the Great Egg Harbor River WMA. From eight to 15 disturbance-indicator species were present at sites in the Upper Great Egg Harbor River study basin.

Atlantic Drainages

A high percentage of Pine Barrens District species was found at Mill Branch at Route 684 and North Branch Absecon Creek at the Garden State Parkway (Table 3.4, Figures 3.9 and 3.10) despite the presence of considerable altered land in their land-use profiles. A single disturbance-indicator species occurred at one of the sites. In contrast, Maple Run at Route 662 supported a low percentage of Pine Barrens District species, a high percentage of non-Pinelands species, and seven disturbance-indicator species.

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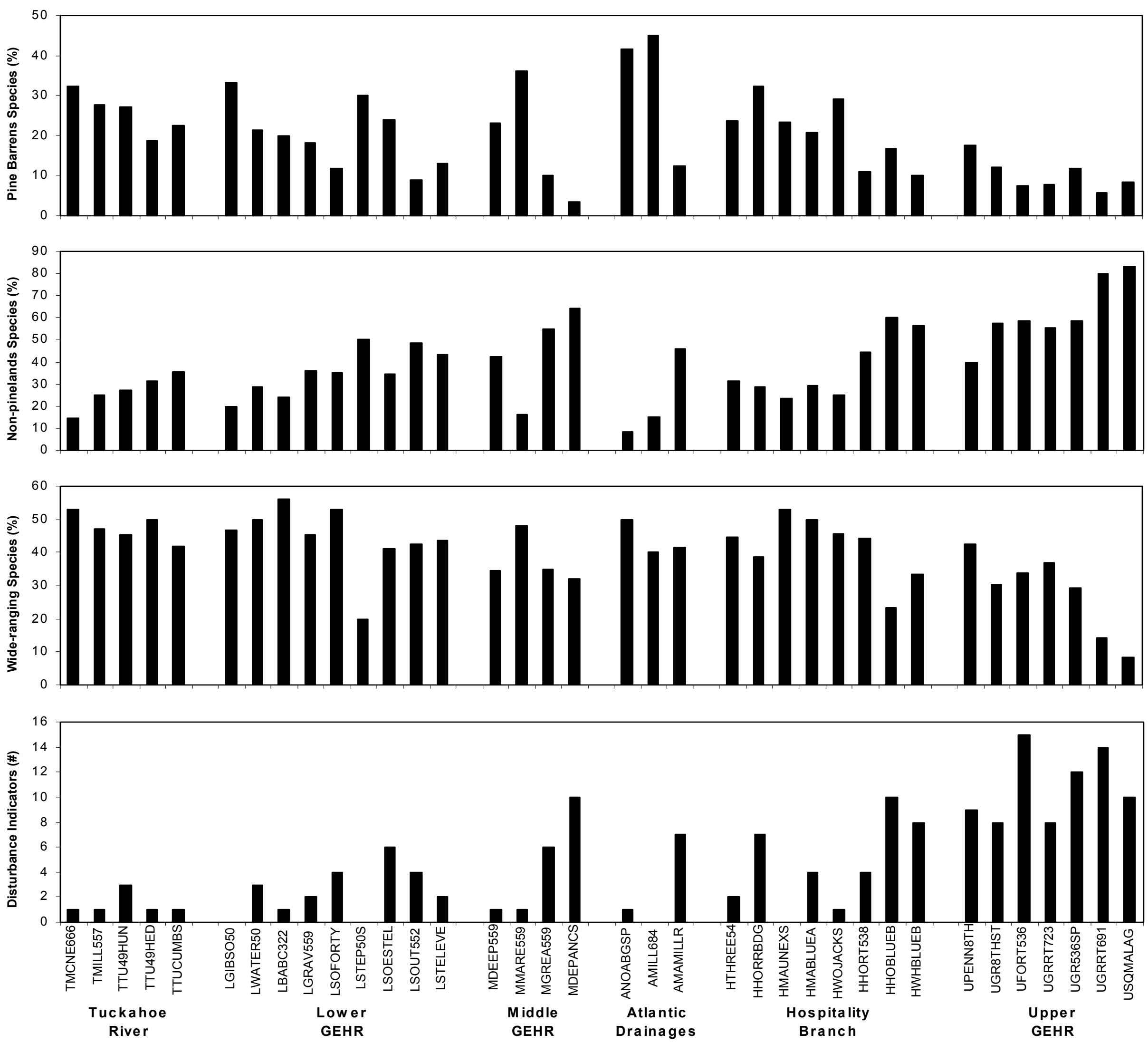

Figure 3.10. The percentage of Pine Barrens District, wide-ranging, and non-Pinelands species and number of disturbance-indicator species present at 36 stream sites in the Great Egg Harbor River WMA. Wide-ranging species are native to both the Pine Barrens District and the Middle District. Non-Pinelands species include plants native to the Middle District and exotic species. Stream-site codes are ordered by DCA axis 1 scores within each study basin. The six study basins are ordered by increasing percentage of altered land. Refer to Table 3.4 for site code explanations.

4 Fish Assemblages

Introduction

Results from previous Commission studies in the Mullica River and Rancocas Creek basins (Zampella and Bunnell 1998, Zampella et al. 2001, 2003) indicated that the presence of peripheral and introduced fish species was associated with basins characterized by a high percentage of upland agriculture and developed land and surface waters with elevated pH and specific conductance values. Peripheral species are normally distributed outside the Pinelands and introduced species are not native to New Jersey (Hastings 1984). In this report, peripheral and introduced species are referred to as nonnative to the Pinelands. In contrast to assemblages with nonnative fish present, relatively unaltered basins supported fish assemblages composed only of native Pinelands species. Hastings (1984) categorized the native Pinelands fish species as restricted-characteristic and widespread-characteristic. Restricted-characteristic species are generally limited to the Pinelands, whereas widespread-characteristic species are distributed throughout most of the state. In 2002, Commission scientists surveyed fish in Great Egg Harbor River Watershed Management Area (WMA) streams and impoundments. The results of this assessment are presented in this chapter.

Methods

Study Sites

Thirty-two stream sites and 10 impoundments were surveyed in the Great Egg Harbor River WMA (Tables 4.1 and 4.2). Stream sites were typically located at road crossings, where the water tended to be relatively deep and where pools were more common. Nonnative fish are more likely to be found in pool habitats because most of these species are typical of lake and pond environments (Hastings 1984). The majority of the stream sites were located at New Jersey Department of Environmental Protection Ambient Biomonitoring Network (NJDEP AMNET) stations. Other criteria used to select survey sites were drainage-area land-use characteristics, accessibility, and suitability as fish-survey sites. Sampling reaches consisted of a 20-m length of stream divided into two 10-m sections located upstream and downstream of a

Table 4.1. Median pH and specific conductance (μS cm^{-1}) values and the percentage of developed land, upland agricultural land, and altered land (developed land and upland agriculture) for 32 Great Egg Harbor River WMA stream-fish survey sites. Water quality was measured at the stream-fish sites, except for UGR8THST (measured upstream at UGRERT54) and TTARKBOG (measured downstream at TTAR548S). Refer to Chapter 2 for details regarding water-quality monitoring.

Site Code	pH	SC	Dev. Land	Upland Agric.	Altered Land
AMAMILLR	5.7	100	41.0	0.7	41.7
AMILL684	5.0	44	27.4	1.8	29.3
ANOABGSP	5.5	100	51.5	0.2	51.7
HFAJACKS	5.0	40	11.4	7.5	19.0
HHOBLUEB	6.1	74	20.0	30.7	50.7
HHORRBDG	5.8	63	14.6	18.7	33.3
HHORT538	6.0	63	24.3	22.7	47.0
HMABLUEA	5.5	48	6.9	25.8	32.7
HWHRT659	6.0	57	24.9	21.1	45.9
LBABC322	4.6	59	14.3	7.8	22.1
LGIBSO50	4.3	43	6.4	1.7	8.1
LGRAV559	4.5	75	14.4	1.5	15.8
LSOESTEL	4.8	102	13.0	19.4	32.4
LSOFORTY	5.5	54	9.1	8.4	17.5
LSOUT552	5.3	60	10.1	11.1	21.2
LSTEP50S	5.5	33	9.1	3.0	12.2
MDEEP559	4.8	63	9.3	7.8	17.1
MDEPANCS	6.1	147	19.4	21.3	40.7
MGREA559	5.1	66	18.3	12.7	31.1
MMARE559	4.6	41	4.6	2.2	6.9
TMCNE666	4.4	51	4.9	0.5	5.4
TTARKBOG	4.8	61	2.5	5.8	8.3
TTU49HED	4.9	42	3.7	7.4	11.1
TTU49HUN	4.9	34	5.2	9.9	15.0
UFORT536	6.1	106	42.4	11.2	53.6
UGR536SP	6.2	83	40.0	7.6	47.6
UGR8THST	5.8	75	27.9	7.8	35.7
UGREA536	5.9	87	35.9	7.9	43.8
UGRRT691	6.1	177	72.9	6.7	79.7
UGRRT723	6.0	80	34.5	8.6	43.1
UPENN8TH	5.9	134	15.0	33.5	48.5
UPENNY54	5.2	114	16.5	31.4	47.9

Table 4.2. Median pH and specific conductance (μS cm^{-1}) values and the percentage of developed land, upland agricultural land, and altered land (developed land and upland agriculture) for 10 Great Egg Harbor River WMA impoundment-fish survey sites. Water quality was measured at the outflow of impoundments, except for LSTMAPLE (measured upstream at LSTELEVE), LWA50BOG (measured downstream at LWATER50), and UGRBPARK (measured downstream at UGRRT5691). Refer to Chapter 2 for details regarding water-quality monitoring.

Site Code	pH	SC	Dev. Land	Upland Agric.	Altered Land
HFAJACKL	5.0	40	11.4	7.5	19.0
HHOTIMBD	6.0	72	22.7	28.0	50.7
HMAJACKS	5.1	50	7.0	27.6	34.6
LSTMAPLE	5.4	36	11.1	2.4	13.5
LWA50BOG	4.1	94	6.8	4.5	11.4
MGRLENAP	4.8	75	15.6	10.7	26.2
MMKPEACU	4.0	139	9.5	1.7	11.2
TTUCUMBL	5.4	38	9.1	7.0	16.1
TWAAETNA	4.2	66	1.4	3.6	5.0
UGRBPARK	6.1	177	82.5	2.8	85.3

bridge or road crossing or a single 20-m upstream or downstream section. The location of each sampling station was determined using the NJDEP AMNET coverage or orthophotoquads and a geographic information system.

Characterizing Stream Conditions

Several site-specific and regional watershed-disturbance variables were used to characterize each fish-survey site. The variables included pH, specific conductance, and land use (Tables 4.1 and 4.2). Specific conductance and pH were measured under baseflow conditions at or near stream and impoundment sampling sites (Chapter 2). Upstream land-use profiles were prepared using ArcView software and NJDEP 1995/1997 land-use data (Chapter 1).

Fish Surveys

Fish-sampling methods were the same as those used in the Rancocas Creek Basin study (Zampella et al. 2003). At each stream station, all habitats within the 20-m long stream reach were sampled using a 4-mm mesh nylon seine. Stream sites were sampled for 15 minutes on one occasion between June and October 2002. In October 2004, stream sites where nonnative fish were not found in 2002 were sampled again using the same methods. Fish collected during both sampling events were pooled for the analysis. Impoundments were sampled on a single occasion for 30 minutes between June and October 2002.

The fish-survey data, which include the number of individuals of each species collected at each site and distribution maps for each species, are presented in Appendix 3. This appendix also describes the location of each sampling site and includes latitude and longitude. Taxonomic nomenclature follows that used in Page and Burr (1991). The Commission maintains a fish collection that includes voucher specimens for each site.

The number of individuals collected at a site was used to determine presence/absence and to calculate relative abundance. Relative abundance was calculated as: (number of individuals of a species/total number of individuals) × 100. Some juvenile *Esox* species (*E. niger* or *E. americanus*), *Enneacanthus* species (*E. obesus* or *E. gloriosus*), and *Lepomis* species (*L. gibbosus* or *L. macrochirus*) could not be identified to species and were not included in subsequent data analyses.

Fish-community Gradients

Detrended correspondence analysis (DCA) was used to order fish species and survey sites based on presence/absence data. The same data were used to classify or group species and sites using TWINSPAN. These techniques are described in greater detail in Zampella et al. (2001) and Chapter 3. Stream sites and impoundments were analyzed separately. Because rare species can have a disproportionate effect on ordinations, only species occurring at more than one site were included in the gradient analyses. The yellow perch, which was the only species collected from two stream sites, was also excluded from the stream ordination. Deleting this species improved the ordering of the sites along the first DCA axis.

Spearman rank correlation and graphical analysis were used to determine if the fish-community composition of streams and impoundments, represented by the DCA-ordination axes, varied in relation to environmental factors. The environmental variables included pH, specific conductance, and the percentage of developed land, upland agriculture, and altered land (developed land and upland agriculture) in a basin.

For streams and impoundments, differences in biogeography and watershed conditions between the first two TWINSPAN-derived site classes were compared using Mann-Whitney U tests. Biogeography was represented by the percentage composition of native and nonnative fish species. Watershed conditions were represented by pH, specific conductance, and the percentage of altered land (developed land and upland agriculture). To determine if watershed conditions differed between sites with only native species and those with native and nonnative species present, Mann-Whitney U tests were used to compare pH, specific conductance, and altered-land values between sites with and without nonnatives. Logistic regression was used to estimate the probability of finding nonnative species at various pH, specific conductance, and altered-land values for streams and impoundments. An alpha level of 0.05 was used to identify important relationships revealed by the correlation and logistic regression analyses and to evaluate differences between the various site groups.

RESULTS

Stream-fish Surveys

The number of individuals collected per site ranged from 9 to 122. The mean (±1 SD) and median number of individuals per site was 37.6 (±26.0) and 29.5, respectively. Twenty-two fish species were represented, including 13 native Pinelands species, six peripheral species, and three introduced species (Table 4.3). Species richness ranged from 3 to 13 species per site, with a mean (±1 SD) and median richness of 8.1 (±2.6) and 8.0, respectively.

Native species were present at all stream sites (Figures 4.1 and 4.2). The chain pickerel, pirate perch, swamp darter, and eastern mudminnow, which were the most frequently encountered native species, were collected from over two-thirds of the sites (Figure 4.2). The mean relative abundance of native fish was 71% (Figure 4.3). The most abundant native species were the swamp darter and eastern mudminnow.

Nonnative species were present at 78% of the stream sites (Figures 4.1 and 4.2). The most frequently encountered nonnative species were the tessellated darter, pumpkinseed, bluegill, and golden shiner. These four species were collected from 25% to 44% of the sites (Figure 4.2). The mean relative abundance of nonnative fish was 29% (Figure 4.3).

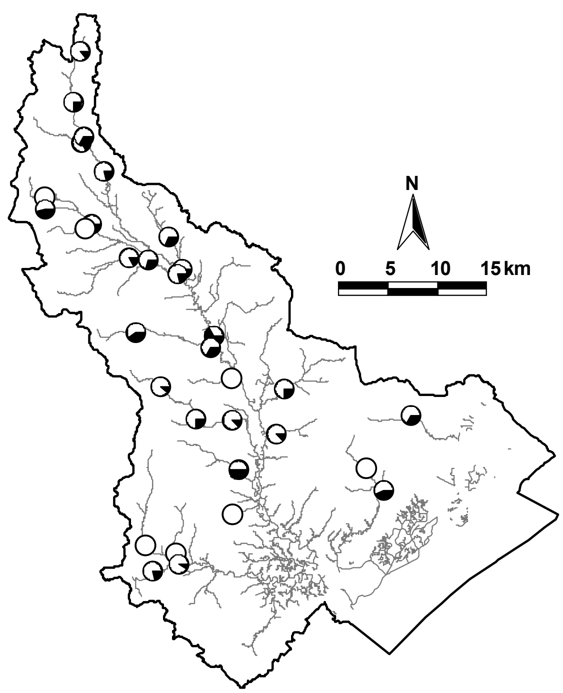

Figure 4.1. Pie charts showing the percentage of native species (white) and nonnative species (black) present at 32 Great Egg Harbor River WMA stream sites.

Table 4.3. Common and scientific names for 22 fish species collected in Great Egg Harbor River WMA streams and impoundments. A positive sign (+) indicates that the species was present and a negative sign (-) indicates that a species was not collected during the surveys. Nomenclature follows Page and Burr (1991). Biogeographic classification is from Hastings (1979, 1984).

Scientific Name	Species Code	Common Name	Streams	Imps.
Native Pinelands Species				
Restricted-characteristic Species				
Acantharchus pomotis	AcanPomo	mud sunfish	+	+
Ameiurus natalis	AmeiNata	yellow bullhead	+	+
Aphredoderus sayanus	AphrSaya	pirate perch	+	+
Enneacanthus chaetodon	EnneChae	blackbanded sunfish	+	+
Enneacanthus obesus	EnneObes	banded sunfish	+	+
Etheostoma fusiforme	EtheFusi	swamp darter	+	+
Widespread-characteristic Species				
Anguilla rostrata	AnguRost	American eel	+	+
Enneacanthus gloriosus	EnneGlor	bluespotted sunfish	+	+
Erimyzon oblongus	ErimOblo	creek chubsucker	+	+
Esox americanus	EsoxAmer	redfin pickerel	+	-
Esox niger	EsoxNige	chain pickerel	+	+
Noturus gyrinus	NotuGyri	tadpole madtom	+	-
Umbra pygmaea	UmbrPygm	eastern mudminnow	+	+
Non-Pinelands Species				
Peripheral Species				
Ameiurus nebulosus	AmeiNebu	brown bullhead	+	-
Etheostoma olmstedi	EtheOlms	tessellated darter	+	-
Fundulus diaphanus	FundDiap	banded killifish	+	-
Lepomis gibbosus	LepoGibb	pumpkinseed	+	+
Notemigonus crysoleucas	NoteChry	golden shiner	+	+
Perca flavescens	PercFlav	yellow perch	+	+
Introduced Species				
Lepomis macrochirus	LepoMacr	bluegill	+	+
Micropterus salmoides	MicrSalm	largemouth bass	+	+
Pomoxis nigromaculatus	PomoNigr	black crappie	+	+

The most abundant nonnative species was the tessellated darter, which, on average, was more abundant than most native species. The banded killifish and black crappie were present at only one site each.

Impoundment-fish Surveys

The number of individuals collected per site ranged from 34 to 297. The mean (±1 SD) and median number of individuals per site was 134.6 (±90.4) and 128.5. Seventeen fish species were represented, including 11 native Pinelands species, three peripheral species, and three introduced species (Table 4.3). Species richness ranged from 4 to 8 species per site, with a mean (± 1 SD) and median richness of 6.2 (±1.1) and 6.0, respectively.

Native species were present in all but one of the 10 impoundments. The chain pickerel, swamp darter, banded sunfish, and bluespotted sunfish occurred at more than 50% of the sites (Figure 4.4). The mean relative abundance of native fish was 58% (Figure 4.5). The banded sunfish was the most abundant native species in the impoundment assemblages. The redfin pickerel and tadpole madtom were the only native species not collected from impoundments.

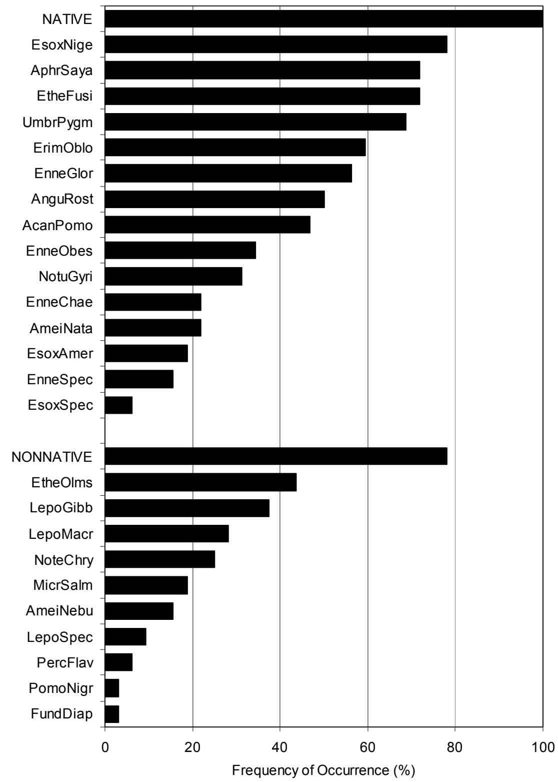

Figure 4.2. Frequency of occurrence of fish species at 32 Great Egg Harbor River WMA stream sites. Refer to Table 4.3 for key to fish names.

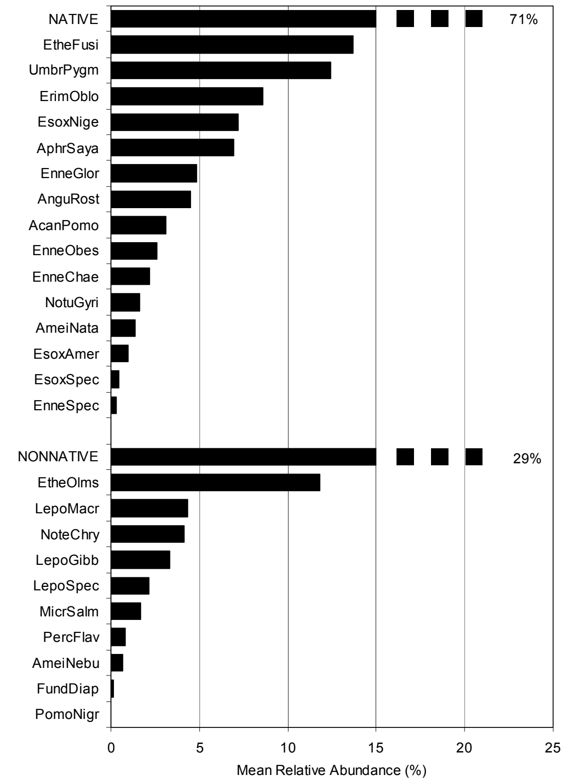

Figure 4.3. Mean relative abundance of fish species at 32 Great Egg Harbor River WMA stream sites. Refer to Table 4.3 for key to fish names.

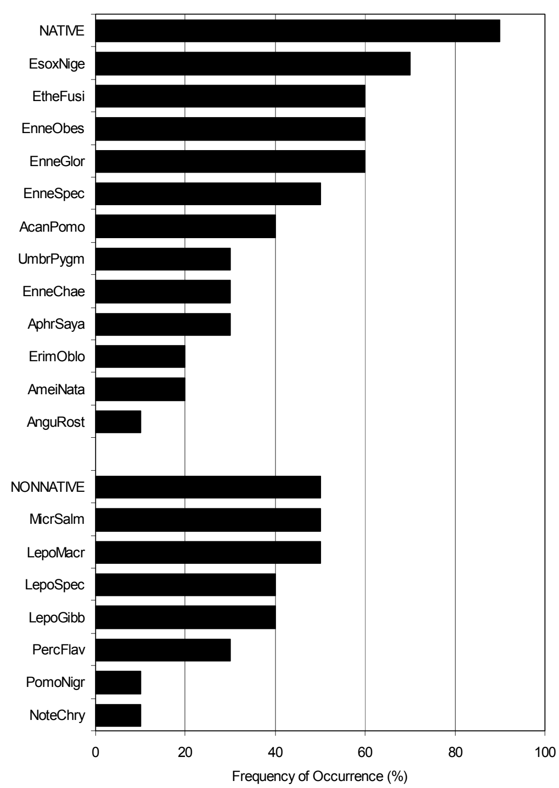

Figure 4.4. Frequency of occurrence of fish species at 10 Great Egg Harbor River WMA impoundments. Refer to Table 4.3 for key to fish names.

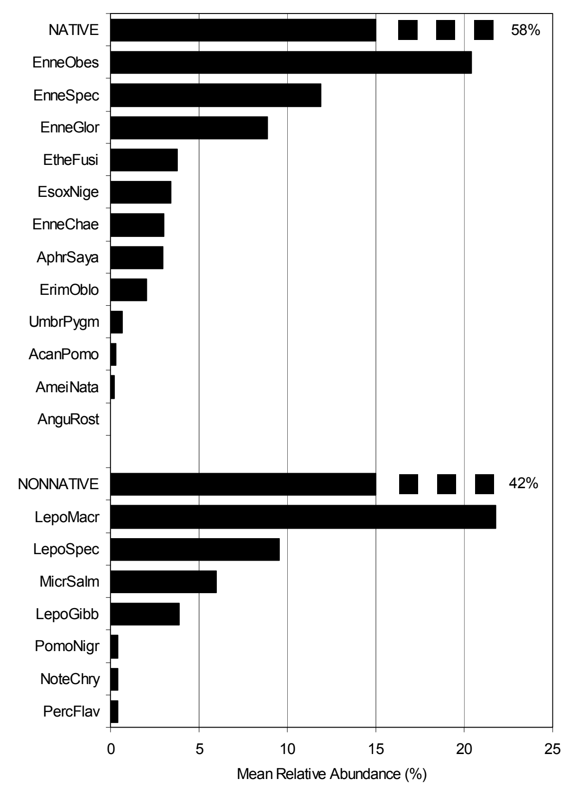

Figure 4.5. Mean relative abundance of fish species at 10 Great Egg Harbor River WMA impoundments. Refer to Table 4.3 for key to fish names.

Nonnative species were present at 50% of the impoundments (Figure 4.6). The most frequently encountered nonnative species were the largemouth bass and bluegill (Figures 4.4). The mean relative abundance of nonnative fish was 42% (Figure 4.5). The bluegill was the most abundant nonnative species and, on average, was more abundant than any native species. Although present at some stream sites, the brown bullhead, tessellated darter, and banded killifish were absent from all 10 impoundments (Table 4.3). An important difference between the stream and impoundment survey results was a greater frequency of occurrence and greater relative abundance for pumpkinseeds, bluegills, and largemouth bass in impoundments. Similar results were found during fish surveys in the Mullica River Basin (Zampella et al. 2001).

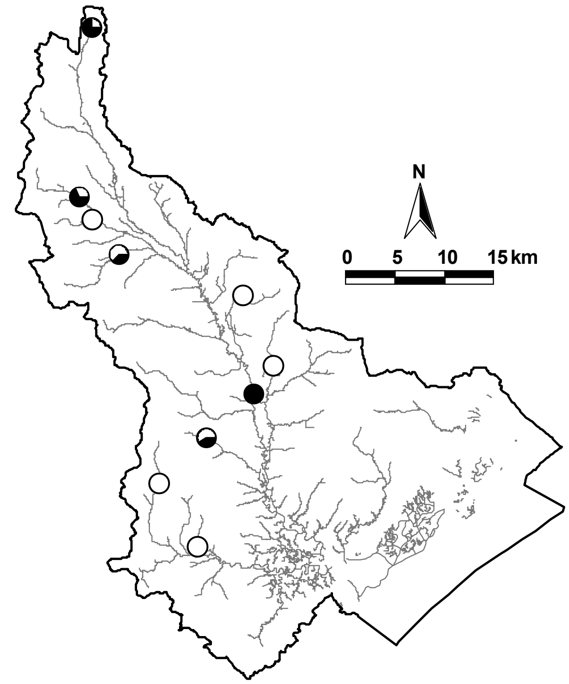

Figure 4.6. Pie charts showing the percentage of native species (white) and nonnative species (black) present at 10 Great Egg Harbor River WMA impoundments.

Stream-fish Community Gradient

The first DCA axis of the site ordination contrasted stream sites with fish assemblages composed primarily of native species with those supporting a higher percentage of nonnative species (Tables 4.4 and 4.5, Figure 4.7). The percentage of native species decreased (r = -0.46, $p = 0.008$) and the percentage of nonnative species increased (r = 0.46, $p = 0.008$) along this community gradient (Figure 4.8). Although most nonnative species were more closely associated with sites on the right side of the ordination diagram, the tessellated darter was associated with sites on the left side of the diagram. Nonnative fish species were generally found at stream sites with higher pH, specific conductance, and altered-land values (Figure 4.9).

Table 4.4. Raw DCA axis 1 and axis 2 site scores for 19 stream-fish species and 14 impoundment-fish species in the Great Egg Harbor River WMA. Species are ordered by axis 1 scores. Nonnative species are indicated with an asterisk. Refer to Table 4.3 for key to fish names.

Stream Fish				Impoundment Fish			
Species	Species Code	Axis 1	Axis 2	Species	Species Code	Axis1	Axis2
Esox americanus	EsoxAmer	-114	-175	*Ameiurus natalis*	AmeiNata	-138	113
Anguilla rostrata	AnguRost	-88	130	*Acantharchus pomotis*	AcanPomo	-66	-73
Etheostoma olmstedi	EtheOlms *	-61	277	*Erimyzon oblongus*	ErimOblo	-56	77
Umbra pygmaea	UmbrPygm	-28	82	*Enneacanthus obesus*	EnneObes	-18	83
Esox niger	EsoxNige	60	111	*Enneacanthus chaetodon*	EnneChae	7	102
Etheostoma fusiforme	EtheFusi	66	154	*Umbra pygmaea*	UmbrPygm	64	332
Erimyzon oblongus	ErimOblo	91	-36	*Etheostoma fusiforme*	EtheFusi	89	176
Aphredoderus sayanus	AphrSaya	102	30	*Aphredoderus sayanus*	AphrSaya	104	-110
Enneacanthus obesus	EnneObes	116	-8	*Esox niger*	EsoxNige	126	-84
Acantharchus pomotis	AcanPomo	130	-91	*Enneacanthus gloriosus*	EnneGlor	135	109
Enneacanthus gloriosus	EnneGlor	141	98	*Lepomis macrochirus*	LepoMacr *	244	55
Enneacanthus chaetodon	EnneChae	154	61	*Micropterus salmoides*	MicrSalm *	244	55
Lepomis gibbosus	LepoGibb *	171	87	*Lepomis gibbosus*	LepoGibb *	341	47
Lepomis macrochirus	LepoMacr *	229	345	*Perca flavescens*	PercFlav *	379	158
Noturus gyrinus	NotuGyri	240	206				
Notemigonus crysoleucas	NoteChry *	245	-15				
Ameiurus natalis	AmeiNata	270	93				
Ameiurus nebulosus	AmeiNebu *	311	97				
Micropterus salmoides	MicrSalm *	327	149				

There was a weak, significant relationship between the order of stream sites along the first DCA axis and increasing pH (r = 0.36, p = 0.046) (Figure 4.10). Specific conductance and the percentage of upland agriculture, developed land, and altered land were not associated with the stream-community gradient.

A decrease in the percentage of native species was associated with increasing pH (r = -0.39, p = 0.027), specific conductance (r = -0.35, p = 0.049), developed land (r = -0.40, p = 0.024), and altered land (r = -0.36, p = 0.042). Opposite trends were observed for nonnative species. There was no relationship between the percentage of native and nonnative species and upland agriculture.

Table 4.5. Raw DCA axis 1 and axis 2 site scores for 32 stream sites in the Great Egg Harbor River WMA based on an ordination of species presence/absence data. Sites are ordered by axis 1 scores.

Study Basin	Site Name	Site Code	Axis 1	Axis 2
Lower Great Egg	Gibson Creek at Route 50	LGIBSO50	0	68
Lower Great Egg	South River at Estelle Avenue	LSOESTEL	4	72
Lower Great Egg	South River at Forty Wire Road	LSOFORTY	20	107
Lower Great Egg	Gravelly Run at Route 559	LGRAV559	26	99
Tuckahoe River	McNeals Branch at Route 666	TMCNE666	37	22
Upper Great Egg	Great Egg Harbor River at Route 723	UGRRT723	43	99
Lower Great Egg	South River at Route 552	LSOUT552	44	97
Middle Great Egg	Deep Run at Route 559	MDEEP559	44	116
Upper Great Egg	Great Egg Harbor River at Route 536 Spur	UGR536SP	45	121
Upper Great Egg	Great Egg Harbor River at Eighth Street	UGR8THST	51	104
Upper Great Egg	Penny Pot Stream at Eighth Street	UPENN8TH	55	166
Atlantic Drainage	Mill Branch at Route 684	AMILL684	59	60
Tuckahoe River	Tuckahoe River at Route 49 near Head Of River	TTU49HED	59	35
Upper Great Egg	Great Egg Harbor River at Route 691	UGRRT691	71	13
Hospitality Brook	Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	75	111
Middle Great Egg	Great Egg Harbor River at Route 559	MGREA559	78	259
Upper Great Egg	Four Mile Branch at Route 536	UFORT536	80	99
Lower Great Egg	Babcock Creek at Route 322	LBABC322	82	61
Tuckahoe River	Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	102	61
Hospitality Brook	Hospitality Branch at Route 633	HHOBLUEB	105	48
Tuckahoe River	Tarkiln Branch below powerline right-of-way	TTARKBOG	113	64
Hospitality Brook	Faraway Branch at Jackson Road	HFAJACKS	116	0
Middle Great Egg	Mare Run at Route 559	MMARE559	123	71
Atlantic Drainage	North Branch Absecon Creek at Garden State Parkway	ANOABGSP	126	145
Lower Great Egg	Stephen Creek at Route 50	LSTEP50S	129	192
Upper Great Egg	Penny Pot Stream at Route 54	UPENNY54	135	5
Hospitality Brook	Hospitality Branch at Route 538	HHORT538	149	137
Hospitality Brook	Whitehall Branch at Route 659	HWHRT659	152	75
Hospitality Brook	Marsh Lake Branch at Blue Anchor Road	HMABLUEA	155	80
Upper Great Egg	Great Egg Harbor River at Route 536	UGREA536	167	158
Middle Great Egg	Deep Run at Eighth Street	MDEPANCS	187	122
Atlantic Drainage	Maple Run at Route 662	AMAMILLR	210	58

Table 4.6. Raw DCA axis 1 and axis 2 site scores for 10 impoundments in the Great Egg Harbor River WMA based on an ordination of species presence/absence data. Sites are ordered by axis 1 scores.

Study Basin	Site Name	Site Code	Axis 1	Axis 2
Lower Great Egg	Watering Race Branch impoundment above Route 322	LWA50BOG	0	53
Middle Great Egg	Makepeace Lake	MMKPEACU	1	162
Hospitality Brook	Faraway Branch impoundment at Jackson Road	HFAJACKL	38	0
Tuckahoe River	Tuckahoe River impoundment at Route 637	TTUCUMBL	39	88
Tuckahoe River	Warners Mill Stream impoundment at Aetna Drive	TWAAETNA	62	17
Hospitality Brook	Cedar Lake - lower	HMAJACKS	146	68
Lower Great Egg	Maple Lake	LSTMAPLE	185	73
Upper Great Egg	Great Egg Harbor River impoundment at Berlin Park	UGRBPARK	238	18
Hospitality Brook	Timber Lake - lower	HHOTIMBD	238	100
Middle Great Egg	Lake Lenape	MGRLENAP	302	79

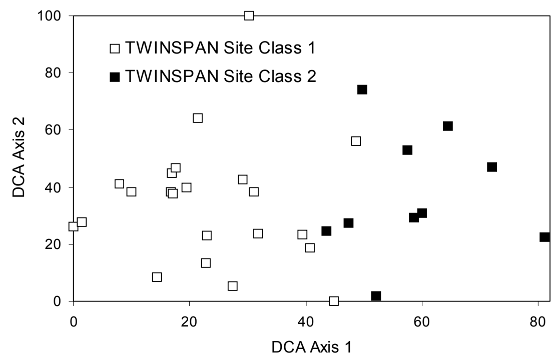

Figure 4.7. DCA ordination diagram and TWINSPAN classification for 32 Great Egg Harbor River WMA stream-fish sites. Refer to Table 4.5 for site names ordered by DCA axis 1 scores.

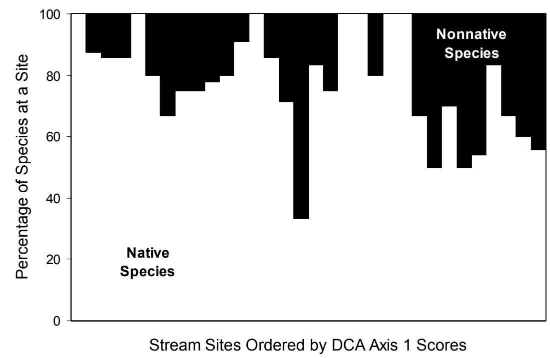

Figure 4.8. Percentage of native and nonnative fish species found at 32 Great Egg Harbor River WMA steams. Refer to Table 4.5 for site names ordered by DCA axis 1 scores.

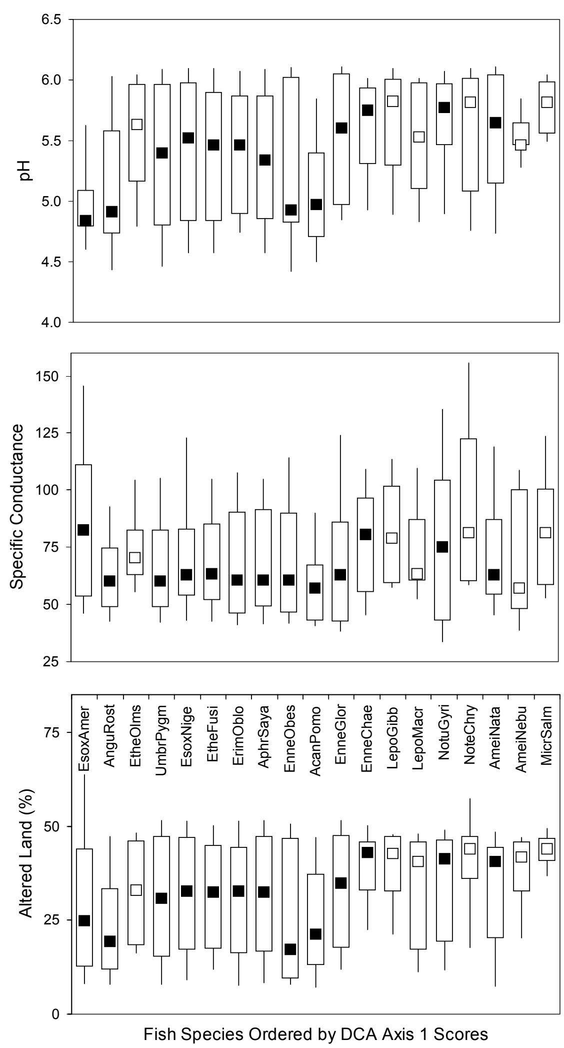

Figure 4.9. The pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) associated with fish species found at 32 Great Egg Harbor River WMA stream sites. Box plots show the first, second (median), and third quartiles and the 10th and 90th percentiles for each variable. Open squares denote nonnative fish species. Refer to Table 4.3 for key to fish names.

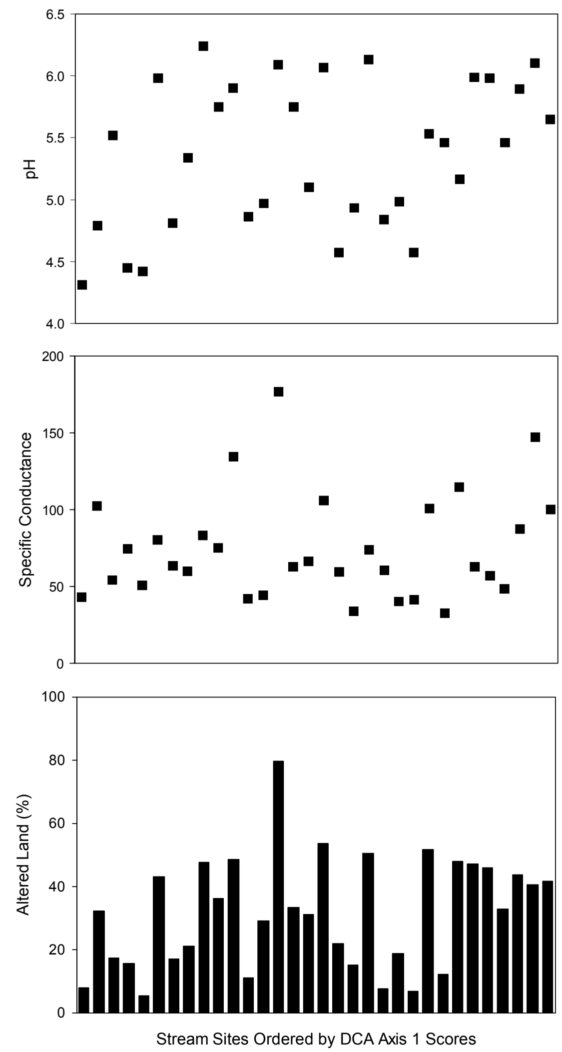

Figure 4.10. Median pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) for 32 Great Egg Harbor River WMA stream sites. DCA axis 1 represents a stream-fish community gradient. Refer to Table 4.5 for site names ordered by DCA axis 1 scores.

The first division of the TWINSPAN classification separated a group of 22 stream sites, characterized by a higher percentage of native species (Site Class 1), from a group of ten stream sites, characterized by a higher percentage of nonnative species (Site Class 2) (Figures 4.7 and 4.11). Native restricted and widespread species were present at over 90% of the sites in both site classes, but frequency of occurrence values for individual native species differed between the two groups (Figure 4.12). The redfin pickerel, American eel, eastern mudminnow, chain pickerel, and swamp darter were more frequently encountered in Site Class 1, whereas the mud sunfish, bluespotted sunfish, blackbanded sunfish, tadpole madtom, and yellow bullhead were more frequently encountered in Site Class 2. The creek chubsucker, pirate perch, and banded sunfish were almost equally represented at sites in both classes. For nonnative species, peripheral species were present at 60% of the sites in Site Class 1 and 90% of those in Site Class 2. The tessellated darter accounted for the high percentage of peripheral species in Site Class 1 and was the only nonnative species that occurred more frequently in this site class. Introduced species occurred at only 14% of sites in Site Class 1 and 80% of the sites in Site Class 2.

The mean (±1 SD) and median number of nonnative species per site was 1.2 (±0.9) and 1.0 for Site Class 1 and 3.2 (±1.9) and 3.0 for Site Class 2. Based on Mann-Whitney U tests, there was a significant difference in the percentage of native and nonnative

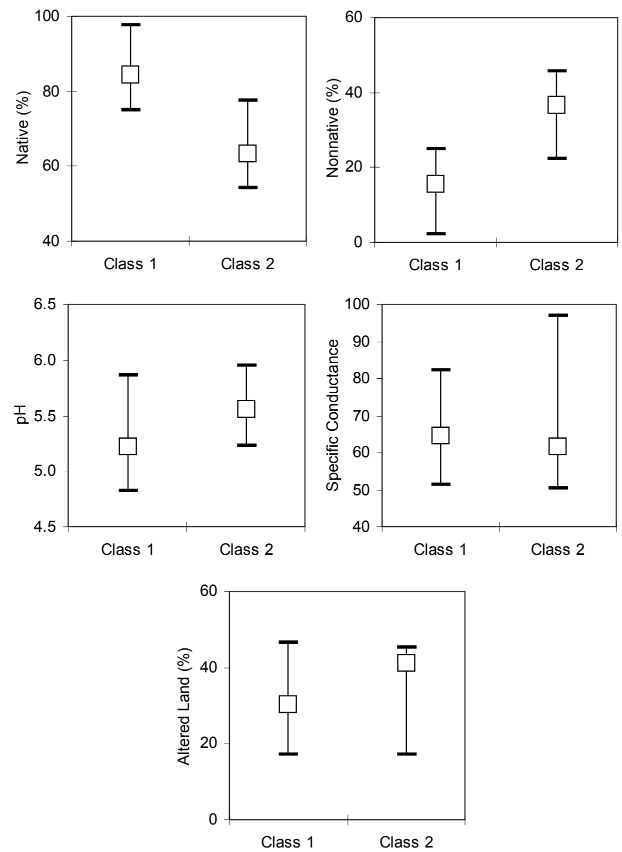

Figure 4.11. Median and 1st and 3rd quartile percentage of native and nonnative fish species, pH, specific conductance (μS cm^{-1}), and altered land (developed and upland agriculture) values for two TWINSPAN-derived site classes for 32 Great Egg Harbor River WMA stream sites.

