THE MULLICA RIVER BASIN

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

PINELANDS COMMISSION
LONG-TERM ENVIRONMENTAL-MONITORING PROGRAM
2001

Cover image is a 1995/97 color-infrared aerial photograph (National Aerial Photography Program for the United States Geological Survey) showing developed, agricultural, and forested land within a portion of the Springers Brook drainage of the Mullica River Basin.

THE MULLICA RIVER BASIN

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INTRODUCTION

The Pinelands Commission is responsible for the implementation of the Comprehensive Management Plan (CMP) for the Pinelands National Reserve. The CMP's regional planning and regulatory programs are intended to protect the essential character of the Pinelands, including the quality of surface and ground waters, promote compatible agriculture, and encourage appropriate development patterns. In the early 1990's, the Commission initiated a long-term environmental-monitoring program with the ultimate goal of evaluating the ecological consequences of the plan. The main objectives of the program were to characterize the effect of existing land-use patterns on aquatic and wetland resources and to monitor long-term changes in these resources. The Mullica River Basin has been the main focus of the monitoring program (Figure 1). This watershed was selected because it is centrally located, consists of several large drainage basins that display a range of land-use and zoning characteristics, and includes large tracts of public land. Additionally, the water resources and general ecology of the basin have been extensively studied.

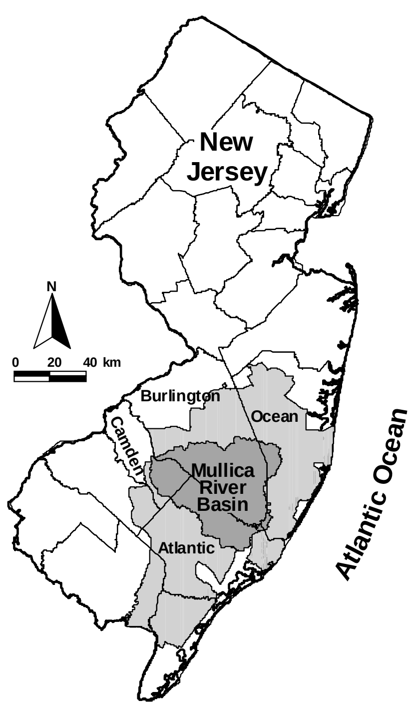

Figure 1. Regional location of the Mullica River Basin in the Pinelands National Reserve.

The Commission's monitoring program employs a multifaceted-hierarchical approach involving several regional ecological indicators (Figure 2). Various land-use activities affect the ecological integrity of the Pinelands by fragmenting the landscape, altering stream flows, and degrading surface and ground waters. The percentage of different land-use/land-cover types in a basin represents a measure of these activities. Several water-quality attributes, such as pH, specific conductance, and nitrate-nitrogen concentration, are good indicators of land-use related Pinelands-watershed disturbances. In Pinelands streams, water quality that varies from the acid and low-nutrient conditions found in forested basins is frequently associated with changes in the composition of characteristic aquatic and wetland communities. Among these changes are the establishment of nonnative species and the loss of some native species.

LANDSCAPE-LEVEL INDICATORS
Land use/Land cover
Atlantic White Cedar Landscapes
WATERSHED-LEVEL INDICATORS
Surface-water Quality
Stream Discharge
COMMUNITY-LEVEL INDICATORS
Stream Vegetation
Atlantic White Cedar Swamps
Pond Vegetation
Fish Assemblages
Anuran (Frog and Toad) Assemblages

Figure 2. Regional ecological indicators for the Pinelands National Reserve.

This report presents the results of the Commission's Mullica River Basin long-term environmental-monitoring program. The major findings of studies that were published as part of the program are summarized, and unpublished data are analyzed and discussed. All biological data collected during the study are included in the report as appendices, along with water-quality data that have not been previously published. The report includes three parts. Part 1 describes the changing landscape of the Mullica River Basin. Part 2 characterizes the status of the region's surface waters and relates water quality to land-use patterns. In Part 3, the composition of aquatic and wetland communities are described in relation to site-specific and regional drainage-basin characteristics.

PART 1
LANDSCAPES

1 THE MULLICA RIVER BASIN STUDY AREA

INTRODUCTION

The Mullica River Basin lies almost entirely within the Pinelands National Reserve and drains portions of 23 municipalities in Atlantic, Burlington, Camden, and Ocean Counties (Figure 1.1). The basin comprises several major tributaries, including Nescochague Creek, Sleeper Branch, Upper Mullica River above Sleeper Branch, Batsto River, Wading River (West Branch Wading River), Oswego River (East Branch Wading River), Bass River, Hammonton Creek, and Lower Mullica River Basin tributaries, including Landing Creek (Figure 1.2).

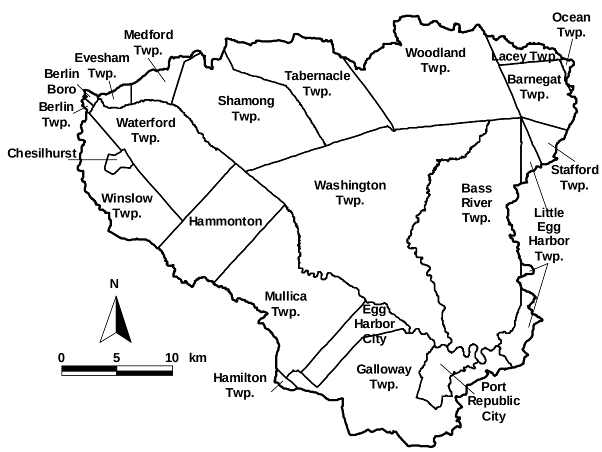

Figure 1.1. Municipalities of the Mullica River Basin.

The unconfined Kirkwood-Cohansey aquifer system underlies the Mullica River Basin (Rhodehamel 1973, Zapecza 1989, Johnson and Watt 1996). The aquifer is composed of the Kirkwood Formation and the overlying Cohansey Sand, which is the dominant surficial deposit. Less-extensive deposits, including the Beacon Hill Gravel, Bridgeton Formation, and Cape May Formation, overly the Cohansey Sand. The Kirkwood Formation does not crop out within the basin.

The Mullica River Basin displays a diverse range of natural and human-dominated landscapes. The major drainage basins are characterized by distinct land-use patterns that provide a study in contrast between heavily altered landscapes and extensive forest lands. In this chapter, the land-use characteristics of each major drainage basin and the management areas designated through the Pinelands Comprehensive Management Plan (CMP) are summarized. The methods used to delineate drainage areas and prepare land-use and management-area profiles are also described.

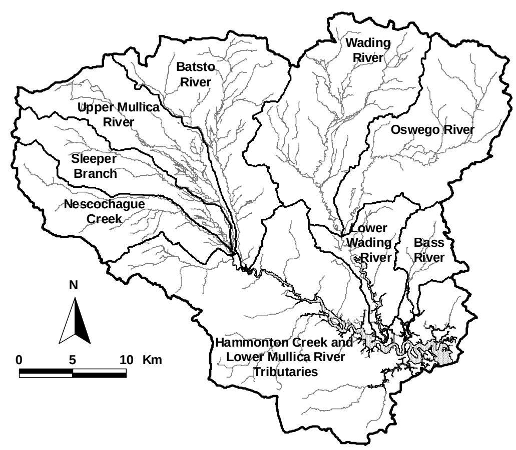

Figure 1.2. Major drainages of the Mullica River Basin.

DEVELOPMENT OF LAND-USE AND MANAGEMENT-AREA PROFILES

Land-use/Land-cover Data

Land-use/land-cover profiles for selected drainage basins were prepared using ArcView software (Environmental Systems Research Institute Inc., Redlands, CA, 1988 - 1992) and digital land-use/land-cover data obtained from the New Jersey Department of Environmental Protection (NJDEP, 1995/97 Land Use/Land Cover Update 2001). The NJDEP data combine land-use mapping compiled using 1995/1997 aerial photography, the 1986 freshwater-wetlands maps created through the New Jersey Freshwater Wetlands Mapping Program, and a hydrology coverage. Land uses were classified using a modified Anderson et al. (1976) system. Wetlands were classified according to Cowardin et al. (1979).

The 1995/1997 map represents an update to the coverage created through the NJDEP's original 1986

Integrated Terrain Unit Mapping (ITUM) project. The ITUM project created a wetlands coverage that was different from that produced by the Freshwater Wetlands Mapping Program. When the two themes were combined, the freshwater-wetlands coverage was given precedence over the original ITUM classifications. This modification affected the classification of two important Pinelands agricultural-land uses. The ITUM map included blueberry farms as orchards and cranberry bogs as a separate land-use type. The updated 1995/1997 map included cranberry bogs under the broader agricultural-wetlands class, which includes several agricultural-land uses. Blueberry farms fell within both agricultural wetlands and a subclass of agriculture (orchards/vineyards/nurseries/horticultural).

The NJDEP data set describes land-use/land-cover using both the general Anderson Level I classification and various subclasses (Table 1.1). The general classes include urban, agriculture, barren land, forest, wetlands, and water. Except where noted, a revised Pinelands terminology is used throughout this report (Table 1.1). Pinelands land-use/land-cover types are developed land, upland agriculture (including orchards), wetland agriculture, barren land, upland forest, wetlands, and water. The combined area of upland forest, wetlands, and water is described as forest land. For simplicity, the term land use is used throughout this report when referring to the NJDEP land-use/land-cover data.

Drainage-basin Delineations

Drainage basin boundaries used throughout this report were prepared using ArcView software and digital hydrography data obtained from the NJDEP (1996). Several Hydrologic Unit Code-14 (HUC-14) lines were modified. HUC-14 boundaries were not available for some monitoring sites. These basins were delineated using digital topographic maps, ArcView, and on-screen digitizing.

Pinelands Management Areas

The Commission's regional-planning and land-allocation program divides the Pinelands 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 Mullica River Basin include the Preservation Area District, Forest Area, Special Agricultural Production Area (blueberry and cranberry agriculture), Agricultural Production Area, Rural Development Area, Pinelands Village, Pinelands Town, and Regional Growth Area (Figure 1.3). Management-area profiles for drainage basins were prepared using ArcView software and management-area coverages (Pinelands Commission, Land Capability Map, November 1999).

THE MULLICA RIVER BASIN

The 1474-km^2 Mullica River Basin is dominated by undeveloped forest land (Figures 1.4 and 1.5). State-owned forests and wildlife-management areas are important components of the landscape. Only 15% of the basin is developed or farmed. Most developed land and upland agriculture is found in the headwater areas of the Mullica River, Sleeper Branch, Nescochague Creek, Hammonton Creek, and Landing Creek drainage basins. Upland agriculture is also a dominant landscape feature in several Batsto River headwater basins. In the West Branch Wading River and Oswego River basins and in the headwaters of the Bass River basin, developed land and upland agriculture cover less than 10% of the basin area. Most of the wetland agriculture found in the Mullica River Basin is located within the West Branch Wading River and Oswego River basins.

Preservation Area District, which is the dominant management area in the basin (Figures 1.3 and 1.6), includes large tracts of public land. Forest Areas are located along the southern and eastern borders of the basin. Special Agricultural Production Areas are concentrated in the center of the basin within the West Branch Wading River and Oswego River systems. Pinelands Villages are found throughout the basin. Agricultural Production Areas, Rural Development Areas, Pinelands Towns, and Regional Growth Areas are located primarily along the western and southern parts of the watershed.

Wading River (West Branch of the Wading River)

The 226-km^2 West Branch of the Wading River is located within Burlington County. Like the Oswego River basin, nearly all of the drainage area is forest land. About two-thirds of the basin is within the Preservation Area District. Wetland agriculture is the dominant land use, which is reflected in the high percentage of land classified as Special Agricultural Production Area.

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

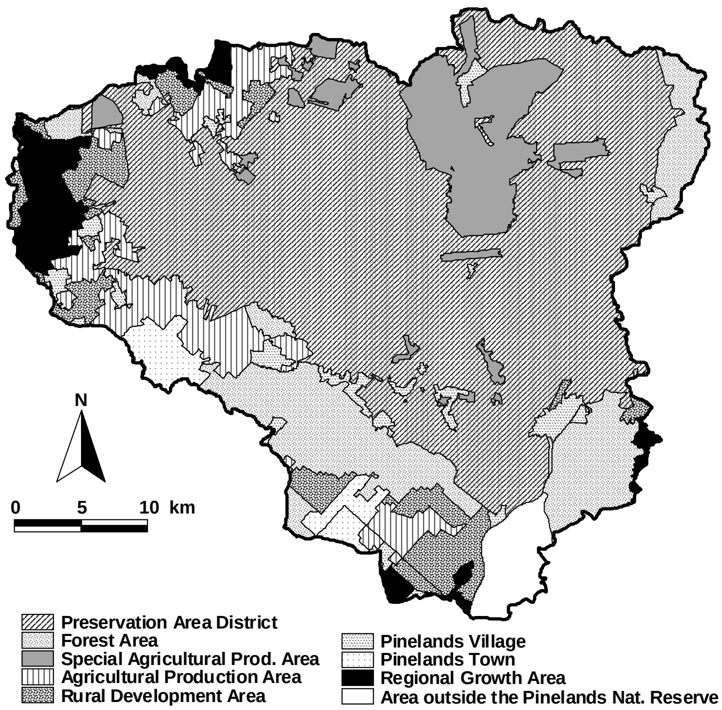

Figure 1.3. Pinelands management areas in the Mullica River Basin.

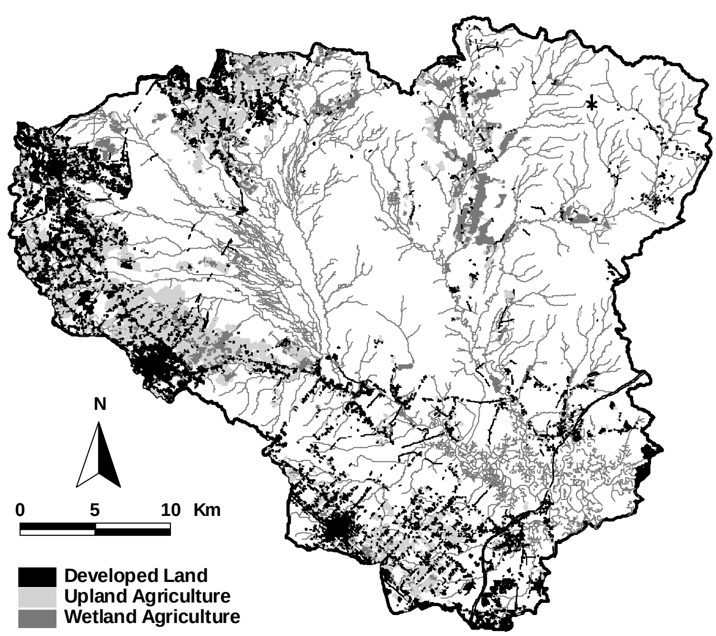

Figure 1.4. Developed land, upland agriculture, and wetland agriculture in the Mullica River Basin. Unshaded areas represent forest land (uplands, wetlands, and water) and barren land.

Oswego River (East Branch of the Wading River)

The Oswego River drains portions of Ocean County and Burlington County. More than 95% of this 188-km^2 watershed is forest land. Upland agriculture, wetland agriculture, barren land, and developed land each make up less than one percent of the drainage. Three-quarters of the basin is classified as Preservation Area District. Most of the remaining area is designated as Forest Area.

Lower Wading River

The portion of the Wading River basin located below the confluence of the West Branch of the Wading River and the Oswego River includes several small tributaries. Fifteen percent of the Lower Wading River basin area consists of water and wetlands. Less than five percent is developed or farmed. Preservation Area District is the principal management area in this portion of the watershed.

Bass River

The 9.5-km^2 Bass River basin is primarily forest land designated Preservation Area District. The basin is located in Burlington County with the headwaters of one tributary, Tommys Branch, extending into Ocean County. The two principal tributaries of the Bass River are the East Branch of the Bass River and the West Branch of the Bass River. The combined area of developed land, upland agriculture, and wetland agriculture represents less than five percent of the Bass River basin. The lower reaches of this stream are tidal.

Hammonton Creek and Lower Mullica River Tributaries

The Hammonton Creek basin is located entirely within Atlantic County. A majority of the 53.3-km^2 basin is forest land. Forest land covers more than 90% of the drainage system's three small tributary basins (Petties Branch, Nortons Branch, and Brockaways Branch). Above these tributaries, most of the basin is developed or farmed with upland agriculture representing the dominant land-use activity. Wetland agriculture covers less than five percent of the basin. Forest Area is the dominant management-area classification. In order of increasing area, the other principal management areas are Agricultural Production Area, Pinelands Town, and Pinelands Village. A municipal sewage-treatment plant discharges directly to Hammonton Creek at Route 542 in Hammonton.

A number of tributaries that flow directly to the Lower Mullica River are located in Atlantic and Burlington Counties. The largest drainage is the 83.1-km^2 Landing Creek basin, which includes a mix of undeveloped, agricultural, and urban tributary basins. The basin is primarily forest land. Moderate levels of upland agriculture and developed land are found in the Rubins Run and Indian Cabin Creek basins and in the upper reaches of Landing Creek. Portions of the Union Creek basin are urbanized. About a third of the Elliots Creek basin is farmed or developed, with upland agriculture representing the dominant land use. This land-use diversity is reflected in the management-area classifications found within the Landing Creek drainage area.

Most of the other basins in the Lower Mullica River area are dominated by forest land and are classified mainly as Preservation Area District or Forest Area. Exceptions include the Clarks Mill Stream and the Morses Mill Stream basins where developed and agricultural lands are most extensive. Most of the land in these two basins is classified as Rural Development Area.

Nescochague Creek

The Nescochague Creek basin lies within the boundaries of Camden and Atlantic Counties. About half of the 114-km^2 basin is developed land and upland agriculture. One percent is wetland agriculture. Three-quarters of the Nescochague Creek basin is designated as either Agricultural Production Area, Regional Growth Area, Pinelands Town, Pinelands Village, or Rural Development Area. Nearly one-half of the Albertson Brook basin, a tributary system of Nescochague Creek, is developed land or upland agriculture. This profile reflects the makeup of the Blue Anchor Brook and Pump Branch basins, two tributary systems of the Albertson Brook. Domestic-wastewater infiltration lagoons are located at one site in the Blue Anchor Brook basin. A majority of the Great Swamp Branch basin, which includes Cedar Brook, is farmed or developed, with upland agriculture as the dominant land-use activity. Wetland agriculture covers less than two percent of the Great Swamp Branch basin. Agricultural Production Area is the major management-area designation in this basin. Most of the remaining portions of this Nescochague Creek tributary basin are classified as Pinelands Town and Preservation Area District.

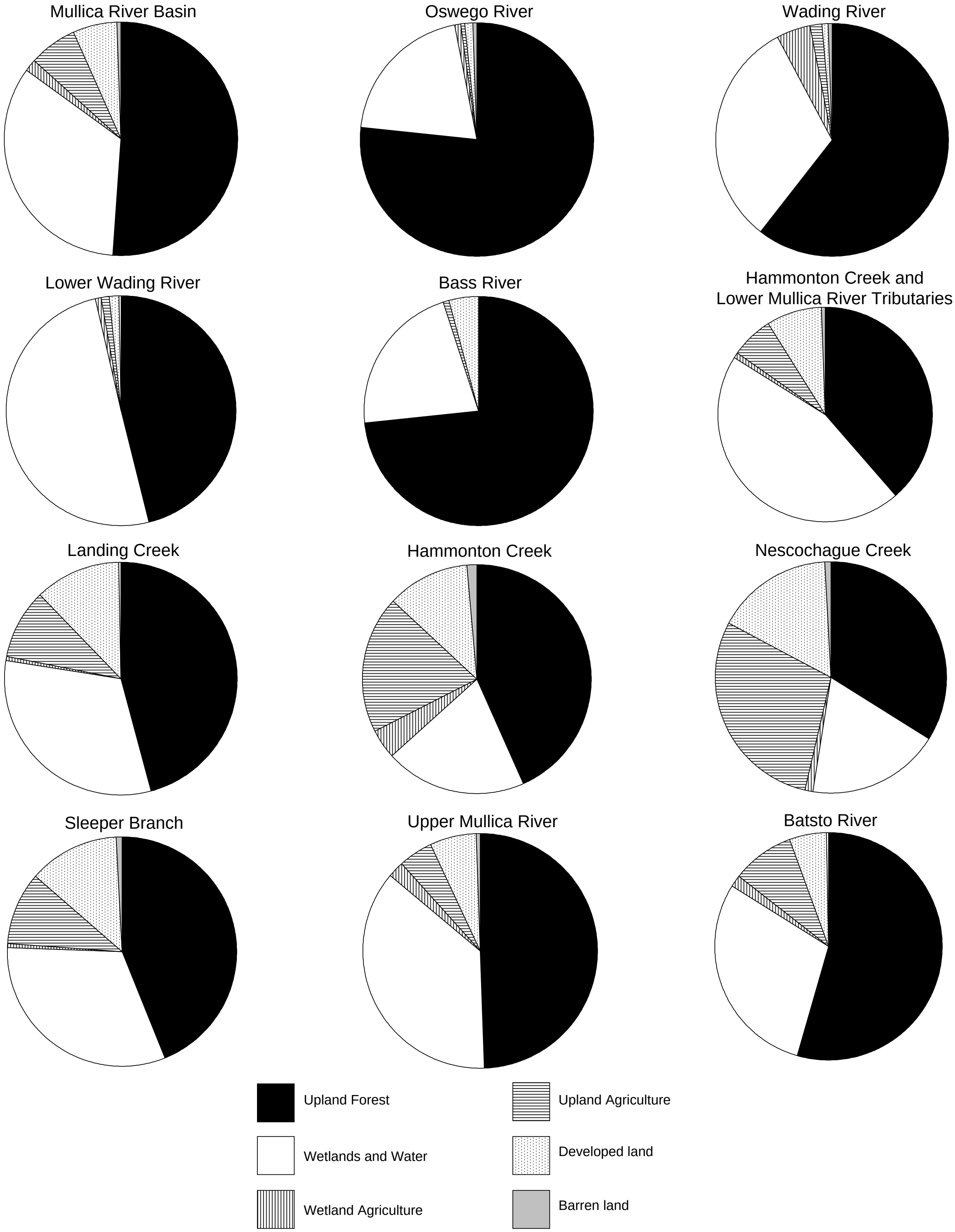

Figure 1.5. Mullica River Basin land-use profiles. Refer to Table 1.1 for descriptions of each land-use/land-cover class.

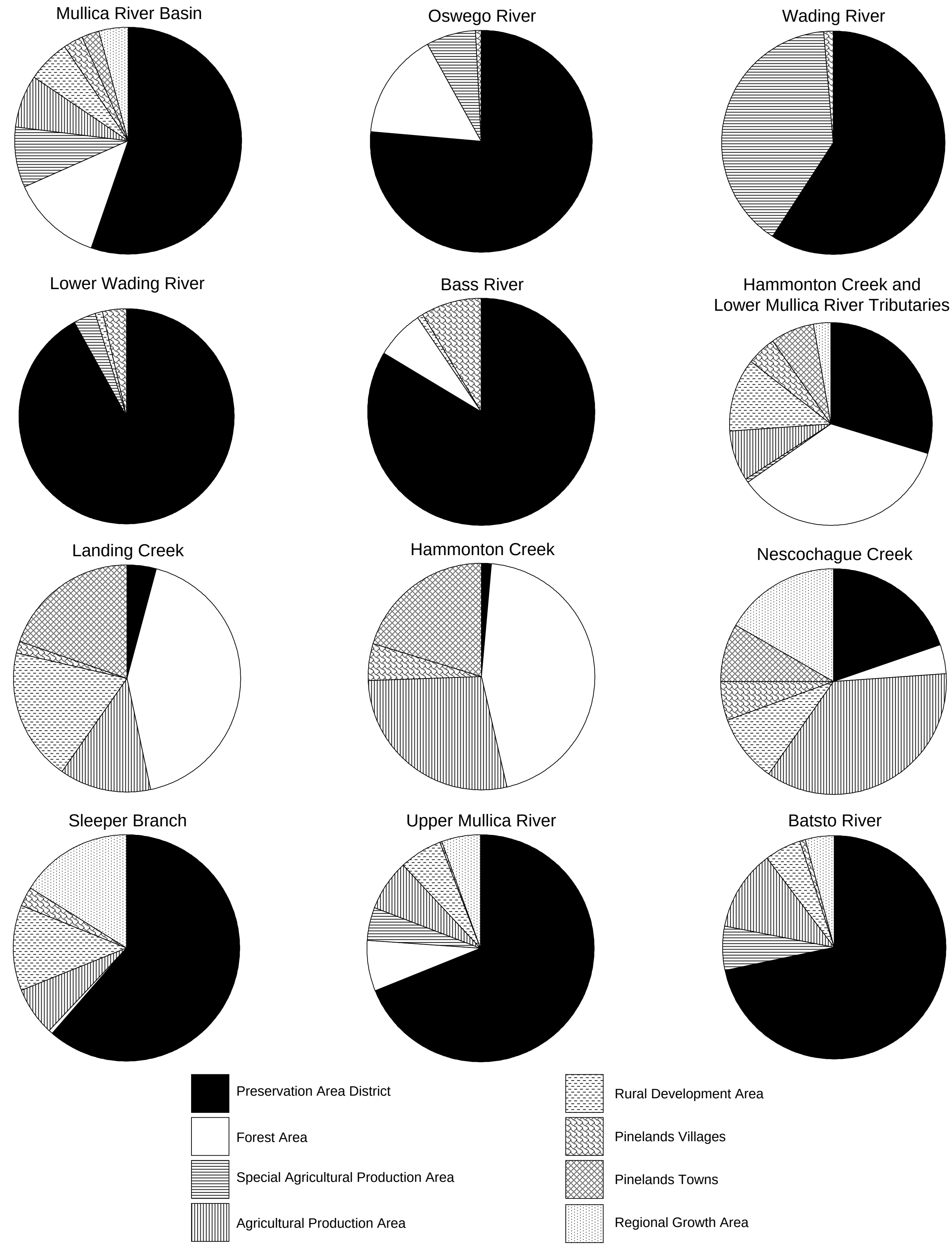

Figure 1.6. Mullica River Basin management-area profiles.

Sleeper Branch

The 93.7-km^2 Sleeper Branch system drains portions of Atlantic and Camden Counties. Broad wetlands found in the lower reaches of the drainage extend into Burlington County. Most of the basin is forest land within the Preservation Area District. Wetland agriculture covers less than one percent of the Sleeper Branch basin. The relatively high percentage of altered land recorded for the basin is due to extensive developed land and upland agriculture found in the headwaters within portions of the Hays Mill Creek, Wildcat Branch, and Cooper Branch basins. Regional Growth Area and Rural Development Area are the dominant management areas in these tributary basins. A wastewater spray field was formerly located in the lower portions of the Hays Mill Creek and Cooper Branch basins. About one-third of the Clark Branch drainage, which includes Price Branch, is developed land and upland agriculture. Nearly one-half of the Clark Branch basin is designated for development or agriculture with about one-third classified as Agricultural Production Area. Saltars Ditch, a stream diversion created in the eighteenth century, diverts water from the Sleeper Branch to the Mullica River near Atsion, blurring the hydrologic boundaries between the two basins.

Upper Mullica River

The 122-km^2 Upper Mullica River above Sleeper Branch drains portions of Atlantic, Burlington and Camden Counties. The basin is predominantly forest land designated as Preservation Area District. Developed land is concentrated in the headwater areas of the Mullica River above its confluence with the Alquatka Branch. Regional Growth Area and Rural Development Area dominate these headwater areas. Forest land covers most of the Alquatka Branch drainage. Preservation Area District and Forest Area are the principal management areas found within this tributary basin. Upland agriculture and Agricultural Production Areas dominate the upper reaches of the Wesickaman Creek basin, which flows to the Upper Mullica River below Atsion Lake.

Batsto River

The 184-km^2 Batsto River basin is located entirely within Burlington County. The land-use activities and management areas in this mostly forested watershed reflect the conditions found in the three major tributary basins, the Springers Brook, Batsto River above Skit Branch, and Skit Branch, which display distinctly different landscape profiles. Upland agricultural and developed lands are most extensive within the Springers Brook basin, reflecting the heavily altered landscape found in the Indian Mills Brook and Muskingum Brook tributary systems. Another tributary of Springers Brook, Deep Run, is all forest land. About one-third of the Springers Brook basin is designated Preservation Area District, with Agricultural Production Areas, Rural Development Areas, and Regional Growth Areas representing a significant part of the drainage.

About three-quarters of the Batsto River basin above its confluence with Skit Branch is forest land. In order of increasing area, the dominant land uses within this drainage include developed land, wetland agriculture, and upland agriculture. Portions of this headwater region are classified as Agricultural Production Area and Special Agricultural Production Area. More than 95% of the Skit Branch basin is forest land. Wetland agriculture is found in the upper reaches of Tom Roberts Branch, a tributary of Skit Branch. With the exception of a small area within the Tom Roberts Branch basin that is classified as Special Agricultural Production Area, the Skit Branch basin is designated Preservation Area District. Below its confluence with Springers Brook and Skit Branch, the Batsto River is forest land within the Preservation Area District.

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2 LANDSCAPE CHANGES IN THE MULLICA RIVER BASIN

INTRODUCTION

Human-induced landscape alterations can have a substantial impact on ecosystem structure and function (Turner 1987, Robinson et al. 1995, Roland and Taylor 1997, Dow and DeWalle 2000). In the Pinelands, unique acid-water plant and animal communities are vulnerable to changes associated with water-quality degradation from developed and agricultural landscapes (Zampella and Laidig 1997, Zampella and Bunnell 1998, Bunnell and Zampella 1999, Zampella and Bunnell 2000). Because of the relationship between land-use patterns and Pinelands biota, monitoring landscape changes provides one of the most direct measures of the effect of Commission land-use policies on the Pinelands ecosystem.

Two basic approaches can be used to describe a landscape. Land cover represents the actual biophysical material on the Earth's surface. Land use depicts the way that humans utilize a portion of land or body of water. Using detailed land-cover information, Commission scientists completed a study that quantified changes in the Mullica River Basin landscape between 1979 and 1991 (Bunnell et al. 2001). This period corresponds to the first twelve years of the Commission's planning effort. The methodology and results of the study are summarized in this chapter.

Several questions were addressed in the landscape study. First, what were the major land-cover transitions and changes in landscape structure (i.e., land-cover patch sizes) that occurred in the basin between 1979 and 1991? Second, did land-cover transitions occur in accordance with the different land-use intensities permitted by the Pinelands Comprehensive Management Plan's management-area designations (Chapter 1)? Third, how did the land-cover data created through this study compare to satellite-derived land-cover data generated by Landsat Thematic Mapper (TM) and aerial-photograph based land-use data created by the New Jersey Department of Environmental Protection (NJDEP)? The Landsat and NJDEP data are much less detailed than the Commission's land-cover data, but offer great promise for long-term monitoring of the Pinelands landscape.

METHODS

Study Sites

Because of the photo interpretation effort required to map detailed land cover within the entire Mullica River Basin, a tessellated-stratified random design was used to generate a statistically based sample that included seventy-two 225-ha photoplots. (Stehman and Overton 1994, Lathrop et al. 1997). The sample of 72 photoplots covered 11% (16,200 ha) of the basin (Figure 2.1).

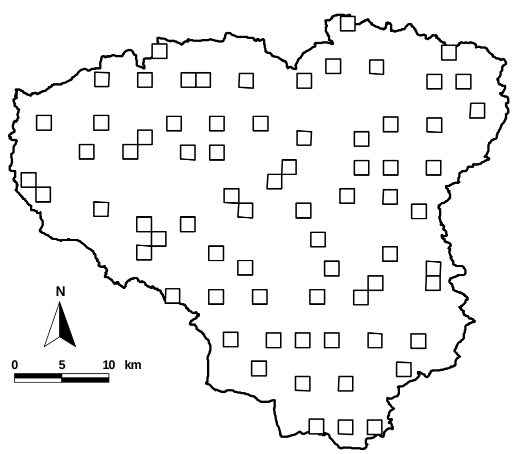

Figure 2.1. Location of 72 photoplots in the Mullica River Basin.

Commission Land-cover Mapping

Land cover was mapped in the 72 photoplots using aerial photography from 1979 and 1991. The classification system was modified from the National Oceanic and Atmospheric Administration's Coastal Change Analysis Program (NOAA, C-CAP, Dobson et al. 1995) (Table 2.1). The Commission's human-altered land covers were somewhat more detailed and woody land covers less detailed compared to the C-CAP classification scheme. The Commission map also did not distinguish between upland and wetland covers. On the Commission maps, developed land was composed of several residential and nonresidential cover types, and consisted mostly of impervious covers such as structures and paved surfaces.

Table 2.1. Commission land-cover types and related Landsat and NJDEP classes found within 72 photoplots in the Mullica River Basin. Commission and Landsat classifications were modified from the NOAA Coastal Change Analysis Program (Dobson et al. 1995). For Commission forest, scrub/shrub, herbaceous, barren-land, and water cover types, disturbances included development, agricultural activities, resource extraction, timber harvests, and fire. The NJDEP classification scheme follows Anderson et al. (1976). NJDEP land-use classes are referred to using the revised Pinelands terminology (Table 1.1, Chapter 1).

1979 and 1991 Commission Land-cover Types	1991 Landsat Thematic Mapper Land-cover Types	1995 NJDEP Land-use Classes
● Developed land • Residential development, including houses/driveways, outbuildings, and swimming pools • Nonresidential development, including buildings/asphalt, paved roads, railroads, campground vehicles, and junkyards/ storage areas	● Developed land (% impervious and barren land) • Light: wooded (25 - 50%) • Light: unwooded (25 - 50%) • Moderate (50 - 75%) • High (> 75%)	● Developed land, excluding recreational lands and athletic fields • Rural density residential development • Low density residential development • Medium density residential development • High density residential development • Nonresidential development, including commercial/services, industrial, transportation/communication/utilities, and other urban uses
● Crop land, including crop land, turf fields, and gardens ● Orchards • Tree farms ● Blueberry fields ● Cranberry bogs, including bogs and reservoirs	● Agricultural land ● Vines/Bushes	● Upland agriculture, excluding orchards/vineyards/nurseries/horticultural areas ● Orchards/vineyards/nurseries/horticultural areas ● Wetland agriculture
● Managed grassland • Residential grass (lawns) • Nonresidential grass, including pastures/ corrals, recreation land, athletic fields, commercial lawns, and roadside vegetation ● Herbaceous, including several unmanaged disturbance-related herbaceous covers	● Grassland, including managed and unmanaged herbaceous areas	● Recreation lands, athletic fields, and managed wetlands ● Herbaceous wetlands ● Old Fields (< 25% brush covered)
● Forest, including undeveloped vegetated land and several disturbance-related tree covers ● Scrub/shrub, including several disturbance-related scrub/shrub covers	● Forest, including seven forest types ● Scrub/shrub, including two scrub/ shrub types	● Upland forest and wetlands, excluding scrub/shrub subclasses and tidal, herbaceous, disturbed, and managed wetlands ● Upland forest and wetlands composed of scrub/shrub subclasses and excluding tidal, herbaceous, disturbed, and managed wetlands
● Barren land • Residential barren land • Nonresidential barren land, including several disturbance-related barren-land covers • Sand roads • Fire breaks	● Barren land, including barren land and areas with < 25% vegetated cover	● Barren land, including extractive mining, altered lands, transitional areas, undifferentiated barren lands, and disturbed wetlands
● Salt marsh	● Salt marsh, including unconsolidated shore and emergent wetlands	● Tidal wetlands, including saline marshes
● Water, including tidal water, retention basins, impoundments, irrigation ponds, ditches/canals, and other disturbance-related water cover	● Water, including unconsolidated shore and emergent wetlands	● Water and tidal waters

Agricultural land was separated into crop land, blueberry fields, cranberry bogs, orchards, and tree farms. Grassland cover included residential grass (lawn areas) and nonresidential grass, such as athletic and recreation fields, commercial lawns, pasture land (including corrals), and roadside vegetation. Roadside vegetation consisted of herbaceous areas along paved and sand roads. Management of this cover type varied widely.

Other cover types, including water, barren land, herbaceous, and scrub/shrub covers, were only delineated on the Commission maps when clearly associated with recent fire or past and present human-related land-use disturbances. These disturbances were limited to development, agricultural activities, resource extraction, and timber harvesting. Resource extraction areas included small and large-scale sand

and gravel operations. Tidal water, salt marsh, and forest cover were also mapped. Tidal water and salt marsh covers were delineated using NJDEP Freshwater Wetlands data from 1986 as a guide (NJDEP 1996). Forest cover included tree cover associated with any of the previously mentioned land-use disturbances and all undeveloped vegetated cover. These land covers were combined as forest cover because the vast majority was forested and the primary interest was human-altered land. The minimum mapping unit was 5 m^2 ($5x10^{-4}$ ha).

Landscape Structure and Transitions

Summary statistics were calculated for each photoplot for the 1979 and 1991 periods. Statistics included the mean, median, and first and third quartile patch sizes, the number of patches, and the total land-cover area for twelve major land-cover types and for all cover types combined. The individual patch statistics represent measures of landscape structure in the basin. The twelve cover types were developed land, managed grassland, barren land, crop land, orchards, blueberry fields, cranberry bogs, forest, scrub/shrub, herbaceous, salt marsh, and water (Table 2.1). To determine if there were differences in landscape structure between the two periods, the Wilcoxon matched-pairs test was used on a photoplot by photoplot basis to compare the summary attributes for the twelve cover types and for all types combined. A 1979 - 1991 transition matrix was also generated. This matrix provided "from-to" information for the twelve land-cover types. Land-cover area and number of patch values were projected to the entire basin by dividing the photoplot-based values by 0.11. The 0.11 value was the proportion of the basin represented by the photoplots.

Pinelands Management Area Analysis

Ninety-eight percent of the Mullica River Basin falls within the Pinelands National Reserve. The Commission's land-allocation system divides the Mullica River Basin into eight management areas with different permitted land uses (Pinelands Commission, Land Capability Map, November 1999, Figure 1.3, Chapter 1). The 1979 to 1991 land-cover transition matrix was partitioned by management area to evaluate whether landscape changes occurred in the appropriate management areas. Within the basin, 55% of the Pinelands National Reserve is Preservation Area District (Figure 2.2). The other seven management areas total less than 13% each. Although the basin-wide percentage of most management areas is similar in the photoplot-based sample, extrapolation of results from the sample must be made with caution because the sample was not specifically designed to be representative of the management areas in the basin.

NJDEP Land-use Map Comparison

The 1995 NJDEP land-use data (Chapter 1) were used in three separate analyses. The first analysis determined the percentage of Commission land-cover types within selected NJDEP land-use classes and subclasses (Table 2.1). Both 1986 and 1995 NJDEP land-use maps were analyzed. NJDEP land-use classes are referred to using the revised Pinelands terminology (Table 1.1, Chapter 1). For the second analysis, the Commission's 1991 map was used to evaluate the accuracy of impervious-surface estimates in the 1995 NJDEP map. During the NJDEP map-update process, the amount of impervious surface was visually estimated at five percent intervals for each NJDEP land-use polygon. The total amount of

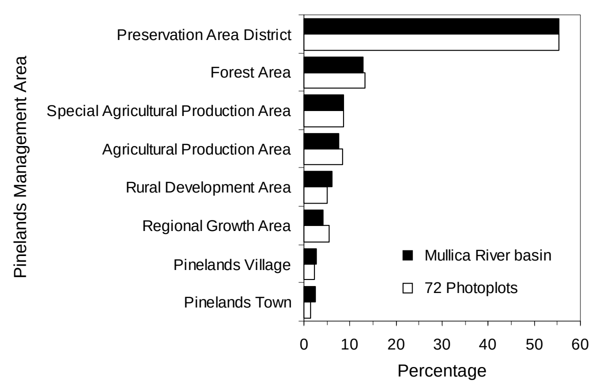

Figure 2.2. Percentage composition of Pinelands Management Areas for 72 photoplots and for the entire Mullica River Basin.

developed land from the Commission map and the total amount of impervious surface from the NJDEP map were determined for each estimate interval. Pearson product-moment correlation was used to assess the relationship between the Commission and NJDEP totals for each estimate interval.

NJDEP Land-use Transitions

The NJDEP land-use data also identified which land-use polygons changed between 1986 and 1995. The third analysis used these data to evaluate the land-use changes that occurred in the basin during this nine-year period. Transition matrices for eight major land-use classes were generated for the entire basin and for the Pinelands National Reserve between the two years. The eight land-use classes were developed land, upland agriculture, wetland agriculture, barren land, upland forest, wetlands, water, and tidal waters and wetlands (Table 1.1, Chapter 1).

Landsat Thematic Mapper Comparison

The Commission's 1991 land-cover map was also compared to a land-cover map classified from 1991 TM imagery by Rutgers University scientists at the Center for Remote Sensing and Spatial Analysis. A TM image is a mosaic of 30 x 30-m pixels (blocks) that corresponds to land-cover conditions. Details on image processing and classification procedures are given in Lathrop et al. (1997). The TM classification process resulted in a map of the basin with a land-cover type assigned to each 30 x 30-m pixel. The classification scheme followed that used by C-CAP (Table 2.1). The Commission map was compared to the TM map using two approaches. In the first comparison, the Wilcoxon matched-pairs test was used to determine if there were differences in the total land-cover area of eight cover types between the Commission map and the TM map. The eight cover types included in this analysis were developed land, agricultural land, vines/bushes, grassland, woody land (scrub/shrub and forest cover), barren land, salt marsh, and water (Table 2.1). For the second analysis, the Commission map was used to quantify the land-cover composition of individual TM cover types.

Results

Landscape Structure

Based on the Commission maps, forest cover represented about 75% of the Mullica River Basin in both periods (Figure 2.3). All other cover types totaled less than 5% each. The combined area of developed-land, managed-grassland, agricultural-land, and barren-land cover types covered 13% and 15% of the basin in 1979 and 1991, respectively. Approximately 80% of all patches were less than 0.5 ha in both periods. Salt marsh and forest land represented the largest patches and developed and managed grassland represented the smallest patches (Table 2.2). Sixty percent of the total number of patches in both periods were classified as developed land, managed grassland, and barren land, approximately 30% of the total were vegetated (forest, scrub/shrub, and herbaceous), and the remaining 10% were composed of agricultural land, salt marsh, and water.

There was a significant difference in several cover types between 1979 and 1991 (Table 2.2). The total area and the number of developed-land, managed-grassland, and barren-land patches increased due to the increase in the residential and nonresidential cover types, fire breaks, and paved and sand roads (Figure 2.4). Managed grassland displayed the greatest increase in total area due mostly to the relatively large increase in residential lawns.

The loss in total agricultural area between periods was small. Crop land and orchards decreased and blueberry fields increased in area, but the differences were not significant (Figure 2.4, Table 2.2). Of all twelve cover types, only crop land and orchards showed a decrease in the number of patches between the two years. The trend for crop land was significant (Table 2.2). Although the area and the number of patches increased for cranberry bogs, the statistical significance of this change could not be determined because the number of photoplot pairs was too low (n = 6) to complete the matched-pairs tests (Sokal and Rohlf 1987). Salt marsh cover was not tested because it did not change between periods (Figure 2.4).

The change in forest land between 1979 and 1991 represented the largest overall decrease in area (Figure 2.4). For this cover type, there was a significant increase in the number of patches and a significant decrease in total area and median and third quartile patch sizes (Table 2.2). Based on median photoplot values, there was a 19% increase in the number of patches and a 17% decrease in median forest-land

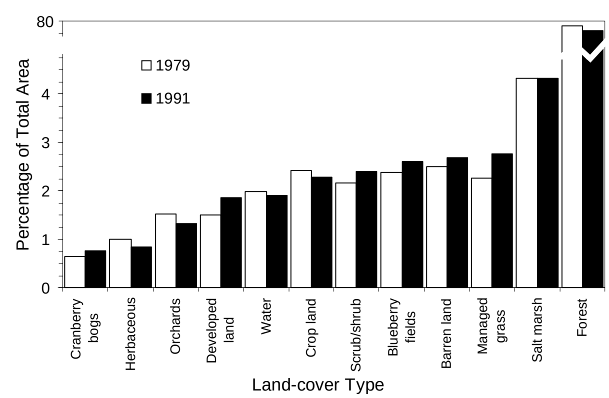

Figure 2.3. Land-cover composition in 72 photoplots for 1979 and 1991 in the Mullica River Basin.

Table 2.2. Summary statistics and results of Wilcoxon matched-pairs tests for individual land-cover types and all types combined. Tests were completed on summary statistics in 72 photoplots (11% of the basin) between 1979 and 1991. An alpha level of 0.05 was used in all tests. Significant results are indicated with a box. The initial *p*-level, the number of site pairs in which the land cover was present (*n*), and the median attribute value for both periods are given. Land-cover area and the number of patches were projected as basin-wide values by dividing the site-based number by 0.11. Cranberry bogs and salt marsh covers were not included in the Wilcoxon tests because of the low n for cranberry bogs and lack of change between periods for salt marsh.

		Mean patch size		Median patch size			First quartile patch size			Third quartile patch size			Total land cover area			Number of patches		
Land-cover type	n	1979 (ha)	1991 (ha)	Initial *p*-level	1979 (ha)	1991 (ha)	Initial *p*-level	1979 (ha)	1991 (ha)	Initial *p*-level	1979 (ha)	1991 (ha)	Initial *p*-level	1979 (ha)	1991 (ha)	Initial *p*-level	1979 (ha)	1991 (ha)
Developed land	50	0.09	0.09	0.695	0.04	0.04	0.286	0.02	0.02	0.004	0.07	0.07	0.000	2222	2744	0.000	22506	28089
Managed grassland	43	0.16	0.16	0.531	0.07	0.08	0.128	0.03	0.03	0.484	0.17	0.18	0.000	3322	4076	0.000	23470	28935
Barren land	69	0.50	0.45	0.629	0.15	0.14	0.084	0.07	0.05	0.013	0.40	0.40	0.001	3691	3944	0.001	8821	9839
Crop land	25	0.68	0.69	0.234	0.41	0.54	0.039	0.15	0.26	0.396	0.68	1.06	0.023	3575	3356	0.003	2428	1964
Orchards	15	0.54	0.48	0.117	0.59	0.35	0.612	0.20	0.20	0.678	0.73	0.71	0.507	2250	1946	0.575	1128	1118
Blueberry fields	13	0.93	0.95	0.059	0.69	0.71	0.080	0.36	0.35	0.398	1.35	1.19	0.790	3500	3839	0.374	2419	2519
Cranberry bogs	6	1.27	1.59	-	0.84	1.21	-	0.43	0.60	-	1.65	2.06	-	952	1130	-	700	773
Herbaceous	45	0.25	0.19	0.014	0.14	0.12	0.099	0.06	0.05	0.127	0.31	0.22	0.111	1486	1226	0.043	3428	3683
Scrub/shrub	51	0.38	0.31	0.410	0.18	0.20	0.554	0.09	0.08	0.150	0.46	0.43	0.621	3195	3529	0.122	4747	5265
Forest	69	10.17	7.57	0.002	0.54	0.45	0.016	0.08	0.07	0.000	3.81	3.39	0.003	113851	112366	0.000	19178	22824
Salt marsh	7	23.32	23.32	-	12.73	12.73	-	0.94	0.94	-	24.18	24.18	-	6360	6360	-	227	227
Water	45	0.31	0.27	0.039	0.16	0.15	0.084	0.08	0.07	0.300	0.35	0.30	0.619	2910	2797	0.012	2446	2846
All cover types	72	0.44	0.40	0.005	0.16	0.15	0.280	0.07	0.06	0.000	0.47	0.39	-	-	-	0.000	91498	108084

patch size. For all patches regardless of cover type, there was a significant increase in the number of patches and a significant decrease in the median and third quartile patch-size values. Although not included in the statistical analysis, mean patch size also decreased between periods for forest land and all cover types combined. These results indicated that fragmentation of forest land and the landscape as a whole occurred during the period. Using Landsat satellite imagery, similar structural changes have been reported for forest land in other studies in the Pinelands (Luque et al. 1994, Luque 2000 a, b).

Land-cover Transitions

Retention values, which represent the amount of a land-cover type that did not change between 1979 and 1991, ranged from 49% - 100% (Table 2.3). Based on the 72 photoplots, a total of 5.3% of the total basin area was estimated to have changed cover type between periods. These changes included several major basin-wide transitions. Orchard land was converted to crop land and blueberry fields. Barren land cover was also converted to blueberry fields. Crop land was converted to orchards and managed grassland, and some crop land succeeded to scrub/shrub cover. Herbaceous cover succeeded to scrub/shrub cover and forest cover. Scrub/shrub cover was converted to forest cover. A large percentage of the total area that succeeded from herbaceous to scrub/shrub cover, herbaceous to forest cover, and scrub/shrub to forest cover between periods occurred in abandoned agricultural fields and other fields.

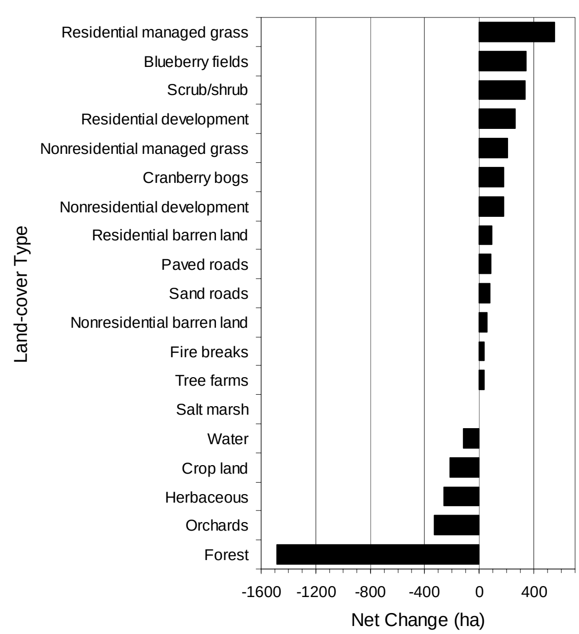

Figure 2.4. Net change in land-cover area between 1979 and 1991 in the Mullica River Basin. Change values are basin-wide numbers that have been extrapolated from 72 photoplots (11% of the basin).

Table 2.3. Transition matrix for land-cover types between 1979 and 1991. The top number (bolded) is the percentage area (± 1 SD) and the bottom number is the total area (ha) for cover-type transitions and the basin totals. Data were generated from 72 photoplots (11% sample of the basin) and land-cover area totals were projected to the entire basin by dividing site-based values by 0.11. Retention values are on the diagonal and represent the percentage and area of a land-cover type that did not change between 1979 and 1991.