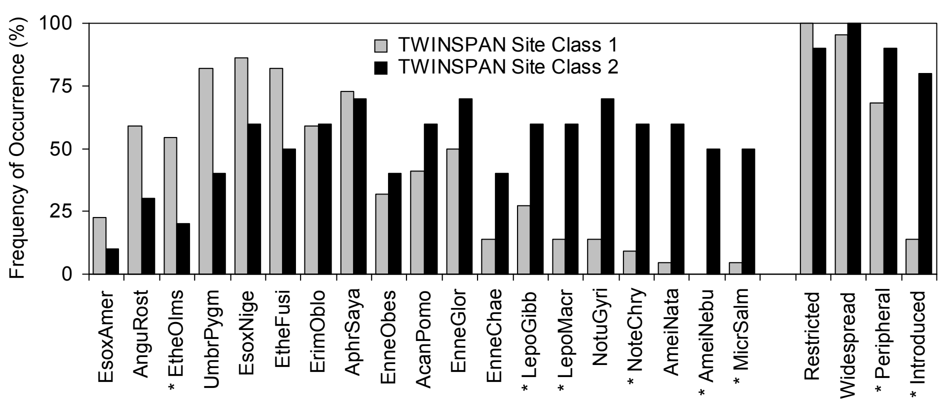

Figure 4.12. Frequency of occurrence values for fish species and biogeographic groups for two TWINSPAN-derived site classes for 32 Great Egg Harbor River WMA stream sites. Fish species are ordered by DCA axis 1 species scores. An asterisk denotes nonnative-fish species and biogeographic groups. Refer to Table 4.3 for key to fish names.

species between the two site classes (p = 0.012). Although median pH and altered land values were higher for Site Class 2 (Figure 4.11), differences between site classes were not significant. There was no significant difference in specific conductance between site classes.

Of the 32 stream sites, only seven sites had fish assemblages composed entirely of native fish, whereas assemblages at 25 sites included both native and nonnative species. Based on the results of Mann-Whitney U tests, there was a significant difference in pH (p = 0.043), specific conductance (p = 0.002), and the percentage of altered land (p = 0.026) between streams with and without nonnatives. Altered land, pH, and specific conductance values were higher for sites with nonnative species present (Figure 4.13).

Logistic regression results revealed a significant relationship between the presence of nonnative stream fish and pH (p = 0.015), specific conductance (p = 0.001), and altered land (p = 0.021). The probability of finding nonnative fish at a stream site increased with increasing pH, specific conductance, and altered land (Figure 4.14).

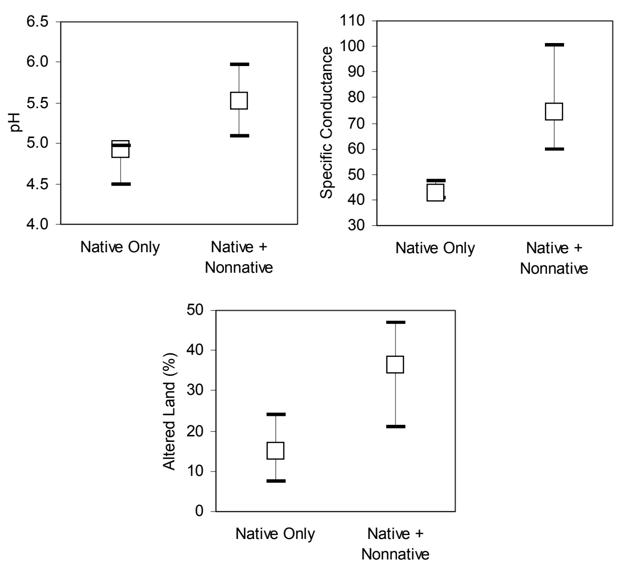

Figure 4.13. Median and 1st and 3rd quartile pH, specific conductance (μS cm^{-1}), and altered land (developed and upland agriculture) values for 32 Great Egg Harbor River WMA stream sites with and without nonnative fish species.

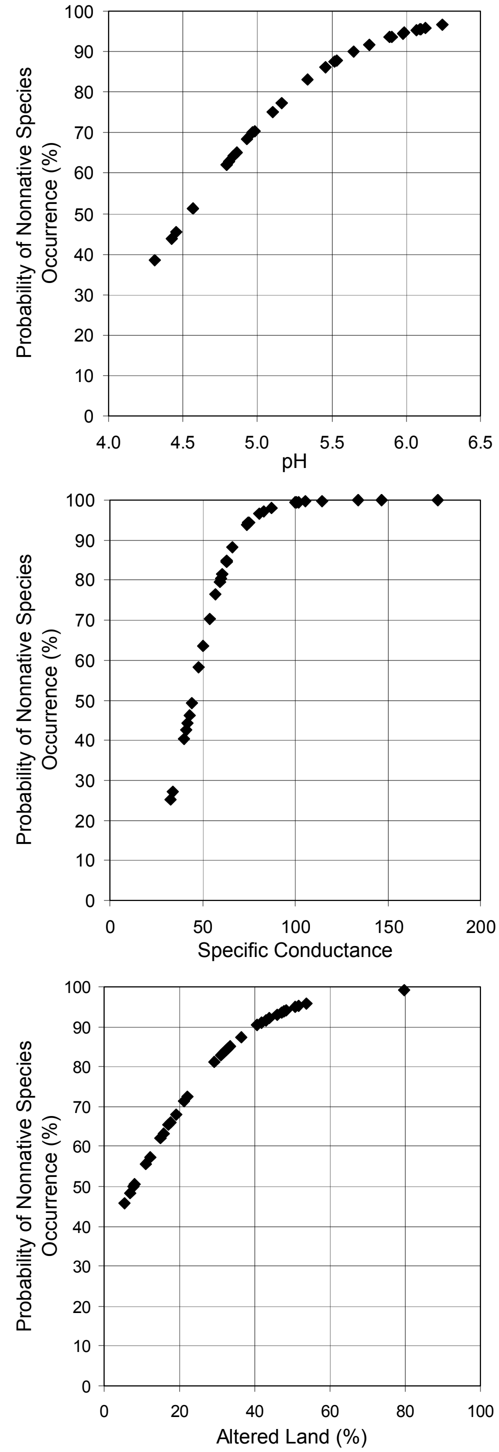

Figure 4.14. Logistic regression results showing the predicted probability of finding nonnative fish species in relation to pH, specific conductance (μS cm^{-1}), and altered land (developed and upland agriculture) for 32 Great Egg Harbor River WMA stream sites.

Impoundment-fish Community Gradient

Similar to the ordination of stream sites, the first DCA axis of the impoundment ordination contrasted sites with and without nonnative species (Tables 4.4 and 4.6, Figure 4.15). The percentage of native species decreased (r = -0.92, $p < 0.001$) and the percentage of nonnative species increased (r = 0.92, $p < 0.001$) along this community gradient (Figure 4.16). Nonnative fish were generally found at impoundments with higher pH, specific conductance, and altered-land values (Figure 4.17).

The order of impoundments along the first DCA axis was associated with increasing pH (r = 0.64, $p = 0.048$), developed land (r = 0.64, $p = 0.048$), and altered land (r = 0.66, $p = 0.038$)(Figure 4.18). Specific conductance and upland agriculture were not related to the impoundment-community gradient.

A decrease in the percentage of native species was associated with an increase in the percentage of developed land (r = -0.73, $p = 0.016$) and altered land (r = -0.73, $p = 0.016$). Opposite trends were observed for nonnative species. There was no relationship between the percentage of native and nonnative species and pH, specific conductance, or upland agriculture.

The first division of the TWINSPAN classification separated a group of six impoundments that supported mostly native species (Site Class 1) from the remaining four impoundments, characterized by a high percentage of nonnative species (Site Class 2) (Figures 4.15 and 4.19). Based on Mann-Whitney U tests, there was a significant difference in the percentage of native and nonnative species ($p = 0.010$) between the two site classes. Although Site Class 2 generally had higher pH, specific conductance, and altered-land values than Site Class 1, these differences were not significant.

Of the 10 impoundments, five supported only native species and five supported native and nonnative species. Compared to impoundments with native-only assemblages, sites with nonnative species had higher pH and altered-land values (Figure 4.20). Based on Mann-Whitney U tests, there was a significant difference only for altered land ($p = 0.032$) between these impoundment types.

Logistic regression results indicated a significant relationship between the presence of nonnative fish and pH ($p = 0.021$) and altered land ($p = 0.006$). There was no relationship with specific conductance. As with the stream results, the probability of finding nonnative fish in impoundments increased with increasing pH and altered land (Figure 4.21).

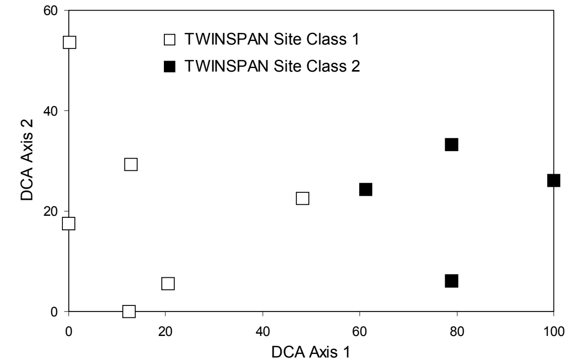

Figure 4.15. DCA ordination diagram and TWINSPAN classification for 10 Great Egg Harbor River WMA impoundments. Refer to Table 4.6 for site names ordered by DCA axis 1 scores.

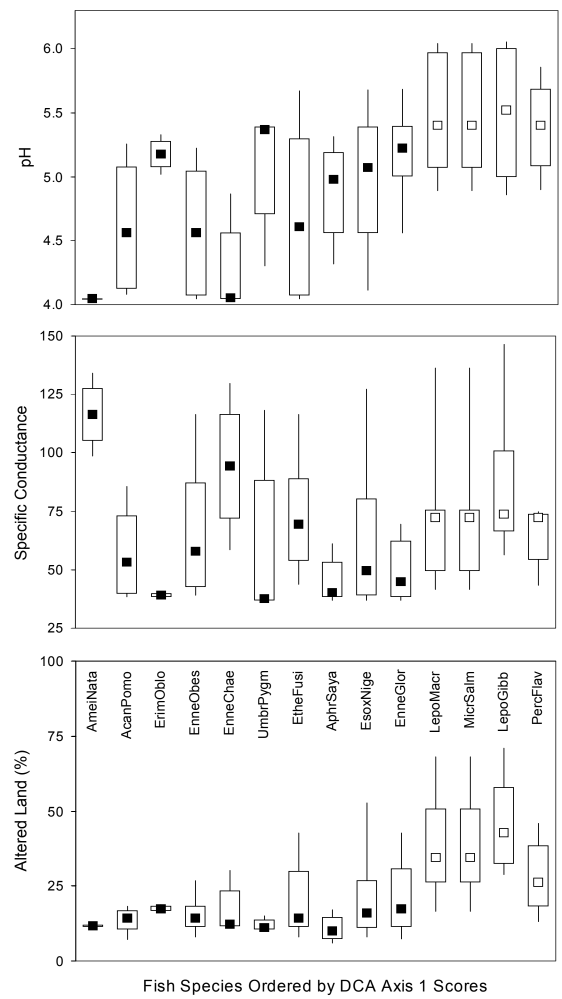

Figure 4.17. The pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) associated with fish species found at 10 Great Egg Harbor River WMA impoundments. Box plots show the first, second (median), and third quartiles and the 10th and 90th percentiles for each variable. Open squares denote nonnative fish species. Refer to Table 4.3 for key to fish names.

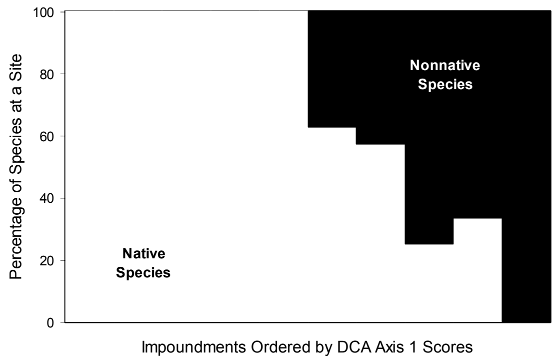

Figure 4.16. Percentage of native and nonnative species found at 10 Great Egg Harbor River WMA impoundments. Refer to Table 4.6 for site names ordered by DCA axis 1 scores.

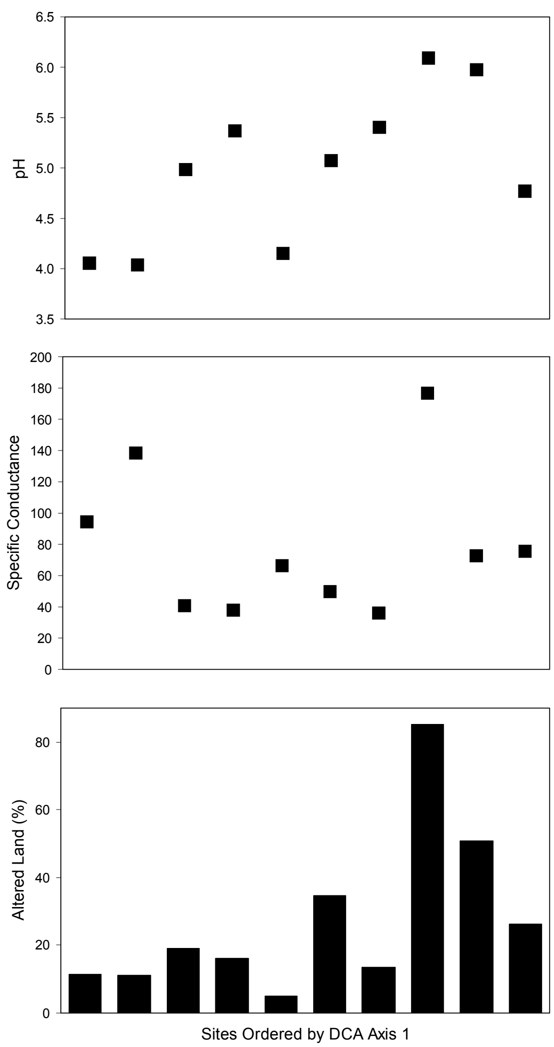

Figure 4.18. Median pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) for 10 Great Egg Harbor River WMA impoundments. DCA axis 1 represents an impoundment-fish community gradient. Refer to Table 4.6 for site names ordered by DCA axis 1 scores.

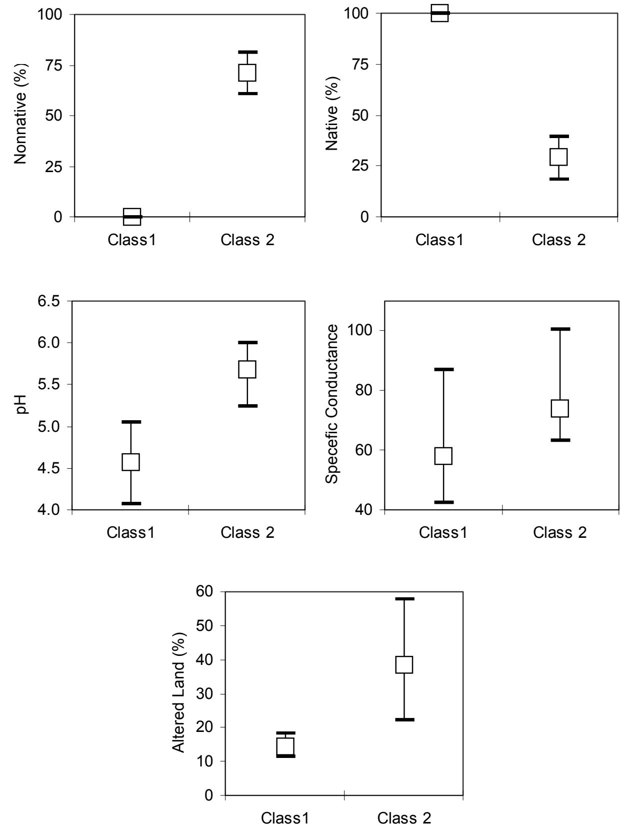

Figure 4.19. Median and 1st and 3rd quartile percentage native and nonnative species, pH, specific conductance (μS cm^{-1}), and altered land (developed and upland agriculture) values for two TWINSPAN-derived site classes for 10 Great Egg Harbor River WMA impoundments.

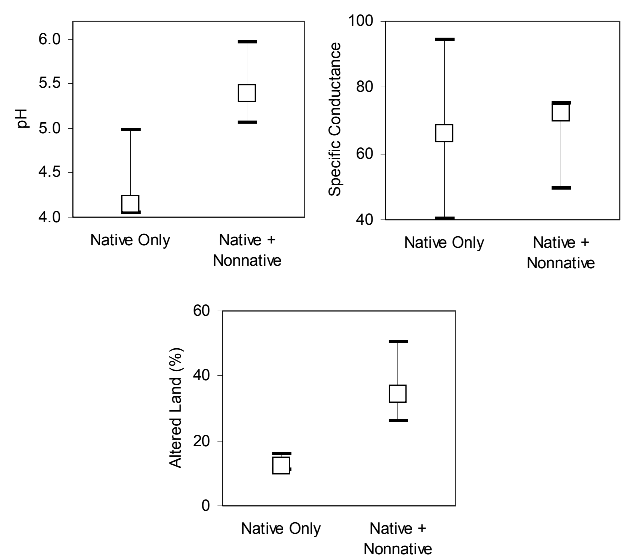

Figure 4.20. Median and 1st and 3rd quartile pH, specific conductance (μS cm^{-1}), and altered land (developed and upland agriculture) values for 10 Great Egg Harbor River WMA impoundments with and without nonnative fish species.

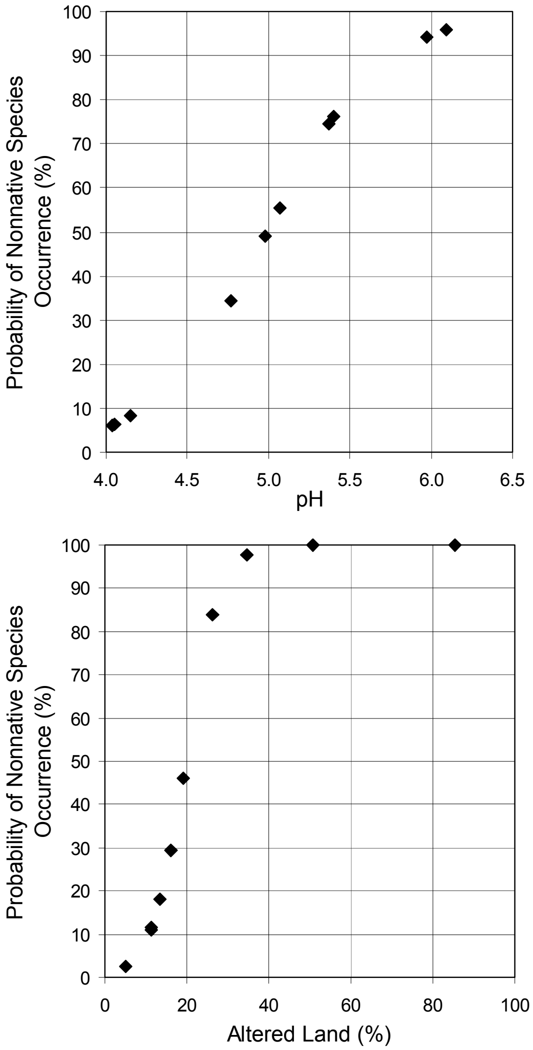

Figure 4.21. Logistic regression results showing the predicted probability of finding nonnative fish species in relation to pH and altered land (developed land and upland agriculture) for 10 Great Egg Harbor River WMA impoundments.

Comparison with Previous Commission Watershed Studies

Results from this study were somewhat different than those found in previous Commission studies. In the Mullica River Basin and Rancocas Creek Basin studies, there was a strong relationship between most watershed-disturbance variables and stream and impoundment fish-community gradients (Zampella et al. 2001, 2003). In this study, pH was the only factor related to both fish-community gradients. The general lack of a strong association between the community gradients and most watershed-disturbance variables may be due to three related factors.

First, the overall relationship between land use and water quality was not as good in the Great Egg Harbor River WMA compared to the Mullica River and Rancocas Creek basins (Chapter 2). Secondly, the range of watershed conditions at fish-survey sites in the Great Egg Harbor River WMA was different than the range for the Mullica River and Rancocas Creek basins. In the Great Egg Harbor River WMA, there were fewer minimally altered reference sites and the range in pH values among sites was more narrow. For example, only 13% of the stream-fish sites in the Great Egg Harbor River WMA had basins with #10% altered land, compared to 39% for the Rancocas Creek Basin and 35% for the Mullica River Basin. Similarly, only 9% of the Great Egg Harbor River WMA stream-fish sites had median pH values #4.5, compared to 17% for the Rancocas Creek Basin and 15% for the Mullica River Basin. There were no stream-fish sites in the Great Egg Harbor River WMA with a median pH value >6.5, whereas 29% of the Rancocas Creek Basin sites and 22% of the Mullica River Basin sites exceeded this value.

Lastly, the frequency of occurrence and mean relative abundance of nonnative fish species was greater for sites in the Great Egg Harbor River WMA compared to the Rancocas Creek and Mullica River basins. For example, nonnative fish species were present at 78% of the stream-fish sites in the Great Egg Harbor River WMA, compared to 54% of the Rancocas Creek Basin sites and 44% of the Mullica River Basin sites.

These factors influence the effectiveness of gradient analysis in ranking the ecological integrity of stream and impoundment sites based on fish-community data because ordination results may be more difficult to interpret where strong environmental gradients are lacking (Zampella and Bunnell 1998). However, despite the results of the Great Egg Harbor River WMA gradient analysis, there were some obvious differences in watershed conditions between sites with and without nonnative species. Furthermore, the correlation and logistic regression results revealed a clear relationship between the presence of nonnative fish and watershed disturbance.

Study-basin Characterizations

Tuckahoe River

Four stream sites and two impoundments were surveyed in the Tuckahoe River study basin. Fifteen fish species were collected, including 12 native and three nonnative species. This basin had the lowest mean percentage of nonnative species per site (Figure 4.22). The majority of sites surveyed in this basin supported fish assemblages composed entirely of native species and occupied a position on the native species side of both fish-community gradients (Figures 4.23 and 4.24). Two sites supported nonnative fish species, including the Tuckahoe River at Route 49 near Head of River and Tarkiln Brook below a powerline right-of-way (Appendix 3). A single pumpkinseed was present at the Tuckahoe River site, which is immediately above a USGS gaging station weir equipped with a fish ladder. The golden shiner and bluegill were present at the Tarkiln Brook site, which was located within Belleplain State Forest.

Lower Great Egg Harbor River

A total of 20 fish species were found in the seven stream sites and two impoundments surveyed in the Lower Great Egg Harbor River study basin. These included 13 native species and seven nonnative species. Most of the sites were placed on the native species side of the fish-community gradients (Figures 4.23 and 4.24). Two of the nine sites surveyed supported assemblages composed entirely of native species (Appendix 3). These sites were Gibson Creek at Route 50 and a Watering Race Branch impoundment. Despite supporting seven nonnative species, this study basin displayed the second lowest mean percentage of nonnative species per site (Figure 4.22). Introduced species were only found at two sites on Stephens Creek (Maple Lake and Stephens Creek at Route 50). Maple Lake is located within the Maple Lake Wildlife Management Area and the Stephens Creek at Route 50 site is immediately below an impoundment near the head of tide.

Middle Great Egg Harbor River

Four stream sites and two impoundments were surveyed in the Middle Great Egg Harbor River study basin. Twenty species of fish were present in this study basin, including 13 native and seven nonnative species. Sites in this study basin displayed the widest range of conditions (Figures 4.23 and 4.24). This study basin exhibited the highest mean percentage of nonnative species per site (Figure 4.22). Two sites (Mare Run at Route 559 and Makepeace Lake) supported assemblages composed entirely of native fish. Assemblages at the other four sites included native and nonnative species and all four sites supported introduced species. One of these sites, Lake

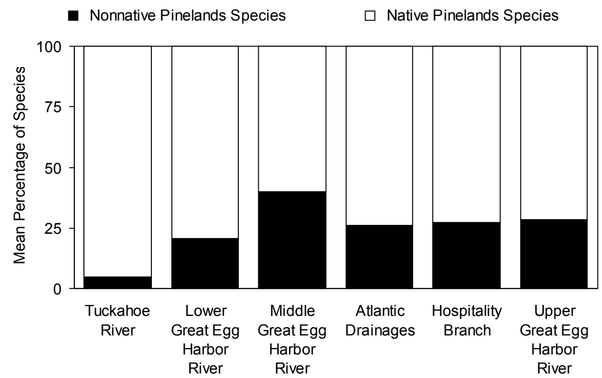

Figure 4.22. Mean percentage of native and nonnative fish species from stream sites in each study basin in the Great Egg Harbor River WMA.

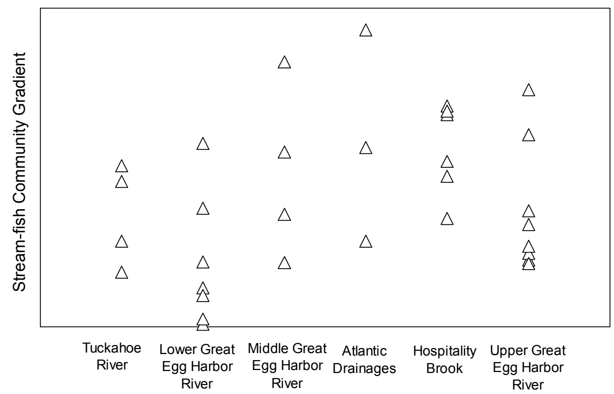

Figure 4.23. Position of fish-survey sites along the stream-fish community gradient, represented by DCA axis 1 site scores, in the six Great Egg Harbor River WMA study basins. Refer to Table 4.5 for site names ordered by the first DCA axis.

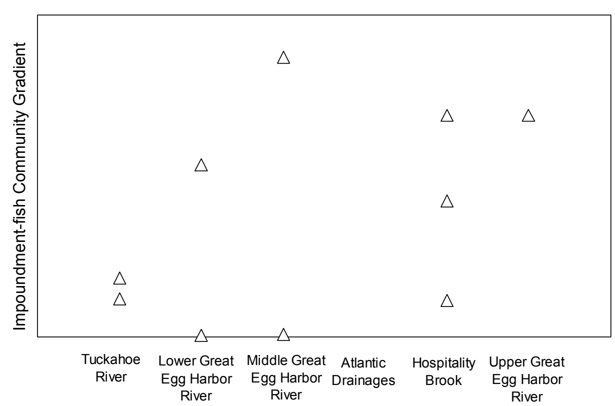

Figure 4.24. Position of fish-survey sites along the impoundment-fish community gradient, represented by DCA axis 1 site scores, in the six Great Egg Harbor River WMA study basins. Refer to Table 4.6 for site names ordered by the first DCA axis.

Lenape, supported the highest nonnative species richness (n = 6) of all the impoundments surveyed and was the only impoundment where all three of the introduced species collected during the Great Egg Harbor River WMA surveys were present (Table 4.3). Lake Lenape was also the only site surveyed for fish where native species were not found.

Atlantic Drainages

The three sites surveyed in this study basin were stream sites. These three sites were spread across the stream-fish community gradient (Figure 4.23). Fifteen fish species were collected from this study basin, including 10 native and five nonnative species. Nonnative species were absent only from Mill Branch at Route 864. The mean percentage of nonnative species per site was 26% (Figure 4.22).

Hospitality Brook

Six stream sites and three impoundments were surveyed in the Hospitality Brook study basin. The 21 species collected included 12 native species and all nine nonnative species found during the Great Egg Harbor River WMA surveys (Table 4.3). Although sites from the Hospitality Brook study basin displayed a range of conditions, most sites occupied the middle portion of the fish-community gradients (Figures 4.23 and 4.24). The mean percentage of nonnative species per site was 27% (Figure 4.22). Nonnative fish species were present at six sites. Two sites in this study basin supported the highest nonnative species richness (n = 6) of all the stream sites surveyed in Great Egg Harbor River WMA. These were the Hospitality Brook at Route 538 and Whitehall Branch at Route 659. The Hospitality Brook at Route 538 site was below an impoundment and was the only site where banded killifish were collected. The Whitehall Branch at Route 659 site was just upstream from an impoundment and was the only stream site with all three introduced species present.

Upper Great Egg Harbor River

Eight stream sites and one impoundment were surveyed in the Upper Great Egg Harbor River study basin. Of the 18 species collected in this study basin, 12 were native and six were nonnative. Sites from this study basin displayed a range of conditions along the fish-community gradients (Figures 4.23 and 4.24). The mean percentage of nonnative species per site was 29% (Figure 4.22). This was the only study basin where nonnative species were present at every site surveyed. The Great Egg Harbor River impoundment at Berlin Park was the only impoundment other than Lake Lenape in the Middle Great Egg Harbor River study basin that lacked restricted Pinelands fish species.

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5 Anuran Assemblages

Introduction

Previous Commission studies conducted in the Mullica River and Rancocas Creek basins indicated that the presence of individual border-entrant anuran species and assemblages dominated by these species were associated with watersheds characterized by a high percentage of developed land and upland agriculture and surface waters with elevated pH and dissolved-solid concentrations (Bunnell and Zampella 1999, Zampella and Bunnell 2000, Zampella et al. 2001, 2003). Border entrants, such as the bullfrog, are anuran species that are widely distributed outside the Pinelands, but usually do not occur in the region except in habitats altered by human activity (Table 5.1) (Conant 1962, 1979). In this report, border-entrant species are referred to as nonnative to the Pinelands. In both basins, the distribution of assemblages with nonnative anurans present contrasted with those composed of native Pine Barrens species and wide-ranging species. Pine Barrens species, which include Pine Barrens treefrogs and carpenter frogs, are restricted to Pinelands habitats, whereas wide-ranging species are distributed throughout southern New Jersey (Conant 1962, 1979).

In 2003, Commission scientists surveyed anurans in the Great Egg Harbor River Watershed Management Area (WMA). Surveys were conducted at permanent, stream impoundments during the calling season of carpenter frogs and bullfrogs (Figure 5.1). Previous Commission studies indicated that the native carpenter frog is generally absent from sites with bullfrogs, a border-entrant species. Both species prefer permanent-water habitat types and share a similar breeding period. However, the bullfrog is associated with degraded waters, whereas the carpenter frog is usually found in acid-water Pinelands habitats.

Table 5.1. Common and scientific names for Pine Barrens, wide-ranging, and border-entrant anuran species found in the New Jersey Pinelands (Conant 1979). Nomenclature follows Conant and Collins (1998).

Scientific Name	Common Name
Native Pinelands Species	
Pine Barrens Species	
Hyla andersonii	Pine Barrens treefrog
Rana virgatipes	carpenter frog
Wide-ranging Species	
Bufo woodhousii fowleri	Fowler's toad
Pseudacris c. crucifer	northern spring peeper
Rana clamitans melanota	green frog
Rana utricularia	southern leopard frog
Scaphiopus h. holbrooki	eastern spadefoot
Non-Pinelands Species	
Border-entrant Species	
Acris c. crepitans	northern cricket frog
Hyla versicolor	northern gray treefrog
Pseudacris triseriata kalmi	New Jersey chorus frog
Rana catesbeiana	bullfrog
Rana palustris	pickerel frog
Rana sylvatica	wood frog

Prior to calculating frequency of occurrence values for each species, the pool of 40 sites was reduced to 34 sites. Three sites were deleted because no anurans were heard calling. Inventories for adjacent survey sites that represented the same habitat type were pooled, reducing three pairs of survey sites to three single sites. Impoundments ranged from small, tributary impoundments to flooded, abandoned cranberry bogs and large lakes.

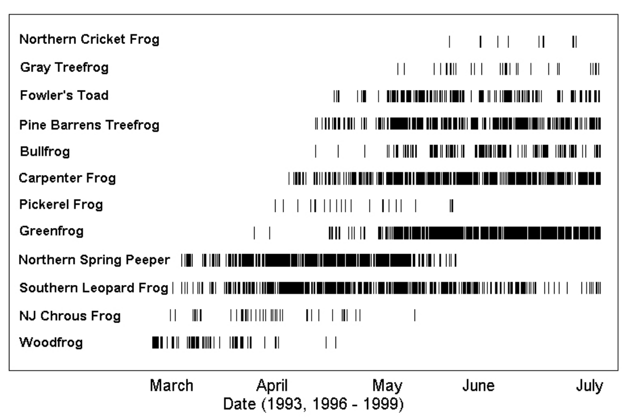

Figure 5.1. Breeding phenology of 12 anurans in the Mullica River Basin. Each vertical bar represents a survey night when a species was heard calling (Zampella et al. 2001).

Methods

Study Sites

Forty stream impoundments were surveyed for vocalizing anurans in the Great Egg Harbor River WMA. Sites were selected based on land-use characteristics, accessibility, and suitability as survey sites. The location of each sampling station was determined using orthophotoquads and a GIS.

Characterizing Survey-site Conditions

Several site-specific and regional watershed-disturbance variables were used to characterize each anuran-survey site. The variables included pH, specific conductance, and land use (Table 5.2). Specific conductance and pH were measured under baseflow conditions at or near most anuran-survey sites (Chapter 2). Upstream land-use profiles were prepared using ArcView software and NJDEP 1995/97 land-use data (Chapter 1).

Anuran-vocalization Surveys

Nighttime vocalization surveys were conducted during May and June 2001. Each site was visited on one occasion. Four sites were surveyed a second time because neither bullfrogs nor carpenter frogs were heard during the first visit. The number of calling individuals heard during a five-minute period was estimated using a ranking system where 0 = none, 1 = 1 calling, 2 = 2-5 calling, 3 = 6-10 calling, and 4 = >10 calling individuals. This ranking system is the same as that used in earlier Commission studies (Bunnell and Zampella 1999, Zampella and Bunnell 2000, Zampella et al. 2001, 2003).

Appendix 4 contains the anuran-survey data for the Great Egg Harbor River WMA sites surveyed. The appendix includes the number of individuals of each species heard at each site, distribution maps for each species, the air temperature and relative humidity recorded during site visits, the individuals who conducted the surveys, site-location descriptions, and latitude and longitude. Taxonomic nomenclature follows Conant and Collins (1998).

Anuran-community Gradient

Presence/absence was determined for each species heard at a site. Detrended correspondence analysis (DCA) was used to order anuran species and survey sites based on presence/absence data. The same data were used to classify or group species and sites using TWINSPAN. These techniques are described in greater detail in Zampella et al. (2001). Because rare species can have a disproportionate effect on ordinations, only species occurring at more than one site were included in the gradient analysis. Sites with only one species were also excluded from the gradient analysis.

Spearman rank correlation was used to determine if anuran-species composition, represented by the first DCA axis, varied in relation to environmental factors. The environmental variables included pH, specific conductance, and the percentage of developed land, upland agriculture, and altered land (developed land and upland agriculture) in a basin.

Differences in biogeography and watershed conditions between the first two TWINSPAN-derived site classes were evaluated using Mann-Whitney U Tests. The percentage of native and nonnative species, pH, specific conductance, and the percentage of altered land (developed land and upland agriculture) were compared between the two site classes. To evaluate

Table 5.2. Median pH and specific conductance (μS cm^{-1}) values and the percentage of developed land, upland agriculture, and altered land (developed and upland agriculture) for 34 Great Egg Harbor River WMA anuran-survey sites. Water quality was measured at the outflow of the impoundments, except for HMAALBER (measured upstream at HMABLUEA), HWHSUNSL (measured downstream at HWHWHITE), LSOLLEWE (measured downstream at LSOESTEL), LSTMAPLE (measured upstream at LSTELEVE), and UGRBPARK (measured downstream at UGRRT691). A dash indicates that water-quality data were not available for a particular anuran site. Refer to Chapter 2 for details regarding water-quality monitoring.

Site Code	pH	SC	Dev. Land	Upland Agric.	Altered Land
HFAJACKL	5.0	40	11.4	7.5	19.0
HHOBLUEB	6.1	74	20.0	30.7	50.7
HHOBRADD	5.5	58	18.0	15.4	33.4
HHOCRANE	6.0	63	24.3	22.7	47.0
HHODIAMO	5.8	61	21.0	18.2	39.2
HHOEIGHD	5.8	53	13.4	15.9	29.3
HHOTIMBD	6.0	72	22.7	28.0	50.7
HHOTIMBU	-	-	16.7	17.9	34.6
HMAALBER	5.5	48	7.6	24.6	32.3
HMAJACKS	5.1	50	7.0	27.6	34.6
HMAPINEY	5.8	112	14.4	24.3	38.7
HMAUNEXL	5.0	75	7.0	34.2	41.2
HWHBLUEL	-	-	15.5	31.8	47.3
HWHSUNSL	6.2	61	25.3	18.1	43.4
LCEHARDL	5.2	77	10.9	0.0	10.9
LGIFIRST	-	-	14.1	1.7	15.9
LJALEIPZ	6.3	78	14.1	14.3	28.5
LSOLLEWE	4.8	102	15.8	24.3	40.1
LSTEP50L	5.5	33	9.1	3.0	12.2
LSTMAPLE	5.4	36	11.1	2.4	13.5
MDEPANCL	6.1	147	19.4	21.3	40.7
MGRLENAP	4.8	75	15.6	10.7	26.2
MMKPEACU	4.0	139	9.1	1.5	10.7
TTARK548	4.8	61	2.1	5.6	7.8
TTU49HUN	4.9	34	5.2	9.9	15.0
TTUCUMBL	5.4	38	9.1	7.0	16.1
TWAAETNA	4.2	66	1.4	3.6	5.0
UFOCRYST	-	-	59.2	4.5	63.8
UGRBPARK	6.1	177	82.5	2.8	85.3
UGRBROOK	5.9	87	35.9	7.9	43.8
UGRERT54	5.8	75	28.4	7.9	36.3
UGRTRASB	-	-	48.0	13.5	61.5
UGRTRDIC	-	-	60.5	3.6	64.1
UPENNY54	5.2	114	16.5	31.4	47.9

watershed conditions between sites with bullfrogs only, sites with carpenter frogs only, and sites with both species, analysis of variance (ANOVA) was used to compare pH, specific conductance, and the percentage of altered land between these three site groups. The ANOVA was completed using ranked data. Logistic regression was used to estimate the probability of hearing carpenter frogs and bullfrogs at various pH, specific conductance, and altered-land values. An alpha level of 0.05 was used to identify important relationships revealed by the correlation and logistic regression analyses and to assess differences between the various site groups.

RESULTS

Eight anuran species were heard during the surveys of the 34 sites, including the two Pine Barrens species, three wide-ranging species, and three border-entrant species (Table 5.3). In order of decreasing frequency of occurrence, the species heard during the surveys were the bullfrog, green frog, Fowler's toad, carpenter frog, northern gray treefrog, northern cricket frog, Pine Barrens treefrog, and southern leopard frog. Native-anuran species were heard at 97% of the 34 sites and nonnative-anuran species were heard at 76% of the sites (Figure 5.2). Bullfrogs occurred at all but one site where other nonnative-anuran species were heard.

Table 5.3. Frequency of occurrence and geographic affinity of eight anuran species heard at 34 Great Egg Harbor River WMA impoundments. For geographic affinity, PB = Pine Barrens species, WR = wide-ranging species, and BE = border-entrant species (Conant 1979).

Species	Geo. Affinity	Number of Sites	Percentage of Total
Bullfrog	BE	25	74
Green frog	WR	21	62
Fowler's toad	WR	19	56
Carpenter frog	PB	14	41
No. gray treefrog	BE	9	26
No. cricket frog	BE	6	18
Pine Barrens treefrog	PB	1	3
So. leopard frog	WR	1	3
Native species	PB + WR	33	97
Nonnative species	BE	26	76

Prior to the gradient analysis, seven additional sites were removed from the pool of 34 sites because only one species was heard calling. Of these seven sites, green frogs and Fowler's toads were each heard at three sites and bullfrogs were heard at one site. Pine Barrens treefrogs and southern leopard frogs were excluded from the gradient analysis because they occurred at only one site. The remaining 27 sites and six species were analyzed.

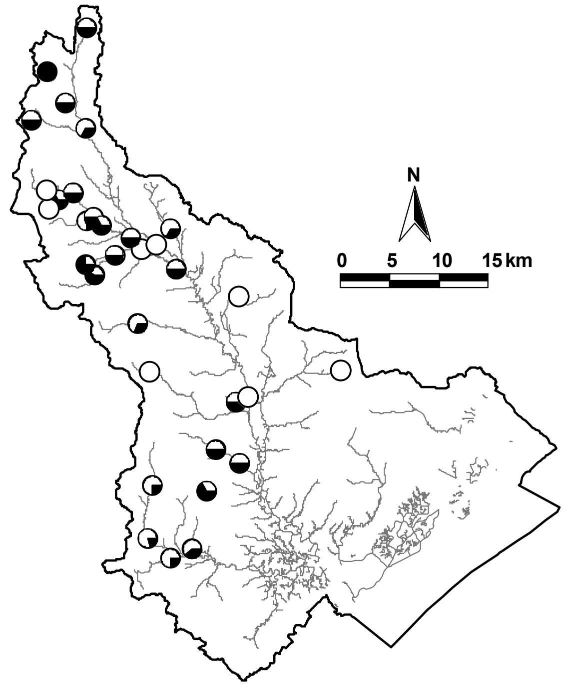

Figure 5.2. Pie charts showing the percentage of native species (white) and nonnative species (black) present at 34 Great Egg Harbor River WMA impoundment sites.

The first DCA axis of the ordination of 27 sites contrasted sites where carpenter frogs, green frogs, and northern cricket frogs were heard with those where Fowler's toads were present (Tables 5.4 and 5.5, Figure 5.3). The occurrence of carpenter frogs, green frogs, and cricket frogs decreased and the occurrence of Fowler's toads increased along the community gradient (Figure 5.4). The was no relationship between the community gradient and the occurrence of bullfrogs or northern gray treefrogs. There was also no trend in the overall percentage of native and nonnative species per site along the community gradient.

The order of sites along the first DCA axis was not associated with any of the watershed-disturbance variables, including pH, specific conductance, and the percentage of developed land, upland agriculture, and altered land in the associated drainage (Figure 5.5). All species were heard at a range of watershed conditions (Figure 5.6). Five sites placed in the middle of the anuran-community gradient supported all three native species included in the analysis and displayed some of the lowest percentages of nonnative species per site. These five sites were among those with the lowest pH and altered-land values.

A decrease in the percentage of native species was associated with increasing pH (r = -0.45, p = 0.032). The opposite trend was observed for the percentage of nonnative species and pH. There was no relationship between the percentage of native or nonnative species and specific conductance, developed land, upland agriculture, and altered land.