1979 Land-cover types	1991 Land-cover types: Developed land	Managed grassland	Barren land	Crop land	Orchards	Blueberry fields	Cranberry bogs	Herb-aceous	Scrub/ shrub	Forest	Salt marsh	Water	1979 Mullica Basin net total
Developed land	**97.7**	**0.6**	**0.9**	**-**	**<0.1**	**-**	**-**	**0.1**	**0.5**	**0.1**	**-**	**-**	**1.5 (± 3.2)**
	2171	13	20	-	1	-	-	3	10	3	-	-	2222
Managed grassland	**1.6**	**92.6**	**1.1**	**0.3**	**0.5**	**0.4**	**-**	**1.3**	**1.1**	**1.0**	**-**	**-**	**2.3 (± 4.2)**
	55	3077	38	10	15	13	-	45	37	33	-	-	3322
Barren land	**2.9**	**1.9**	**85.5**	**0.3**	**0.2**	**4.6**	**0.1**	**0.8**	**2.2**	**1.0**	**-**	**0.5**	**2.5 (± 2.1)**
	108	69	3156	13	8	169	2	29	82	38	-	19	3691
Crop land	**0.6**	**6.1**	**1.1**	**73.1**	**13.4**	**1.2**	**<0.1**	**1.0**	**3.2**	**0.2**	**-**	**-**	**2.4 (± 7.0)**
	22	218	39	2614	478	42	1	37	116	9	-	-	3575
Orchards	**0.1**	**1.7**	**0.9**	**27.5**	**61.7**	**6.1**	**-**	**1.3**	**0.3**	**0.3**	**-**	**-**	**1.5 (± 5.9)**
	1	39	20	618	1388	137	-	30	8	8	-	-	2250
Blueberry fields	**-**	**0.5**	**0.9**	**0.1**	**0.1**	**95.8**	**0.6**	**0.6**	**1.1**	**0.3**	**-**	**0.1**	**2.4 (± 9.0)**
	-	16	33	2	2	3352	20	22	38	12	-	3	3500
Cranberry bogs	**-**	**-**	**0.4**	**-**	**-**	**-**	**99.4**	**-**	**-**	**-**	**-**	**0.3**	**0.6 (± 3.0)**
	-	-	3	-	-	-	946	-	-	-	-	3	952
Herbaceous	**2.0**	**2.5**	**3.0**	**1.8**	**-**	**3.4**	**-**	**48.7**	**21.1**	**15.2**	**-**	**2.1**	**1.0 (± 1.9)**
	30	38	44	27	-	51	-	725	314	226	-	31	1486
Scrub/shrub	**0.5**	**2.2**	**1.5**	**1.1**	**1.0**	**0.8**	**0.4**	**2.3**	**59.2**	**30.7**	**-**	**0.2**	**2.2 (± 3.0)**
	18	70	49	36	33	24	12	73	1893	981	-	6	3195
Forest	**0.3**	**0.5**	**0.4**	**<0.1**	**<0.1**	**<0.1**	**0.1**	**0.2**	**0.8**	**97.5**	**-**	**<0.1**	**77.3 (± 26.7)**
	340	536	498	35	21	47	134	227	922	111056	-	35	113851
Salt marsh	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**100**	**-**	**4.3 (± 16.8)**
	-	-	-	-	-	-	-	-	-	-	6360	-	6360
Water	**-**	**<0.1**	**1.5**	**-**	**-**	**0.1**	**0.5**	**1.2**	**3.8**	**<0.1**	**-**	**92.8**	**2.0 (± 5.2)**
	-	1	45	-	-	3	15	35	109	1	-	2699	2910
1991 Mullica Basin net total	**1.9 (± 3.9)**	**2.8 (± 5.2)**	**2.7 (± 1.9)**	**2.3 (± 6.7)**	**1.3 (± 4.6)**	**2.6 (± 10.5)**	**0.8 (± 3.5)**	**0.8 (± 1.4)**	**2.4 (± 4.0)**	**76.3 (± 26.5)**	**4.3 (± 16.8)**	**1.9 (± 5.1)**	**100**
	2744	4076	3944	3356	1946	3839	1130	1226	3529	112366	6360	2797	1474 km^2

Between 1979 and 1991, the total amount of herbaceous and scrub/shrub cover that succeeded to forest cover was similar to the amount of forest cover that was converted to herbaceous and scrub/shrub cover. The vast majority of the latter transition occurred as a result of fire and timber harvests.

There was an net decrease of forest land between 1979 and 1991 (Figure 2.4). The majority of the developed land, managed grassland, and barren land created between 1979 and 1991 originated from forest land (Table 2.3). Conversion of various previously disturbed covers accounted for the additional increase in these three cover types. Compared to crop land, orchards, and blueberry fields, the percentage of new cranberry bogs created from forest land was high. All the new bogs were established in abandoned bogs that succeeded to forest cover prior to 1979.

Pinelands Management Area Analysis

The type of land-cover changes were consistent with the management areas in which the transitions occurred (Figure 2.5). Although there were increases in developed land and managed grassland in all eight management areas, the largest gains occurred in Regional Growth and Rural Development Areas. Barren land increased in the Special Agricultural Production Areas and Preservation Area District due to agricultural activities and the expansion of resource extraction areas. The decrease in barren land in Agricultural Production Areas was due mostly to the creation of blueberry fields. Barren land decreased in Regional Growth Areas due to the development of land cleared prior to 1979.

Major agricultural transitions were limited to Regional Growth Areas, Agricultural Production Areas, and Special Agricultural Production Areas. There was a conversion of crop land to orchards in Regional Growth Areas. An opposite trend was observed for these two cover types in Agricultural Production Areas. The creation of blueberry fields and cranberry bogs between 1979 and 1991 occurred in Agricultural Production Areas and Special Agricultural Production Areas.

Herbaceous cover was lost in all management areas except the Special Agricultural Production Areas and Pinelands Villages. There were small increases in these two management areas. Scrub/shrub cover was lost to developed land, managed grassland, and crop land in Regional Growth Areas and succeeded to forest land in abandoned cranberry bogs and timber harvest areas in the Special Agricultural Production Areas. The relatively large gain in scrub/shrub in the Preservation Area was due to forest lost to fire and timber harvests. Forest was lost to developed land and managed grassland in Rural Development Areas and increased in Pinelands Towns due to succession of herbaceous and scrub/shrub cover in abandoned fields.

NJDEP Land-use Map Comparison

The comparison of the Commission land-cover types and NJDEP land-use classes showed that the composition of the NJDEP land-use classes that were analyzed was similar in 1986 and 1995 (Bunnell et al. 2001). All the NJDEP land-use classes were composed of several Commission land-cover types (Figure 2.6). The comparison confirmed the high, medium, low, and rural density classifications assigned to residential land use by the NJDEP. All four NJDEP residential land-use subclasses included some nonresidential developed cover, which was mostly structures (with associated impervious areas) and paved roads. The amount of total managed grassland cover delineated on the Commission map was fairly constant among the four NJDEP residential land-use subclasses. About two-thirds of the NJDEP nonresidential-developed land-use subclass area was classified as nonresidential development and managed grassland cover on the Commission map. Twenty-three percent of the total area designated as developed land by NJDEP was classified as developed-land cover on the Commission map. The NJDEP recreation land, athletic field, and managed wetland land-use subclasses were composed mostly of managed grassland, developed land, and barren land cover. These three Commission cover types were primarily associated with recreation areas such as athletic fields, campgrounds, and parks.

Approximately two-thirds of the NJDEP upland-agriculture land-use class, excluding orchards, was classified as blueberry fields, orchards, and crop land on the Commission map (Figure 2.6). About one-half of the NJDEP wetland-agriculture land-use subclass

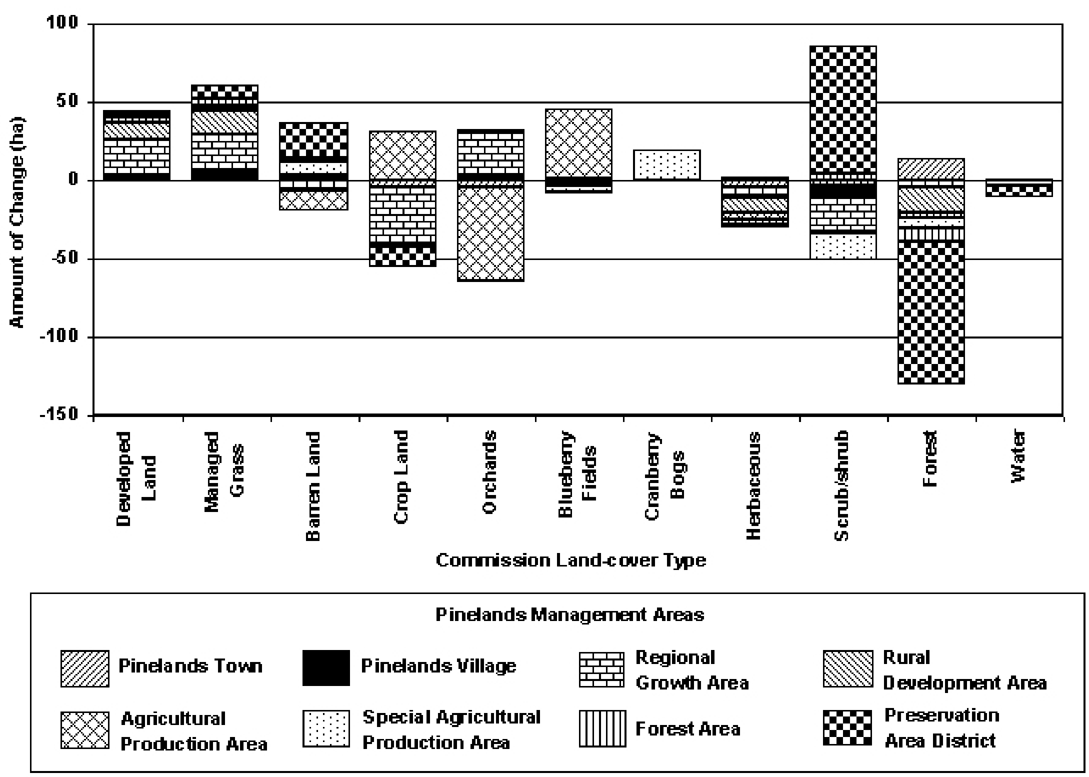

Figure 2.5. Changes in land-cover area by Pinelands Management Area between 1979 and 1991 in 72 photoplots in the Mullica River Basin.

was composed of blueberry fields and one-quarter was cranberry bogs. The NJDEP orchard subclass was also about one-half blueberry field cover. The inclusion of blueberry fields in both the NJDEP wetland-agriculture and orchard subclasses was due to the integration of a wetland coverage into the original 1986 NJDEP land-use map (Chapter 1).

Based on the Commission map, the NJDEP barren land class was composed primarily of barren land, forest, scrub/shrub, and water covers. These Commission cover types were generally associated with resource-extraction activities. The NJDEP herbaceous-wetland subclass and the total area covered by upland-forest scrub/shrub and wetland scrub/shrub subclasses were characterized as being dominated by forest cover because all undeveloped vegetated land was classified as forest land on the Commission map. The NJDEP old-field subclass was predominantly herbaceous, scrub/shrub, and forest cover. Although this land-use was defined as being <25% brush cover in the Anderson et al. (1976) classification scheme, it was dominated by scrub/shrub cover. There was good correspondence between areas classified by the Commission as forest and areas mapped by NJDEP as upland forest and wetlands, excluding scrub/shrub cover. Areas designated as water by the Commission corresponded to areas mapped as water and tidal waters by the NJDEP. As mentioned previously, the 1986 NJDEP Freshwater Wetland data were used as a guide for the

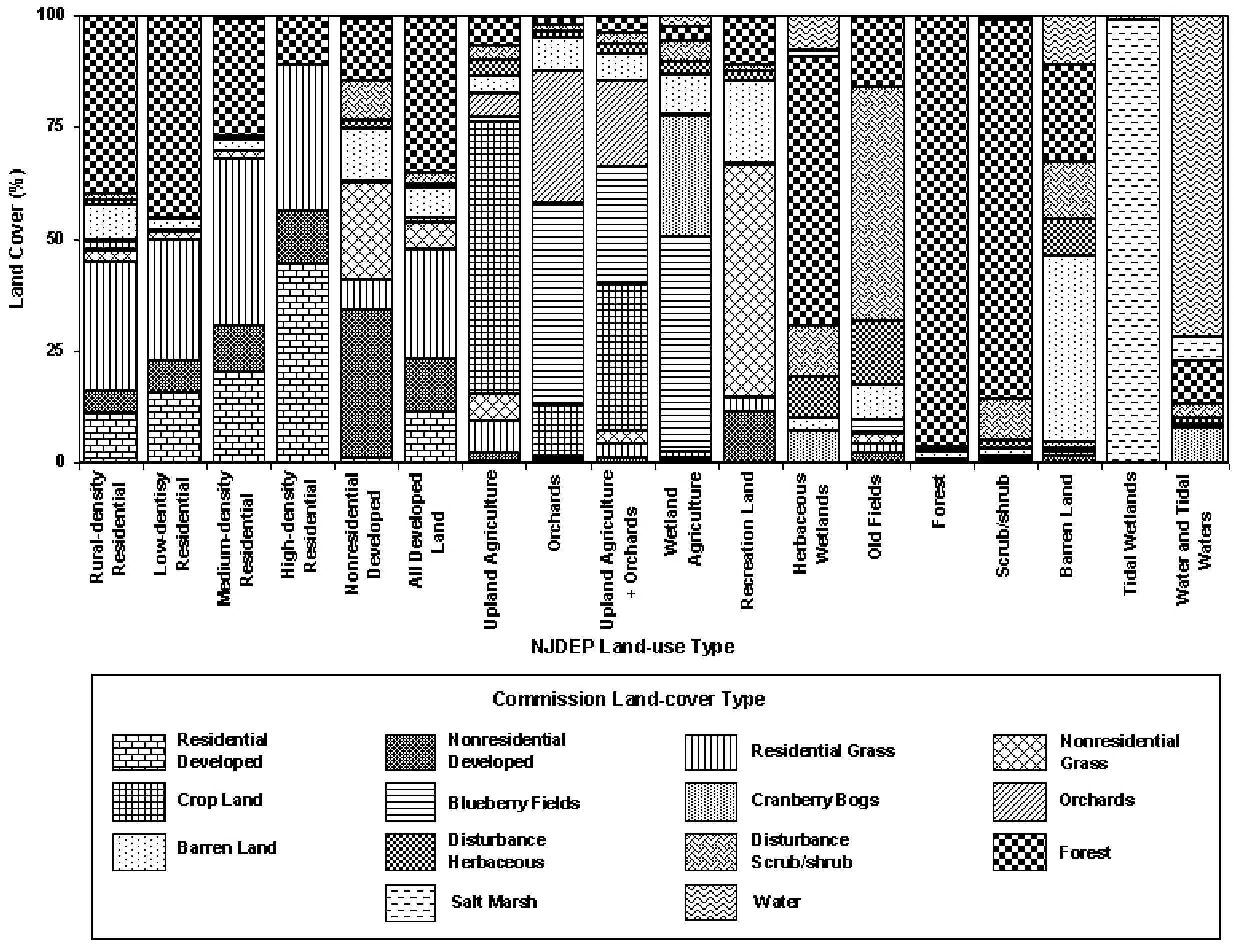

Figure 2.6. Land-cover composition of 1995 NJDEP land-use classes and subclasses in 72 photoplots in the Mullica River Basin. Refer to Table 1.1 (Chapter 1) and Table 2.1 for details regarding NJDEP land-use classes. The upland-agriculture class includes upland agriculture and excludes orchards, vineyards, nurseries, and horticultural areas. The orchard subclass includes only orchards, vineyards, nurseries, and horticultural areas. Recreation land includes recreation land, athletic fields, and managed wetlands. Forest includes upland forest and wetlands and excludes scrub/shrub subclasses, and tidal, herbaceous, disturbed, and managed wetlands. Scrub/shrub includes upland forest and wetlands composed of scrub/shrub subclasses and excludes tidal, herbaceous, disturbed, and managed wetlands.

delineation of salt marsh on the 1991 Commission map. The cranberry-bog cover included in the NJDEP water and tidal waters class was due to the classification of cranberry reservoirs and bogs as cranberry bogs on the Commission map (Table 2.1).

There was a strong positive relationship between the amount of developed land depicted by the Commission map and the amount of impervious-surface cover in the NJDEP map for each impervious-surface estimate interval (r = 0.99, $p < 0.05$) (Figure 2.7). Although this indicated that the visual estimates of impervious surface in the NJDEP map were accurate, there were small differences between the two maps for each estimate interval. Compared to developed land in the Commission map, impervious-surface estimates tended to be lower in NJDEP polygons that were classified as 5% to 50% impervious cover and higher in those estimated at 55% to 100% impervious cover (Figure 2.7).

For the whole basin, 23% of the 1995 NJDEP developed-land use area was designated as impervious surface by the NJDEP. As mentioned previously, the comparison of the Commission map to the NJDEP map in the 72 photoplots indicated that 23% of the NJDEP developed-land use was actually developed cover. These results strongly suggest that the impervious surface estimates accurately represented developed land throughout the basin and that the 72-photoplot sample adequately characterized the NJDEP developed-land use.

NJDEP Land-use Transitions

NJDEP land-use transitions from 1986 through 1995 within the Pinelands National Reserve and the entire basin, including the small area located outside the Reserve, were similar (Tables 2.4 and 2.5). Retention values were generally high and ranged from about 60% for barren land to 100% for tidal waters and wetlands. The majority of the land-use changes during this period occurred with barren land, upland agriculture, developed land, and upland-forest land. Most of the barren-land conversion was to upland forest and developed-land uses. The transition of barren land to upland-forest occurred primarily in resource-extraction areas. Although a small amount of upland agriculture was converted to developed land, the greatest change in upland agriculture was succession to upland-forest land. Conversely, upland-forest land was lost to upland agriculture, barren land,

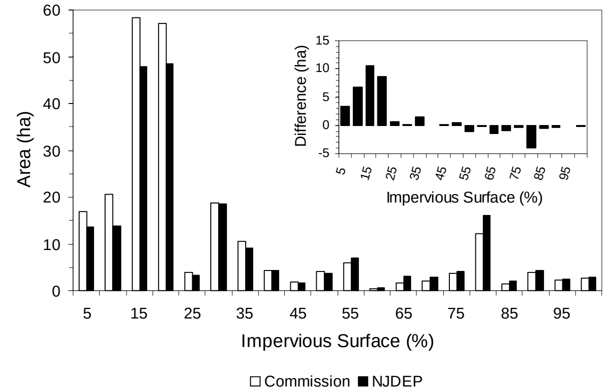

Figure 2.7. Total amount of developed land depicted on the 1991 Commission map and the amount of impervious surface depicted on the 1995 NJDEP map for each impervious-surface estimate interval. The difference (Commission developed land minus NJDEP impervious surface) for each estimate interval is shown in the inset.

and developed land, with the largest amount being converted to developed land. In both the Pinelands National Reserve and the entire basin, developed land created from upland agriculture and upland-forest land between 1986 and 1995 was predominantly residential development. The amount of residential versus nonresidential development created from barren land during the nine-year period was similar.

Landsat Thematic Mapper Comparison

There was a significant difference in total area between the Commission and TM maps for several cover types (Bunnell et al. 2001). Compared to the Commission map, the amount of barren-land, grassland, and woody-land (scrub/shrub and forest) cover was lower in the TM map, and the amount of developed and agricultural-land cover was higher. Differences in water, vines/bushes, and salt marsh cover were not significant.

Most of the developed cover delineated on the Commission map was included as developed land in the TM map. Total developed land was significantly higher in the TM map compared to the Commission map because of the large amount of managed-grassland and forest cover present in the TM developed type (Figure 2.8). The land-cover composition of the TM developed type was similar to that for the NJDEP developed-land class (Figures 2.6 and 2.8). Total developed land in the TM map was separated into four developed types (high, moderate, low: wooded, and low: unwooded) based on the

Table 2.4. Transition matrix for major NJDEP land-use classes between 1986 and 1995 in the Pinelands National Reserve portion of the Mullica River Basin. NJDEP land-use classes are referred to using the revised Pinelands terminology (Table 1.1, Chapter 1). Transition values represent the percentage of the land-use area in each year.

	1995 Land-use class								1986
1986 Land-use class	Upland agriculture	Wetland agriculture	Barren land	Upland forest	Developed land	Water	Wetlands	Tidal water and wetlands	Mullica Basin net total (ha)
Upland agriculture	92.3	0.0	0.3	5.0	2.3	0.0	0.0	0.0	10281.8
Wetland agriculture	0.0	98.3	0.0	0.0	0.0	0.0	1.6	0.0	2315.3
Barren land	3.4	0.0	61.6	27.1	5.1	2.8	0.0	0.0	775.2
Upland forest	0.3	0.0	0.2	98.5	1.0	0.0	0.0	0.0	74338.4
Developed land	0.2	0.0	0.1	1.0	98.7	0.0	0.0	0.0	7516.1
Water	0.0	1.2	0.4	0.0	0.0	98.0	0.4	0.0	1809.4
Wetlands	0.0	0.3	0.0	0.0	0.1	0.0	99.6	0.0	38916.1
Tidal water and wetlands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	7956.7
1995 Basin total (ha)	9758.4	2429.2	673.4	74041.5	8439.6	1804.5	38802.9	7959.6	1,439 km^2

Table 2.5. Transition matrix for major NJDEP land-use types between 1986 and 1995 in the entire Mullica River Basin. NJDEP land-use classes are referred to using the revised Pinelands terminology (Table 1.1, Chapter 1). Transition values represent the percentage of the land-use area in each year.

	1995 Land-use class								1986
1986 Land-use class	Upland agriculture	Wetland agriculture	Barren land	Upland forest	Developed land	Water	Wetlands	Tidal water and wetlands	Mullica Basin net total (ha)
Upland agriculture	92.0	0.0	0.3	5.1	2.5	0.0	0.0	0.0	10380.8
Wetland agriculture	0.0	98.0	0.0	0.0	0.3	0.0	1.6	0.0	2323.2
Barren land	3.2	0.0	60.8	26.5	6.7	2.7	0.0	0.0	822.0
Upland forest	0.3	0.0	0.2	98.3	1.1	0.0	0.0	0.0	75870.6
Developed land	0.2	0.0	0.1	1.0	98.7	0.0	0.0	0.0	7960.9
Water	0.0	1.2	0.4	0.0	0.0	98.0	0.4	0.0	1857.3
Wetlands	0.0	0.3	0.0	0.0	0.1	0.0	99.6	0.0	39866.3
Tidal water and wetlands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	8312.6
1995 Basin total (ha)	9822.4	2430.5	719.2	75415.7	9092.2	1853.8	39744.6	8315.3	1,474 km^2

amount of impervious and barren-land cover present (Table 2.1). The comparison with the Commission map showed that the amount of developed cover in each of the four TM developed types was only slightly underestimated. Grassland was significantly lower in the TM map compared to the Commission map because herbaceous and managed grassland together comprised a relatively small proportion of the TM grassland type and the majority of the managed-grassland cover in the Commission map was included in the TM developed types.

The TM agricultural type included almost all of the crop-land and orchard cover present in the Commission map. However, agricultural land was significantly higher in the TM map compared to the Commission map because three-quarters of all blueberry-field cover from the Commission map was included as agricultural land rather than vines/bushes in the TM map (Figure 2.8). The majority of these blueberry fields were from the west-central part of the basin near Hammonton. Although the TM vines/bushes type included most of the remaining blueberry-field cover and two-thirds of the cranberry-bog cover present on the Commission map, vines/bushes cover was lower in the TM map versus the Commission map due to the exclusion of that large amount of blueberry-field cover from the TM vines/bushes type. The lack of significance for the difference in vines/bushes cover between the two maps may have been due to the low number of photoplot pairs (n = 7) with this cover combination in common.

Barren land was significantly lower in the TM map compared to the Commission map because barren-land cover from the Commission map was present in several other TM cover types (Figure 2.8). Most of the barren-land cover that was included in TM types other than the TM barren-land type was cleared lots, sand roads, and fire breaks, which may be too small or narrow to be adequately captured by the 30 x 30-m TM pixel. Only one-third of the TM barren-land type was classified as barren-land cover in the Commission map. The composition of the TM barren-land type was similar to that for the NJDEP barren-land class (Figures 2.6 and 2.8). As with the NJDEP barren-land class, the majority of the Commission cover types present in the TM barren-land type was associated with resource-extraction activities.

Total woody land was significantly lower in the TM map versus the Commission map due to the amount of forest cover included in other TM cover types (Figure 2.8). Based on the Commission map, TM forest and scrub/shrub types were both characterized as being predominantly forest land. The scrub/shrub type was characterized as forest cover mostly due to large areas in three photoplots being classified as forest in the Commission map and as scrub/shrub in the TM map. One area that appeared as mixed tree and scrub/shrub cover was harvested prior to 1979 and the other two areas were located in upland portions of the Pine Plains. The Pine Plains are dominated by short-stature pine and oak species.

Although there was no significant difference in water cover between the two maps, about one-half of the TM water type was composed of forest cover and other covers combined. The presence of forest cover in the TM water type is at least partly due to the sinuosity of water-body shorelines and narrowness of small impoundments. There was good agreement for salt marsh cover between the TM and Commission maps. This is important for C-CAP because one of the primary objectives is to monitor changes in wetland land-cover in coastal regions of the United States (Dobson et al. 1995).

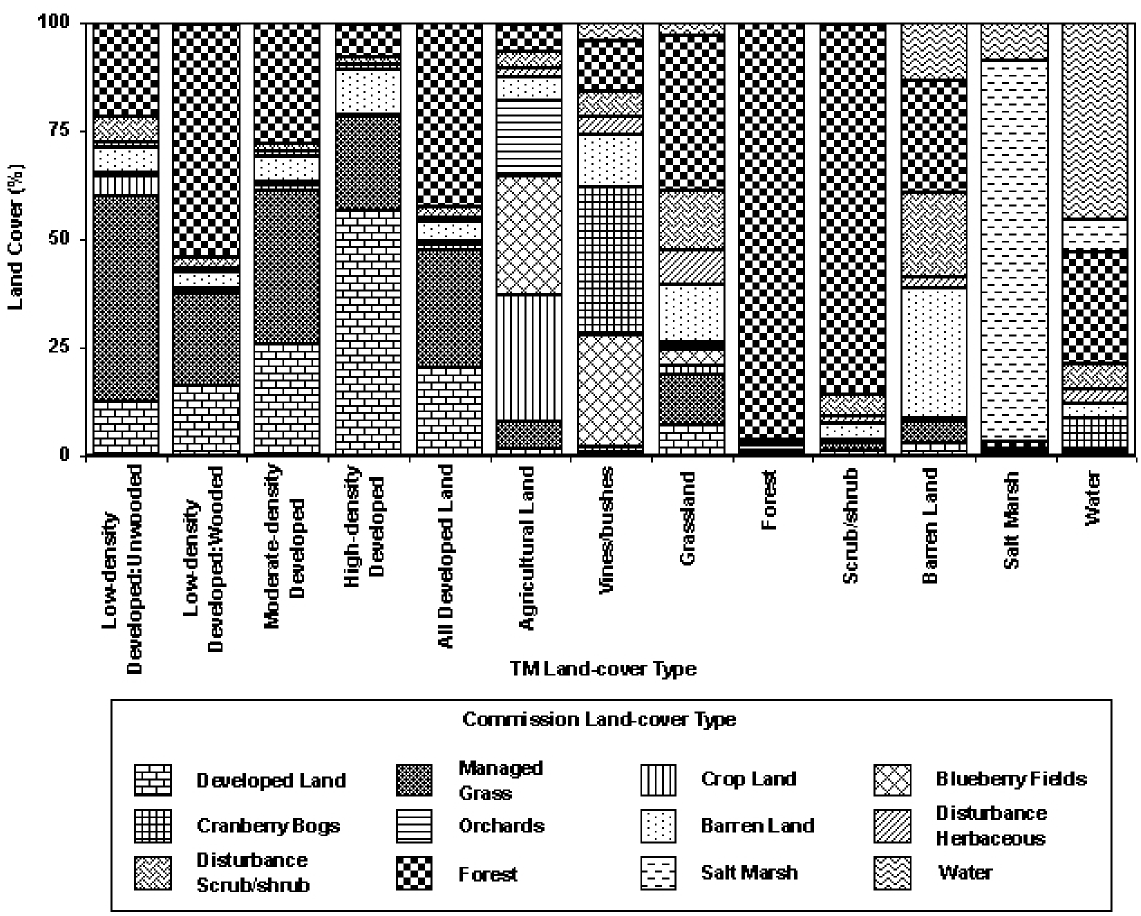

Figure 2.8. Land-cover composition of 1991 Landsat Thematic Mapper (TM) cover types in 72 photoplots in the Mullica River Basin. Refer to Table 2.1 for details regarding TM land-cover types.

Summary and Conclusions

This study indicated that the major land-cover transitions between 1979 and 1991 were the loss of forest land to development and associated cover types and the conversion of one agricultural type to another. These landscape changes were consistent with those permitted in Commission management areas. The larger increases in development-related covers were limited to management areas where growth is encouraged. Agricultural transitions occurred in Regional Growth Areas, Agricultural Production Areas, and Special Agricultural Production Areas. Resource extraction and timber harvest operations were concentrated in the Special Agricultural Production Areas and the Preservation Area District.

The verification of the accuracy of the NJDEP impervious-surface estimates and the characterization of the land-cover composition of individual land uses is important because the NJDEP map is a statewide coverage that has many applications. Impervious land cover has been recently recognized as a major indicator of the status of environmental conditions. The land-cover composition of individual NJDEP land uses can be used to create models that better quantify the impacts of developed land-use disturbance on ecosystem function. Although some cover types were classified more accurately than others in the TM map, the results of the TM map characterization indicated that satellite imagery has potential for landscape monitoring in the Pinelands.

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3 Atlantic White Cedar Swamp Landscapes

Introduction

Atlantic white cedar (*Chamaecyparis thyoides*) swamps are valued for their ecological, cultural, and economic qualities (Little 1951, McCormick 1979, Wander 1981, Reinert and Zappalorti 1988, Roman et al. 1990, Craig and Dobkin 1993, Mylecraine and Zimmermann 2000). Various estimates of the extent of Pinelands cedar swamps indicate that these wetlands have declined since European colonization (Mylecraine and Zimmermann 2000). This decline has been attributed to conversion to other wetland vegetation types, due primarily to disturbances such as timber harvesting and fire (Little 1950, Roman et al. 1990), or gradual replacement by hardwoods in the absence of disturbance (Little 1950).

To assess the status of Atlantic white cedar swamps in the Mullica River Basin, Commission and Rutgers University scientists used recent satellite imagery, aerial photography, and a geographic information system to detect landscape changes in these wetlands from 1930 through 1991 (Zampella and Lathrop 1997). A parallel study analyzed the size-class structure of swamps included in the landscape survey to determine if there is any evidence that cedar-swamp succession is controlled by hardwood replacement (Zampella et al. 1999). The results of both studies are summarized in this chapter.

Landscape Changes in Cedar Swamps

Landsat Thematic Mapper digital imagery from 1991 was used to create an initial cedar inventory for the landscape-change study (Zampella and Lathrop 1997). A total of 1286 separate cedar swamp complexes covering 7058 ha were mapped. Thirty-two sites were chosen from this pool by randomly selecting complexes representing a range of swamp size classes. A 61-year (1930-1991) trend analysis of the selected cedar-swamp complexes was completed using aerial photography from seven periods (Table 3.1). For each period, homogenous patches were delineated and classified using several cover types, including cedar, swamp hardwoods, lowland pine (*Pinus rigida*), shrub wetlands (evergreen and deciduous), emergent wetlands, and water. Red maple (*Acer rubrum*) was generally the dominant tree in the swamp-hardwoods cover type. The abundance of each cover type was estimated using a cover scale where 0 = < 5%, 1 = 5-25%, 2 = 25-50%, 3 = 50-75%, and 4 > 75%. For example, a patch with 50-75% cedar cover (C), 25-50% swamp-hardwood cover (H), and 5-25% shrub cover (S) was classified as C3-H2-S1. A total of 981 cedar patches covering 1417 ha were followed throughout the 61-year period. A cedar patch was defined as a patch with cedar present during at least one of the seven time periods. Cedar patches represented 40% of the 3500 ha of vegetation mapped during the study. Disturbances associated with timber harvesting, wildfire, and flooding were also recorded for each patch.

Table 3.1. The percentage of total cedar-patch area (1417 ha) disturbed by timber harvesting, flooding, and wildfire from 1930 to 1991.

Period	Harvesting	Flooding	Wildfire
1930	6.0	0.0	0.0
1940	2.0	0.1	0.0
1951	4.4	0.0	0.0
1961/1962	4.4	0.1	0.0
1974	2.4	1.5	0.0
1978/1979	0.3	1.5	4.2
1991	0.0	1.6	0.0

The Role of Disturbance

Over the 61-year period, the composition of individual cedar patches in the Mullica River Basin changed in response to varying disturbance regimes (Table 3.1). Although less than 10% of the total cedar-patch area was disturbed during a single period, most cedar loss observed between 1930 and 1991 was associated with disturbance. Cedar harvesting was extensive before 1930, but most of the swamps harvested during that period regenerated. In later years, timber harvesting increased the likelihood that a cedar swamp would be converted to another wetland type. Deer browsing was identified as one factor that may play a role in the decline of successful cedar regeneration following a harvest. Most flooding was associated with beaver activity, and a single wildfire was responsible for the loss of 59.8 ha of cedar. Only one small patch was lost to development, and no cedar loss was associated with agricultural activities.

Landscape Trends

There was a small but consistent increase in Atlantic white cedar cover from 1930 - 1991 (Figure 3.1). This increase was associated with a decrease in shrub cover and an increase in swamp-hardwood cover. Flooding during the latter part of the study period resulted in a small increase in water and emergent-wetland cover. The total area composed of cedar patches with > 75% cedar cover (C4 patches) remained relatively constant from 1930 to 1991 (Figure 3.2). A pronounced decrease in the total area of cedar patches with < 5% cover (C0 patches) was observed.

Although the general trends in cedar-dominated patches suggested a relatively static cedar inventory, changes in the composition of individual cedar patches indicated a dynamic landscape. For individual patches, the cedar cover observed in two adjacent time periods was similar but this similarity decreased with time. The patch composition observed in 1930 was significantly different in 1991. The dominant between-period transitions were conversion of cedar to shrub cover and succession from shrub to cedar. Between 1930 and 1991, the net gains and net losses in cedar cover for the total cedar-patch area (1417 ha) was 39% and 24%, respectively. These long-term changes were also most closely related to changes in shrub cover. Replacement of cedar by hardwoods was not a major transition.

The transition from the 1930 landscape to the 1991 landscape was dominated by changes in cedar patches that displayed < 5% or > 75 % cedar cover in 1930. In 1930, the area of patches with < 5% cedar cover was dominated by shrubs, and a majority of the patches were the result of timber harvesting. The dominant trend for patches with < 5% cedar in 1930 was succession to wetlands with either 5-25% or >75% cedar cover in 1991. Patches that succeeded to wetlands with 5-25% or 25-50% cedar were dominated by hardwood, pine, and shrub cover. These patches may not have originated from disturbed cedar-dominated wetlands. There was a net loss of cedar in patches that displayed > 75% cedar cover in 1930. Most of this loss was associated with a disturbance. For these original C4 patches, the dominant transition was to shrub cover. Replacement by swamp hardwoods, which was comparatively minor, was associated with the conversion of cedar-dominated swamps to swamps with 25-50% cedar in 1991.

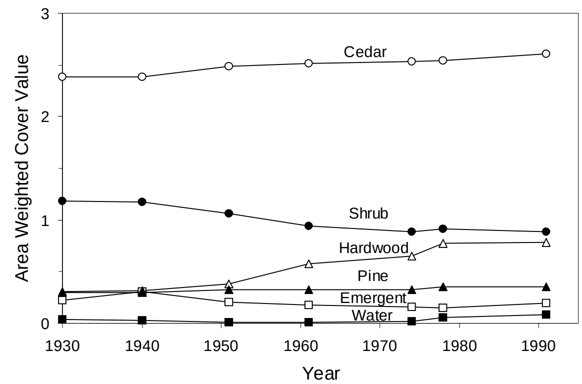

Figure 3.1. Changes in cedar-patch cover from 1930 to 1991. Area-weighted cover values for each cover type within a specific period were calculated as $\sum$ [(patch cover value)(patch area)]/total area. Modified from Zampella and Lathrop (1997).

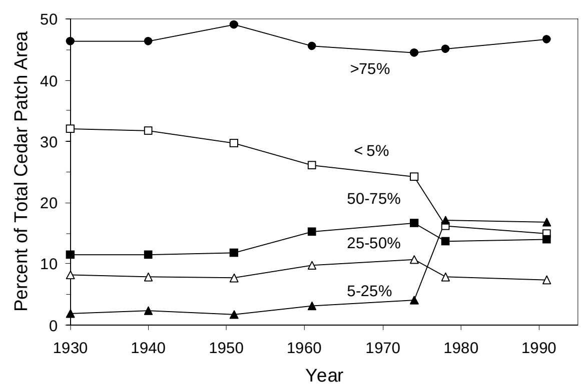

Figure 3.2. Changes in the percentage of total cedar-patch area (1417 ha) represented by patches with varying cedar abundance from 1930 to 1991. Cedar abundance is expressed as ranges of percent-cover values. Modified from Zampella and Lathrop (1997).

Long-term Prospects for Sustaining Atlantic White Cedar

A major conclusion of the landscape-change study was that although the prospects for sustaining Atlantic white cedar wetlands in the Mullica River Basin are generally good, long-term success depends on many factors. The long-term effects of wildfire regimes and flooding associated with beaver activity are impossible to predict. The successful regeneration of swamps harvested before 1930 suggests that timber harvesting and maintaining a dynamic cedar inventory are not incompatible. During the 61-year period, net cedar losses were balanced primarily by regeneration of areas that were disturbed before 1930. However, due to the lack of successful regeneration of more recently harvested swamps, the possibility that future disturbances may result in a net loss of cedar swamps must be recognized and the post-harvest management of swamps, including deer exclusion and control of competing vegetation, should be emphasized. Replacement of cedar by hardwoods in undisturbed cedar swamps was not as common as generally considered, which indicates that cedar harvesting to rejuvenate stands is not necessary to maintain these wetlands. Finally, restoration of cedar in emergent or shrub wetlands previously dominated by cedar was proposed as a management strategy with both economic and ecological advantages.

Hardwood Recruitment in Atlantic White Cedar Swamps

A widely cited assumption is that in the absence of disturbances, Atlantic white cedar is eventually replaced by hardwoods as individual cedar trees die (Buell and Cain 1943, Little 1950, Motzkin et al. 1993). However, the landscape-level study of Mullica River Basin cedar swamps (Zampella and Lathrop 1997) indicated that replacement of cedar by hardwoods did not generally occur in the absence of large-scale disturbances. To determine if on-site conditions supported these findings, Commission and Rutgers scientists analyzed the size-class structure of 39 cedar patches selected from the landscape-level inventory (Zampella et al. 1999). In the absence of disturbance, analysis of size-class data can provide an indication of the potential contribution of a tree species to the next generation of canopy species (Harper 1977, Veblen 1992).

All 39 patches chosen for study displayed > 75% cedar-canopy cover in 1991 and were established before 1930 as determined by inspection of aerial photography. Two to twelve 100-m^2 plots were established in each patch and the diameters of all tree stems greater than 1-m tall were measured. These data were used to determine the mean size-class distribution, mean stem density, and mean basal area of each tree species for each patch.

The study addressed two related questions. First, is cedar or any of the associated hardwoods able to reproduce in these patches? Second, is the overall abundance of associated tree species in these patches and their potential to replace cedar related to cedar size-class structure?

Patch Structure

More than 90% of the total basal area in all 39 patches was composed of Atlantic white cedar. Standing-dead cedar trees were found in all patches. Hardwood species, which included red maple, blackgum (*Nyssa sylvatica*), sweetbay (*Magnolia virginiana*), and grey birch (*Betula populifolia*), occurred at low densities and contributed little to total basal area. Red maple was the most common hardwood species. Small-diameter stems (<10 cm) of all tree species, which represent potential canopy recruits, occurred at low frequencies. Stems with a diameter of 2.5-4.9 cm represented the majority of cedar and maple stems that were < 5 cm in diameter. For red maple, relative basal area, canopy cover, the density of large-diameter ($\geq$10 cm) stems, and the relative density of small (< 10 cm) and large ($\geq$10 cm) diameter stems (expressed as a percentage of total small-diameter and large-diameter cedar and maple stems) increased in relation to increasing cedar-stem size and decreasing cedar-stem density.

Cedar Succession

For most patches, the cedar size-class distribution patterns were characteristic of self-thinning, even-aged stands. Indications that the cedar swamps were senescent were generally lacking. Although several red maple structural attributes increased in relation to increasing cedar-stem size and decreasing cedar-stem density, the absolute density of 5-9.9 cm diameter cedar was greater than that of red maple, and the difference in the absolute density of < 5 cm diameter maple and cedar stems was not significant. Of greater importance was the observation that red maple was not common in the understory and was a minor component of all 39 cedar stands. None of the hardwood species occurred at densities that would permit it to quickly exploit canopy gaps created by the death of cedar. A conclusion of the study was that hardwood replacement of cedar in swamps is not a certain outcome of cedar-swamp succession. If it does occur, it may take centuries and only result in conversion to mixed stands dominated by cedar.

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PART 2
WATER RESOURCES

4 WATER QUALITY

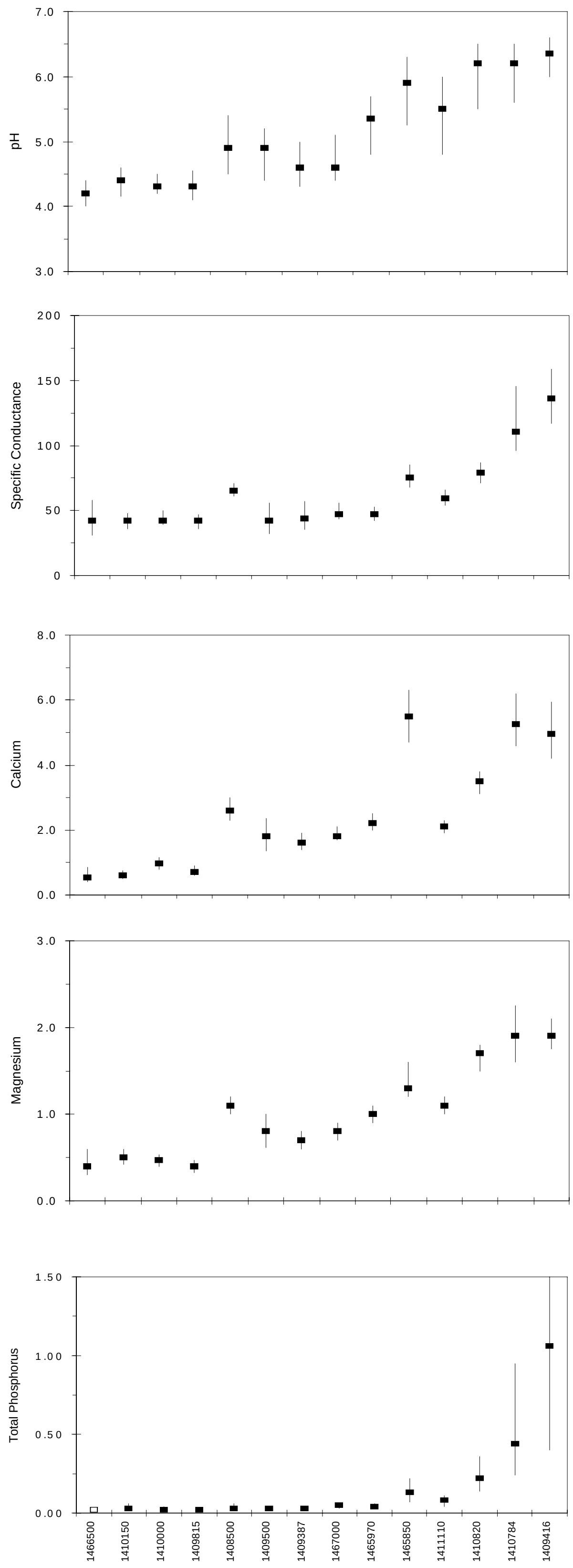
INTRODUCTION

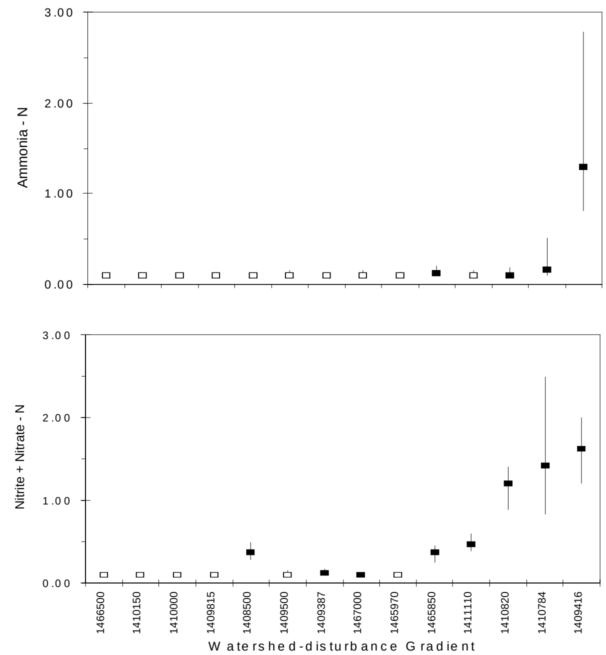
The surface-water quality associated with undisturbed watersheds represents a major component of the essential character of the Pinelands region. Streams draining forested watersheds are typically acidic and nutrient-poor (Morgan and Good 1988, Zampella 1994). In contrast, streams draining upland agriculture and developed lands display elevated pH and dissolved-solid concentrations (Morgan and Good 1988, Watt and Johnson 1992, Zampella 1994, Johnson and Watt 1996). Invasion of the region's aquatic and wetland plant communities by nonnative species and the loss of native species are among the biological consequences of water-quality degradation (Morgan and Philipp 1986, Ehrenfeld and Schneider 1991, Patrick 1996, Zampella and Laidig 1997). Furthermore, the acid waters that characterize streams in forested watersheds may prevent the invasion of native fish (Hastings 1979, 1984, Graham and Hastings 1984, Gonzalez and Dunson 1987, Graham 1993, Zampella and Bunnell 1998) and amphibian communities (Gosner and Black 1957, Freda and Dunson 1986, Bunnell and Zampella 1999) by nonnative species. Because of the primary importance of water quality to the ecological integrity of the Pinelands, water-quality investigations have been a major element of the Commission's long-term environmental-monitoring program. The main focus of these studies has been the association between land-use activities, nutrient enrichment, and changes in pH. In this chapter, previously published Commission studies are summarized and the results of an assessment of water-quality in the Mullica River Basin are presented.

PINELANDS WATER-QUALITY GRADIENTS

An initial Commission study (Zampella 1994) demonstrated that land-use related watershed disturbance can have a substantial effect on the natural water chemistry of Pinelands streams. The study was based on United States Geological Survey (USGS) water-quality data collected at 14 stream sites located throughout the Pinelands, including five sites within the Mullica River Basin. Analysis of the water-quality data revealed a gradient of increasing pH, specific conductance, and concentrations of dissolved calcium, dissolved magnesium, total nitrite plus nitrate as nitrogen, total ammonia as nitrogen, and total phosphorus that paralleled a watershed-disturbance gradient of increasing urban and agricultural land-use intensity and wastewater flow (Figure 4.1). Correlations among all seven water-quality attributes were high. Very low pH and nitrite plus nitrate, calcium, and magnesium concentrations distinguished water quality in the four least-disturbed streams from all other stream stations. Ammonia and total phosphorus concentrations were low at all but the most highly disturbed stream stations. The high ammonia and total phosphorus concentrations at these stations were attributed to sewage discharges. Although seasonal effects were observed for pH, calcium, magnesium, and specific conductance, the water-quality characteristics of streams located at opposite ends of the watershed-disturbance gradient remained relatively distinct regardless of the season.

The study provided a regional context in which to assess the status of Mullica River streams. The five Mullica River sites displayed a range of water quality and watershed conditions. Water quality in the East Branch Bass River near New Gretna (Stage Road), the Oswego River at Harrisville, and the West Branch Wading River at Maxwell was comparable to that of McDonalds Branch. As a USGS Hydrologic Benchmark station, McDonalds Branch in Lebanon State Forest served as a reference for water quality in undisturbed Pinelands watersheds. The high percentage of agricultural land in the Wading River (9.5%) was attributed to extensive cranberry and blueberry lands rather than upland agriculture which dominated land cover in the other basins with high agricultural-land cover. The Batsto River at Batsto and the Mullica River at the outlet of Atsion Lake displayed land-use related watershed-disturbance and water-quality characteristics intermediate between the four least-disturbed streams and the eight other sites. The Hammonton Creek at Wescoatville was the most highly disturbed of the 14 stream sites studied.





Station Number	Station Name	Sewage Flow	Percentage of Altered-land Cover
1466500	McDonalds Branch in Lebanon State Forest	0.0	0.0
1410150	East Branch Bass River Near New Gretna	0.0	3.2
1410000	Oswego River at Harrisville	0.0	6.2
1409815	West Branch Wading River at Maxwell	0.0	10.0
1408500	Toms River Near Toms River	4.4	14.7
1409500	Batsto River at Batsto	0.0	15.8
1409387	Mullica River at Outlet of Atsion Lake	0.0	16.3
1467000	North Branch Rancocas Creek at Pemberton	4.4	17.9
1465970	North Branch Rancocas Creek at Browns Mills	3.6	29.3
1465850	South Branch Rancocas Creek at Vincentown	4.6	33.6
1411110	Great Egg Harbor River at Weymouth	5.4	35.9
1410820	Great Egg harbor River near Blue Anchor	21.4	43.3
1410784	Great Egg Harbor River Near Sicklerville	53.0	47.0
1409416	Hammonton Creek at Wescoatville	76.0	72.6

Figure 4.1. Pinelands surface-water quality gradients. Sites are ordered along the watershed-disturbance gradient by increasing percentage of altered-land cover and sewage flows (1000/gal/day/mi^2). Water-quality values are medians and quartiles. Values below detection limits for total ammonia (0.10 mg L^{-1}), total nitrite plus nitrate (0.10 mg L^{-1}), and total phosphorus (0.02 mg L^{-1}) are shown as open squares. All values except pH and specific conductance (μS cm^{-1}) are in mg L^{-1}. Modified from Zampella (1994).

SPECIFIC CONDUCTANCE AND pH AS INDICATORS OF WATERSHED DISTURBANCE IN PINELANDS STREAMS

A second region-wide Commission study assessed the use of field measurements of pH and specific conductance as indicators of land-use related watershed disturbance in Pinelands streams (Dow and Zampella 2000). Simple linear regression was used to relate specific conductance and pH, measured at 45 Pinelands stream sites over a two-year period (September 1992 through August 1994), to the percentage of altered land (developed land and upland agriculture) in a watershed. Developed land included all urban and residential areas. Agricultural land was limited to upland agriculture. Cranberry farms were not included in the altered-land class because lime and fertilizer applications were considered to be low compared to those of most upland-agricultural uses. In the separate regression models, altered land explained 56% of the variability in specific conductance and 48% of the variability in pH. Accounting for the dominant altered land-use type (developed land versus upland agriculture) did not significantly alter the relationships between median pH and specific conductance values and the percentage of altered land for a site. Furthermore, the water-quality/altered-land relationships did not vary significantly across subregions represented by major drainage basins (Barnegat Bay-Little Egg Harbor, Great Bay, and Great Egg Harbor Bay). The relationships obtained using median values for the two-year period were similar to those developed using data from any single-sample period within the entire study period.

Multiple regression was used to simultaneously relate specific conductance and pH to land use in a basin. This approach greatly improved the relationship between the water-quality variables and altered land in a drainage basin. The joint use of pH and specific conductance explained 79% of the variability in altered land. The results of the multiple regression analysis were used to develop a model-response plot that allows for an inverse prediction of pH and specific conductance based on the percentage of altered land in a basin (Figure 4.2).

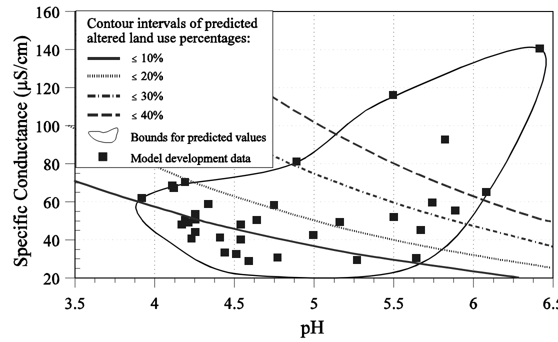


Figure 4.2. Model-response plot showing the predicted percentage of altered land (developed land and upland agriculture) in a basin based on measurements of specific conductance and pH. The bounds for predicted values are based on the data used in the development of the model. Modified from Dow and Zampella (2000).

COOPERATIVE PINELANDS COUNTY PROGRAM

As part of a cooperative monitoring program with the Burlington County Health Department and the Atlantic County Utilities Authority, Commission scientists collected water-quality data at 32 sites within the Mullica River Basin. The water-quality data collected at these sites between 1988 and 1994 are summarized in Dow (1996). The field and laboratory methods used in the program are also described in this report. Although sampling frequency and period of record varied among sites, there was no systematic seasonal bias in the sampling frequency. Water-quality parameters measured at all 32 sites included pH, specific conductance, dissolved oxygen, nitrite plus nitrate as nitrogen, and ammonia as nitrogen. Total phosphorus was measured as phosphate at 26 sites and as phosphorus at the remaining six sites. Dissolved calcium and dissolved magnesium were also measured at 26 sites.

A limitation of the cooperative Pinelands water-quality monitoring program was the use of different protocols by the county laboratories. For example, detection limits for the different forms of nitrogen varied between laboratories. Such differences prevented the comparison of water quality in streams located within the different counties. To enhance regional and national consistency, the Commission embarked on a cooperative venture with the USGS to characterize surface-water quality in the Mullica River Basin.

SURFACE-WATER QUALITY IN THE MULLICA RIVER BASIN

Through agreements with the Pinelands Commission, the USGS collected water-quality data at 18 Mullica River Basin sites from October 1995 through September 1998 (Table 4.1, Figure 4.3). The objectives of this cooperative program were to establish a comprehensive baseline-data set for the Mullica River Basin, to characterize water quality across a range of watershed conditions, and to relate water quality to land-use patterns. The USGS and the New Jersey Department of Environmental Protection (NJDEP) independently collected water-quality data at eight additional sites in the basin (Table 4.1, Figure 4.3). Four of these eight sites were sampled for only one year during the three-year study period. The 26 stations were monitored from four to six times each year. Instantaneous stream-discharge measurements were also made at 24 of the 26 stations. Specific conductance, pH, calcium, magnesium, chloride, sulfate, nitrite plus nitrate as nitrogen, ammonia as nitrogen, and total phosphorus were among the water-quality variables measured (Table 4.1). Dissolved orthophosphorus was also measured at the 18 Commission sites. All measurements for the Commission-USGS program were completed under baseflow conditions. The raw data for the three-year period were published in the annual USGS water-data reports (Reed et al. 1997, 1998, 1999).

The 26 drainage areas displayed a wide range of land-use conditions (Table 4.1). The percentage of total developed land, upland agriculture, and wetland agriculture in these basins ranged from 0% to 64%.

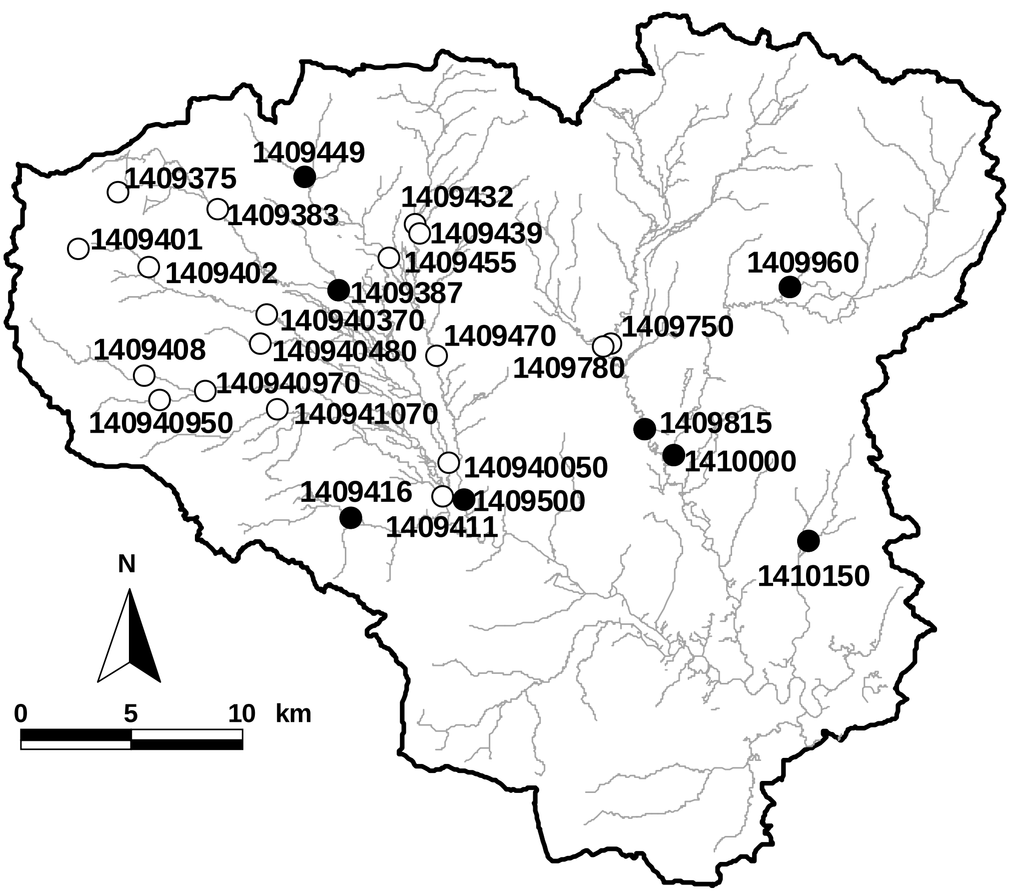


Figure 4.3. Location of USGS water quality monitoring sites and station numbers. Commission and NJDEP sites are shown as open and black circles, respectively. Refer to Table 4.1 for site descriptions.

Table 4.1. USGS water-quality monitoring stations in the Mullica River Basin. Median water-quality values are for a 3-yr period (October 1995 - September 1998) except as noted. All medians except pH and specific conductance (SC, μS cm^{-1}) are mg L^{-1}. Refer to Figure 4.3 for site locations.

		Land Use			Median Water-quality Values								
Stream Station	Station Number	Developed Land	Upland Agriculture	Wetland Agriculture	pH	SC	Calcium	Magnesium	Chloride	Sulfate	Ammonia	Nitrate	Total P
Oswego River basin													
Papoose Branch near Sim Place (1)	1409960	0.0	0.0	0.0	4.2	39	0.50	0.30	3.3	3.3	< 0.03	< 0.05	< 0.01
Oswego River at Harrisville (2)	1410000	1.0	0.6	0.9	4.3	51	0.62	0.43	4.6	7.1	< 0.03	0.07	0.01
Wading River basin													
Tulpehocken Creek near Jenkins	1409780	0.1	0.1	0.1	4.6	33	0.42	0.27	2.9	2.7	0.02	< 0.05	< 0.01
Wading River above Tulpehocken Creek	1409750	1.2	2.5	3.8	4.5	41	0.66	0.39	4.3	5.2	< 0.03	< 0.05	0.02
Wading River at Maxwell (1)	1409815	0.9	1.8	4.9	4.4	43	0.57	0.36	4.1	4.8	< 0.03	< 0.05	0.02
Bass River basin													
East Branch Bass River	1410150	2.0	0.0	0.0	4.4	48	0.47	0.51	6.0	3.8	< 0.03	< 0.05	< 0.01
Hammonton Creek basin													
Hammonton Creek at Wescoatville	1409416	21.4	34.3	6.2	6.5	118	5.5	2.2	15	12	< 0.03	1.27	0.13
Nescochague Creek basin													
Pump Branch near Waterford Works	1409408	24.3	23.2	0.0	6.5	82	3.1	2.3	13	4.0	< 0.02	1.10	< 0.01
Blue Anchor Brook at Elm	140940950	23.9	27.7	0.2	7.0	73	2.9	1.5	10	5.6	< 0.02	0.11	0.03
Albertson Brook near Elm	140940970	22.0	24.9	0.1	6.4	74	3.1	2.0	11	6.1	< 0.02	0.84	< 0.01
Great Swamp Branch	140941070	12.6	49.7	1.2	6.2	122	8.3	3.8	11	20	0.02	2.25	< 0.01
Nescochague Creek at Pleasant Mills	1409411	16.4	29.3	1.1	5.7	67	3.1	1.8	9.3	8.4	< 0.02	0.32	< 0.01
Sleeper Branch basin													
Hays Mill Creek at Atco	1409401	35.7	14.3	1.7	6.8	104	4.8	2.4	17	6.6	< 0.02	0.58	< 0.01
Hays Mill Creek near Chesilhurst	1409402	36.7	10.1	0.9	6.5	97	3.6	1.8	16	6.5	< 0.02	1.05	< 0.01
Sleeper Branch near Atsion	140940370	22.8	8.6	0.5	5.9	63	2.1	1.2	10	4.7	< 0.02	0.51	< 0.01
Clark Branch near Atsion	140940480	12.4	24.1	0.4	4.6	63	2.6	1.4	7.6	9.3	< 0.02	< 0.05	< 0.01
Mullica River basin													
Mullica River near Atco	1409375	42.2	6.9	0.0	6.8	123	4.9	1.9	22	9.6	< 0.02	0.40	< 0.01
Mullica River at Jackson Road	1409383	13.3	3.9	3.1	4.5	70	1.2	0.62	9.0	3.9	< 0.02	< 0.05	< 0.01
Mullica River at outlet of Atsion Lake	1409387	9.5	2.8	2.0	4.5	51	1.2	0.62	6.2	5.3	< 0.03	0.11	< 0.01
Mullica River at Constable Bridge	140940050	6.5	4.7	2.2	5.0	45	1.2	0.70	6.8	4.3	0.02	0.07	< 0.01
Basto River basin													
Batsto River at Hampton Furnace	1409432	3.6	14.2	4.4	5.2	49	1.7	1.1	5.3	6.0	< 0.02	0.42	< 0.01
Skit Branch at Hampton Furnace	1409439	0.4	0.8	2.7	4.5	31	0.37	0.26	3.0	3.6	< 0.02	< 0.05	< 0.01
Indian Mills Brook (1)	1409449	22.4	29.1	0.8	6.8	100	5.9	2.7	13	11	< 0.03	0.30	0.08
Springers Brook near Hampton Furnace	1409455	17.0	23.2	1.7	6.3	112	6.4	2.9	15	13	< 0.02	0.14	< 0.01
Batsto River at Quaker Bridge	1409470	6.5	11.3	2.2	5.4	50	2.2	1.2	6.5	5.8	< 0.02	0.14	< 0.01
Batsto River at Batsto	1409500	5.4	9.3	1.8	4.8	54	2.0	0.99	6.0	8.0	< 0.03	0.14	< 0.01

(1) Period of record (October 1997 - September 1998) (2) Period of record (October 1995 - September 1996)

Streams in the five least-altered drainage basins were selected as reference-stream sites, which are stream-sites that are minimally impacted by land-use related disturbances. The five reference-stream sites were Papoose Branch, Tulpehocken Creek, Skit Branch, Oswego River, and East Branch Bass River. Upland agriculture plus developed land did not exceed two percent in any of these basins. Wetland-agriculture cover ranged from 0% to 2.7%. The five most heavily altered watersheds, excluding Hammonton Creek, were selected to represent degraded-stream sites. These sites included the Mullica River near Atco, Hays Mills Creek at Atco, Indian Mills Brook, Blue Anchor Brook, and Great Swamp Branch. Upland agriculture and developed land in these five basins ranged from 49% to 62% and 13% to 42%, respectively. Wetland-agriculture cover was less than two percent. The Hammonton Creek basin was also heavily altered and was the only drainage with a point-source wastewater discharge. Above the Hammonton Creek monitoring site, 56% of the land use in the basin was developed land and upland agriculture. An additional 6.2% of the drainage was wetland agriculture.

Data Analysis

First, second (median), and third quartiles and the 10th and 90th percentiles were calculated for specific conductance, pH, calcium, magnesium, chloride, sulfate, nitrite plus nitrate, ammonia, dissolved orthophosphorus, and total phosphorus. Censored values (values that are below laboratory detection limits) were reported for calcium, nitrite plus nitrate, ammonia, and total phosphorus. Calcium was reported as below detection limit (< 0.10 mg L^{-1}) at only two sites on a single date. The detection limit for nitrite plus nitrate was 0.05 mg L^{-1}. Although the ammonia detection limit for the 18 Commission-USGS stations was reported by the USGS as either 0.01, 0.015 or 0.02 mg L^{-1}, the actual detection-limit value was constant at 0.02 mg L^{-1} over the three-year period (Jacob Gibs, personal communication). The ammonia detection limit for the eight NJDEP-USGS stations was 0.03 mg L^{-1}. The detection limit for orthophosphorus was 0.01 L^{-1}. A detection limit of 0.01 mg L^{-1} was used for total phosphorus on all but one date when a limit of 0.05 mg L^{-1} was used at six sites. These six phosphorus values were deleted when calculating the statistics for those sites. All other censored values were equated to zero when calculating the summary statistics, but detection limits were used when reporting the results.

Forward stepwise regression was used to relate median pH, specific conductance, calcium, magnesium, sulfate, and chloride values to the percentage of developed land, upland agriculture, and wetland agriculture in each drainage basin. Land-use profiles were prepared using the NJDEP 1995/1997 land-use/land cover data (Chapter 1). Nitrite plus nitrate, ammonia, and total phosphorus were not included in the regression analyses due to the high frequency of censored values. Correlation analysis was used to evaluate associations between the different water-quality attributes included in the regression analyses.

Results

Water-quality conditions recorded for the 26 stream sites were clearly related to watershed conditions (Figure 4.4, Table 4.1). Except for ammonia, the water-quality attributes increased along the watershed-disturbance gradient characterized by increasing developed-land and upland-agriculture cover. As suggested by the individual water-quality/land-use relationships, most variables were intercorrelated. The strikingly different characteristics of the reference-stream sites and the degraded-stream sites illustrate the effect of land-use patterns on Pinelands water-quality (Table 4.2). The multiple regression analyses confirmed the trends indicated by the graphical analysis. The analysis revealed strong relationships between developed land and upland agriculture in a drainage basin and pH, specific conductance, calcium, magnesium, and chloride (Table 4.3), explaining from 84% to 89% of the variability in the water-quality variables. Compared to developed land, agricultural land accounted for a greater percentage of the variation in calcium and magnesium concentrations. Conversely, developed land explained a greater percentage of the variability in pH and specific conductance. Developed land explained 84% of the variability in chloride concentrations. The contribution of upland agriculture to the chloride model was negligible. Upland agriculture alone accounted for 53% of the variability in sulfate concentration. Wetland agriculture was not retained in any of the models. The percentage of wetland agriculture in the drainage basins that were monitored did not exceed the level above which developed land or upland agriculture would be expected to have an effect.

Table 4.2. Land-use and water-quality characteristics of five reference-stream sites, five degraded-stream sites, and Hammonton Creek. All values are medians.

Factor	Reference Sites	Degraded Sites	Hammonton Creek
Upland agriculture (%)	< 1.0	27.7	34.3
Wetland agriculture (%)	< 1.0	< 1.0	6.2
Developed land (%)	< 1.0	23.9	21.4
Total altered land (%)	2.0	51.7	61.9
Calcium, dissolved (mg L^{-1})	0.47	4.9	5.5
Magnesium, dissolved (mg L^{-1})	0.30	2.4	2.2
Chloride, dissolved (mg L^{-1})	3.3	13	15
pH (standard units)	4.4	6.8	6.5
Specific conductance (μS cm^{-1})	39	104	118
Sulfate, dissolved (mg L^{-1})	3.6	9.6	12
Ammonia-N, dissolved (mg L^{-1})	< 0.03	< 0.03	< 0.03
Nitrite + nitrite-N, dis. (mg L^{-1})	< 0.05	0.40	1.27
Total phosphorus (mg L^{-1})	<0.01	<0.01	0.13

The change in specific conductance, which increased from a median of 39 μS cm^{-1} for the reference-site streams to a median of 104 μS cm^{-1} for the degraded-stream sites, reflected the increases in the concentrations of major ions along the Mullica River Basin watershed-disturbance gradient. Specific conductance, which is expressed in microsiemens per centimeter (μS cm^{-1}) at 25°C, is a measure of the ability of water to conduct an electrical current. It is related to the type and concentration of ions present. Calcium, magnesium, sodium, potassium, chloride,

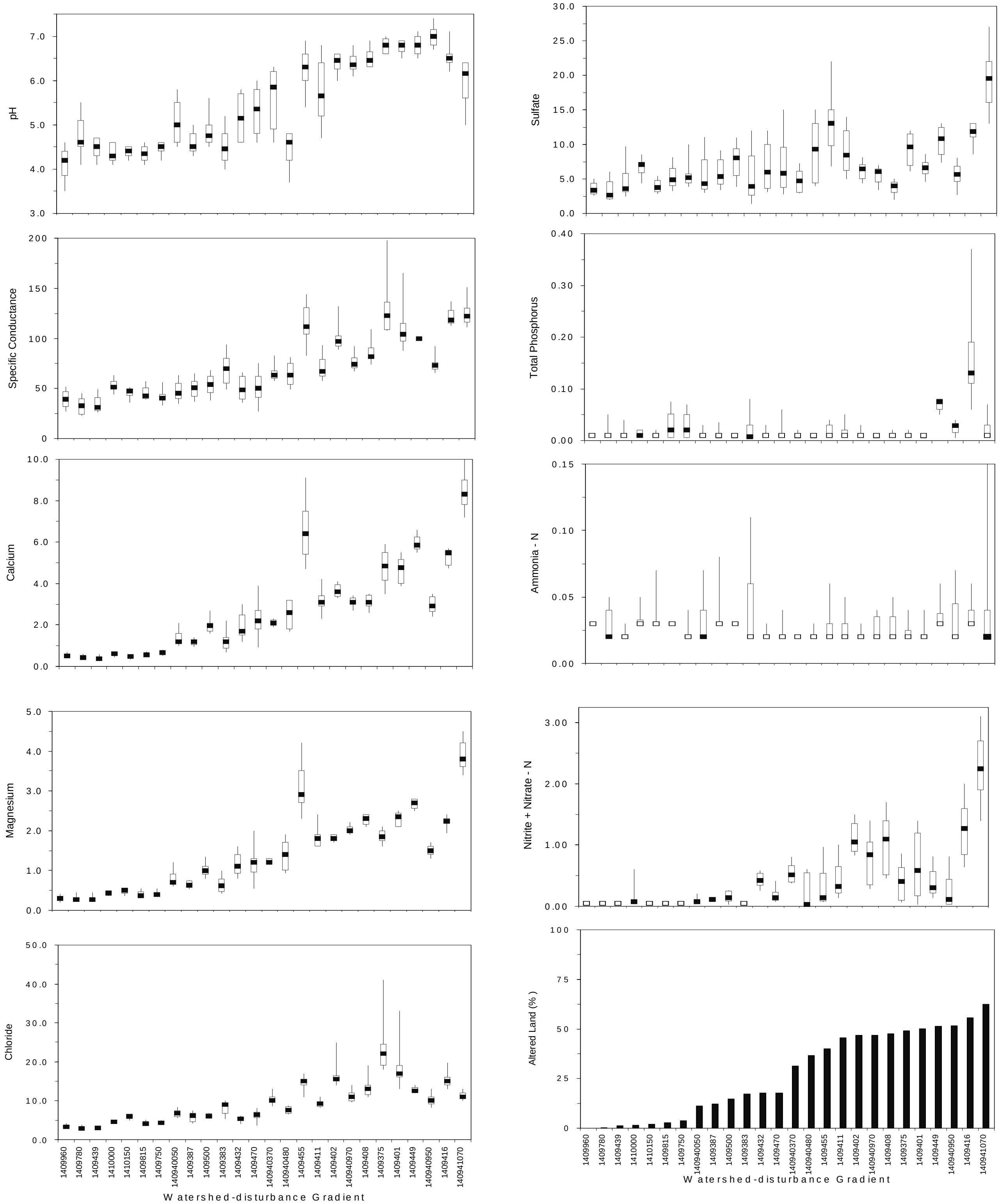


Figure 4.4. Mullica River Basin surface-water quality gradients. Sites are ordered along the watershed-disturbance gradient by increasing percentage of altered-land cover (developed land and upland agriculture). Water-quality values are medians, quartiles, and 10^{th} and 90^{th} percentiles. Values below detection limit for ammonia - N (0.02 or 0.03 mg L^{-1}), nitrate + nitrite - N (0.05 mg L^{-1}) and total phosphorus (0.01 mg L^{-1}) are shown as open squares. All values except pH and specific conductance ($\mu S\ cm^{-1}$) are in mg L^{-1}. Stream-station names are given in Table 4.1.

Table 4.3. Results of the multiple-regression analysis relating land use to water quality. All units except pH are common log values.

	R-square Values			Regression Coefficients		
	Total	Upland Agriculture	Developed Land	Intercept	Upland Agriculture	Developed Land
pH, field (standard units)	0.863	0.114	0.750	4.277	0.028	0.057
specific conductance, field ($\mu S\ cm^{-1}$)	0.840	0.144	0.696	1.592	0.006	0.009
calcium, dissolved ($mg\ L^{-1}$)	0.882	0.647	0.235	-0.233	0.019	0.017
magnesium, dissolved ($mg\ L^{-1}$)	0.894	0.693	0.202	-0.414	0.018	0.014
chloride, dissolved ($mg\ L^{-1}$)	0.891	0.046	0.844	0.606	0.004	0.016
sulfate, dissolved ($mg\ L^{-1}$)	0.533	0.533	-------	0.630	0.011	-------

and sulfate ions contribute significantly to conductance in most Pinelands waters.

Unlike most freshwater systems, weathering of carbonate rock is not a major source of calcium and magnesium in Pinelands streams (Morgan and Good 1988). Yuretich et al. (1981) attributed elevated calcium and magnesium levels in the Mullica River and the Batsto River to possible deep ground-water contributions. Morgan and Good (1988), who more accurately characterized the extent of agricultural and developed land in the headwaters of these two streams, associated the elevated levels of calcium and magnesium with land-use related watershed disturbance. The same pattern has been observed along a wide range of Pinelands watershed conditions (Zampella 1994). Liming is one potential source of these two base cations (Johnson and Watt 1996).

Marine aerosols are a source of sodium and chloride in both disturbed and undisturbed Pinelands streams (Morgan and Good 1988, Yuretich et al. 1981), but the increase in chloride along the watershed disturbance gradient probably reflects land-use patterns. Hay and Campbell (1990) and Robinson et al. (1996) reported a state-wide increase in chloride in New Jersey streams, including several Mullica River sites, from 1976 through 1986. Trends in concentrations of both sodium and chloride were associated with application rates of road-deicing salts (Robinson et al. 1996).

The Pinelands support an acid-water flora and fauna which suggests that undisturbed Pinelands waters have always been acidic (Kaufman et al. 1988, Morgan 1991). Due to acid deposition, current acidity is controlled primarily by sulfate, with naturally occurring dissolved organic carbon playing an important role (Morgan 1991). The inverse relationship between sulfate concentrations and pH suggests that other processes are influencing pH in basins disturbed by developed land and upland agriculture. Elevated pH in degraded streams appears to be related to increases in base cations and alkalinity. Enhanced primary productivity associated with nutrient enrichment may also play a role (Morgan 1985).

Although orthophosphorus was detected at all 18 Commission monitoring sites on at least one occasion, median concentrations did not exceed the 0.01 $mg\ L^{-1}$ detection limit at any site. Median total phosphorus concentrations equaled or exceeded the 0.01 $mg\ L^{-1}$ detection limit in six streams. Three of these streams, which included Hammonton Creek, Indian Mills Brook, and Blue Anchor Brook, drained watersheds with more than 50% altered land in the drainage basin. The three other stream sites are the two Wading River stations and the Oswego River at Harrisville. The Oswego River is one of the five reference-stream sites. Total altered land in the two Wading River drainage basins is about 7.5%, with wetland agriculture representing the dominant altered-land use.

Median ammonia values were below detection limit at all but three stream sites where the median concentration was 0.02 $mg\ L^{-1}$. No clear relationship between this form of nitrogen and land-use was apparent. In the Pinelands, elevated phosphorus and ammonia levels have usually been associated with direct sewage discharges (Fusillo 1981, Schornick and Ram 1978, Zampella 1994). The low ammonia levels observed across the nonpoint source land-use disturbance gradient are consistent with Morgan and

Good's (1988) conclusion that watershed disturbance had no effect on this nutrient.

Carter (1998) estimated nonpoint source phosphorus and nitrogen loads for five New Jersey Coastal Plain drainage basins, including the Mullica River Basin. With the exception of the Mullica River Basin, urban land use was the most significant contributor to nonpoint nitrogen and phosphorus loads. For the Mullica River Basin, the modeling exercise indicated that agricultural lands were a significant source of these two nutrients.

Howes and Teal (1995) reported that a 15 ha cranberry bog in Massachusetts was a net source of inorganic nitrogen and phosphorus to an outflowing stream. Ammonia accounted for most of the dissolved inorganic nitrogen exported from the bogs. Concentrations of ammonia and acid-leachable phosphate in outflowing waters were about four times the inflowing concentrations.

With one exception, the Oswego River at Harrisville, nitrite plus nitrate was below the 0.05 mg L^{-1} detection limit at the five reference-stream sites. A median value of 0.07 mg L^{-1} was recorded for the Oswego River. Nitrite plus nitrate was detected in most streams with more than 10% altered land in the basin. The highest median concentrations were reported from Great Swamp Branch (2.25 mg L^{-1}) and Hammonton Creek (1.27 mg L^{-1}), the two most heavily degraded stream sites. Nonpoint sources of nitrites and nitrates include fertilizers and septic tanks. Stackelberg et al. (2000) reported that nitrate concentrations in water samples drawn from shallow Kirkwood-Cohansey monitoring wells in undeveloped areas were less than 1.0 mg L^{-1} compared to median concentrations of 3.0 mg L^{-1} and 13 mg L^{-1} for urban and agricultural land, respectively. Szabo et al. (1997) also found elevated nitrate concentrations in Kirkwood-Cohansey wells associated with agricultural land. The effect of nonpoint sources of nitrite plus nitrate on Hammonton Creek is complicated by the existence of a direct sewage discharge.

Drainage-basin Characterizations

Wading River, Oswego River, and Bass River

The six monitoring stations in the Wading River, Oswego River, and Bass River consistently displayed low pH and low ion concentrations (Table 4.1). Dissolved calcium and magnesium concentrations ranged from 0.42 to 0.66 mg L^{-1} and 0.27 to 0.51 mg L^{-1}, respectively. Median chloride concentrations ranged from 2.9 to 6.0 mg L^{-1}, with the highest value reported for the East Branch Bass River. Median sulfate concentrations were variable, ranging from 2.7 to 7.1 mg L^{-1}. The sulfate concentrations for the two Wading River stations and the Oswego River at Harrisville were within the range reported for sites in the more heavily impacted western drainage basins. Both specific conductance and pH reflected characteristic Pinelands values. Median pH ranged from 4.2 to 4.6. The highest median specific conductance value was 51 $\mu S\ cm^{-1}$. Nitrite plus nitrate concentrations were below the 0.05 mg L^{-1} detection limit at all sites except Oswego River at Harrisville. A median value of 0.07 mg L^{-1} reported for this station represented five measurements made over a one-year period. The detection limit for this nitrogen species was exceeded on four of the five dates. Median ammonia levels were below the detection limits at all but Tulpehocken Creek where the median values was 0.02 mg L^{-1}. This basin is entirely within Wharton State Forest. Median total phosphorus concentrations equaled or exceeded the 0.01 mg L^{-1} detection limit at the Wading River above Tulpehocken Creek and the Oswego River at Harrisville stations. The median total phosphorus value for the Wading River at Maxwell also exceeded the detection limit. However, this median was based on only four samples which included two below detection limit values. Except for the elevated phosphorus and ammonia concentrations, water quality at the stream stations within the Wading River, Oswego River, and Bass River was characteristic of undisturbed Pinelands waters.

Hammonton Creek

Of the streams sampled, Hammonton Creek was the only one receiving a direct wastewater discharge. Developed land and upland agriculture covered more than one-half of this basin. Overall, the water quality reported for this stream was among the most degraded of all streams in the Mullica River Basin. The concentrations of all chemical constituents were elevated at this site (Table 4.1). Median pH and specific conductance values were 6.5 and 118 $\mu S\ cm^{-1}$. The median total phosphorus level of 0.13 mg L^{-1} was the highest reported for the Mullica River Basin. Median nitrite plus nitrate concentrations were also high at 1.27 mg L^{-1}. The median ammonia concentration did not exceed the 0.03 mg L^{-1} detection limit.

Nescochague Creek

Five stations were monitored in the Nescochague Creek basin. Streams in this basin displayed a range of water-quality conditions (Table 4.1). Great Swamp Branch was clearly the most degraded stream sampled during the 3-yr period. The basin is heavily altered, with 50% of the area covered by upland agriculture. Median calcium, magnesium, sulfate, and nitrite plus nitrate concentrations were the highest reported for the Mullica River Basin (Table 4.1). Calcium and magnesium concentrations and specific conductance were generally elevated at the other four Nescochague Creek sites, and sulfate concentrations were variable. Elevated pH was reported for all five sites, ranging from a median of 5.7 at Nescochague Creek to 7.0 at Blue Anchor Brook. Median ammonia concentrations were below the detection limit at all sites except Great Swamp Branch where a median of 0.02 mg L^{-1} was reported. Nitrite plus nitrate concentrations were consistently high, ranging from 0.11 at Blue Anchor Brook to 2.25 at Great Swamp Branch. Compared to the four tributaries, water quality in the Nescochague Creek at Pleasant Mills appeared to show some recovery.

Sleeper Branch

Water quality at the four Sleeper Branch basin stations deviated from reference-site conditions (Table 4.1). Calcium, magnesium, chloride, and nitrite plus nitrate concentrations, pH, and specific conductance were high at the two Hays Mills Creek stations. The elevated chloride concentrations may reflect the more highly urbanized character of this basin. Water-quality conditions generally improved downstream at the main-stem Sleeper Branch station, although nitrite plus nitrate remained elevated. Clark Branch represented the least disturbed stream among the Sleeper Branch basin sites. Specific conductance and pH at this site approached reference-site values. Neither ammonia nor total phosphorus exceeded detection limits at any of the Sleeper Branch basin sites.

Upper Mullica River

Overall water quality at all but one of the four Upper Mullica River stations approached reference-site conditions (Table 4.1). All four stations were located along the main-stem of the river. Degraded water quality at the Atco site reflected the high percentage of developed land in the headwaters of the basin. Except for ammonia and total phosphorus, median values for all water quality attributes were elevated at this site. Water quality improves dramatically at the Jackson Road site which is located below the confluence of the Alquatka Branch. Elevated nitrite plus nitrate concentrations at the Atsion Lake and Constable Bridge sites distinguished these two sites from Mullica River Basin reference sites. Flows from Saltars Ditch, Wesickaman Creek, and a Springers Brook diversion may have contributed to these elevated concentrations. Total phosphorus concentrations were below detection limits at all four Upper Mullica River sites.

Batsto River

Water quality was monitored at six Batsto River basin sites (Table 4.1). Conditions at these sites ranged from those found at reference sites to those associated with streams at the disturbed end of the land-use related watershed-disturbance gradient. Water quality at the Skit Branch site represented reference-site conditions. This site was characterized by low pH, specific conductance, and dissolved solid concentrations. Neither ammonia, nitrite plus nitrate, nor phosphorus exceeded detection limits at Skit Branch. Conditions found at the Indian Mills Brook and Springers Brook sites contrasted sharply with those of Skit Branch. The degraded water quality at these sites reflected the heavily altered lands in their drainage basins. Water quality reported for the three main-stem Batsto River sites was intermediate between the extremes displayed by Skit Branch and Indian Mills Brook. Median nitrite plus nitrate concentrations were elevated at all three sites, with the highest concentrations found at the Hampton Road site located above the confluence of Springers Brook and Skit Branch. Ammonia was below the detection limit at all Batsto River basin sites. Overall, water quality along the main stem of the Batsto River was comparable to that found at the Jackson Road, Atsion Lake, and Constable Bridge sites in the Upper Mullica River basin. In both basins, headwater land-use patterns continued to influence water quality at downstream sites located within extensive forested landscapes.

FIELD MEASUREMENTS OF pH AND SPECIFIC CONDUCTANCE

As an ancillary component of the Commission's biological-monitoring program, Commission scientists completed field measurements of pH and specific conductance at 103 stream sites where stream-vegetation, fish, and anurans were surveyed. A significant portion of the Wading River basin was not sampled.

Specific conductance was measured with an Orion model 122 meter and pH was measured with an Orion model 250A meter. With a few exceptions, monitoring rounds were conducted during baseflow conditions over a three to eight day period in June, July, August, and October 1999. Six sites were sampled less frequently and nine sites were sampled 10 days after the main June sampling round. Field pH and specific conductance were also measured at 47 off-stream ponds. Pond measurements were completed from March through October 1999. Individual ponds were sampled from two to eight times. All available data were used to calculate median values for each stream and pond sampling site. The complete data set is presented in Appendix 1.

Results

The relationship between stream pH and specific conductance and land-use followed the typical watershed-disturbance pattern. Both water-quality variables increased as the percentage of developed land and upland agriculture in a drainage basin increased (Figures 4.5 and 4.6). The wide range in median specific conductance values observed at sites in basins with less than 10% altered land was probably due to the very low median pH (< 4.5) found at these stream sites. The contribution of hydrogen ions to specific conductance increases exponentially in these highly acid waters, resulting in a dramatic increase in specific conductance (Figure 4.7).

Specific conductance and pH were higher on the more heavily developed and farmed western side of the Mullica River Basin (Figures 4.8 and 4.9). Reference-site conditions were associated with forested basins. With two exceptions, wetland

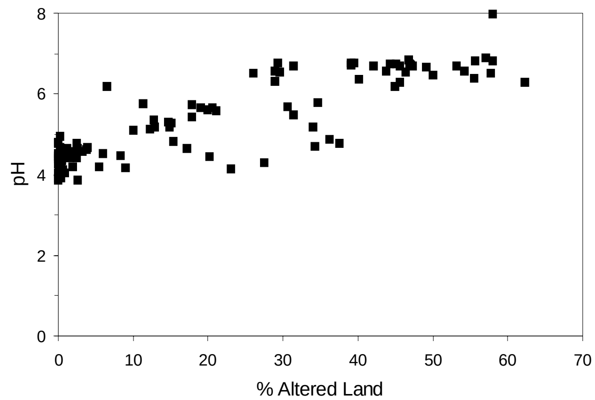


Figure 4.5. The relationship between pH and the percentage of altered land (developed land and upland agriculture) in a drainage basin for 103 stream sites in the Mullica River Basin.

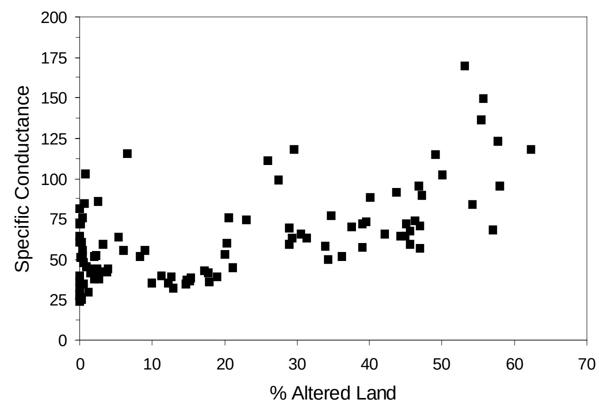


Figure 4.6. The relationship between specific conductance (μS cm^{-1}) and the percentage of altered land (developed land and upland agriculture) in a drainage basin for 103 stream sites in the Mullica River Basin.

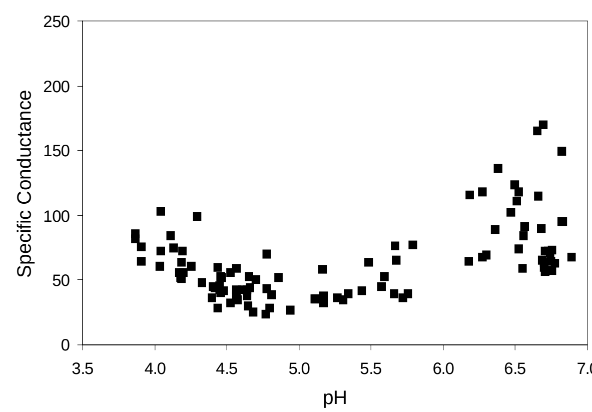


Figure 4.7. The relationship between pH and specific conductance (μS cm^{-1}) for 103 stream sites in the Mullica River Basin.

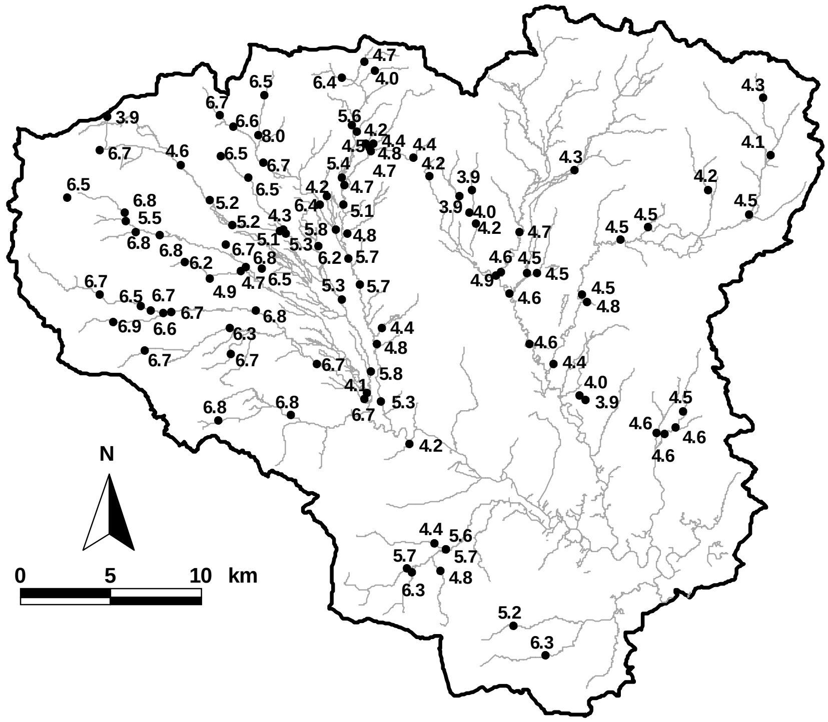


Figure 4.8. Median pH values for 103 streams sites in the Mullica River Basin.

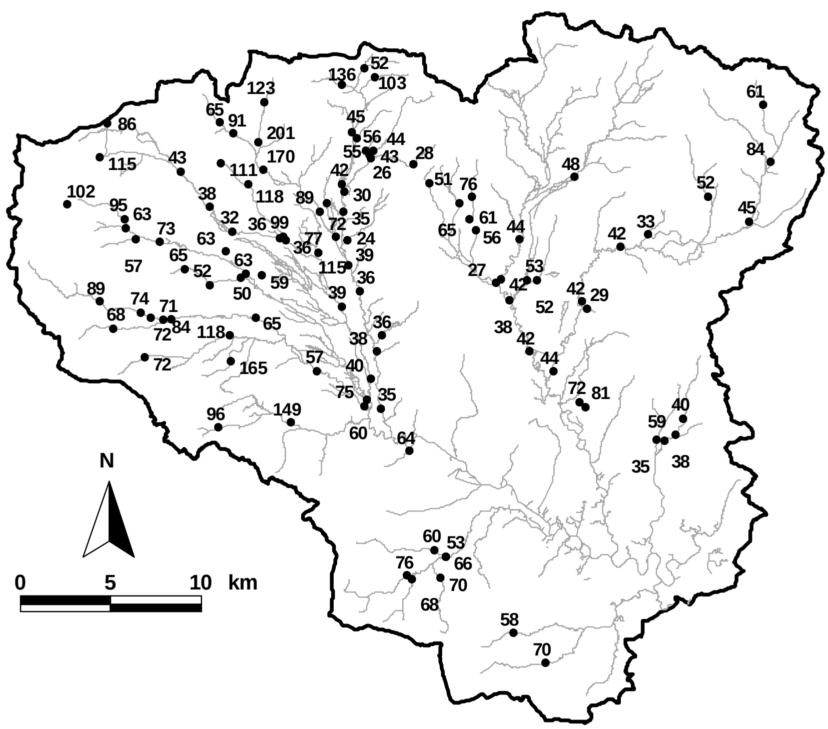
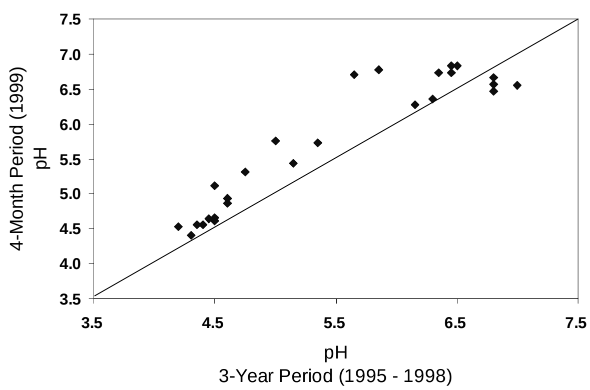


Figure 4.9. Median specific conductance ($\mu S\ cm^{-1}$) values for 103 stream sites in the Mullica River Basin.

agriculture covered less than 10% of the stream basins included in the sample. This coverage is below the level at which an effect would be expected from upland agriculture or developed land. However, two streams that drained basins with 25% to 34% wetland agriculture displayed pH and specific conductance values characteristic of Pinelands reference sites.

For the 26 USGS stream sites, the relationships obtained using median values for the four-month period were similar to those developed using data for the three-year (1995 - 1998) period. Median values for these two different periods were correlated (Figure 4.10), indicating that the 1999 data provide a good relative comparison of stream sites. Compared to the longer-term data set, specific conductance values for the four-month period were generally lower and pH values were higher. These differences probably reflect the seasonal bias of the 1999 data set, which was collected during a growing season characterized by extreme low-flow conditions.



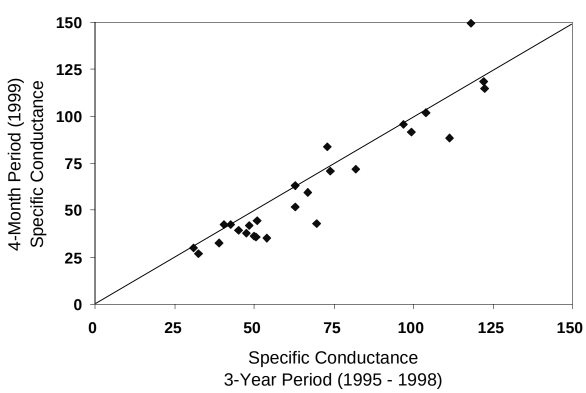


Figure 4.10. A comparison of pH and specific conductance (μS cm^{-1}) values for 26 stream sites based on data collected by the USGS over a three-year period and data collected by the Commission of a four month period.

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5 STREAM DISCHARGE

INTRODUCTION

In 1991, the Pinelands Commission, in cooperation with the United States Geological Survey (USGS) and the Camden County Municipal Utilities Authority (CCMUA), initiated a program to monitor the potential impact of interbasin transfers of wastewater on baseflows (stream flows derived from groundwater) at 12 stream sites in the western portion of the Mullica River Basin (Table 5.1, Figure 5.1). Baseflows have been measured at each site at least four times each year since 1991. The primary source of the diverted flows is groundwater pumped from individual private and public water-supply wells. Commission scientists used established trend-analysis methods to detect and quantify changes in measured discharge at the 12 stream-gaging sites for the period of May 1991 through September 1998. The results of this analysis are presented in this chapter.

METHODS

Mean daily-discharge data collected at neighboring USGS continuously monitored discharge sites, called index sites, were used in the trend analysis to remove some of the background variability in the study site discharge data before performing the trend analysis. Seasonal and annual variations in stream discharge that are unrelated to external stresses imposed by water diversions are a source of background variability. In this step, simple linear regression is used to relate discharge at a study site to that measured at an index site. The resulting regression model is then used to predict daily study-site discharge based on the measured index-site value. The difference between the predicted study-site baseflows and the actual values are referred to as residuals. A change in the residuals through time indicates that a change in baseflow conditions has occurred.

Several statistical tests can be used for the trend analysis (Helsel and Hirsch 1992). Monotonic-trend methods, including regression analysis and the nonparametric Mann-Kendall test, are used to detect gradual and continuing changes in stream discharge over time. Step-trend tests, including the two sample t-test and the nonparametric rank-sum test, are used to compare stream flows from two separate time periods. The applicability and sensitivity of these methods were assessed in a previous Commission study (Dow 1999). In this investigation, a series of simulated-baseflow reductions were imposed on McDonalds Branch in Lebanon State Forest and the East Branch Bass River in Bass River State Forest. Both sites were continuously monitored USGS stream-gaging stations. Several other continuously monitored USGS streams were used as index sites. The simulated-baseflow reductions were used to assess what minimum percentage change could be detected by the different trend tests and what factors affected the trend-detection sensitivity.

Table 5.1. Camden County stream-gaging sites in the Mullica River Basin. USGS station names have been shortened.

Station Name	USGS Station Number	Drainage Area km^2
Mullica River near Atco	01409375	8.34
Hays Mill Creek at Atco	01409401	9.84
Hays Mill Creek near Chesilhurst	01409402	18.5
Cooper Branch near Chesilhurst	0140940250	5.00
Wildcat Branch near Chesilhurst	0140940310	5.88
Sleeper Branch near Atsion	0140940370	41.7
Sleeper Branch Diversion (Saltars Ditch)	0140940365	----
Clark Branch near Atsion	0140940480	16.6
Pump Branch near Waterford Works	01409408	25.3
Blue Anchor Brook at Elm	0140940950	12.6
Albertson Brook near Elm	0140940970	44.3
Great Swamp Branch	0140941070	20.9

The results of the McDonalds Branch and Bass River simulations indicated that a long period of study is needed to detect relatively small percentage reductions in baseflow. More than eight years of quarterly discharge data were needed to detect a 10 percent reduction in mean annual discharge. More than 16 years of quarterly discharge data were needed to detect a five percent reduction in mean annual discharge. Other factors that influenced the outcome of the trend analyses included the strength of the relationship between study-site baseflows and index-site baseflows, the time intervals between samples, and missing data points.

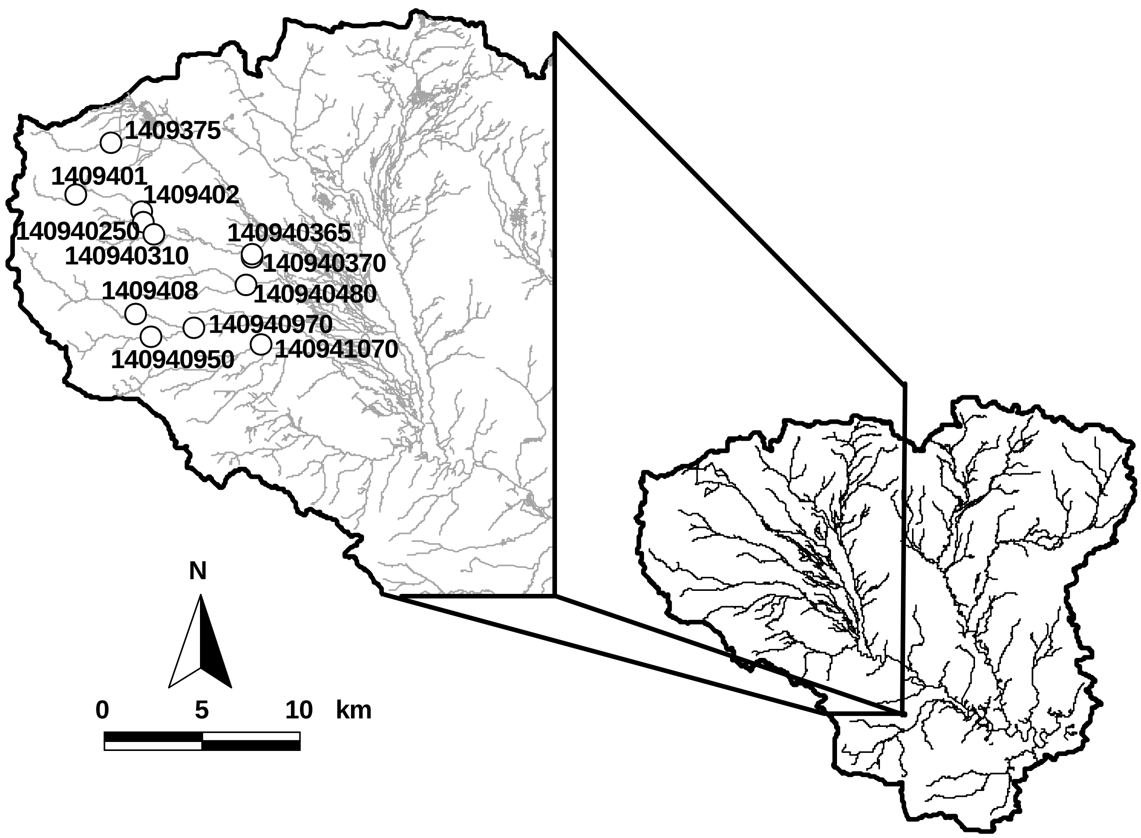

Figure 5.1. Location of USGS discharge-monitoring sites and station numbers. Refer to Table 5.1 for site names.

Results of the simulation study also indicated that monotonic-trend tests are superior to step-trend tests in the absence of a single, constant stress with a defined starting point. Based on this finding, regression analysis and the Mann-Kendall test were used to analyze the Mullica River Basin data set. An alpha level of 0.05 was used in all analyses.

RESULTS

For the study period, data on monthly sewage flow to the CCMUA's wastewater treatment facility in Camden were available for February 1995 through September 1998. The median monthly effluent flow for this period was 0.54 million gallons per day (mgd) with a maximum monthly flow of 0.88 mgd. The trend analysis found no significant changes in baseflows for any of the 12 Mullica River Basin monitoring sites indicating that the interbasin transfers occurring through the 1998 study period were below the threshold that can be detected by the statistical methods used.