The first division of the TWINSPAN classification separated a group of 17 sites (Site Class 1) from a group of 10 sites (Site Class 2) (Figures 5.3 and 5.7). Native species were heard at all sites in both site classes, but the frequency of occurrence of individual native species differed between the two classes (Figure 5.8). Carpenter frogs were heard only at sites in Site Class 1 and green frogs were heard much more frequently in this site class. In contrast, Fowler's toads were heard much more frequently in Site Class 2. Nonnative species were heard calling at 88% of the sites in Site Class 1 and all of the sites in Site Class 2. Northern cricket frogs were heard slightly more frequently at sites in Site Class 1, whereas bullfrogs were heard more frequently in Class 2. Northern gray treefrogs were almost equally represented in both site classes.

Table 5.4. Raw DCA axis 1 and 2 scores for species heard at anuran-survey sites in the Great Egg Harbor River WMA. Species are ordered by axis 1 scores.

Species	Axis 1	Axis 2
Carpenter frog	-43	71
Northern cricket frog	-10	276
Green frog	43	-71
Northern gray treefrog	122	200
Bullfrog	134	77
Fowler's toad	266	133

Table 5.5. Raw DCA axis 1 and 2 site scores for 27 anuran-survey sites in the Great Egg Harbor River WMA based on an ordination of species presence/absence data. Sites are ordered by axis 1 scores. Refer to Appendix 4 for additional information on each site.

Study Basin	Site Name	Site Code	Axis 1	Axis 2
Upper Great Egg	Great Egg Harbor River impoundment at Route 54	UGRERT54	0	0
Hospitality Brook	Timber Lakes - upper	HHOTIMBU	27	142
Lower Great Egg	Stephen Lake	LSTEP50L	31	88
Hospitality Brook	Faraway Branch impoundment at Jackson Road	HFAJACKL	45	26
Middle Great Egg	Pancoast Mill Pond	MDEPANCL	45	26
Upper Great Egg	Penny Pot Stream impoundment at Route 54	UPENNY54	45	26
Hospitality Brook	Marsh Lake Branch impoundment at Unexpected Road	HMAUNEXL	49	111
Hospitality Brook	Hospitality Branch impoundment at Eighth Street (combined with HHOEIGHU)	HHOEIGHD	64	69
Hospitality Brook	Cedar Lake - upper	HMAPINEY	72	121
Hospitality Brook	Cedar Lake - lower	HMAJACKS	85	114
Lower Great Egg	Maple Lake	LSTMAPLE	88	3
Upper Great Egg	Great Egg Harbor River tributary impoundment at Routes 706 and 536 Spur	UGRTRASB	88	3
Middle Great Egg	Makepeace Lake (combined with MMKPEACD)	MMKPEACU	89	44
Tuckahoe River	Tuckahoe River impoundment at Route 49	TTU49HUN	97	83
Tuckahoe River	Tarkiln Brook impoundment at Route 548	TTARK548	100	53
Tuckahoe River	Tuckahoe River impoundment at Cumberland Avenue	TTUCUMBL	100	53
Tuckahoe River	Warners Mill Stream impoundment at Aetna Drive	TWAAETNA	105	82
Hospitality Brook	Diamond Lake	HHODIAMO	130	162
Upper Great Egg	Crystal Spring Lake	UFOCRYST	141	85
Upper Great Egg	New Brooklyn Lake	UGRBROOK	148	46
Hospitality Brook	Sunset Lake	HWHSUNSL	174	137
Lower Great Egg	Gibson Creek impoundment at First Avenue	LGIFIRST	174	137
Hospitality Brook	Braddock Lake (combined with HHOCAINL)	HHOBRADD	200	105
Hospitality Brook	Cranes Lake	HHOCRANE	200	105
Hospitality Brook	Timber Lakes - lower	HHOTIMBD	200	105
Lower Great Egg	Harding Lakes	LCEHARDL	200	105
Upper Great Egg	Great Egg Harbor River impoundment at Berlin Park	UGRBPARK	200	105

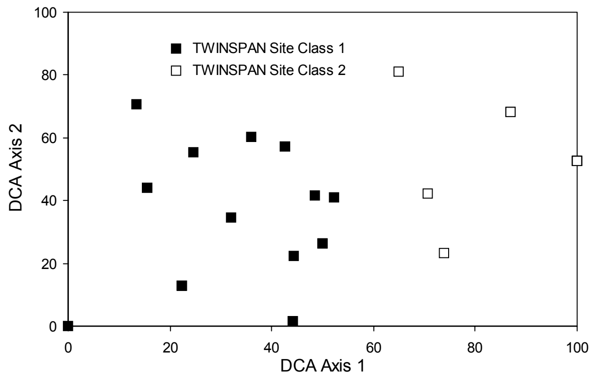

Figure 5.3. DCA ordination diagram and TWINSPAN classification for 27 Great Egg Harbor River WMA impoundments. Refer to Table 5.5 for site names ordered by DCA axis 1 scores. Individual squares may represent more than one site.

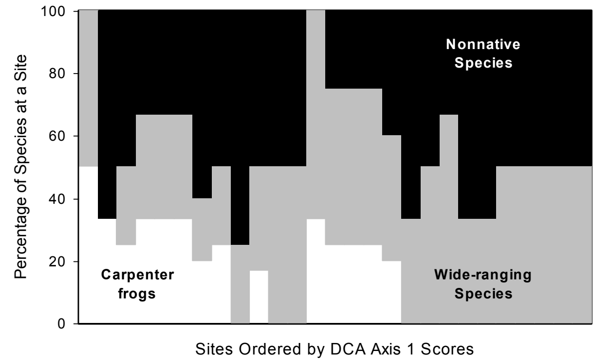

Figure 5.4. Percentage of carpenter frogs, wide-ranging species, and nonnative species heard at 27 Great Egg Harbor River WMA impoundments. Refer to Table 5.5 for site names ordered by DCA axis 1 scores.

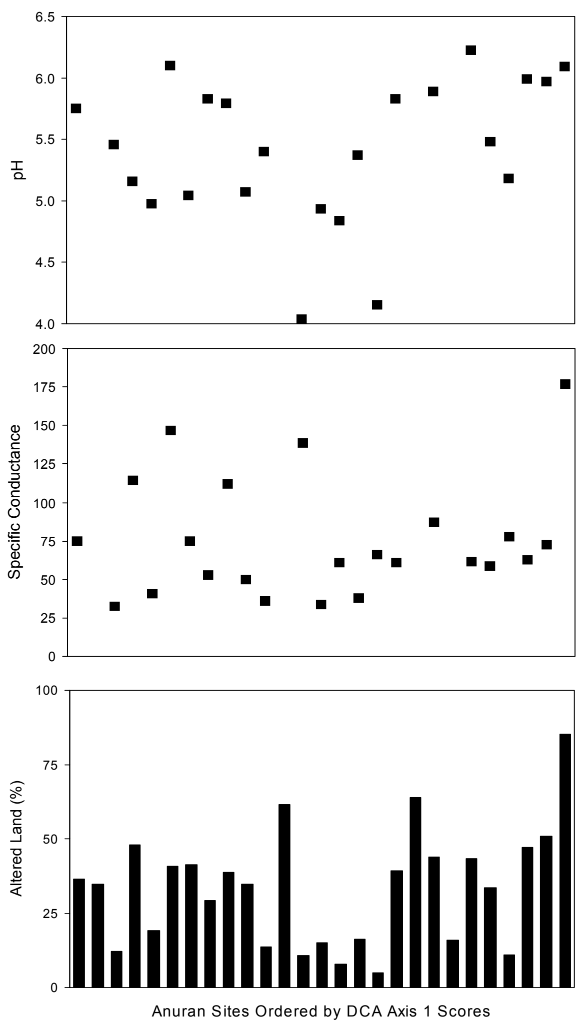

Figure 5.5. Median pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) for 27 Great Egg Harbor River WMA impoundments. DCA axis 1 represents an anuran-community gradient. Refer to Table 5.5 for site names ordered by DCA axis 1 scores.

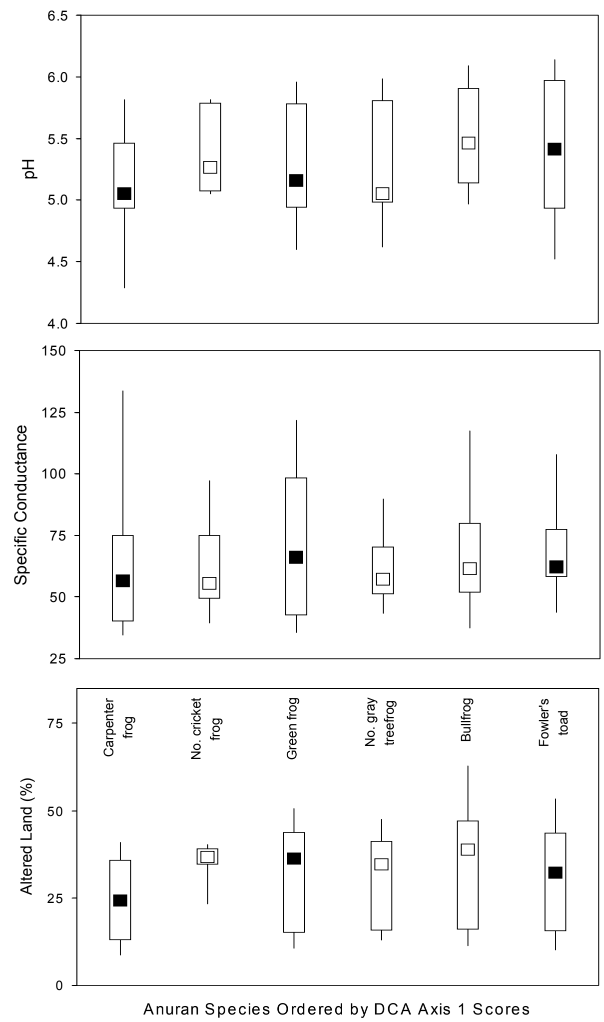

Figure 5.6. The pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) associated with anuran species heard at 27 Great Egg Harbor River WMA impoundments. Box plots show the first, second (median), and third quartiles and the 10th and 90th percentiles for each variable. Open squares denote nonnative species.

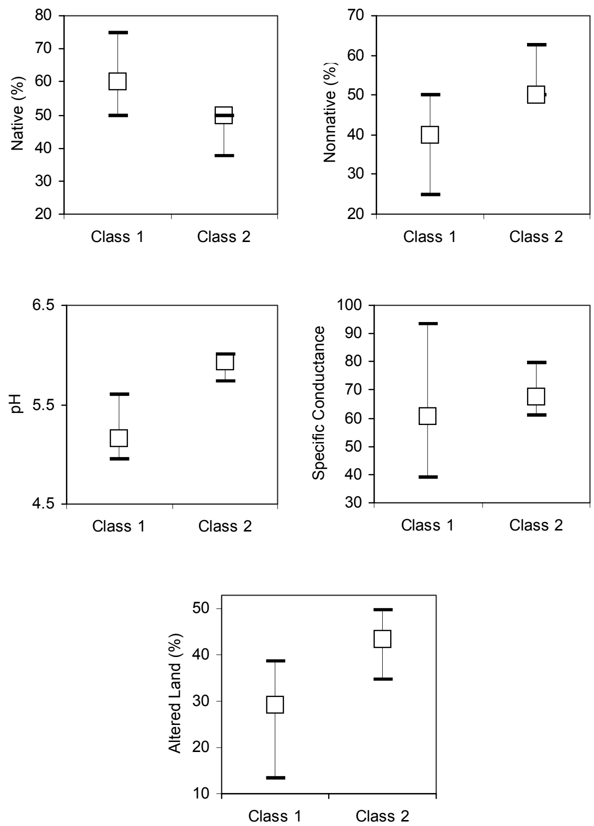

Figure 5.7. The percentage of native and nonnative species and median and 1st and 3rd quartile pH, specific conductance (μS cm^{-1}), and altered land (developed land and upland agriculture) values for two TWINSPAN-derived site classes for 27 Great Egg Harbor River WMA impoundments. TWINSPAN Site Class 1 and 2 were characterized by a higher percentage of native and nonnative species, respectively.

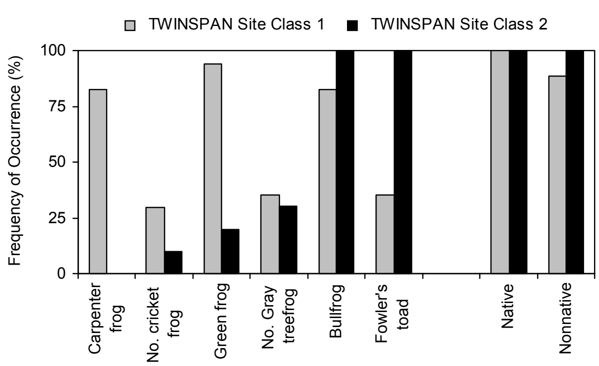

Figure 5.8. Frequency of occurrence for anuran species and native and nonnative species groups for two TWINSPAN-derived site classes representing 27 Great Egg Harbor River WMA impoundments. TWINSPAN Site Class 1 and 2 were characterized by a higher percentage of native and nonnative species, respectively. Anuran species are ordered by DCA axis 1 species scores.

The mean (±SD) and median number of native species per site was 2.1 (±0.8) and 2.0 for Site Class 1 and 1.2 (±0.4) and 1.0 for Site Class 2. The mean (±SD) and median number of nonnative species per site was 1.5 (±0.9) and 1.0 for Site Class 1 and 1.4 (±0.5) and 1.0 for Site Class 2.

Although Site Class 1 was characterized by a higher percentage of native species and Site Class 2 was characterized by a higher percentage of nonnative species (Figure 5.7), based on Mann-Whitney U tests, these differences were not significant. However, there was a significant difference in pH ($p = 0.005$) and altered land ($p = 0.040$) between the two site classes. Site Class 1 had lower pH and altered-land values compared to Site Class 2. There was no difference in specific conductance between the two site classes.

All 27 sites included in the gradient analysis supported carpenter frogs, bullfrogs, or both species. Carpenter frogs were heard vocalizing from 14 (52%) sites, bullfrogs were heard calling from 24 (89%) sites, and both species were present at 11 (41%) sites. The 27 sites were grouped into those with carpenter frogs only (n = 3), those with bullfrogs only (n = 13), and those with both species (n = 11) to compare watershed conditions between these three groups. Sites that supported only carpenter frogs generally displayed lower pH and altered-land values compared to sites that supported only bullfrogs (Figure 5.9). Sites with both species present displayed conditions more similar to sites with only carpenter frogs. However, the ANOVA results indicated there was no significant difference in pH, specific conductance, or altered land between these three groups.

Based on call ranks, there was a significant negative correlation between the number of carpenter frogs calling at a site and both pH ($r = -0.63$, $p = 0.001$) and the percentage of altered land in a watershed ($r = -0.39$, $p = 0.047$). In contrast, there was a significant positive association between the number of bullfrogs heard at a site and the percentage of altered land in a basin ($r = 0.40$, $p = 0.040$). There was no relationship between bullfrog call ranks and pH or between specific conductance and the number of carpenter frogs or bullfrogs heard at a site.

Logistic regression results revealed a significant relationship between the presence of carpenter frogs and altered land ($p = 0.015$) and pH ($p = 0.003$). The probability of hearing carpenter frogs decreased with increasing pH and altered land in a basin (Figure 5.10). The presence of carpenter frogs was not related to

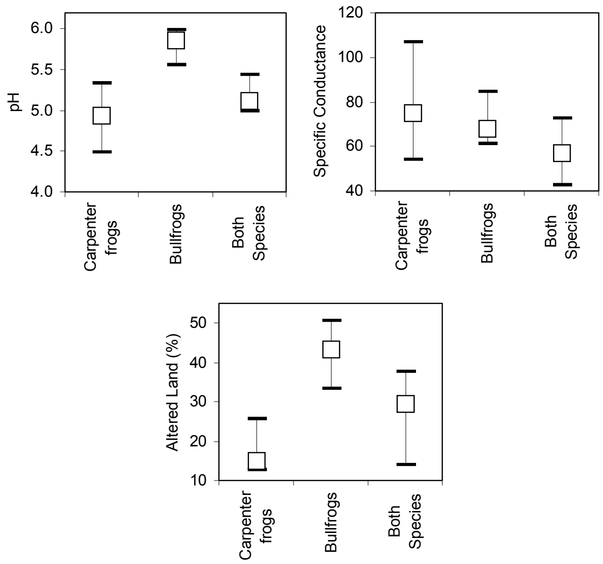

Figure 5.9. First, second (median), and third quartiles for pH, specific conductance (μS cm^{-1}) and altered land (developed and upland agriculture) at 27 Great Egg Harbor River WMA impoundments with carpenter frogs only (n = 3), bullfrogs only (n = 13), and both species (n = 11).

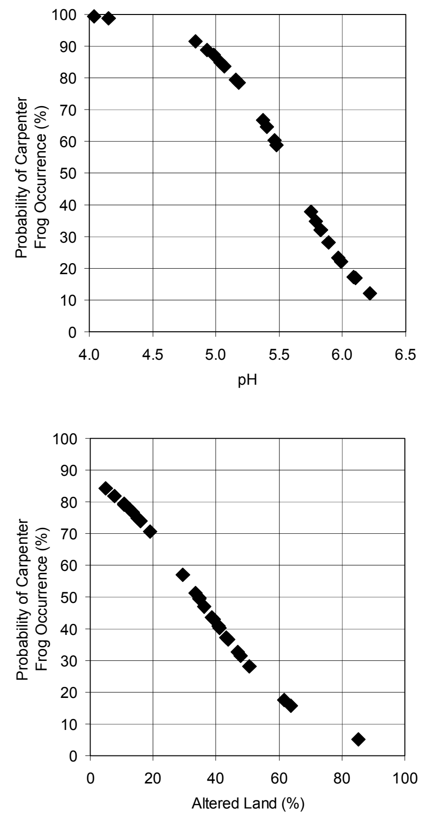

Figure 5.10. Logistic regression results showing the predicted probability of finding carpenter frogs in relation to pH and altered land (developed land and upland agriculture) for 27 Great Egg Harbor River WMA impoundments.

specific conductance. There were no significant relationships between the presence of bullfrogs and altered land, pH, or specific conductance. The lack of a significant relationship between bullfrog occurrence and the three watershed-disturbance variables was due to their presence at all but three sites included in the analysis.

Comparison with Previous Commission Watershed Studies

The results of this study differed from those of the Mullica River Basin and Rancocas Creek Basin studies in two major ways (Zampella et al. 2001, 2003). The frequency of occurrence of several anuran species differed among the three watersheds. Compared to 42 Rancocas Creek Basin impoundments and 67 Mullica River Basin impoundments, the native southern leopard frog and Pine Barrens treefrog occurred less frequently and the nonnative northern gray treefrog, northern cricket frog, and bullfrog occurred more frequently at sites in the Great Egg Harbor River WMA. It is unlikely that these differences were due to differences in survey period or habitat type. The general absence of Pine Barrens treefrogs and southern leopard frogs in the Great Egg Harbor River WMA may be partly due to the widespread occurrence of bullfrogs. In the Mullica River Basin, Pine Barrens treefrogs were generally absent and southern leopard frogs occurred infrequently at sites with bullfrogs (Zampella and Bunnell 2000).

The gradient analysis results also differed between the three watersheds. In the Mullica River Basin and Rancocas Creek Basin studies, there was a strong relationship between most watershed-disturbance variables and anuran-community composition (Zampella et al. 2001, 2003). In this study, none of the watershed-disturbance variables were related to the anuran-community gradient. Similar to the conclusions drawn from the fish-assemblage gradient analysis (Chapter 4), the lack of a relationship between the anuran-community gradient and the watershed-disturbance variables may be due to three related factors. First, the overall relationship between land use and water quality was not as good in the Great Egg Harbor River WMA compared to the Mullica River and Rancocas Creek basins (Chapter 2). Secondly, the range of watershed conditions at anuran-surveys sites in the Great Egg Harbor River WMA was different than the range for the Rancocas Creek Basin and Mullica River Basin impoundments. In the Great Egg Harbor River WMA, there were fewer minimally altered reference sites and the range in pH values among sites was more narrow. For example, only 7% of the anuran-survey sites in the Great Egg Harbor River WMA had basins with #10% altered land, compared to 40% for the Rancocas Creek Basin and 46% for the Mullica River Basin. Lastly, as previously mentioned, the frequency of occurrence of nonnative anuran species, especially bullfrogs, was greater in the Great Egg Harbor River WMA compared to the Rancocas Creek and Mullica River basins. In the Great Egg Harbor River WMA, bullfrogs were heard at 89% of the surveys sites included in the gradient analysis, compared to 52% of the Rancocas Creek Basin sites and 49% of the Mullica River Basin sites. These factors influence the effectiveness of gradient analysis in ranking the ecological integrity of sites based on anuran-community data because ordination results may be more difficult to interpret where strong gradients are lacking (Zampella and Bunnell 1998).

Two key similarities between the Great Egg Harbor River WMA study and the other two basin studies were related to the distribution of native and nonnative species and the occurrence of carpenter frogs. Increasing pH was associated with an increase in the percentage of nonnative species per site and a decrease in the percentage of native species per site and there was evidence that suggested carpenter frogs provided a relatively good measure of watershed conditions. The logistic regression and correlation analysis results indicated that, as pH and the percentage of altered land in a basin increase, the probability of hearing carpenter frogs at a site and the number of carpenter frogs heard calling per site decreased.

Study-basin Characterizations

Tuckahoe River

The four sites surveyed in the Tuckahoe River study basin occupied the middle of the anuran-community gradient (Figure 5.11). Three of the five species heard in this study basin were native species. This was the only study basin where native carpenter frogs, green frogs, and Fowler's toads were heard calling at all of the sites surveyed. The native Pine Barrens treefrog was also heard calling at one site (Tuckahoe River impoundment above Route 49) in this study basin. This was the only impoundment in the entire Great Egg Harbor River WMA where Pine Barrens treefrogs were heard. The Tuckahoe River study basin displayed the second lowest mean percentage of nonnative species per site (Figure 5.12). Bullfrogs were heard calling from three of the four sites surveyed and northern gray treefrogs were heard at two sites. Northern cricket frogs were not heard at any of the Tuckahoe River study basin sites.

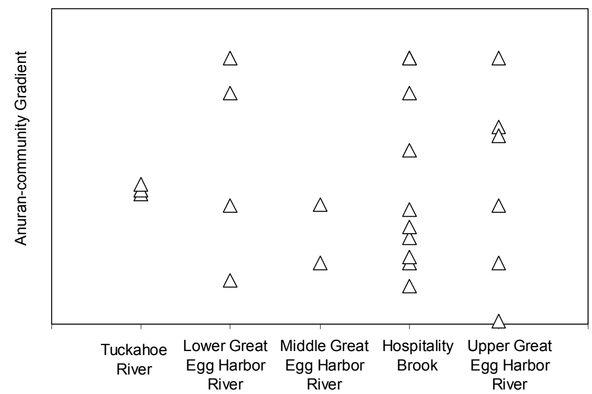

Figure 5.11. Position of anuran-survey sites along the anuran-community gradient, represented by DCA axis 1 site scores, in the six Great Egg Harbor River WMA study basins. Refer to Table 5.5 for site names ordered by the first DCA axis.

Lower Great Egg Harbor River

The four sites surveyed in the Lower Great Egg Harbor River study basin were spread across the anuran-community gradient (Figure 5.11). Of the six species heard in this study basin, three were native species and three were nonnative species. Carpenter frogs were heard at only one site, whereas bullfrogs were present at all four sites. Northern cricket frogs and

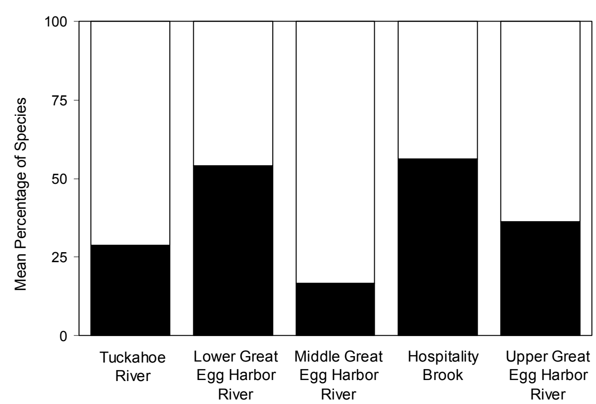

Figure 5.12. Mean percentage of native species (white) and nonnative species (black) from impoundments in each study basin in the Great Egg Harbor River WMA.

northern gray treefrogs were each heard at only one site. This study basin displayed the second highest mean percentage of nonnative species per site (Figure 5.12).

Middle Great Egg Harbor River

Only two sites were surveyed in the Middle Great Egg Harbor River study basin. These two sites were placed on the carpenter frog-green frog side of the anuran-community gradient because both species were heard at the two sites (Figure 5.11). One site, Makepeace Lake, was one of only two sites surveyed in the entire Great Egg Harbor River WMA that supported only native species. The Middle Great Egg Harbor River study basin displayed the lowest mean percentage of nonnative species per site (Figure 5.12) because the bullfrog was the only nonnative species heard in the study basin and was present at only one of the two sites surveyed.

Hospitality Brook

The eleven sites surveyed in the Hospitality Brook study basin were spread across the anuran-community gradient (Figure 5.11). Three native species and three nonnative species were heard in the study basin. Carpenter frogs and green frogs were present at five sites and Fowler's toads were heard at six sites. The native southern leopard frog, which was excluded from the gradient analysis, was heard calling from one site (Faraway Branch impoundment) in the study basin. This study basin displayed the highest mean percentage of nonnative species per site (Figure 5.12). Bullfrogs were heard at all 11 sites surveyed in the study basin and northern gray treefrogs and northern cricket frogs were each heard at five sites. One site, Cedar Lake - lower, was the only site surveyed in the Great Egg Harbor River WMA that supported all six species included in the gradient analysis.

Upper Great Egg Harbor River

Similar to the Hospitality Brook study basin, the six sites surveyed in the Upper Great Egg Harbor River study basin were spread across the anuran-community gradient (Figure 5.11). Three native species and two nonnative species were heard in the study basin. Carpenter frogs were heard at only two sites, Fowler's toads were present at three sites, and green frogs were heard at five sites. Except for Makepeace Lake in the Middle Great Egg Harbor River study basin, the Great Egg Harbor River impoundment above Route 54 was the only other site in the Great Egg Harbor River WMA that supported only native species. The mean percentage of nonnative species per site for the Upper Great Egg Harbor River study basin was 36% (Figure 5.12). Bullfrogs were present at all but one site. Northern gray treefrogs were heard at only one site. The Great Egg Harbor River tributary impoundment above Route 689, which was deleted prior to the gradient analysis, was the only site surveyed in the Great Egg Harbor River WMA where no native species were heard. Only bullfrogs were heard calling from this site.

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Summary

Major Findings

The results of the Great Egg Harbor River Watershed Management Area (WMA) study differed in some ways from the Rancocas Creek and Mullica River basin studies (Zampella et al. 2001, 2003). In both previous studies, the surface-water quality and biological communities found in forested stream basins contrasted with those attributes found in basins with a high percentage of altered land (developed land and upland agriculture). Acid water and typical Pinelands biological communities characterized survey sites in forest-dominated stream basins. Elevated pH and specific conductance and nonnative plant and animal species were associated with stream basins with a high percentage of altered land.

The association between land use and both pH and specific conductance in the Great Egg Harbor River WMA was statistically significant, but the relationships were not as strong as those reported for the Rancocas Creek and Mullica River basins. The relationship between land use and nutrients were generally similar in the three basins. Nitrite plus nitrate concentrations generally increased as the percentage of altered land in a drainage basin increased. Elevated ammonia levels were most apparent in the most heavily altered basins in the Rancocas Creek Basin and the Great Egg Harbor River WMA. No clear relationship between land use and phosphorus existed in either of the three major watersheds.

In the Mullica River and Rancocas Creek basins, fish and anuran assemblages varied along a watershed-disturbance gradient characterized by increases in pH, specific conductance, and the percentage of altered land in a basin. In the Great Egg Harbor River WMA, the DCA-derived anuran-community gradient was not associated with these three watershed-disturbance variables; however, the percentage of native and nonnative anuran species was associated with pH. As pH increased, the percentage of native species decreased and the percentage of nonnative species increased. Furthermore, as pH and the percentage of altered land in a basin increased, the probability of hearing native carpenter frogs at a site and the number of carpenter frogs heard calling per site decreased. In contrast, the number of nonnative bullfrogs heard at a site increased with the percentage of altered land in a basin. These trends support the use of both species as indicators of watershed conditions.

A weak, significant relationship existed between the stream-fish community gradient and pH. A weak positive correlation also existed between the percentage of nonnative stream-fish species and pH, specific conductance, and altered land. The impoundment-fish community gradient was associated with variations in pH and altered land, and the percentage of nonnative impoundment-fish species was positively correlated with altered land.

The lack of strong or consistent relationships between the DCA-derived anuran and fish community gradients and the watershed-disturbance variables may be due to the general absence of minimally disturbed fish or anuran reference sites and the widespread distribution of nonnative species.

As in the Mullica River and Rancocas Creek studies, the percentage of native-plant species decreased and the percentage of non-Pinelands species and disturbance-indicator plant species increased as pH and the percentage of altered land in a basin increased. Specific conductance increased toward the nonnative-species end of the stream-vegetation gradient, although the relationship was not statistically significant.

Comparison of Study Basins

The Great Egg Harbor River WMA comprises six major study basins, including the Hospitality Branch, Upper Great Egg Harbor River, Middle Great Egg Harbor River, Lower Great Egg Harbor River, Atlantic Drainage basins (Absecon Creek and Patcong Creek), and Tuckahoe River. Ecological integrity, based on land-use related disturbance, water quality, and the composition of stream vegetation and fish and anuran assemblages, varied among the six basins.

A method for comparing the ecological integrity of study basins was first presented in the Rancocas Creek Basin report. The method was modified in a subsequent analysis of Mullica River Basin data (Zampella et al., in press). In the Mullica River Basin assessment, ecological-integrity scores for stream sites were derived by ranking pH and specific conductance values and community-ordination scores and converting the scores to a relative scale of 0 to 100.

Low pH and specific conductance and biological communities characterized by native species were represented by high attribute scores. In contrast, high pH and specific conductance values and biological communities with a higher percentage of nonnative plant or animal species were represented by low attribute scores. The individual attribute scores were then used to calculate a median multiple-indicator, ecological-integrity score for each site. The association between altered land and the multiple indicator scores based on pH, specific conductance, stream fish, impoundment fish, on-stream anuran assemblages, and stream vegetation was stronger than that displayed by any of the individual variables except impoundment fish. A similar approach was used in the Rancocas Creek Basin study, except that the scores included altered land and excluded impoundment-fish assemblages. In both the Mullica River and Rancocas Creek studies, stream vegetation, fish, and anuran community gradients, which represented variations in the percentage of native species, were intercorrelated.

The multiple-indicator approach was not used in the Great Egg Harbor River WMA for several reasons. Fish and anuran community gradients derived using ordination were not clearly associated with the watershed-disturbance variables, and the four biological-community gradients were not intercorrelated. The absence of strong and consistent fish and frog community gradients was due at least partly to the widespread occurrence of nonnative fish and anuran species and the lack of contrast between native and mixed-native-nonnative assemblages. Because of access and habitat-suitability limitations, fewer fish, frog, and vegetation sampling sites were co-located in the Great Egg Harbor River WMA assessment compared to Mullica River and Rancocas Creek studies. Although development of concise and comprehensive comparisons between study sites is difficult because clear parallel gradients of ecological integrity were not found among the four biological communities and water-quality varied within study basins, an attempt has been made to summarize and compare the status of each study basin.

Tuckahoe River

The Tuckahoe River study basin was the least altered of all Great Egg Harbor River WMA study basins. Four sites represented reference sites, which are minimally disturbed streams that provide a standard for comparing water quality at other sites. Streams in the basin were characterized by low pH, relatively low conductance, and typical Pinelands communities compared to the other Great Egg Harbor River WMA study basins. This study basin had the highest mean percentage of native fish species. Most sites surveyed supported fish assemblages composed entirely of native species. Although nonnative bullfrogs were heard calling from three of the four sites surveyed in the study basin, native carpenter frogs were heard calling at all four sites. The Tuckahoe River study basin supported the lowest number of disturbance-indicator plant species of all the Great Egg Harbor River WMA study basins. The study-basin sites were generally characterized by a relatively high percentage of Pine Barrens District plant species and a low percentage of non-Pinelands plant species, but on average about 25% of all plant species were non-Pinelands plants.

Lower Great Egg Harbor River

The Lower Great Egg Harbor River study-basin streams were characterized by low or moderately elevated pH. Specific conductance values were generally lower than all other study basins except the Tuckahoe River. Although only two of the nine Lower Great Egg Harbor River sites surveyed supported fish assemblages composed entirely of native species, this study basin had the second-lowest mean percentage of nonnative fish species per site. Native carpenter frogs were heard at only one site, whereas bullfrogs were present at all four sites surveyed in the study basin. The study basin displayed the second highest mean percentage of nonnative anuran species per site. On average, non-Pinelands species represented about one-third of the plants found at study-basin sites. The average percentage of disturbance-indicator species was lower than all other study basins except the Tuckahoe River.

Middle Great Egg Harbor River

A wide range of median pH and specific conductance values was found for sites in the Middle Great Egg Harbor River study basin, however, the pH of most streams was low and similar to that reported for the Tuckahoe River study basin. Although two of six sites supported fish assemblages composed entirely of native species, the study basin exhibited the highest mean percentage of nonnative fish species per site. Carpenter frogs were heard at both sites surveyed in the Middle Great Egg Harbor River study basin. Bullfrogs were present at one of the two sites. The percentage of non-Pinelands plants was fairly high at most sites.

Atlantic Drainages

The Atlantic Drainages study basin was heavily altered. The study-basin streams were generally characterized by moderately elevated pH and elevated specific conductance values. Nonnative fish species were absent at only one of three stream sites surveyed. On average, nonnative fish species comprised about one-quarter of the fish assemblages at these sites. Although water-quality and fish data suggest that streams in this study basin displayed some level of impairment, the mean percentage of non-Pinelands plants was low compared to the other Great Egg Harbor River study basins.

Hospitality Branch

Compared to other study basins, median pH was elevated in the highly altered Hospitality Branch study basin. Specific conductance at most sites was moderately elevated. Nonnative fish species were present at six of the nine sites surveyed, where they averaged 41% of the assemblages. Bullfrogs were heard at all eleven survey sites, whereas carpenter frogs were heard at only five sites. The high percentage of non-Pinelands plants species found at three sites contrasted with five other Hospitality Branch sites which displayed a lower percentage of these species.

Upper Great Egg Harbor River

Streams in the Upper Great Egg Harbor River study basin displayed the most highly degraded water quality of the six Great Egg Harbor River WMA study basins. This study basin, which was the only one where nonnative fish species were present at every site surveyed, supported the highest percentage of nonnative fish, non-Pinelands plants, and indicator plant species. Bullfrogs were present at all but one of six sites surveyed. Carpenter frogs were heard at only two sites.

CONCLUSION

The relationships between developed land and upland agriculture and water-quality and biological communities in the Great Egg Harbor River WMA was more variable than those revealed in the Mullica River and Rancocas Creek basin studies. Most survey sites in the Great Egg Harbor River WMA displayed some level of aquatic degradation. Non-Pinelands fish, anuran, and plant species were widespread in the Great Egg Harbor River WMA and few sites could be characterized as reference sites. The results of this study highlight the scarcity of Pinelands streams displaying characteristic water quality and native aquatic communities in the Great Egg Harbor River WMA, which represents almost 25% of the Pinelands National Reserve.

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APPENDIX 1. pH AND SPECIFIC CONDUCTANCE DATA

Appendix 1.1. Water-quality monitoring sites in the Great Egg Harbor River WMA. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name and Description	Site Code
Maple Run at Route 662 Egg Harbor Twp. and Northfield City, Atlantic Co. (lat 39°22'32.59", long 74°34'17.99", Pleasantville quad).	AMAMILLR
Mill Branch at Route 684 Egg Harbor Twp., Atlantic Co. (lat 39°23'44.88", long 74°35'35.31", Pleasantville quad).	AMILL684
North Branch Absecon Creek at Garden State Parkway Egg Harbor Twp., Atlantic Co. (lat 39°26'42.24", long 74°32'19.73", Pleasantville quad).	ANOABGSP
Faraway Branch at Jackson Road Monroe Twp., Gloucester Co. (lat 39°36'58.54", long 74°56'10.02", Buena quad).	HFAJACKS
Hospitality Branch at Route 633 Monroe Twp., Gloucester Co. (lat 39°38'40.78", long 74°59'08.66", Williamstown quad).	HHOBLUEB
Hospitality Branch at Cain's Mill Road Folsom Boro, Atlantic Co. (lat 39°36'03.20", long 74°52'54.65", Buena quad).	HHOCAINS
Hospitality Branch at Sharps Road Monroe Twp., Gloucester Co. (lat 39°36'42.06", long 74°55'08.27", Buena quad).	HHODIAMO
Hospitality Branch at Eighth Street Folsom Boro, Atlantic Co. (lat 39°34'18.57", long 74°49'37.06", Newtonville quad).	HHOEIGHT
Hospitality Branch at Pennsylvania/Reading railroad bridge Folsom Boro, Atlantic Co. (lat 39°35'18.06", long 74°51'30.90", Newtonville quad).	HHORRBDG
Hospitality Branch at Route 538 Monroe Twp., Gloucester Co. (lat 39°37'14.09", long 74°55'37.29", Buena quad).	HHORT538
Hospitality Branch at Whitehall Road Monroe Twp., Gloucester Co. (lat 39°38'17.81", long 74°56'53.96", Williamstown quad).	HHOWHITE
Marsh Lake Branch at Blue Anchor Road Buena Vista Twp., Atlantic Co. (lat 39°35'23.02", long 74°52'53.90", Buena quad).	HMABLUEA
Marsh Lake Branch at Jackson Road Buena Vista Twp., Atlantic Co. (lat 39°35'08.19", long 74°54'06.84", Buena quad).	HMAJACKS
Marsh Lake Branch at Piney Hollow Road Franklin Twp., Gloucester Co. (lat 39°34'31.42", long 74°56'12.98", Buena quad).	HMAPINEY
Marsh Lake Branch at Unexpected Road Buena Vista and Franklin Twp., Atlantic and Gloucester Co. (lat 39°33'57.52", long 74°55'33.72", Buena quad).	HMAUNEXS
Three Pond Branch at Route 54 Buena Vista Twp., Atlantic Co. (lat 39°34'51.82", long 74°52'02.39", Newtonville quad).	HTHREE54
Whitehall Branch at Blue Bell Road Monroe Twp., Gloucester Co. (lat 39°38'04.43", long74°59'03.18", Williamstown quad).	HWHBLUEB
Whitehall Branch at Whitehall Road Monroe Twp., Gloucester Co. (lat 39°38'01.48", long 74°56'59.77", Williamstown quad).	HWHWHITE
White Oak Branch at Jackson Road Monroe Twp., Gloucester Co. (lat 39°35'46.49", long 74°55'04.68", Buena quad).	HWOJACKS
Babcock Creek at Route 322 Hamilton Twp., Atlantic Co. (lat 39°28'08.73", long 74°41'32.86", Mays Landing quad).	LBABC322
Cedar Brook at Route 606 Hamilton Twp., Atlantic Co. (lat 39°26'58.29", long 74°44'56.57", Mays Landing quad).	LCEHARDS

Site Name and Description	Site Code
Gibson Creek at Route 50 Estell Manor City, Atlantic Co. (lat 39°21'10.81", long 74°45'22.83", Tuckahoe quad).	LGIBSO50
Gravelly Run at Route 559 Hamilton Twp., Atlantic Co. (lat 39°25'37.98", long 74°42'06.15", Mays Landing quad).	LGRAV559
Jack Pudding Branch at Leipzig Road Hamilton Twp., Atlantic Co. (lat 39°28'42.37", long 74°37'36.83", Mays Landing quad).	LJALEIPZ
Miry Run at Route 559 Hamilton and Egg Harbor Twps., Atlantic Co. (lat 39°24'38.77", long 74°40'07.94", Mays Landing quad).	LMIRT559
South River at Estelle Avenue Hamilton Twp., Atlantic Co. (lat 39°28'15.65", long 74°50'35.25", Dorothy quad).	LSOESTEL
South River at Forty Wire Road Hamilton and Weymouth Twps., Atlantic Co. (lat 39°26'25.14", long 74°45'19.23", Dorothy quad).	LSOFORTY
South River at Route 552 Hamilton Twp., Atlantic Co. (lat 39°26'27.57", long 74°48'00.24", Dorothy quad).	LSOUT552
Stephen Creek at Eleventh Avenue Estell Manor City, Atlantic Co. (lat 39°24'55.88", long 74°47'42.57", Dorothy quad).	LSTELEVE
Stephen Creek at Route 50 Estell Manor City, Atlantic Co. (lat 39°23'37.70", long 74°44'53.48", Mays Landing quad).	LSTEP50S
Watering Race Branch at Route 50 Hamilton Twp., Atlantic Co. (lat 39°28'22.56", long 74°42'55.68", Mays Landing quad).	LWATER50
Deep Run at Route 559 Hamilton Twp., Atlantic Co. (lat 39°30'26.67", long 74°46'55.11", Newtonville quad).	MDEEP559
Deep Run at Route 54 Buena Boro, Atlantic Co. (lat 39°31'20.83", long 74°55'12.53", Buena quad).	MDEEPR54
Deep Run at Eighth Street Buena Vista Twp., Atlantic Co. (lat 39°31'18.07", long 74°52'22.42", Newtonville quad).	MDEPANCS
Great Egg Harbor River at Route 559 Hamilton Twp., Atlantic Co. (lat 39°31'05.88", long 74°46'43.03", Newtonville quad).	MGREA559
Great Egg Harbor River at Route 616 Hamilton Twp., Atlantic Co. (lat 39°27'16.24", long 74°44'01.44", Mays Landing quad).	MGREA616
Mare Run at Route 559 Hamilton Twp., Atlantic Co. (lat 39°28'43.34", long 74°45'27.53", Dorothy quad).	MMARE559
Makepeace Stream at Route 623 Hamilton Twp., Atlantic Co. (lat 39°32'47.63", long 74°45'05.97", Newtonville quad).	MMKRT623
McNeals Branch at Route 666 Estell Manor City, Atlantic Co. (lat 39°18'56.96", long 74°49'27.60", Tuckahoe quad).	TMCNE666
Mill Creek at Route 557 Upper Twp., Cape May Co. (lat 39°17'02.91", long 74°47'31.42", Tuckahoe quad).	TMILL557
Tarkiln Branch at Route 548 Upper Twp., Cape May Co. (lat 39°18'19.24", long 74°49'56.65", Tuckahoe quad).	TTAR548S
Tarkiln Branch below powerline right-of-way Upper Twp., Cape May Co. (lat 39°17'58.86", long 74°51'13.45", Tuckahoe quad).	TTARKBOG
Tuckahoe River at Route 49 near Head of River Upper Twp. and Estell Manor City, Cape May and Atlantic Co. (lat 39°18'24.82", long 74°49'12.65", Tuckahoe quad).	TTU49HED

Site Name and Description	Site Code
Tuckahoe River at Route 49 at Hunters Mill Maurice River Twp. and Estell Manor City, Cumberland Co. (lat 39°19'26.33", long 74°51'40.34", Tuckahoe quad).	TTU49HUN
Tuckahoe River at Route 637 Estell Manor City, Atlantic Co. (lat 39°22'20.50", long 74°51'12.41", Tuckahoe quad).	TTUCUMBS
Warners Mill Stream at Aetna Drive Estell Manor City, Atlantic Co. (lat 39°18'50.04", long 74°48'20.06", Tuckahoe quad).	TWAAETNA
Four Mile Branch at Route 536 Monroe Twp., Gloucester Co. (lat 39°41'47.56", long 74°56'23.61", Williamstown quad).	UFORT536
Great Egg Harbor River at Route 536 Spur Winslow Twp., Camden Co. (lat 39°44'01.87", long 74°57'03.82", Williamstown quad).	UGR536SP
Great Egg Harbor River at Route 536 Winslow Twp., Camden Co. (lat 39°42'05.96", long 74°56'14.78", Williamstown quad).	UGREA536
Great Egg Harbor River at Route 54 Folsom Boro, Atlantic Co. (lat 39°35'41.19", long 74°51'06.72", Newtonville quad).	UGRERT54
Great Egg Harbor River at Route 691 Winslow Twp. and Berlin Boro, Camden Co. (lat 39°46'51.18", long 74°56'34.70", Clementon quad).	UGRRT691
Great Egg Harbor River at Route 723 Winslow Twp., Camden Co. (lat 39°40'10.19", long 74°54'47.99", Williamstown quad).	UGRRT723
Penny Pot Stream at Eighth Street Folsom Boro, Atlantic Co. (lat 39°34'48.42", long 74°49'03.11", Newtonville quad).	UPENN8TH
Penny Pot Stream at Route 54 Hammonton Town, Atlantic Co. (lat 39°36'34.86", long 74°50'02.95", Newtonville quad).	UPENNY54
Squankum Branch at Malaga Road Monroe Twp., Gloucester Co. (lat 39°40'04.44", long 74°57'37.99", Williamstown quad).	USQMALAG

Appendix 1.2. Specific conductance (SC, :S cm^{-1}) and pH values for 55 water-quality sites in the Great Egg Harbor River WMA. Refer to Chapter 2 (Water Quality) for methodology. A dash (-) indicates that a steam was dry.