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PART 3
AQUATIC AND WETLAND COMMUNITIES

6 Stream Vegetation

Introduction

It has been nearly a century since Witmer Stone (1911) wrote his seminal work on the plants of southern New Jersey. In it, he described the flora of the Pine Barrens (Pinelands) and adjacent biogeographic regions, which he called the Coast Strip, the Cape May District, and the Middle District. The Middle District is a broad region of the Coastal Plain that lies west and north of the Pine Barrens. Stone (1911) indicated that species typically found in the Middle District intruded well within the region "where extensive clearings have been effected and maintained for long periods of years..."(page 74). He also wrote that "In extensive Pine Barren settlements of long standing, as Vineland, Landisville, Hammonton, etc., a good many native plants of the Middle district have followed the weeds and become established where richer soil has been developed, and, while they are listed in the following pages [of his report], the fact of their origin should be borne in mind, and their presence at these stations should not be regarded as evidence that these species were originally found in the Pine Barrens"(page 101).

More recent Pinelands studies have shown that land-use related disturbances are associated with changes in the composition of characteristic aquatic and wetland plant communities. Based on a study of Pinelands swamps, Ehrenfeld (1983) suggested that nutrient enrichment was the most important environmental change associated with increasing land-use intensity in Pinelands watersheds. Swamp sites in developed or agricultural drainage areas lost characteristic Pinelands species and were invaded by exotic species, cosmopolitan species, and species from adjacent regions. Morgan and Philipp (1986) reported that many plant species were confined to either polluted (elevated pH and nitrate-nitrogen concentrations) or unpolluted (low pH and nitrate-nitrogen concentrations) Pinelands streams. In polluted streams, characteristic Pinelands plant species were replaced by peripheral or nonnative species. Both Ehrenfeld (1983) and Morgan and Philipp (1986) used Stone's (1911) species accounts to provide a general reference point for assessing floristic changes associated with watershed disturbances that have occurred since the earlier part of this century.

Besides documenting the effect of watershed disturbance on native Pinelands flora, the studies conducted by Ehrenfeld (1983) and Morgan and Philipp (1986) demonstrated the potential value of plant species as indicators of environmental conditions. To further evaluate the use of plants as indicators of watershed disturbance in Pinelands streams, Commission scientists completed an initial study relating stream vegetation to watershed conditions (Zampella and Laidig 1997).

Stream Vegetation as an Indicator of Watershed Conditions

The Commission's initial stream-vegetation study (Zampella and Laidig 1997) related the composition of channel and bank vegetation found at twenty Pinelands stream sites to eighteen regional and site-specific environmental variables. The stream sites, which included eighteen sites in the Mullica River Basin, displayed a wide range of water-quality conditions and drainage-basin characteristics. A total of 240 plant species were found at these sites. The complete plant-species inventory and detailed descriptions of station dimensions and locations are given in Laidig and Zampella (1996).

In this initial study, ordination techniques were used to explore stream-vegetation patterns and to relate these patterns to environmental conditions. Ordination is a term used to describe multivariate analysis methods that arrange sites along axes based on species-composition data. Species and samples (sites) are ordered along a few axes with each axis explaining some of the variation in the species-composition data. When the arrangement of sites along two axes (represented by sample scores) are plotted as a two-dimensional diagram, sites that display similar species composition generally appear close together. Thus, ordination provides an objective means of comparing species composition among sites.

Two ordination methods, detrended correspondence analysis (DCA, Hill 1979a, Hill and Gauch 1980) and canonical correspondence analysis (CCA, ter Braak 1986), were used to relate the species composition of the twenty sites to environmental gradients represented by several factors. The factors were the percentage of developed land and upland agriculture within a drainage area, specific conductance, pH, stream discharge, mean channel-water depth, mean channel width, overbank flooding, channel and bank substrate, bank tree and shrub cover, adjacent tree cover, latitude, and longitude.

With DCA, an indirect gradient analysis method, the ordination axes represent species-composition gradients. Environmental gradients are inferred from these patterns. If available, environmental data can be correlated with the sample scores for each axis. CCA represents a constrained ordination technique. It is a direct gradient analysis method that immediately relates species composition to environmental factors. The sample scores derived with CCA represent linear combinations of environmental variables that explain the greatest amount of variation in the species data.

TWINSPAN (Hill 1979b) is a classification technique that complements ordination. This widely used method partitions the points in an ordination diagram, grouping sites with similar species composition.

The results of the canonical correspondence analysis (CCA) and the detrended correspondence analysis (DCA) were similar. In both analyses, the major patterns in the plant-species composition for the twenty stream sites were related to a watershed-disturbance gradient characterized by increasing upland-agriculture and developed-land use in a drainage area, pH, specific conductance, and channel sediment. The similarity in results between DCA and CCA indicated that the environmental variables included in the CCA adequately described the main variation in the species composition revealed by DCA.

A clear difference in species composition existed between sites located in forested watersheds and those in highly developed or farmed basins. The percentage of plant species classified by Stone (1911) as Pine Barrens District species decreased along the watershed-disturbance gradient, while the percentage of Middle District species increased. Identification of sensitive species, or species found only at undisturbed sites, was complicated by high species variability among relatively undisturbed sites and the persistence of some species at more recently disturbed sites. However, stream sites in the more heavily impacted watersheds supported a unique group of peripheral or exotic plant species, comprising 29 species and referred to as disturbance-indicator species, that replaced characteristic Pine Barrens species (Table 6.1).

The Commission's initial stream-vegetation study demonstrated that the presence of disturbance-indicator species and the ranking of stream sites based on an ordination of plant-species data using DCA provide relatively good measures of land-use related watershed disturbance in Pinelands streams. These findings provided the basis and methods for a full assessment of the status of stream vegetation in the Mullica River Basin.

The Status of Stream Vegetation in the Mullica River Basin

The Commission's initial study of Mullica River stream vegetation (Zampella and Laidig 1997) established the rationale and the methods needed to conduct a comprehensive survey of the basin. The expanded monitoring program was initiated to increase the baseline inventory of Mullica River stream vegetation and to more fully characterize the status of these biological resources within the tributary systems of the basin.

Methods

Study Sites

Seventy-two Mullica River Basin stream sites were surveyed as part of the expanded stream-vegetation monitoring program. The major criteria used to select survey stations were drainage-area land-use characteristics, accessibility, and suitability as plant-survey sites. Most sites consisted of a 100-m length of stream divided into four 25-m sections. Eight sites were only 25-m long. The sampling area at each site included the channel and a two-meter wide belt transect along each bank. Due to access limitations, portions of the Wading River basin were not surveyed. The location of each sampling station was registered with a global positioning system (GPS).

Characterizing Stream Conditions

Several major drainage-basin and local-habitat attributes were characterized at each site. Specific conductance was measured with an Orion model 122 meter and pH was measured with an Orion model 250A meter (Chapter 4). Upstream land-use profiles were prepared using ArcView software and 1995/1997 land-use data, and basin areas were measured using

Table 6.1. Disturbance-indicator species in the 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	eulalia or Japanese 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

digital hydrography data (Chapter 1). Bankfull-channel width, dominant channel-bed substrate, stream-bank forest type, and adjacent-forest types were determined for each 25-m section. The dominant channel-bed substrate found within one meter of the left and right banks and in the center of the channel was subjectively characterized as gravel, sand, or muck (silt, clay, detritus, and muck). The forest type in the 2-m wide belt transect located along each stream bank was classified as hardwood swamp, Atlantic white cedar swamp, scrub cedar, pitch pine lowland, upland pine or oak forest, deciduous shrub wetland, evergreen shrub wetland, or emergent wetland. The same approach was used to categorize the adjacent-forest type located beyond the 2-m wide belt transect. For each stream site, the median bankfull-channel width was calculated and frequency of occurrence values were determined for the dominant channel-bed substrate, stream-bank forest types, and adjacent-forest types.

Plant-species Surveys

Plant-survey methods were similar to those used by Zampella and Laidig (1997). At each site, channel and bank plants were surveyed on a single occasion during each of three time periods (May-June, July-August, and September-October) covering a single growing season. All surveys were conducted from 1996 through 1999. The eighteen Mullica River Basin sites sampled during the Commission's initial stream-vegetation study were surveyed again during this period. Separate presence/absence tallies were completed for each 25-m stream section, resulting in four sampling areas for each 100-m stream station. All plants were classified as either Pine Barrens District species, Middle District species, or species found in both the Pine Barrens District and the Middle District following Stone (1911). 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 the appendix. The appendix also describes the location of each site, including latitude and longitude, the sampling dates, and the individuals who conducted the surveys. The Commission maintains a herbarium collection that includes at least one voucher specimen for each plant species collected from each of the major Mullica River Basin tributary systems.

Stream-vegetation Gradients

Detrended correspondence analysis (DCA) and TWINSPAN were used to ordinate and classify plant species and sampling sites based on presence/absence data. To limit the effect of rare species on the ordination, only species occurring at two or more sites were included in the analysis. 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, wetland agriculture, and developed land in a basin, pH, specific conductance, longitude, and channel muck. Selection of these variables was based on the results of the initial stream-vegetation study (Zampella and Laidig 1997). An alpha level of 0.05 was used to identify important relationships revealed by the correlation analysis. Because the high density of sampling sites in the basin may influence the outcome of the correlation analyses, these tests were performed primarily to evaluate general trends and the relative strength of the relationships between community gradients and environmental factors.

Results

Plant-species Surveys

A total of 305 vascular plants, including 232 herbaceous and 73 woody species, were found at the 72 stream sites. Total and herbaceous plant-species richness ranged from 21 to 90 and 10 to 69, respectively. The mean (± 1 SD) number of species found at the 72 sites was 50 ± 14. Median species richness was also 50. Eighty species were represented by a single occurrence. Sixteen stream sites accounted for more than three-quarters of these single-occurrence plant species. The other 225 species included 170 herbaceous plants and 55 woody plants.

A small number of woody and herbaceous plants were frequently encountered at the 72 stream sites. Several woody species occurred at more than half of the study sites. Among these were *Acer rubrum* (red maple), *Chamaecyparis thyoides* (Atlantic white cedar), and *Nyssa sylvatica* (black gum). Common shrubs, listed in order of decreasing frequency of occurrence, included *Clethra alnifolia* (sweet pepperbush), *Vaccinium corymbosum* (highbush blueberry), *Eubotrys racemosa* (fetterbush), *Rhododendron viscosum* (swamp azalea), *Chamaedaphne calyculata* (leatherleaf), and *Ilex glabra* (inkberry). *Smilax rotundifolia* (common greenbrier) and *Vaccinium macrocarpon* (large cranberry) were also found at a majority of the stream sites. Aquatic macrophytes that occurred in the stream channel at more that 20% of the sites and that are considered typical of the Pine Barrens included *Sparganium americanum* (slender bur-reed), *Scirpus subterminalis* (swaying bulrush or water club-rush), *Sagittaria engelmanniana* (Engelmann's arrowhead), *Juncus militaris* (bayonet rush), *Eleocharis robbinsii* (Robbin's spike-rush), *Nuphar variegata* (bullhead lily), *Orontium aquaticum* (golden club), *Eriocaulon aquaticum* (seven-angled pipewort), and *Potamogeton confervoides* (alga-like pondweed). Frequently encountered wetland species, found primarily on the stream banks, included *Leersia oryzoides* (rice cut-grass), *Triadenum virginicum* (marsh Saint John's-wort), *Dulichium arundinaceum* (dulichium or three-way sedge), *Glyceria obtusa* (blunt manna-grass), *Lysimachia terrestris* (swamp loosestrife), and *Aster novi-belgii* (New York aster).

Disturbance-indicator species were found at 36 stream sites (Figure 6.1). The most commonly encountered indicator plants were, in order of decreasing frequency of occurrence, *Ludwigia palustris* (water purslane), *Galium tinctorium* (stiff marsh bedstraw), *Mikania scandens* (climbing hempweed), *Callitriche heterophylla* (larger water starwort), *Polygonum sagittatum* (arrow-leaved tearthumb), *Impatiens capensis* (spotted touch-me-not), *Polygonum hydropiperoides* (mild water pepper), *Polygonum punctatum* (dotted smartweed), *Bidens frondosa* (beggar ticks), *Boehmeria cylindrica* (false nettle), *Eupatorium dubium* (eastern joe-pye weed), and *Panicum clandestinum* (deertongue grass). The number of plant species classified by Stone (1911) as being characteristic of either the Pine Barrens District, the Middle District, or both districts were nearly equally represented. Fourteen plant species were exotics. The occurrence of two of these exotic species, *Microstegium vimineum* (eulalia or Japanese stilt grass) and *Berberis*

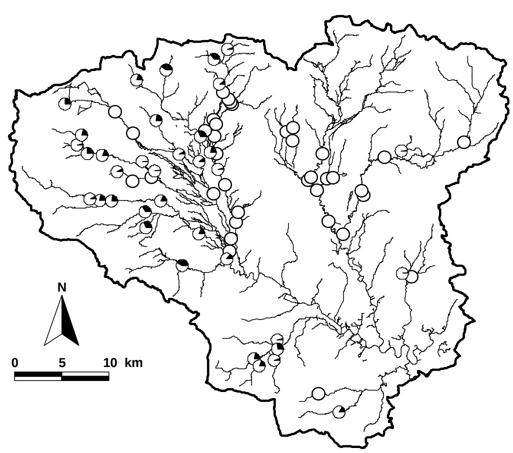

Figure 6.1. Pie charts showing the percentage of the total number of species that are disturbance-indicators (black) found at each of 72 stream sites in the Mullica River Basin.

thunbergii (Japanese barberry) is significant because of their impacts on native vegetation communities (Barden 1987, Ehrenfeld 1997). Stiltgrass occurred at eleven sites and was occasionally found in great abundance. Barberry was found scattered throughout a single site. *Lonicera japonica* (Japanese honeysuckle), *Polygonum cespitosum* (cespitose knotweed), and *Taraxacum officinale* (dandelion) occurred in low abundance at from three to five sites. All the other exotic species were represented by a single occurrence at low abundance. Non-Pinelands species were encountered more frequently on the western side of the basin (Figure 6.2)

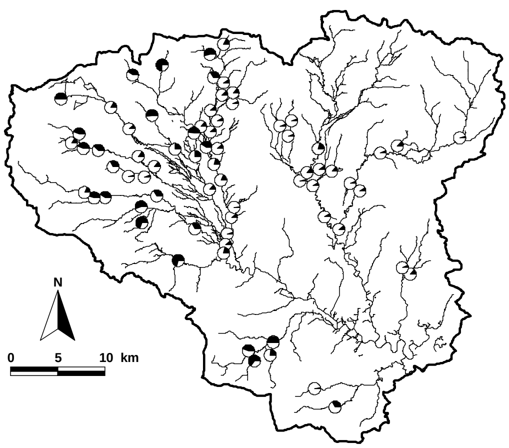

Figure 6.2. Pie charts showing as black the percentage of non-Pinelands plant species found at 72 stream sites in the Mullica River Basin.

Stream-vegetation Gradients

The first DCA axis contrasted stream sites with a high percentage of species restricted to the Pine Barrens District with those sites supporting a high percentage of non-Pinelands species (Figure 6.3, Table 6.2). The percentage of Pine Barrens District species decreased along this stream-vegetation community gradient while the percentage of non-Pinelands species and the percentage and absolute number of disturbance-indicator plant species increased (Figures 6.4 and 6.5). These contrasts were related to differences in the range of watershed conditions associated with each plant species (Figure 6.6, Table 6.3).

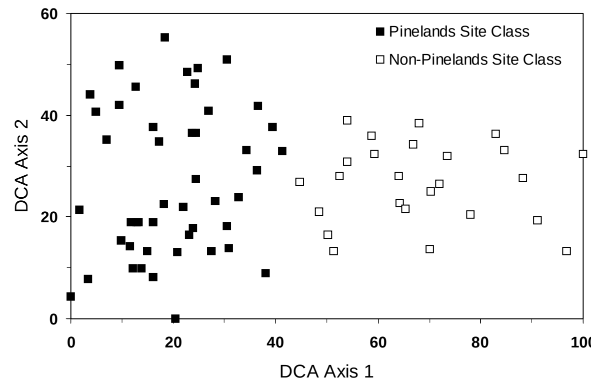

Figure 6.3. DCA ordination diagram and TWINSPAN classification for 72 Mullica River Basin stream sites. Refer to Table 6.2 for site names ordered by DCA axis 1 scores.

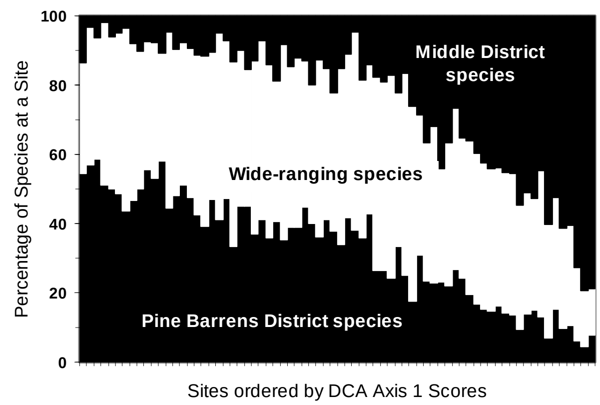

Figure 6.4. Biogeography of plants found at 72 Mullica River Basin stream sites. Wide-ranging species are native to both the Pine Barrens District and the Middle District. Refer to Table 6.2 for site names ordered by DCA axis 1 scores.

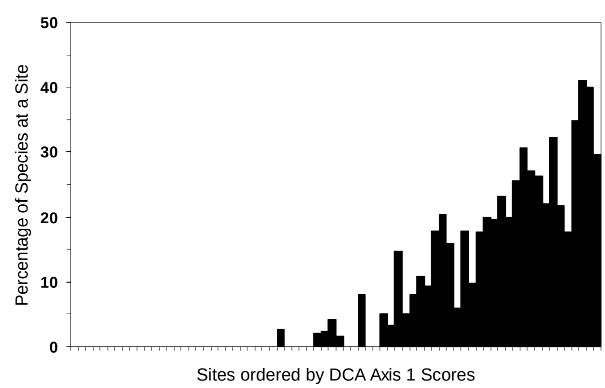

Figure 6.5. Percentage of indicator species at 72 Mullica River Basin stream sites. Refer to Table 6.2 for site names ordered by DCA axis 1 scores.

Table 6.2. DCA axis 1 and 2 site scores for 72 stream-vegetation monitoring sites in the Mullica River Basin. Sites are ordered by raw axis 1 ordination scores. Refer to Appendix 2 for additional information on each site.

Basin study unit	Site	Site code	Axis 1	Axis 2
Batsto River	Deep Run below Hampton Road	BDEEPDKE	0	15
Wading River	Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	6	74
Upper Mullica River	Mullica River below Constable Bridge	MMUCONST	12	27
Batsto River	Penn Swamp Branch above Batona Trail bridge	BPEBRIDG	13	153
Batsto River	Skit Branch below Carranza Road	BSKITCAR	17	141
Wading River	Shane Branch above fourth dike above Carranza Road	WSA4DIKE	24	122
Lower Mullica River	Clarks Mill Stream at Leibig Street and Odessa Avenue	LCLODESS	33	146
Oswego River	Buck Run below Old Martha Road	OBUCKRUN	33	173
Sleeper Branch	Sleeper Branch above Mullica River	MSLPLEAS	34	53
Wading River	Shane Branch above Carranza Road	WSACARRA	40	49
Batsto River	Skit Branch above Hampton Road	BSKITHAM	41	66
Batsto River	Batsto River below Penn Swamp Branch	BBAPENNS	42	34
Oswego River	Oswego River below Beaver Dam Road	OOSBEAVR	44	158
Oswego River	Oswego River below Route 679	OOSHARST	45	66
Oswego River	Oswego River above Martha	OOSOLMAR	46	66
Wading River	Wading River below Ford Road	WWEFORDR	48	34
Batsto River	Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	52	46
Wading River	Wading River above Route 563	WWEEVANB	56	28
Upper Mullica River	Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	56	66
Wading River	Featherbed Branch below Carranza Road	WFEACARR	56	131
Oswego River	Oswego River above Oswego Lake	OOSLAKUP	60	121
Batsto River	Batsto River tributary above Carranza Road	BBATRCAR	63	78
Batsto River	Batsto River tributary near Moore's Meadow Road	BBATRMOO	64	192
Upper Mullica River	Mullica River at northern border of Wilderness Area	MMUWILDR	71	0
Batsto River	Batsto River above Hampton Road	BBATHAMP	72	45
Sleeper Branch	Clark Branch at Parkdale	MCLJOHNS	76	76
Bass River	East Branch Bass River above Stage Road	AEASTAGE	79	168
Batsto River	Batsto River side channel below Quaker Bridge Road	BBAQUAKR	80	57
Bass River	West Branch Bass River above Stage Road	AWESTAGE	82	127
Wading River	Wading River above Tulpehocken Creek	WWETULPC	83	62
Batsto River	Batsto River tributary below Hay Road	BBATRMAN	84	160
Wading River	Wading River below Mile Run	WWEMILER	85	95
Batsto River	Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	85	127
Oswego River	Papoose Branch below Jenkins Road	OPAPOOSE	86	171
Sleeper Branch	Sleeper Branch diversion (Saltars Ditch)	MSLSALTD	93	142
Batsto River	Batsto River at Lower Forge	BBALFORG	95	46
Sleeper Branch	Sleeper Branch at Parkdale	MSLEPARK	98	80
Wading River	Hospitality Brook below Route 563	WHOSPITA	106	63
Sleeper Branch	Clark Branch above Burnt Mill Road	MCLBURNT	106	177
Nescochague Creek	Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	107	48
Wading River	Little Hauken Run below Route 563	WLIHAUKN	114	83
Upper Mullica River	Mullica River above Route 534	MMULJACK	119	115
Batsto River	Batsto River below Route 532	BBART532	126	101
Sleeper Branch	Cooper Branch above Burnt Mill Road	MCOBURNT	127	145
Nescochague Creek	Nescochague Creek at Pleasant Mills	NNEMILLS	132	31
Lower Mullica River	Indian Cabin Creek above Landing Creek	LINCABIN	137	131
Upper Mullica River	Mullica River above Central New Jersey/Conrail railroad bridge	MMURRBRG	143	114
Upper Mullica River	Mullica River tributary above Quaker Bridge Road	MMUTRQUA	155	93
Batsto River	Batsto River above Carranza Road	BBACARRZ	168	73
Nescochague Creek	Nescochague Creek near West Mill Road	NNEWESTM	174	57
Batsto River	Springers Brook below Deep Run	BSPRDIKE	178	46
Lower Mullica River	Morses Mill Stream below College Drive	LMORSESM	182	97
Nescochague Creek	Albertson Brook above derelict bridge below Route 206	NALDEREL	187	107
Lower Mullica River	Elliots Creek at Bremen Avenue	LELIOBRE	187	135
Sleeper Branch	Price Branch below Burnt Mill Road	MPRBURNT	204	125
Sleeper Branch	Sleeper Branch at Maple Island	MSLMAPLE	206	112
Batsto River	Indian Mills Brook above Oakshade Road (above Shadow Lake)	BINSHADS	222	97
Lower Mullica River	Landing Creek below Alternate Route 561	LLANDMOS	223	79
Nescochague Creek	Albertson Brook above Fleming Pike	NALBFLEM	227	75
Sleeper Branch	Hays Mill Creek above Tremont Avenue	MHATREMO	232	119
Sleeper Branch	Wildcat Branch below Burnt Mill Road	MWIBURNT	236	133
Batsto River	Springers Brook above Hampton Road	BSPRIHAM	243	47
Lower Mullica River	Landing Creek above Indian Cabin Road	LLANDIND	244	87
Upper Mullica River	Mullica River below Jackson-Medford Road	MMULADYS	250	92
Nescochague Creek	Blue Anchor Brook above Pump Branch	NBLCONFL	255	111
Nescochague Creek	Great Swamp Branch below Route 613	NGRMIDDL	271	71
Upper Mullica River	Wesickaman Creek below Three Bridge Road	MWETHREE	288	126
Lower Mullica River	Union Creek above Alternate Route 561	LUNIOMOS	294	115
Batsto River	Horse Pond Stream below Butterworth's Bogs Road	BHOBUTTR	306	96
Lower Mullica River	Hammonton Creek above Chestnut Avenue	LHACHEST	316	67
Batsto River	Muskingum Brook above Tuckerton Road	BMUSKTUC	336	46
Nescochague Creek	Cedar Brook near Hammonton Airport	NCEAIRPO	347	112

Table 6.3. DCA axis 1 and 2 species scores for 225 plants included in the stream-vegetation analyses. Species are ordered by raw axis 1 ordination scores.

Species	Axis 1	Axis 2	Species	Axis 1	Axis 2	Species	Axis 1	Axis 2
Danthonia sericea var. epilis	-160	432	*Eupatorium pilosum*	28	319	*Mitchella repens*	231	271
Schizaea pusilla	-156	50	*Isoetes echinospora*	33	-166	*Lycopus uniflorus*	233	-23
Utricularia cornuta	-153	-92	*Gaylussacia baccata*	36	218	*Juncus effusus*	245	10
Lycopodium alopecuroides	-134	177	*Rhynchospora capitellata*	37	-5	*Ilex verticillata*	248	165
Muhlenbergia torreyana	-115	-182	*Nymphaea odorata*	47	59	*Cephalanthus occidentalis*	255	-98
Drosera filiformis	-114	-11	*Rhexia virginica*	50	8	*Carex albolutescens*	257	75
Eriocaulon compressum	-114	473	*Carex atlantica*	50	276	*Viburnum dentatum*	260	-46
Carex trisperma	-113	514	*Euthamia tenuifolia*	52	-85	*Carex crinita*	262	-74
Cladium mariscoides	-111	-115	*Hypericum canadense*	57	-2	*Eleocharis ovata*	262	-17
Carex exilis	-109	245	*Smilax herbacea*	59	57	*Bidens frondosa*	265	82
Pogonia ophioglossoides	-107	357	*Panicum ensifolium*	60	-33	*Woodwardia areolata*	266	175
Utricularia fibrosa	-102	187	*Lilium superbum*	62	358	*Decodon verticillatus*	267	162
Schizachyrium scoparium	-98	-133	*Panicum scabriusculum*	65	-152	*Carex intumescens*	278	63
Carex livida	-98	289	*Proserpinaca pectinata*	65	176	*Kalmia latifolia*	282	280
Polygala cruciata	-94	-36	*Carex folliculata*	71	233	*Hypericum mutilum*	283	-21
Betula populifolia	-93	379	*Potamogeton confervoides*	74	57	*Phragmites australis*	292	144
Muhlenbergia uniflora	-90	-39	*Sassafras albidum*	74	248	*Diospyros virginiana*	293	-16
Eriocaulon decangulare	-87	-115	*Rhynchospora chalarocephala*	75	48	*Eupatorium dubium*	295	38
Lyonia mariana	-86	-15	*Dulichium arundinaceum*	76	72	*Solidago rugosa*	295	78
Xyris difformis	-85	-63	*Eupatorium resinosum*	86	-79	*Thelypteris simulata*	298	193
Zizania aquatica	-83	-234	*Hypericum denticulatum*	89	-155	*Toxicodendron radicans*	306	177
Xyris smalliana	-81	207	*Panicum dichotomum*	90	120	*Apios americana*	309	27
Eleocharis tuberculosa	-79	110	*Nuphar variegata*	91	124	*Parthenocissus quinquefolia*	315	181
Habenaria clavellata	-76	58	*Panicum verrucosum*	92	-26	*Lindernia dubia*	316	-9
Sarracenia purpurea	-76	250	*Triadenum virginicum*	97	79	*Erechtites hieracifolia*	317	64
Drosera rotundifolia	-76	256	*Smilax pseudochina*	102	53	*Polygonum hydropiperoides*	321	30
Panicum virgatum	-74	-134	*Chamaecyparis thyoides*	102	146	*Ludwigia palustris*	322	67
Iris prismatica	-71	-120	*Glyceria obtusa*	106	77	*Scutellaria lateriflora*	324	13
Vaccinium pallidum	-69	-63	*Pontederia cordata*	108	-92	*Polygonum punctatum*	325	147
Eriophorum virginicum	-69	275	*Iris versicolor*	109	-76	*Echinochloa muricata*	328	-107
Andropogon virginicus var. abbreviatus	-64	162	*Viola lanceolata*	111	-36	*Galium tinctorium*	330	49
Rhynchospora alba	-64	210	*Aronia arbutifolia*	112	203	*Lycopus virginicus*	330	116
Cyperus dentatus	-62	-184	*Oxypolis rigidior*	117	45	*Microstegium vimineum*	338	-10
Hypericum densiflorum	-60	-65	*Agrostis perennans var. elata*	118	-76	*Onoclea sensibilis*	340	25
Drosera intermedia	-53	21	*Lysimachia terrestris*	129	18	*Mikania scandens*	341	29
Gaylussacia dumosa	-51	287	*Rhododendron viscosum*	130	183	*Cyperus strigosus*	342	-30
Carex striata	-49	149	*Magnolia virginiana*	138	205	*Toxicodendron vernix*	342	243
Eriocaulon aquaticum	-48	120	*Peltandra virginica*	142	59	*Asclepias incarnata*	344	-133
Myrica pensylvanica	-47	340	*Scirpus cyperinus*	144	76	*Vitis labrusca*	347	200
Vaccinium macrocarpon	-44	42	*Smilax glauca*	144	135	*Potamogeton epihydrus*	348	10
Panicum spretum	-43	-252	*Osmunda regalis*	147	144	*Thelypteris palustris*	352	-10
Gaylussacia frondosa	-43	342	*Lyonia ligustrina*	147	211	*Panicum clandestinum*	355	118
Orontium aquaticum	-42	207	*Alnus serrulata*	153	125	*Polygonum sagittatum*	356	39
Aster nemoralis	-40	207	*Viburnum nudum var. nudum*	156	272	*Bidens connata*	363	64
Leiophyllum buxifolium	-38	-135	*Vaccinium corymbosum*	158	130	*Lobelia cardinalis*	364	22
Lobelia nuttallii	-34	-156	*Aster novi-belgii*	160	179	*Boehmeria cylindrica*	365	24
Calamagrostis cinnoides	-31	-14	*Liquidambar styraciflua*	162	101	*Rosa palustris*	365	28
Eleocharis robbinsii	-30	-53	*Acer rubrum*	163	109	*Rubus sp.*	366	101
Chamaedaphne calyculata	-27	88	*Clethra alnifolia*	167	132	*Callitriche heterophylla*	368	93
Gaultheria procumbens	-27	264	*Eubotrys racemosa*	169	144	*Glyceria canadensis*	379	4
Kalmia angustifolia	-25	180	*Carex venusta*	169	160	*Impatiens capensis*	379	117
Bartonia virginica	-19	199	*Quercus ilicifolia*	170	169	*Taraxacum officinale*	379	167
Carex bullata	-18	-104	*Osmunda cinnamomea*	170	208	*Dryopteris carthusiana*	379	203
Carex collinsii	-18	502	*Leersia oryzoides*	176	89	*Carex lurida*	386	101
Juncus pelocarpus	-17	52	*Carex pensylvanica*	177	0	*Glyceria striata*	398	213
Ilex laevigata	-14	390	*Agrostis hyemalis*	182	-67	*Polygonum cespitosum*	400	148
Lachnanthes caroliniana	-13	-119	*Andropogon virginicus var. virginicus*	185	163	*Elodea nuttallii*	405	-98
Juncus canadensis	-13	-38	*Quercus alba*	194	259	*Potamogeton pusillus*	408	68
Juncus militaris	-12	-69	*Woodwardia virginica*	195	204	*Sambucus canadensis*	415	-12
Bartonia paniculata	-10	207	*Bidens coronata*	196	-170	*Lonicera japonica*	416	181
Smilax laurifolia	-9	427	*Smilax rotundifolia*	196	104	*Polygonum arifolium*	421	44
Amelanchier canadensis	-6	242	*Spiraea tomentosa*	197	-147	*Aster racemosus*	428	143
Sabatia difformis	-3	27	*Agrostis perennans*	199	60	*Salix nigra*	433	171
Eleocharis flavescens var. olivacea	-2	-30	*Rubus hispidus*	199	204	*Cinna arundinacea*	445	147
Utricularia geminiscapa	0	276	*Itea virginica*	204	155	*Oxalis stricta*	448	91
Pinus rigida	1	136	*Nyssa sylvatica*	206	173	*Typha latifolia*	450	-67
Eleocharis tenuis	3	-27	*Carex atlantica var. capillacea*	208	254	*Epilobium coloratum*	456	57
Ilex glabra	4	113	*Sparganium americanum*	209	101	*Pilea pumila*	463	154
Smilax walteri	4	117	*Cuscuta sp.*	214	79	*Cardamine pensylvanica*	464	22
Carex stricta	5	-57	*Eleocharis acicularis*	217	-81	*Aralia nudicaulis*	469	258
Sagittaria engelmanniana	10	-52	*Viola primulifolia*	223	120	*Bidens discoidea*	473	143
Utricularia purpurea	14	-199	*Agrostis hyemalis var. scabra*	228	-50	*Lemna sp.*	473	143
Potamogeton oakesianus	14	-199	*Carex canescens*	228	51	*Phalaris arundinacea*	484	-74
Scirpus subterminalis	25	26	*Ilex opaca*	230	121	*Ceratophyllum echinatum*	485	197
Panicum longifolium	28	-84	*Dioscorea villosa*	231	177	*Carex stipata*	512	103

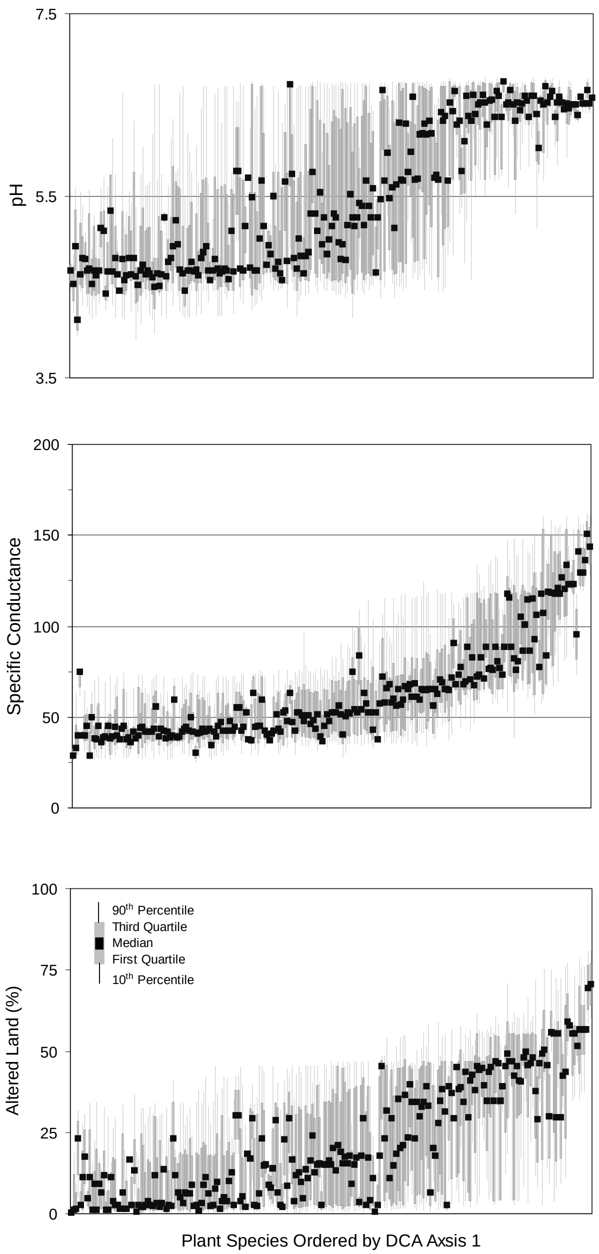

Figure 6.6. The pH, specific conductance (μS cm^{-1}) and percentage of altered land (developed land and upland agriculture) associated with plant species found at 72 stream sites. Refer to Table 6.3 for species names ordered by DCA axis 1 scores.

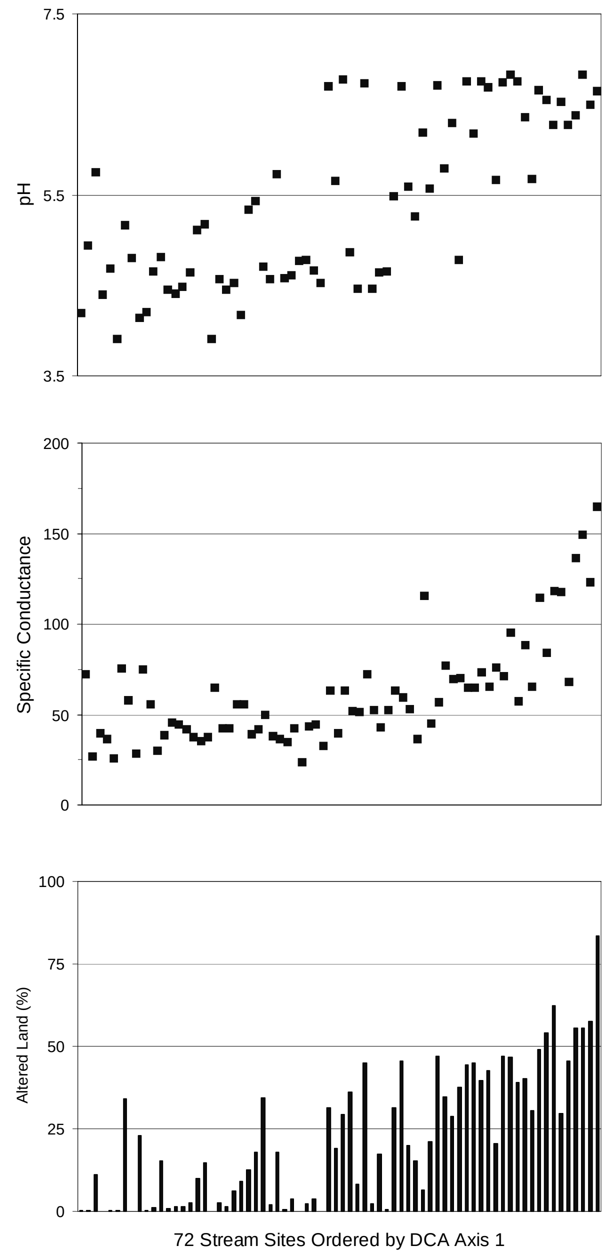

Figure 6.7. The pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) for 72 Mullica River Basin stream sites. DCA Axis 1 represents a stream-vegetation community gradient. Refer to Table 6.2 for site names ordered by DCA axis 1 scores.

The order of stream sites along the first axis of the DCA site-ordination diagram was associated with increasing pH (r = 0.73), specific conductance (r = 0.68), and the percentage of developed land (r = 0.72) and upland agriculture (r = 0.70) in the basin (Figure 6.7). Stream sites on the right side of the diagram displayed higher pH and specific conductance and a higher percentage of developed land and upland agriculture in the drainage basin than those on the left side of the diagram. Although the relationship was not as strong, this first axis was also correlated with geographic position represented by longitude (r = - 0.52). Because most developed lands and upland farms are found on the western side of the basin, this last association is probably related to land-use patterns, although the possible influence of biogeography on species composition cannot be discounted. The *p* level for all five relationships was < 0.001. Neither wetland agriculture nor channel muck were correlated with the first DCA axis. The order of stream sites along the second DCA axis did not reflect differences in the distribution of Pine Barrens District, non-Pinelands, or disturbance-indicator plant species and was not related to differences in water quality or land use.

The TWINSPAN classification revealed similar differences among the stream stations. The first TWINSPAN division separated a group of 47 sites with a higher percentage of Pine Barrens District plant species (Pinelands site class) from 25 sites characterized by a high percentage of non-Pinelands plants and disturbance-indicator species (non-Pinelands site class) (Figure 6.8). Disturbance-indicator species were found at some sites included in the Pine Barrens class, suggesting that this class included some moderately disturbed streams. The two major site classes were also distinguished by contrasting pH, specific conductance, and land-use (Figure 6.8). A second division of the non-Pinelands site class separated eight sites which, as a group, displayed the highest pH and specific conductance values and the highest percentage of upland agriculture or developed land. This group of sites also supported the highest mean number of disturbance-indicator plants at 15 ± 4.6. Differences in adjacent-forest type between the two TWINSPAN groups suggested that canopy cover may influence species composition. Hardwood-swamp cover was the dominant cover at 38% of the sites in the Pinelands site class, compared to 92% of the sites in the non-Pinelands site class. While cedar swamp cover was dominant at 32% of the sites in the Pinelands site class, it was not dominant at any of the non-Pinelands sites.

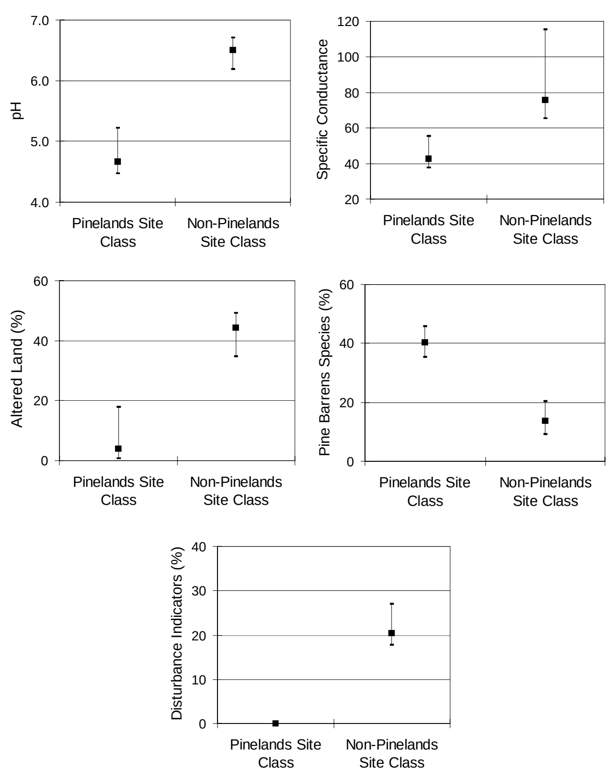

Figure 6.8. Median and 1st and 3rd quartile specific conductance (μS cm^{-1}), pH, percentage of altered land (developed land and upland agriculture), percentage of Pine Barrens species, and percentage of disturbance-indicator values for two TWINSPAN-derived site classes for 72 Mullica River Basin stream sites.

Drainage-basin Characterizations

Wading River, Oswego River, and Bass River

A high percentage of Pine Barrens District plants characterized the Wading River and Oswego River stream sites. All 18 sites in these basins were associated with the undisturbed end of the stream-vegetation community gradient (Table 6.2, Figure 6.9). With one exception, all sites lacked disturbance-indicator species. The one exception was the occurrence of a single specimen of *Dioscorea villosa* (common wild yam) at Papoose Branch. Two sites,

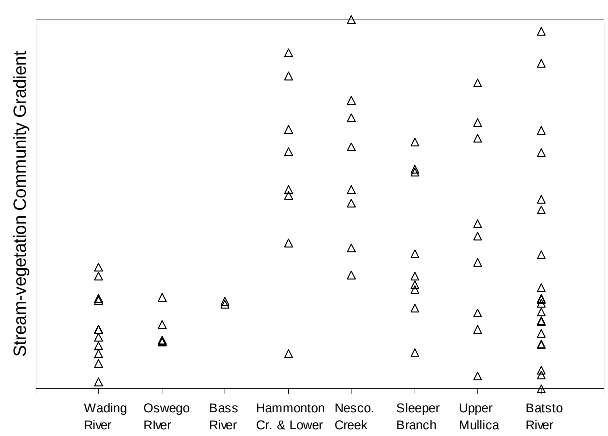

Figure 6.9. Position of stream-vegetation survey sites along stream-vegetation community gradients, represented by DCA axis 1 site scores, in eight Mullica River Basin stream systems. Refer to Table 6.2 for site names ordered by DCA axis 1 scores.

Little Hauken Run and Hospitality Brook, occupied a transitional position along the stream-vegetation gradient that was similar to Mullica River Basin sites that were characterized by a high percentage of Pine Barrens District species, but also supported indicator species. Typical Pinelands species found in the Wading River and Oswego River basins included *Scirpus subterminalis*, *Potamogeton confervoides*, *Orontium aquaticum*, *Eriocaulon aquaticum*, *Sagittaria engelmanniana*, *Utricularia fibrosa* (fibrous bladderwort), and *Juncus pelocarpus* (brown-fruited rush). Study sites in the Bass River watershed also supported a typical Pinelands flora as depicted by the position of West Branch and East Branch sites on the stream-vegetation community gradient (Figure 6.9). The occurrence of two disturbance-indicator species, *Panicum clandestinum* (deertongue grass) and *Polygonum hydropiperoides* (mild water pepper), at the West Branch Bass River site appeared to be related to a localized disturbance.

Hammonton Creek and Lower Mullica River Tributaries

The composition of stream vegetation at most Lower Mullica River tributary sites differed from that found at sites at the undisturbed end of the vegetation gradient (Table 6.2, Figure 6.9). Clarks Mill Stream, which fell within the range of other stream sites characterized by a high percentage of Pine Barrens District species, was the only Lower Mullica River tributary with no disturbance-indicator species. Disturbance-indicator species were found at all five Landing Creek basin sites. Most of these sites were associated with the disturbed end of the community gradient. Union Creek harbored seven exotic species, the most found at any of the 72 survey sites. Although a high percentage of Pine Barrens District species were found at Indian Cabin Creek, this site occupied a transitional position along the community gradient. The Hammonton Creek site is shown at the extreme end of the community gradient. Sixteen disturbance-indicator species were found at this stream site. The vegetation in the Hammonton Creek was among the more highly altered in the Mullica River Basin. *Microstegium vimineum* was especially abundant at this site.

Nescochague Creek

Most of the Nescochague Creek sites were characterized by a high percentage of non-Pinelands species. These sites were associated with the more disturbed end of the stream-vegetation community gradient (Table 6.2, Figure 6.9). Two sites, Pump Branch and Nescochague Creek at Pleasant Mills, occupied a transitional position along the community gradient. Both sites were characterized by a high percentage of Pine Barrens District species. Disturbance-indicator species were found at all eight Nescochague Creek sites, ranging from seven species at the Pump Branch site to 21 species at the Great Swamp Branch site. The Great Swamp Branch disturbance-indicator species tally was the highest recorded for the Mullica River Basin. The disturbance-indicator species encountered most frequently in the Nescochague Creek basin included *Ludwigia palustris*, *Mikania scandens*, *Galium tinctorium*, *Boehmeria cylindrica*, and *Polygonum hydropiperoides*.

Sleeper Branch

A range of conditions was encountered among the ten Sleeper Branch basin sites (Table 6.2, Figure 6.9). A number of disturbance-indicator species, including *Ludwigia palustris*, *Callitriche heterophylla*, *Mikania scandens*, and *Impatiens capensis* (spotted touch-me-not), were found at stream sites that supported a high percentage of non-Pinelands species. These sites were located on Hays Mill Creek, Wildcat Branch, Price Branch, and the uppermost Sleeper Branch site at Maple Island. A single disturbance-indicator plant was found at three sites with a high percentage of Pine Barrens District species. These included sites along Cooper Branch, Sleeper Branch at Parkdale, and Saltars Ditch. All three sites occupied a transitional position along the stream-vegetation community gradient. The integrity of stream vegetation continued to improve along the main stem of the Sleeper Branch. The vegetation found at the Sleeper Branch above its confluence with the Mullica River reflected undisturbed conditions.

Upper Mullica River

The stream vegetation found at sites in the Upper Mullica River reflected a range of conditions (Table 6.2, Figure 6.9). The Wesickaman Creek and the uppermost Mullica River site at Jackson-Medford Road occupied a position at the disturbed end of the vegetation-community gradient. Both sites were characterized by a high percentage of non-Pinelands species and supported a high number of disturbance-indicator species. A high percentage of Pine Barrens District species characterized the other six Upper Mullica River sites. Three of these sites occupied a transitional position along the stream-vegetation gradient and three fell within the range of undisturbed sites. Several disturbance-indicator species were found at two of the transitional sites, including the main stem below Atsion Lake and an unnamed tributary that flows to the main stem at Quaker Bridge Road. In both cases, degraded streams may be the source of the disturbance-indicator species. The main-stem site is located immediately below the confluence of the Wesickaman Creek, and the unnamed tributary pirates water from the Springers Brook in the Batsto River basin.

Batsto River

The Batsto River system provides a case study of the effect of land-use related watershed disturbance of stream communities. There was a distinct difference in the vegetation found in streams draining forest land and streams draining basins with a high percentage of developed land and upland agriculture (Table 6.2, Figure 6.9). Sites in the Skit Branch drainage represented characteristic Pinelands stream communities. No disturbance indicators were found in this tributary system. In contrast, the stream vegetation found at most Springers Brook sites was characterized by a high percentage of non-Pinelands species. Four Springers Brook sites occupied positions towards the disturbed end of the stream-vegetation community gradient. Twenty six of the 29 disturbance-indicator species were encountered in the Springers Brook drainage, which includes Indian Mills Brook and Muskingum Brook. Disturbance-indicator species found in all three streams included two aquatic plants, *Callitriche heterophylla* and *Ludwigia palustris*, and several wetland plants, including *Mikania scandens*, *Galium tinctorium*, *Bidens connata* (purple-stemmed beggar ticks), *Polygonum sagittatum*, *Microstegium vimineum*, *Lobelia cardinalis* (cardinal flower), and *Cyperus strigosus* (straw-colored cyperus). Muskingum Brook was the most degraded site in the Springers Brook system. Plants found at this site included 20 disturbance-indicator species and a number of non-Pinelands plants that were not found at any of the other Mullica River Basin study sites. The invasive exotic, *Microstegium vimineum*, was abundant along Muskingum Brook. The stream vegetation found at Deep Run, a Springers Brook tributary that drains forest land, was characteristic of undisturbed Pinelands streams. Most sites along the main stem of the Batsto River occupied a position at the undisturbed end of the stream-vegetation community gradient.

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7 Atlantic White Cedar Swamps

Introduction

Ehrenfeld and Schneider (1990, 1991, 1993) demonstrated that adjacent residential development and stormwater runoff compromised the ecological integrity of Pinelands Atlantic white cedar (*Chamaecyparis thyoides*) swamps. Ecological changes associated with these local land-use impacts included the loss of native Pinelands plant species, an increase in the occurrence of nonnative and upland-plant species, increased species richness, reduced *Sphagnum* cover, and low cedar-seedling germination. To assess the effect of regional watershed disturbance on the same community attributes, Commission scientists completed a study of cedar swamps found throughout the Mullica River Basin (Laidig and Zampella 1999). The study addressed three main questions. First, do species richness and native, nonnative, and upland plant-species composition vary in relation to watershed disturbance. Second, is there a difference in *Sphagnum* cover and seedling germination between cedar swamps in disturbed and undisturbed watersheds? Finally, do site-specific environmental conditions vary in relation to watershed disturbance? The results of the published Commission study are summarized in this chapter.

Study Sites

Four 20 x 50-m permanent macroplots were established on state-owned lands in each of six Mullica River Basin drainage basins. These basins represented watersheds with a high (Albertson Brook and Pump Branch), moderate (Mullica River and Batsto River), and low (Bass River and Wading River) degree of watershed disturbance associated with upstream developed and agricultural land uses (Figure 7.1, Table 7.1). Field work for the study was completed in 1995 and 1996.

Species Inventory

Six tree species were found in the canopy and subcanopy of the study sites. Cedar represented more than 80% of live-stem basal area at all sites and was the dominant tree at 23 sites, with canopy cover ranging from 50-75% to > 75%. *Acer rubrum* (red maple), which was found in the canopy of 11 sites, was codominant with cedar at one site. Other associated canopy and subcanopy trees included *Magnolia virginiana* (sweetbay), *Nyssa sylvatica* (black gum), *Pinus rigida* (pitch pine), and *Betula populifolia* (gray birch). A total of ninety-nine vascular plants, including 65 herbaceous and 34 woody species, were found in the understory of the 24 swamp sites. Most of the ninety-four plants that were identified to species are indigenous to the Pinelands and are considered wetland plants (Table 7.2). Only ten species were classified as either Middle District species by Stone (1911, Chapter 6) or as facultative-upland plants by Reed (1997) (Table 7.3). No exotic species were found during the survey. All ten Middle District species were found in the low-disturbance class and none were unique to the high-disturbance sites. The complete plant-species inventory and supporting information are presented in Appendix 3.

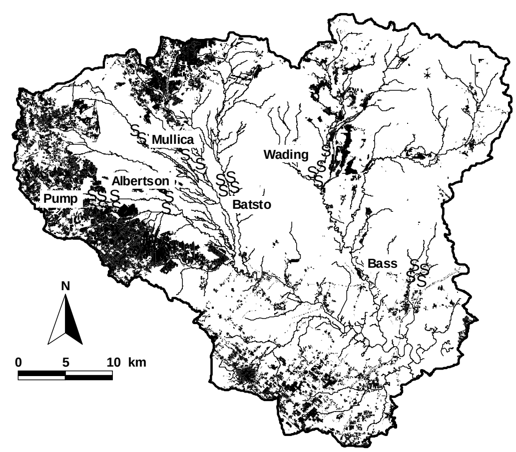

Figure 7.1. Location of Mullica River Basin cedar-swamp study sites. Developed and agricultural lands are shaded in black.

Community Gradients

Detrended correspondence analysis (Chapter 1) was used to ordinate the canopy-cover data. The first axis

Table 7.1. Watershed characteristics associated with 24 Mullica River Basin cedar-swamp macroplots. Percentage land-cover values are for upstream drainage areas. Agriculture includes upland agriculture and blueberry fields. Water-quality values are medians based on data from Reed et al. (1997) collected at stream stations nearest to the macroplots. Nutrient values are given as mg L^{-1}. USGS station numbers are listed below each stream name. Modified from Laidig and Zampella (1999).

	Watershed-disturbance class					
	Low		Moderate		High	
Attribute	Bass River (E) 01410150	Wading River (W) 01409750	Batsto River (B) 01409470	Mullica River (M) 01409387	Pump Branch (P) 01409408	Albertson Brook (A) 0140940970
Total area (km^2)	21.1	81.1	140.4	85.4	29.0	44.4
Percentage land cover						
Developed	1.2	1.3	5.6	9.1	20.5	20.2
Agriculture	0	8.4	10.5	8.8	23.8	27.4
Cranberry bogs	0	1.0	2.5	0	0	0
Water quality						
Specific conductance (μS cm^{-1})	50	41	54	57	88	76
pH	4.4	4.4	5.3	4.4	6.3	6.3
Ammonia-N, dissolved	<0.02	0.01	0.03	<0.02	0.05	0.04
Nitrite plus nitrate-N, dissolved	0.06	<0.05	0.11	0.11	0.91	0.69
Total phosphorus	<0.01	0.04	0.03	<0.01	<0.01	<0.01

Table 7.2. Geographic (Stone 1911) and wetland (Reed 1997) classification of 94 understory-plant species.

Classification	Number of species
Geographic classification	
Pine Barrens District	37
Pine Barrens/Middle District	45
Middle District	6
Unclassified	6
Wetland classification	
Obligate wetland	50
Facultative wetland	22
Facultative	14
Facultative upland	6
Unclassified	2

of the resulting ordination represented a gradient of increasing maple-canopy cover and basal area. The first DCA axis of a separate understory-species ordination contrasted the eight high-disturbance swamp sites with most low-disturbance and moderate-disturbance sites, but revealed no clear difference between the latter two site types (Figure 7.2). No association was found between the order of sites along this primary understory-community gradient and site-specific topographic (hummock cover, hollow cover,

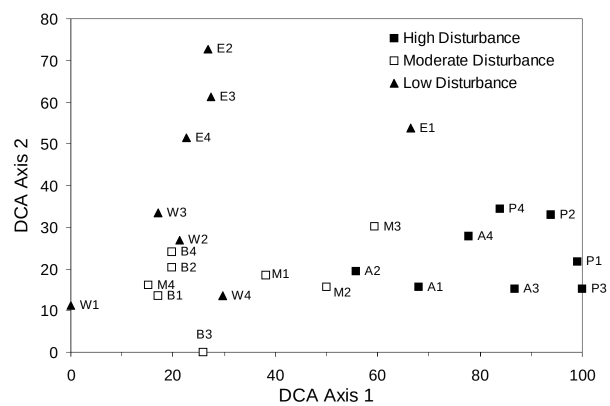

Figure 7.2. Cedar-swamp understory-species ordination. Refer to Table 7.1 for drainage basin codes.

and topographic variability), soil (litter cover and peat depth), hydrologic (water-table level, flooding, and distance to the adjacent stream), or shading (canopy closure) factors. However, this community gradient was correlated with the first axis of the canopy ordination, suggesting that red maple canopy cover influenced understory composition. Total species richness, the percentage of obligate-wetland species, and the percentage of Pine Barrens species decreased along this understory-species community gradient, while the percentage of facultative-wetland species and the percentage of Middle District species increased (Figures 7.3 and 7.4).

Table 7.3. Middle District (MD) and facultative-upland (FACU) plant species present in the Mullica River Basin cedar-swamp macroplots and their frequency of occurrence (%) in each watershed-disturbance class.

		Watershed-disturbance Class		
Species	Classification	Low	Moderate	High
Gaylussacia baccata (black huckleberry)	FACU	37.5	50.0	12.5
Hypericum mutilum (dwarf St. John's wort)	MD	12.5	12.5	0.0
Ilex opaca (American holly)	MD	12.5	12.5	37.5
Kalmia angustifolia (sheep laurel)	FACU	0.0	12.5	0.0
Mitchella repens (partridgeberry)	MD, FACU	87.5	75.0	75.0
Peltandra virginica (arrow arum)	MD	50.0	62.5	50.0
Parthenocissus quinquefolia (Virginia creeper)	MD, FACU	12.5	0.0	87.5
Sassafras albidum seedlings (Sassafras)	FACU	62.5	25.0	87.5
Smilax glauca (glaucus greenbriar)	FACU	37.5	62.5	87.5
Toxicodendron radicans (poison ivy)	MD	50.0	25.0	100.0

DIFFERENCES BETWEEN WATERSHED-DISTURBANCE CLASSES

Species Richness, Biogeography, and Upland Plant Species

Several significant differences were found between the three watershed-disturbance classes. The species composition of the high-disturbance swamp sites, represented by the first-axis site scores of the understory-species ordination, were different from those of the low-disturbance and moderate-disturbance sites. The mean percentage of Pine Barrens plant species was lower in the high-disturbance sites compared to the low-disturbance sites. No difference was found between disturbance classes when the percentage of Pine Barrens/Middle District species or the percentage of Pine Barrens plus Pine Barrens/Middle District species were compared.

Although the percentage of Middle District species was higher in the high-disturbance class compared to the moderate-disturbance class, the mean difference in the actual number of taxa was less than two species. No difference in the percentage of Middle District plants was found when the high-disturbance and low-disturbance swamps were compared. The same results were obtained when comparing facultative-upland species. The only significant difference in the distribution of Middle District or facultative-upland plants between the low-disturbance and high-disturbance classes was the absence of *Hypericum mutilum* (dwarf St. John's wort) and a greater frequency of occurrence of *Parthenocissus quinquefolia* (Virginia creeper) in the high-disturbance swamp sites.

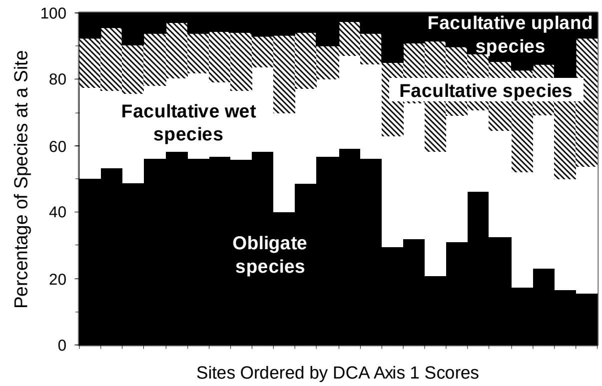

Figure 7.3. Wetland classification of plants found at 24 Mullica River Basin cedar swamps.

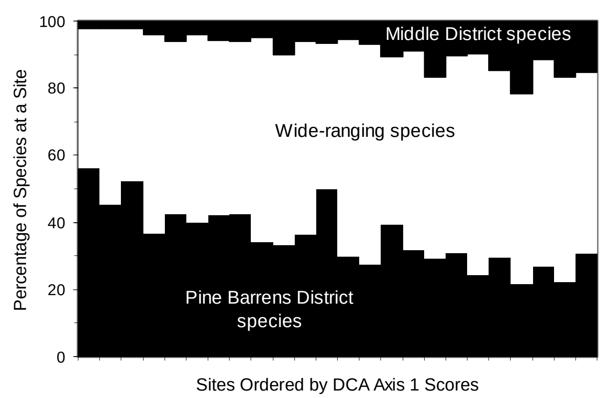

Figure 7.4. Biogeography of plants found at 24 Mullica River Basin cedar swamps. Wide-ranging species are native to both the Pine Barrens District and the Middle District.

Sphagnum Cover and Seedling Germination

Sphagnum moss cover, which is an indication of optimal cedar seedbed conditions, was lowest in the high-disturbance sites compared to the low-disturbance sites, but there were no significant differences in overall seedbed conditions (represented by eleven microhabitat variables) and cedar-seedling density among the three disturbance classes. The eleven microhabitat variables were the percent cover of leaf litter, woody debris, tree base, hollow, hummock, herbaceous vegetation, *Sphagnum*, other bryophytes, and tall, medium, and low shrubs.

Site Conditions

Canopy composition, represented by the first-axis site scores of the canopy ordination, and canopy closure differed significantly between watershed-disturbance classes. Canopy closure of the high-disturbance class was greater than that of the low-disturbance class. The canopy-composition ordination scores were generally higher in the high-disturbance class. No difference in hummock cover, hollow cover, topographic variability, litter cover, peat depth, water-table level (mean and range), flooding frequency, or distance to the adjacent stream was found among the three watershed classes.

Summary and Conclusions

The Commission study did not reveal any significant difference in the percentage of plants from surrounding biogeographic regions or the percentage of upland species between low-disturbance and high-disturbance sites. Although both of these community attributes were higher in high-disturbance sites than in moderate-disturbance sites, the differences were relatively minor. Virginia creeper was the only Middle District species that occurred more frequently in high-disturbance swamp sites. No exotic species were encountered during the study. None of the community attributes distinguished low-disturbance swamp sites from moderate-disturbance sites. The observation that reduced *Sphagnum* cover was associated with disturbance was confounded by the lack of significant differences in overall seedbed conditions or seedling density.

Because there were no significant site-specific differences in soil, topographic, or hydrologic characteristics among the three disturbance classes, differences in understory-species composition between the high-disturbance class and the other two classes may be related to a higher percentage of maple in the canopy and greater canopy closure rather than the effect of watershed disturbance. This possibility was supported by the observation that the understory-species composition of low-disturbance and moderate-disturbance swamp sites with and without maple in the canopy were significantly different. Biogeographic differences between site classes was also partly attributed to location within the region.

The differences between the results of this study and those of Ehrenfeld and Schneider (1990, 1991, 1993) reflects the effects of local versus regional land-use disturbances on Atlantic white cedar swamps. The contrast between the results of this investigation and Pinelands stream-vegetation studies (Morgan and Phillip 1986, Zampella and Laidig 1997, Chapter 8) also indicates that distant, upstream land-use disturbances have different effects on aquatic communities and the wetlands that border Pinelands streams. Unlike in-stream communities, Atlantic white cedar swamps in state-owned lands appear to be buffered from the effects of regional land-use related watershed disturbances.

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8 Pond Vegetation

Introduction

In 1998, Commission scientists completed a field study characterizing 13 intermittent ponds located in the northwestern portion of the Mullica River Basin (Laidig et al. 2001). All harbor breeding populations of Pine Barrens treefrog (*Hyla andersonii*). A comprehensive plant-species list was completed for each pond, and the boundaries of patches dominated by trees, shrubs, and herbaceous cover were mapped in the field using a global positioning system. The adjacent land use and forest types, bathymetry, substrate, water levels, and water-quality characteristics of each pond were also described. Water-quality attributes included pH, specific conductance, and total organic carbon. The 13 ponds were initially selected as part of an earlier Commission study that examined the composition of adult and larval frog and toad species in relation to site-specific, local, and regional environmental variables (Bunnell and Zampella 1999, Chapter 10). Nine of the 13 ponds are found in what appeared to be naturally occurring depressions. The remaining four ponds represented excavated basins that were probably dug for fill material. A third Commission study (Zampella and Laidig 2001) compared the plant-species composition, cover-type patch structure, and selected environmental characteristics of the natural ponds with those features found in excavated basins. These studies contributed to the Commission's long-term vegetation studies in two main ways. Baseline data sets describing the vegetation and environmental conditions found at these ponds were established. The studies also provided additional insight into the relationship between regional watershed disturbance and off-stream wetland communities. Portions of the pond studies that describe the effect of regional land-use patterns on aquatic and wetland vegetation are summarized in this chapter. Selected environmental characteristics of the 13 ponds are also described.

Environmental Characteristics

All 13 ponds were embedded in an upland pine-oak or pitch pine lowland forest matrix. Adjacent land use varied among sites (Table 8.1). The water in all 13 ponds was acid with a median pH ranging from 3.8 to 4.6. Median specific conductance values ranged from 23 to 76 μS cm^{-1}. Compared to the natural ponds, the pH of the excavated ponds was higher and the specific conductance and total organic-carbon concentrations were lower. Higher hydrogen-ion concentrations in the natural ponds probably contributed to the elevated specific-conductance values. Gently sloping shorelines characterized the natural ponds, whereas cut banks characterized the excavated ponds. All 13 ponds were shallow (Figure 8.1). The natural ponds were also generally larger than the excavated ponds. The near-surface mineral soil at most ponds was sand. Loamy sands were found at three excavated ponds and one natural pond.

Table 8.1. Percentage of three land-use types within a 750-m radius of each pond.

Summary statistics	Developed land	Upland agriculture	Wetland agriculture
Mean ± 1 SD	1.0 ± 1.7	4.9 ± 9.8	0.3 ± 0.6
Range	0 - 4.8	0 - 30.7	0 - 2.3
Median	0.2	0	0

Species Inventory and Vegetation Zonation

A total of 52 herbaceous species and 34 woody species were found at the 13 ponds. The complete plant species inventory is presented in Appendix 4. Twenty-six herbs and eight woody species were represented by a single-site occurrence. The excavated ponds contained the majority (82%) of these unique species. Total, woody, and herbaceous species richness were greater in the excavated versus the natural ponds.

Fourteen broad cover types were delineated based on the dominant species present (Figure 8.2). High *Sphagnum* cover was associated with all of the vascular-plant dominated cover types found in the natural ponds. The aquatic-vegetation cover type found at one excavated pond was created by merging patches dominated by *Scirpus subterminalis* (swaying bulrush) or *Nymphaea odorata* (white water lily). The emergent-herb cover type was characterized by several emergent-plant species including *Eleocharis microcarpa* (small-fruited

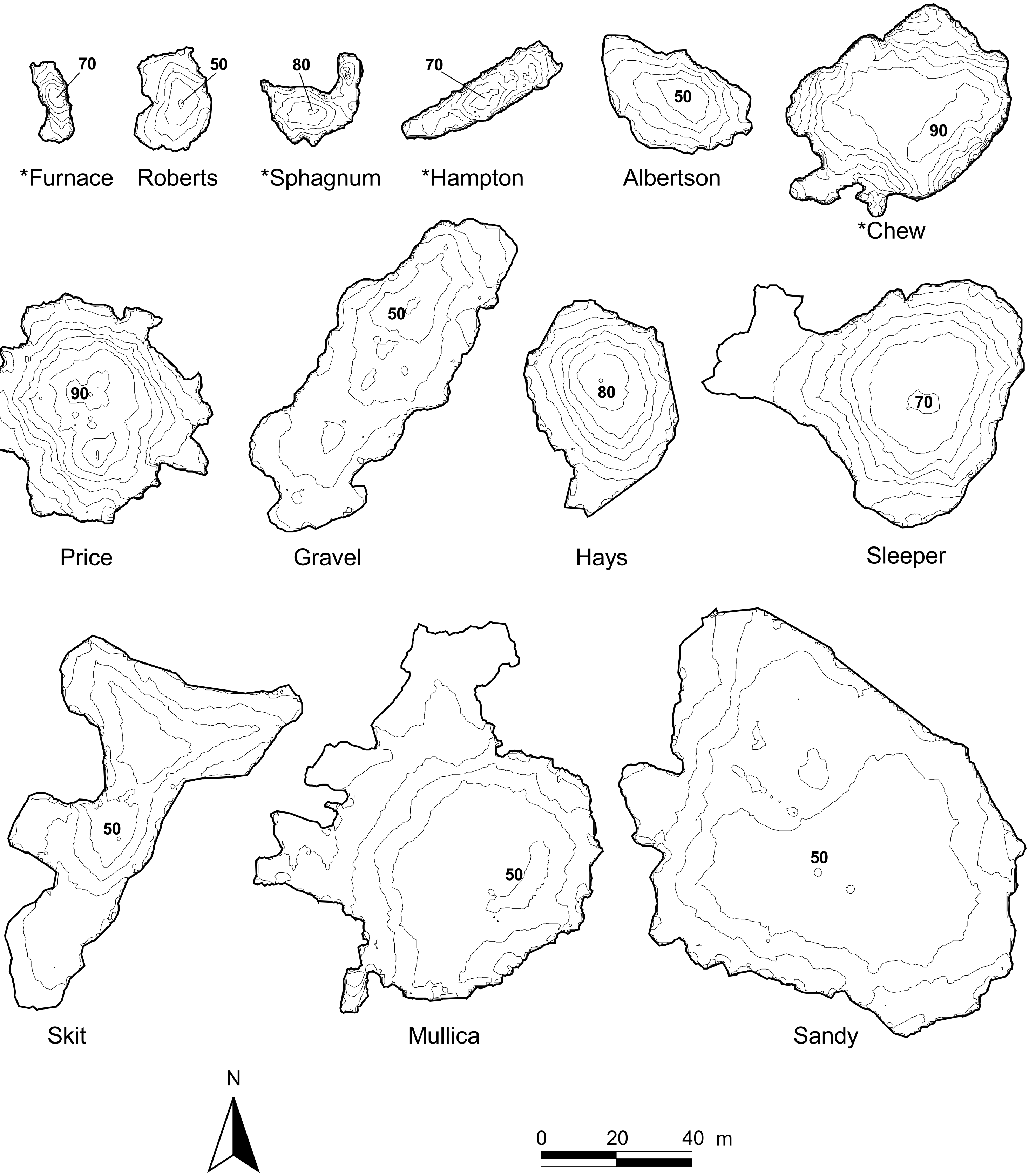

Figure 8.1. Pond bathymetry (March 1998) with 10-cm contour intervals. Excavated basins are denoted with an asterisk. The number associated with each pond is the maximum-depth (cm) contour.

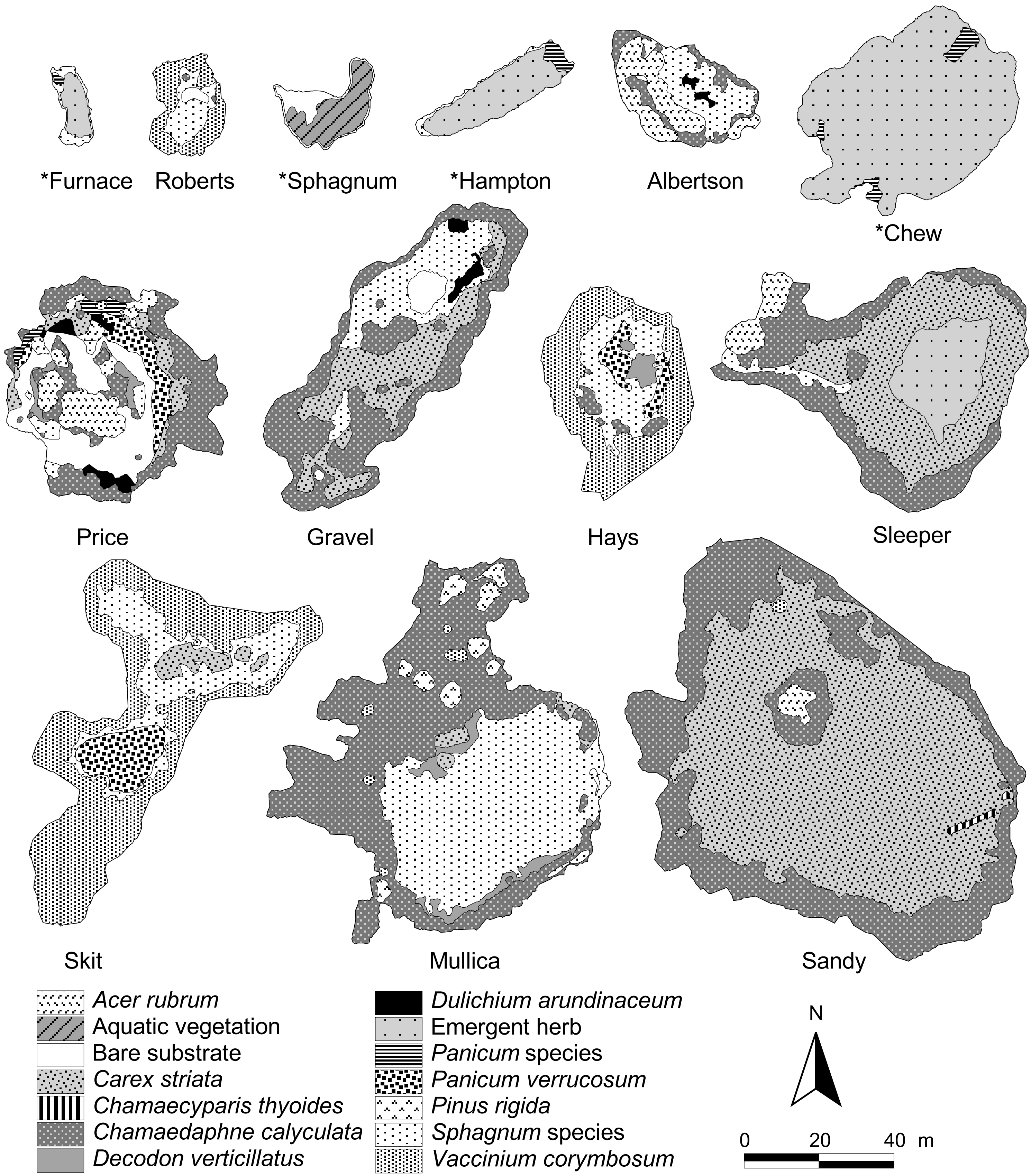

Figure 8.2. Pond cover types (September 1998). Excavated basins are denoted with an asterisk.

spike-rush), *Erianthus giganteus* (plume-grass), *Juncus pelocarpus* (brown-fruited rush), *Proserpinaca pectinata* (cut-leaved mermaid-weed), *Triadenum virginicum* (marsh Saint John's-wort), and *Xyris smalliana* (Small's yellow-eyed grass). The detailed composition of each patch type is given in Laidig et al. (2001). The excavated ponds lacked the distinct vegetation zonation and shrub border found in the natural ponds (Figure 8.2). Three natural ponds were characterized by a *Vaccinium corymbosum* (highbush blueberry) zone that surrounded an open-water *Sphagnum* zone. A prominent *Chamaedaphne calyculata* (leatherleaf) shrub zone bordered the other six natural ponds. This shrub zone surrounded *Carex striata* (Walter's sedge), *Sphagnum*, or bare substrate zones.

The Relationship of Regional Land-use Patterns to Pond Vegetation

Only three species, *Hypericum mutilum* (Canada Saint John's-wort), *Panicum virgatum* (switchgrass), and *Peltandra virginica* (arrow arum) were classified by Stone (1911) as not being characteristic of the Pine Barrens District. Each of these species occurred at a single site and all were found in an excavated basin. Although it is not classified as a disturbance-indicator plant (Chapter 6), *Hypericum mutilum* is usually associated with degraded wetlands (Ehrenfeld 1983, Zampella and Laidig 1997). The other two species are found throughout the Mullica River Basin. A comparison of the natural and excavated ponds revealed no significant differences in the percentage or absolute number of species classified by Stone (1911) as characteristic of the Pine Barrens District, common to both the Pine Barrens District and the adjacent Middle district, or characteristic of the Middle District and Coast Strip.

The general absence of non-Pinelands species and indicator species (Chapter 6) in the 13 ponds is especially noteworthy. Several of the ponds are located in watersheds with moderate to high levels of developed land and upland agriculture. Streams in these disturbed basins display elevated pH and dissolved-solid concentrations and support vegetation characterized by the presence of non-Pinelands species. Like the cedar swamps studied by the Commission (Laidig and Zampella 1999, Chapter 7), the acid-water ponds are not in direct contact with streams and appear to be buffered from upstream land-use disturbances that influence in-stream conditions.

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9 Fish Assemblages

Introduction

Streams and impoundments in relatively unaltered Pinelands watersheds support a characteristic acid-water fish fauna comprising fourteen species (Hastings 1979, Hastings 1984). Hastings (1984) categorized the native Pinelands fish as restricted-characteristic or widespread-characteristic species. Within New Jersey, restricted-characteristic species are mostly limited to the Pinelands. This group of native fish includes the yellow bullhead (*Ameiurus natalis*), pirate perch (*Aphredoderus sayanus*), banded sunfish (*Enneacanthus obesus*), blackbanded sunfish (*Enneacanthus chaetodon*), mud sunfish (*Acantharchus pomotis*), and swamp darter *(Etheostoma fusiforme*). Widespread-characteristic fish species, which are found in other parts of the state, include the American eel (*Anguilla rostrata*), eastern mudminnow (*Umbra pygmaea*), redfin pickerel (*Esox americanus*), chain pickerel (*Esox niger*), ironcolor shiner (*Notropis chalybaeus*), creek chubsucker (*Erimyzon oblongus*), tadpole madtom (*Noturus gyrinus*), and bluespotted sunfish (*Enneacanthus gloriosus*). The ironcolor shiner is rare in most of New Jersey and may no longer occur in the Mullica River Basin (Hastings 1984).

The general absence of nonnative fish in unmodified Pinelands waters is attributed to the physiological effect of low pH or the absence of a suitable food source due to the low productivity that typifies the region (Hastings 1979, Graham 1993, Graham and Hastings 1984, Gonzalez and Dunson 1987). Hastings (1979, 1984) classified the nonindigenous fish found in the Pinelands as either peripheral or introduced species. Peripheral species are native to other parts of New Jersey and are found in waters along the boundaries of the Pinelands. Introduced species are not native to the state. The golden shiner (*Notemigonus crysoleucas*), brown bullhead (*Ameiurus nebulosus*), pumpkinseed (*Lepomis gibbosus*), and tessellated darter (*Etheostoma olmstedi*) are among the peripheral species found in the region. The bluegill (*Lepomis macrochirus*) and largemouth bass *(Micropterus salmoides*) are the most widespread of the introduced species.

Fish communities are generally useful indicators of aquatic degradation (Karr et al. 1985, Berkman et al. 1986, Steedman 1988, Fausch et al. 1990, Karr 1991). Based on studies indicating that changes in Pinelands fish assemblages are associated with water-quality degradation (Hastings 1979, 1984, Graham 1993, Graham and Hastings 1984), Commission scientists began surveying fish assemblages in the Mullica River Basin. The results of an initial study (Zampella and Bunnell 1998) provided the basis for a comprehensive survey of the watershed. This initial study addressed two main questions. First, do fish community attributes (species composition, relative abundance, and species richness) of reference-sites (sites that are minimally impacted by land-use related disturbances) vary along watershed-disturbance gradients? Second, which fish community attributes distinguish reference-site fish assemblages from those found at modified sites? The ultimate goal of the investigation was to assess the utility of fish assemblages as indicators of watershed conditions.

Fish Assemblages as Indicators of Watershed Conditions

The Commission's initial stream-assemblage study (Zampella and Bunnell 1998) compared acid-water fish assemblages found at five Pinelands reference-sites to assemblages at 12 other stream sites displaying a range of pH and specific conductance values and upstream land-use characteristics. Nineteen fish species were collected at the 17 Mullica River Basin sites during surveys conducted between 1992 and 1995. These species included six nonnative fish and all thirteen native fish reported to occur in the Mullica River Basin by Hastings (1984). The number of species (species richness) found at a site ranged from 8 to 15 species. Species richness did not clearly distinguish reference-sites from degraded sites. The total number of individuals collected was greater at sites with high plant cover compared to sites with low plant cover, but there was no difference in species richness between these two site types.

Native species occurred across a range of conditions and dominated the assemblages of all 17 sites. Among the 13 native Pinelands species, the creek chubsucker was most closely associated with high-pH stream sites. The six nonnative fish species included four peripheral species and two introduced species. These species were less abundant than native species and most site occurrences were represented by a single individual. All were limited to sites where the pH was greater than 5.5 and, except for the tessellated darter, were found only at stream sites with median conductance values greater than 60 μS cm^{-1}.

The tessellated darter is the only nonnative species considered characteristic of stream habitats. The other nonnative species encountered in the study are more typical of Pinelands lakes and ponds (Hastings 1984), which are primarily on-stream impoundments. This habitat association probably accounted for the general rarity of nonnative species in the disturbed streams.

Detrended correspondence analysis (DCA, Chapter 6) was used to order fish species and stream sites based on presence/absence data. A second ordination was produced using relative-abundance data. The results of these separate analyses were similar. In both, the first DCA axis contrasted the occurrence of native fish species with the occurrence of nonnative fish. The order of sites along the first axis of both DCA ordinations, which represents a fish-community gradient, was correlated with a complex watershed-disturbance gradient characterized by increasing pH, specific conductance, and the percentage of developed land and upland agriculture in a drainage basin. These fish-community gradients were also correlated with native and restricted-characteristic species richness and the percentage of native and restricted-characteristic species.

The study demonstrated several major points regarding the use of fish assemblages as indicators of Pinelands watershed conditions. First, the presence of nonnative species is a useful indicator of aquatic degradation represented by elevated pH and specific conductance values and a high percentage of developed land or upland agriculture in a basin. Second, a ranking of stream sites based on an ordination of species data (presence/absence or relative abundance) provides a good estimate of watershed conditions. Finally, the contrast between reference-site assemblages and assemblages found at degraded-stream sites was more pronounced when presence/absence data were analyzed. These conclusions were applied directly to a full assessment of the status of fish assemblages in the Mullica River Basin.

THE STATUS OF FISH ASSEMBLAGES IN THE MULLICA RIVER BASIN

The Commission's initial study of Mullica River Basin fish assemblages (Zampella and Bunnell 1998) provided the basis for an expanded fish-sampling program that was carried out between 1995 and 1999. The expanded fish-monitoring program allowed the Commission to increase the baseline inventory of Mullica River Basin fish assemblages and to more fully characterize the status of fish communities within the tributary systems of the basin. Because the nonnative fish encountered during the initial study are typically associated with lakes and ponds, the expanded monitoring program included both streams and impoundments in each of the major Mullica River drainage basins.

Methods

Study Sites

The major criteria used to select survey stations were drainage-area land-use characteristics, accessibility, and suitability as fish survey sites. Sixty-four stream sites and 30 impoundments were surveyed throughout the Mullica River Basin. Due to access limitations, portions of the Wading River basin were not surveyed. The location of each sampling station was registered with a global positioning system.

Characterizing Stream Conditions

Major drainage-basin and local-habitat attributes were characterized at each site in conjunction with the stream-vegetation surveys (Chapter 6). Specific conductance was measured with an Orion model 122 meter and pH was measured with an Orion model 250A meter (Chapter 4). In-stream measurements taken below the outflow of lakes and ponds were used to characterize the pH and specific conductance of impoundments. Upstream land-use profiles were prepared using ArcView software and New Jersey Department of Environmental Protection 1995/1997 land-use data, and basin areas were measured using NJDEP digital hydrography data (Chapter 1). Each stream reach was divided into 25-m sections. Bankfull-channel width, the dominant channel-bed substrate, stream-bank forest type, and adjacent-forest types were determined for each 25-m section. The dominant channel-bed substrate found within one meter of the left and right banks and in the center of the channel was subjectively characterized as gravel, sand, and muck (silt, clay, detritus, and muck). In-stream plant cover within one meter of each bank was estimated using the Braun-Blanquet cover scale (where 1 < 5%, 2 = 5 - 25%, 3 = 25 - 50%, 4 = 50 - 75%, and 5 = 75 - 100%). For each stream site, median bankfull-channel width and in-stream plant-cover values were calculated and the frequency of occurrence of the dominant channel-bed substrates were determined.

Fish Surveys

Fish sampling methods were similar to those used by Zampella and Bunnell (1998). At each stream station, all habitats in a 100-m long stream reach were sampled using a 4-mm mesh nylon seine. Sites were sampled for one hour on two to four separate occasions (Cedar Brook was sampled only once) between May and October. Impoundments were sampled on a single occasion for a period of one hour. One impoundment (Batsto Lake) was sampled on two dates. The fish-survey data, which include the number of individuals of each species collected at each site on individual dates and distribution maps for each species are presented in Appendix 5. This appendix also describes the location of each sampling site, including latitude and longitude, and identifies the individuals who conducted the surveys. Taxonomic nomenclature follows that used in Fuller et al. (1999). The Commission maintains a fish collection that includes voucher specimens for each stream site. For each species, the number of individuals collected at a site during all visits conducted between 1992 and 1999 were pooled. These pooled data were 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 (Chapter 6) was used to order fish species and sampling sites based on presence/absence data. The same data were used to classify or group species and sites using TWINSPAN. Stream sites and impoundments were analyzed separately. All default options were used for the ordination and classification analyses. Because rare species can have a disproportionate effect on ordinations, only species occurring at two or more sites were included in the gradient analysis. Four sites were not included in the ordinations. These included two unnamed Batsto River tributaries where less than a 100-m section was sampled and two sites (Wading River at Tumbling Dam and Oswego River below Oswego Lake) where pH and specific conductance data were not collected. Both the Wading River and Oswego River sites were located very close to another station along the same stream.

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 selected environmental conditions. Based on the results of the Commission's initial fish study, the first axis site scores of the DCA ordinations were correlated with median pH and specific conductance and the percentage of developed land and agricultural land in a basin. The percentage of wetland agriculture, bankfull-stream width, impoundment area, median channel-plant cover, frequency of occurrence of channel-substrate type, latitude, and longitude were also included in the analysis. An alpha level of 0.05 was used to identify important relationships revealed by the correlation analysis. Because the high density of sampling sites in the basin may influence the outcome of the correlation analyses, these tests were performed primarily to evaluate general trends and the relative strength of the relationships between community gradients and environmental factors.

Results

Stream-fish Surveys

Twenty-one species were collected during the stream surveys, including the 13 native Pinelands species previously reported as occurring in the Mullica River Basin, five peripheral species, and two introduced species. Species richness ranged from 8 to 15 species. The mean (± 1 SD) and median number of species collected at the 64 sites was 9.3 ± 2.6 and 10, respectively. The eastern mudminnow, chain pickerel, swamp darter, and banded sunfish were the most frequently encountered native species (Figure 9.1).

The native tadpole madtom was collected at only 20% of the stream sites. Likewise, Hastings (1984) noted that this species was found in only 16% of Mullica River collections and suggested that it might be regarded as a peripheral species.

Nonnative species were collected at 24 stream sites. None was found at more than 20% of the sites (Figure 9.1) and none were abundant (Figure 9.2). Where found, the median relative abundance of nonnative species, as a group, was 7.4 %. In order of decreasing frequency of occurrence, the nonnative fish included the tessellated darter, bluegill, largemouth bass, pumpkinseed, brown bullhead, golden shiner, and yellow perch (*Perca flavescens*). The tessellated darter was the most frequently encountered nonnative fish species. The yellow perch, a peripheral species that was not found in the Commission's initial survey (Zampella and Bunnell 1998), occurred at only one site along Hammonton Creek. Hastings (1984) also identified Hammonton Creek as the only nontidal area in the basin where the yellow perch was reported to occur.

Impoundment-fish Surveys

Twenty fish species were collected from the 30 impoundments, including 12 native and 8 nonnative species. Species richness ranged from 3 to 15 species. The mean (± 1 SD) and median number of species collected at the 30 impoundments was 8.2 (± 2.5) and 8.0, respectively. Tadpole madtom was the only native Pinelands species not found in the impoundments. The three native *Enneacanthus* species, the banded sunfish, blackbanded sunfish, and bluespotted sunfish, were among the most frequently encountered native species and dominated the impoundment assemblages (Figures 9.3 and 9.4).

Nonnative species were found at 15 impoundments. The tessellated darter was absent from all 30 sites. The yellow perch, which was collected from Hammonton Creek, was also found in Hammonton Lake. The black crappie (*Pomoxis nigromaculatus*), a species that was not found during the stream surveys, was collected at four sites in the Upper Mullica River, Neschochague Creek, and Hammonton

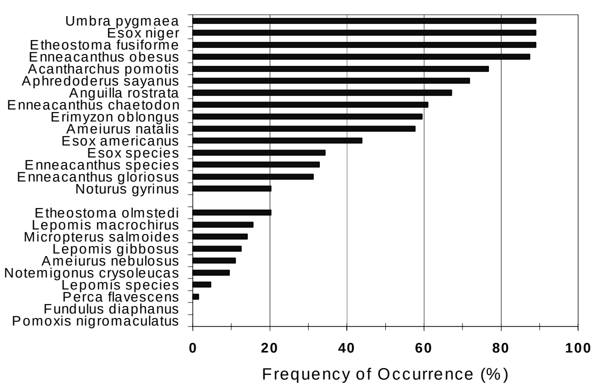

Figure 9.1. Frequency of occurrence of fish species at 64 Mullica River Basin stream sites.

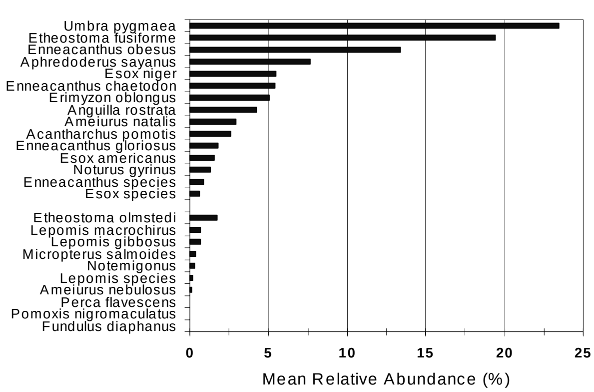

Figure 9.2. Mean relative abundance of fish species at 64 Mullica River Basin stream sites.

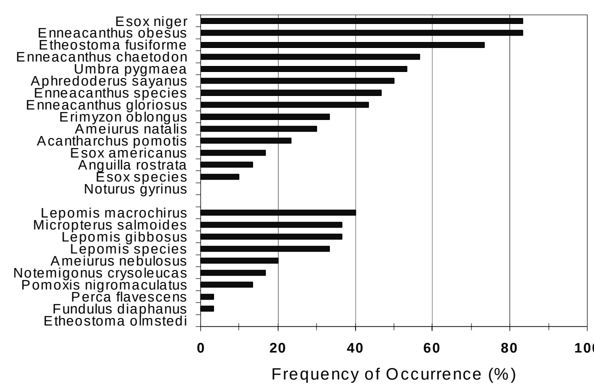

Figure 9.3. Frequency of occurrence of fish species at 30 Mullica River Basin impoundments.

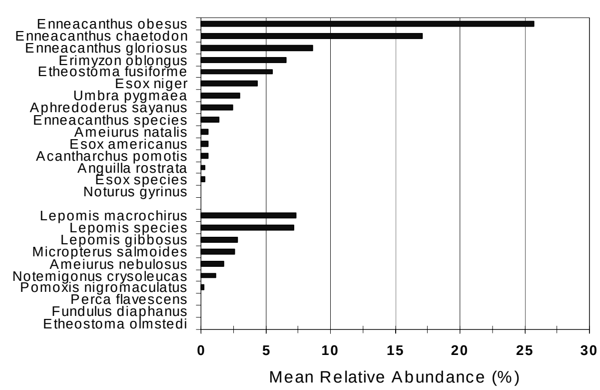

Figure 9.4. Mean relative abundance of fish species at 30 Mullica River Basin impoundments.

Creek basins. A single banded killifish *(Fundulus diaphanus*) was collected from Atco Lake in the Sleeper Branch basin. Graham (1978) also collected the banded killifish from this impoundment. With the exception of the Upper Mullica River basin collection, the black crappie and the banded killifish records are consistent with those reported by Hastings (1984). An important difference between the stream and impoundment survey results is the greater frequency of occurrence and greater relative abundance for pumpkinseeds, bluegills, and largemouth bass in impoundments. Where found, the median relative abundance of nonnative species as a group was 34.6%. When all individuals, including those not identified to species, were included, the median value was 36.7%.

Stream-fish Community Gradient

The initial DCA ordination of species presence/absence data for 60 stream sites was affected by six outliers which compressed the order of the remaining 54 sites along the first axis. The six outliers displayed similar environmental and biological characteristics. Common environmental features included low pH (< 4.7), narrow-ditched channels, and small drainage areas with less than 10% developed land or farmed land within the basin. Five of the six stream reaches were located in abandoned cranberry bogs. The extreme position of these sites was due to their low species richness, composed of three to five native species, and similar species composition. Banded sunfish, redfin pickerel, and eastern mudminnow were found at all six sites. Mud sunfish and chain pickerel were collected at four of the sites. By deleting these six sites from the final analysis, the other sites were spread more evenly along the first axis.

The first DCA axis of the final ordination contrasted stream sites with fish assemblages composed entirely of native species with those including both native and nonnative species (Tables 9.1and 9.2, Figure 9.5). The percentage of nonnative species increased along this community gradient (Figure 9.6), which was associated with differences in the range of watershed conditions where the native and nonnative species were found (Table 9.1, Figure 9.7). The order of stream sites along the first DCA axis was associated with increasing pH (r = 0.82), specific conductance (r = 0.62), and the percentage of developed land (r = 0.78) and upland agriculture (r = 0.76) in a basin

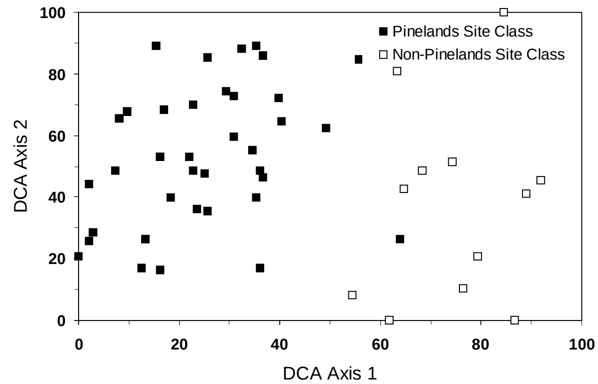

Figure 9.5. DCA ordination diagram for stream fish in the Mullica River Basin. Refer to Table 9.2 for site names ordered by DCA axis 1 scores.

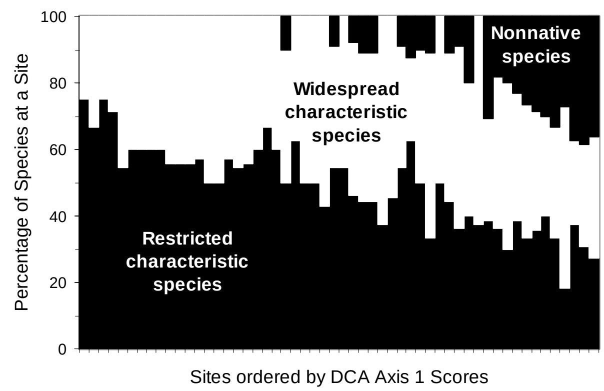

Figure 9.6. Biogeography of fish found at 54 Mullica River Basin stream sites. Refer to Table 9.2 for site names ordered by DCA axis 1 scores.

(Figure 9.8). The gradient was also correlated with longitude (r = -0.57). The *p* level for all five relationships was < 0.001. A higher percentage of nonnative species was found on the more heavily-altered western side of the basin, suggesting that the association between longitude and community composition was related to land-use patterns (Figure 9.9). Neither the percentage of wetland agriculture, basin size, bankfull-channel width, channel sediments, nor median vegetation cover were associated with this stream community gradient.

Nonnative species were absent at five sites shown at the disturbed end of the community gradient. The presence of the tadpole madtom was the most obvious common trait among four of these sites. Species that were not included in the ordination but that support the general position of two of these sites were a *Lepomis* (species not known) found at Hays Mills Creek and a tessellated darter found immediately

Table 9.1. Raw DCA axis 1 and axis 2 species scores for 19 stream-fish species and 18 impoundment-fish species in the Mullica River Basin. Species are ordered by DCA axis 1 species scores.

Stream fish				Impoundment fish			
Species	Species code	Axis 1	Axis 2	Species	Species code	Axis 1	Axis 2
Enneacanthus chaetodon	EnneChae	-116	62	*Esox americanus*	EsoxAmer	-108	300
Acantharchus pomotis	AcanPomo	-42	20	*Acantharchus pomotis*	AcanPomo	-1	72
Enneacanthus gloriosus	EnneGlor	-41	305	*Umbra pygmaea*	UmbrPygm	16	152
Umbra pygmaea	UmbrPygm	-35	42	*Aphredoderus sayanus*	AphrSaya	82	132
Enneacanthus obesus	EnneObes	-28	6	*Enneacanthus obesus*	EnneObes	94	207
Ameiurus natalis	AmeiNata	-6	97	*Enneacanthus chaetodon*	EnneChae	138	324
Esox americanus	EsoxAmer	3	-164	*Ameiurus natalis*	AmeiNata	139	159
Aphredoderus sayanus	AphrSaya	37	117	*Etheostoma fusiforme*	EtheFusi	188	224
Etheostoma fusiforme	EtheFusi	106	46	*Erimyzon oblongus*	ErimOblo	216	388
Esox niger	EsoxNige	117	89	*Esox niger*	EsoxNige	231	192
Anguilla rostrata	AnguRost	126	103	*Enneacanthus gloriosus*	EnneGlor	247	385
Erimyzon oblongus	ErimOblo	147	139	*Anguilla rostrata*	AnguRost	260	-87
Etheostoma olmstedi	EtheOlms	156	171	*Micropterus salmoides*	MicrSalm	340	387
Noturus gyrinus	NotuGyri	156	366	*Lepomis macrochirus*	LepoNebu	363	183
Lepomis macrochirus	LepoMacro	234	7	*Ameiurus nebulosus*	AmeiNebu	377	152
Micropterus salmoides	MicrSalm	239	-182	*Lepomis gibbosus*	LepoGibb	382	215
Lepomis gibbosus	LepoGibb	243	-235	*Notemigonus crysoleucas*	NoteCrys	395	60
Notemigonus crysoleucas	NoteCrys	251	108	*Pomoxis nigromaculatus*	PomoNigr	461	57
Ameiurus nebulosus	AmeiNebu	265	115				

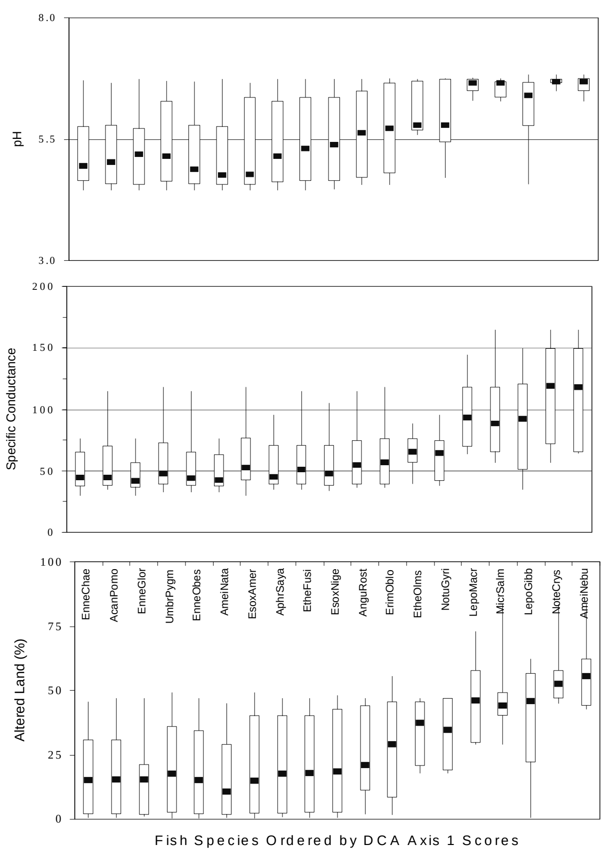

Figure 9.7. The pH, specific conductance (μS cm-1) and percentage of altered land (developed land and upland agriculture) associated with fish species found at 54 stream sites. Box plots show the first, second (median), and third quartiles and the 10^{th} and 90^{th} percentiles for each variable. Refer to Table 9.1 for key to fish names.

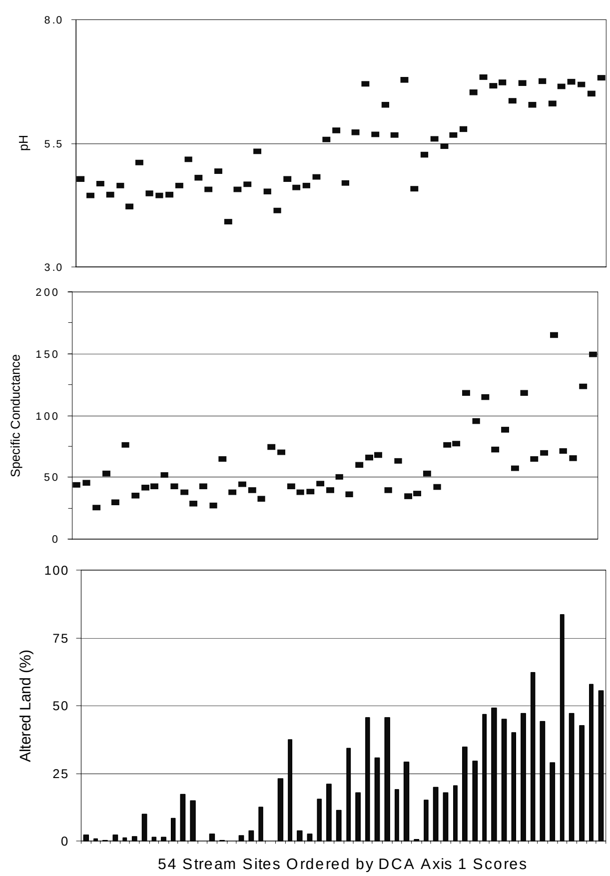

Figure 9.8. Median pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) for 54 Mullica River Basin stream sites. DCA Axis 1 represents a stream-fish community gradient. Refer to Table 9.2 for site names ordered by DCA axis 1 scores.