Site Name	Site Code	Date	pH	SC
Maple Run at Route 662	AMAMILLR	04/09/02	5.75	133.0
Maple Run at Route 662	AMAMILLR	05/08/02	5.65	98.2
Maple Run at Route 662	AMAMILLR	06/21/02	6.36	76.7
Maple Run at Route 662	AMAMILLR	07/19/02	6.74	80.5
Maple Run at Route 662	AMAMILLR	08/09/02	5.95	91.7
Maple Run at Route 662	AMAMILLR	09/20/02	5.64	104.8
Maple Run at Route 662	AMAMILLR	10/24/02	5.98	101.1
Maple Run at Route 662	AMAMILLR	12/31/02	5.18	97.4
Maple Run at Route 662	AMAMILLR	01/17/03	5.55	100.2
Maple Run at Route 662	AMAMILLR	02/10/03	5.30	149.3
Maple Run at Route 662	AMAMILLR	03/27/03	5.39	141.7
Mill Branch at Route 684	AMILL684	04/09/02	5.24	44.2
Mill Branch at Route 684	AMILL684	05/08/02	4.97	45.2
Mill Branch at Route 684	AMILL684	06/21/02	5.15	43.7
Mill Branch at Route 684	AMILL684	07/19/02	5.51	38.1
Mill Branch at Route 684	AMILL684	08/09/02	5.19	39.3
Mill Branch at Route 684	AMILL684	09/20/02	5.76	39.9
Mill Branch at Route 684	AMILL684	10/24/02	4.87	43.9
Mill Branch at Route 684	AMILL684	12/31/02	4.26	56.7
Mill Branch at Route 684	AMILL684	01/17/03	4.86	56.3
Mill Branch at Route 684	AMILL684	02/10/03	4.77	53.2
Mill Branch at Route 684	AMILL684	03/27/03	4.45	57.7
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	04/09/02	5.60	96.5
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	05/08/02	5.50	96.4
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	06/21/02	5.35	95.7
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	07/19/02	6.05	99.0
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	08/09/02	5.81	112.8
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	09/20/02	5.63	130.3
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	10/24/02	5.53	120.0
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	12/31/02	5.86	102.7
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	01/17/03	5.43	100.4
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	02/10/03	5.09	102.7
North Branch Absecon Creek at Garden State Parkway	ANOABGSP	03/27/03	5.47	95.0
Faraway Branch at Jackson Road	HFAJACKS	04/08/02	5.30	39.7
Faraway Branch at Jackson Road	HFAJACKS	05/07/02	5.27	35.4
Faraway Branch at Jackson Road	HFAJACKS	06/19/02	4.98	30.0
Faraway Branch at Jackson Road	HFAJACKS	07/17/02	5.52	36.2
Faraway Branch at Jackson Road	HFAJACKS	08/07/02	5.70	40.5
Faraway Branch at Jackson Road	HFAJACKS	09/18/02	4.17	40.3
Faraway Branch at Jackson Road	HFAJACKS	10/22/02	5.42	37.8
Faraway Branch at Jackson Road	HFAJACKS	12/27/02	3.83	136.9
Faraway Branch at Jackson Road	HFAJACKS	01/15/03	4.89	56.8
Faraway Branch at Jackson Road	HFAJACKS	02/05/03	4.26	78.2
Faraway Branch at Jackson Road	HFAJACKS	03/25/03	4.33	62.6
Hospitality Branch at Route 633	HHOBLUEB	04/08/02	6.24	63.3
Hospitality Branch at Route 633	HHOBLUEB	05/07/02	6.13	63.3
Hospitality Branch at Route 633	HHOBLUEB	06/19/02	6.48	62.9
Hospitality Branch at Route 633	HHOBLUEB	07/17/02	6.37	65.3
Hospitality Branch at Route 633	HHOBLUEB	08/07/02	6.43	68.2
Hospitality Branch at Route 633	HHOBLUEB	09/18/02	6.13	75.5
Hospitality Branch at Route 633	HHOBLUEB	10/22/02	5.81	74.1
Hospitality Branch at Route 633	HHOBLUEB	12/27/02	4.74	90.4
Hospitality Branch at Route 633	HHOBLUEB	01/15/03	5.79	84.6
Hospitality Branch at Route 633	HHOBLUEB	02/05/03	5.70	78.8
Hospitality Branch at Route 633	HHOBLUEB	03/25/03	5.21	79.5
Hospitality Branch at Cain's Mill Road	HHOCAINS	06/19/02	5.38	47.9

Site Name	Site Code	Date	pH	SC
Hospitality Branch at Cain's Mill Road	HHOCAINS	07/17/02	5.67	54.2
Hospitality Branch at Cain's Mill Road	HHOCAINS	08/07/02	6.06	52.3
Hospitality Branch at Cain's Mill Road	HHOCAINS	09/18/02	6.16	57.3
Hospitality Branch at Cain's Mill Road	HHOCAINS	10/22/02	5.98	58.3
Hospitality Branch at Cain's Mill Road	HHOCAINS	12/27/02	4.79	88.3
Hospitality Branch at Cain's Mill Road	HHOCAINS	01/15/03	5.18	73.8
Hospitality Branch at Cain's Mill Road	HHOCAINS	02/05/03	5.48	74.5
Hospitality Branch at Cain's Mill Road	HHOCAINS	03/25/03	4.73	70.9
Hospitality Branch at Sharps Road	HHODIAMO	06/19/02	5.99	51.4
Hospitality Branch at Sharps Road	HHODIAMO	07/17/02	6.46	49.3
Hospitality Branch at Sharps Road	HHODIAMO	08/07/02	6.19	50.3
Hospitality Branch at Sharps Road	HHODIAMO	09/18/02	5.88	58.1
Hospitality Branch at Sharps Road	HHODIAMO	10/22/02	5.83	61.0
Hospitality Branch at Sharps Road	HHODIAMO	12/27/02	5.46	83.2
Hospitality Branch at Sharps Road	HHODIAMO	01/15/03	5.49	74.8
Hospitality Branch at Sharps Road	HHODIAMO	02/05/03	5.49	79.6
Hospitality Branch at Sharps Road	HHODIAMO	03/25/03	5.78	72.9
Hospitality Branch at Eighth Street	HHOEIGHT	06/20/02	5.83	50.2
Hospitality Branch at Eighth Street	HHOEIGHT	07/18/02	6.22	49.5
Hospitality Branch at Eighth Street	HHOEIGHT	08/08/02	5.96	50.4
Hospitality Branch at Eighth Street	HHOEIGHT	09/19/02	6.34	51.6
Hospitality Branch at Eighth Street	HHOEIGHT	10/23/02	5.88	52.7
Hospitality Branch at Eighth Street	HHOEIGHT	12/30/02	4.87	73.3
Hospitality Branch at Eighth Street	HHOEIGHT	01/16/03	5.09	71.7
Hospitality Branch at Eighth Street	HHOEIGHT	02/06/03	5.38	71.3
Hospitality Branch at Eighth Street	HHOEIGHT	03/26/03	5.17	66.5
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	04/08/02	5.81	63.7
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	05/07/02	6.20	55.3
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	06/19/02	5.57	49.3
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	07/18/02	6.41	61.4
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	08/08/02	5.75	66.4
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	09/19/02	5.81	62.9
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	10/23/02	5.82	58.3
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	12/30/02	4.67	73.3
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	01/16/03	4.81	73.8
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	02/06/03	5.19	70.5
Hospitality Branch at Pennsylvania/Reading railroad bridge	HHORRBDG	03/26/03	5.04	62.1
Hospitality Branch at Route 538	HHORT538	04/08/02	6.53	68.2
Hospitality Branch at Route 538	HHORT538	05/07/02	6.14	61.0
Hospitality Branch at Route 538	HHORT538	06/19/02	5.99	55.1
Hospitality Branch at Route 538	HHORT538	07/17/02	6.02	53.6
Hospitality Branch at Route 538	HHORT538	08/07/02	5.99	58.8
Hospitality Branch at Route 538	HHORT538	09/18/02	6.13	58.8
Hospitality Branch at Route 538	HHORT538	10/22/02	5.94	62.8
Hospitality Branch at Route 538	HHORT538	12/27/02	5.45	87.2
Hospitality Branch at Route 538	HHORT538	01/15/03	5.77	81.3
Hospitality Branch at Route 538	HHORT538	02/05/03	5.57	83.3
Hospitality Branch at Route 538	HHORT538	03/25/03	5.92	80.4
Hospitality Branch at Whitehall Road	HHOWHITE	06/19/02	5.94	61.3
Hospitality Branch at Whitehall Road	HHOWHITE	07/17/02	6.16	61.8
Hospitality Branch at Whitehall Road	HHOWHITE	08/07/02	6.36	66.4
Hospitality Branch at Whitehall Road	HHOWHITE	09/18/02	6.30	69.9
Hospitality Branch at Whitehall Road	HHOWHITE	10/22/02	6.52	72.4
Hospitality Branch at Whitehall Road	HHOWHITE	12/27/02	5.68	84.1
Hospitality Branch at Whitehall Road	HHOWHITE	01/15/03	5.97	90.1
Hospitality Branch at Whitehall Road	HHOWHITE	02/05/03	5.97	80.9
Hospitality Branch at Whitehall Road	HHOWHITE	03/25/03	5.86	87.5
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	04/08/02	6.08	49.5
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	05/07/02	5.85	48.1

Site Name	Site Code	Date	pH	SC
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	06/19/02	5.46	46.9
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	07/17/02	5.98	40.2
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	08/07/02	6.14	38.8
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	09/18/02	6.04	38.5
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	10/22/02	5.40	44.7
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	12/27/02	4.86	73.2
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	01/15/03	5.01	68.0
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	02/05/03	5.39	64.3
Marsh Lake Branch at Blue Anchor Road	HMABLUEA	03/25/03	4.59	59.7
Marsh Lake Branch at Jackson Road	HMAJACKS	06/19/02	4.93	49.6
Marsh Lake Branch at Jackson Road	HMAJACKS	07/17/02	5.85	42.1
Marsh Lake Branch at Jackson Road	HMAJACKS	08/07/02	6.09	43.8
Marsh Lake Branch at Jackson Road	HMAJACKS	09/18/02	5.73	44.6
Marsh Lake Branch at Jackson Road	HMAJACKS	10/22/02	5.42	49.2
Marsh Lake Branch at Jackson Road	HMAJACKS	12/27/02	4.41	90.1
Marsh Lake Branch at Jackson Road	HMAJACKS	01/15/03	4.65	80.4
Marsh Lake Branch at Jackson Road	HMAJACKS	02/05/03	4.86	72.9
Marsh Lake Branch at Jackson Road	HMAJACKS	03/25/03	5.07	65.6
Marsh Lake Branch at Piney Hollow Road	HMAPINEY	06/19/02	5.32	91.5
Marsh Lake Branch at Piney Hollow Road	HMAPINEY	07/17/02	5.80	108.9
Marsh Lake Branch at Piney Hollow Road	HMAPINEY	08/07/02	-	-
Marsh Lake Branch at Piney Hollow Road	HMAPINEY	09/18/02	5.79	138.9
Marsh Lake Branch at Piney Hollow Road	HMAPINEY	10/22/02	6.20	239.0
Marsh Lake Branch at Piney Hollow Road	HMAPINEY	12/27/02	5.25	115.0
Marsh Lake Branch at Piney Hollow Road	HMAPINEY	01/15/03	5.79	101.4
Marsh Lake Branch at Piney Hollow Road	HMAPINEY	02/05/03	5.46	118.1
Marsh Lake Branch at Piney Hollow Road	HMAPINEY	03/25/03	5.91	63.2
Marsh Lake Branch at Unexpected Road	HMAUNEXS	04/08/02	5.04	92.2
Marsh Lake Branch at Unexpected Road	HMAUNEXS	05/07/02	5.16	83.9
Marsh Lake Branch at Unexpected Road	HMAUNEXS	06/19/02	5.31	51.7
Marsh Lake Branch at Unexpected Road	HMAUNEXS	07/17/02	5.75	53.0
Marsh Lake Branch at Unexpected Road	HMAUNEXS	08/07/02	5.93	53.9
Marsh Lake Branch at Unexpected Road	HMAUNEXS	09/18/02	5.31	57.5
Marsh Lake Branch at Unexpected Road	HMAUNEXS	10/22/02	5.00	71.3
Marsh Lake Branch at Unexpected Road	HMAUNEXS	12/27/02	5.01	107.6
Marsh Lake Branch at Unexpected Road	HMAUNEXS	01/15/03	4.87	99.9
Marsh Lake Branch at Unexpected Road	HMAUNEXS	02/05/03	4.93	77.0
Marsh Lake Branch at Unexpected Road	HMAUNEXS	03/25/03	4.85	74.8
Three Pond Branch at Route 54	HTHREE54	04/08/02	-	-
Three Pond Branch at Route 54	HTHREE54	05/07/02	-	-
Three Pond Branch at Route 54	HTHREE54	06/19/02	4.34	99.4
Three Pond Branch at Route 54	HTHREE54	07/18/02	-	-
Three Pond Branch at Route 54	HTHREE54	08/08/02	-	-
Three Pond Branch at Route 54	HTHREE54	09/19/02	-	-
Three Pond Branch at Route 54	HTHREE54	10/23/02	-	-
Three Pond Branch at Route 54	HTHREE54	12/30/02	4.36	148.5
Three Pond Branch at Route 54	HTHREE54	01/16/03	4.12	143.5
Three Pond Branch at Route 54	HTHREE54	02/06/03	4.45	121.1
Three Pond Branch at Route 54	HTHREE54	03/26/03	4.34	97.9
Whitehall Branch at Blue Bell Road	HWHBLUEB	04/08/02	6.53	55.1
Whitehall Branch at Blue Bell Road	HWHBLUEB	05/07/02	5.98	51.0
Whitehall Branch at Blue Bell Road	HWHBLUEB	06/19/02	5.61	44.1
Whitehall Branch at Blue Bell Road	HWHBLUEB	07/17/02	6.24	49.2
Whitehall Branch at Blue Bell Road	HWHBLUEB	08/07/02	6.27	48.9
Whitehall Branch at Blue Bell Road	HWHBLUEB	09/18/02	6.20	74.3
Whitehall Branch at Blue Bell Road	HWHBLUEB	10/22/02	6.18	79.5
Whitehall Branch at Blue Bell Road	HWHBLUEB	12/27/02	5.33	57.6
Whitehall Branch at Blue Bell Road	HWHBLUEB	01/15/03	5.91	63.9
Whitehall Branch at Blue Bell Road	HWHBLUEB	02/05/03	5.95	66.2

Site Name	Site Code	Date	pH	SC
Whitehall Branch at Blue Bell Road	HWHBLUEB	03/25/03	5.53	57.2
Whitehall Branch at Whitehall Road	HWHWHITE	06/19/02	6.35	56.8
Whitehall Branch at Whitehall Road	HWHWHITE	07/17/02	6.37	55.9
Whitehall Branch at Whitehall Road	HWHWHITE	08/07/02	6.72	60.3
Whitehall Branch at Whitehall Road	HWHWHITE	09/18/02	6.04	61.9
Whitehall Branch at Whitehall Road	HWHWHITE	10/22/02	6.22	65.1
Whitehall Branch at Whitehall Road	HWHWHITE	12/27/02	5.35	60.6
Whitehall Branch at Whitehall Road	HWHWHITE	01/15/03	5.74	72.9
Whitehall Branch at Whitehall Road	HWHWHITE	02/05/03	5.21	75.7
Whitehall Branch at Whitehall Road	HWHWHITE	03/25/03	6.46	61.4
White Oak Branch at Jackson Road	HWOJACKS	04/08/02	3.73	153.3
White Oak Branch at Jackson Road	HWOJACKS	05/07/02	3.98	121.6
White Oak Branch at Jackson Road	HWOJACKS	06/19/02	3.87	90.7
White Oak Branch at Jackson Road	HWOJACKS	07/17/02	-	-
White Oak Branch at Jackson Road	HWOJACKS	08/07/02	-	-
White Oak Branch at Jackson Road	HWOJACKS	09/18/02	-	-
White Oak Branch at Jackson Road	HWOJACKS	10/22/02	-	-
White Oak Branch at Jackson Road	HWOJACKS	12/27/02	4.45	64.9
White Oak Branch at Jackson Road	HWOJACKS	01/15/03	4.00	130.1
White Oak Branch at Jackson Road	HWOJACKS	02/05/03	3.86	135.7
White Oak Branch at Jackson Road	HWOJACKS	03/25/03	3.98	104.8
Babcock Creek at Route 322	LBABC322	04/09/02	4.71	59.1
Babcock Creek at Route 322	LBABC322	05/08/02	4.29	60.5
Babcock Creek at Route 322	LBABC322	06/21/02	4.57	54.3
Babcock Creek at Route 322	LBABC322	07/19/02	5.45	40.9
Babcock Creek at Route 322	LBABC322	08/09/02	5.24	41.7
Babcock Creek at Route 322	LBABC322	09/20/02	4.99	44.4
Babcock Creek at Route 322	LBABC322	10/24/02	4.80	49.6
Babcock Creek at Route 322	LBABC322	12/31/02	4.35	112.7
Babcock Creek at Route 322	LBABC322	01/17/03	4.12	100.3
Babcock Creek at Route 322	LBABC322	02/10/03	3.91	102.3
Babcock Creek at Route 322	LBABC322	03/27/03	4.15	115.4
Cedar Brook at Route 606	LCEHARDS	06/20/02	5.08	41.8
Cedar Brook at Route 606	LCEHARDS	07/18/02	5.89	68.9
Cedar Brook at Route 606	LCEHARDS	08/09/02	-	-
Cedar Brook at Route 606	LCEHARDS	09/20/02	-	-
Cedar Brook at Route 606	LCEHARDS	10/23/02	-	-
Cedar Brook at Route 606	LCEHARDS	12/31/02	5.05	84.1
Cedar Brook at Route 606	LCEHARDS	01/17/03	4.96	108.8
Cedar Brook at Route 606	LCEHARDS	02/10/03	5.37	132.4
Cedar Brook at Route 606	LCEHARDS	03/27/03	5.28	70.8
Gibson Creek at Route 50	LGIBSO50	04/09/02	4.31	45.8
Gibson Creek at Route 50	LGIBSO50	05/08/02	4.24	42.9
Gibson Creek at Route 50	LGIBSO50	06/21/02	4.83	30.7
Gibson Creek at Route 50	LGIBSO50	07/18/02	4.69	25.1
Gibson Creek at Route 50	LGIBSO50	08/09/02	5.22	24.9
Gibson Creek at Route 50	LGIBSO50	09/20/02	4.28	27.2
Gibson Creek at Route 50	LGIBSO50	10/25/02	3.87	30.8
Gibson Creek at Route 50	LGIBSO50	12/30/02	4.71	56.9
Gibson Creek at Route 50	LGIBSO50	01/16/03	4.13	51.7
Gibson Creek at Route 50	LGIBSO50	02/06/03	4.19	51.3
Gibson Creek at Route 50	LGIBSO50	03/26/03	4.35	49.6
Gravelly Run at Route 559	LGRAV559	04/09/02	4.21	74.7
Gravelly Run at Route 559	LGRAV559	05/08/02	4.07	77.1
Gravelly Run at Route 559	LGRAV559	06/21/02	4.77	61.7
Gravelly Run at Route 559	LGRAV559	07/19/02	5.13	45.9
Gravelly Run at Route 559	LGRAV559	08/09/02	5.69	53.0
Gravelly Run at Route 559	LGRAV559	09/20/02	5.27	48.6
Gravelly Run at Route 559	LGRAV559	10/24/02	4.45	54.3

Site Name	Site Code	Date	pH	SC
Gravelly Run at Route 559	LGRAV559	12/31/02	4.79	91.9
Gravelly Run at Route 559	LGRAV559	01/17/03	4.19	86.2
Gravelly Run at Route 559	LGRAV559	02/10/03	4.37	80.3
Gravelly Run at Route 559	LGRAV559	03/27/03	4.40	78.8
Jack Pudding Branch at Leipzig Road	LJALEIPZ	06/21/02	6.84	64.7
Jack Pudding Branch at Leipzig Road	LJALEIPZ	07/19/02	9.62	74.4
Jack Pudding Branch at Leipzig Road	LJALEIPZ	08/09/02	6.64	77.8
Jack Pudding Branch at Leipzig Road	LJALEIPZ	09/20/02	6.25	69.7
Jack Pudding Branch at Leipzig Road	LJALEIPZ	10/24/02	6.20	68.9
Jack Pudding Branch at Leipzig Road	LJALEIPZ	12/31/02	6.43	345.0
Jack Pudding Branch at Leipzig Road	LJALEIPZ	01/17/03	6.31	122.4
Jack Pudding Branch at Leipzig Road	LJALEIPZ	02/10/03	5.80	222.0
Jack Pudding Branch at Leipzig Road	LJALEIPZ	03/27/03	5.41	86.8
Miry Run at Route 559	LMIRT559	06/21/02	4.61	80.4
Miry Run at Route 559	LMIRT559	07/19/02	-	-
Miry Run at Route 559	LMIRT559	08/09/02	-	-
Miry Run at Route 559	LMIRT559	09/20/02	4.72	155.6
Miry Run at Route 559	LMIRT559	10/24/02	3.87	175.7
Miry Run at Route 559	LMIRT559	12/31/02	5.27	116.1
Miry Run at Route 559	LMIRT559	1/17/03	4.16	119.2
Miry Run at Route 559	LMIRT559	2/10/03	4.44	119.1
Miry Run at Route 559	LMIRT559	3/27/03	4.16	103.1
South River at Estelle Avenue	LSOESTEL	04/09/02	5.12	97.9
South River at Estelle Avenue	LSOESTEL	05/07/02	4.79	100.3
South River at Estelle Avenue	LSOESTEL	06/20/02	5.02	99.0
South River at Estelle Avenue	LSOESTEL	07/18/02	5.29	100.4
South River at Estelle Avenue	LSOESTEL	08/08/02	5.47	102.1
South River at Estelle Avenue	LSOESTEL	09/19/02	4.69	101.4
South River at Estelle Avenue	LSOESTEL	10/23/02	4.30	105.3
South River at Estelle Avenue	LSOESTEL	12/30/02	4.76	131.8
South River at Estelle Avenue	LSOESTEL	01/16/03	4.77	121.6
South River at Estelle Avenue	LSOESTEL	02/06/03	4.68	122.5
South River at Estelle Avenue	LSOESTEL	03/26/03	5.02	109.9
South River at Forty Wire Road	LSOFORTY	04/09/02	5.93	52.8
South River at Forty Wire Road	LSOFORTY	05/08/02	5.52	53.8
South River at Forty Wire Road	LSOFORTY	06/20/02	5.29	51.1
South River at Forty Wire Road	LSOFORTY	07/19/02	6.16	49.6
South River at Forty Wire Road	LSOFORTY	08/09/02	6.23	49.4
South River at Forty Wire Road	LSOFORTY	09/20/02	5.92	50.4
South River at Forty Wire Road	LSOFORTY	10/25/02	6.58	53.9
South River at Forty Wire Road	LSOFORTY	12/31/02	4.85	68.4
South River at Forty Wire Road	LSOFORTY	01/17/03	4.76	63.0
South River at Forty Wire Road	LSOFORTY	02/10/03	5.49	60.1
South River at Forty Wire Road	LSOFORTY	03/27/03	4.79	66.2
South River at Route 552	LSOUT552	04/09/02	5.58	58.2
South River at Route 552	LSOUT552	05/08/02	5.66	59.4
South River at Route 552	LSOUT552	06/20/02	5.51	57.8
South River at Route 552	LSOUT552	07/18/02	5.34	58.0
South River at Route 552	LSOUT552	08/08/02	5.96	59.7
South River at Route 552	LSOUT552	09/19/02	5.09	58.4
South River at Route 552	LSOUT552	10/25/02	6.08	63.9
South River at Route 552	LSOUT552	12/31/02	4.91	117.8
South River at Route 552	LSOUT552	01/17/03	4.86	78.8
South River at Route 552	LSOUT552	02/10/03	4.90	74.5
South River at Route 552	LSOUT552	03/27/03	4.66	77.0
Stephen Creek at Eleventh Avenue	LSTELEVE	04/09/02	5.94	36.2
Stephen Creek at Eleventh Avenue	LSTELEVE	05/08/02	6.11	36.6
Stephen Creek at Eleventh Avenue	LSTELEVE	06/20/02	5.60	34.8
Stephen Creek at Eleventh Avenue	LSTELEVE	07/18/02	5.40	30.7

Site Name	Site Code	Date	pH	SC
Stephen Creek at Eleventh Avenue	LSTELEVE	08/08/02	6.02	32.1
Stephen Creek at Eleventh Avenue	LSTELEVE	09/19/02	5.13	32.7
Stephen Creek at Eleventh Avenue	LSTELEVE	10/25/02	6.31	35.5
Stephen Creek at Eleventh Avenue	LSTELEVE	12/31/02	4.99	52.9
Stephen Creek at Eleventh Avenue	LSTELEVE	01/17/03	4.34	48.9
Stephen Creek at Eleventh Avenue	LSTELEVE	02/10/03	5.10	41.5
Stephen Creek at Eleventh Avenue	LSTELEVE	03/27/03	4.65	46.9
Stephen Creek at Route 50	LSTEP50S	04/09/02	5.46	31.8
Stephen Creek at Route 50	LSTEP50S	05/08/02	6.07	33.0
Stephen Creek at Route 50	LSTEP50S	06/21/02	5.68	32.7
Stephen Creek at Route 50	LSTEP50S	07/18/02	5.59	29.0
Stephen Creek at Route 50	LSTEP50S	08/09/02	5.69	28.2
Stephen Creek at Route 50	LSTEP50S	09/20/02	4.16	28.8
Stephen Creek at Route 50	LSTEP50S	10/25/02	5.82	31.2
Stephen Creek at Route 50	LSTEP50S	12/30/02	5.01	38.4
Stephen Creek at Route 50	LSTEP50S	01/16/03	4.68	38.6
Stephen Creek at Route 50	LSTEP50S	02/06/03	4.41	34.8
Stephen Creek at Route 50	LSTEP50S	03/27/03	5.09	38.1
Watering Race Branch at Route 50	LWATER50	04/09/02	4.11	104.1
Watering Race Branch at Route 50	LWATER50	05/08/02	4.00	94.3
Watering Race Branch at Route 50	LWATER50	06/21/02	3.97	81.2
Watering Race Branch at Route 50	LWATER50	07/19/02	5.69	59.7
Watering Race Branch at Route 50	LWATER50	08/09/02	5.98	63.1
Watering Race Branch at Route 50	LWATER50	09/20/02	5.30	70.6
Watering Race Branch at Route 50	LWATER50	10/24/02	5.41	78.5
Watering Race Branch at Route 50	LWATER50	12/31/02	4.05	112.5
Watering Race Branch at Route 50	LWATER50	01/17/03	3.86	105.4
Watering Race Branch at Route 50	LWATER50	02/10/03	3.82	114.1
Watering Race Branch at Route 50	LWATER50	03/27/03	4.01	105.1
Deep Run at Route 559	MDEEP559	04/08/02	5.14	63.2
Deep Run at Route 559	MDEEP559	05/07/02	5.22	62.7
Deep Run at Route 559	MDEEP559	06/20/02	4.45	56.5
Deep Run at Route 559	MDEEP559	07/18/02	6.30	56.8
Deep Run at Route 559	MDEEP559	08/08/02	5.82	52.8
Deep Run at Route 559	MDEEP559	09/19/02	5.14	56.9
Deep Run at Route 559	MDEEP559	10/23/02	4.28	68.2
Deep Run at Route 559	MDEEP559	12/30/02	4.57	80.7
Deep Run at Route 559	MDEEP559	01/16/03	4.81	73.2
Deep Run at Route 559	MDEEP559	02/06/03	4.63	78.3
Deep Run at Route 559	MDEEP559	03/26/03	4.69	75.4
Deep Run at Route 54	MDEEPR54	04/08/02	6.54	801.0
Deep Run at Route 54	MDEEPR54	05/07/02	6.47	597.0
Deep Run at Route 54	MDEEPR54	06/19/02	6.38	524.0
Deep Run at Route 54	MDEEPR54	07/17/02	6.74	793.0
Deep Run at Eighth Street	MDEPANCS	06/19/02	5.96	104.0
Deep Run at Eighth Street	MDEPANCS	07/17/02	9.66	169.1
Deep Run at Eighth Street	MDEPANCS	08/08/02	6.27	162.6
Deep Run at Eighth Street	MDEPANCS	09/19/02	6.30	155.4
Deep Run at Eighth Street	MDEPANCS	10/22/02	6.10	142.7
Deep Run at Eighth Street	MDEPANCS	12/27/02	5.63	140.7
Deep Run at Eighth Street	MDEPANCS	01/15/03	6.05	147.2
Deep Run at Eighth Street	MDEPANCS	02/05/03	5.75	146.9
Deep Run at Eighth Street	MDEPANCS	03/25/03	6.32	136.7
Great Egg Harbor River at Route 559	MGREA559	04/08/02	5.80	67.1
Great Egg Harbor River at Route 559	MGREA559	05/07/02	5.10	64.2
Great Egg Harbor River at Route 559	MGREA559	06/20/02	4.89	59.2
Great Egg Harbor River at Route 559	MGREA559	07/18/02	5.95	51.6
Great Egg Harbor River at Route 559	MGREA559	08/08/02	5.46	52.5
Great Egg Harbor River at Route 559	MGREA559	09/19/02	5.55	53.6

Site Name	Site Code	Date	pH	SC
Great Egg Harbor River at Route 559	MGREA559	10/23/02	6.01	66.2
Great Egg Harbor River at Route 559	MGREA559	12/30/02	4.55	94.7
Great Egg Harbor River at Route 559	MGREA559	01/16/03	4.87	78.4
Great Egg Harbor River at Route 559	MGREA559	02/06/03	4.85	89.4
Great Egg Harbor River at Route 559	MGREA559	03/26/03	4.46	85.8
Great Egg Harbor River at Route 616	MGREA616	06/20/02	4.77	61.6
Great Egg Harbor River at Route 616	MGREA616	07/19/02	6.12	56.1
Great Egg Harbor River at Route 616	MGREA616	09/20/02	6.06	62.7
Great Egg Harbor River at Route 616	MGREA616	10/24/02	4.96	75.4
Great Egg Harbor River at Route 616	MGREA616	12/31/02	4.11	95.1
Great Egg Harbor River at Route 616	MGREA616	01/17/03	4.30	83.1
Great Egg Harbor River at Route 616	MGREA616	03/27/03	4.45	84.4
Mare Run at Route 559	MMARE559	04/09/02	4.53	41.3
Mare Run at Route 559	MMARE559	05/07/02	4.30	45.5
Mare Run at Route 559	MMARE559	06/20/02	4.57	35.8
Mare Run at Route 559	MMARE559	07/18/02	5.42	28.2
Mare Run at Route 559	MMARE559	08/09/02	5.27	26.5
Mare Run at Route 559	MMARE559	09/20/02	4.91	30.9
Mare Run at Route 559	MMARE559	10/24/02	4.16	39.5
Mare Run at Route 559	MMARE559	12/31/02	4.77	59.1
Mare Run at Route 559	MMARE559	01/17/03	4.30	56.0
Mare Run at Route 559	MMARE559	02/10/03	4.78	49.7
Mare Run at Route 559	MMARE559	03/27/03	4.56	55.4
Makepeace Stream at Route 623	MMKRT623	04/12/02	4.22	138.8
Makepeace Stream at Route 623	MMKRT623	05/07/02	4.11	130.1
Makepeace Stream at Route 623	MMKRT623	06/20/02	4.02	137.4
Makepeace Stream at Route 623	MMKRT623	07/18/02	4.53	129.4
Makepeace Stream at Route 623	MMKRT623	08/08/02	3.67	157.1
Makepeace Stream at Route 623	MMKRT623	09/19/02	4.04	153.5
Makepeace Stream at Route 623	MMKRT623	10/23/02	4.42	138.2
Makepeace Stream at Route 623	MMKRT623	12/30/02	4.00	134.2
Makepeace Stream at Route 623	MMKRT623	01/16/03	3.88	146.0
Makepeace Stream at Route 623	MMKRT623	02/06/03	4.01	150.4
Makepeace Stream at Route 623	MMKRT623	03/26/03	4.17	138.5
McNeals Branch at Route 666	TMCNE666	04/09/02	4.34	50.5
McNeals Branch at Route 666	TMCNE666	05/08/02	4.69	50.5
McNeals Branch at Route 666	TMCNE666	06/20/02	4.57	37.8
McNeals Branch at Route 666	TMCNE666	07/18/02	4.76	29.3
McNeals Branch at Route 666	TMCNE666	08/08/02	4.83	28.5
McNeals Branch at Route 666	TMCNE666	09/19/02	4.13	34.6
McNeals Branch at Route 666	TMCNE666	10/23/02	4.62	43.8
McNeals Branch at Route 666	TMCNE666	12/30/02	4.19	72.1
McNeals Branch at Route 666	TMCNE666	01/16/03	4.20	63.9
McNeals Branch at Route 666	TMCNE666	02/06/03	4.42	61.9
McNeals Branch at Route 666	TMCNE666	03/26/03	4.21	59.5
Mill Creek at Route 557	TMILL557	04/09/02	4.36	82.4
Mill Creek at Route 557	TMILL557	05/08/02	4.19	82.4
Mill Creek at Route 557	TMILL557	06/20/02	4.03	66.1
Mill Creek at Route 557	TMILL557	07/18/02	4.66	54.4
Mill Creek at Route 557	TMILL557	08/08/02	4.78	51.4
Mill Creek at Route 557	TMILL557	09/19/02	4.23	79.5
Mill Creek at Route 557	TMILL557	10/23/02	4.35	85.5
Mill Creek at Route 557	TMILL557	12/30/02	4.60	98.2
Mill Creek at Route 557	TMILL557	01/16/03	4.48	65.2
Mill Creek at Route 557	TMILL557	02/06/03	5.19	58.3
Mill Creek at Route 557	TMILL557	03/26/03	4.11	84.0
Tarkiln Branch at Route 548	TTAR548S	06/20/02	4.74	44.5
Tarkiln Branch at Route 548	TTAR548S	07/18/02	5.58	41.0
Tarkiln Branch at Route 548	TTAR548S	08/08/02	5.65	87.4

Site Name	Site Code	Date	pH	SC
Tarkiln Branch at Route 548	TTAR548S	09/19/02	4.50	66.5
Tarkiln Branch at Route 548	TTAR548S	10/23/02	4.84	74.0
Tarkiln Branch at Route 548	TTAR548S	12/30/02	5.24	64.2
Tarkiln Branch at Route 548	TTAR548S	01/16/03	4.38	60.6
Tarkiln Branch at Route 548	TTAR548S	02/06/03	5.16	55.4
Tarkiln Branch at Route 548	TTAR548S	03/26/03	4.53	54.9
Tarkiln Branch below powerline right-of-way	TTARKBOG	08/09/02	5.40	47.6
Tarkiln Branch below powerline right-of-way	TTARKBOG	09/19/02	4.82	76.0
Tarkiln Branch below powerline right-of-way	TTARKBOG	10/23/02	4.36	102.0
Tarkiln Branch below powerline right-of-way	TTARKBOG	12/30/02	4.71	81.4
Tarkiln Branch below powerline right-of-way	TTARKBOG	01/16/03	4.21	74.9
Tarkiln Branch below powerline right-of-way	TTARKBOG	02/06/03	5.11	52.3
Tarkiln Branch below powerline right-of-way	TTARKBOG	03/26/03	4.26	65.8
Tuckahoe River at Route 49 near Head of River	TTU49HED	04/09/02	4.80	42.0
Tuckahoe River at Route 49 near Head of River	TTU49HED	05/08/02	4.88	46.2
Tuckahoe River at Route 49 near Head of River	TTU49HED	06/20/02	4.87	33.5
Tuckahoe River at Route 49 near Head of River	TTU49HED	07/18/02	5.81	29.5
Tuckahoe River at Route 49 near Head of River	TTU49HED	08/08/02	5.33	29.8
Tuckahoe River at Route 49 near Head of River	TTU49HED	09/19/02	5.34	33.8
Tuckahoe River at Route 49 near Head of River	TTU49HED	10/23/02	4.43	38.9
Tuckahoe River at Route 49 near Head of River	TTU49HED	12/30/02	4.86	64.3
Tuckahoe River at Route 49 near Head of River	TTU49HED	01/16/03	4.02	57.8
Tuckahoe River at Route 49 near Head of River	TTU49HED	02/06/03	4.57	52.3
Tuckahoe River at Route 49 near Head of River	TTU49HED	03/26/03	4.42	53.9
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	04/09/02	5.58	33.8
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	05/08/02	4.67	37.5
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	06/20/02	4.93	28.6
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	07/18/02	5.51	27.3
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	08/08/02	6.17	28.7
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	09/19/02	5.19	27.5
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	10/23/02	4.82	30.5
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	12/30/02	5.67	53.2
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	01/16/03	3.95	48.2
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	02/06/03	4.49	41.6
Tuckahoe River at Route 49 at Hunters Mill	TTU49HUN	03/26/03	4.02	48.1
Tuckahoe River at Route 637	TTUCUMBS	04/09/02	5.89	37.7
Tuckahoe River at Route 637	TTUCUMBS	05/08/02	4.97	42.0
Tuckahoe River at Route 637	TTUCUMBS	06/20/02	4.98	36.0
Tuckahoe River at Route 637	TTUCUMBS	07/18/02	5.93	31.0
Tuckahoe River at Route 637	TTUCUMBS	08/08/02	6.18	32.1
Tuckahoe River at Route 637	TTUCUMBS	09/19/02	5.58	29.7
Tuckahoe River at Route 637	TTUCUMBS	10/23/02	5.91	35.7
Tuckahoe River at Route 637	TTUCUMBS	12/30/02	5.37	67.4
Tuckahoe River at Route 637	TTUCUMBS	01/16/03	4.26	60.0
Tuckahoe River at Route 637	TTUCUMBS	02/06/03	4.55	53.2
Tuckahoe River at Route 637	TTUCUMBS	03/26/03	4.32	55.4
Warners Mill Stream at Aetna Drive	TWAAETNA	06/20/02	4.47	43.5
Warners Mill Stream at Aetna Drive	TWAAETNA	08/09/02	4.84	42.0
Warners Mill Stream at Aetna Drive	TWAAETNA	09/19/02	4.00	68.3
Warners Mill Stream at Aetna Drive	TWAAETNA	10/23/02	4.03	59.9
Warners Mill Stream at Aetna Drive	TWAAETNA	12/30/02	4.11	87.1
Warners Mill Stream at Aetna Drive	TWAAETNA	01/16/03	3.66	85.6
Warners Mill Stream at Aetna Drive	TWAAETNA	02/06/03	4.65	74.3
Warners Mill Stream at Aetna Drive	TWAAETNA	03/26/03	4.19	64.1
Four Mile Branch at Route 536	UFORT536	04/08/02	6.26	106.3
Four Mile Branch at Route 536	UFORT536	05/07/02	6.07	100.9
Four Mile Branch at Route 536	UFORT536	06/19/02	6.62	88.6
Four Mile Branch at Route 536	UFORT536	07/17/02	6.90	74.4
Four Mile Branch at Route 536	UFORT536	08/07/02	6.54	73.0

Site Name	Site Code	Date	pH	SC
Four Mile Branch at Route 536	UFORT536	09/18/02	6.33	74.7
Four Mile Branch at Route 536	UFORT536	10/22/02	6.05	109.2
Four Mile Branch at Route 536	UFORT536	12/27/02	5.38	125.1
Four Mile Branch at Route 536	UFORT536	01/15/03	5.88	105.7
Four Mile Branch at Route 536	UFORT536	02/05/03	5.71	145.8
Four Mile Branch at Route 536	UFORT536	03/25/03	5.92	125.2
Great Egg Harbor River at Route 536 Spur	UGR536SP	04/08/02	6.36	83.0
Great Egg Harbor River at Route 536 Spur	UGR536SP	05/07/02	6.30	77.9
Great Egg Harbor River at Route 536 Spur	UGR536SP	06/19/02	6.38	65.0
Great Egg Harbor River at Route 536 Spur	UGR536SP	07/17/02	6.84	54.9
Great Egg Harbor River at Route 536 Spur	UGR536SP	08/07/02	6.46	40.0
Great Egg Harbor River at Route 536 Spur	UGR536SP	09/18/02	6.24	46.3
Great Egg Harbor River at Route 536 Spur	UGR536SP	10/22/02	5.81	84.9
Great Egg Harbor River at Route 536 Spur	UGR536SP	12/27/02	4.64	130.2
Great Egg Harbor River at Route 536 Spur	UGR536SP	01/15/03	5.16	95.7
Great Egg Harbor River at Route 536 Spur	UGR536SP	02/05/03	5.67	156.2
Great Egg Harbor River at Route 536 Spur	UGR536SP	03/25/03	5.14	102.4
Great Egg Harbor River at Route 536	UGREA536	06/19/02	6.58	60.4
Great Egg Harbor River at Route 536	UGREA536	07/17/02	6.85	52.3
Great Egg Harbor River at Route 536	UGREA536	08/07/02	6.62	44.7
Great Egg Harbor River at Route 536	UGREA536	09/18/02	6.19	51.3
Great Egg Harbor River at Route 536	UGREA536	10/22/02	5.44	89.6
Great Egg Harbor River at Route 536	UGREA536	12/27/02	5.20	87.2
Great Egg Harbor River at Route 536	UGREA536	01/15/03	5.28	90.4
Great Egg Harbor River at Route 536	UGREA536	02/05/03	5.89	125.8
Great Egg Harbor River at Route 536	UGREA536	03/25/03	5.33	92.3
Great Egg Harbor River at Route 54	UGRERT54	04/08/02	6.02	74.9
Great Egg Harbor River at Route 54	UGRERT54	05/07/02	6.01	69.2
Great Egg Harbor River at Route 54	UGRERT54	06/20/02	5.75	56.3
Great Egg Harbor River at Route 54	UGRERT54	07/18/02	6.53	53.2
Great Egg Harbor River at Route 54	UGRERT54	08/08/02	5.70	53.5
Great Egg Harbor River at Route 54	UGRERT54	09/19/02	6.03	56.4
Great Egg Harbor River at Route 54	UGRERT54	10/23/02	5.96	75.0
Great Egg Harbor River at Route 54	UGRERT54	12/30/02	4.62	97.0
Great Egg Harbor River at Route 54	UGRERT54	01/16/03	5.26	77.9
Great Egg Harbor River at Route 54	UGRERT54	02/06/03	5.51	103.4
Great Egg Harbor River at Route 54	UGRERT54	03/26/03	4.82	86.7
Great Egg Harbor River at Route 691	UGRRT691	04/08/02	6.08	186.2
Great Egg Harbor River at Route 691	UGRRT691	05/07/02	6.09	169.3
Great Egg Harbor River at Route 691	UGRRT691	06/19/02	6.26	135.8
Great Egg Harbor River at Route 691	UGRRT691	07/17/02	6.18	147.5
Great Egg Harbor River at Route 691	UGRRT691	08/07/02	6.00	97.8
Great Egg Harbor River at Route 691	UGRRT691	09/18/02	6.03	176.8
Great Egg Harbor River at Route 691	UGRRT691	10/22/02	5.96	174.4
Great Egg Harbor River at Route 691	UGRRT691	12/27/02	6.17	392.0
Great Egg Harbor River at Route 691	UGRRT691	01/15/03	5.92	234.0
Great Egg Harbor River at Route 691	UGRRT691	02/05/03	6.31	534.0
Great Egg Harbor River at Route 691	UGRRT691	03/25/03	6.12	265.0
Great Egg Harbor River at Route 723	UGRRT723	04/08/02	5.98	88.4
Great Egg Harbor River at Route 723	UGRRT723	05/07/02	5.22	74.6
Great Egg Harbor River at Route 723	UGRRT723	06/19/02	6.19	62.9
Great Egg Harbor River at Route 723	UGRRT723	07/17/02	6.54	50.5
Great Egg Harbor River at Route 723	UGRRT723	08/07/02	6.57	48.2
Great Egg Harbor River at Route 723	UGRRT723	09/18/02	6.40	52.9
Great Egg Harbor River at Route 723	UGRRT723	10/22/02	6.07	80.4
Great Egg Harbor River at Route 723	UGRRT723	12/27/02	4.73	103.2
Great Egg Harbor River at Route 723	UGRRT723	01/15/03	5.80	85.7
Great Egg Harbor River at Route 723	UGRRT723	02/05/03	5.91	121.3
Great Egg Harbor River at Route 723	UGRRT723	03/25/03	5.56	95.3

Site Name	Site Code	Date	pH	SC
Penny Pot Stream at Eighth Street	UPENN8TH	04/08/02	5.90	134.2
Penny Pot Stream at Eighth Street	UPENN8TH	05/07/02	6.02	125.1
Penny Pot Stream at Eighth Street	UPENN8TH	06/20/02	5.82	123.0
Penny Pot Stream at Eighth Street	UPENN8TH	07/18/02	6.50	114.3
Penny Pot Stream at Eighth Street	UPENN8TH	08/08/02	6.07	111.2
Penny Pot Stream at Eighth Street	UPENN8TH	09/19/02	6.27	120.9
Penny Pot Stream at Eighth Street	UPENN8TH	10/23/02	5.92	152.7
Penny Pot Stream at Eighth Street	UPENN8TH	12/30/02	5.23	158.7
Penny Pot Stream at Eighth Street	UPENN8TH	01/16/03	5.24	149.5
Penny Pot Stream at Eighth Street	UPENN8TH	02/06/03	5.37	183.6
Penny Pot Stream at Eighth Street	UPENN8TH	03/26/03	5.45	148.3
Penny Pot Stream at Route 54	UPENNY54	06/20/02	5.44	84.5
Penny Pot Stream at Route 54	UPENNY54	07/18/02	5.65	78.0
Penny Pot Stream at Route 54	UPENNY54	08/08/02	5.45	76.3
Penny Pot Stream at Route 54	UPENNY54	09/19/02	5.39	88.7
Penny Pot Stream at Route 54	UPENNY54	10/23/02	5.16	114.3
Penny Pot Stream at Route 54	UPENNY54	12/30/02	4.96	138.1
Penny Pot Stream at Route 54	UPENNY54	01/17/03	4.80	185.4
Penny Pot Stream at Route 54	UPENNY54	02/06/03	4.71	159.2
Penny Pot Stream at Route 54	UPENNY54	03/26/03	4.31	135.9
Squankum Branch at Malaga Road	USQMALAG	04/08/02	6.37	109.7
Squankum Branch at Malaga Road	USQMALAG	05/07/02	6.17	104.9
Squankum Branch at Malaga Road	USQMALAG	06/19/02	6.56	94.8
Squankum Branch at Malaga Road	USQMALAG	07/17/02	6.93	114.7
Squankum Branch at Malaga Road	USQMALAG	08/07/02	-	-
Squankum Branch at Malaga Road	USQMALAG	09/18/02	-	-
Squankum Branch at Malaga Road	USQMALAG	10/22/02	6.47	100.2
Squankum Branch at Malaga Road	USQMALAG	12/27/02	5.70	207.0
Squankum Branch at Malaga Road	USQMALAG	01/15/03	5.81	154.3
Squankum Branch at Malaga Road	USQMALAG	02/05/03	5.96	268.0
Squankum Branch at Malaga Road	USQMALAG	03/25/03	6.23	148.4

APPENDIX 2. STREAM-VEGETATION DATA

Appendix 2.0. Stream-vegetation monitoring sites in the Great Egg Harbor River WMA. Stream sections are 10 m in length. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name and Description	Site Code
Maple Run at Route 662 Egg Harbor Twp. and Northfield City, Atlantic Co. (lat 39°22'32.59", long 74°34'17.99", Pleasantville quad). Sections located upstream and downstream from Mill Road (Route 662).	AMAMILLR
Mill Branch at Route 684 Egg Harbor Twp., Atlantic Co. (lat 39°23'44.88", long 74°35'35.31", Pleasantville quad). Sections located downstream from Spruce Avenue (Route 684).	AMILL684
North Branch Absecon Creek at Garden State Parkway Egg Harbor Twp., Atlantic Co. (lat 39°26'42.24", long 74°32'19.73", Pleasantville quad). Sections located downstream from the Garden State Parkway North.	ANOABGSP
Hospitality Branch at Route 633 Monroe Twp., Gloucester Co. (lat 39°38'40.78", long 74°59'08.66", Williamstown quad). Sections located downstream from Blue Bell Road (Route 633).	HHOBLUEB
Hospitality Branch at Pennsylvania/Reading railroad bridge Folsom Boro, Atlantic Co. (lat 39°35'18.06", long 74°51'30.90", Newtonville quad). Sections located upstream and downstream from railroad bridge at Route 54.	HHORRBDG
Hospitality Branch at Route 538 Monroe Twp., Gloucester Co. (lat 39°37'14.09", long 74°55'37.29", Buena quad). Sections located downstream from Coles Mills Road (Route 538).	HHORT538
Marsh Lake Branch at Blue Anchor Road Buena Vista Twp., Atlantic Co. (lat 39°35'23.02", long 74°52'53.90", Buena quad). Sections located downstream from Blue Anchor Road.	HMABLUEA
Marsh Lake Branch at Unexpected Road Buena Vista and Franklin Twp., Atlantic and Gloucester Co. (lat 39°33'57.52", long 74°55'33.72", Buena quad). Sections located downstream from Unexpected Road.	HMAUNEXS
Three Pond Branch at Route 54 Buena Vista Twp., Atlantic Co. (lat 39°34'51.82", long 74°52'02.39", Newtonville quad). Sections located upstream from Route 54.	HTHREE54
Whitehall Branch at Blue Bell Road Monroe Twp., Gloucester Co. (lat 39°38'04.43", long 74°59'03.18", Williamstown quad). Sections located upstream (above Malaga Road) and downstream from Blue Bell Road (Route 633).	HWHBLUEB
White Oak Branch at Jackson Road Monroe Twp., Gloucester Co. (lat 39°35'46.49", long 74°55'04.68", Buena quad). Sections located upstream and downstream from Jackson Road.	HWOJACKS
Babcock Creek at Route 322 Hamilton Twp., Atlantic Co. (lat 39°28'08.73", long 74°41'32.86", Mays Landing quad). Sections located downstream from Route 322.	LBABC322
Gibson Creek at Route 50 Estell Manor City, Atlantic Co. (lat 39°21'10.81", long 74°45'22.83", Tuckahoe quad). Sections located upstream and downstream from Route 50.	LGIBSO50
Gravelly Run at Route 559 Hamilton Twp., Atlantic Co. (lat 39°25'37.98", long 74°42'06.15", Mays Landing quad). Sections located upstream and downstream from Mays Landing - Somers Point Road (Route 559).	LGRAV559
South River at Estelle Avenue Hamilton Twp., Atlantic Co. (lat 39°28'15.65", long 74°50'35.25", Dorothy quad). Sections located upstream and downstream from Estelle Avenue.	LSOESTEL

Site Name and Description	Site Code
South River at Forty Wire Road Hamilton and Weymouth Twps., Atlantic Co. (lat 39°26'25.14", long 74°45'19.23", Dorothy quad). Sections located upstream and downstream from Forty Wire Road (Walkers Forge Road).	LSOFORTY
South River at Route 552 Hamilton Twp., Atlantic Co. (lat 39°26'27.57", long 74°48'00.24", Dorothy quad). Sections located upstream and downstream from (Bears Head Road) Route 552.	LSOUT552
Stephen Creek at Eleventh Avenue Estell Manor City, Atlantic Co. (lat 39°24'55.88", long 74°47'42.57", Dorothy quad). Sections located upstream and downstream from Eleventh Avenue.	LSTELEVE
Stephen Creek at Route 50 Estell Manor City, Atlantic Co. (lat 39°23'37.70", long 74°44'53.48", Mays Landing quad). Sections located downstream from Route 50.	LSTEP50S
Watering Race Branch at Route 50 Hamilton Twp., Atlantic Co. (lat 39°28'22.56", long 74°42'55.68", Mays Landing quad). Sections located upstream and downstream from Route 50.	LWATER50
Deep Run at Route 559 Hamilton Twp., Atlantic Co. (lat 39°30'26.67", long 74°46'55.11", Newtonville quad). Sections located downstream from Route 559.	MDEEP559
Deep Run at Route 54 Buena Boro, Atlantic Co. (lat 39°31'20.83", long 74°55'12.53", Buena quad). Sections located downstream from Route 54.	MDEEPR54
Deep Run at Eighth Street Buena Vista Twp., Atlantic Co. (lat 39°31'18.07", long 74°52'22.42", Newtonville quad). Sections located downstream from Eighth Street.	MDEPANCS
Great Egg Harbor River at Route 559 Hamilton Twp., Atlantic Co. (lat 39°31'05.88", long 74°46'43.03", Newtonville quad). Sections located downstream from Route 559.	MGREA559
Mare Run at Route 559 Hamilton Twp., Atlantic Co. (lat 39°28'43.34", long 74°45'27.53", Dorothy quad). Sections located downstream from Route 559.	MMARE559
McNeals Branch at Route 666 Estell Manor City, Atlantic Co. (lat 39°18'56.96", long 74°49'27.60", Tuckahoe quad). Sections located upstream and downstream from Cape May Avenue (Route 666).	TMCNE666
Mill Creek at Route 557 Upper Twp., Cape May Co. (lat 39°17'02.91", long 74°47'31.42", Tuckahoe quad). Sections located upstream and downstream from Route 557.	TMILL557
Tuckahoe River at Route 49 near Head Of River Upper Twp. and Estell Manor City, Cape May and Atlantic Co. (lat 39°18'24.82", long 74°49'12.65", Tuckahoe quad). Sections located upstream and downstream from Route 49.	TTU49HED
Tuckahoe River at Route 49 at Hunters Mill Maurice River Twp. and Estell Manor City, Cumberland Co. (lat 39°19'26.33", long 74°51'40.34", Tuckahoe quad). Sections located upstream and downstream from Route 49.	TTU49HUN
Tuckahoe River at Route 637 Estell Manor City, Atlantic Co. (lat 39°22'20.50", long 74°51'12.41", Tuckahoe quad). Sections located upstream from Cumberland Avenue (Route 637).	TTUCUMBS
Four Mile Branch at Route 536 Spur Monroe Twp., Gloucester Co. (lat 39°41'47.56", long 74°56'23.61", Williamstown quad). Sections located upstream from Route 536 Spur.	UFORT536

Site Name and Description	Site Code
Great Egg Harbor River at Route 536 Spur Winslow Twp., Camden Co. (lat 39°44'01.87", long 74°57'03.82", Williamstown quad). Sections located upstream and downstream from Williamstown - New Freedom Road (Route 536 Spur).	UGR536SP
Great Egg Harbor River at Eighth Street Folsom Boro, Atlantic Co. (lat 39°34'32.97", long 74°49'20.29", Newtonville quad). Sections located upstream from Eighth Street.	UGR8THST
Great Egg Harbor River at Route 691 Winslow Twp. and Berlin Boro, Camden Co. (lat 39°46'51.18", long 74°56'34.70", Clementon quad). Sections located upstream from Watsontown - New Freedom Road (Route 691).	UGRRT691
Great Egg Harbor River at Route 723 Winslow Twp., Camden Co. (lat 39°40'10.19", long 74°54'47.99", Williamstown quad). Sections located downstream from Williamstown-Winslow Road (Route 723).	UGRRT723
Penny Pot Stream at Eighth Street Folsom Boro, Atlantic Co. (lat 39°34'48.42", long 74°49'03.11", Newtonville quad). Sections located upstream and downstream from Eighth Street.	UPENN8TH
Squankum Branch at Malaga Road Monroe Twp., Gloucester Co. (lat 39°40'04.44", long 74°57'37.99", Williamstown quad). Sections located upstream and downstream from Malaga Road (Route 659).	USQMALAG

Appendix 2.1. Plant species at stream-monitoring sites in the Great Egg Harbor River WMA. Filled circles indicate a species was present at a site. Refer to Chapter 3 (Stream Vegetation) for sampling details. Refer to Appendix 2.0 for site descriptions and explanations of site codes. Plant common names are presented in Appendix 2.2.

Species	Sites																		
	AMAMILLR	AMILL684	ANOABGSP	HHOBLUEB	HHORRBDG	HHORT538	HMABLUEA	HMAUNEXS	HTHREE54	HWHBLUEB	HWOJACKS	LBABC322	LGIBSO50	LGRAV559	LSOESTEL	LSOFORTY	LSOUT552	LSTELEVE	LSTEP50S
Herbaceous plants:																			
Acalypha rhomboidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agrostis perennans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agrostis sp.	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-
Ambrosia artemisiifolia	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Antennaria plantaginiflora	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apios americana	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	!	!	-	-
Apocynum cannabinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Asclepias incarnata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Asclepias syriaca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster novi-belgii	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	!	!	-	-
Aster vimineus	-	-	-	-	-	-	-	-	-	!	-	-	-	-	!	-	-	-	-
Aster sp.	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bartonia paniculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bidens connata	!	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Bidens coronata	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Bidens discoidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bidens frondosa	!	-	-	!	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bidens vulgata	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-
Bidens sp.	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	!
Boehmeria cylindrica	!	-	-	-	-	!	-	-	-	-	-	-	-	-	!	-	-	-	-
Callitriche heterophylla	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cardamine sp.	!	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Carex albolutescens	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex atlantica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-
Carex atlantica var. capillacea	-	-	-	!	-	-	!	-	-	-	-	-	!	-	-	-	-	!	-
Carex bullata	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex collinsii	-	-	-	-	-	-	-	-	-	-	-	!	-	-	!	-	-	-	-
Carex crinita	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Carex folliculata	-	-	-	-	-	-	!	-	-	-	-	-	!	-	-	!	-	-	-
Carex lurida	!	-	-	!	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-
Carex striata	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Carex stricta	-	-	-	-	-	-	-	!	!	-	-	-	-	-	-	-	-	-	-
Carex sp.	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Ceratophyllum echinatum	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chasmanthium laxum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chimaphila maculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cuscuta sp.	-	-	-	!	!	!	-	-	-	!	-	-	-	-	!	-	-	-	-
Cyperus brevifolioides	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyperus sesquiflorus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species	Sites																	
	AMAMILLR	AMILL684	ANOABGSP	HHOBLUEB	HHORRBDG	HHORT538	HMABLUEA	HMAUNEXS	HTHREE54	HWHBLUEB	HWOJACKS	LBABC322	LGIBSO50	LGRAV559	LSOESTEL	LSOFORTY	LSOUT552	LSTELEVE	LSTEP50S
Cyperus strigosus	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	!	-	-
Decodon verticillatus	!	-	!	!	-	-	!	-	!	!	!	!	-	-	!	!	-	!	-
Dioscorea villosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Drosera intermedia	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Drosera rotundifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dulichium arundinaceum	-	-	!	-	!	-	!	-	!	-	!	-	-	-	-	!	-	-	-
Echinochloa muricata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis acicularis	-	-	-	-	!	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis flavescens var. olivacea	-	-	!	-	!	-	!	-	!	-	-	-	-	-	-	-	-	-	-
Eleocharis ovata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis robbinsii	-	-	-	-	!	-	!	-	!	-	-	-	-	-	-	-	-	-	-
Eleocharis tenuis	-	-	-	-	!	-	!	-	-	-	!	-	-	-	-	-	-	-	-
Elodea canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elodea nuttallii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equisetum arvense	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Erechtites hieracifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriocaulon aquaticum	-	-	-	-	!	-	-	-	-	-	-	-	!	-	!	-	-	-	-
Eupatorium dubium	-	-	-	!	!	-	-	-	-	!	-	-	-	-	-	!	-	-	-
Eupatorium leucolepis	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Eupatorium perfoliatum	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-
Eupatorium resinosum	-	-	-	-	!	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Eupatorium serotinum	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Euphorbia maculata	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Euthamia tenuifolia	-	-	-	-	!	-	-	-	-	-	-	-	-	!	-	-	-	-	-
Festuca elatior	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Galium tinctorium	-	-	!	!	-	-	!	-	-	!	-	-	-	-	!	-	!	-	-
Glyceria obtusa	-	!	!	-	!	-	!	-	!	!	!	-	-	-	!	-	-	-	-
Glyceria striata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!
Grass sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypericum canadense	-	-	!	-	!	-	-	-	!	-	-	-	-	!	-	-	-	-	-
Hypericum mutilum	-	-	-	-	-	-	-	-	-	!	-	-	-	-	!	-	-	-	-
Hypochoeris raticata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-
Impatiens capensis	!	-	-	!	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-
Iris versicolor	-	-	-	-	!	!	!	-	-	-	-	-	-	-	-	!	-	-	!
Juncus canadensis	-	-	!	-	!	!	!	-	-	-	-	-	-	!	!	-	-	-	-
Juncus effusus	!	-	!	-	-	!	!	-	!	!	-	!	-	!	!	!	!	-	-
Juncus militaris	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus pelocarpus	-	-	!	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Juncus tenuis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lachnanthes caroliniana	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leersia oryzoides	!	!	-	-	!	!	!	-	!	!	-	!	!	!	!	!	!	!	-
Lemna sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lobelia cardinalis	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Lobelia nuttallii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ludwigia alternifolia	-	-	-	-	-	!	!	-	-	!	-	-	-	-	-	-	-	-	-

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Ludwigia palustris	!	-	-	!	-	-	!	-	!	-	-	!	-	-	-	!	-	-	-
Ludwigia sphaerocarpa	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopus uniflorus	-	-	-	-	!	!	!	-	-	-	-	!	-	-	-	!	-	-	!
Lycopus virginicus	!	!	-	-	-	!	-	-	-	-	-	-	-	!	!	-	-	!	-
Lysimachia terrestris	-	!	-	-	!	-	!	-	!	-	-	!	-	-	!	!	!	-	-
Microstegium vimineum	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mikania scandens	-	-	-	-	-	-	-	-	-	!	-	-	-	-	!	-	-	-	-
Mitchella repens	-	-	-	-	-	-	-	-	-	-	-	!	!	-	-	-	!	-	-
Nuphar variegata	-	!	!	-	-	-	-	-	!	!	!	-	-	-	-	-	-	-	-
Nymphaea odorata	-	!	-	-	!	-	!	-	-	-	-	!	-	-	-	-	-	-	-
Onoclea sensibilis	-	-	-	-	!	-	-	!	-	!	!	!	-	-	-	!	!	-	-
Osmunda cinnamomea	-	-	-	!	-	-	-	-	-	!	-	-	!	-	!	-	!	!	-
Osmunda regalis	-	-	-	-	!	-	!	-	-	-	-	-	!	-	!	!	-	-	-
Oxalis stricta	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Oxypolis rigidior	-	-	-	-	!	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Panicum clandestinum	-	-	-	!	!	!	-	-	-	!	!	-	-	!	-	-	-	-	-
Panicum dichotomum	-	-	-	-	!	-	-	-	-	-	-	!	!	!	!	!	!	-	-
Panicum dichotomiflorum	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Panicum scabriusculum	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum verrucosum	-	-	-	-	-	-	-	-	!	-	-	-	-	-	!	-	-	-	-
Panicum virgatum	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	!	-	-
Panicum sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	!	-
Peltandra virginica	-	-	-	!	!	-	!	-	!	-	-	!	!	!	!	!	!	-	-
Phalaris arundinacea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-
Phragmites australis	-	-	-	-	!	-	!	-	-	-	!	-	-	-	-	-	-	-	-
Phytolacca americana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pilea pumila	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa pratensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum arifolium	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-
Polygonum cespitosum	-	-	-	-	-	-	-	-	-	-	-	-	-	!	!	-	-	-	-
Polygonum cuspidatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum hydropiperoides	!	-	-	-	!	-	!	-	-	-	-	-	-	-	!	-	-	!	-
Polygonum pensylvanica	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Polygonum persicaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Polygonum punctatum	-	-	-	-	-	-	-	-	!	-	-	-	-	!	-	-	-	-	-
Polygonum sagittatum	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	!	-	-	-
Polygonum sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pontederia cordata	!	-	-	-	!	-	!	-	!	-	-	!	-	-	-	-	-	-	-
Potamogeton confervoides	-	-	!	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-
Potamogeton epihydrus	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	!	-	-	-
Potamogeton oakesianus	-	!	-	-	!	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Potamogeton pusillus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potamogeton sp.	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus sceleratus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Rhexia virginica	-	-	-	-	!	!	-	-	!	-	!	-	-	!	!	-	-	-	-
Rhynchospora chalarocephala	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhynchospora macrostachya	-	-	-	-	!	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Rhynchospora sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-
Rumex sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatia difformis	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sagittaria engelmanniana	-	-	-	-	!	-	-	-	-	-	-	-	!	-	!	-	-	-	-
Sarracenia purpurea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scirpus cyperinus	!	-	!	-	!	!	-	-	-	-	-	!	-	!	!	-	-	-	-
Scirpus subterminalis	-	-	!	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Scutellaria lateriflora	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Solanum nigrum	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Solidago canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solidago rugosa	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Sparganium americanum	!	!	-	!	!	-	-	-	!	!	-	!	!	!	!	!	!	!	-
Spiranthes sp.	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Sporobolis sp.	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thelypteris palustris	-	-	-	-	!	-	!	-	-	-	-	-	-	-	-	-	-	!	-
Thelypteris simulata	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-
Triadenum virginicum	-	!	-	!	!	!	!	-	!	-	!	!	-	-	!	!	!	-	-
Typha latifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-
Utricularia fibrosa	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utricularia geminiscapa	-	-	-	!	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Utricularia inflata	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utricularia purpurea	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utricularia sp.	-	-	-	-	-	!	-	-	-	!	-	-	-	-	-	-	-	-	-
Viola lanceolata	-	!	-	-	!	-	-	-	!	-	-	-	-	-	-	!	-	-	-
Viola sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Woodwardia areolata	!	-	-	-	-	-	-	-	-	!	!	!	!	-	-	!	!	!	-
Woodwardia virginica	-	-	-	-	-	-	-	-	!	-	!	-	-	-	!	-	-	-	-
Woody plants:																			
Acer rubrum	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!
Alnus serrulata	-	!	-	-	!	-	!	!	-	-	-	-	-	-	!	-	-	-	-
Amelanchier canadensis	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Aronia arbutifolia	-	!	!	-	-	-	-	!	-	-	-	-	!	!	-	!	!	-	-
Berberis thunbergii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-
Betula nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Campsis radicans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cephalanthus occidentalis	!	!	-	-	!	-	!	!	-	-	!	-	-	-	!	-	-	-	-
Chamaecyparis thyoides	-	!	!	-	!	-	!	-	!	-	!	!	!	!	!	-	-	-	-
Chamaedaphne calyculata	-	!	-	-	-	-	-	-	!	-	!	-	-	-	!	-	-	-	-
Clethra alnifolia	!	-	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!
Cornus amomum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corylus americana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diospyros virginiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species	AMAMILLR	AMILL684	ANOABGSP	HHOBLUEB	HHORRBDG	HHORT538	HMABLUEA	HMAUNEXS	HTHREE54	HWHBLUEB	HWOJACKS	LBABC322	LGIBSO50	LGRAV559	LSOESTEL	LSOFORTY	LSOUT552	LSTELEVE	LSTEP50S
Eubotrys racemosa	!	-	!	-	-	!	!	!	!	-	!	!	!	!	!	!	!	!	!
Gaylussacia frondosa	-	-	!	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Hypericum densiflorum	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilex glabra	-	-	!	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-
Ilex laevigata	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Ilex opaca	-	-	-	-	!	!	-	-	-	-	-	!	-	!	-	-	-	-	!
Ilex verticillata	-	-	-	-	-	-	!	!	!	-	-	-	-	!	-	-	!	!	-
Itea virginica	!	-	-	-	-	-	-	!	-	-	-	-	!	-	!	-	-	-	!
Juniperus virginiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!
Kalmia angustifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liquidambar styraciflua	-	-	-	!	-	-	-	-	!	-	!	-	-	-	-	-	-	-	-
Lonicera japonica	!	-	-	!	-	-	-	-	-	!	-	-	!	!	-	!	!	!	-
Lyonia ligustrina	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	!	-	-
Magnolia virginiana	-	-	-	-	!	!	!	!	-	!	!	!	!	!	!	!	!	!	-
Morus alba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-
Myrica pensylvanica	-	-	!	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	!	-	!	-	-	-	!	-	-	-	!	-	!	-
Parthenocissus quinquefolia	-	!	-	-	!	-	!	!	-	-	!	-	!	-	-	!	!	!	-
Pinus rigida	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Prunus serotina	-	-	-	!	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Quercus falcata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus phellos	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-
Quercus stellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus velutina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhododendron viscosum	-	!	!	!	!	!	!	-	!	-	!	!	!	!	!	!	-	-	-
Rosa multiflora	-	-	-	!	-	-	!	-	-	!	-	-	-	-	!	-	-	!	-
Rubus hispidus	-	-	-	!	!	!	-	-	-	-	-	-	!	!	-	!	!	!	-
Rubus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix sp.	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	!	-	!	-
Sambucus canadensis	-	-	-	!	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-
Smilax glauca	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Smilax rotundifolia	!	-	-	!	!	!	!	!	!	!	-	!	-	!	-	!	!	!	-
Smilax walteri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spiraea tomentosa	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toxicodendron radicans	-	-	-	!	-	-	!	-	-	!	-	-	!	-	-	-	-	-	!
Toxicodendron vernix	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-
Vaccinium corymbosum	-	!	!	!	!	!	!	!	!	-	!	!	!	!	!	!	!	!	!
Vaccinium macrocarpon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viburnum dentatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-
Viburnum nudum var. nudum	-	-	-	-	!	-	!	!	-	-	-	-	-	-	!	-	-	-	-
Vitis labrusca	!	-	-	!	!	!	-	-	-	!	-	-	-	-	-	!	!	!	-
Wisteria sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!

Species	Sites																	
	LWATER50	MDEEP559	MDEEPR54	MDEPANCS	MGREA559	MMARE559	TMCNE666	TMILL557	TTU49HED	TTU49HUN	TTUCUMBS	UFORT536	UGR536SP	UGR8THST	UGRRT691	UGRRT723	UPENN8TH	USQMALAG
Herbaceous plants:																		
Acalypha rhomboidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Agrostis perennans	-	-	-	-	!	-	-	-	-	-	-	!	-	!	-	-	-	-
Agrostis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ambrosia artemisiifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Antennaria plantaginiflora	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-
Apios americana	-	-	-	-	-	!	!	-	!	!	-	!	-	-	-	-	-	-
Apocynum cannabinum	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Asclepias incarnata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-
Asclepias syriaca	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Aster nemoralis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster novi-belgii	-	-	-	-	-	-	!	-	!	-	-	-	-	-	-	-	!	-
Aster vimineus	-	-	-	!	!	-	-	-	-	-	!	-	-	-	-	!	-	-
Aster sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bartonia paniculata	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Bidens connata	-	-	-	!	-	-	-	-	-	-	-	-	!	-	!	-	-	!
Bidens coronata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bidens discoidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-
Bidens frondosa	-	-	-	!	!	-	-	-	-	-	-	!	!	!	-	-	-	-
Bidens vulgata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bidens sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boehmeria cylindrica	-	-	-	!	-	-	-	-	-	-	-	!	!	!	!	!	-	!
Callitriche heterophylla	-	-	-	-	-	-	-	-	-	-	-	!	!	-	!	!	!	!
Cardamine sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex albolutescens	-	-	-	!	!	-	-	-	-	-	!	!	-	-	-	!	-	-
Carex atlantica	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Carex atlantica var. capillacea	-	!	-	!	-	-	!	-	-	-	-	-	-	-	-	-	-	-
Carex bullata	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-
Carex collinsii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex crinita	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex folliculata	-	-	-	-	!	!	!	-	-	-	-	-	-	-	-	-	!	-
Carex lurida	-	-	-	!	-	-	-	-	!	-	-	!	-	-	-	!	!	-
Carex striata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex stricta	-	!	-	-	!	-	-	!	!	-	-	-	-	-	-	-	-	-
Carex sp.	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	!	-
Ceratophyllum echinatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-
Chasmanthium laxum	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Chimaphila maculata	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-
Cuscuta sp.	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	!
Cyperus brevifolioides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyperus sesquiflorus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-
Cyperus strigosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Decodon verticillatus	-	-	-	-	-	-	-	!	-	-	!	!	-	-	-	!	!	-
Dioscorea villosa	-	-	-	-	-	!	-	-	-	-	-	-	!	-	!	-	-	!
Drosera intermedia	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-

Species	LWATER50	MDEEP559	MDEEPR54	MDEPANCS	MGREA559	MMARE559	TMCNE666	TMILL557	TTU49HED	TTU49HUN	TTUCUMBS	UFORT536	UGR536SP	UGR8THST	UGRRT691	UGRRT723	UPENN8TH	USQMALAG
Drosera rotundifolia	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Dulichium arundinaceum	-	-	-	-	-	-	-	-	-	!	-	!	-	!	-	-	-	-
Echinochloa muricata	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis acicularis	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Eleocharis flavescens var. olivacea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis ovata	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Eleocharis robbinsii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis tenuis	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Elodea canadensis	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-
Elodea nuttallii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-
Equisetum arvense	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Erechtites hieracifolia	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Eriocaulon aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eupatorium dubium	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	!	-
Eupatorium leucolepis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eupatorium perfoliatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eupatorium resinosum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eupatorium serotinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Euphorbia maculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Euthamia tenuifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Festuca elatior	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-
Galium tinctorium	-	-	-	!	-	-	-	-	-	-	-	!	!	!	!	-	!	-
Glyceria obtusa	-	!	-	-	-	-	!	-	-	-	-	!	-	!	-	-	!	-
Glyceria striata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grass sp.	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Hypericum canadense	!	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypericum mutilum	-	-	-	!	!	-	-	-	-	!	-	!	!	!	!	!	-	-
Hypochoeris raticata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Impatiens capensis	-	-	!	!	-	-	-	-	-	-	-	!	!	-	!	-	-	!
Iris versicolor	-	!	-	-	-	!	!	-	-	-	-	-	-	!	-	!	!	-
Juncus canadensis	-	-	-	-	!	-	!	-	-	-	-	-	!	!	-	-	!	-
Juncus effusus	-	!	-	!	!	-	!	-	!	!	!	!	!	!	!	!	!	-
Juncus militaris	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-
Juncus pelocarpus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Juncus tenuis	-	-	-	-	!	-	-	-	-	-	!	-	!	-	-	!	-	-
Lachnanthes caroliniana	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Leersia oryzoides	!	!	-	!	!	-	-	!	!	!	!	!	!	!	!	!	!	!
Lemna sp.	-	-	-	!	-	-	-	-	-	-	-	-	!	-	!	-	-	-
Lobelia cardinalis	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Lobelia nuttallii	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Ludwigia alternifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ludwigia palustris	!	-	-	-	-	-	-	-	-	!	-	!	!	!	!	!	!	!
Ludwigia sphaerocarpa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopus uniflorus	-	-	-	!	!	-	-	!	!	-	-	-	!	!	-	!	!	-
Lycopus virginicus	-	-	-	!	!	-	-	-	-	-	-	!	!	!	!	!	!	!

Species	Sites																	
	LWATER50	MDEEP559	MDEEPR54	MDEPANCS	MGREA559	MMARE559	TMCNE666	TMILL557	TTU49HED	TTU49HUN	TTUCUMBS	UFORT536	UGR536SP	UGR8THST	UGRRT691	UGRRT723	UPENN8TH	USQMALAG
Lysimachia terrestris	!	!	-	-	-	!	!	-	-	-	-	!	-	-	-	!	!	-
Microstegium vimineum	-	-	-	-	!	-	-	-	-	-	-	!	!	!	-	-	!	!
Mikania scandens	-	-	-	!	!	-	-	-	-	-	-	!	!	!	!	!	-	-
Mitchella repens	-	!	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Nuphar variegata	!	-	-	-	-	-	!	!	-	!	-	-	-	-	!	-	-	-
Nymphaea odorata	-	-	-	-	-	-	-	-	!	!	!	-	-	-	-	-	-	-
Onoclea sensibilis	-	-	!	-	!	-	-	-	-	-	-	!	!	!	!	!	-	-
Osmunda cinnamomea	-	-	-	-	!	!	-	!	!	-	-	!	!	-	!	-	-	-
Osmunda regalis	!	-	-	!	-	-	!	!	-	-	-	-	-	-	-	-	!	-
Oxalis stricta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-
Oxypolis rigidior	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum clandestinum	-	!	-	-	-	-	!	-	-	-	!	!	!	!	-	!	!	-
Panicum dichotomum	-	!	-	!	!	-	-	!	!	-	-	-	-	-	!	!	!	-
Panicum dichotomiflorum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum scabriusculum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum verrucosum	!	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Panicum virgatum	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum sp.	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peltandra virginica	!	!	-	-	!	!	!	-	!	!	!	!	-	!	-	!	!	-
Phalaris arundinacea	-	-	-	-	-	-	-	-	-	-	-	!	-	!	-	-	-	-
Phragmites australis	-	-	-	-	-	-	-	-	-	-	-	!	-	!	!	-	-	-
Phytolacca americana	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pilea pumila	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!
Poa pratensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!
Poa sp.	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum arifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!
Polygonum cespitosum	-	-	-	!	!	-	-	-	-	-	-	-	!	-	!	!	!	-
Polygonum cuspidatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!
Polygonum hydropiperoides	!	-	-	!	!	-	-	-	-	!	-	-	-	!	!	!	!	-
Polygonum pensylvanica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum persicaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum punctatum	-	-	-	-	-	-	-	-	-	-	-	!	-	-	!	-	-	-
Polygonum sagittatum	-	-	!	-	-	-	-	-	-	-	-	!	!	-	!	-	!	!
Polygonum sp.	-	-	!	-	-	-	-	-	-	-	-	!	-	!	-	-	-	!
Pontederia cordata	-	-	-	-	-	-	-	-	!	!	-	-	-	-	-	-	-	-
Potamogeton confervoides	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Potamogeton epihydrus	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Potamogeton oakesianus	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Potamogeton pusillus	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potamogeton sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus sceleratus	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhexia virginica	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	!	!	-
Rhynchospora chalarocephala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhynchospora macrostachya	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Rhynchospora sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species	Sites																	
	LWATER50	MDEEP559	MDEEPR54	MDEPANCS	MGREA559	MMARE559	TMCNE666	TMILL557	TTU49HED	TTU49HUN	TTUCUMBS	UFORT536	UGR536SP	UGR8THST	UGRRT691	UGRRT723	UPENN8TH	USQMALAG
Rumex sp.	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatia difformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-
Sagittaria engelmanniana	-	-	-	-	-	-	-	-	!	-	-	-	-	!	-	-	!	-
Sarracenia purpurea	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-
Scirpus cyperinus	!	-	-	-	!	-	!	-	-	-	-	!	-	-	-	-	-	-
Scirpus subterminalis	-	-	-	-	-	-	!	!	!	!	!	!	-	-	-	-	-	-
Scutellaria lateriflora	-	-	-	!	!	-	-	-	-	-	-	!	!	!	-	!	!	-
Solanum nigrum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solidago canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-
Solidago rugosa	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Sparganium americanum	-	!	!	-	!	!	!	-	-	!	!	!	!	!	-	!	!	!
Spiranthes sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sporobolis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thelypteris palustris	-	-	-	!	!	-	-	-	-	-	-	!	-	-	-	-	-	-
Thelypteris simulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triadenum virginicum	!	-	-	!	!	-	-	-	!	!	!	-	-	!	-	-	!	-
Typha latifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-
Utricularia fibrosa	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-
Utricularia geminiscapa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utricularia inflata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utricularia purpurea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utricularia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viola lanceolata	-	-	-	-	-	-	-	-	-	-	-	!	-	!	-	-	-	-
Viola sp.	-	-	!	-	!	-	-	-	-	-	-	-	-	-	-	-	!	-
Woodwardia areolata	!	-	-	-	-	!	-	!	-	!	-	!	!	!	-	!	!	-
Woodwardia virginica	-	-	-	-	-	-	!	-	-	-	!	-	-	-	-	-	-	-
Woody plants:																		
Acer rubrum	!	!	!	!	-	!	!	!	!	!	!	!	!	!	!	!	!	!
Alnus serrulata	-	-	-	-	-	-	!	!	-	-	-	-	-	-	-	-	-	-
Amelanchier canadensis	-	-	-	-	-	-	-	!	-	!	-	-	-	-	-	-	-	-
Aronia arbutifolia	-	-	-	-	-	-	!	!	!	-	!	!	!	-	-	!	-	-
Berberis thunbergii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Betula nigra	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Campsis radicans	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Cephalanthus occidentalis	!	-	-	-	!	-	-	-	-	!	!	-	-	-	-	!	!	-
Chamaecyparis thyoides	!	!	-	-	-	!	!	!	!	-	-	-	-	-	-	-	!	-
Chamaedaphne calyculata	-	-	-	-	-	-	-	!	-	!	-	-	-	-	-	-	-	-
Clethra alnifolia	!	!	-	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!
Cornus amomum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-
Corylus americana	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-
Diospyros virginiana	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Eubotrys racemosa	!	!	-	!	-	!	!	!	!	-	!	!	!	!	-	-	!	-
Gaylussacia frondosa	!	!	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Hypericum densiflorum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilex glabra	-	-	-	-	-	!	-	!	-	-	-	-	-	-	-	-	-	-

Species	LWATER50	MDEEP559	MDEEPR54	MDEPANCS	MGREA559	MMARE559	TMCNE666	TMILL557	TTU49HED	TTU49HUN	TTUCUMBS	UFORT536	UGR536SP	UGR8THST	UGRRT691	UGRRT723	UPENN8TH	USQMALAG
	Sites																	
Ilex laevigata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilex opaca	-	!	!	!	-	!	-	!	!	-	-	-	-	-	!	-	-	-
Ilex verticillata	!	-	-	-	-	-	!	-	-	-	-	-	-	-	!	-	-	-
Itea virginica	!	-	-	-	-	-	-	!	-	-	-	-	!	-	-	-	!	-
Juniperus virginiana	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-
Kalmia angustifolia	-	-	-	-	-	-	-	!	-	-	!	-	-	-	-	-	-	-
Liquidambar styraciflua	-	!	-	-	!	-	-	!	!	-	-	-	-	-	-	-	-	-
Lonicera japonica	-	!	!	-	-	-	-	!	-	-	!	-	-	-	-	!	-	!
Lyonia ligustrina	-	-	-	-	-	-	-	-	!	-	!	-	-	!	-	-	-	-
Magnolia virginiana	!	-	-	-	-	!	!	!	!	!	-	-	-	-	-	-	-	-
Morus alba	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myrica pensylvanica	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	!	-	-	!	!	!	-	!	!	!	-	!	!	-	!	!	-	-
Parthenocissus quinquefolia	!	-	!	-	-	-	!	!	-	-	!	!	!	-	-	-	-	!
Pinus rigida	-	!	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-
Prunus serotina	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Quercus falcata	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-
Quercus phellos	-	!	-	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus stellata	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-
Quercus velutina	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-
Rhododendron viscosum	-	!	-	-	!	!	!	!	!	-	!	-	-	-	-	-	-	-
Rosa multiflora	-	-	!	!	-	-	-	-	-	-	!	!	-	-	-	!	-	!
Rubus hispidus	-	-	!	-	-	!	-	-	-	-	-	!	-	-	-	!	!	!
Rubus sp.	-	-	-	-	-	-	-	-	-	-	-	-	!	-	!	!	-	-
Salix sp.	-	-	!	-	-	-	-	-	-	!	!	!	-	-	!	-	-	-
Sambucus canadensis	-	-	!	!	-	-	-	-	-	-	-	!	-	-	!	-	-	!
Smilax glauca	-	!	-	-	-	-	-	-	-	-	-	-	-	-	-	-	!	-
Smilax rotundifolia	!	!	-	!	!	!	!	!	!	!	!	!	!	!	!	!	!	-
Smilax walteri	!	-	-	-	-	-	!	-	-	-	-	-	-	-	-	-	-	-
Spiraea tomentosa	-	-	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-
Toxicodendron radicans	!	-	-	-	!	-	-	-	-	-	!	!	-	!	!	-	-	!
Toxicodendron vernix	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium corymbosum	!	!	-	-	!	!	!	-	!	!	!	!	!	!	-	!	!	-
Vaccinium macrocarpon	-	-	-	-	-	-	-	-	-	!	-	-	-	-	-	-	-	-
Viburnum dentatum	-	-	-	-	-	-	-	-	!	-	-	-	-	-	!	-	-	-
Viburnum nudum var. nudum	-	-	-	-	-	!	!	-	!	-	-	-	-	-	-	-	-	-
Vitis labrusca	!	-	!	-	-	-	-	!	-	-	!	-	-	-	-	-	-	!
Wisteria sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 2.2. Scientific and common names of plants found at stream-vegetation sites in the Great Egg Harbor River WMA. Taxonomic nomenclature follows Gleason and Cronquist (1991). Common names are taken from various sources.