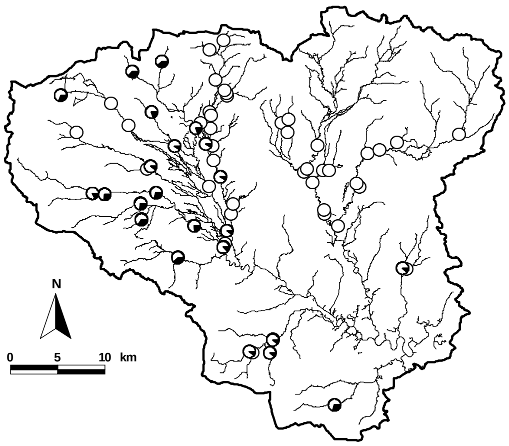

Figure 9.9. Pie charts showing the percentage of native (white) and nonnative (black) fish species present at 64 stream sites in the Mullica River Basin.

outside the 100-m stream section of the Batsto River at Lower Forge site. The absence of nonative species at Union Creek, another site included in this group, may be due to the absence of large impoundments in the drainage basin and the lack of suitable habitat for tessellated darter.

The first division of the TWINSPAN classification separated a group of 12 stream sitesfrom all other sites (Figures 9.5 and 9.10). The 12 sites, which represented a non-Pinelands site class, were characterized by high nonnative-species richness. Nonnative fish, primarily the tessellated darter, were found at 29% of the remaining 42 sites, which represented a Pinelands site class. Contrasting pH, specific conductance, and developed-land and upland-agriculture cover in the associated basins also distinguished the two major site classes, while more subtle environmental differences existed between the subclasses within the major groups.

Impoundment-fish Community Gradients

The community patterns and environmental relationships revealed by the ordination of impoundment-species data were similar to those found for streams. The first DCA axis contrasted sites with and without nonnative species (Tables 9.1 and 9.2, Figures 9.11 and 9.12). The percentage of nonnative species increased along this community gradient, which was related to the range of watershed conditions associated with each fish species (Figure 9.13).

As with the stream analysis, the order of impoundments along the first DCA axis was associated with increasing pH (r = 0.89), the percentage of developed land (r = 0.85) and upland agriculture (r = 0.83) in a basin, and longitude (r = - 0.70) (Figure 9.14).

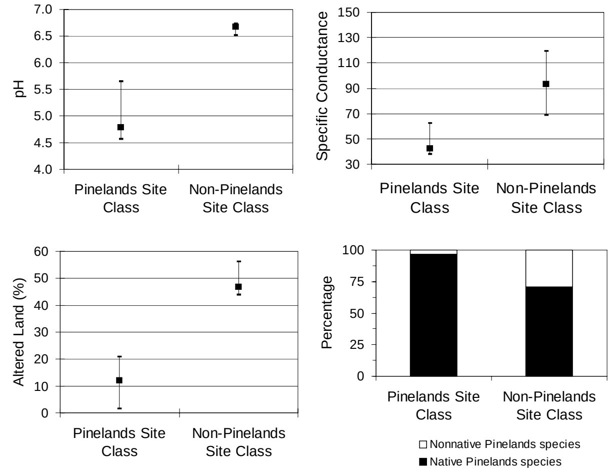

Figure 9.10. Median and 1st and 3rd quartile specific conductance (μS cm^{-1}), pH, and percentage of altered-land (developed land and upland agriculture) values for two TWINSPAN-derived site classes for 54 Mullica River Basin stream sites.

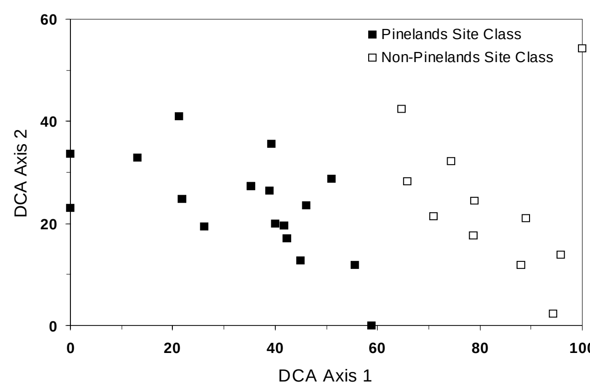

Figure 9.11. DCA ordination diagram and TWINSPAN classification for 30 Mullica River Basin impoundments. Refer to Table 9.3 for site names ordered by DCA axis 1 scores.

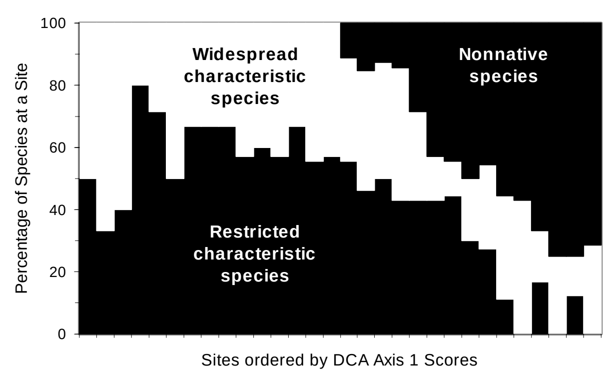

Figure 9.12. Biogeography of fish found at 30 Mullica River Basin impoundments. Refer to Table 9.3 for site names ordered by DCA axis 1 scores.

Table 9.2. Raw DCA axis 1 and axis 2 site scores for 54 stream sites in the Mullica River Basin based on an ordination of species presence/absence data. Sites are ordered by DCA axis 1 scores.

Basin	Site	Site Code	Axis 1	Axis 2
Batsto River	Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	0	28
Batsto River	Skit Branch below Carranza Road	BSKITCAR	3	60
Oswego River	Oswego River below Beaver Dam Road	OOSBEAVR	3	35
Wading River	Little Hauken Run below Route 563	WLIHAUKN	4	39
Batsto River	Skit Branch above Hampton Road	BSKITHAM	10	66
Batsto River	Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	11	89
Oswego River	Oswego River below Route 679	OOSHARST	11	89
Oswego River	Oswego River above Oswego Lake	OOSLAKUP	13	92
Oswego River	Oswego River above Martha	OOSOLMAR	13	92
Wading River	Hospitality Brook below Route 563	WHOSPITA	17	23
Upper Mullica River	Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	18	36
Upper Mullica River	Mullica River above Route 534	MMULJACK	18	36
Oswego River	Buck Run below Old Martha Road	OBUCKRUN	21	121
Wading River	Featherbed Branch below Carranza Road	WFEACARR	22	22
Wading River	Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	22	72
Wading River	Wading River above Route 563	WWEEVANB	22	72
Bass River	East Branch Bass River above Stage Road	AEASTAGE	23	93
Wading River	Wading River below Mile Run	WWEMILER	25	54
Upper Mullica River	Mullica River at northern border of Wilderness Area	MMUWILDR	30	72
Sleeper Branch	Sleeper Branch above Mullica River	MSLPLEAS	31	95
Oswego River	Papoose Branch below Jenkins Road	OPAPOOSE	31	66
Lower Mullica River	Elliots Creek at Bremen Avenue	LELIOBRE	32	49
Wading River	Wading River above Tulpehocken Creek	WWETULPC	34	65
Batsto River	Batsto River below Penn Swamp Branch	BBAPENNS	35	116
Wading River	Wading River below Ford Road	WWEFORDR	35	48
Batsto River	Batsto River above Carranza Road	BBACARRZ	40	101
Sleeper Branch	Clark Branch at Parkdale	MCLJOHNS	42	99
Upper Mullica River	Mullica River below Constable Bridge	MMUCONST	42	81
Batsto River	Batsto River side channel below Quaker Bridge Road	BBAQUAKR	44	120
Lower Mullica River	Landing Creek above Indian Cabin Road	LLANDIND	47	75
Nescochague Creek	Nescochague Creek at Pleasant Mills	NNEMILLS	47	75
Batsto River	Batsto River at Lower Forge	BBALFORG	48	121
Lower Mullica River	Union Creek above Alternate Route 561	LUNIOMOS	48	54
Bass River	West Branch Bass River above Stage Road	AWESTAGE	49	23
Sleeper Branch	Sleeper Branch at Parkdale	MSLEPARK	49	66
Lower Mullica River	Indian Cabin Creek above Landing Creek	LINCABIN	50	117
Upper Mullica River	Mullica River below Central New Jersey/Conrail railroad bridge	MMURRBRG	50	63
Batsto River	Batsto River above Hampton Road	BBATHAMP	54	98
Lower Mullica River	Landing Creek below Alternate Route 561	LLANDMOS	55	88
Batsto River	Springers Brook below Deep Run	BSPRDIKE	67	85
Upper Mullica River	Wesickaman Creek below Three Bridge Road	MWETHREE	74	11
Sleeper Branch	Hays Mill Creek above Tremont Avenue	MHATREMO	76	115
Upper Mullica River	Mullica River below Jackson-Medford Road	MMULADYS	84	0
Nescochague Creek	Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	86	110
Batsto River	Springers Brook above Hampton Road	BSPRIHAM	87	36
Nescochague Creek	Nescochague Creek near West Mill Road	NNEWESTM	88	58
Nescochague Creek	Great Swamp Branch below Route 613	NGRMIDDL	93	66
Nescochague Creek	Albertson Brook above derelict bridge below Route 206	NALDEREL	101	70
Lower Mullica River	Morses Mill Stream below College Drive	LMORSESM	104	14
Nescochague Creek	Cedar Brook near Hammonton Airport	NCEAIRPO	108	28
Nescochague Creek	Albertson Brook above Fleming Pike	NALBFLEM	115	136
Batsto River	Indian Mills Brook above Oakshade Road (above Shadow Lake)	BINSHADS	118	0
Batsto River	Muskingum Brook above Tuckerton Road	BMUSKTUC	121	56
Lower Mullica River	Hammonton Creek above Chestnut Avenue	LHACHEST	125	62

Table 9.3. Raw DCA axis 1 and axis 2 site scores for 30 impoundments in the Mullica River Basin based on an ordination of species presence/absence data. Sites are ordered by axis 1 scores.

Basin	Site	Site Code	Axis 1	Axis 2
Batsto River	Batsto River headwater impoundment below Route 532	BBATS532	0	73
Batsto River	Deep Run impoundment below Hampton Road	BDEEPIMP	0	110
Wading River	Bulls Branch impoundment (Otter Pond)	WBUOTTER	46	75
Wading River	Featherbed Branch impoundment below Carranza Road	WFEIMPD1	75	47
Oswego River	Oswego River impoundment above Old Cedar Bridge-Barnegat Road	OOSCEDRI	77	104
Oswego River	Oswego River impoundment at Howardsville	OOSHOWIM	92	123
Batsto River	Skit Branch beaver pond above Carranza Road	BSKWIDEN	124	95
Batsto River	Roberts (Tom Roberts) Branch beaver pond above Carranza Road	BTOIMPCA	124	95
Sleeper Branch	Sleeper Branch bogs at Route 206	MSL206BG	124	95
Bass River	Lake Absegami	AEAABSDW	137	98
Upper Mullica River	Goshen Pond	MMUGOSHN	138	66
Bass River	West Branch Bass River impoundment above Stage Road (Pilgrim Lake)	AWEPILGL	141	121
Oswego River	Harrisville Pond	OOSHARLK	147	122
Oswego River	Oswego Lake	OOSWLAKE	149	131
Lower Mullica River	Egg Harbor City Lake below Route 563	LINLAKED	158	146
Sleeper Branch	Cooper Branch impoundment near Tremont Avenue and Burnt Mill Road	MCOIMPNT	162	108
Batsto River	Batsto Lake	BBATLAKE	180	90
Upper Mullica River	Atsion Lake	MMUATSIO	196	149
Nescochague Creek	Albertson Brook impoundment below Route 206 (Paradise Lakes)	NALPARAD	207	191
Batsto River	Indian Mills Brook impoundment above Oakshade Road (Shadow Lake)	BINSHADW	228	42
Batsto River	Indian Mills Brook impoundment above Old Schoolhouse Road	BINSCHOO	232	92
Lower Mullica River	Lake Fred	LMOSTOCK	250	117
Sleeper Branch	Atco Lake	MHAATCOL	262	142
Upper Mullica River	Mullica River impoundment at Jackson-Medford Road (Lady’s Lake)	MMULADYL	277	129
Nescochague Creek	Great Swamp Branch impoundment above Route 30	NGREAR30	278	105
Nescochague Creek	Pump Branch impoundment near Cedar Avenue	NPUIMPNT	310	149
Batsto River	Indian Mills Lake at dam	BMULAKED	313	116
Nescochague Creek	Pump Branch impoundment at Ha-Lu-Wa-Sa	NPUHALUW	332	183
Lower Mullica River	Hammonton Lake	LHAMLAKE	337	78

The *p* level for all four relationships was < 0.001. The weak relationship between the community gradient represented by the first DCA axis and specific conductance ($r = 0.41$, $p = 0.02$), was due largely to the nonlinear relationship between pH and

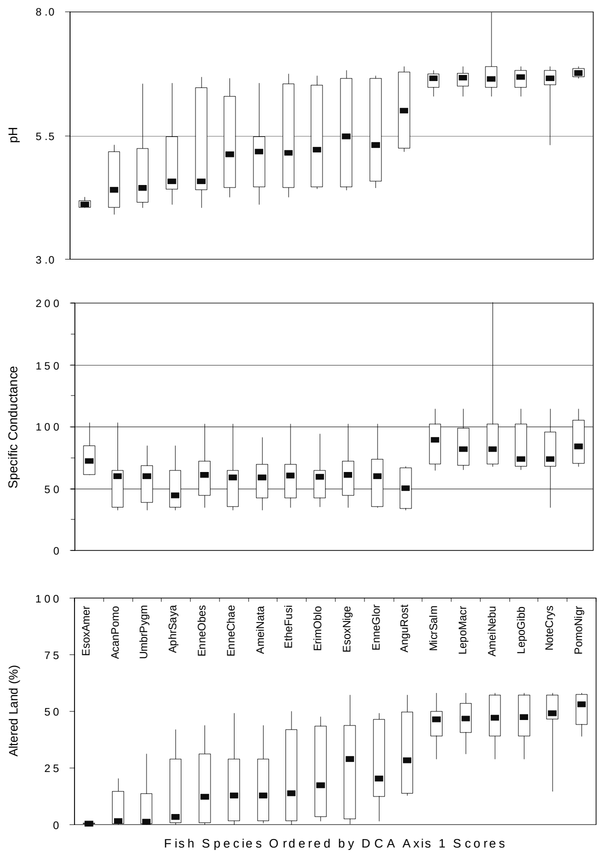

Figure 9.13. The pH, specific conductance ($\mu S\ cm^{-1}$) and percentage of altered-land (developed land and upland agriculture) associated with fish species found at 30 impoundments. Box plots show the first, second (median), and third quartiles and the 10^{th} and 90^{th} percentiles for each variable. Refer to Table 9.1 for key to fish names.

conductance at very low pH values (Chapter 4). As with the stream assemblages, the association between longitude and community composition was related to land-use patterns because most nonnative species were found on the more heavily altered western side of the Mullica River Basin (Figure 9.15). The major difference between the stream and impoundment assemblages was the dominance or near dominance of nonnative species in impoundments within the most heavily altered watersheds. The TWINSPAN classification of impoundments clearly demonstrates this distinction.

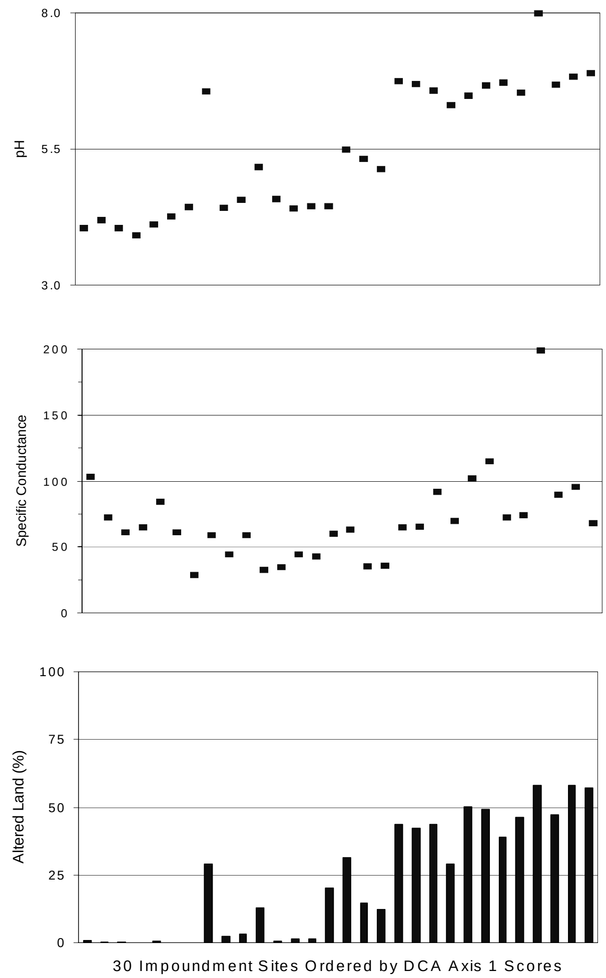

Figure 9.14. Median pH, specific conductance ($\mu S\ cm^{-1}$), and percentage of altered-land (developed land and upland agriculture) for 30 Mullica River Basin impoundments. DCA axis 1 represents a stream-fish community gradient. Refer to Table 9.3 for site names ordered by DCA axis 1 scores.

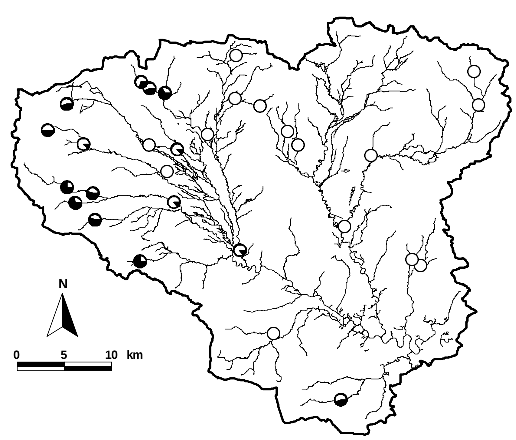

Figure 9.15. Pie charts showing the percentage of native (white) and nonnative (black) fish species present at 30 impoundment sites in the Mullica River Basin.

The first division of the TWINSPAN classification separated a group of 11 impoundments (non-Pinelands site class), characterized by elevated pH, specific conductance, and a high percentage of altered land (developed land and upland agriculture) in the basins, from the remaining 19 Pinelands sites (Figures 9.11 and 9.16). The number of nonnative species found at the degraded sites ranged from two to five, with a mean (± 1 SD) of 4.2 ± 1.2 species. Assemblages at all but four impoundments in the larger Pinelands site class were composed entirely of native species. The four exceptions supported only one or two nonnative species and displayed a native-species richness similar to the other sites in the Pinelands site class.

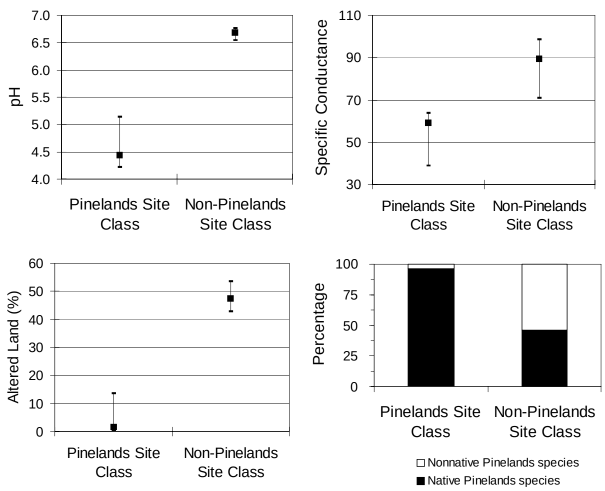

Figure 9.16. Median and 1st and 3rd quartile specific conductance (μS cm^{-1}), pH, and percentage of altered-land (developed land and upland agriculture) values for two TWINSPAN-derived site classes for 30 Mullica River Basin impoundments.

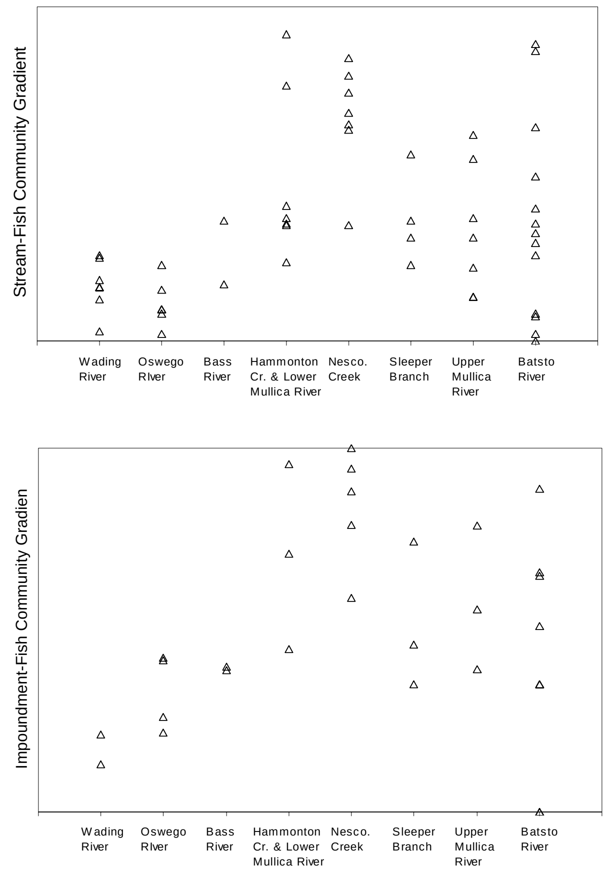

Figure 9.17. Position of fish-survey sites along fish community gradients, represented by DCA axis 1 site scores, in eight Mullica River Basin stream systems. Refer to Tables 9.2 and 9.3 for site names ordered by DCA axis 1 scores.

Drainage-basin Characterizations

Wading River, Oswego River, and Bass River

Fish assemblages in the Oswego River and Wading River basins were characterized by the absence of nonnative fish. All stream and impoundment sites in these two basins supported native-fish assemblages and occupied a position at the undisturbed end of the fish-community gradient (Tables 9.2 and 9.3, Figure 9.17). Except for the West Branch of the Bass River, nonnative fish were absent from all the Bass River basin sites. Pumpkinseeds were collected at the West Branch site on a single sampling date. This peripheral species placed the West Branch at a transitional position along the stream-fish community gradient. The absence of pumpkinseed from an impoundment located immediately upstream from the collection site suggested that this peripheral species may have entered the acid-water stream from tidal areas where it is known to occur (Hastings 1984).

Hammonton Creek and Lower Mullica River Tributaries

Most Lower Mullica River tributary sites occupied a transitional position along the fish-community gradients (Tables 9.2 and 9.3, Figure 9.17). The tessellated darter was the most frequently encountered nonnative species found in these stream systems. Bluegills, largemouth bass, and pumpkinseeds were collected from Morses Mill Stream below Lake Fred, an impoundment that also supported a mixed assemblage of native and nonnative fish. In the Hammonton Creek basin, nonnative fish were collected from Hammonton Creek and Hammonton Lake. Both sites occupied an extreme position at the disturbed end of the fish-community gradients.

Nescochague Creek

Nonnative fish were collected from all 12 streams and impoundments surveyed in the Nescochague Creek basin. As indicated by their position on the fish-community gradients (Tables 9.2 and 9.3, Figure 9.17), stream and impoundment assemblages in this basin were among the most heavily modified communities found in the Mullica River Basin. The Nescochague Creek at Pleasant Mills, which was the only site in the Nescochague Creek basin where nonnative bass or sunfish were not collected, occupied a transitional position along the stream-fish community gradient.

Sleeper Branch

Fish assemblages in the Sleeper Branch basin reflected a range of conditions (Tables 9.2 and 9.3, Figures 9.17). Nonnative fish were collected from impoundments in the Hays Mills Creek and Cooper Branch tributary systems and from Sleeper Branch at Parkdale. Although only a single *Lepomis* (species not known) was collected from Hays Mill Creek, the overall species composition placed this site towards the disturbed end of the fish-community gradient. Assemblages composed entirely of native species were found at the remaining Sleeper Branch sites.

Upper Mullica River

Conditions in the Upper Mullica River varied along its length (Tables 9.2 and 9.3, Figure 9.17). Stream and impoundment assemblages found upstream from the Alquatka Branch confluence were composed of native and nonnative species. Only native species were collected at sites between the confluence of the Alquatka Branch and Atsion Lake. Pumpkinseeds were collected at Atsion Lake and at a main-stem site located downstream from the lake. Both bluegills and largemouth bass were collected from the Wesickaman Creek, which flows to the Upper Mullica River below Atsion Lake. With the exception of tessellated darters collected above the mouth of the Sleeper Branch, no nonnative species were found in the three remaining sites along the main stem of the Upper Mullica River.

Batsto River

The widest range of conditions were found in the Batsto River basin (Tables 9.2 and 9.3, Figure 9.17). Streams and impoundments in the tributaries of the heavily altered Springers Brook system supported fish assemblages with a high percentage of nonnative species, while only native fish were found in the forested Skit Branch system. The only nonnative species found along the length of the Batsto River above Batsto Lake was the tessellated darter. Largemouth bass and a single golden shiner were collected from Batsto Lake.

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10 ANURAN ASSEMBLAGES

INTRODUCTION

Acid-water Pinelands habitats support anuran (frog and toad) assemblages that are distinctly different from those found in other parts of New Jersey (Conant 1962, Conant 1979). Five frog species and two toad species are native to the region. Based on their geographic affinity, Conant (1979) categorized these native Pinelands anurans as Pine Barrens species and wide-ranging species. Pine Barrens species include the Pine Barrens treefrog (*Hyla andersonii*) and carpenter frog (*Rana virgatipes*). In New Jersey, both species are confined to Pinelands habitats. Wide-ranging species, which are distributed throughout southern New Jersey, include the green frog (*Rana clamitans melanota*), southern leopard frog (*Rana utricularia*), northern spring peeper (*Pseudacris crucifer crucifer*), Fowler's toad (*Bufo woodhousii fowleri*), and eastern spadefoot (*Scaphiopus holbrooki holbrooki*).

The New Jersey chorus frog (*Pseudacris triseriata kalmi*), gray treefrog (*Hyla versicolor* and *H. chrysoscelis*), northern cricket frog (*Acris crepitans crepitans*), wood frog (*Rana sylvatica sylvatica*), pickerel frog (*Rana palustris*), and bullfrog (*Rana catesbeiana*) are normally unable to enter the Pinelands except in habitats disturbed by human activity. Conant (1979) classified these six nonnative Pinelands anurans as border-entrant species. The low pH of surface waters is considered a major factor preventing the establishment of these species in undisturbed Pinelands habitats (Gosner and Black 1957, Freda and Dunson 1986, Freda and Morin 1984).

Anuran assemblages have been used as indicators of environmental degradation in parts of the United States and Canada (Moyle 1973, Hecnar and M'Closkey 1996, Moyle and Randall 1998). Based on evidence that nonnative anurans are less acid tolerant than native species and can enter the region in human-altered areas (Gosner and Black 1957, Conant 1962, 1979, Freda and Morin 1984), Commission scientists began to survey anuran assemblages to evaluate their use as indicators of watershed disturbance. The results of two initial Commission studies (Bunnell and Zampella 1999, Zampella and Bunnell 2000) provided the basis for a comprehensive survey of the Mullica River watershed.

ANURAN ASSEMBLAGES AS INDICATORS OF WATERSHED CONDITIONS

Basin-wide Anuran Survey

The Commission's initial basin-wide study (Zampella and Bunnell 2000) compared the anuran-community composition at survey sites in the more intensely developed and farmed western portion of the Mullica River Basin to those in the less-disturbed eastern portion of the basin. The western portion of the basin, which included the Nescochague Creek, Sleeper Branch, Upper Mullica River, and Batsto River basins, was called the Mullica River system. The eastern portion, referred to as the Wading River system, comprised the Wading River, Oswego River, and Bass River basins.

Several questions were addressed in the study. First, are there differences in the distribution and abundance of individual anuran species between the two river systems? Second, are there differences in the composition of anuran assemblages between the two systems? Third, is the distribution and abundance of individual anuran species associated with land-use disturbance? Finally, what is the relationship between the bullfrog and native Pinelands anuran species? The presence of bullfrogs in the Pinelands is especially important because this species has been implicated in the decline of native anurans in the western United States (Moyle 1973, Bury and Luckenback 1976, Hammerson 1982, Schwalbe and Rosen 1988, Kupferberg 1997).

Eighty-seven sites, representing a range of habitat types, including natural and excavated ponds, forested and nonforested stream crossings, abandoned cranberry bogs, and impoundments, were surveyed in 1993. Ten anuran species, including six native Pinelands species and four border-entrants, were heard vocalizing at these sites. Native species were found throughout the Mullica River Basin, but border-entrant species were heard only in the western portion of the basin. Most of the sites that supported border-entrants were on-stream sites. Bullfrogs, the most frequently encountered border-entrant species, were heard more often at sites located adjacent to upland agriculture and developed land. The native carpenter frog occurred more frequently at unaltered sites. Pine Barrens treefrogs and carpenter frogs were generally absent at sites where bullfrogs were heard vocalizing.

Detrended correspondence analysis (DCA) and TWINSPAN (Chapter 6) were used to ordinate and classify species and sites based on presence/absence data. The TWINSPAN classification separated the 87 sites into four relatively distinct anuran assemblages that included a carpenter frog-green frog-leopard frog group, a Pine Barrens treefrog-spring peeper group, a spring peeper-Fowler's toad-green frog-bullfrog group, and a green frog group. The spring peeper-Fowler's toad-green frog-bullfrog group, which included all of the pickerel frog occurrences and most of the cricket frog occurrences, was found more frequently in the Mullica River system.

The first axis of the DCA ordination separated bullfrogs, cricket frogs, and pickerel frogs from the other species. This axis also contrasted the carpenter frog-green frog-leopard frog and the Pine Barrens treefrog-spring peeper groups with the spring peeper-Fowler's toad-green frog-bullfrog and the green frog groups. A significant difference in DCA site scores between the eastern and the western portion of the Mullica River Basin was due to the presence of bullfrogs, cricket frogs, and pickerel frogs at sites in the Mullica River system and the general absence of native species at those sites.

The results of this initial survey emphasized three important points regarding the use of anuran assemblages as indicators of Pinelands watershed disturbance. First, the presence of individual border-entrant species and assemblages dominated by these species were associated with adjacent upland agriculture and developed land. Second, the general absence of the two Pine Barrens species at sites with bullfrogs indicated that the presence of bullfrogs may adversely affect native-anuran diversity. Finally, because the majority of sites that supported border-entrant species were stream sites, on-stream anuran communities may be better indicators of overall watershed conditions compared to off-stream communities.

Pond Communities

The Commission scientists also conducted a more intensive study of off-stream anuran-pond communities in the Mullica River Basin (Bunnell and Zampella 1999). In 1996, adult and larval (tadpoles) anurans were surveyed at 14 acid-water ponds located along the transition from forested to agricultural and urban landscapes (Figure 10.1). The pH in these ponds ranged from 3.9 to 4.4. The primary objective of the study was to determine if adult-anuran assemblages and larval recruitment varied in relation to site-specific environmental factors and local and regional landscape characteristics. Six native species and four border-entrant species were heard during the surveys. The native species included Pine Barrens treefrogs, carpenter frogs, leopard frogs, green frogs, spring peepers, and Fowler's toads. Border-entrants included wood frogs, chorus frogs, gray treefrogs, and cricket frogs. The native species were more frequently encountered and more abundant than any border-entrant species. Border-entrants were heard at only six ponds. Anuran larvae were collected in 11 of the 14 ponds. All were larvae of native-Pinelands species.

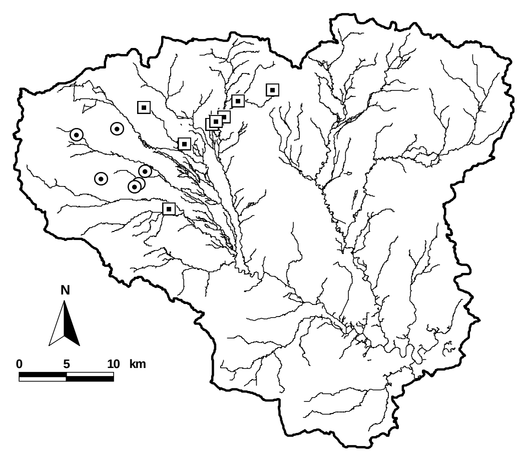

Figure 10.1. Location of 14 off-stream ponds in the Mullica River Basin. Squares represent ponds with native-species assemblages and circles indicate mixed native and border-entrant species assemblages.

Detrended correspondence analysis was used to order adult anuran species and ponds based on adult presence/absence data. The first DCA axis, which represented a community gradient, contrasted native-anuran assemblages with mixed native and border-entrant assemblages. Geographic position was the major factor that distinguished sites with and without border entrant species. Although not a significant result, most of the border-entrant species occurred at sites located close to upland agriculture or developed land. The results of this study suggested that although adults of border-entrant species may be found at Pinelands ponds near altered landscapes, pond acidity may prevent their successful reproduction and recruitment.

THE STATUS OF ANURAN ASSEMBLAGES IN THE MULLICA RIVER BASIN

The Commission's initial anuran-assemblage studies (Bunnell and Zampella 1999, Zampella and Bunnell 2000) provided the basis for an expanded anuran monitoring program. The expanded program, conducted from 1996 through 1999, allowed the Commission to increase the baseline inventory of Mullica River basin anuran assemblages and to more fully characterize the status of anuran communities within the basin.

Methods

Study Sites

Two-hundred forty-two sites were surveyed for vocalizing anurans in the Mullica River Basin (Appendix 6). These sites were selected based on land-use characteristics, accessibility, and suitability as survey sites. The location of each listening point was registered with a global positioning system (GPS). Two-hundred twenty-seven sites remained after deleting sites where no anurans were heard and combining the results of several adjacent sites that were monitored in different years. Several general habitat types, consisting of on-stream and off-stream sites with variable hydrology, were represented (Table 10.1). The habitat classifications and proportion of each habitat type surveyed were similar to those reported in the Commission's initial basin-wide anuran study (Zampella and Bunnell 2000). Based on site visits conducted during vocalization surveys and dry periods in the fall of 1997 and 1998, along with eight years of observations during field work, the hydrology of each site was classified as either permanent, temporary, or unknown (unclassified) (Figure 10.2).

The habitat types included 67 stream impoundments, 52 nonforested-stream crossings, four forested-stream crossings, seven forested wetlands, 41 natural off-stream ponds, 42 excavated off-stream ponds, six abandoned cranberry bogs, three active cranberry bogs, and five ditches. Impoundments were large,

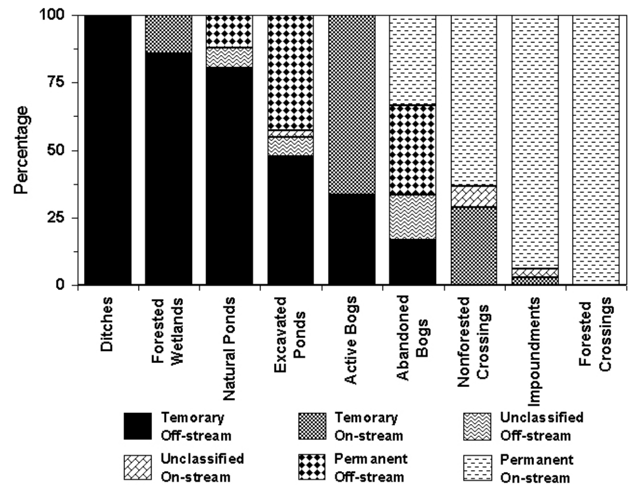

Figure 10.2. Hydrologic classification of nine anuran habitat types.

Table 10.1. Frequency of occurrence (as a percentage) of twelve anuran species at nine habitat types. For geographic affinity, PB = Pine Barrens species, WR = wide-ranging species, and BE = border-entrant species.

	Number of sites	Mean (± 1 SD) species richness	Total species richness	Pickerel frog	Northern cricket frog	Gray treefrog	New Jersey chorus frog	Wood frog	Bullfrog	Pine Barrens treefrog	Fowler's toad	Southern leopard frog	Carpenter frog	Northern spring peeper	Green frog
Geographic affinity				BE	BE	BE	BE	BE	BE	PB	WR	WR	PB	WR	WR
Active cranberry bogs	3	3.7 (± 2.1)	7	-	-	-	33	-	-	33	33	67	67	100	33
Forested crossings	4	1.5 (± 0.6)	3	-	-	-	-	-	-	-	-	-	100	25	25
Ditches	5	2.0 (± 0.7)	5	-	-	-	40	80	20	-	20	-	-	40	-
Aband. cranberry bogs	6	6.0 (± 1.7)	9	-	-	-	17	17	33	83	100	83	67	100	100
Forested wetlands	7	1.7 (± 1.0)	6	-	-	-	14	29	-	-	29	14	-	71	14
Natural ponds	41	5.3 (± 1.8)	11	-	2	20	24	39	10	83	37	83	61	98	73
Excavated ponds	42	4.3 (± 2.1)	11	-	2	17	10	21	40	50	48	55	43	74	71
Nonforested crossings	52	3.3 (± 1.5)	11	-	2	4	4	2	17	29	29	48	60	62	77
Impoundments	67	4.0 (± 1.5)	11	7	9	-	1	3	49	19	67	54	66	46	75
Total	227	4.0 (± 1.8)	12	2	4	7	10	15	29	39	46	56	56	67	70

open-water habitats with a mean surface area (± 1 SD) of 67.1 ± 83.7 ha. Forested and nonforested crossings were on-stream sites located at roads. Forested stream crossings were bordered by trees, and nonforested stream crossings were streams or small (< 0.5 ha) impoundments bordered by shrub or emergent vegetation communities. The mean area for excavated ponds, which included irrigation ponds, retention basins, and borrow pits, was 2.9 ± 3.9 ha. The mean area for natural ponds was 7.6 ± 16.4 ha. Abandoned bogs were former cranberry bogs or impoundments that succeeded to mixed shrub/emergent wetlands with open water. Ditch sites were roadside ditches. Several sites that were depicted by digital-hydrography data (Chapter 1) as being connected to a stream were classified as off-stream sites. These sites included ponds that were either the source of a stream or sites that were formerly connected to a stream by a ditch.

Characterizing Survey-site Conditions

Several site-specific, local, and regional environmental attributes were used to characterize each anuran-survey site. The attributes included latitude and longitude, land use, basin area, habitat-patch size, specific conductance, and pH. Land-use profiles were prepared using ArcView software and 1995/97 land-use data obtained from the New Jersey Department of Environmental Protection (NJDEP, Chapter 1). Drainage-basin land-use profiles were prepared for the on-stream sites. For off-stream sites, profiles were created based on land-uses found within a 1500-m diameter circle (177 ha) centered on the listening point of each site. A similar technique was used to characterize adjacent land use in the Commission's initial study of off-stream ponds (Bunnell and Zampella 1999).

Specific conductance and pH were measured in the field under baseflow conditions (Chapter 4). For on-stream impoundments, specific conductance and pH were measured in the stream below the outflow of the impoundment. Off-stream pond measurements were made near the center of the pond. Specific conductance and pH data were not available for all sites. Basin areas were measured using NJDEP digital-hydrography data (Chapter 1). For sites with a distinct boundary, habitat-patch size was measured using digital aerial photography from 1995/97 (National Aerial Photography Program for United States Geological Survey). The latitude and longitude of each site was determined from the GPS points.

Anuran-vocalization Surveys

Anuran-survey methods were similar to those used in earlier Commission studies (Bunnell and Zampella 1999, Zampella and Bunnell 2000). Nighttime vocalization surveys were generally conducted from the beginning of the anuran breeding season (late February/early March) through June in 1993 and 1996 through 1999. The number of calling individuals heard in 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. The number of visits varied among sites. The majority of sites were surveyed monthly during a single breeding season.

Presence/absence was determined for each species heard at a site by pooling the results of all surveys. Following Conant (1979), all anurans were classified as Pine Barrens, wide-ranging, or border-entrant species. The complete anuran-survey data set is presented in Appendix 6. This appendix includes the number of individuals of each species heard at each site during individual site visits. Nonvocalizing individuals observed during the surveys are also listed. Taxonomic nomenclature follows Conant and Collins (1998). Other information given in Appendix 6 includes distribution maps for each species, site-location descriptions, latitude and longitude, the air temperature and relative humidity recorded during site visits, and the individuals who conducted the surveys. The Commission maintains a collection of cassette-tape recordings that document vocalizations heard during each site visit.

Anuran-community Gradients

Detrended correspondence analysis and TWINSPAN (Chapter 6) were used to ordinate and classify anuran species and survey sites based on presence/absence data for 227 sites. Only vocalizing individuals were included in the analysis. All default options were used for the ordination and classification procedures. Using a subset of the basin-wide data, separate analyses were also completed for permanent on-stream sites, temporary on-stream sites, and off-stream sites (temporary and permanent). Forty-three sites were removed from the pool of 227 sites prior to completing the three separate site-type analyses.

Eleven sites were deleted because they were only surveyed for wood frogs. Fourteen sites were deleted because only one species was present. Six on-stream sites located directly adjacent to impoundment survey sites were deleted. Inventories for adjacent survey sites that represented the same habitat type were pooled, reducing ten pairs of survey sites to ten single sites. A set of three adjacent survey sites were also combined as one site.

Spearman rank correlation and graphical analysis were used to determine if anuran-community composition, represented by the DCA-ordination axes and TWINSPAN groups, varied in relation to environmental conditions. The permanent on-stream, temporary on-stream, and off-stream sites were analyzed separately. For each site type, the first DCA-axis site scores were correlated with the percentage of developed land, upland agriculture, and wetland agriculture in a basin or surrounding area, pH, specific conductance, basin area, habitat-patch size, latitude, and longitude. To assess biogeographic relationships, these axes were also correlated with the percentage of Pine Barrens species, wide-ranging species, and border-entrant species found at each site. An alpha level of 0.05 was used to identify important relationships revealed by the correlation analysis. Because the high density of sampling sites in the basin may influence the outcome of the correlation analyses, these tests were performed primarily to evaluate general trends and the relative strength of the relationships between community gradients and environmental factors.

Differences in pH, specific conductance, hydrology, geographic affinity, and adjacent or upstream altered land (developed land and upland agriculture) between TWINSPAN-derived site groups were analyzed graphically. The percentage of sites with Pine Barrens species, wide-ranging species, and border-entrant species present in each of the eight study basins was also compared graphically. The first-axis DCA-site scores from analysis of the permanent on-stream sites, temporary on-stream sites, and off-stream sites were graphed separately for each of the eight study basins to compare the relative position of survey-site assemblages along the three community gradients.

Results

Basin-wide Anuran Survey

Twelve anuran species were heard during the surveys, including the two Pine Barrens species, four wide-ranging species, and six border-entrant species (Table 10.1). In order of increasing frequency of occurrence, the species found during the survey included the pickerel frog, cricket frog, gray treefrog, chorus frog, wood frog, bullfrog, Pine Barrens treefrog, Fowler's toad, southern leopard frog, carpenter frog, spring peeper, and green frog. The only native Pinelands species that was not heard at any survey site was the eastern spadefoot, a wide-ranging species (Conant 1979). The green frog and the bullfrog were the most frequently encountered native and border-entrant species. As in previous Commission studies (Bunnell and Zampella 1999, Zampella and Bunnell 2000), Pine Barrens and wide-ranging species were encountered more frequently than any border-entrant species, and border-entrant species were more closely associated with the western portion of the Mullica River Basin (Figure 10.3).

Clear differences in breeding phenology, or timing of the breeding period, were evident for some of the species heard during the surveys (Figure 10.4). The wood frog was the first species to initiate breeding and the northern cricket frog was the last. Several species continued to vocalize beyond the end of the survey period. The breeding phenology results indicate that the surveys successfully captured the vocalization periods for all species.

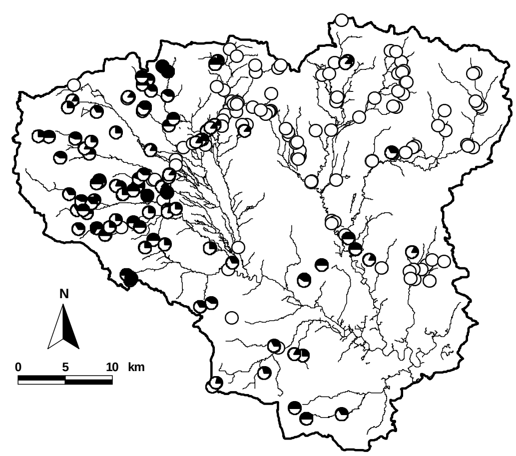

Figure 10.3. Pie charts showing the percentage of native (white) and nonnative (black) anuran species present at 227 Mullica River Basin survey sites.

Species richness at the 227 sites ranged from 1 to 9 species. The mean (± 1 SD) number of species heard at a site was 4.0 ± 1.8. The median value was also 4.0. Total and mean species richness varied among the individual habitat types surveyed (Table 10.1).

Although most species were found at a variety of habitat types, there appeared to be differences in habitat preferences among species (Table 10.1). Pickerel frogs were limited to impoundments, whereas gray treefrogs were absent from this habitat type. Carpenter frogs, green frogs, and spring peepers were the only species heard at forested-stream crossings. Neither the Pine Barrens treefrog nor the carpenter frog were heard at ditches or forested-wetland sites.

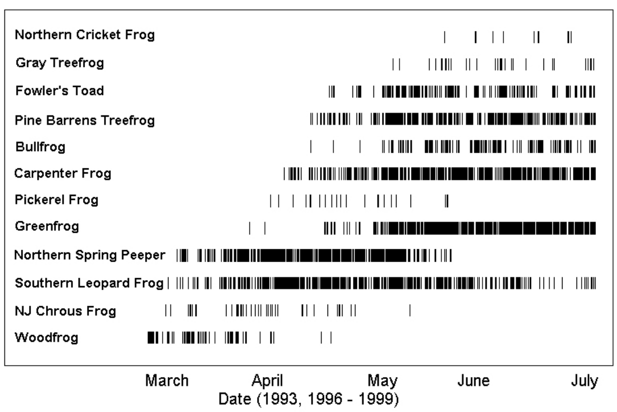

Figure 10.4. Breeding phenology of 12 anurans in the Mullica River Basin. Each vertical bar represents a survey night when a species was heard calling.

Basin-wide Anuran-community Gradients

The first DCA axis of the initial site ordination of all 227 sites revealed a hydrologic gradient reflecting differences in landscape position (on-stream versus off-stream sites) and hydrology (temporary-water versus permanent-water sites) (Figure 10.5). Most permanent on-stream and permanent off-stream sites were located on the right side of the ordination diagram. Temporary on-stream and off-stream sites were concentrated on the left side of the ordination diagram. The unclassified sites were distributed throughout the center of the diagram.

The order of anuran species along the first DCA axis of the species ordination also reflected landscape position and hydrology (Figure 10.6). Wood frogs, chorus frogs, gray treefrogs, Pine Barrens treefrogs, and spring peepers were heard more frequently at temporary off-stream sites. The position of these five species along the first DCA axis contrasted with that of pickerel frogs, cricket frogs, bullfrogs, Fowler's toads, green frogs, and carpenter frogs, which were heard calling at a higher percentage of permanent on-stream sites. Leopard frogs did not show a clear landscape position or hydrologic preference.

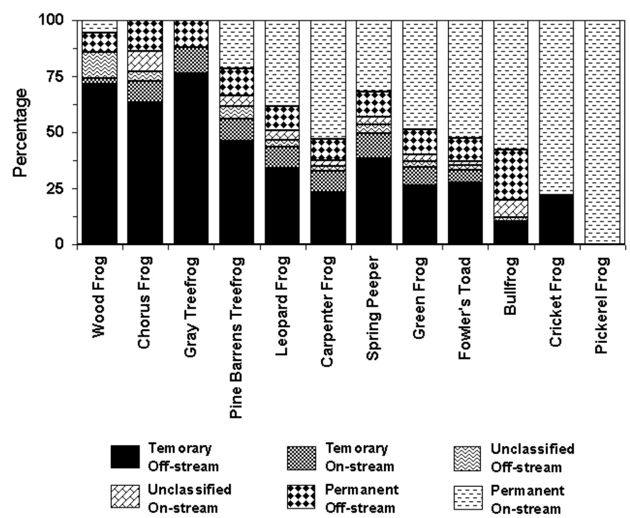

Figure 10.6. Percentage of each hydrologic-site type where anuran species were heard calling.

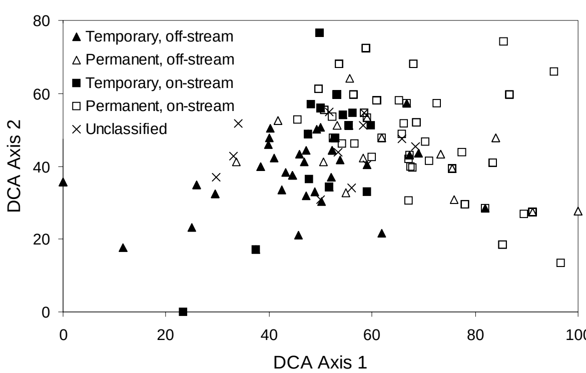

Figure 10.5. DCA ordination diagram for 227 anuran sites with hydrologic-site type classifications.

The TWINSPAN classification of the 227 sites separated a group of 14 sites from the other 213 sites (Figure 10.7). These 14 sites were primarily temporary off-stream sites where wood frogs, chorus frogs, and springer peepers were heard. Although the other 213 sites included all landscape-position and hydrologic-site types, the majority of sites in this group were permanent on-stream sites. A second division of this large site class separated a group composed primarily of permanent-water sites from the other sites. This group of 45 sites included the majority of the cricket frog occurrences and all of the pickerel frog and bullfrog occurrences.

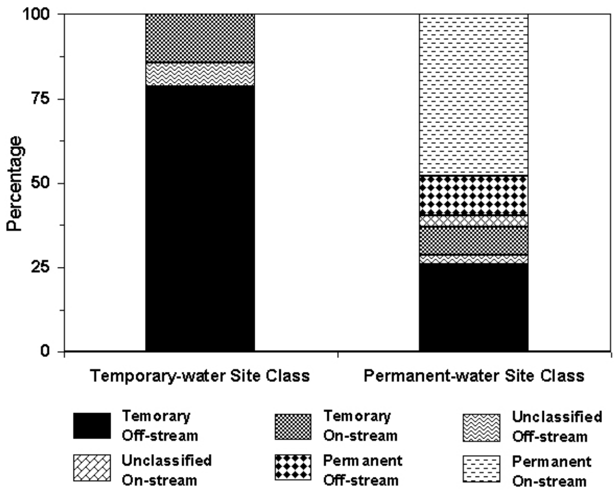

Figure 10.7. Percentage of the six hydrologic-site types in two TWINSPAN site classes for 227 Mullica River Basin sites.

Table 10.3. Frequency of occurrence of individual anuran species and biogeographic groups in three hydrologic-site types.

Species	Permanent on-stream sites (n = 78)	Temporary on-stream sites (n = 23)	Off-stream sites (n = 83)
	Frequency of occurrence (%)		
Pine Barrens species	68	74	75
Pine Barrens treefrog	24	58	69
Carpenter frog	63	61	54
Wide-ranging species	100	100	100
Green frog	78	78	76
Fowler's toad	67	35	49
Southern leopard frog	50	74	73
Northern spring peeper	53	87	92
Border-entrant species	46	35	55
Bullfrog	45	22	23
Pickerel frog	6	-	-
Northern cricket frog	9	-	2
Wood frog	3	-	28
New Jersey chorus frog	-	13	19
Gray treefrog	-	9	18
Total number of species	10	9	11
Minimum species richness	2	2	2
Mean (± 1 SD) species richness	4.0 (± 1.4)	4.3 (± 1.4)	5.0 (± 1.9)
Median species richness	4	4	5
Maximum species richness	8	7	9

Permanent On-stream Community Gradient

Seventy-eight of the 102 permanent on-stream sites were included in the gradient analysis (Table 10.2). A total of 10 species were heard at the 78 sites, including both Pine Barrens species, the four wide-ranging species, and four of the border-entrant species (Tables 10.3 and 10.4). Pine Barrens species were heard at 68% of the sites and wide-ranging species at 100% of the sites. Border-entrant species were heard at 46% of the sites. With one exception, bullfrogs were present at every site where other border-entrant species occurred.

The first DCA axis of the site ordination contrasted sites where only native species were heard with those that included border-entrant species (Figure 10.8). The percentage of Pine Barrens species decreased ($r = -0.91$, $p < 0.001$) and the percentage of border-entrant species increased ($r = 0.89$, $p < 0.001$) along this community gradient (Figure 10.9). These relationships reflected differences in the range of watershed conditions where native and nonnative species were present (Figure 10.10). The ordering of sites along the first DCA axis was associated with increasing pH ($n = 43$, $r = 0.79$), specific conductance ($n = 43$, $r = 0.61$), and the percentage of developed land ($r = 0.75$), upland agriculture ($r = 0.73$), and wetland agriculture ($r = 0.43$) in the basin (Figure 10.11). This first axis was also correlated with decreasing latitude ($r = -0.42$) and longitude ($r = -0.71$).

Table 10.4. Raw DCA axis 1 and 2 species scores for species found at the permanent on-stream sites, temporary on-stream sites, and off-stream sites. Species are ordered by axis 1 scores.

Permanent on-stream sites (n = 78)			Temporary on-stream sites (n = 23)			Off-stream sites (n = 83)		
Species	Axis 1	Axis 2	Species	Axis 1	Axis 2	Species	Axis 1	Axis 2
Pine Barrens treefrog	-75	-83	Fowler's toad	-87	146	Carpenter frog	-52	11
Southern leopard frog	-20	146	Gray treefrog	-0	353	Pine Barrens treefrog	-19	142
Carpenter frog	-13	191	Carpenter frog	39	-71	Southern leopard frog	19	186
Wood frog	93	344	Southern leopard frog	48	-64	Wood frog	63	301
Green frog	108	136	Green frog	179	170	Northern spring peeper	144	195
Northern spring peeper	129	-53	Pine Barrens treefrog	184	41	New Jersey chorus frog	146	340
Fowler's toad	179	59	Northern spring peeper	188	135	Green frog	172	79
Bullfrog	276	101	Bullfrog	311	13	Gray treefrog	202	121
Pickerel frog	347	415	New Jersey chorus frog	366	41	Fowler's toad	206	-66
Northern cricket frog	358	-91				Northern cricket frog	320	433
						Bullfrog	333	66

Table 10.2. Raw DCA axis 1 and axis 2 site scores for 78 permanent on-stream anuran-survey sites in the Mullica River Basin based on an ordination of species presence/absence data. Sites are ordered by axis 1 scores. Refer to Appendix 6 for additional information on each site.

Study basin	Site name	Site code	Axis 1	Axis 2
Wading River	Sykes Branch above Sooy Road	WSYKSOOY	0	98
Wading River	Pope Branch impoundment below Route 72	WPO72MM9	0	98
Wading River	Shoal Branch tributary impoundment above Baptist Road	WSOTRIMP	0	98
Oswego River	Oswego River impoundment above Beaver Dam Road	OOSBEAVI	0	98
Oswego River	Large Plains Branch tributary impoundment above Baptist Road	OPLTRIMP	5	50
Batsto River	Roberts (Tom Roberts) Branch beaver pond above Carranza Road	BTOIMPCA	25	158
Oswego River	Plains Branch impoundment above Beaver Dam Road	OPLBEAVR	25	158
Batsto River	Batsto River headwater impoundment below Route 532	BBATS532	26	67
Wading River	Biddle Branch impoundment above Route 72	WBIDDL72	26	67
Wading River	Sykes Branch pond near stream above Sooy Road	WSYSOOPD	26	67
Batsto River	Roberts (Tom Roberts) Branch impoundment below Route 532	BTOIM532	26	67
Wading River	Wading River above Route 563 at Speedwell	WWESPEED	47	164
Batsto River	Skit Branch beaver impoundment between Hampton and Carranza Roads	BSKBEAVD	47	164
Wading River	Shreve Branch above Sooy Road	WSRESOOY	47	164
Batsto River	Skit Branch above Carranza Road	BSKITCAR	47	164
Oswego River	Oswego River above Beaver Dam Road	OOSBEAVR	47	164
Oswego River	Oswego River impoundment above Old Cedar Bridge-Barnegat Road	OOSCEDRI	49	132
Batsto River	Batsto Lake	BBATLAKE	49	132
Sleeper Branch	Clark Branch impoundment above Johnson Road (combined with MCLJOHNS)	MCLIMPNT	51	105
Bass River	West Branch Bass River upstream of second dike above Stage Road	AWEPILGD	51	105
Wading River	Bulls Branch bog upstream of first dike above East Sandy Ridge Road	WBUHERBI	51	105
Batsto River	Skit Branch beaver pond above Batona Campground	BSKWIDEN	51	105
Wading River	Shane Branch above Carranza Road (combined with WSAUPIMP)	WSACARRA	51	105
Wading River	Wading River below Route 563 (combined with WWE563UP)	WWE563DW	51	66
Upper Mullica River	Northern Alquatka Branch tributary impoundment above Jackson-Medford Road	MALTRBOY	51	66
Oswego River	Yellow Dam Branch impoundment on western side of Old Half Way Road	OYEHALFI	51	66
Lower Mullica River	Pine Creek impoundment above Seventh Avenue	LPINE7TH	54	0
Batsto River	Batsto River above Carranza Road	BBACARRZ	58	69
Bass River	Lake Absegami below bridge	AEAABSDW	64	133
Bass River	Tommys Branch impoundment above Dans Bridge Road	ATOMMYIM	64	133
Oswego River	Oswego Lake (combined with OBRESTRM)	OOSWLAKE	64	133
Batsto River	Skit Branch beaver pond between Carranza Road and Batona campground	BSKBEAVU	64	133
Wading River	Ives Branch impoundment below Route 679 (combined with WIVE679U)	WIVE679D	64	133
Oswego River	Oswego River impoundment at Howardsville	OOSHOWIM	64	133
Batsto River	Mannis Duck Pond tributary above Hampton Road	BBATRMAH	64	41
Wading River	Bulls Branch impoundment (Otter Pond)	WBUOTTER	75	91
Wading River	Featherbed Branch above Carranza Road (combined with WFEIMPD1, WFEIMPUP1, WFEIMPUP2, and WFEIMPUP3)	WFEIMPUP	77	96
Batsto River	Roberts (Tom Roberts) Branch below Birches Road (combined with BTOBIRCU)	BTOBIRCD	77	96
Oswego River	Harrisville Pond	OOSHARLK	83	125
Upper Mullica River	Southern Alquatka Branch tributary impoundment above Jackson-Medford Road	MALTRFRI	84	71
Nescochague Creek	Panther Branch impoundment on northern side of Richards Road	NPACRANB	85	105
Wading River	Reeds Branch bog above Route 563	WRE563PD	85	15
Lower Mullica River	Rubins Run impoundment below Frankfurt Avenue (combined with LRUFRANU)	LRUFRAND	89	184
Wading River	Chatsworth Lake	WWE532LK	91	129
Sleeper Branch	Sleeper Branch bogs at Route 206	MSL206BG	106	127
Batsto River	Deep Run impoundment above Hampton Road	BDEEPRUN	106	127
Upper Mullica River	Goshen Pond	MMUGOSHN	110	97
Nescochague Creek	Pump Branch impoundment near Cedar Avenue	NPUIMPNT	118	51
Sleeper Branch	Clark Branch above Route 536	MCLRK536	124	32
Sleeper Branch	Cooper Branch impoundment near Tremont Avenue and Burnt Mill Road	MCOIMPNT	124	65
Upper Mullica River	Eastern Mullica River tributary above Hampton Road	MMUTRHAM	136	87
Lower Mullica River	Egg Harbor City Lake below Route 563 (combined with LINLAKEU)	LINLAKED	138	122
Nescochague Creek	Albertson Brook impoundment below Route 206 (Paradise Lakes)	NALPARAD	143	75
Nescochague Creek	Great Swamp Branch below Union Road	NGRUNION	154	3
Nescochague Creek	Great Swamp impoundment below Walker Road (combined with NGRWALKU)	NGRWALKD	173	61
Nescochague Creek	Nescochague Lake at Route 623 (combined with NNEJACKS)	NNESLAKE	173	61
Batsto River	Horse Pond Stream above Butterworth's Bogs Road	BHOBUTTR	173	61
Upper Mullica River	Mullica River impoundment above Jackson-Medford Road (Lady's Lake)	MMULADYL	173	61
Sleeper Branch	Hays Mill Creek impoundment above Cooper Folly Road	MHAFOLLY	173	61
Batsto River	Indian Mills Brook impoundment above Oakshade Road (Shadow Lake)	BINSHADW	178	200
Nescochague Creek	Blue Anchor Brook impoundment above Spring Garden-Winslow Road	NBLSPRNG	188	99
Lower Mullica River	Lake Fred	LMOSTOCK	188	99
Nescochague Creek	Pump Branch impoundment at camp Ha-Lu-Wa-Sa	NPUHALUW	195	36
Batsto River	Indian Mills Lake	BMULAKED	208	132
Batsto River	Indian Mills Brook impoundment above Old Schoolhouse Road	BINSCHOO	208	132
Upper Mullica River	Wesickaman Creek above Atsion Road	MWEATSIO	208	132
Sleeper Branch	Wildcat Branch impoundment below Route 30	MWILD30D	210	30
Batsto River	Springers Brook impoundment on northern side of Indian Ann Trail	BSPTRAIL	228	178
Nescochague Creek	Great Swamp Branch impoundment above Myrtle Street	NGRMYRTL	228	80
Nescochague Creek	Drivers Branch impoundment below Columbia Road	NDRCOLUM	228	80
Nescochague Creek	Great Swamp Branch tributary impoundment above Route 30	NGRTRI30	228	80
Nescochague Creek	Great Swamp Branch tributary impoundment above Myrtle Street	NGRTRRED	228	80
Sleeper Branch	Atco Lake	MHAATCOL	228	80
Lower Mullica River	Morses Mill Stream impoundment below Route 561	LMO561IM	228	80
Lower Mullica River	Hammonton Lake	LHAMLAKE	231	51
Nescochague Creek	Blue Anchor Brook impoundment above Route 30	NBLABBOG	236	4
Sleeper Branch	Beaverdam Lake	MWIBEAVR	236	4
Nescochague Creek	Great Swamp Branch impoundment above Route 30	NGREAR30	271	23

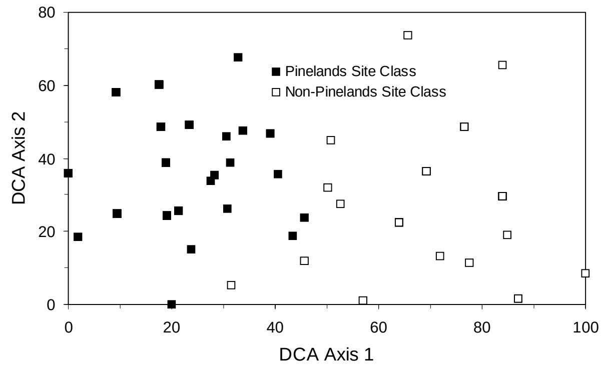

Figure 10.8. DCA ordination diagram and TWINSPAN classification for 78 permanent on-stream sites. Refer to Table 10.2 for site names ordered by DCA axis 1 scores.

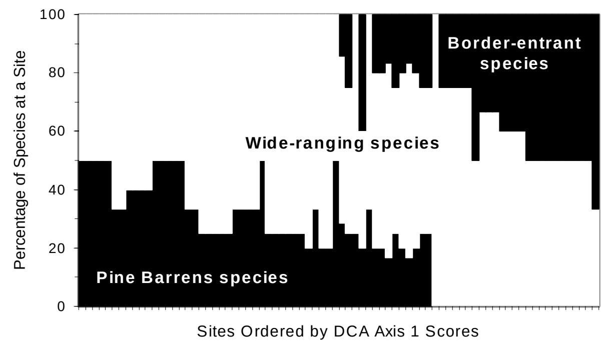

Figure 10.9. Biogeography of anurans heard at 78 permanent on-stream Mullica River Basin sites. Refer to Table 10.2 for site names ordered by DCA axis 1 scores.

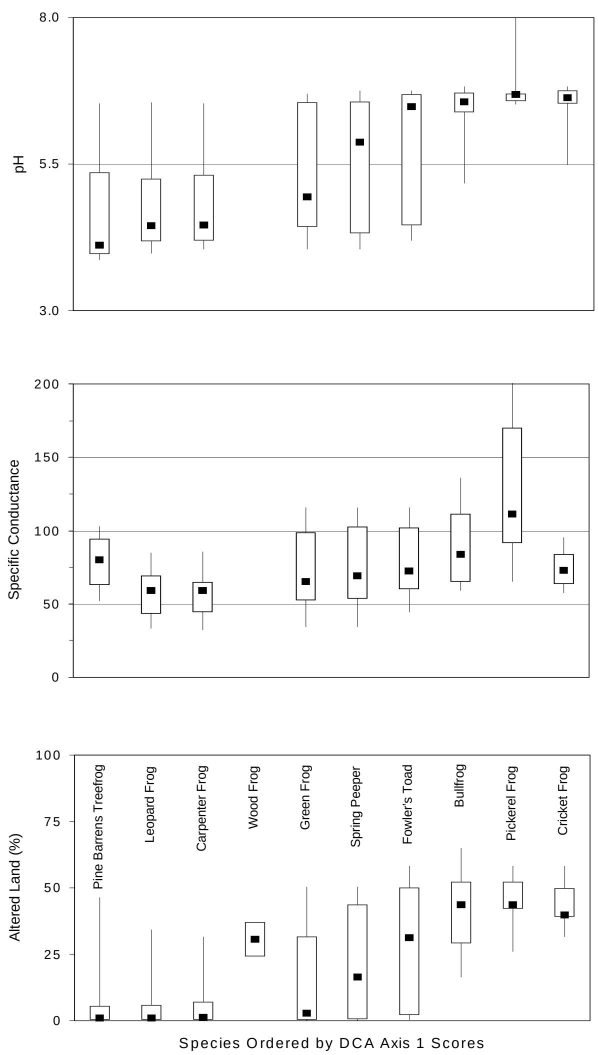

Figure 10.10. The pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) associated with anuran species heard at 78 permanent on-stream sites. Box plots show the first, second (median), and third quartiles and the 10th and 90th percentiles for each variable.

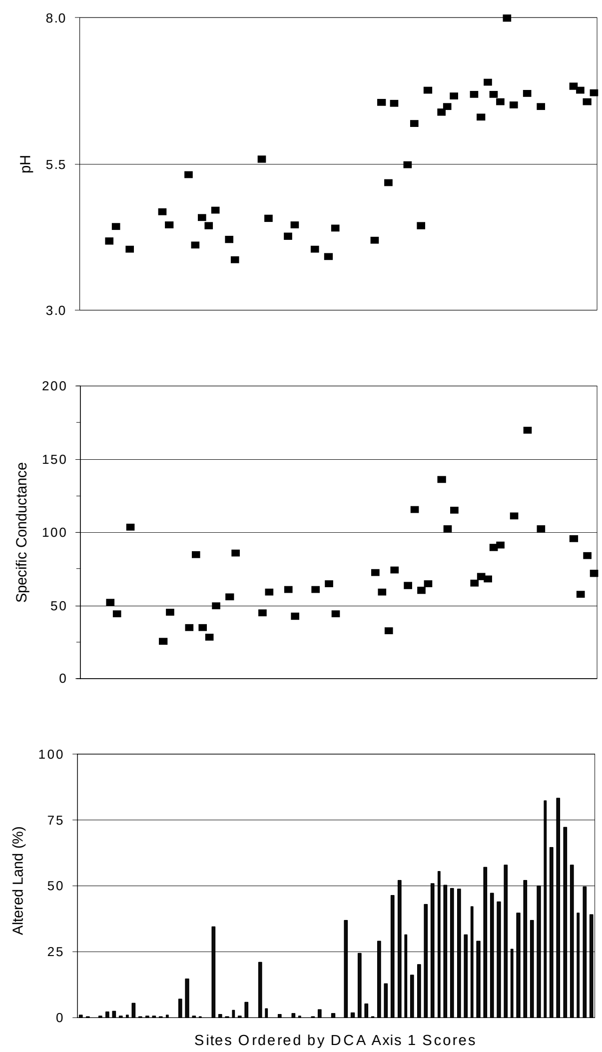

Figure 10.11. Median pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) for 78 permanent on-stream Mullica River Basin sites. DCA axis 1 represents an anuran community gradient. Refer to Table 10.2 for site names ordered by DCA axis 1 scores.

The *p* level for all seven of these relationships was < 0.001. The association between latitude and longitude and anuran-community composition was probably related to land-use patterns because border-entrant species were found more frequently on the heavily altered western and southern portions of the Mullica River Basin (Figure 10.3). Neither basin area nor habitat-patch size were associated with the community gradient.

The first division of the TWINSPAN classification separated 48 sites characterized by Pine Barrens species (Pinelands site class) from 30 sites with a high percentage of border-entrant species (non-Pinelands site class) (Figure 10.8). Compared to the Pinelands site class, the non-Pinelands sites class was characterized by elevated pH and specific conductance and a high percentage of altered land in the associated drainage basins (Figure 10.12). Bullfrogs were present at all but two of the sites in the non-Pinelands site class. Pine Barrens species were heard at only five sites in this group. A second division of the non-Pinelands site class separated five sites that displayed some of the highest pH and specific conductance values. Pine Barrens species were absent at these five sites, which were among the six sites in the Mullica River Basin that supported pickerel frogs.

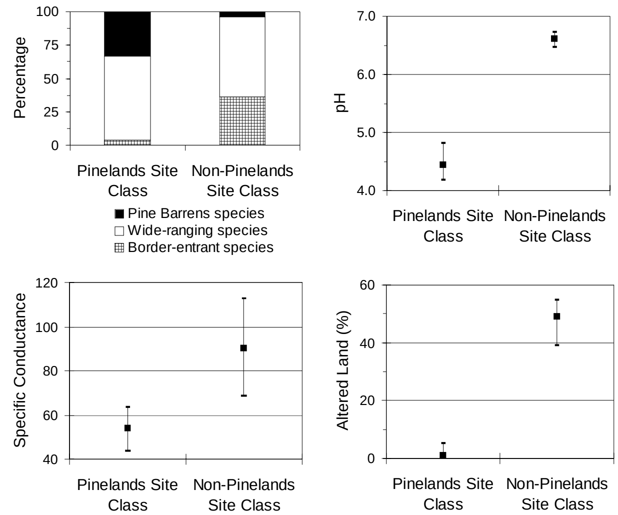

Figure 10.12. The percentage of Pine Barrens, wide-ranging, and border-entrant species, and median and 1st and 3rd quartile pH, specific conductance (μS cm^{-1}), and altered-land (developed land and upland agriculture) values for two TWINSPAN-derived site classes for 78 permanent on-stream sites.

Temporary On-stream Community Gradient

Twenty-three of the 27 temporary on-stream sites were included in the analysis (Table 10.5). A total of nine species were heard at the 23 sites, including the two Pine Barrens species, the four wide-ranging species, and three border-entrant species (Tables 10.3 and 10.4). Pine Barrens species were heard at 74% of the sites and wide-ranging species at 100%. Border-entrant species were heard at 35% of the sites. The bullfrog was the most frequently encountered border-entrant species.

Table 10.5. Raw DCA axis 1 and axis 2 site scores for 23 temporary on-stream anuran survey sites in the Mullica River Basin based on an ordination of species presence/absence data. Sites are ordered by axis 1 scores. Refer to Appendix 6 for additional information on each site.

Study basin	Site name	Site code	Axis 1	Axis 2
Upper Mullica River	Mullica River tributary above Route 206	MMUTR206	0	4
Oswego River	Dry Branch impoundment above Route 539	ODRYLUCY	50	72
Nescochague Creek	Great Swamp tributary above Walker Road	NGRTRWAL	70	201
Bass River	East Branch Bass River above Dans Bridge Road	AEADANRD	73	44
Oswego River	Plains Branch tributary impoundment above Jenkins Road	OPLTRMOR	75	37
Batsto River	Batsto River impoundment above Route 532	BBATN532	92	0
Batsto River	Mannis Duck Pond tributary impoundment near High Crossing	BBATRMAI	92	59
Upper Mullica River	Uppermost Wesickaman Creek reservoir above Route 534	MWEHDBOG	92	59
Oswego River	Cranberry bogs on Jenkins Road (combined OOSSIMNO and OOSSIMSO)	OOSSIMPL	92	59
Batsto River	Deep Run tributary above Hampton Road	BDETRHAM	113	42
Wading River	Western Tulpehocken Creek tributary-north of Central New Jersey/Conrail railroad	WTUTRWNO	113	42
Wading River	Bulls Branch above East Sandy Ridge Road	WBUSANDY	128	42
Batsto River	Skit Branch tributary below Carranza Road	BSKTRBRN	128	42
Wading River	Western Tulpehocken Creek tributary - south of Central New Jersey/Conrail railroad	WTUTRWSO	128	42
Sleeper Branch	Gun Branch above Central New Jersey/Conrail railroad	MGUHEADU	138	175
Bass River	Dans Bridge Branch tributary above Dans Bridge Road	ADATRDED	138	80
Lower Mullica River	Rubins Run impoundment below Pestalozzi Street	LRUPESTA	158	37
Lower Mullica River	Hammonton Creek tributary impoundment above Plymouth Road	LHATRPLY	181	63
Wading River	Mile Run impoundment above Speedwell-Friendship Road	WMILIMPU	183	152
Lower Mullica River	Union Creek tributary impoundment above Antwerp Avenue	LUNTRANT	188	38
Lower Mullica River	Nortons Branch impoundment above Sailor Boy Road	LNOSALOR	225	75
Lower Mullica River	Brockaways Branch below Route 623	LBR623DW	246	80
Lower Mullica River	Morses Mill Stream flooded swamp above Route 561	LMO561UP	277	88

The first DCA axis of the site ordination contrasted sites dominated by native species with those that included border-entrant species (Figure 10.13). The percentage of border-entrant species increased along this community gradient (r = 0.65, $p < 0.001$, Figure 10.14). There was a slight decrease in the percentage of wide-ranging species (r = -0.46, $p < 0.03$) and no trend for Pine Barrens species along the gradient. The first DCA axis of the site ordination was correlated with decreasing latitude (r = -0.54, $p < 0.008$), which indicated that sites in the southern portion of the Mullica River Basin had a higher percentage of border-entrant species. Neither the percentage of developed land, upland agriculture, or wetland agriculture in a basin, habitat-patch area, longitude, or basin area were related to the community gradient. The TWINSPAN classification separated a group of nine sites characterized by a higher percentage of border-entrant species and a higher percentage of altered land in a basin (non-Pinelands site class) from a group of 14 sites characterized by a higher percentage of Pine Barrens species and a lower percentage of altered land in a basin (Pinelands site class) (Figures 10.13 and 10.15).

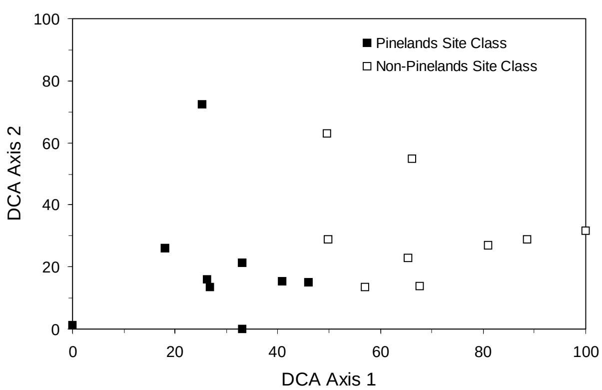

Figure 10.13. DCA ordination diagram and TWINSPAN classification of 23 temporary on-stream anuran sites. Refer to Table 10.5 for site names ordered by DCA axis 1 scores.

Figure 10.14. Biogeographic affinity for anuran species heard at 23 temporary on-stream sites. Refer to Table 10.5 for site names ordered by DCA axis 1 scores.

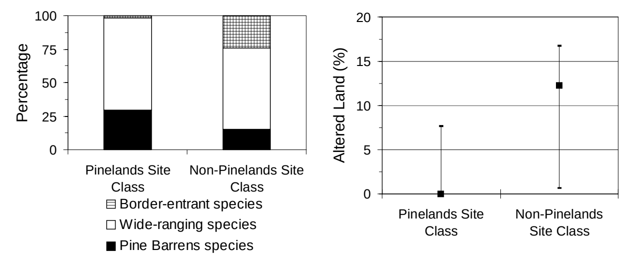

Figure 10.15. The percentage of Pine Barrens, wide-ranging, and border-entrant species and median and 1st and 3rd quartile altered-land (developed land and upland agriculture) values for two TWINSPAN-derived site classes for 23 temporary on-stream sites.

Off-stream Anuran-community Gradient

Eighty-three of the 98 off-stream sites were included in the analysis (Table 10.6). A total of 11 species were heard at the 83 sites, including both Pine Barrens species, the four wide-ranging species, and five border-entrant species (Tables 10.3 and 10.4). Pine Barrens species were heard at 75% of the sites and wide-ranging species at 100%. Border-entrant species were heard at 55% of the sites. The wood frog and bullfrog were the most frequently encountered border-entrant species.

As with the on-stream sites, the first DCA axis of the off-stream ordination contrasted sites dominated by native species with those where border-entrant species were heard calling (Figure 10.16). The percentage of Pine Barrens species decreased (r = -0.86, $p < 0.001$) and the percentage of border-entrant species increased (r = 0.63, $p < 0.001$) along this community gradient (Figure 10.17). No trend was found for wide-ranging species. These relationships were related to differences in the range of watershed conditions where native and border-entrant species were heard (Figure 10.18). The first DCA axis was also correlated with longitude (r = -0.66, $p < 0.001$) and the percentage of adjacent developed land (r = 0.50, $p < 0.001$) and upland agriculture (r = 0.57, $p < 0.001$) (Figure 10.19). As with the permanent on-stream assemblages, a higher percentage of border-

Table 10.6. Raw DCA axis 1 and axis 2 site scores for 83 off-stream anuran-survey sites in the Mullica River Basin based on an ordination of species presence/absence data. Sites are ordered by axis 1 scores. Refer to Appendix 6 for additional information on each site.

Study basin	Site name	Site code	Axis 1	Axis 2
Upper Mullica River	Wesickaman Creek downstream pond	MWEHEADD	0	164
Batsto River	Pond at Birches and Moores Meadow Roads	BTOMMPND	38	68
Lower Mullica River	Big Goose Pond	LLATRGOO	48	175
Nescochague Creek	Middle Road pond	NGRMIDPD	52	206
Wading River	Superfund long-thin pond	WPOPTHIN	53	122
Wading River	Northern Bulls Branch borrow pit	WBUBORON	53	122
Wading River	Shreve Branch spong	WSRSPONG	53	122
Wading River	Southern Bulls Branch borrow pit	WBUBOROS	53	122
Wading River	Shoal Branch tributary dry spong	WSOTRDRY	53	122
Upper Mullica River	Gravel pond (Gravel)	MMUGRAVL	53	122
Batsto River	Skit Sphagnum pond (Sphagnum)	BSKSPHGM	53	122
Wading River	Tulpehocken Creek upstream pond	WTUPONDU	53	122
Oswego River	Howardsville pond	OOSHOWPD	53	122
Wading River	Isolated Pope Branch pond	WPOPISOL	53	122
Wading River	Southern superfund pond	WPOSUPRS	53	122
Wading River	Northern superfund pond	WPOSUPRN	53	122
Bass River	Allen pond	ABAALLEN	55	152
Wading River	Hidden pond at Route 679	WIVHIDEN	55	152
Oswego River	Eastern hidden pond on Jenkins Road	OOSHIDEE	60	93
Oswego River	Western hidden pond on Jenkins Road	OOSHIDEW	60	93
Upper Mullica River	Atsion railroad pond	MMUATSRR	61	107
Bass River	Small Allen pond	AWESMALL	62	169
Batsto River	Roberts (Tom Roberts) cripple	BTOMCRIP	62	169
Oswego River	Oswego River pockmark pond	OOSWPOCK	63	213
Lower Mullica River	Smilax pond	LLBSMILX	64	206
Nescochague Creek	Albertson pond (Albertson)	NALBPOND	76	181
Batsto River	Hampton Road pond (Hampton)	BDEHAMPD	76	121
Batsto River	Hampton Furnace pond (Furnace)	BBAFURNP	76	121
Wading River	Decou Pond	WPODECOU	78	91
Wading River	Tulpehocken Creek eastern tributary-south of railroad	WTUTRESO	78	91
Batsto River	Shotgun site	BBASHOTG	78	91
Wading River	Batona Trail dike pond	WWEDIKEP	78	91
Wading River	Tulpehocken Creek eastern tributary-north of railroad	WTUTRENO	78	91
Batsto River	Skit Branch headwater pond (Skit)	BSKIHEAD	78	91
Oswego River	Oswego Lake borrow pit	OOSBOROW	78	91
Wading River	Tulpehocken Creek eastern tributary-northeast of railroad	WTUTRENE	78	91
Wading River	Isolated Tibbs Branch pond	WTIBPOND	79	150
Sleeper Branch	Sandy Causeway pond (Sandy)	MCLSANDY	84	172
Sleeper Branch	Isolated Sleeper pond (Sleeper)	MSLEISOL	84	172
Upper Mullica River	Isolated Mullica pond (Mullica)	MMULISOL	92	121
Upper Mullica River	Western Mullica River tributary above Hampton Road	MMUTRSTO	92	117
Lower Mullica River	Nature Conservancy pond	LCL561NC	93	255
Lower Mullica River	Rusty car seat pond	LMURUSTY	93	255
Wading River	Tulpehocken Creek downstream pond	WTUPONDD	96	132
Upper Mullica River	Wesickaman Creek headwater borrow pit	MWEBOROW	96	95
Wading River	Western Savoy Boulevard pond	WRESAVYW	96	95
Batsto River	Springers Brook mud puddle	BSPPUDDL	98	139
Oswego River	Old Half Way Road pond	OYEHALFP	98	81
Batsto River	Skit Branch herbaceous area (combined BSKTRHAU and BSKTRHAMD	BSKTRHAM	98	81
Upper Mullica River	Atco Raceway pond	MMUATCOR	98	145
Upper Mullica River	Wesickaman Creek upstream pond	MWEHEADU	99	139
Batsto River	Roberts (Tom Roberts) pond (Roberts)	BTOMSKIT	99	139
Sleeper Branch	Chew Road spong	MCLCHEWS	104	145
Batsto River	Springers Brook railroad pond	BSPRRPND	109	8
Wading River	Eastern Savoy Boulevard pond	WRESAVYE	109	80
Upper Mullica River	Hampton Road trail borrow pit	MMUTRBOR	112	153
Nescochague Creek	Abandoned Albertson bog	NALABBOG	113	139
Sleeper Branch	Johnson pond	MCLJPOND	115	87
Sleeper Branch	Fire Warden pond	MSLWARDN	115	87
Sleeper Branch	Chew pond (Chew)	MCLRUSNK	117	162
Sleeper Branch	Hays Mill pond (Hays)	MHASPRAY	121	239
Batsto River	High Crossing flooded area	BBATRHIX	123	105
Sleeper Branch	Blueberry field pond	MSLBLUEB	126	92
Upper Mullica River	Wesickaman pond (Wesickaman)	MWESPOND	127	192
Nescochague Creek	Columbia Road irrigation pond	NNEIRRIG	129	163
Lower Mullica River	Big Goose Pond borrow pit	LLAGOOBP	136	146
Sleeper Branch	Price Branch pond (Price)	MPRICEPD	140	128
Sleeper Branch	4x4 pond	MSL4X4PD	141	151
Batsto River	Cranberry bog on Butterworth's Bogs Road	BHOCRBOG	145	267
Nescochague Creek	Pump Branch irrigation pond	NPUMISOL	150	133
Sleeper Branch	Forbidden pond	MCLFORBI	152	170
Nescochague Creek	Flooded swamp near Pump Branch	NPUSWAMP	174	69
Batsto River	Abandoned bog on Oakshade Road	BINOAKBG	175	92
Sleeper Branch	Hays Mill retention basin	MHARETEN	214	68
Upper Mullica River	Southern Willow Grove Road Lake	MWEWILLS	214	68
Nescochague Creek	Thin finger pond	NGRFINGR	217	113
Upper Mullica River	Northern Willow Grove Road Lake	MWEWILLN	217	113
Lower Mullica River	Herbaceous area near Route 602 retention basin	LHAMHERB	226	127
Nescochague Creek	Pump Branch borrow pit	NPUBOROW	235	141
Sleeper Branch	Pestleton Road borrow pit	MPRPESTL	239	130
Batsto River	Stokes Road pond near shooting range	BINSTOKE	253	73
Batsto River	Hot dog stand pond	BSPHOTDG	253	73
Nescochague Creek	Elm retention basin	NBLELMRE	270	0

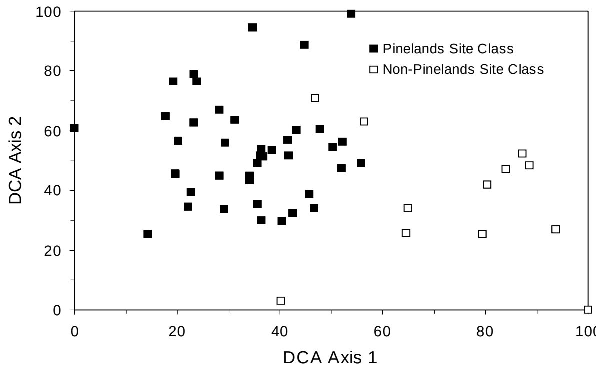

Figure 10.16. DCA ordination diagram and TWINSPAN classification for 83 off-stream sites. Refer to Table 10.6 for site names ordered by DCA axis 1 scores.

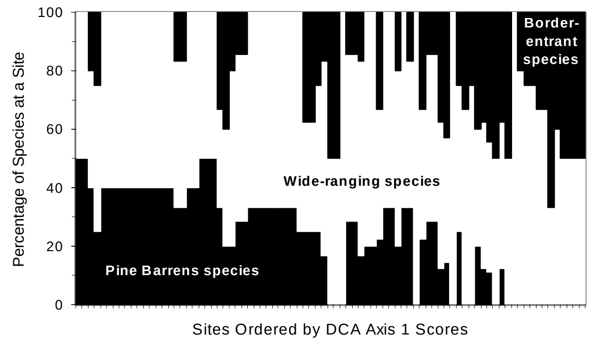

Figure 10.17. Biogeography of anurans heard at 83 off-stream Mullica River Basin sites. Refer to Table 10.6 for site names ordered by DCA axis 1 scores.

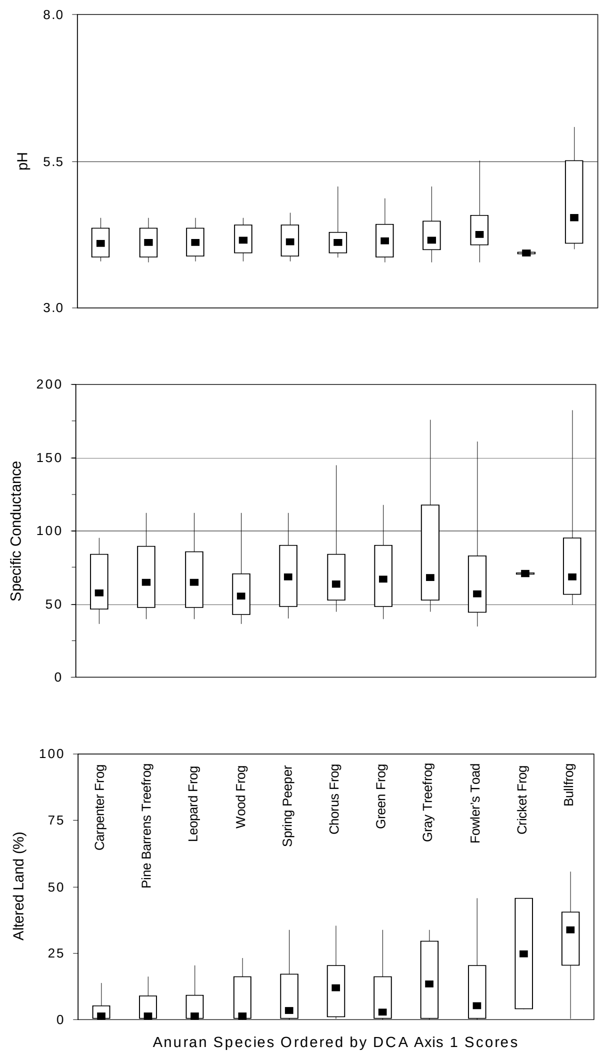

Figure 10.18. The pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) associated with anuran species heard at 83 off-stream sites. Box plots show the first, second (median), and third quartiles and the 10th and 90th percentiles for each variable.

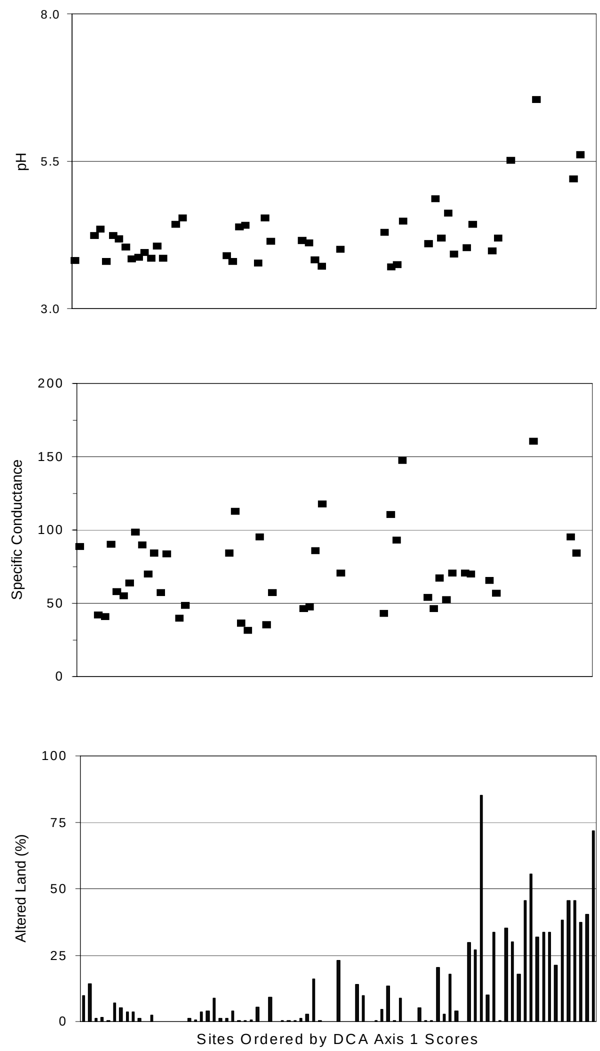

Figure 10.19. Median pH, specific conductance (μS cm^{-1}), and percentage of altered land (developed land and upland agriculture) for 83 off-stream Mullica River Basin sites. DCA axis 1 represents an anuran community gradient. Refer to Table 10.6 for site names ordered by DCA axis 1 scores.

entrant species was found at sites on the heavily altered western side of the basin (Figure 10.3), suggesting that the association between longitude and community composition was related to land-use patterns. Wetland agriculture, latitude, and habitat-patch area were not associated with the community gradient.

Unlike the results for the permanent on-stream sites, the off-stream community gradient, represented by the first DCA axis, was only weakly associated with increasing pH (n = 44, r = 0.38, $p < 0.01$) and was not related to specific conductance (Figure 10.19). The lack of a strong relationship between the community gradient and these two parameters may be due to the high acidity found at most of these sites. Only four of the 44 sites where pH was measured had a median pH > 5.0. These four sites were among those with the highest DCA scores and adjacent altered-land values. Bullfrogs were heard at all four sites and Pine Barrens species were absent. The pH may have been elevated at these sites either because they were within an altered landscape or because they were excavated ponds. Compared to natural ponds, excavated ponds typically displayed elevated pH and lower specific conductance values (Figure 10.20). Similar differences in pond chemistry were observed between natural and artificial ponds in the Commission's initial anuran study (Bunnell and Zampella 1999) and pond-vegetation study (Chapter 8).

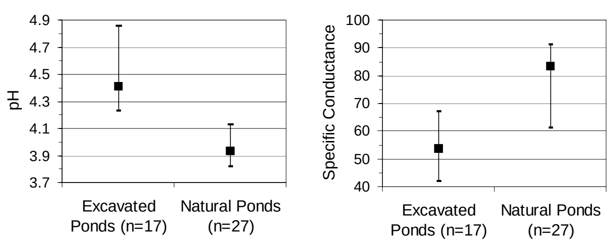

Figure 10.20. Median and 1st and 3rd quartile specific conductance (μS cm^{-1}) and pH values for excavated and natural ponds.

The first division of the TWINSPAN classification for off-stream sites separated 15 sites, characterized by a high percentage of border-entrant species (non-Pinelands site class), from the other 68 sites (Pinelands site class, Figure 10.21). The non-Pinelands site class was characterized by permanent-water sites and the Pinelands sites class was dominated by temporary-water habitats. Adjacent altered land, specific conductance, and pH were generally higher in the non-Pinelands site class compared to the Pinelands site class. However, conductance and pH were only measured at four of the 15 sites in the non-Pinelands site class. The Pinelands sites class was characterized by a higher percentage of Pine Barrens species. Although bullfrogs were present at seven sites, the number of vocalizing individuals was low compared to that for Pine Barrens species, which were found at all seven sites.

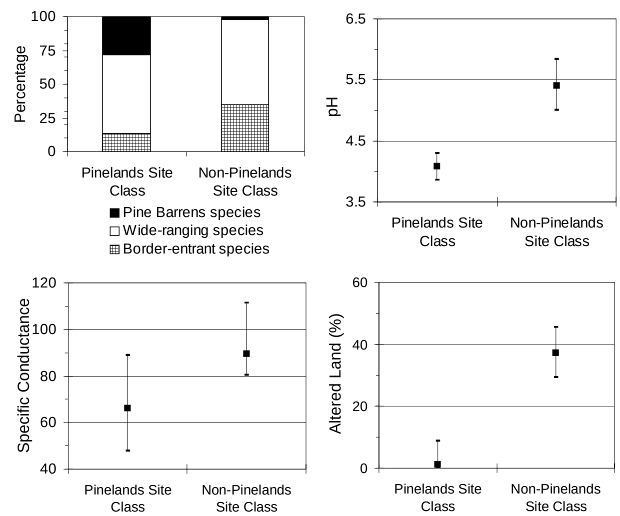

Figure 10.21. The percentage of Pine Barrens, wide-ranging, and border-entrant species, and median and 1st and 3rd quartile pH, specific conductance (μS cm^{-1}), and altered-land (developed land and upland agriculture) values for two TWINSPAN-derived site classes for 83 off-stream sites in the Mullica River Basin.

Drainage Basin Characterizations

Wading River, Oswego River, and Bass River

Sites in the Wading River, Oswego River, and Bass River basins were dominated by native species and generally lacked border-entrant species (Figure 10.22). Pine Barrens species occurred at almost as many sites as wide-ranging species in these basins. In the three site-type ordination analyses, the majority of the sites from these drainages were associated with the undisturbed end of the community gradients (Figure 10.23). Pine Barrens treefrogs and carpenter frogs were heard at a large percentage of the sites, and bullfrogs were not present at any of the sites surveyed in these basins. Other border-entrant species, including wood frogs and gray treefrogs, were heard at only eight sites. Six of these sites were excavations. The higher pH of excavated habitats may provide an opportunity for pond-breeding border-entrant species to survive in landscapes dominated by acid-water habitats (Gosner and Black 1957, Freda and Dunson 1986).

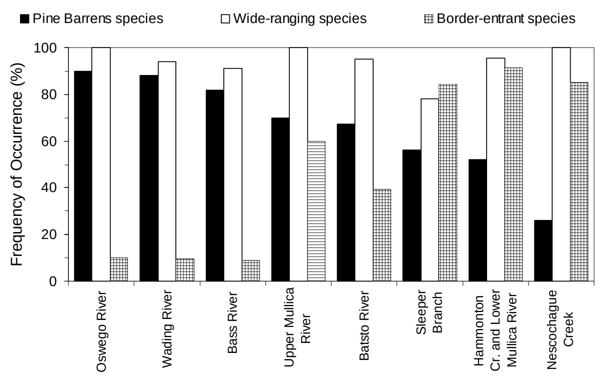

Figure 10.22. Frequency of occurrence of geographic-species groups at sites in eight Mullica River Basin stream systems.

Hammonton Creek and Lower Mullica River Tributaries

In contrast to the Wading River, Oswego River, and Bass River basins, assemblages at sites in the Hammonton Creek and Lower Mullica River tributaries were among the most altered anuran communities found in the Mullica River Basin (Figure 10.22). The majority of the sites in these basins were associated with the disturbed end of the community gradients (Figure 10.23). Only one site lacked border-entrant species. Bullfrogs were present at most of the sites and at all of the impoundments surveyed in these basins. Border-entrant species were heard at all four Hammonton Creek sites. Pine Barrens species were absent from these four sites.

Nescochague Creek

Pine Barrens species were infrequently heard in the Nescochague Creek basin (Figure 10.22). Bullfrogs were present at most of the sites and at all of the impoundments surveyed in this basin. Although assemblages at a few sites were dominated by Pine Barrens species, most Nescochague Creek sites were associated with the disturbed end of the community gradients (Figure 10.23). Several sites in Blue Anchor Brook and Great Swamp Branch drainages were among the most altered anuran assemblages surveyed in the Mullica River Basin.

Sleeper Branch

Anuran assemblages at sites in the Sleeper Branch basin varied. The majority of these sites occupied a

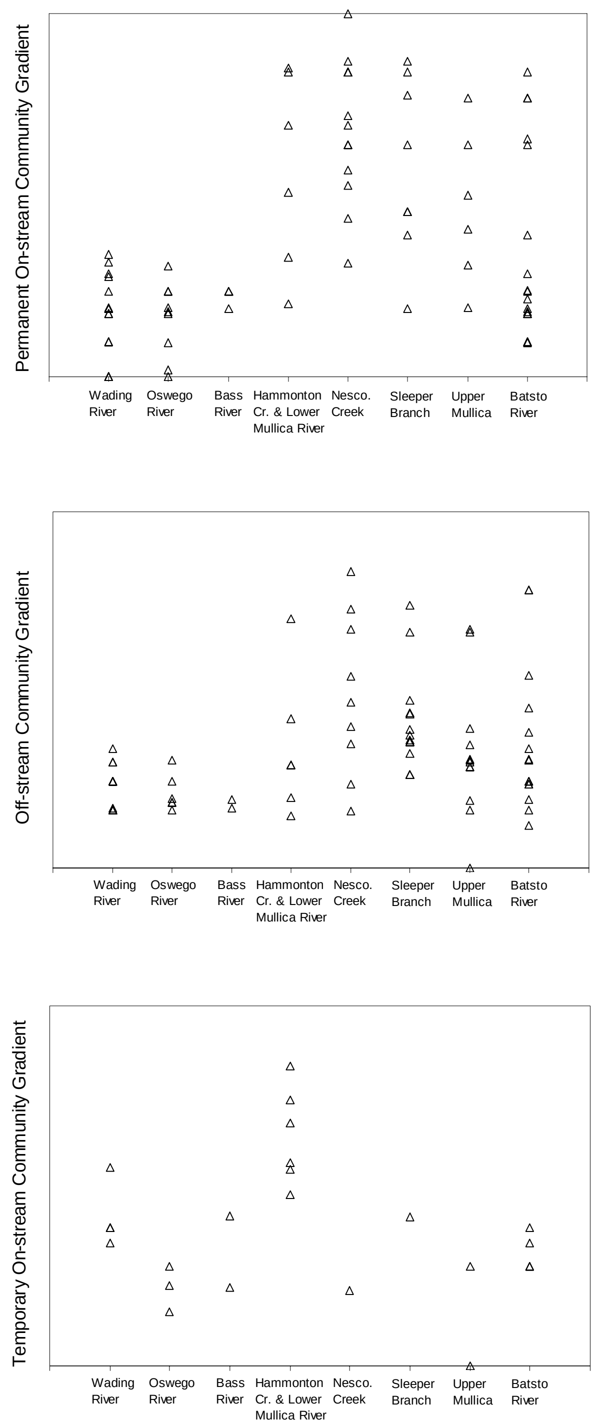

Figure 10.23. Position of anuran-survey sites along anuran-community gradients, represented by DCA axis 1 site scores, in the eight Mullica River Basin stream systems. Refer to Tables 10.2, 10.5, and 10.6 for site names ordered by the first DCA axes.

transitional position along the community gradients (Figure 10.23). Many of these sites were off-stream ponds. Although Pine Barrens species were heard at about half of the Sleeper Branch sites, border-entrant species were present at 85% of the sites in this basin (Figure 10.22). This drainage is the only basin where border-entrant species were found at more sites than wide-ranging species. Carpenter frogs were heard at a third of the sites and bullfrogs were present at about half of the sites. The most modified assemblages occurred at four impoundments on Hays Mill Creek and Wildcat Branch. Pine Barrens species were absent, but bullfrogs were heard calling at all four impoundments.

Upper Mullica River

Upper Mullica River basin survey sites were distributed throughout the community gradients (Figure 10.23). This range in anuran-assemblage composition occurred because border-entrant species and Pine Barrens species were heard at a similar number of sites in this basin (Figure 10.22). However, carpenter frogs were present at almost twice as many sites as bullfrogs, and Pine Barrens treefrogs were calling from half of the sites in this drainage. Anuran assemblages differed at sites along the main stem of the Mullica River and the Wesickaman Creek, one of its tributary systems. A degraded headwater impoundment on the Upper Mullica River supported bullfrogs and no Pine Barrens species, whereas Goshen Pond, an acid-water impoundment located between the mouth of Alquatka Branch and Atsion Lake, was dominated by native species. Although one bullfrog was heard calling during one visit at an Alquatka Branch impoundment, sites in this relatively undisturbed tributary system supported native-anuran assemblages. In contrast to the difference in assemblages found in the Mullica River, the opposite was found for Wesickaman Creek. Relatively undisturbed headwater sites in the Wesickaman Creek basin were dominated by native anurans. A downstream impoundment on Wesickaman Creek in an agricultural and developed area had bullfrogs and pickerel frogs and no Pine Barrens species present.

Batsto River

The effect of watershed disturbance on Pinelands anuran communities was especially obvious in the Batsto River basin. The number of sites with Pine Barrens species was greater than the number of sites with border-entrant species (Figure 10.22). Although several sites in this basin were located at the disturbed end of the community gradients, assemblages at many sites were characteristic Pinelands communities (Figure 10.23). Sites within the heavily degraded stream systems on the western side of this basin had a high percentage of border-entrant species. Bullfrogs were present at almost all of these sites and carpenter frogs were completely absent. Sites within the forested stream systems that drain the eastern portion of the basin were dominated by native assemblages. Carpenter frogs were heard at almost all of these sites and bullfrogs were heard at only one site on Deep Run. Only native species were heard calling from Batsto Lake, the most downstream site surveyed in this drainage.