Scientific/Common Name	Scientific/Common Name	Scientific/Common Name
Herbaceous plants:		
Acalypha rhomboidea	*Carex collinsii*	*Elodea canadensis*
three-seeded mercury	Collins' sedge	Canada water-weed
Agrostis perennans	*Carex crinita*	*Elodea nuttallii*
upland bent-grass	fringed sedge	Nuttall's water-weed
Ambrosia artemisiifolia	*Carex folliculata*	*Equisetum arvense*
common ragweed	long sedge	field horsetail
Antennaria plantaginiflora	*Carex lurida*	*Erechtites hieracifolia*
plantain-leaved pussytoes	sallow sedge	pilewort
Apios americana	*Carex striata*	*Eriocaulon aquaticum*
groundnut	Walter's sedge	seven-angled pipewort
Apocynum cannabinum	*Carex stricta*	*Eupatorium dubium*
Indian hemp	tussock sedge	eastern joe-pye weed
Asclepias incarnata	*Ceratophyllum echinatum*	*Eupatorium leucolepis*
swamp milkweed	prickly hornwort	white-bracted boneset
Asclepias syriaca	*Chasmanthium laxum*	*Eupatorium perfoliatum*
common milkweed	slender spike-grass	boneset
Aster nemoralis	*Chimaphila maculata*	*Eupatorium resinosum*
bog aster	striped wintergreen	pine barrens boneset
Aster novi-belgii	*Cuscuta sp.*	*Eupatorium serotinum*
New York aster	dodder	late-flowering boneset
Aster vimineus	*Cyperus brevifolioides*	*Euphorbia maculata*
small white aster	umbrella sedge	spotted spurge
Bartonia paniculata	*Cyperus sesquiflorus*	*Euthamia tenuifolia*
twining bartonia	umbrella sedge	slender-leaved goldenrod
Bidens connata	*Cyperus strigosus*	*Festuca elatior*
purple-stemmed beggar ticks	straw-colored cyperus	tall fescue
Bidens coronata	*Decodon verticillatus*	*Galium tinctorium*
northern tickseed-sunflower	swamp loosestrife	stiff marsh bedstraw
Bidens discoidea	*Dioscorea villosa*	*Glyceria obtusa*
small beggar ticks	common wild yam	blunt manna-grass
Bidens frondosa	*Drosera intermedia*	*Glyceria striata*
beggar ticks	spatulate-leaved sundew	fowl manna-grass
Bidens vulgata	*Drosera rotundifolia*	*Hypericum canadense*
tall beggar ticks	round-leaved sundew	Canada Saint John's-wort
Boehmeria cylindrica	*Dulichium arundinaceum*	*Hypericum mutilum*
false nettle	three-way sedge	dwarf Saint John's-wort
Callitriche heterophylla	*Echinochloa muricata*	*Hypochoeris raticata*
larger water starwort	American barnyard grass	cat's ear
Cardamine sp.	*Eleocharis acicularis*	*Impatiens capensis*
bitter-cress	needle spike-rush	spotted touch-me-not
Carex albolutescens	*Eleocharis flavescens var. olivacea*	*Iris versicolor*
greenish-white sedge	green spike-rush	larger blue flag
Carex atlantica	*Eleocharis ovata*	*Juncus canadensis*
Atlantic sedge	blunt spike-rush	Canada rush
Carex atlantica var. capillacea	*Eleocharis robbinsii*	*Juncus effusus*
Howe's sedge	Robbin's spike-rush	common rush
Carex bullata	*Eleocharis tenuis*	*Juncus militaris*
button sedge	slender spike-rush	bayonet rush

Scientific/Common Name

Juncus pelocarpus
brown-fruited rush
Juncus tenuis
slender rush
Lachnanthes caroliniana
redroot
Leersia oryzoides
rice cut-grass
Lemna sp.
duckweed
Lobelia cardinalis
cardinal flower
Lobelia nuttallii
Nuttall's lobelia
Ludwigia alternifolia
seedbox
Ludwigia palustris
water purslane
Ludwigia sphaerocarpa
globe-fruited seedbox
Lycopus uniflorus
northern bugleweed
Lycopus virginicus
Virginia bugleweed
Lysimachia terrestris
swamp loosestrife
Microstegium vimineum
stiltgrass
Mikania scandens
climbing hempweed
Mitchella repens
partridge berry
Nuphar variegata
bullhead lily
Nymphaea odorata
white water lily
Onoclea sensibilis
sensitive fern
Osmunda cinnamomea
cinnamon fern
Osmunda regalis
royal fern
Oxalis stricta
upright yellow wood-sorrel
Oxypolis rigidior
cowbane
Panicum clandestinum
deertongue grass
Panicum dichotomiflorum
spreading panic-grass
Panicum dichotomum
forked panic-grass

Scientific/Common Name

Panicum scabriusculum
sheathed panic-grass
Panicum verrucosum
warty panic-grass
Panicum virgatum
switchgrass
Peltandra virginica
arrow arum
Phalaris arundinacea
reed canary grass
Phragmites australis
common reed
Phytolacca americana
pokeweed
Pilea pumila
clearweed
Poa pratensis
Kentucky bluegrass
Polygonum arifolium
halberd-leaved tearthumb
Polygonum cespitosum
cespitose knotweed
Polygonum cuspidatum
Japanese knotweed
Polygonum hydropiperoides
mild water pepper
Polygonum pensylvanica
Pennsylvania smartweed
Polygonum persicaria
ladies' thumb
Polygonum punctatum
dotted smartweed
Polygonum sagittatum
arrow-leaved tearthumb
Pontederia cordata
pickerel-weed
Potamogeton confervoides
alga-like pondweed
Potamogeton epihydrus
Nuttall's pondweed
Potamogeton oakesianus
Oakes' pondweed
Potamogeton pusillus
small pondweed
Ranunculus sceleratus
cursed buttercup
Rhexia virginica
Virginia meadow beauty
Rhynchospora chalarocephala
loose-headed beaked-rush
Rhynchospora macrostachya
horned beaked-rush

Scientific/Common Name

Rumex sp.
dock
Sabatia difformis
lance-leaved sabatia
Sagittaria engelmanniana
Engelmann's arrowhead
Sarracenia purpurea
pitcher plant
Scirpus cyperinus
wool-grass
Scirpus subterminalis
water club-rush
Scutellaria lateriflora
mad-dog skullcap
Solanum nigrum
black nightshade
Solidago canadensis
Canada goldenrod
Solidago rugosa
rough-stemmed goldenrod
Sparganium americanum
slender bur-reed
Spiranthes sp.
ladies'-tresses
Sporobolis sp.
rush-grass
Thelypteris palustris
marsh fern
Thelypteris simulata
bog fern
Triadenum virginicum
marsh Saint John's-wort
Typha latifolia
broad-leaved cat-tail
Utricularia fibrosa
fibrous bladderwort
Utricularia geminiscapa
hidden-fruited bladderwort
Utricularia inflata
floating bladderwort
Utricularia purpurea
purple bladderwort
Viola lanceolata
lance-leaved violet
Woodwardia areolata
netted chain fern
Woodwardia virginica
Virginia chain fern

Scientific/Common Name

Woody plants:

Acer rubrum
red maple

Alnus serrulata
smooth alder

Amelanchier canadensis
oblongleaf juneberry

Aronia arbutifolia
red chokeberry

Berberis thunbergii
Japanese barberry

Betula nigra
river birch

Campsis radicans
trumpet creeper

Cephalanthus occidentalis
buttonbush

Chamaecyparis thyoides
Atlantic white cedar

Chamaedaphne calyculata
leatherleaf

Clethra alnifolia
sweet pepperbush

Cornus amomum
silky dogwood

Corylus americana
American hazel

Diospyros virginiana
persimmon

Eubotrys racemosa
fetterbush

Gaylussacia frondosa
dangleberry

Hypericum densiflorum
bushy Saint John's-wort

Ilex glabra
inkberry

Ilex laevigata
smooth winterberry

Ilex opaca
American holly

Ilex verticillata
winterberry

Itea virginica
Virginia willow

Juniperus virginiana
red cedar

Kalmia angustifolia
sheep laurel

Liquidambar styraciflua
sweet gum

Lonicera japonica
Japanese honeysuckle

Lyonia ligustrina
maleberry

Magnolia virginiana
sweet bay

Morus alba
white mulberry

Myrica pensylvanica
bayberry

Nyssa sylvatica
black gum

Parthenocissus quinquefolia
Virginia creeper

Pinus rigida
pitch pine

Prunus serotina
black cherry

Quercus falcata
spanish oak

Quercus phellos
willow oak

Quercus stellata
post oak

Quercus velutina
black oak

Rhododendron viscosum
swamp azalea

Rosa multiflora
multiflora rose

Rubus hispidus
swamp dewberry

Rubus sp.
blackberry

Salix sp.
willow

Sambucus canadensis
common elder

Smilax glauca
glaucous greenbrier

Smilax rotundifolia
common greenbrier

Smilax walteri
red-berried greenbrier

Spiraea tomentosa
steeplebush

Toxicodendron radicans
poison ivy

Toxicodendron vernix
poison sumac

Vaccinium corymbosum
highbush blueberry

Vaccinium macrocarpon
large cranberry

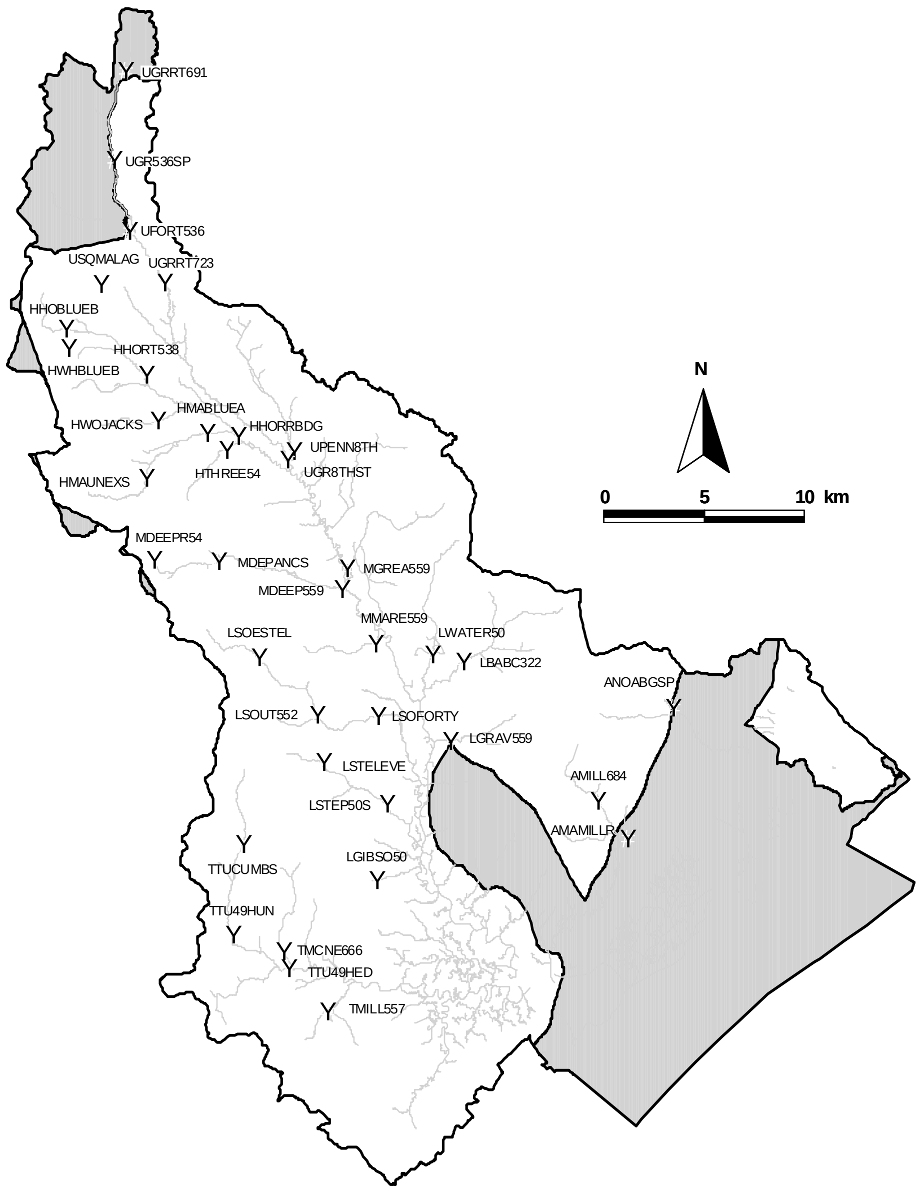
Viburnum dentatum
southern arrowwood

Viburnum nudum var. nudum
naked withe-rod

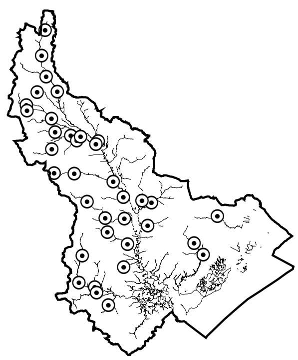
Vitis labrusca
fox grape

Wisteria sp.
wisteria

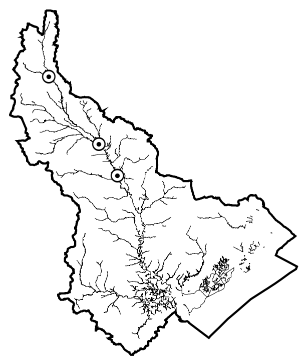
APPENDIX 2.3. PLANT-DISTRIBUTION MAPS



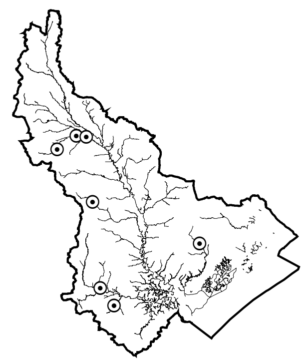
Location of 37 stream-vegetation survey sites in the Great Egg Harbor River WMA. Shaded areas are outside the Pinelands National Reserve. Distribution maps for plants found at two or more sites are on the following pages. Refer to Appendix 2.0 for site descriptions and explanations of site codes.



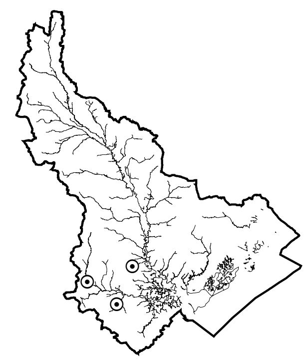
Acer rubrum
red maple



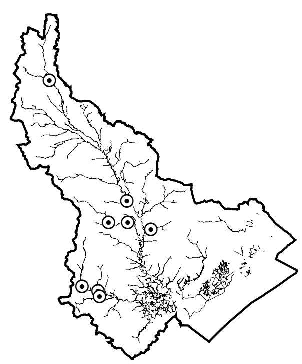
Agrostis perennans
upland bent-grass



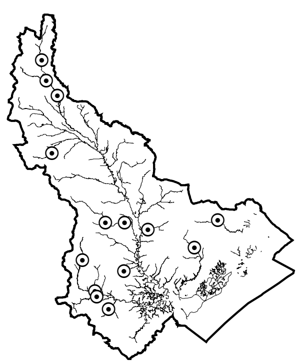
Alnus serrulata
smooth alder



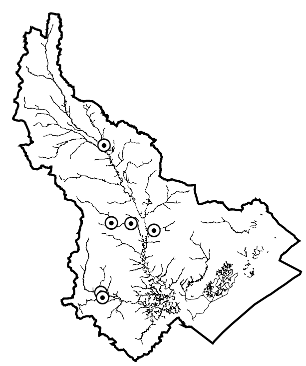
Amelanchier canadensis
oblongleaf juneberry



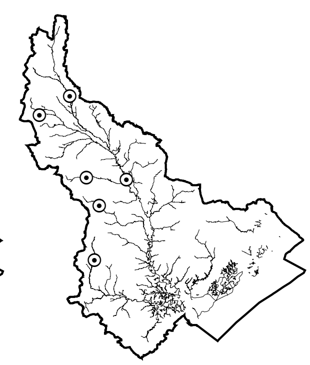
Apios americana
groundnut



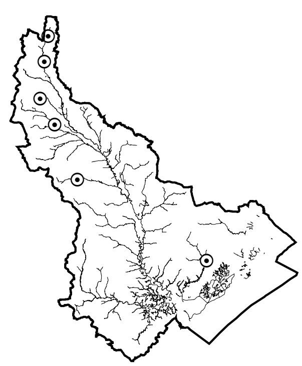
Aronia arbutifolia
red chokeberry



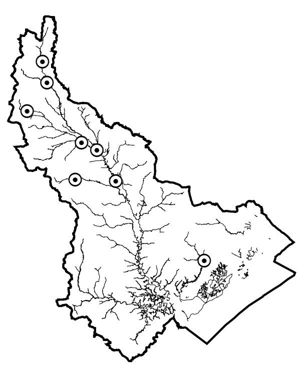
Aster novi-belgii
New York aster



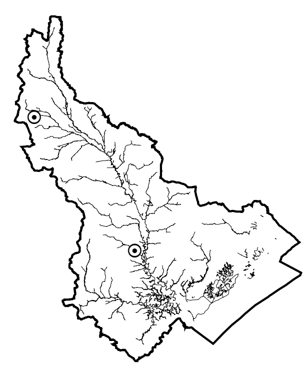
Aster vimineus
small white aster



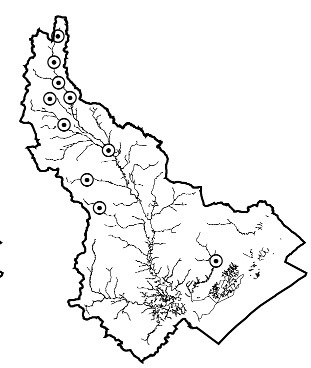
Bidens connata
purple-stemmed beggar ticks



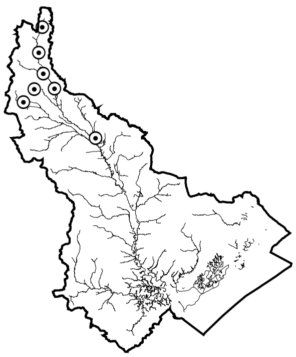
Bidens frondosa
beggar ticks



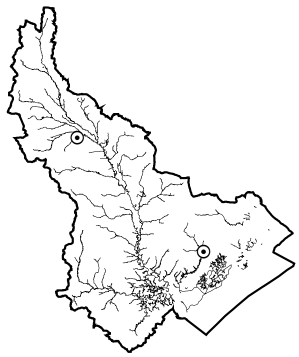
Bidens sp.
beggar ticks



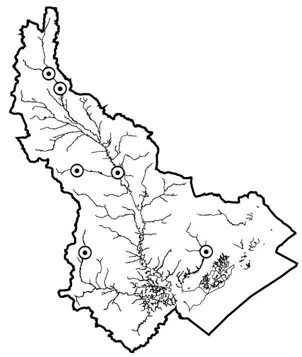
Boehmeria cylindrica
false nettle



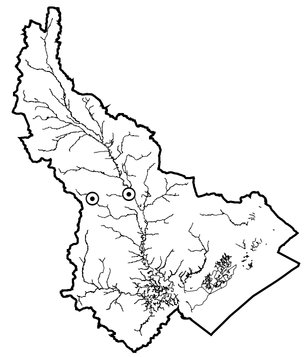
Callitriche heterophylla
larger water starwort



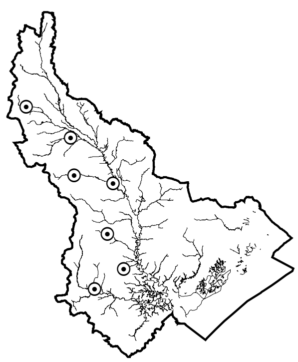
Cardamine sp.
bitter-cress



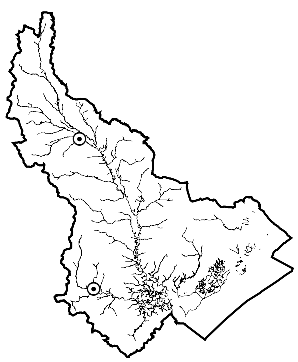
Carex albolutescens
greenish-white sedge



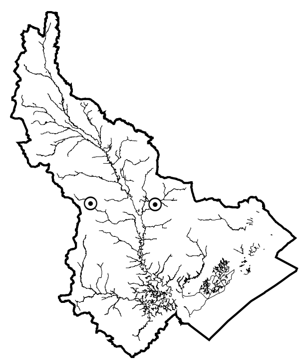
Carex atlantica
Atlantic sedge



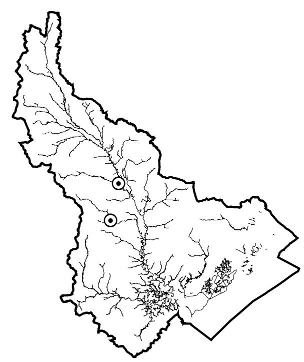
Carex atlantica var. capillacea
Howe's sedge



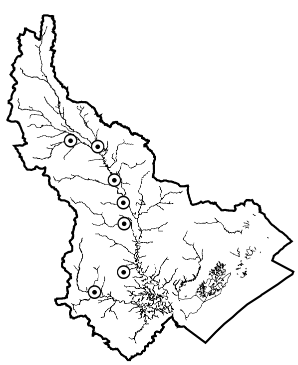
Carex bullata
button sedge



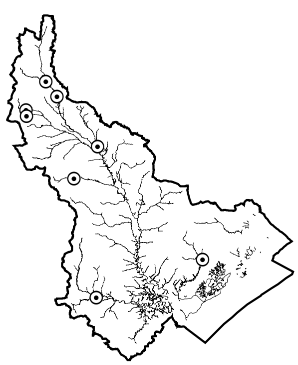
Carex collinsii
Collins' sedge



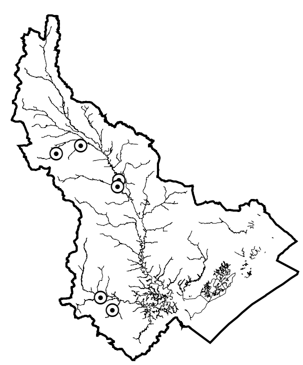
Carex crinita
fringed sedge



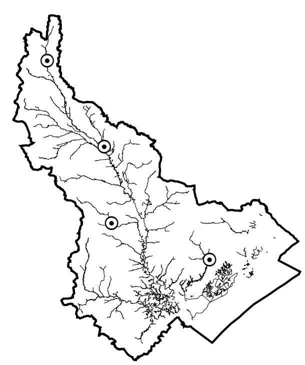
Carex folliculata
long sedge



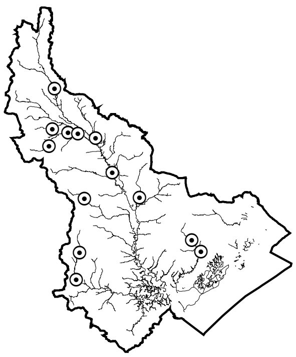
Carex lurida
sallow sedge



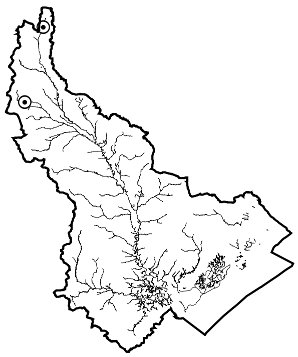
Carex stricta
tussock sedge



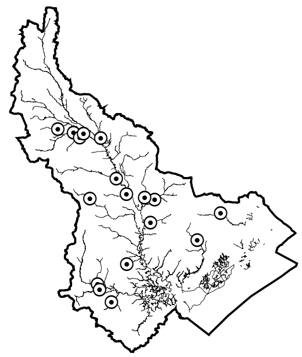
Carex sp.
sedge



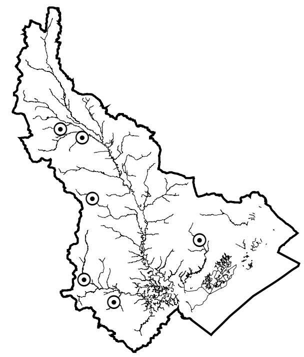
Cephalanthus occidentalis
buttonbush



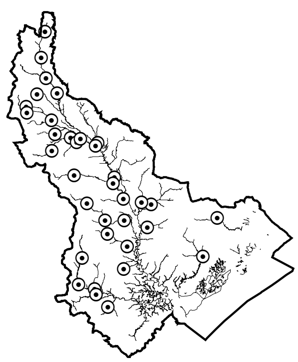
Ceratophyllum echinatum
prickly hornwort



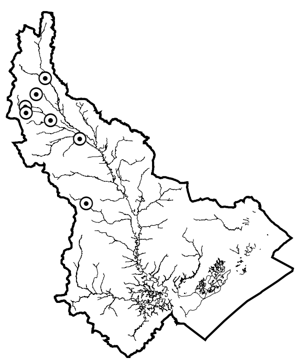
Chamaecyparis thyoides
Atlantic white cedar



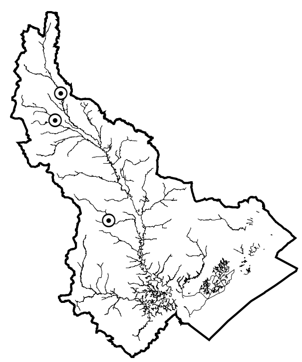
Chamaedaphne calyculata
leatherleaf



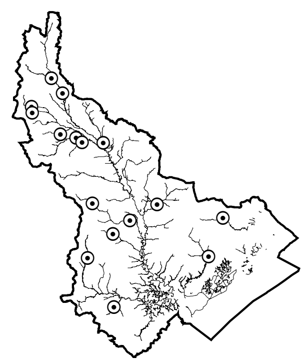
Clethra alnifolia
sweet pepperbush



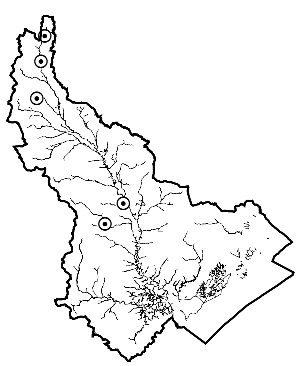
Cuscuta sp.
dodder



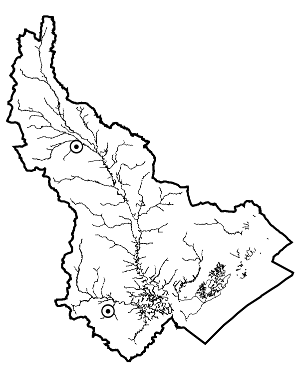
Cyperus strigosus
straw-colored cyperus



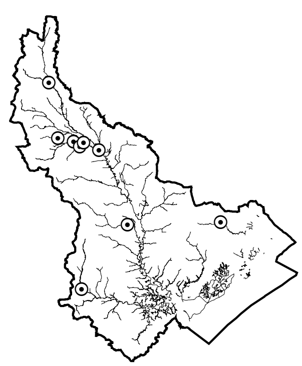
Decodon verticillatus
swamp loosestrife



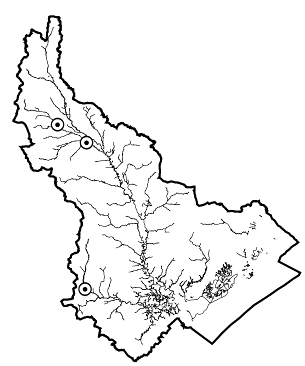
Dioscorea villosa
common wild yam



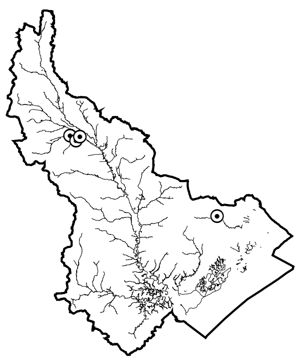
Drosera intermedia
spatulate-leaved sundew



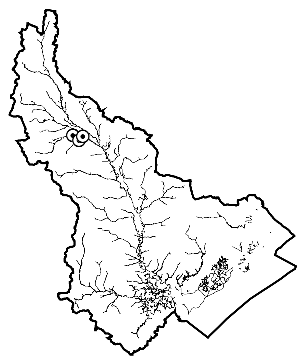
Dulichium arundinaceum
three-way sedge



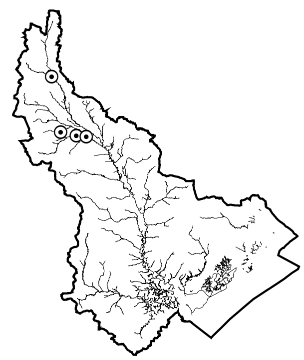
Eleocharis acicularis
needle spike-rush



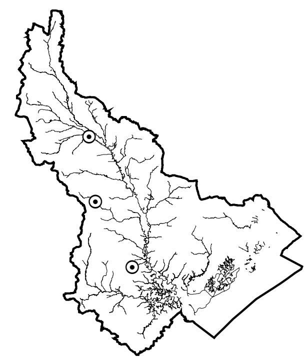
Eleocharis flavescens var. olivacea
green spike-rush



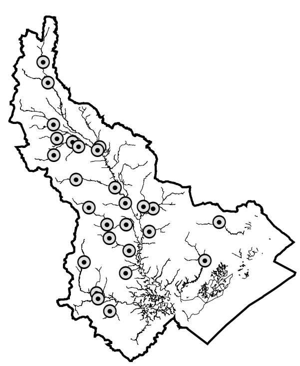
Eleocharis robbinsii
Robbin's spike-rush



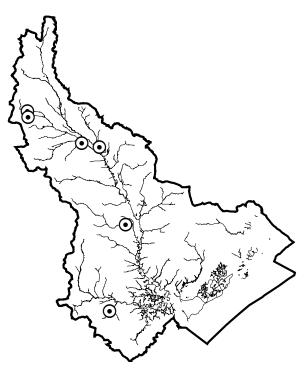
Eleocharis tenuis
slender spike-rush



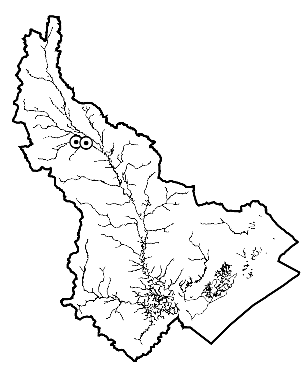
Eriocaulon aquaticum
seven-angled pipewort



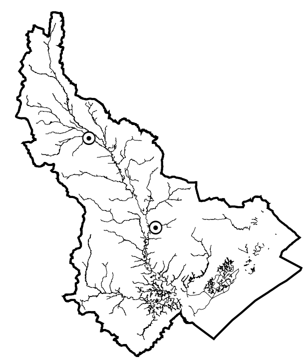
Eubotrys racemosa
fetterbush



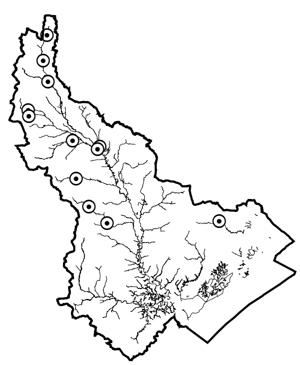
Eupatorium dubium
eastern joe-pye weed



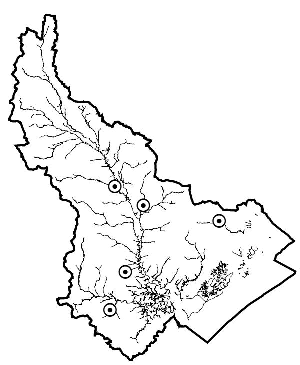
Eupatorium resinosum
pine barrens boneset



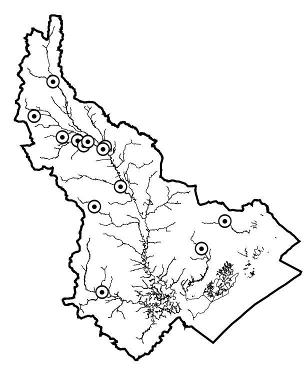
Euthamia tenuifolia
slender-leaved goldenrod



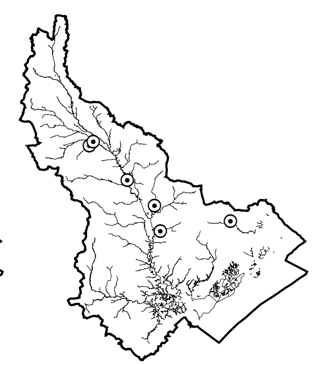
Galium tinctorium
stiff marsh bedstraw



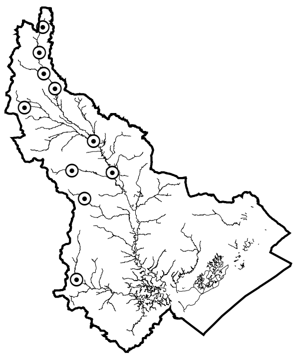
Gaylussacia frondosa
dangleberry



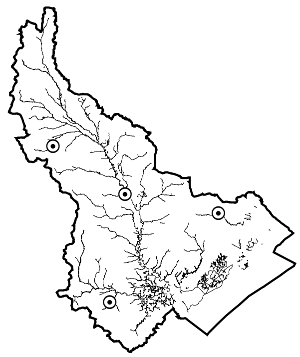
Glyceria obtusa
blunt manna-grass



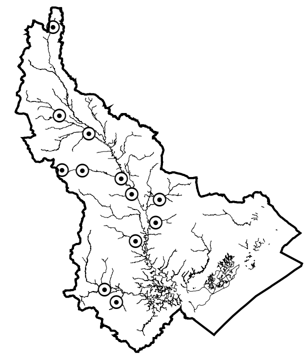
Hypericum canadense
Canada Saint John's-wort



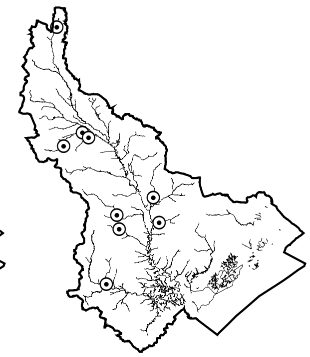
Hypericum mutilum
dwarf Saint John's-wort



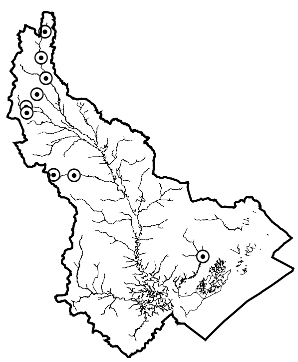
Ilex glabra
inkberry



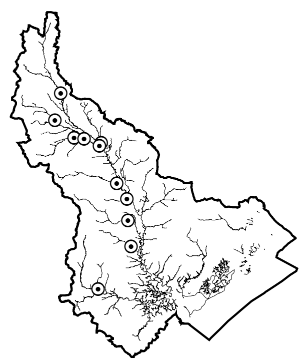
Ilex opaca
American holly



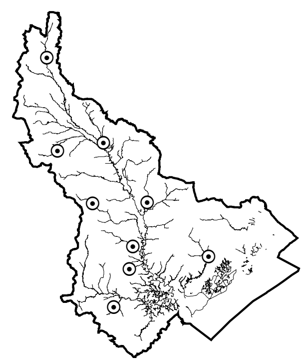
Ilex verticillata
winterberry



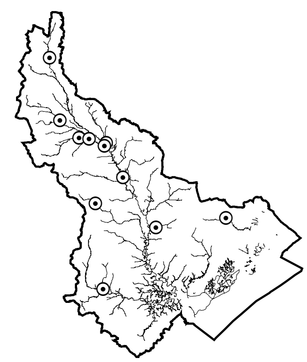
Impatiens capensis
spotted touch-me-not



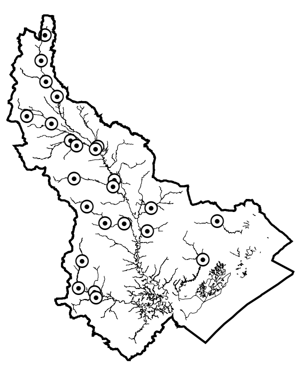
Iris versicolor
larger blue flag



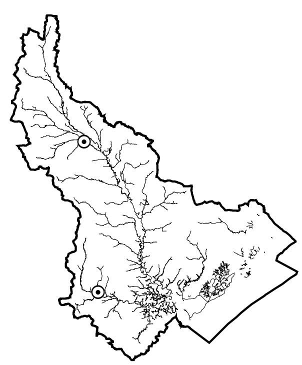
Itea virginica
Virginia willow



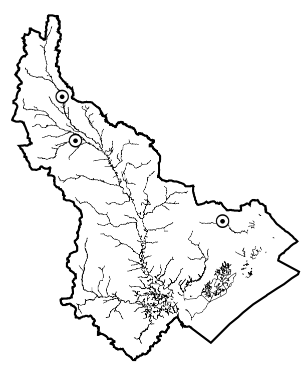
Juncus canadensis
Canada rush



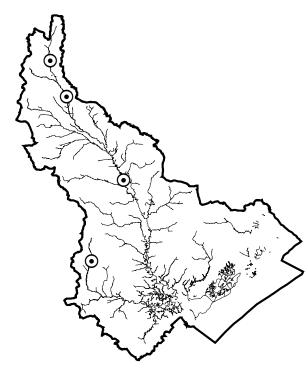
Juncus effusus
common rush



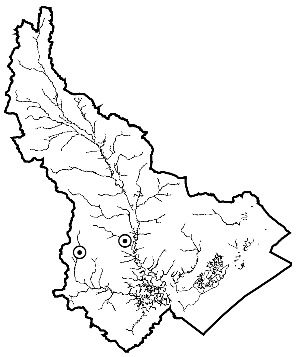
Juncus militaris
bayonet rush



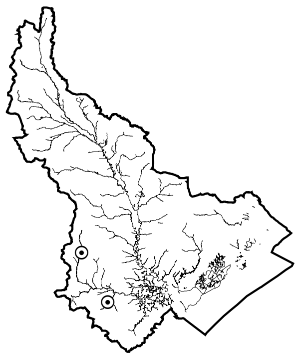
Juncus pelocarpus
brown-fruited rush



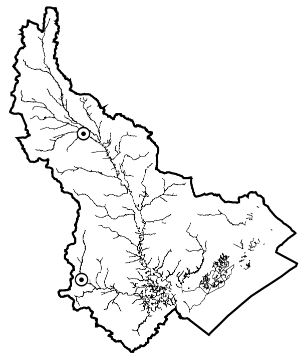
Juncus tenuis
slender rush



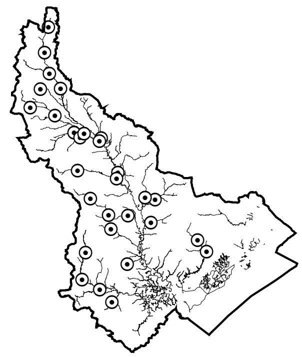
Juniperus virginiana
red cedar



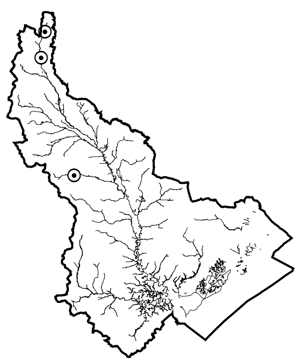
Kalmia angustifolia
sheep laurel



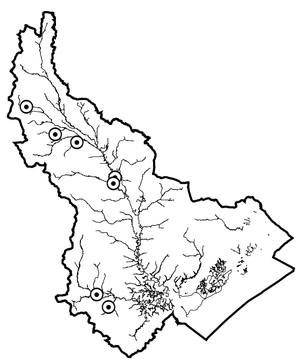
Lachnanthes caroliniana
redroot



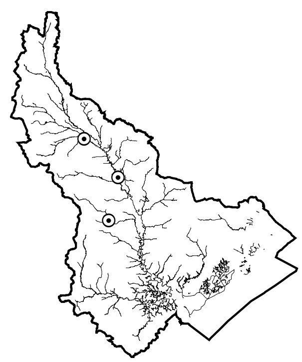
Leersia oryzoides
rice cut-grass



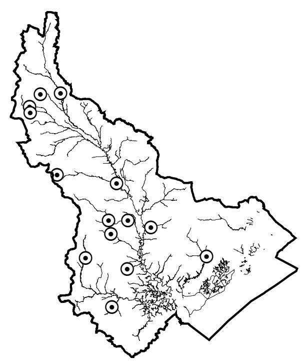
Lemna sp.
duckweed



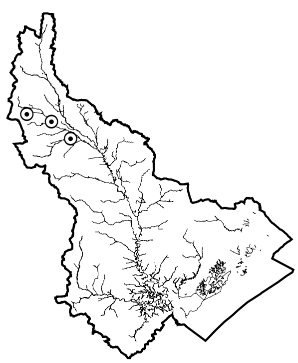
Liquidambar styraciflua
sweet gum



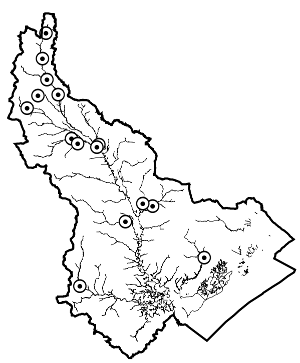
Lobelia cardinalis
cardinal flower



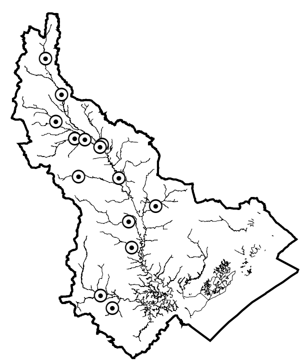
Lonicera japonica
Japanese honeysuckle



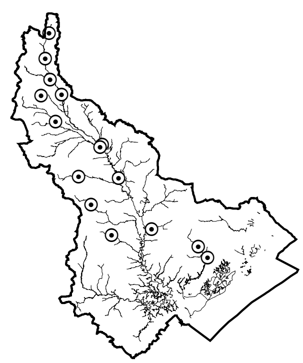
Ludwigia alternifolia
seedbox



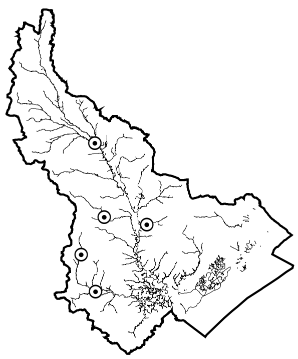
Ludwigia palustris
water purslane



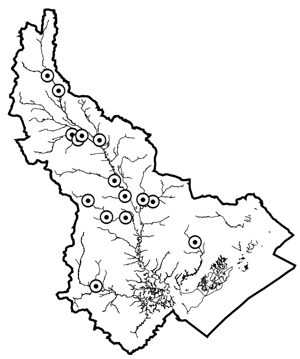
Lycopus uniflorus
northern bugleweed



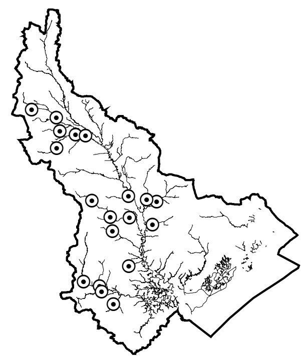
Lycopus virginicus
Virginia bugleweed



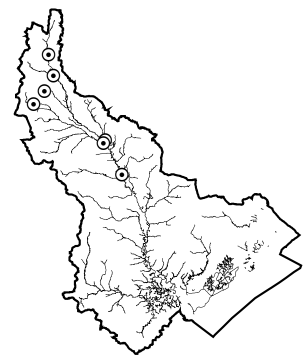
Lyonia ligustrina
maleberry



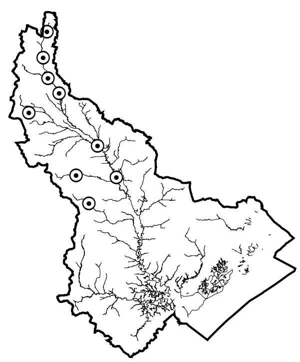
Lysimachia terrestris
swamp loosestrife



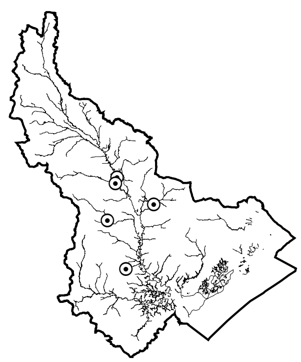
Magnolia virginiana
sweet bay



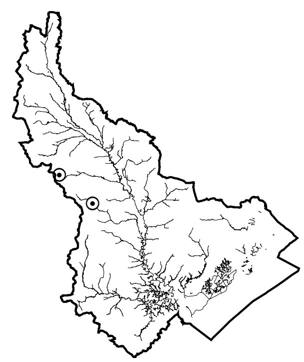
Microstegium vimineum
stiltgrass



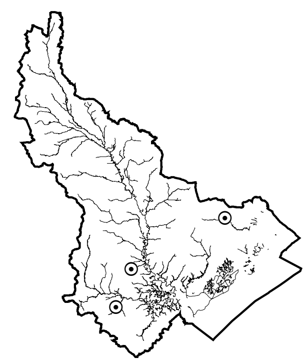
Mikania scandens
climbing hempweed



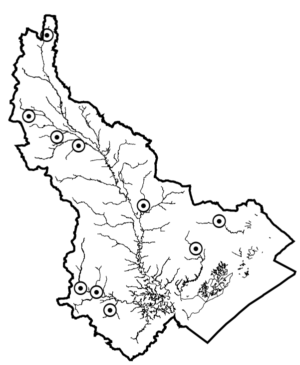
Mitchella repens
partridge berry



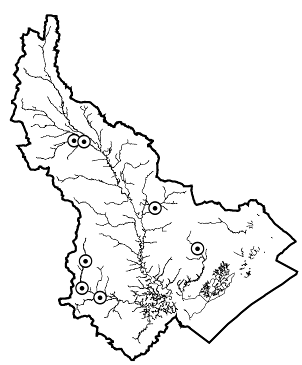
Morus alba
white mulberry



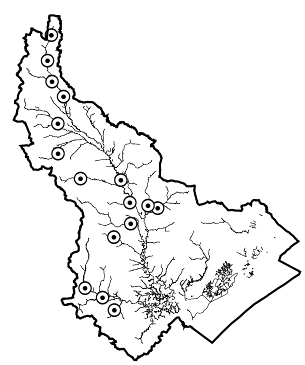
Myrica pensylvanica
bayberry



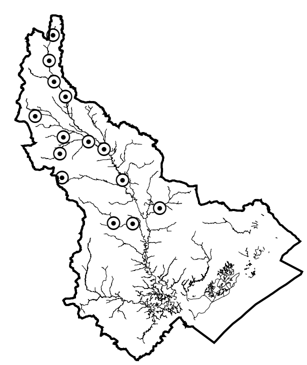
Nuphar variegata
bullhead lily



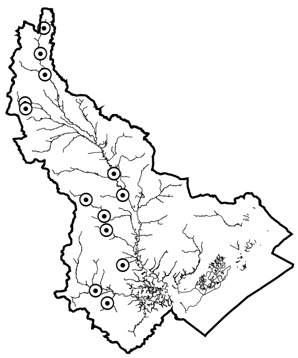
Nymphaea odorata
white water lily



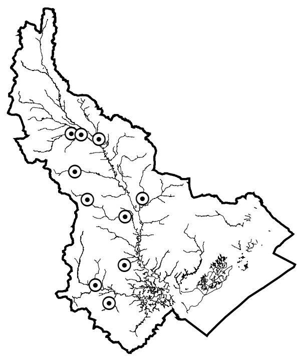
Nyssa sylvatica
black gum



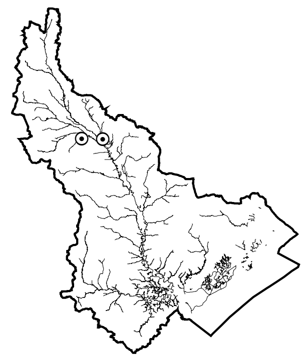
Onoclea sensibilis
sensitive fern



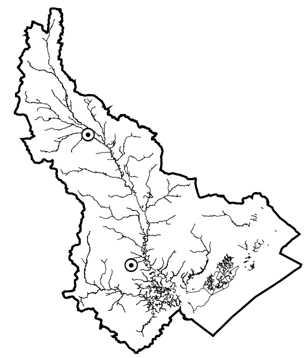
Osmunda cinnamomea
cinnamon fern



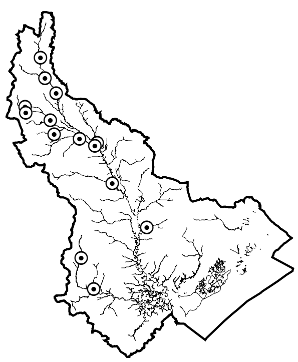
Osmunda regalis
royal fern



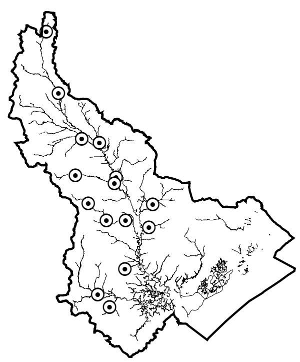
Oxalis stricta
upright yellow wood-sorrel



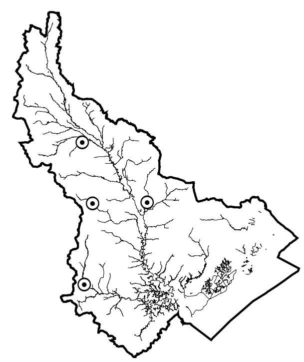
Oxypolis rigidior
cowbane



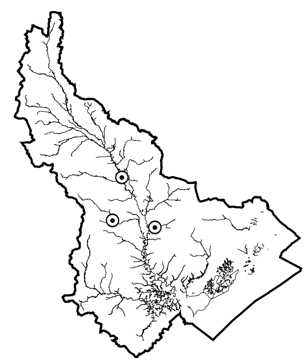
Panicum clandestinum
deertongue grass



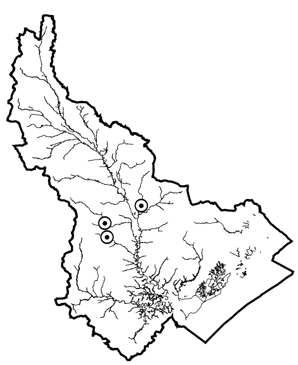
Panicum dichotomum
forked panic-grass



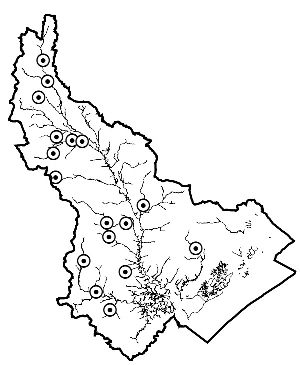
Panicum verrucosum
warty panic-grass



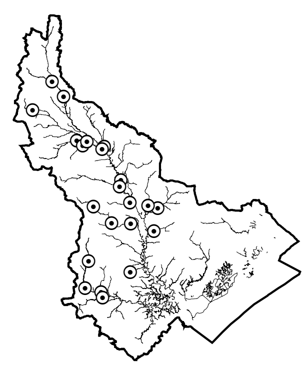
Panicum virgatum
switchgrass



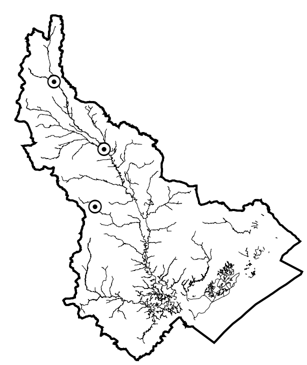
Panicum sp.
panic-grass



Parthenocissus quinquefolia
Virginia creeper

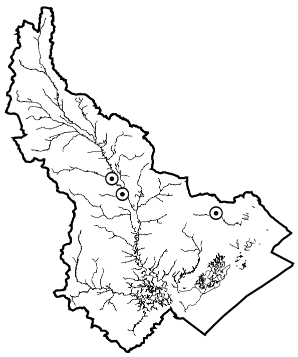


Peltandra virginica
arrow arum

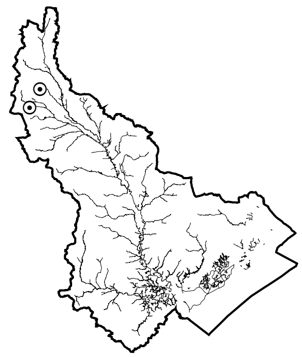


Phalaris arundinacea
reed canary grass

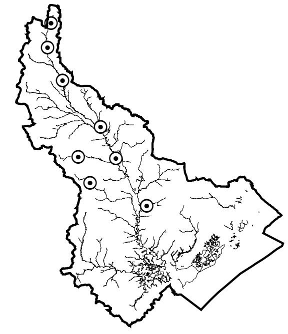
Phragmites australis
common reed



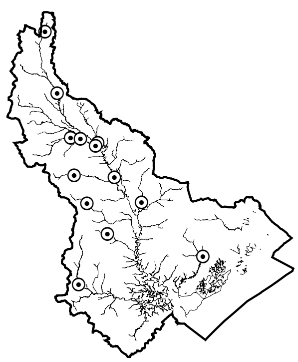
Pinus rigida
pitch pine



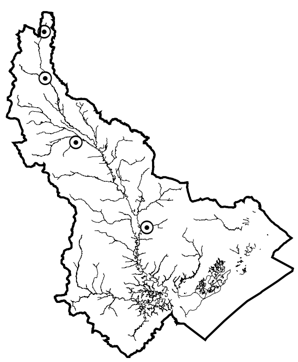
Polygonum arifolium
halberd-leaved tearthumb



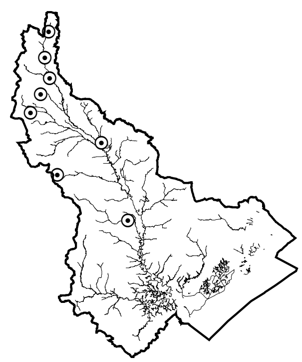
Polygonum cespitosum
cespitose knotweed



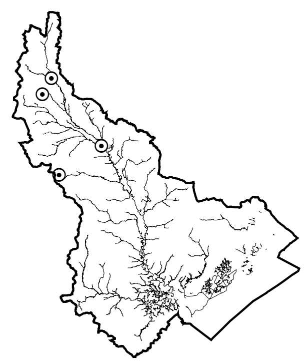
Polygonum hydropiperoides
mild water pepper



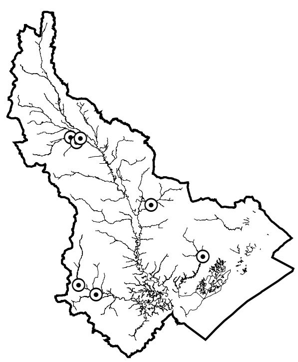
Polygonum punctatum
dotted smartweed



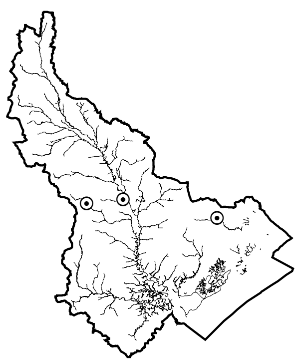
Polygonum sagittatum
arrow-leaved tearthumb



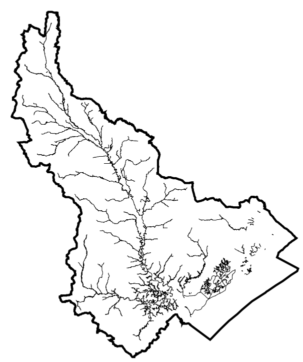
Polygonum sp.
smartweed



Pontederia cordata
pickerel-weed

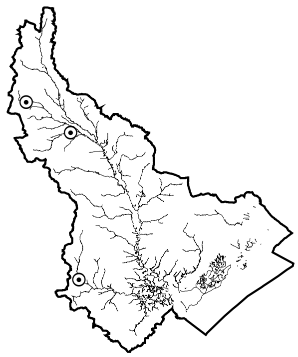


Potamogeton confervoides
alga-like pondweed

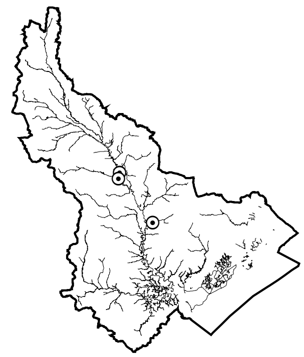


Potamogeton epihydrus
Nuttall's pondweed

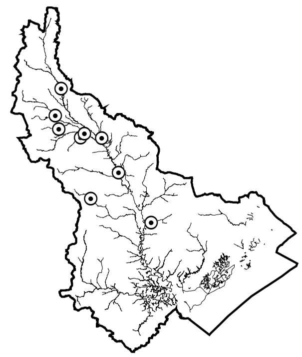
Potamogeton oakesianus
Oakes' pondweed



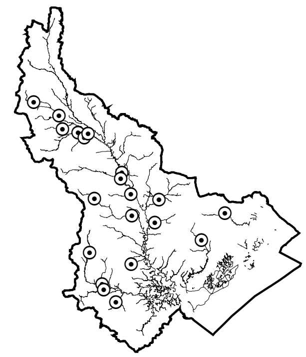
Prunus serotina
black cherry



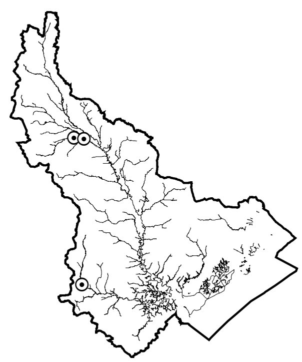
Quercus phellos
willow oak



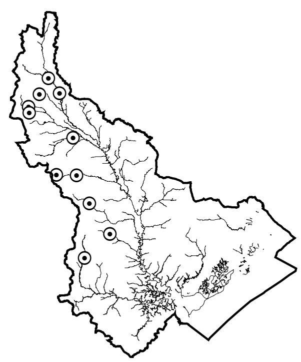
Rhexia virginica
Virginia meadow beauty



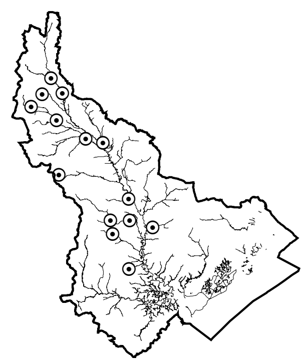
Rhododendron viscosum
swamp azalea



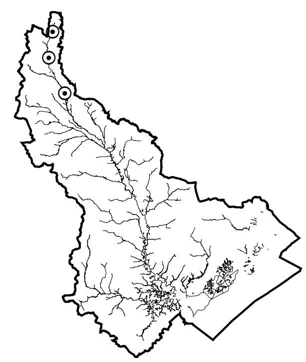
Rhynchospora macrostachya
horned beaked-rush



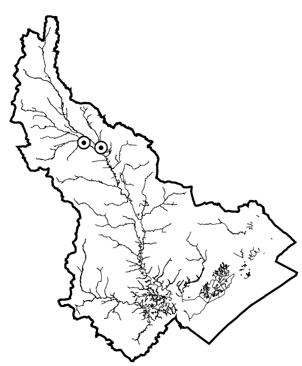
Rosa multiflora
multiflora rose



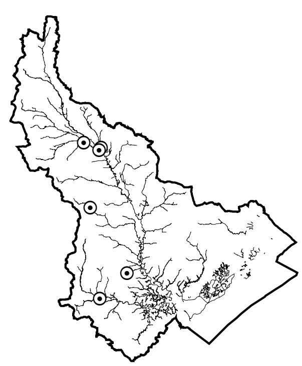
Rubus hispidus
swamp dewberry



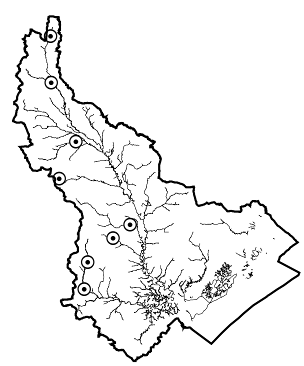
Rubus sp.
blackberry



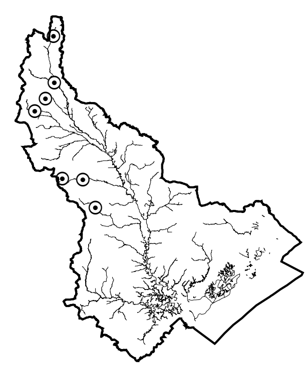
Sabatia difformis
lance-leaved sabatia



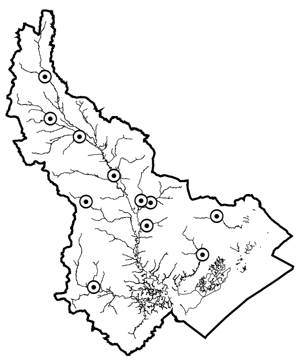
Sagittaria engelmanniana
Engelmann's arrowhead



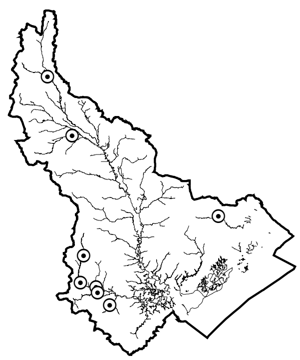
Salix sp.
willow



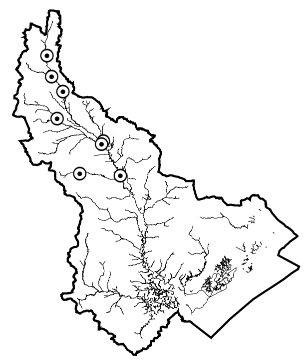
Sambucus canadensis
common elder



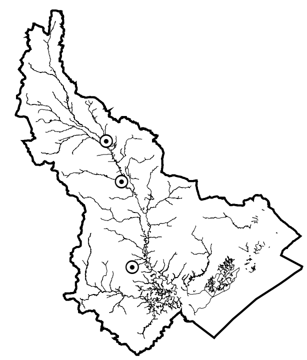
Scirpus cyperinus
wool-grass



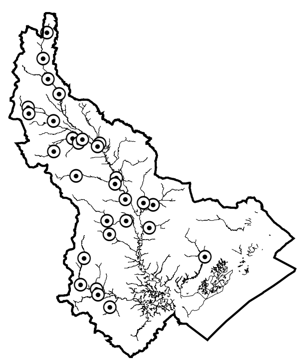
Scirpus subterminalis
water club-rush



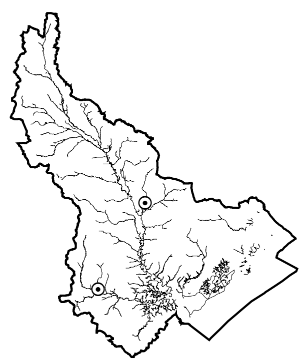
Scutellaria lateriflora
mad-dog skullcap



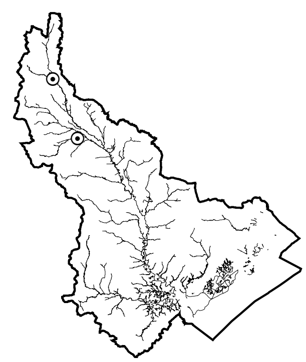
Smilax glauca
glaucous greenbrier



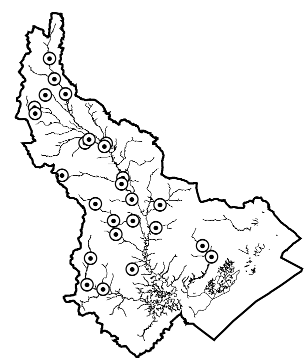
Smilax rotundifolia
common greenbrier



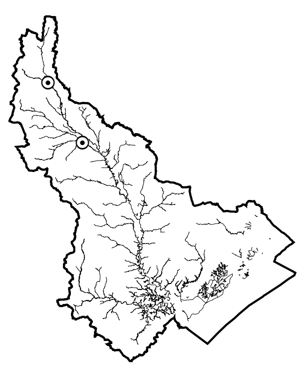
Smilax walteri
red-berried greenbrier



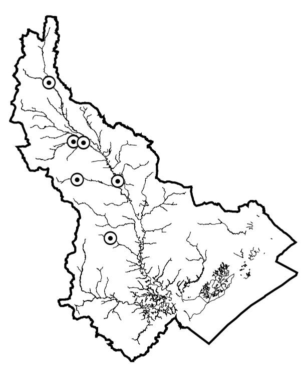
Solidago rugosa
rough-stemmed goldenrod



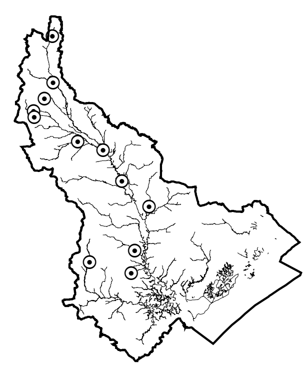
Sparganium americanum
slender bur-reed



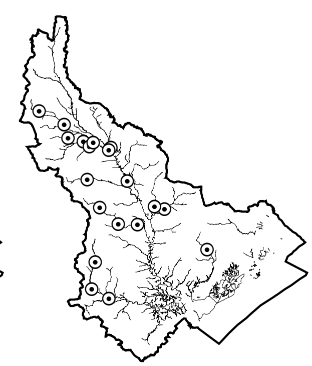
Spiraea tomentosa
steeplebush



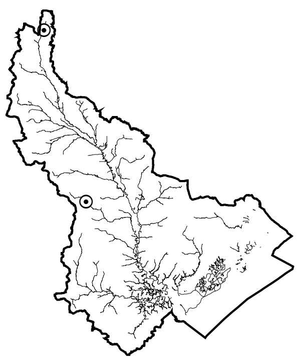
Thelypteris palustris
marsh fern



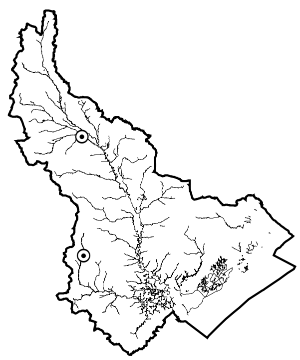
Toxicodendron radicans
poison ivy



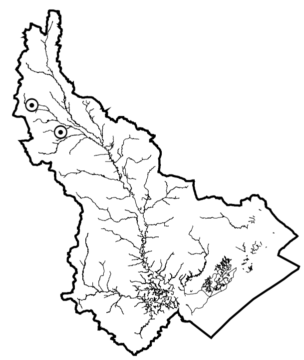
Triadenum virginicum
marsh Saint John's-wort



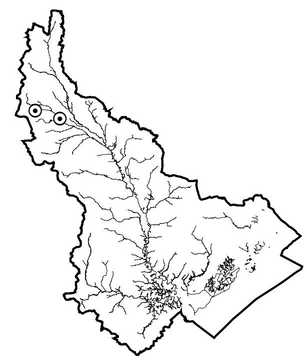
Typha latifolia
broad-leaved cat-tail



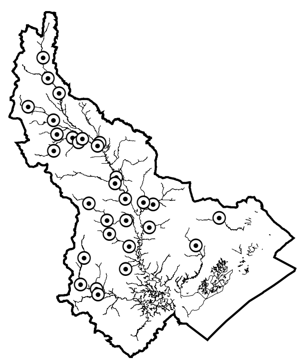
Utricularia fibrosa
fibrous bladderwort



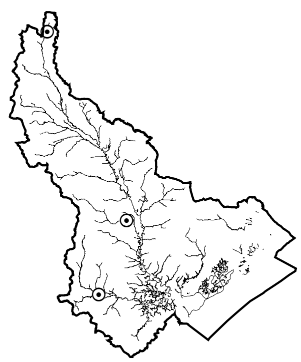
Utricularia geminiscapa
hidden-fruited bladderwort



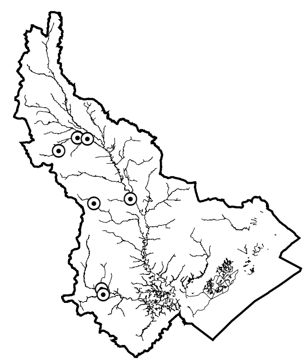
Utricularia sp.
bladderwort



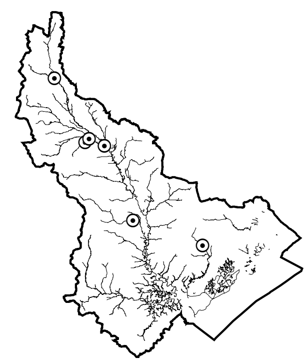
Vaccinium corymbosum
highbush blueberry



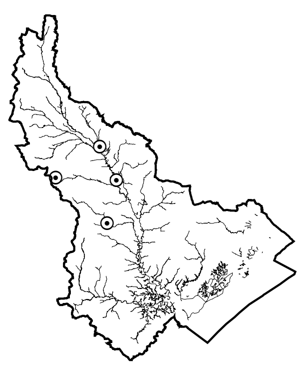
Viburnum dentatum
southern arrowwood



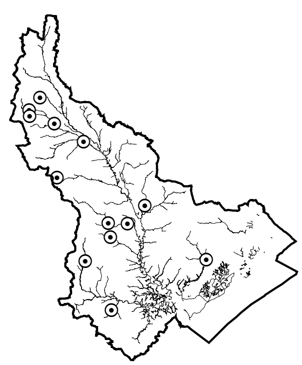
Viburnum nudum var. nudum
naked withe-rod



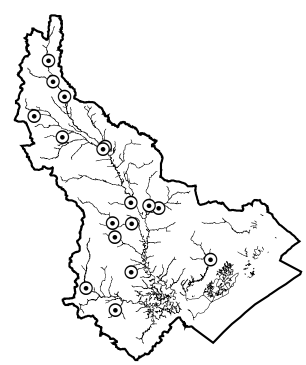
Viola lanceolata
lance-leaved violet



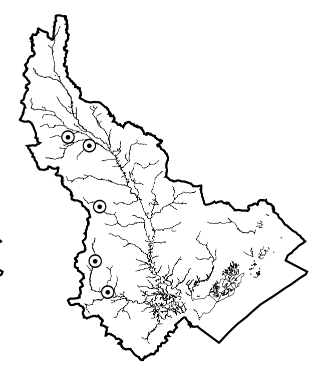
Viola sp.
violet



Vitis labrusca
fox grape



Woodwardia areolata
netted chain fern



Woodwardia virginica
Virginia chain fern

APPENDIX 3. FISH-ASSEMBLAGE DATA

Appendix 3.0. Fish-monitoring sites (streams and impoundments) in the Great Egg Harbor River WMA. Two 10-m sections were sampled for each stream site. Sections were not assigned in impoundments. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name and Description	Site Code
Maple Run at Route 662 Egg Harbor Twp. and Northfield City, Atlantic Co. (lat 39°22'32.59", long 74°34'17.99", Pleasantville quad). Sections located upstream and downstream from Route 662 (Mill Road).	AMAMILLR
Mill Branch at Route 684 Egg Harbor Twp., Atlantic Co. (lat 39°23'44.88", long 74°35'35.31", Pleasantville quad). Sections located upstream and downstream from Route 684 (Spruce Avenue).	AMILL684
North Branch Absecon Creek at Garden State Parkway Egg Harbor Twp., Atlantic Co. (lat 39°26'42.24", long 74°32'19.73", Pleasantville quad). Sections located downstream from Garden State Parkway North.	ANOABGSP
Faraway Branch at Jackson Road Monroe Twp., Gloucester Co. (lat 39°36'58.54", long 74°56'10.02", Buena quad). Sections located downstream from Jackson Road.	HFAJACKS
Faraway Branch impoundment at Jackson Road Monroe Twp., Gloucester Co. (lat 39°36'58.54", long 74°56'10.02", Buena quad). Impoundment upstream from Jackson Road.	HFAJACKL
Hospitality Branch at Route 633 Monroe Twp., Gloucester Co. (lat 39°38'40.78", long 74°59'08.66", Williamstown quad). Sections located downstream from Route 633 (Blue Bell Road).	HHOBLUEB
Hospitality Branch at Pennsylvania/Reading railroad bridge Folsom Bor., Atlantic Co. (lat 39°35'18.06", long 74°51'30.90", Newtonville quad). Sections located downstream from railroad bridge.	HHORRBDG
Hospitality Branch at Route 538 Monroe Twp., Gloucester Co. (lat 39°37'14.09", long 74°55'37.29", Buena quad). Sections located downstream from Route 538 (Coles Mills Road).	HHORT538
Timber Lake - lower Monroe Twp., Gloucester Co. (lat 39°38'17.81", long 74°56'53.96", Williamstown quad). First impoundment on Hospitality Branch, upstream from Whitehouse Road.	HHOTIMBD
Marsh Lake Branch at Blue Anchor Road Buena Vista Twp., Atlantic Co. (lat 39°35'23.02", long 74°52'53.90", Buena quad). Sections located upstream and downstream from Blue Anchor Road.	HMABLUEA
Cedar Lake - lower Buena Vista Twp., Atlantic Co. (lat 39°35'08.19", long 74°54'06.84", Buena quad). Impoundment on Marsh Lake Branch, upstream from Jackson Road.	HMAJACKS
Whitehall Branch at Route 659 Monroe Twp., Gloucester Co. (lat 39°38'04.56", long 74°59'01.48", Williamstown quad). Sections located downstream from Route 659 (Malaga Road).	HWHRT659
Babcock Creek at Route 322 Hamilton Twp., Atlantic Co. (lat 39°28'08.73", long 74°41'32.86", Mays Landing quad). Sections located downstream from Route 322.	LBABC322
Gibson Creek at Route 50 Estell Manor City, Atlantic Co. (lat 39°21'10.81", long 74°45'22.83", Tuckahoe quad). Sections located downstream from Route 50.	LGIBSO50
Gravelly Run at Route 559 Hamilton Twp., Atlantic Co. (lat 39°25'37.98", long 74°42'06.15", Mays Landing quad). Sections located upstream and downstream from Route 559 (Mays Landing - Somers Point Road).	LGRAV559
South River at Estelle Avenue Hamilton Twp., Atlantic Co. (lat 39°28'15.65", long 74°50'35.25", Dorothy quad). Sections located downstream from Estelle Avenue.	LSOESTEL

Site Name and Description	Site Code
South River at Forty Wire Road Hamilton and Weymouth Twps., Atlantic Co. (lat 39°26'25.14", long 74°45'19.23", Dorothy quad). Sections located upstream from Forty Wire Road (Walkers Forge Road).	LSOFORTY
South River at Route 552 Hamilton Twp., Atlantic Co. (lat 39°26'27.57", long 74°48'00.24", Dorothy quad). Sections located upstream and downstream from Route 552 (Bears Head Road).	LSOUT552
Stephen Creek at Route 50 Estell Manor City, Atlantic Co. (lat 39°23'37.70", long 74°44'53.48", Mays Landing quad). Sections located downstream from Route 50.	LSTEP50S
Maple Lake Estell Manor City, Atlantic Co. (lat 39°24'19.65", long 74°46'41.65", Dorothy quad). Impoundment on Stephen Creek, upstream from Maple Avenue.	LSTMAPLE
Watering Race Branch impoundment above Route 322 Hamilton Twp., Atlantic Co. (lat 39°28'53.18", long 74°42'53.15", Mays Landing quad). First impoundment above Route 322.	LWA50BOG
Deep Run at Route 559 Hamilton Twp., Atlantic Co. (lat 39°30'26.67", long 74°46'55.11", Newtonville quad). Sections located upstream and downstream from Route 559.	MDEEP559
Deep Run at Eighth Street Buena Vista Twp., Atlantic Co. (lat 39°31'18.07", long 74°52'22.42", Newtonville quad). Sections located downstream from Eighth Street.	MDEPANCS
Great Egg Harbor River at Route 559 Hamilton Twp., Atlantic Co. (lat 39°31'05.88", long 74°46'43.03", Newtonville quad). Sections located downstream from Route 559.	MGREA559
Lake Lenape Hamilton Twp., Atlantic Co. (lat 39°27'16.24", long 74°44'01.44", Mays Landing quad). Impoundment on Great Egg Harbor River, upstream from Route 616 (Mill Street).	MGRLENAP
Mare Run at Route 559 Hamilton Twp., Atlantic Co. (lat 39°28'43.34", long 74°45'27.53", Dorothy quad). Sections located upstream from Route 559 (Weymouth Road).	MMARE559
Makepeace Lake Hamilton Twp., Atlantic Co. (lat 39°32'47.63", long 74°45'05.97", Newtonville quad). Impoundment on Makepeace Stream, upstream from Route 623 (Weymouth - Elwood Road).	MMKPEACU
McNeals Branch at Route 666 Estell Manor City, Atlantic Co. (lat 39°18'56.96", long 74°49'27.60", Tuckahoe quad). Sections located upstream and downstream from Route 666 (Cape May Avenue).	TMCNE666
Tarkiln Branch below powerline right-of-way Upper Twp., Cape May Co. (lat 39°18'00.78", long 74°51'07.23", Tuckahoe quad). Sections located downstream from second dike below powerline right-of-way.	TTARKBOG
Tuckahoe River at Route 49 near Head Of River Upper Twp. and Estell Manor City, Cape May and Atlantic Co. (lat 39°18'24.82", long 74°49'12.65", Tuckahoe quad). Sections located upstream from Route 49.	TTU49HED
Tuckahoe River at Route 49 at Hunters Mill Maurice River Twp. and Estell Manor City, Cumberland Co. (lat 39°19'26.33", long 74°51'40.34", Tuckahoe quad). Sections located downstream from Route 49.	TTU49HUN
Tuckahoe River impoundment at Route 637 Estell Manor City, Atlantic Co. (lat 39°22'20.50", long 74°51'12.41", Tuckahoe quad). Impoundment upstream from Route 637 (Cumberland Avenue).	TTUCUMBL
Warners Mill Stream impoundment at Aetna Drive Estell Manor City, Atlantic Co. (lat 39°18'50.04", long 74°48'20.06", Tuckahoe quad). Impoundment above Aetna Drive.	TWAAETNA
Four Mile Branch at Route 536 Monroe Twp., Gloucester Co. (lat 39°41'47.56", long 74°56'23.61", Williamstown quad). Sections located upstream from Route 536 (Malaga Road).	UFORT536

Site Name and Description	Site Code
Great Egg Harbor River at Route 536 Spur Winslow Twp., Camden Co. (lat 39°44'01.87", long74°57'03.82", Williamstown quad). Sections located downstream from Route 536 Spur (Williamstown - New Freedom Road).	UGR536SP
Great Egg Harbor River at Eighth Street Folsom Bor., Atlantic Co. (lat 39°34'32.97", long 74°49'20.29", Newtonville quad). Sections located upstream from Eighth Street	UGR8THST
Great Egg Harbor River impoundment at Berlin Park Berlin Bor., Camden Co. (lat 39°47'40.29", long 74°56'14.30", Clementon quad). Impoundment above Route 689 (Cross Keys - Berlin Road).	UGRBPARK
Great Egg Harbor River at Route 536 Winslow Twp., Camden Co. (lat 39°42'05.96", long 74°56'14.78", Williamstown quad). Sections located downstream from Route 536 (New Brooklyn - Cedar Brook Road).	UGREA536
Great Egg Harbor River at Route 691 Winslow Twp. and Berlin Bor., Camden Co. (lat 39°46'51.18", long 74°56'34.70", Clementon quad). Sections located upstream and downstream from Route 691 (Watsontown - New Freedom Road).	UGRRT691
Great Egg Harbor River at Route 723 Winslow Twp., Camden Co. (lat 39°40'10.19", long 74°54'47.99", Williamstown quad). Sections located downstream from Route 723 (Williamstown - Winslow Road).	UGRRT723
Penny Pot Stream at Eighth Street Folsom Bor., Atlantic Co. (lat 39°34'48.42", long 74°49'03.11", Newtonville quad). Sections located upstream and downstream from Eighth Street.	UPENN8TH
Penny Pot Stream at Route 54 Hammonton Town, Atlantic Co. (lat 39°36'34.86", long 74°50'02.95", Newtonville quad). Sections located downstream from Route 54.	UPENNY54

Appendix 3.1. Total number collected for each fish species at monitoring sites in the Great Egg Harbor River Watershed Management Area. A dash (-) indicates that a species was not collected at a site. Surveys were completed by John F. Bunnell, Robert A. Zampella, Nicholas A. Procopio, Tina L. Burns, and Andrew S. DuBrul. Refer to Chapter 4 (Fish Assemblages) for survey methodology. Refer to Appendix 3.0 for detailed site information and Appendix 3.2 for common names for each species.

Species	Site Code and Date													
	AMAMILLR	AMILL684	AMILL684	ANOABGSP	HFAJACKL	HFAJACKS	HHOBLUEB	HHOBLUEB	HHORRBDG	HHORT538	HHOTIMBD	HMABLUEA	HMAJACKS	HWHRT659
	07/15/02	07/15/02	10/20/04	07/15/02	09/18/02	07/01/02	06/10/02	10/13/04	06/10/02	07/01/02	09/11/02	06/14/02	06/21/02	08/01/02
Acantharchus pomotis	5	4	-	-	1	1	2	1	-	-	-	1	-	1
Ameiurus natalis	2	-	-	-	-	-	-	2	-	1	-	6	-	-
Ameiurus nebulosus	1	-	-	-	-	-	-	-	-	-	-	3	-	2
Anguilla rostrata	-	-	1	-	1	-	-	-	-	1	-	-	-	-
Aphredoderus sayanus	2	3	15	4	10	1	5	-	-	1	-	2	-	11
Enneacanthus chaetodon	-	-	-	-	-	-	-	-	2	-	-	1	3	-
Enneacanthus gloriosus	-	15	4	-	30	1	-	1	3	3	4	1	1	-
Enneacanthus obesus	-	-	-	-	25	-	1	-	-	-	-	-	1	2
Enneacanthus species	-	-	-	-	170	2	1	-	-	-	-	-	8	-
Erimyzon oblongus	1	5	1	-	58	117	-	2	2	-	-	6	-	3
Esox americanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Esox niger	-	4	16	3	2	-	2	-	1	2	-	1	8	2
Esox species	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Etheostoma fusiforme	-	6	1	5	-	-	5	8	1	-	3	6	3	4
Etheostoma olmstedi	-	-	-	-	-	-	-	-	7	2	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	3	-	-	-	-
Lepomis gibbosus	1	-	-	-	-	-	-	-	-	5	7	-	2	5
Lepomis macrochirus	-	-	-	8	-	-	-	-	-	2	21	-	1	1
Lepomis species	-	-	-	-	-	-	-	-	-	4	13	-	-	-
Micropterus salmoides	1	-	-	1	-	-	-	-	-	19	3	2	20	1
Notemigonus crysoleucas	2	-	-	-	-	-	-	-	-	14	-	-	-	15
Noturus gyrinus	1	-	-	-	-	-	-	-	-	1	-	5	-	-
Perca flavescens	-	-	-	-	-	-	-	-	4	-	1	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Umbra pygmaea	-	9	6	4	-	-	20	4	-	-	-	9	-	8

Species	Site Code and Date												
	LBABC322 07/11/02	LGIBSO50 08/01/02	LGRAV559 07/11/02	LGRAV559 10/20/04	LSOESTEL 08/01/02	LSOESTEL 10/20/04	LSOFORTY 07/24/02	LSOFORTY 10/20/04	LSOUT552 07/02/02	LSOUT552 10/20/04	LSTEP50S 07/02/02	LSTMAPLE 09/20/02	LWA50BOG 09/18/02
Acantharchus pomotis	2	-	1	-	-	-	-	-	1	-	-	-	1
Ameiurus natalis	-	-	-	-	-	-	-	-	-	-	-	-	1
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	1	-	-
Anguilla rostrata	6	4	1	-	7	-	4	2	5	4	7	-	-
Aphredoderus sayanus	4	-	1	-	3	-	8	8	2	1	-	8	-
Enneacanthus chaetodon	-	-	-	-	-	-	-	-	-	-	-	-	39
Enneacanthus gloriosus	-	-	-	-	-	-	-	-	-	-	15	1	-
Enneacanthus obesus	-	2	-	-	-	-	-	-	-	-	-	-	142
Enneacanthus species	-	-	-	-	-	-	-	-	-	-	-	-	1
Erimyzon oblongus	-	-	-	-	1	1	2	3	-	-	-	-	-
Esox americanus	-	-	-	-	1	-	-	-	-	-	-	-	-
Esox niger	5	-	2	2	1	3	10	3	2	2	-	1	4
Esox species	-	-	-	-	-	-	-	-	-	-	-	-	-
Etheostoma fusiforme	9	-	-	1	21	7	1	3	1	1	-	-	24
Etheostoma olmstedi	-	-	9	10	1	1	31	3	13	4	2	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	2	-	-	-	-	-	-	-	-	1	-	-	-
Lepomis macrochirus	-	-	-	-	-	-	-	-	-	-	7	108	-
Lepomis species	-	-	-	-	-	-	-	-	-	-	-	30	-
Micropterus salmoides	-	-	-	-	-	-	-	-	-	-	-	6	-
Notemigonus crysoleucas	1	-	-	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	-	-	-	-	-	-	-	-	-	7	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	1	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	1	5	-	1	2	1	-	6	1	1	-	4	-

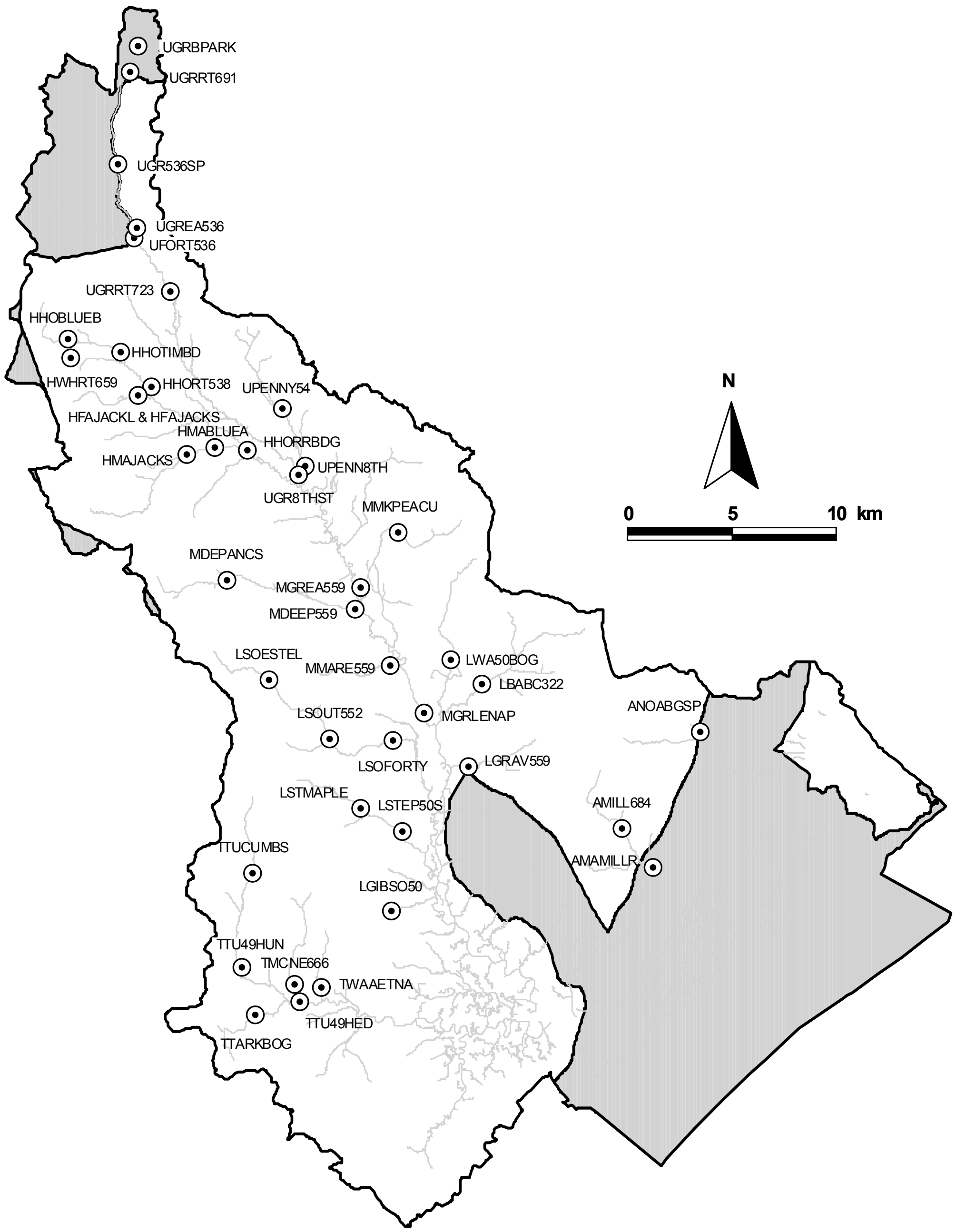
Species	Site Code and Date															
	MDEEP559	MDEPANCS	MGREA559	MGRLENAP	MMARE559	MMARE559	MMKPEACU	TMCNE666	TMCNE666	TTARKBOG	TTU49HED	TTU49HED	TTU49HUN	TTU49HUN	TTUCUMBL	TWAAETNA
	07/02/02	07/11/02	07/02/02	09/18/02	07/02/02	10/20/04	07/15/02	07/24/02	10/27/04	08/01/02	07/24/02	10/27/04	06/21/02	10/27/04	09/20/02	09/20/02
Acantharchus pomotis	-	-	-	-	4	3	-	3	1	5	2	-	-	2	2	1
Ameiurus natalis	-	1	-	-	1	1	1	-	-	3	-	-	-	-	-	-
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	1	-	-	-	-	-	-	1	-	1	1	-	-	-	-	-
Aphredoderus sayanus	-	-	-	-	-	1	-	6	-	4	8	3	8	2	-	25
Enneacanthus chaetodon	-	-	-	-	7	3	3	-	-	-	-	-	-	-	-	-
Enneacanthus gloriosus	1	3	-	-	4	1	-	-	-	-	10	7	2	-	48	40
Enneacanthus obesus	4	1	-	-	-	-	49	-	1	17	-	1	5	5	19	30
Enneacanthus species	-	-	-	-	-	-	-	-	-	-	-	1	-	1	56	5
Erimyzon oblongus	-	-	-	-	2	3	-	1	3	7	21	1	-	24	1	-
Esox americanus	1	-	-	-	-	-	-	2	1	-	1	1	-	-	-	-
Esox niger	1	2	-	-	3	-	-	5	1	2	4	-	5	1	1	12
Esox species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Etheostoma fusiforme	12	4	16	-	1	2	2	5	3	-	-	2	15	72	10	4
Etheostoma olmstedi	12	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	21	-	15	-	-	-	-	-	-	-	1	-	-	-	-
Lepomis macrochirus	1	51	2	113	-	-	-	-	-	7	-	-	-	-	-	-
Lepomis species	-	8	-	79	-	-	-	-	-	-	-	-	-	-	-	-
Micropterus salmoides	-	5	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	1	-	9	-	-	-	-	-	3	-	-	-	-	-	-
Noturus gyrinus	-	1	-	-	-	1	-	-	-	-	-	-	-	1	-	-
Perca flavescens	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	-	-	-	-	1	-	1	12	3	4	4	4	2	1	3	-

Species	Site Code and Date														
	UFORT536	UFORT536	UGR536SP	UGR536SP	UGR8THST	UGR8THST	UGRBPARK	UGREA536	UGRRT691	UGRRT691	UGRRT723	UGRRT723	UPENN8TH	UPENN8TH	UPENNY54
	06/10/02	10/13/04	06/10/02	10/13/04	07/01/02	10/27/04	09/11/02	09/11/02	07/01/02	10/13/04	06/10/02	10/13/04	07/01/02	10/27/04	09/11/02
Acantharchus pomotis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Ameiurus natalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Anguilla rostrata	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-
Aphredoderus sayanus	1	7	2	-	-	1	-	-	7	3	-	-	-	-	2
Enneacanthus chaetodon	2	2	-	-	-	-	-	2	-	-	1	-	-	-	11
Enneacanthus gloriosus	-	2	1	-	-	1	-	3	5	2	-	-	-	-	1
Enneacanthus obesus	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Enneacanthus species	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
Erimyzon oblongus	-	1	-	-	6	-	-	-	-	4	2	-	-	-	1
Esox americanus	-	-	-	-	-	-	-	-	2	3	-	-	-	-	8
Esox niger	3	6	4	-	1	1	1	-	6	7	2	1	1	-	-
Esox species	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Etheostoma fusiforme	6	5	4	1	-	1	-	3	-	-	-	-	2	-	-
Etheostoma olmstedi	7	2	2	1	1	1	-	-	-	-	4	8	4	5	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	2	-	1	-	1	5	11	-	-	-	-	-	-	12
Lepomis macrochirus	-	-	-	-	-	-	20	4	-	-	-	-	-	-	-
Lepomis species	-	-	-	-	-	-	6	30	-	-	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	-	14	-	-	-	-	31
Noturus gyrinus	1	-	-	-	-	-	-	3	-	-	-	-	-	1	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	-	2	1	-	1	8	-	-	12	32	4	-	14	1	-

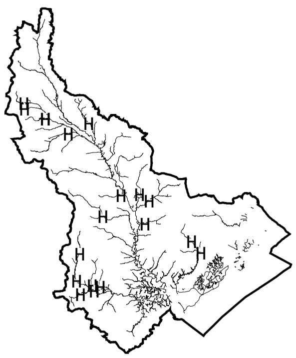
Appendix 3.2. Common and scientific names for 22 fish species collected in Great Egg Harbor River WMA streams and impoundments. Nomenclature follows Page and Burr (1991).

Scientific Name	Common Name
Acantharchus pomotis	mud sunfish
Ameiurus natalis	yellow bullhead
Ameiurus nebulosus	brown bullhead
Anguilla rostrata	American eel
Aphredoderus sayanus	pirate perch
Enneacanthus chaetodon	blackbanded sunfish
Enneacanthus gloriosus	bluespotted sunfish
Enneacanthus obesus	banded sunfish
Erimyzon oblongus	creek chubsucker
Esox niger	chain pickerel
Esox americanus	redfin pickerel
Etheostoma fusiforme	swamp darter
Etheostoma olmstedi	tessellated darter
Fundulus diaphanus	banded killifish
Lepomis gibbosus	pumpkinseed
Lepomis macrochirus	bluegill
Micropterus salmoides	largemouth bass
Notemigonus crysoleucas	golden shiner
Noturus gyrinus	tadpole madtom
Perca flavescens	yellow perch
Pomoxis nigromaculatus	black crappie
Umbra pygmaea	eastern mudminnow

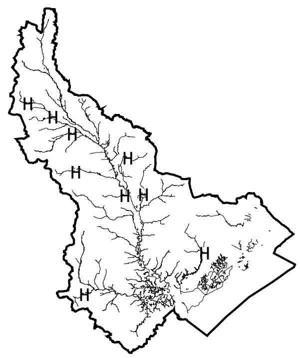
APPENDIX 3.3. FISH-DISTRIBUTION MAPS



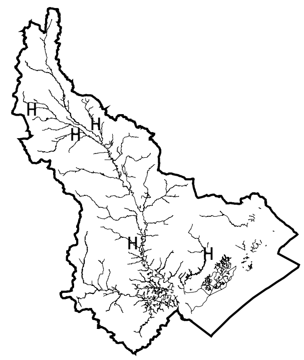
Location of 42 fish-survey sites in the Great Egg Harbor River WMA. Shaded areas are outside the Pinelands National Reserve. Distribution maps on the following pages show where each fish species was present.



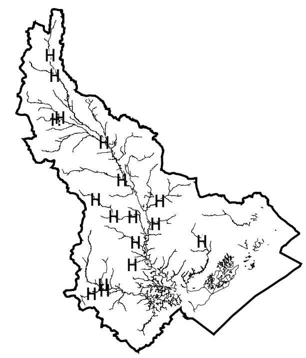
Acantharchus pomotis
mud sunfish



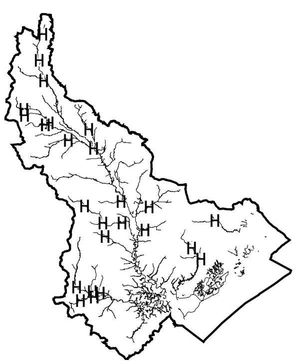
Ameiurus natalis
yellow bullhead



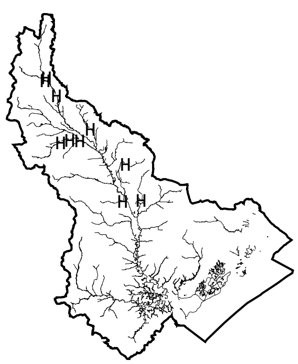
Ameiurus nebulosus
brown bullhead



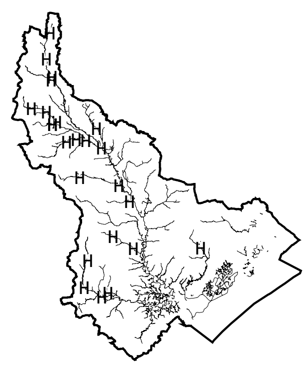
Anguilla rostrata
American eel



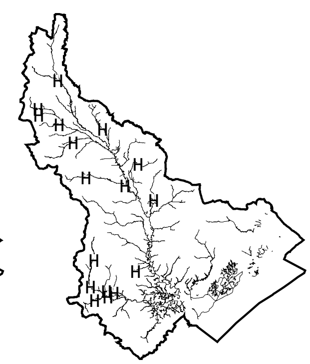
Aphredoderus sayanus
pirate perch



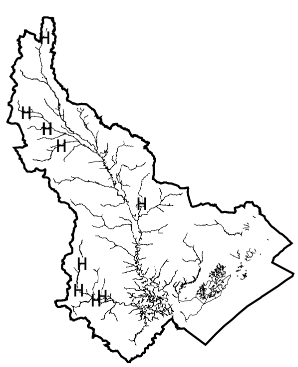
Enneacanthus chaetodon
blackbanded sunfish



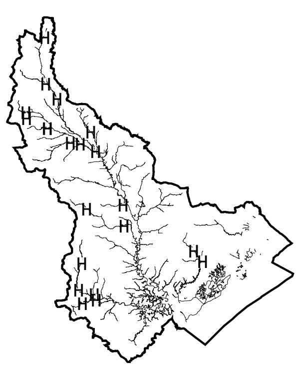
Enneacanthus gloriosus
bluespotted sunfish



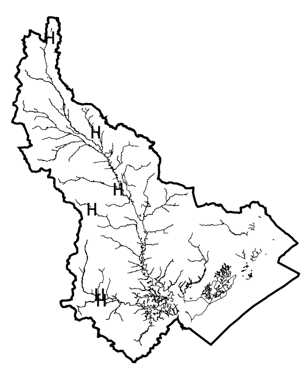
Enneacanthus obesus
banded sunfish



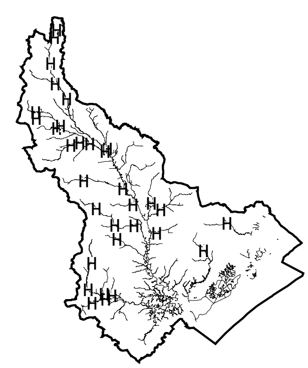
Enneacanthus species



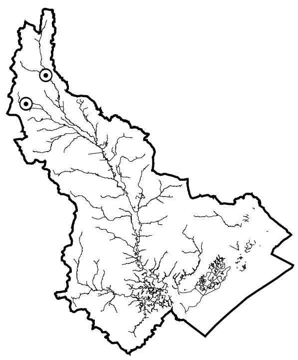
Erimyzon oblongus
creek chubsucker



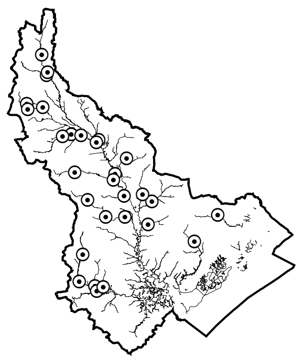
Esox americanus
redfin pickerel



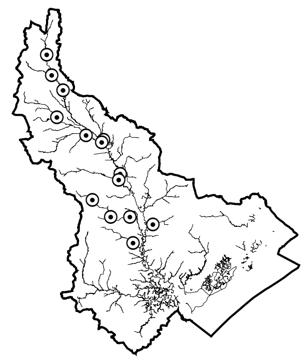
Esox niger
chain pickerel



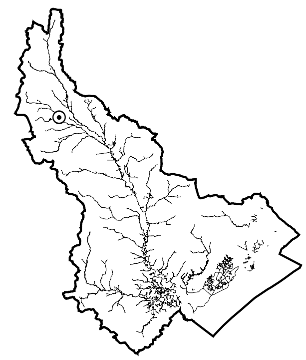
Esox species



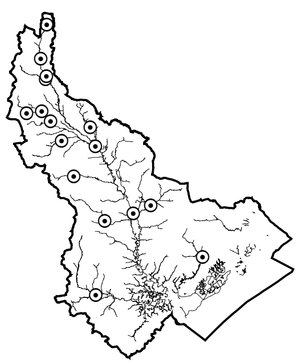
Etheostoma fusiforme
swamp darter



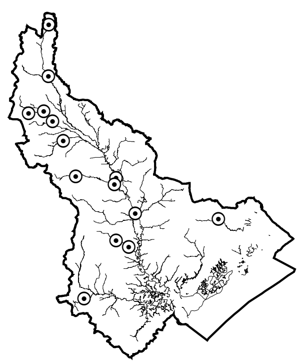
Etheostoma olmstedi
tessellated darter



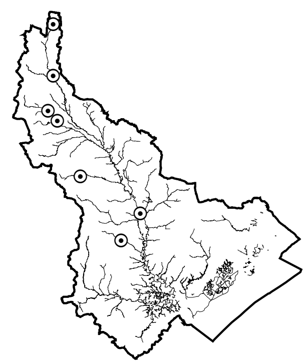
Fundulus diaphanus
banded killifish



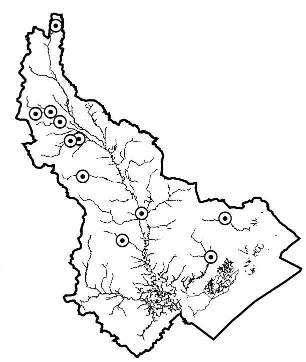
Lepomis gibbosus
pumpkinseed



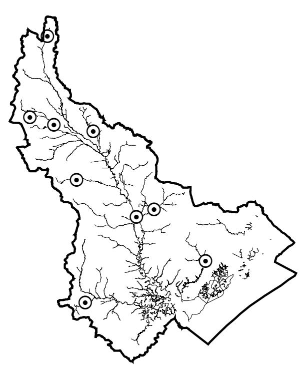
Lepomis macrochirus
bluegill



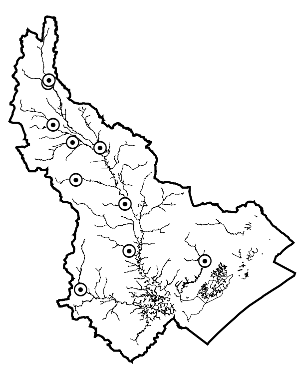
Lepomis species



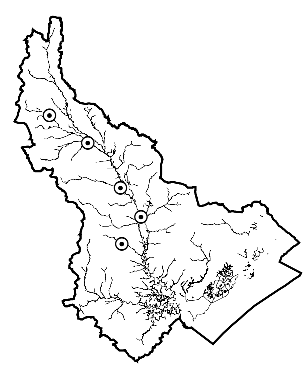
Micropterus salmoides
largemouth bass



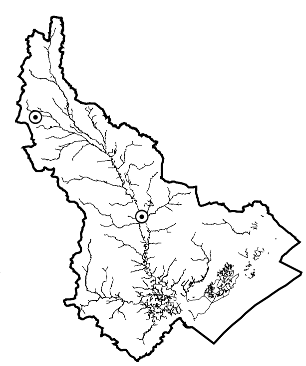
Notemigonus crysoleucas
golden shiner



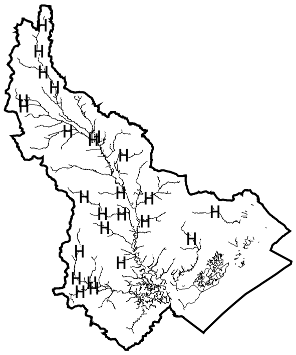
Noturus gyrinus
tadpole madtom



Perca flavescens
yellow perch



Pomoxis nigromaculatus
black crappie



Umbra pygmaea

eastern mudminnow

APPENDIX 4. ANURAN-ASSEMBLAGE DATA

Appendix 4.0. Anuran-monitoring sites in the Great Egg Harbor River WMA. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. The listening point is given in brackets after the site location. Sites are ordered alphabetically by site code.

Site Name and Description	Site Code
Faraway Branch impoundment at Jackson Road Monroe Twp., Gloucester Co. (lat 39°36'58.54", long 74°56'10.02", Buena quad). Impoundment upstream from Jackson Road [Jackson Road].	HFAJACKL
Braddock Lake Folsom Bor., Atlantic Co. (lat 39°36'03.20", long 74°52'54.65", Buena quad). Impoundment on Hospitality Branch, downstream from Cain's Mill Road (Blue Anchor Road) [Cain's Mill Road].	HHOBRADD
Hospitality Branch impoundment at Route 633 Monroe Twp., Gloucester Co. (lat 39°38'40.78", long 74°59'08.66", Williamstown quad). Impoundment upstream from Route 633 (Blue Bell Road)	HHOBLUEB
Cains Mill Lake Folsom Bor., Atlantic Co. (lat 39°36'03.20", long 74°52'54.65", Buena quad). Impoundment on Hospitality Branch, upstream from Cain's Mill Road (Blue Anchor Road) [Cain's Mill Road].	HHOCAINL
Cranes Lake Monroe Twp., Gloucester Co. (lat 39°37'11.83", long 74°55'40.04", Buena quad). Impoundment on Hospitality Branch, upstream from Route 538 (Coles Mill Road) [Route 538].	HHOCRANE
Diamond Lake Monroe Twp., Gloucester Co. (lat 39°36'43.71", long 74°55'05.09", Buena quad). Impoundment on Hospitality Branch, upstream from Sharps Road [Sharps Road].	HHODIAMO
Hospitality Branch impoundment at Eighth Street Folsom Bor., Atlantic Co. (lat 39°34'18.57", long74°49'37.06", Newtonville quad). Impoundment upstream from Eighth Street [Eighth Street].	HHOEIGHU
Hospitality Branch impoundment at Eighth Street Folsom Bor., Atlantic Co. (lat 39°34'18.57", long 74°49'37.06", Newtonville quad). Impoundment downstream from Eighth Street [Eighth Street].	HHOEIGHD
Timber Lake - lower Monroe Twp., Gloucester Co. (lat 39°38'32.83", long 74°57'10.14", Williamstown quad). Impoundment on Hospitality Branch, downstream from North Shore Drive [North Shore Drive].	HHOTIMBD
Timber Lake - upper Monroe Twp., Gloucester Co. (lat 39°38'32.83", long 74°57'10.14", Williamstown quad). Impoundment on Hospitality Branch tributary, upstream from North Shore Drive [North Shore Drive].	HHOTIMBU
Lake Albert Buena Vista Twp., Atlantic Co. (lat 39°35'27.40", long 74°52'11.22", Newtonville quad). Impoundment on Marsh Lake Branch, downstream from sand dike [dike].	HMAALBER
Cedar Lake - lower Buena Vista Twp., Atlantic Co. (lat 39°35'06.12", long 74°54'06.78", Buena quad). Impoundment on Marsh Lake Branch, upstream from Jackson Road [eastern shoreline near outflow].	HMAJACKS
Cedar Lake - upper Franklin Twp., Gloucester Co. (lat 39°34'32.05", long 74°56'13.05", Buena quad). Impoundment on Marsh Lake Branch, upstream from Piney Hollow Road [Piney Hollow Road].	HMAPINEY
Marsh Lake Branch impoundment at Unexpected Road Buena Vista and Franklin Twp., Atlantic and Gloucester Co. (lat 39°33'57.52", long 74°55'33.72", Buena quad). Impoundment upstream from Unexpected Road [Unexpected Road].	HMAUNEXL
Whitehall Branch tributary impoundment at Blue Bell Road Franklin Twp, Gloucester Co. (lat 39°37'36.87", long 74°58'59.19", Williamstown quad). Impoundment upstream from Blue Bell Road [Blue Bell Road].	HWHBLUEL
Sunset Lake Monroe Twp., Gloucester Co. (lat 39°38'08.80", long 74°58'12.53", Williamstown quad). Impoundment on Whitehall Branch, upstream from Victory Avenue [bend in Magnolia Drive].	HWHSUNSL
Harding Lakes Hamilton Twp., Atlantic Co. (lat 39°27'00.53", long 74°45'13.49", Mays Landing quad). Impoundment on Cedar Brook, at second dike upstream from Route 606 (Old Harding Highway or Mill Street) [dike].	LCEHARDL

Site Name and Description	Site Code
Gibson Creek impoundment at First Avenue Estell Manor City, Atlantic Co. (lat 39°22'04.32", long 74°47'18.41", Tuckahoe quad). Impoundment upstream from First Avenue [First Avenue].	LGIFIRST
Jack Pudding Branch impoundment at Leipzig Road Hamilton Twp., Atlantic Co. (lat 39°28'42.37", long 74°37'36.83", Mays Landing quad). Impoundment upstream from Leipzig Road [Leipzig Road].	LJALEIPZ
South River impoundment at Llewellyn Avenue Buena Vista Twp., Atlantic Co. (lat 39°28'39.65", long 74°51'35.59", Dorothy quad). Impoundment upstream from Llewellyn Avenue [Llewellyn Avenue].	LSOLLEWE
Stephen Lake Estell Manor City, Atlantic Co. (lat 39°23'37.11", long 74°44'54.65", Mays Landing quad). Impoundment on Stephen Creek, upstream from Route 50 [Route 50].	LSTEP50L
Maple Lake Estell Manor City, Atlantic Co. (lat 39°24'19.65", long 74°46'41.65", Dorothy quad). Impoundment on Stephen Creek, upstream from Maple Avenue [southwestern shoreline].	LSTMAPLE
Pancoast Mill Pond Buena Vista Twp., Atlantic Co. (lat 39°31'18.07", long 74°52'22.42", Newtonville quad). Impoundment on Deep Run, upstream from Eighth Street [Eighth Street].	MDEPANCL
Lake Lenape Hamilton Twp., Atlantic Co. (lat 39°27'14.16", long 74°44'20.24", Mays Landing quad). Impoundment on Great Egg Harbor River, upstream from Route 616 (Mill Street) [southwestern shoreline near outlet].	MGRLENAP
Makepeace Stream impoundment at Route 623 Hamilton Twp., Atlantic Co. (lat 39°32'41.08", long 74°45'13.43", Newtonville quad). Impoundment downstream from Route 623 (Weymouth - Elwood Road) [Route 623].	MMKPEACD
Makepeace Lake Hamilton Twp., Atlantic Co. (lat 39°32'49.77", long 74°45'01.88", Newtonville quad). Impoundment on Makepeace Stream, upstream from Route 623 (Weymouth - Elwood Road) [northwestern shoreline near outflow].	MMKPEACU
Tarkiln Brook impoundment at Route 548 Upper Twp., Cape May Co. (lat 39°18'19.24", long 74°49'56.65", Tuckahoe quad). Impoundment upstream from Route 548 (Weatherby Road) [Route 548].	TTAR548L
Tuckahoe River impoundment at Route 49 at Hunters Mill Maurice River Twp. and Estell Manor City, Cumberland Co. (lat 39°19'26.26", long 74°51'37.50", Tuckahoe quad). Impoundment upstream from Route 49 [First Avenue].	TTU49HUN
Tuckahoe River impoundment at Cumberland Avenue Estell Manor City, Atlantic Co. (lat 39°22'20.75", long 74°51'15.65", Tuckahoe quad). Impoundment upstream from Route 637 (Cumberland Avenue) [Route 637].	TTUCUMBL
Warners Mill Stream impoundment at Aetna Drive Estell Manor City, Atlantic Co. (lat 39°18'50.04", long 74°48'20.06", Tuckahoe quad). Impoundment above Aetna Drive [Aetna Drive].	TWAAETNA
Crystal Spring Lake Monroe Twp., Gloucester Co. (lat 39°42'33.41", long 75°00'15.44", Pitman East quad). Impoundment on Four Mile Branch, upstream from Herbert Boulevard [Herbert Boulevard].	UFOCRYST
Great Egg Harbor River impoundment at Berlin Park Berlin Bor., Camden Co. (lat 39°47'40.29", long 74°56'14.30", Clementon quad). Impoundment above Route 689 (Cross Keys - Berlin Road) [southeastern shoreline].	UGRBPARK
New Brooklyn Lake Winslow Twp., Camden Co. (lat 39°42'05.99", long 74°56'16.42", Williamstown quad). Impoundment on Great Egg Harbor River, upstream from Route 536 (New Brooklyn - Cedar Brook Road) [southern shoreline].	UGRBROOK
Great Egg Harbor River impoundment at Route 54 Folsom Bor., Atlantic Co. (lat 39°35'41.19", long 74°51'06.72", Newtonville quad). Impoundment upstream from Route 54 [Route 54].	UGRERT54
Great Egg Harbor River tributary impoundment at Routes 706 and 536 Spur Winslow Twp., Camden Co. (lat 39°43'30.86", long 74°57'44.21", Williamstown quad). Impoundment upstream from Routes 706 (New Brooklyn - Blackwood Road) and 536 Spur (Williamstown - New Freedom Road [Asberry Place Road].	UGRTRASB

Site Name and Description	Site Code
Great Egg Harbor River tributary impoundment at Route 689 Gloucester and Winslow Twps., Camden Co. (lat 39°45'12.27", long 74°59'03.82", Clementon quad). Impoundment upstream from Route 689 (Cross Keys - Berlin Road) [Route 689].	UGRTRDIC
Penny Pot Stream impoundment at 14th Street - northern crossing Hammonton Town, Atlantic Co. (lat 39°37'15.70", long 74°50'46.12", Newtonville quad). Impoundment upstream from 14th Street [14th Street].	UPE14STN
Penny Pot Stream impoundment at 14th Street - southern crossing Hammonton Town, Atlantic Co. (lat 39°37'11.25", long 74°50'51.31", Newtonville quad). Impoundment upstream from 14th Street [14th Street].	UPE14STS
Penny Pot Stream impoundment at Second Road Hammonton Town, Atlantic Co. (lat 39°38'17.66", long 74°50'17.49", Hammonton quad). Impoundment downstream from Second Road [Second Road].	UPE2NDRD
Penny Pot Stream impoundment at Route 54 Hammonton Town, Atlantic Co. (lat 39°36'34.86", long 74°50'02.95", Newtonville quad). Impoundment upstream from Route 54 [Route 54].	UPENNY54

Appendix 4.1. Maximum-call ranks for eight anuran species at monitoring sites in the Great Egg Harbor River WMA. Surveys were conducted by John F. Bunnell. Weather codes are 0 = clear, 1 = cloudy, 2 = overcast, 3 = fog/haze, 4 = breezy, 5 = drizzle, 6 = constant rain, 7 = showers, 8 = thunder storm occurred within one hour, and 9 = thunderstorm. Maximum-call ranks are 1 = 1, 2 = 2-5, 3 = 6-10, and 4 > 10 individuals calling. A dash (-) indicates that a species was not heard or observed at a site. Refer to the Methods section for survey methodology. Refer to Appendix 4.0 for detailed site information and Appendix 4.2 for full scientific and common names.

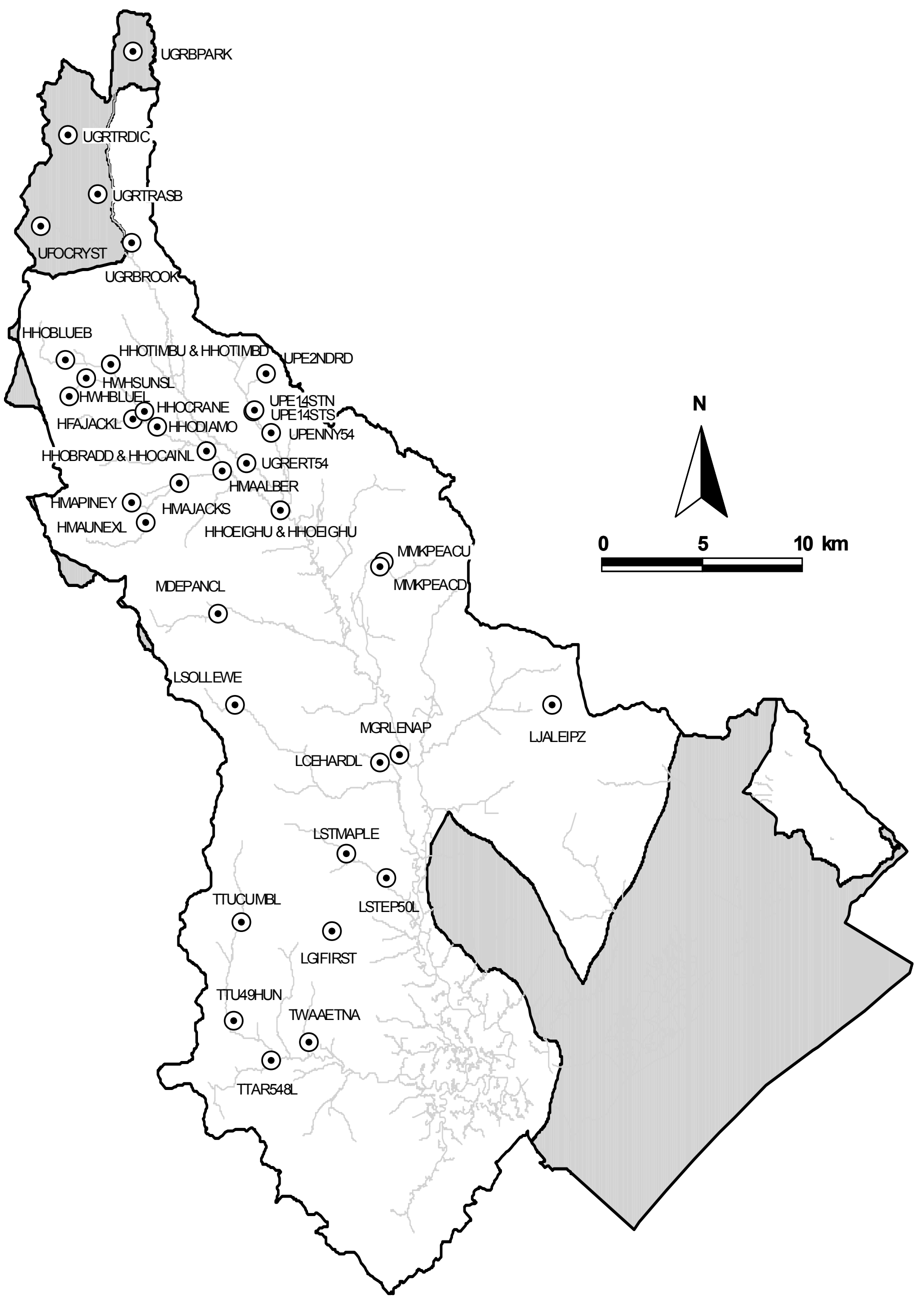
Survey Information			Conditions			Species							
Site Code	Date	Time	Weather Code	Air Temp. (deg. C)	Relative Humidity	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*R. catesbeiana*	*R.. c. melanota*	*R. utricularia*	*R. virgatipes*
HFAJACKL	05/28/02	10:50 PM	0	18.5	96	-	-	-	-	3	3	2	4
HHOBLUEB	06/24/02	11:40 PM	2,3	22.0	100	-	-	-	-	-	1	-	-
HHOBRADD	05/29/02	8:55 PM	0	20.0	83	-	2	-	-	-	-	-	-
HHOBRADD	06/24/02	10:00 PM	2,3	23.5	96	-	-	-	-	1	-	-	-
HHOCAINL	06/24/02	10:00 PM	2,3	23.5	96	-	4	-	-	-	-	-	-
HHOCRANE	05/28/02	11:03 PM	0	18.5	96	-	2	-	-	2	-	-	-
HHODIAMO	05/28/02	11:15 PM	0,2	18.5	96	2	1	-	-	2	-	-	-
HHOEIGHD	05/29/02	10:15 PM	0	20.0	87	-	-	-	1	1	-	-	2
HHOEIGHU	05/29/02	10:15 PM	0	20.0	87	-	-	-	-	2	1	-	2
HHOTIMBD	05/28/02	10:10 PM	0,2	19.5	92	-	1	-	-	1	-	-	-
HHOTIMBU	05/28/02	10:10 PM	0,2	19.5	92	4	-	-	-	2	-	-	2
HMAALBER	05/29/02	9:10 PM	0	20.0	83	-	4	-	-	-	-	-	-
HMAALBER	06/24/02	10:15 PM	2,3	23.5	96	-	4	-	-	-	-	-	-
HMAJACKS	05/29/02	9:35 PM	0	20.0	92	4	4	-	2	2	1	-	1
HMAPINEY	05/29/02	10:00 PM	0	20.0	87	4	-	-	4	2	1	-	-
HMAUNEXL	05/29/02	10:08 PM	0	20.0	87	4	-	-	2	2	2	-	4
HWHBLUEL	06/24/02	11:25 PM	2,3	22.0	100	-	-	-	-	-	2	-	-
HWHBLUEL	06/24/02	11:25 PM	2,3	22.0	100	-	-	-	-	-	2	-	-
HWHSUNSL	05/28/02	10:35 PM	0,2	20.0	92	-	2	-	2	3	-	-	-
LCEHARDL	06/06/02	10:05 PM	0,4	22.0	92	-	4	-	-	3	-	-	-
LGIFIRST	06/06/02	11:30 PM	0,5	22.0	100	-	2	-	2	1	-	-	-
LJALEIPZ	06/24/02	9:23 PM	2,3	24.0	92	-	4	-	-	-	-	-	-
LSOLLEWE	05/29/02	11:00 PM	0	17.5	91	-	-	-	-	-	2	-	-
LSTEP50L	06/06/02	10:45 PM	0,4	22.0	92	4	-	-	-	2	1	-	3
LSTMAPLE	06/06/02	11:00 PM	0	22.0	92	-	-	-	-	2	2	-	-
MDEPANCL	05/29/02	10:40 PM	0	17.0	91	-	-	-	-	2	2	-	2

Survey Information			Conditions			Species							
Site Code	Date	Time	Weather Code	Air Temp. (deg. C)	Relative Humidity	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*R. catesbeiana*	*R.. c. melanota*	*R. utricularia*	*R. virgatipes*
MGRLENAP	06/06/02	9:50 PM	0,4	22.0	92	-	4	-	-	-	-	-	-
MGRLENAP	06/24/02	10:00 PM	2	23.5	96	-	-	-	-	-	-	-	-
MMKPEACD	06/06/02	9:17 PM	0,4	23.0	84	-	2	-	-	-	-	-	4
MMKPEACU	06/06/02	9:17 PM	0,4	23.0	84	-	2	-	-	-	2	-	4
TTARK548	06/11/02	10:00 PM	0,4	24.0	70	-	2	-	-	1	2	-	4
TTU49HUN	06/11/02	9:30 PM	0	25.0	74	-	4	1	2	-	2	-	2
TTUCUMBL	06/11/02	9:17 PM	0	25.0	74	-	2	-	-	2	3	-	2
TWAAETNA	06/11/02	11:00 PM	0,4	24.0	70	-	1	-	2	1	3	-	1
UFOCRYST	05/28/02	9:40 PM	0	20.5	92	-	4	-	4	2	1	-	-
UGRBPARK	05/28/02	8:25 PM	0,4	21.0	84	-	-	-	-	-	-	-	-
UGRBPARK	05/28/02	11:45 PM	0,2	18.0	96	-	1	-	-	3	-	-	-
UGRBROOK	05/28/02	9:09 PM	0	21.0	82	-	2	-	-	2	1	-	-
UGRERT54	06/11/02	12:00 AM	0,4	23.0	69	-	-	-	-	-	2	-	2
UGRTRASB	05/28/02	9:00 PM	0,4	21.0	83	-	-	-	-	3	2	-	-
UGRTRDIC	05/28/02	8:40 PM	0,4	21.0	84	-	-	-	-	2	-	-	-
UPE14STN	06/06/02	8:45 PM	0,4	24.0	85	-	-	-	-	-	-	-	-
UPE14STS	06/06/02	8:45 PM	0,4	24.0	85	-	-	-	-	-	-	-	-
UPE2NDRD	06/06/02	8:30 PM	0,4	24.0	85	-	-	-	-	-	-	-	-
UPENNY54	06/11/02	12:10 AM	0,4	23.0	69	-	-	-	-	2	4	-	4

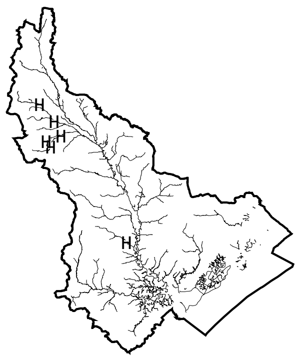
Appendix 4.2. Common and scientific names for eight anuran species heard during vocalization surveys in the Great Egg Harbor River WMA. Nomenclature follows Conant and Collins (1998).

Scientific Name	Common Name
Acris c. crepitans	northern cricket frog
Bufo woodhousii fowleri	Fowler's toad
Hyla andersonii	Pine Barrens treefrog
Hyla versicolor	northern gray treefrog
Rana virgatipes	carpenter frog
Rana clamitans melanota	green frog
Rana utricularia	southern leopard frog
Rana catesbeiana	bullfrog

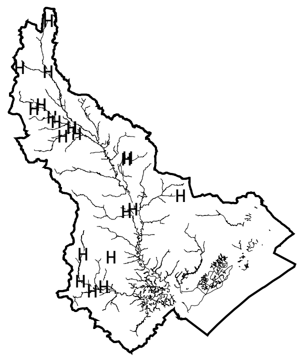
APPENDIX 4.3. ANURAN-DISTRIBUTION MAPS



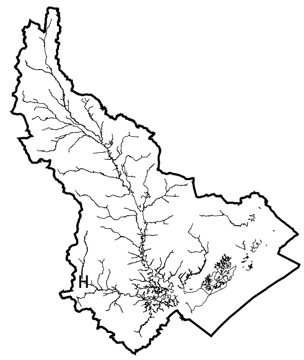
Location of 40 anuran-survey sites in the Great Egg Harbor River WMA. Shaded areas are outside the Pinelands National Reserve. Distribution maps on the following pages show where each anuran species was present.



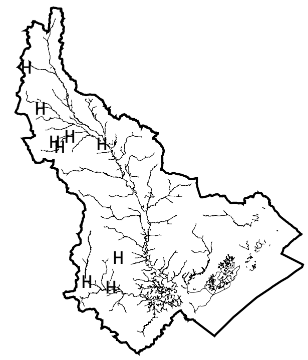
Acris c. crepitans
northern cricket frog



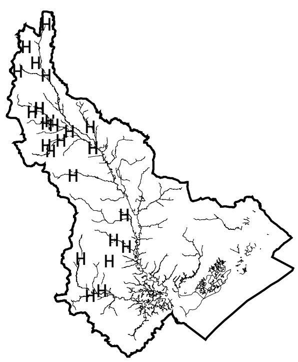
Bufo woodhousii fowleri
Fowler's toad



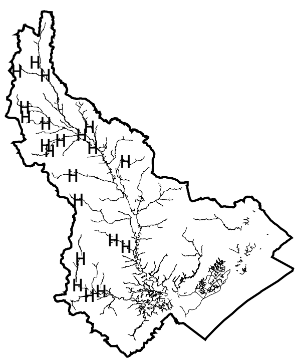
Hyla andersonii
Pine Barrens treefrog



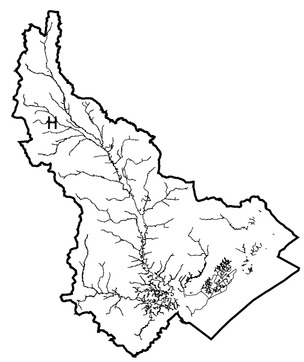
Hyla versicolor
gray treefrog



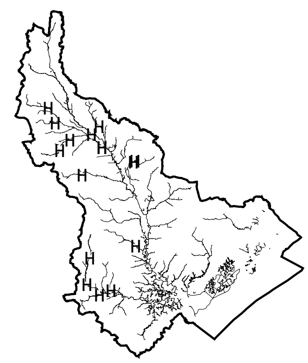
Rana catesbeiana
bullfrog



Rana clamitans melanota
green frog



Rana utricularia
southern leopard frog



Rana virgatipes
carpenter frog