ANNUAL ANURAN SURVEYS

Amphibians have been declining globally since the late 1950's and early 1960's (Houlahan et al. 2000). Possible reasons for amphibian declines vary and include ultraviolet radiation (Blaustein et al. 1994, Kiesecker et al. 2001), aquatic pollution (Berger 1989, Hecnar 1995, Materna et al. 1995, Berrill et al. 1997, Lefcort et al. 1998, Turtle 2000, Davidson et al. 2001), habitat loss (Lannoo et al. 1994, Hecnar 1997), landscape fragmentation (Laan and Verboom 1990, Gulve 1994), disease and infections (Crawshaw 1997, Lips 1998, 1999), and the introduction of non-native amphibians or predatory fish (Hammerson 1982, Hayes and Jennings 1986, Bradford 1989, Braña et al. 1996, Knapp and Matthews 2000). Because of the wide-spread nature of declines, the Commission established 20 long-term monitoring stations to assess temporal changes in the status of Mullica River Basin anurans. Annual vocalization surveys have been conducted at these sites since 1996. Vocalization surveys are recommended as an important step in identifying areas of anuran population decline (Shirose et al. 1997).

Methods

Study Sites

Twenty off-stream ponds were surveyed for vocalizing anurans in the Mullica River Basin (Table

10.7). These 20 ponds were selected as long-term monitoring stations because they are located on the western side of the basin along the interface between forest land and developed and farmed landscapes. Fourteen of the ponds were intensively surveyed for adult and larval anurans during a previous Commission study (Bunnell and Zampella 1999). The vegetation present at 13 of these ponds has also been described in detail (Chapter 8, Laidig et al. 2001, Zampella and Laidig 2001). Eighteen of these ponds are breeding habitat for the state-endangered Pine Barrens treefrog.

Table 10.7. List of 20 ponds surveyed annually from 1996 through 1999. The 10 ponds marked with an asterisk were also surveyed in 1993. See Appendix 6 for details regarding pond locations.

Pond name	Pond code
Hampton Furnace pond (Furnace)	BBAFURNP *
Hampton Road pond (Hampton)	BDEHAMPD *
Skit Branch headwater pond (Skit)	BSKIHEAD
Skit Sphagnum pond (Sphagnum)	BSKSPHGM
Roberts (Tom Roberts) pond (Roberts)	BTOMSKIT
Atco Raceway pond	MMUATCOR *
Gravel pond (Gravel)	MMUGRAVL *
Isolated Mullica pond (Mullica)	MMULISOL
Wesickaman pond (Wesickaman)	MWESPOND
Johnson pond	MCLJPOND *
Chew pond (Chew)	MCLRUSNK *
Sandy Causeway pond (Sandy)	MCLSANDY *
Hays Mill pond (Hays)	MHASPRAY
Price Branch pond (Price)	MPRICEPD
4x4 pond	MSL4X4PD *
Blueberry field pond	MSLBLUEB
Isolated Sleeper pond (Sleeper)	MSLEISOL
Fire Warden pond	MSLWARDN *
Abandoned Albertson bog	NALABBOG *
Albertson pond (Albertson)	NALBPOND

Anuran-vocalization Surveys

Anuran-survey methods were similar to those used in earlier Commission studies (Chapter 10, Bunnell and Zampella 1999, Zampella and Bunnell 2000). From 1996 through 1999, nighttime vocalization surveys were conducted from the beginning of the anuran-breeding season (late February/early March) through June. As part of the Commission's initial basin-wide anuran study (Zampella and Bunnell 2000), 10 of the 20 ponds were also surveyed monthly for calling adults in 1993. The number of calling individuals at each site was estimated within a five-minute period using a ranking system where 0 = none, 1 = 1 calling, 2 = 2-5 calling, 3 = 6-10 calling, and 4 = >10 calling individuals.

Data Analysis

Annual median and maximum vocalization ranks were calculated for each species heard at each site. For each species, the frequency of occurrence at the 20 ponds was determined for each year. These attributes represent regional measures of the distribution and abundance of calling individuals for the species heard. Species were classified as Pine Barrens species, wide-ranging species, or border-entrant species according to Conant (1979). The frequency of occurrence was also calculated for these three groups of species to assess changes in native Pinelands versus non-Pinelands species. All results were analyzed graphically.

Results

A total of 11 species were heard calling at the 20 ponds, including both Pine Barrens species, four of the wide-ranging species, and five of the border-entrant species (Figure 10.24). Species richness for all ponds combined ranged from 8 species in 1993 and 1997 to 11 species in 1996 (Figure 10.25). Variation in annual species richness was primarily due to differences in the frequency of occurrence of border-entrant species (Figure 10.25). These trends were associated with the mean number of visits to each site (Figure 10.25). The overall mean (± 1 SD) number of annual visits to each site was 5.6 ± 2.0. Over the five years, Pine Barrens treefrogs, carpenter frogs, spring peepers, leopard frogs, and green frogs were more frequently encountered than Fowler's toads or any of the five border-entrant species (Figure 10.24). The chorus frog was the only border entrant heard during all five years. A single cricket frog was heard at one pond on one occasion.

Of the five most frequently encountered species, Pine Barrens treefrogs and spring peepers were the most stable with respect to the number of ponds occupied from year to year (Figure 10.24). Spring peepers were the only species to vocalize from the same number of ponds in 1993 as in 1999. Except for wood frogs, the frequency of occurrence for all species decreased between 1996 and 1999. Many species were encountered less frequently in 1997.

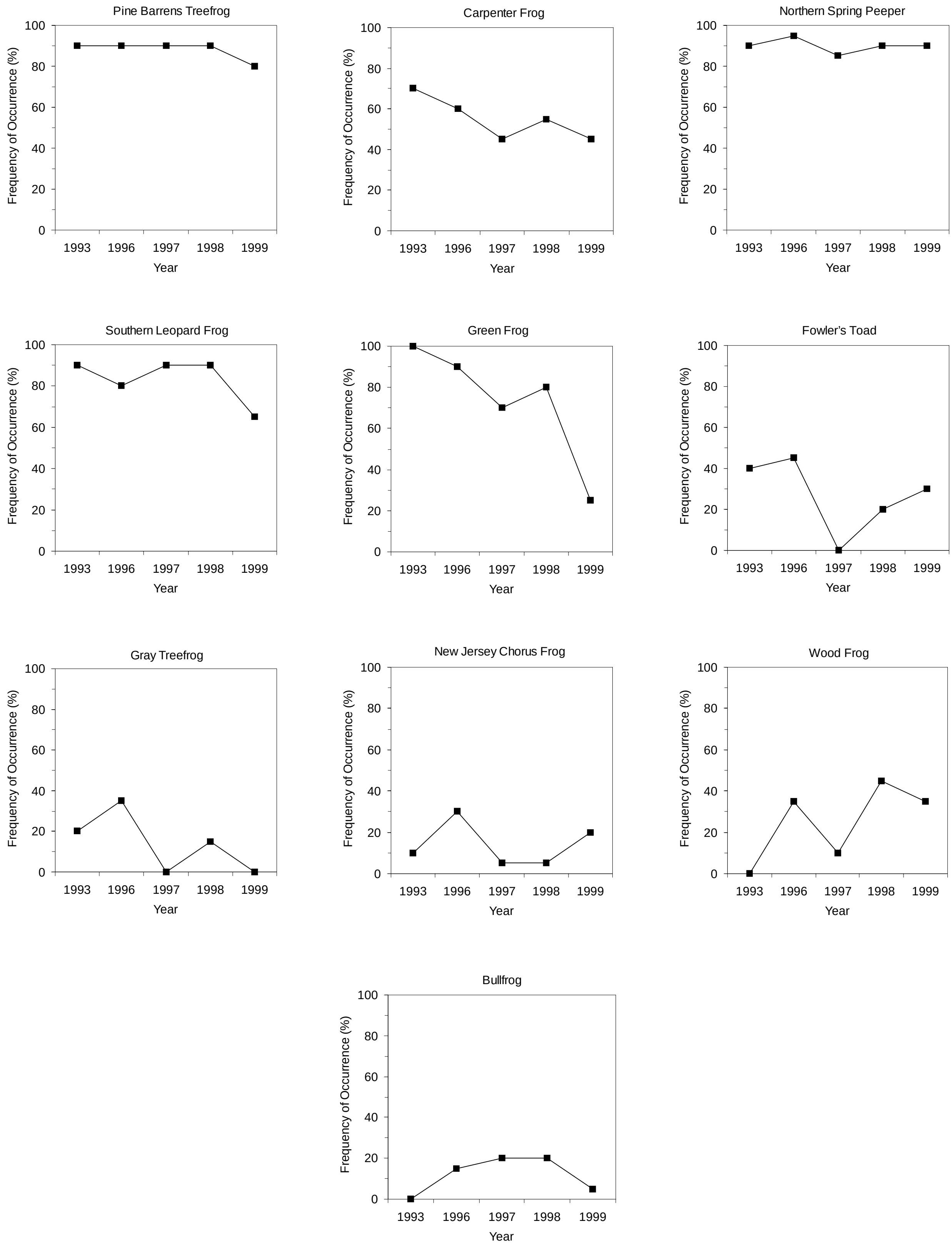

Figure 10.24. Frequency of occurrence of anuran species heard at annual-survey ponds.

Green frogs showed the most pronounced decline during the study period. There was an overall decrease in the frequency of occurrence of Pine Barrens, wide-ranging, and border-entrant species between 1998 and 1999 (Figure 10.25). Pond hydroperiod has been identified as a keystone factor in regulating amphibian populations (Wilbur 1987, Rowe and Dunson 1995, Skelly et al. 1999). Compared to 1996, pond water levels were lower in 1997 and 1998 (Laidig et al. 2001) due to climatic variation.

Based on regional vocalization ranks, Pine Barrens treefrogs and spring peepers were typically the most abundant species calling each year (Figure 10.26). Spring peeper ranks were generally the highest. Although the frequency of occurrence of green frogs decreased substantially during the study period, the annual median and maximum number of calling individuals remained relatively constant. This indicated that the number of vocalizing green frogs may have increased in abundance at the ponds where they were present. Calling ranks also did not vary much over the five years for spring peepers, leopard frogs, or bullfrogs (Figure 10.26). The trend for the number of calling Fowler's toads and gray treefrogs during the survey period mirrors that found for the frequency of occurrence of these two species. For wood frogs, there was an increase in both vocalization ranks and the frequency of occurrence over the survey period. The absence of this species from all ponds in 1993 was probably due to the late start for surveys that year. Surveys were initiated on March 31 in 1993, and wood frogs may have finished breeding by that time (Figure 10.4).

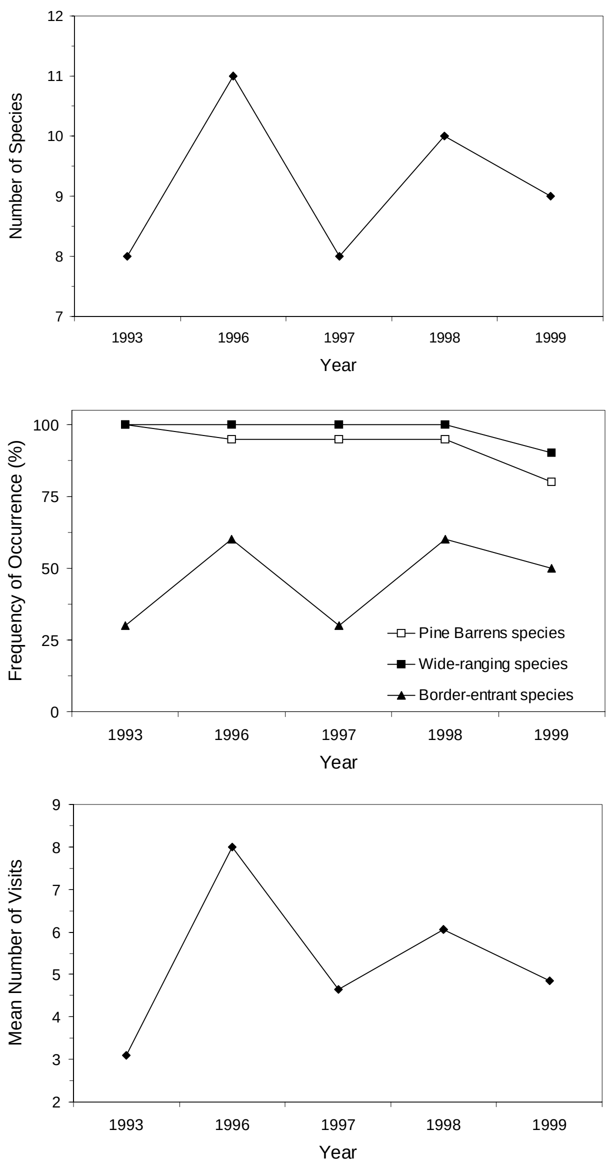

Figure 10.25. Species richness, geographic affinity of anurans, and number of site visits for annual-survey ponds.

ANURAN-DEFORMITY SURVEYS

Physical deformities in anurans, which have been reported from regions throughout the United States and Canada, may be linked to the general problem of amphibian decline. Causal hypotheses for anuran malformations include chemical pollution and parasitic infections (Cooke 1981, Bonin et al. 1997, Rowe et al. 1998, Sessions and Ruth 1990), among other factors. In 1999, Commission scientists examined frogs at six ponds for external abnormalities during a single breeding season.

Methods

Frogs were surveyed for obvious morphological abnormalities at six off-stream ponds. These six sites were among the 20 ponds that were surveyed annually for vocalizing anurans. Adult frogs (mostly vocalizing males) were captured and examined at all six ponds during nighttime surveys in late April or early May. Two of the six ponds were also surveyed in late-June for metamorphosing individuals. Metamorphs were surveyed because physical deformities can also occur in larval anurans (Laposata and Dunson 1998, Rowe et al. 1998). Metamorphs were collected with dipnets during the daytime and examined for deformities. The list of physical

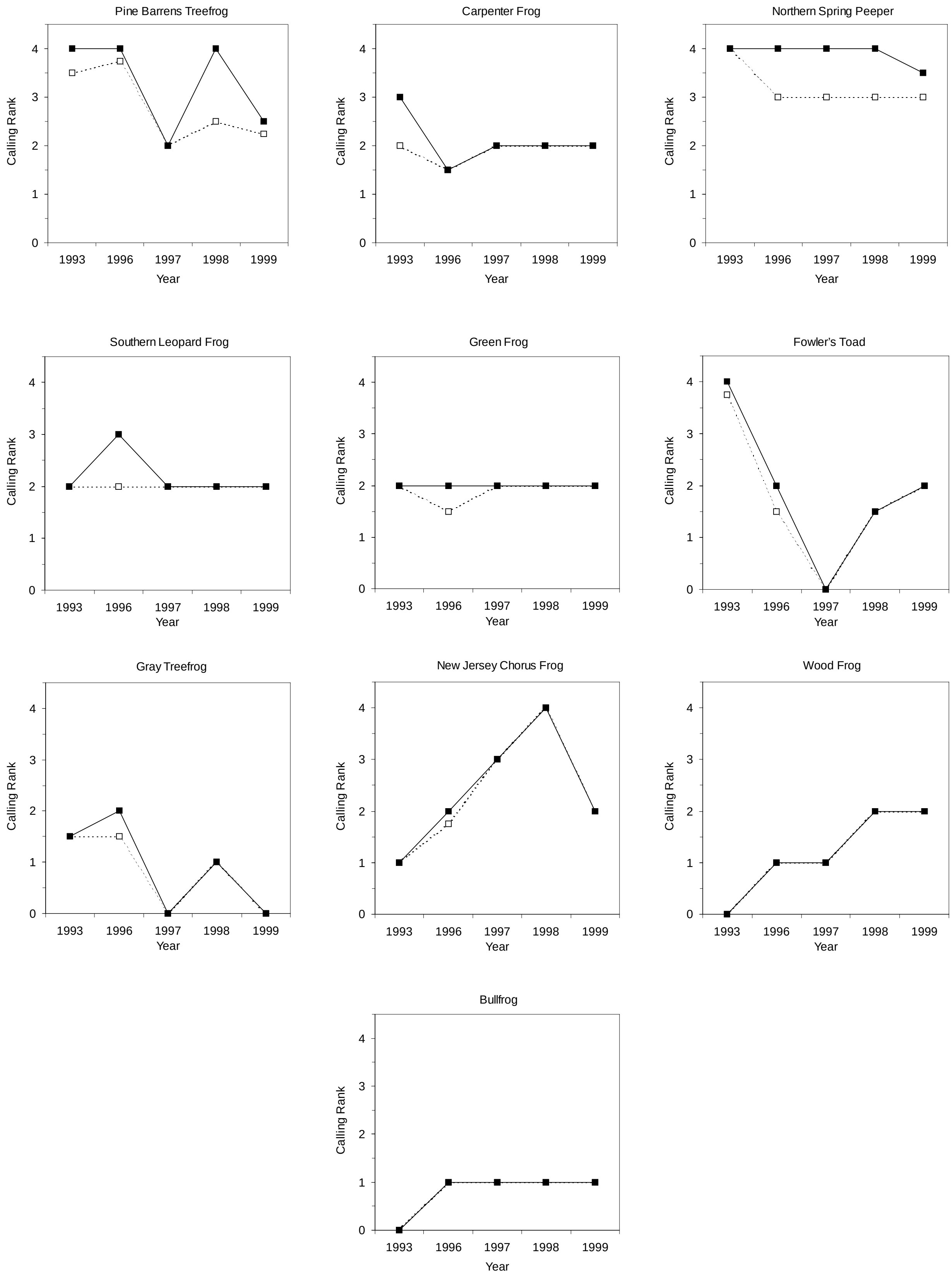

Figure 10.26. Vocalization ranks for anuran species heard at annual-survey ponds. Solid squares represent the maximum calling rank and open squares the median calling rank.

attributes that were examined (Table 10.8) were adopted from the USGS North American Reporting Center for Amphibian Malformations (NARCAM, http://www.npwrc.usgs.gov/narcam).

Table 10.8. Physical attributes examined during deformity surveys.

sex and lifestage (juvenile / metamorph / adult)
postmetamorphic tail (present / partial / absent)
color or pattern (normal / abnormal)
spine (normal / curved left / curved right)
lower jaw length (normal / shortened)
upper jaw length (normal / shortened)
number of eyes
eye size (normal / larger / smaller)
pupil shape (normal / abnormal)
eye position (normal / abnormal)
extra limbs (number)
extra limbs (complete / incomplete)
extra limb origin
upper fore limb (present / partial / absent)
upper fore limb musculature (atrophied / hypertrophied)
lower fore limb (present / partial / absent)
lower fore limb musculature (atrophied / hypertrophied)
fore foot (present / partial / absent)
fore foot digits (shortened / clubbed / fused)
number of fore foot digits
digits missing (I / II / III / IV inside-outside)
upper hind limb (present / partial / absent)
upper hind limb musculature (atrophied / hypertrophied)
lower hind limb (present / partial / absent)
lower hind limb musculature (atrophied / hypertrophied)
hind foot (present / partial / absent)
hind foot digits (shortened / clubbed / fused)
number of hind foot digits
digits missing (I / II / III / IV / V inside-outside)
hind foot webbing (present / absent)
webbing between upper and lower hind leg (present / absent)

Results

A total of 95 frogs were collected during the surveys, including 60 spring peepers, 9 Pine Barrens treefrogs, 4 carpenter frogs, and 22 leopard frogs (Table 10.9). The number of individuals of each species collected at a site varied. Except for one adult leopard frog, none of the individuals exhibited any obvious external abnormalities. The leopard frog was missing a portion of its right hind limb, which was severed and healed over at mid-thigh. Of the 95 frogs examined, 56 individuals were adult frogs and 39 were in various stages of metamorphosis. All metamorphosing frogs had four legs and some amount of tail. Depending on the stage of metamorphosis, mouth shape ranged from that of a tadpole to that of an adult frog. These features are common to larvae at or beyond Gosner (1960) stage 42. The results of the survey of six ponds suggest that the occurrence of anuran malformations may not be a widespread phenomenon in Mullica River Basin ponds.

Table 10.9. Anuran species collected during deformity surveys. See Appendix 6 for pond locations. The asterisk denotes the single leopard frog with a severed leg.

Pond	Pine Barrens treefrog	Northern spring peeper	Carpenter frog	Southern leopard frog
		Adult frogs		
Chew	-	10	-	-
Sleeper	-	6	-	5
Price	-	2	-	1*
Sandy	-	1	4	1
Hampton	-	17	-	1
Furnace	-	8	-	-
		Metamorphic individuals		
Hampton	-	1	-	9
Furnace	9	15	-	5
Total	9	60	4	22

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SUMMARY

SUMMARY

MAJOR FINDINGS

Most of the Mullica River Basin is forest land. Only 15% is developed or farmed. The basin comprises several major stream systems that display a diverse range of land-use patterns. The current status of the aquatic and wetland resources in each system is clearly related to these patterns. The surface-water quality and biological communities found in forested stream basins contrast sharply with those attributes found in basins with a high percentage of upland agriculture and developed land.

The results obtained using different ecological indicators were remarkably similar. Changes in the composition of stream vegetation, fish assemblages, and anuran (frog and toad) communities paralleled gradients of increasing land-use intensity and water-quality degradation. Surface waters characterized by elevated pH and dissolved solids and biological communities that included nonnative plant and animal species were common in stream basins with a high percentage of developed land and upland agriculture. These basins were concentrated on the western side of the Mullica River Basin. Acid waters and typical Pinelands aquatic and wetland communities characterized survey sites in the forest-dominated eastern portion of the drainage. Wetland agriculture, primarily cranberry and blueberry farms, was more frequently encountered in the eastern basins.

Most of the surface-water impacts observed in the basin were associated with nonpoint sources of nutrients and other dissolved solids. Due to variations in ground-water flow patterns and travel times, the current status of surface waters reflects the long-term effects of land-use activities. Temporal factors also influence the status of biological communities because water-quality changes generally precede the establishment of nonnative plant and animal species. The proximity of sources of nonnative species and the ability of these species to colonize new areas are additional factors that may influence the relationship between land-use and the species composition at a site.

Most developed land and upland agriculture was concentrated in the headwaters of the western drainage basins. Although the water quality and biological integrity of these systems generally improved downstream as streams passed through Wharton State Forest, the effect of upstream land-use activities was still apparent. In contrast, studies of Atlantic white cedar swamps and Pinelands ponds indicated that plant and animal communities in forested landscapes appear to be buffered from upstream land-use disturbances that impact nearby in-stream communities.

The land-cover composition of the Mullica River Basin was similar in 1979 and 1991. Most land-cover transitions involved new development or the conversion of one agricultural land use to another and occurred in the appropriate Pinelands management areas. Long-term trends displayed by Atlantic white cedar wetlands demonstrated that the landscape is dynamic.

APPLICATIONS

The relationships revealed through the Mullica River Basin studies offer insight about the eventual response of aquatic and wetland resources to various landscape-pattern scenarios within the Mullica River Basin and other regions in the Pinelands. The results of the studies may provide general descriptive models with land-use policy applications.

The long-term environmental-monitoring studies also helped to refine the concept of essential character introduced in the Pinelands legislation and the Comprehensive Management Plan. Pinelands reference-site conditions were characterized and sets of reliable ecological indicators were established. These concepts can be applied directly to assessments of other Pinelands watersheds and associated aquatic and wetland communities. The concepts can also be used to identify critical areas for acquisition.

As the Commission embarks on its Mullica River Basin watershed-management program, the technical information included in this report can provide the information needed to accurately determine the status of surface waters in the watershed and may serve as the basis for discussions on watershed-management policy issues.

The land-use trend study demonstrated the usefulness of maps produced by the New Jersey Department of Environmental Protection and the Rutgers University Center for Remote Sensing and Spatial Analysis. Future maps created through these efforts can be used to obtain accurate measurements of landscape changes in the Mullica River Basin and other areas of the Pinelands.

The water quality and biological information collected through the Mullica River Basin program represents a baseline data set that can be used for future assessments of the basin's aquatic and wetland resources. As previously discussed, it is reasonable to expect a lag between upland land-use disturbances and changes in surface-water quality and biological-community composition. Absent any unexpected changes in landscape patterns, landscape transitions and associated ecological responses will most likely be subtle.

FUTURE DIRECTIONS

Because changes in pH and specific conductance usually precede shifts in biological community composition, it may be useful to conduct a complete Mullica River Basin assessment of these two water-quality indicators in 2006. Repeat biological assessments should be completed at sites where an increase in these measures is found. Additionally, a representative subset of the entire network of biological sampling sites should be surveyed at that time. The need for a full-scale reassessment of the entire basin can be based on the results of these reduced-scale studies. Annual surveys of the 20 off-stream anuran-monitoring sites should continue uninterrupted. Finally, the knowledge and experience gained through the Mullica River Basin monitoring program should be applied towards establishing an environmental data base for other Pinelands watersheds.

APPENDIX 1. pH AND SPECIFIC CONDUCTANCE DATA

Appendix 1.0.1. Water-quality monitoring sites in the Wading River drainage basin. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name, Location, and Listening Point	Site Code
Arnolds Branch at Route 679 Bass River Twp., Burlington Co. (lat 39°38'46.24", long 74°30'12.04", Jenkins quad). *Latitude and longitude values were obtained using ArcView Software.	WARNCHAT
Bulls Branch impoundment (Otter Pond) Washington Twp., Burlington Co. (lat 39°44'39.05", long 74°34'49.95", Jenkins quad).	WBUOTTER
Featherbed Branch below Carranza Road Tabernacle Twp., Burlington Co. (lat 39°45'36.67", long 74°35'32.30", Chatsworth quad).	WFEACARR
Hospitality Brook below Route 563 Washington Twp., Burlington Co. (lat 39°42'56.29", long 74°32'33.07", Jenkins quad).	WHOSPITA
Little Hauken Run below Route 563 Washington Twp., Burlington Co. (lat 39°42'57.62", long 74°32'06.49", Jenkins quad).	WLIHAUKN
Shane Branch above fourth dike above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°45'49.02", long 74°35'01.71", Chatsworth quad).	WSA4DIKE
Shane Branch above Carranza Road Washington Twp., Burlington Co. (lat 39°45'04.87", long 74°35'06.49", Chatsworth quad).	WSACARRA
Shoal Branch at Chatsworth-Tuckerton Road (Jones Mill Road) Woodland Twp., Burlington Co. (lat 39° 46' 33.60", long 74° 30' 32.40", Chatsworth quad). *Latitude and longitude values were obtained using ArcView Software.	WSHCHATT
Tub Mill Branch at Route 679 Bass River Twp., Burlington Co. (lat 39°38'40.92", long 74°30'02.76", Oswego Lake quad). *Latitude and longitude values were obtained using ArcView Software.	WTUBCHAT
Tulpehocken Creek at Carranza Road Tabernacle Twp., Burlington Co. (lat 39°46'17.09", long 74°36'52.22", Chatsworth quad).	WTUCARRA
Tulpehocken Creek above Big Hawkin Bridge Washington Twp., Burlington Co. (lat 39°42'51.73", long 74°33'57.15", Jenkins quad).	WTUHAWKN
Wading River above Route 563 Washington Twp., Burlington Co. (lat 39°40'30.53", long 74°32'27.17", Jenkins quad).	WWEEVANB
Wading River below Ford Road Washington Twp., Burlington Co. (lat 39°42'16.44", long 74°33'18.43", Jenkins quad).	WWEFORDR
Wading River below Mile Run Washington Twp., Burlington Co. (lat 39°44'22.17", long 74°32'54.72", Jenkins quad).	WWEMILER
Wading River above Tulpehocken Creek Washington Twp., Burlington Co. (lat 39°43'01.10", long 74°33'43.87", Jenkins quad).	WWETULPC

Appendix 1.0.2. Specific conductance (SC, μS cm^{-1}) and pH values for the Wading River basin. Refer to Chapter 4 (Water Quality) for methodology.

Site Name	Site Code	Date	pH	SC
Arnolds Branch at Route 679	WARNCHAT	06/24/99	3.97	70.2
Arnolds Branch at Route 679	WARNCHAT	07/16/99	4.46	73.9
Arnolds Branch at Route 679	WARNCHAT	08/26/99	3.75	86.1
Arnolds Branch at Route 679	WARNCHAT	10/12/99	4.12	60.1
Bulls Branch impoundment (Otter Pond)	WBUOTTER	06/10/99	3.91	74.5
Bulls Branch impoundment (Otter Pond)	WBUOTTER	07/15/99	4.11	56.3
Bulls Branch impoundment (Otter Pond)	WBUOTTER	08/26/99	4.03	56.0
Bulls Branch impoundment (Otter Pond)	WBUOTTER	10/14/99	4.05	65.2
Featherbed Branch below Carranza Road	WFEACARR	06/10/99	3.90	66.7
Featherbed Branch below Carranza Road	WFEACARR	07/16/99	3.92	62.4
Featherbed Branch below Carranza Road	WFEACARR	08/26/99	3.53	68.9
Featherbed Branch below Carranza Road	WFEACARR	10/14/99	3.99	61.5
Hospitality Brook below Route 563	WHOSPITA	06/10/99	4.52	49.0
Hospitality Brook below Route 563	WHOSPITA	07/16/99	4.45	45.8
Hospitality Brook below Route 563	WHOSPITA	08/26/99	4.42	54.2
Hospitality Brook below Route 563	WHOSPITA	10/14/99	4.48	57.2
Little Hauken Run below Route 563	WLIHAUKN	06/10/99	4.97	49.2
Little Hauken Run below Route 563	WLIHAUKN	07/16/99	4.60	44.6
Little Hauken Run below Route 563	WLIHAUKN	08/26/99	4.23	56.0
Little Hauken Run below Route 563	WLIHAUKN	10/14/99	4.31	57.8
Shane Branch above fourth dike above Carranza Road	WSA4DIKE	06/10/99	4.11	52.0
Shane Branch above fourth dike above Carranza Road	WSA4DIKE	07/15/99	4.04	55.6
Shane Branch above fourth dike above Carranza Road	WSA4DIKE	08/26/99	3.24	116.3
Shane Branch above fourth dike above Carranza Road	WSA4DIKE	10/14/99	3.78	95.4
Shane Branch above Carranza Road	WSACARRA	06/10/99	4.53	28.0
Shane Branch above Carranza Road	WSACARRA	07/16/99	4.54	25.5
Shane Branch above Carranza Road	WSACARRA	08/26/99	3.76	92.5
Shane Branch above Carranza Road	WSACARRA	10/14/99	3.87	83.5
Shoal Branch at Jones Mill Road	WSHCHATT	06/24/99	4.34	44.2
Shoal Branch at Jones Mill Road	WSHCHATT	07/20/99	4.45	36.7
Shoal Branch at Jones Mill Road	WSHCHATT	08/26/99	4.20	51.9
Shoal Branch at Jones Mill Road	WSHCHATT	10/14/99	4.32	74.7
Tub Mill Branch at Route 679	WTUBCHAT	06/24/99	3.84	90.5
Tub Mill Branch at Route 679	WTUBCHAT	07/16/99	4.16	46.0
Tub Mill Branch at Route 679	WTUBCHAT	08/26/99	3.72	97.1
Tub Mill Branch at Route 679	WTUBCHAT	10/12/99	3.90	72.3
Tulpehocken Creek at Carranza Road	WTUCARRA	06/24/99	4.17	54.5
Tulpehocken Creek at Carranza Road	WTUCARRA	07/16/99	4.73	37.9
Tulpehocken Creek at Carranza Road	WTUCARRA	08/26/99	3.84	68.8
Tulpehocken Creek at Carranza Road	WTUCARRA	10/14/99	4.20	47.3
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	06/10/99	5.12	24.8
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	07/16/99	5.45	22.6
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	08/26/99	4.47	36.3
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	10/14/99	4.76	28.6
Wading River above Route 563	WWEEVANB	06/10/99	4.56	38.0
Wading River above Route 563	WWEEVANB	07/16/99	4.58	37.5
Wading River above Route 563	WWEEVANB	08/26/99	4.13	58.2
Wading River above Route 563	WWEEVANB	10/14/99	4.57	46.9
Wading River below Ford Road	WWEFORDR	06/14/99	4.80	31.4
Wading River below Ford Road	WWEFORDR	07/16/99	4.63	32.8
Wading River below Ford Road	WWEFORDR	08/26/99	4.26	51.2
Wading River below Ford Road	WWEFORDR	10/14/99	4.65	42.6
Wading River below Mile Run	WWEMILER	06/10/99	4.72	38.8
Wading River below Mile Run	WWEMILER	07/16/99	4.72	35.1
Wading River below Mile Run	WWEMILER	08/26/99	4.06	72.6
Wading River below Mile Run	WWEMILER	10/14/99	4.61	49.8
Wading River above Tulpehocken Creek	WWETULPC	06/10/99	4.64	37.3
Wading River above Tulpehocken Creek	WWETULPC	07/16/99	4.65	34.4
Wading River above Tulpehocken Creek	WWETULPC	08/26/99	4.18	62.8
Wading River above Tulpehocken Creek	WWETULPC	10/14/99	4.58	47.4

Appendix 1.1.1. Water-quality monitoring sites in the Bass River and Oswego River drainage basins. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name, Location, and Listening Point	Site Code
Dans Bridge Branch above Dans Bridge Road Bass River Twp., Burlington Co. (lat 39°38'11.97", long 74°25'34.70", Oswego Lake quad).	ADADANRD
Lake Absegami Bass River Twp., Burlington Co. (lat 39°37'19.49", long 74°25'21.61", New Gretna quad).	AEAABSDW
East Branch Bass River above Stage Road Bass River Twp., Burlington Co. (lat 39°37'24.00", long 74°26'27.95", New Gretna quad).	AEASTAGE
West Branch Bass River above Stage Road Bass River Twp., Burlington Co. (lat 39°37'27.38", long 74°26'45.22", New Gretna quad).	AWESTAGE
Buck Run below Old Martha Road Bass River Twp., Burlington Co. (lat 39°41'58.89", long 74°29'53.22", Oswego Lake quad).	OBUCKRUN
Oswego River below Beaver Dam Road Little Egg Harbor Twp., Ocean Co. (lat 39°44'58.67", long 74°22'38.43", Oswego Lake quad).	OOSBEAVR
Oswego River impoundment above Old Cedar Bridge-Barnegat Road Washington Twp., Burlington Co. (lat 39°45'04.87", long 74°35'06.49", Chatsworth quad).	OOSCEDRI
Oswego River below Route 679 Washington/Bass River Twp., Burlington Co. (lat 39°39'48.45", long 74°31'24.44", Jenkins quad).	OOSHARST
Oswego River impoundment at Howardsville Union Twp., Ocean Co. (lat 39°49'01.32", long 74°21'59.86", Brookville quad).	OOSHOWIM
Oswego River above Oswego Lake Washington/Bass River Twp., Burlington Co. (lat 39°44'07.16", long 74°28'24.16", Oswego Lake quad).	OOSLAKUP
Oswego River above Martha Washington/Bass River Twp., Burlington Co. (lat 39°42'13.56", long 74°30'05.45", Jenkins quad).	OOSOLMAR
Papoose Branch below Jenkins Road Washington/Bass River Twp., Burlington Co. (lat 39°44'31.93", long 74°27'09.67", Oswego Lake quad).	OPAPOOSE
Plains Branch at Jenkins Road Washington/Bass River Twp., Burlington Co. (lat 39°44'31.93", long 74°27'09.67", Woodmansie quad).	OPLNJENK

Appendix 1.1.2. Specific conductance (SC, μS cm^{-1}) and pH values for the Bass River and Oswego River drainage basins. Refer to Chapter 4 (Water Quality) for methodology.

Site Name	Site Code	Date	pH	SC
Dans Bridge Branch above Dans Bridge Road	ADADANRD	06/24/99	4.44	41.1
Dans Bridge Branch above Dans Bridge Road	ADADANRD	07/16/99	4.57	33.0
Dans Bridge Branch above Dans Bridge Road	ADADANRD	08/26/99	4.35	44.5
Dans Bridge Branch above Dans Bridge Road	ADADANRD	10/12/99	4.47	38.8
Lake Absegami	AEAABSDW	06/10/99	4.50	64.3
Lake Absegami	AEAABSDW	07/16/99	4.52	63.3
Lake Absegami	AEAABSDW	08/26/99	4.61	54.7
Lake Absegami	AEAABSDW	10/12/99	4.64	49.1
East Branch Bass River above Stage Road	AEASTAGE	06/10/99	4.62	35.6
East Branch Bass River above Stage Road	AEASTAGE	07/16/99	4.66	34.2
East Branch Bass River above Stage Road	AEASTAGE	08/26/99	4.32	45.6
East Branch Bass River above Stage Road	AEASTAGE	10/12/99	4.51	40.1
West Branch Bass River above Stage Road	AWESTAGE	06/10/99	4.65	32.5
West Branch Bass River above Stage Road	AWESTAGE	07/16/99	4.75	29.6
West Branch Bass River above Stage Road	AWESTAGE	08/26/99	4.26	48.4
West Branch Bass River above Stage Road	AWESTAGE	10/12/99	4.50	36.9
Buck Run below Old Martha Road	OBUCKRUN	06/10/99	4.89	26.2
Buck Run below Old Martha Road	OBUCKRUN	07/16/99	4.96	24.8
Buck Run below Old Martha Road	OBUCKRUN	08/26/99	3.87	78.5
Buck Run below Old Martha Road	OBUCKRUN	10/14/99	4.71	30.8
Oswego River below Beaver Dam Road	OOSBEAVR	06/14/99	4.60	34.7
Oswego River below Beaver Dam Road	OOSBEAVR	07/16/99	4.76	29.3
Oswego River below Beaver Dam Road	OOSBEAVR	08/19/99	4.14	82.3
Oswego River below Beaver Dam Road	OOSBEAVR	10/12/99	4.30	55.8
Oswego River impoundment above Old Cedar Bridge-Barnegat Road	OOSCEDRI	08/19/99	4.12	101.5
Oswego River impoundment above Old Cedar Bridge-Barnegat Road	OOSCEDRI	10/12/99	4.10	67.1
Oswego River below Route 679	OOSHARST	06/10/99	4.40	43.5
Oswego River below Route 679	OOSHARST	07/16/99	4.41	41.5
Oswego River below Route 679	OOSHARST	08/26/99	4.18	49.6
Oswego River below Route 679	OOSHARST	10/14/99	4.46	45.4
Oswego River impoundment at Howardsville	OOSHOWIM	06/14/99	4.25	59.7
Oswego River impoundment at Howardsville	OOSHOWIM	07/16/99	4.20	61.8
Oswego River impoundment at Howardsville	OOSHOWIM	08/19/99	4.34	58.9
Oswego River impoundment at Howardsville	OOSHOWIM	10/12/99	4.26	79.5
Oswego River above Oswego Lake	OOSLAKUP	06/10/99	4.53	38.1
Oswego River above Oswego Lake	OOSLAKUP	07/16/99	4.51	37.2
Oswego River above Oswego Lake	OOSLAKUP	08/26/99	3.96	59.3
Oswego River above Oswego Lake	OOSLAKUP	10/14/99	4.39	46.8
Oswego River above Martha	OOSOLMAR	06/10/99	4.52	39.9
Oswego River above Martha	OOSOLMAR	07/16/99	4.48	38.6
Oswego River above Martha	OOSOLMAR	08/26/99	3.99	67.9
Oswego River above Martha	OOSOLMAR	10/14/99	4.48	43.4
Papoose Branch below Jenkins Road	OPAPOOSE	06/10/99	4.57	29.4
Papoose Branch below Jenkins Road	OPAPOOSE	07/16/99	4.65	27.6
Papoose Branch below Jenkins Road	OPAPOOSE	08/26/99	3.93	60.1
Papoose Branch below Jenkins Road	OPAPOOSE	10/14/99	4.48	35.6
Plains Branch at Jenkins Road	OPLNJENK	06/24/99	4.18	51.2
Plains Branch at Jenkins Road	OPLNJENK	07/16/99	4.33	44.1
Plains Branch at Jenkins Road	OPLNJENK	08/19/99	3.96	88.7
Plains Branch at Jenkins Road	OPLNJENK	10/14/99	4.18	52.9

Appendix 1.2.1. Water-quality monitoring sites in the Lower Mullica River drainage basin. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name, Location, and Listening Point	Site Code
Clarks Mill Stream at Leibig Street and Odessa Avenue Galloway Twp., Atlantic Co. (lat 39°30'47.48", long 74°33'10.33", Green Bank quad).	LCLODESS
Elliots Creek at Bremen Avenue Egg Harbor City Twp., Atlantic Co. (lat 39°32'41.01", long 74°36'22.90", Green Bank quad).	LELIOBRE
Hammonton Creek above Chestnut Avenue Mullica Twp., Atlantic Co. (lat 39°38'02.07", long 74°43'03.70", Atsion quad).	LHACHEST
Hammonton Lake Hammonton Twp., Atlantic Co. (lat 39°37'38.84", long 74°47'20.61", Hammonton quad).	LHAMLAKE
Indian Cabin Creek above Landing Creek Egg Harbor City Twp., Atlantic Co. (lat 39°33'26.19", long 74°36'09.04", Green Bank quad).	LINCABIN
Egg Harbor City Lake above Route 563 Egg Harbor City Twp., Atlantic Co. (lat 39°33'38.41", long 74°36'38.67", Green Bank quad).	LINLAKEU
Landing Creek above Indian Cabin Road Egg Harbor City Twp., Atlantic Co. (lat 39°33'24.32", long 74°36'10.22", Green Bank quad).	LLANDIND
Landing Creek below Alternate Route 561 Egg Harbor City Twp., Atlantic Co. (lat 39°32'45.66", long 74°37'51.25", Egg Harbor City quad).	LLANDMOS
Lucas Branch at Pleasant Route 643 Mullica Twp., Atlantic Co. (lat 39°32'45.66", long 74°37'51.25", Egg Harbor City quad).	LLUCWEEK
Lake Fred Galloway Twp., Atlantic Co. (lat 39°29'46.41", long 74°31'43.47", Green Bank quad).	LMOSTOCK
Union Creek above Alternate Route 561 Egg Harbor City Twp., Atlantic Co. (lat 39°32'39.77", long 74°37'38.68", Egg Harbor City quad).	LUNIOMOS

Appendix 1.2.2. Specific conductance (SC, μS cm^{-1}) and pH values for the Lower Mullica River drainage basin. Refer to Chapter 4 (Water Quality) for methodology.

Site Name	Site Code	Date	pH	SC
Clarks Mill Stream at Leibig Street and Odessa Avenue	LCLODESS	06/09/99	4.95	58.5
Clarks Mill Stream at Leibig Street and Odessa Avenue	LCLODESS	07/20/99	5.35	53.1
Clarks Mill Stream at Leibig Street and Odessa Avenue	LCLODESS	08/19/99	5.40	57.2
Clarks Mill Stream at Leibig Street and Odessa Avenue	LCLODESS	10/12/99	4.98	63.4
Elliots Creek at Bremen Avenue	LELIOBRE	06/09/99	4.76	71.6
Elliots Creek at Bremen Avenue	LELIOBRE	07/20/99	4.84	62.3
Elliots Creek at Bremen Avenue	LELIOBRE	08/19/99	4.79	68.4
Elliots Creek at Bremen Avenue	LELIOBRE	10/12/99	4.66	74.4
Hammonton Creek above Chestnut Avenue	LHACHEST	06/09/99	6.62	161.6
Hammonton Creek above Chestnut Avenue	LHACHEST	07/20/99	6.80	160.5
Hammonton Creek above Chestnut Avenue	LHACHEST	08/19/99	6.85	138.2
Hammonton Creek above Chestnut Avenue	LHACHEST	10/13/99	6.98	128.6
Hammonton Lake	LHAMLAKE	06/09/99	6.70	94.5
Hammonton Lake	LHAMLAKE	07/15/99	6.78	96.5
Hammonton Lake	LHAMLAKE	08/20/99	6.86	106.9
Hammonton Lake	LHAMLAKE	10/13/99	7.26	90.3
Indian Cabin Creek above Landing Creek	LINCABIN	07/20/99	5.80	48.8
Indian Cabin Creek above Landing Creek	LINCABIN	08/19/99	5.59	52.7
Indian Cabin Creek above Landing Creek	LINCABIN	10/12/99	5.20	53.2
Egg Harbor City Lake above Route 563	LINLAKEU	06/09/99	4.49	59.3
Egg Harbor City Lake above Route 563	LINLAKEU	07/20/99	4.39	58.1
Egg Harbor City Lake above Route 563	LINLAKEU	08/19/99	4.56	60.9
Egg Harbor City Lake above Route 563	LINLAKEU	10/12/99	4.28	68.2
Landing Creek above Indian Cabin Road	LLANDIND	06/09/99	5.62	61.9
Landing Creek above Indian Cabin Road	LLANDIND	07/20/99	5.85	60.3
Landing Creek above Indian Cabin Road	LLANDIND	08/19/99	5.73	70.3
Landing Creek above Indian Cabin Road	LLANDIND	10/12/99	5.11	69.1
Landing Creek below Alternate Route 561	LLANDMOS	06/09/99	5.71	75.0
Landing Creek below Alternate Route 561	LLANDMOS	07/20/99	5.87	72.5
Landing Creek below Alternate Route 561	LLANDMOS	08/19/99	5.62	87.0
Landing Creek below Alternate Route 561	LLANDMOS	10/12/99	5.21	76.8
Lucas Branch at Route 643	LLUCWEEK	06/24/99	4.11	65.5
Lucas Branch at Route 643	LLUCWEEK	07/20/99	4.26	56.4
Lucas Branch at Route 643	LLUCWEEK	08/19/99	4.10	71.1
Lucas Branch at Route 643	LLUCWEEK	10/14/99	4.26	62.3
Lake Fred	LMOSTOCK	06/09/99	6.21	70.0
Lake Fred	LMOSTOCK	07/20/99	6.39	70.2
Lake Fred	LMOSTOCK	08/19/99	6.48	65.0
Lake Fred	LMOSTOCK	10/12/99	6.07	69.0
Union Creek above Alternate Route 561	LUNIOMOS	06/09/99	6.14	66.5
Union Creek above Alternate Route 561	LUNIOMOS	07/20/99	6.32	59.6
Union Creek above Alternate Route 561	LUNIOMOS	08/19/99	6.23	69.1
Union Creek above Alternate Route 561	LUNIOMOS	10/12/99	6.59	83.0

Appendix 1.3.1. Water-quality monitoring sites in the Nescochague Creek drainage basin. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name, Location, and Listening Point	Site Code
Albertson Brook above Fleming Pike Waterford Twp., Camden Co. (lat 39°41'35.12", long 74°48'22.58", Hammonton quad).	NALBFLEM
Albertson Brook above derelict bridge below Route 206 Hammonton Twp., Atlantic Co. (lat 39°41'40.59", long 74°44'38.23", Atsion quad).	NALDEREL
Blue Anchor Brook above Pump Branch Waterford Twp., Camden Co. (lat 39°41'33.65", long 74°48'42.87", Hammonton quad).	NBLCONFL
Blue Anchor Brook impoundment above Spring Garden-Winslow Road Winslow Twp., Camden Co. (lat 39°41'16.70", long 74°50'58.08", Hammonton quad).	NBLSPRNG
Cedar Brook near Hammonton Airport Hammonton Twp., Atlantic Co. (lat 39°40'09.64", long 74°45'42.61", Hammonton quad).	NCEAIRPO
Great Swamp Branch impoundment above Route 30 Winslow Twp., Camden Co. (lat 39°40'15.59", long 74°49'32.78", Hammonton quad).	NGREAR30
Great Swamp Branch below Route 613 Hammonton Twp., Atlantic Co. (lat 39°41'03.76", long 74°45'45.93", Hammonton quad).	NGRMIDDL
Nescochague Creek at Pleasant Mills Mullica Twp., Atlantic Co. (lat 39°38'37.35", long 74°39'46.31", Atsion quad).	NNEMILLS
Nescochague Creek near West Mill Road Washington Twp., Burlington Co. (lat 39°39'49.35", long 74°41'51.93", Atsion quad).	NNEWESTM
Pump Branch impoundment at Ha-Lu-Wa-Sa Winslow Twp., Camden Co. (lat 39°42'10.49", long 74°51'31.90", Hammonton quad).	NPUHALUW
Pump Branch impoundment near Cedar Avenue Winslow Twp., Camden Co. (lat 39°41'50.31", long 74°49'43.48", Hammonton quad).	NPUIMPNT
Pump Branch above dike at Winslow/Waterford boundary Winslow Twp., Camden Co. (lat 39°41'38.64", long 74°49'15.68", Hammonton quad).	NPUMDIKE

Appendix 1.3.2. Specific conductance (SC, μS cm^{-1}) and pH values for the Nescochague Creek drainage basin. Refer to Chapter 4 (Water Quality) for methodology.

Site Name	Site Code	Date	pH	SC
Albertson Brook above Fleming Pike	NALBFLEM	06/08/99	6.59	68.4
Albertson Brook above Fleming Pike	NALBFLEM	07/15/99	6.75	69.5
Albertson Brook above Fleming Pike	NALBFLEM	08/20/99	6.73	74.6
Albertson Brook above Fleming Pike	NALBFLEM	10/13/99	6.97	72.4
Albertson Brook above derelict bridge below Route 206	NALDEREL	06/09/99	6.64	62.8
Albertson Brook above derelict bridge below Route 206	NALDEREL	07/19/99	6.66	62.4
Albertson Brook above derelict bridge below Route 206	NALDEREL	08/20/99	6.84	69.0
Albertson Brook above derelict bridge below Route 206	NALDEREL	10/13/99	6.91	66.3
Blue Anchor Brook above Pump Branch	NBLCONFL	06/08/99	6.51	83.6
Blue Anchor Brook above Pump Branch	NBLCONFL	07/15/99	6.60	78.8
Blue Anchor Brook above Pump Branch	NBLCONFL	08/20/99	6.64	86.6
Blue Anchor Brook above Pump Branch	NBLCONFL	10/13/99	6.48	84.3
Blue Anchor Brook impoundment above Spring Garden-Winslow Road	NBLSPRNG	06/08/99	7.00	62.1
Blue Anchor Brook impoundment above Spring Garden-Winslow Road	NBLSPRNG	07/15/99	6.68	62.8
Blue Anchor Brook impoundment above Spring Garden-Winslow Road	NBLSPRNG	08/20/99	6.78	73.0
Blue Anchor Brook impoundment above Spring Garden-Winslow Road	NBLSPRNG	10/13/99	7.02	104.8
Cedar Brook near Hammonton Airport	NCEAIRPO	06/09/99	6.54	177.4
Cedar Brook near Hammonton Airport	NCEAIRPO	07/15/99	6.59	148.6
Cedar Brook near Hammonton Airport	NCEAIRPO	08/20/99	6.71	152.1
Cedar Brook near Hammonton Airport	NCEAIRPO	10/13/99	6.77	185.6
Great Swamp Branch 2nd (and 3rd) impoundments above Route 30	NGREAR30	06/08/99	6.75	70.8
Great Swamp Branch 2nd (and 3rd) impoundments above Route 30	NGREAR30	07/15/99	6.74	65.2
Great Swamp Branch 2nd (and 3rd) impoundments above Route 30	NGREAR30	08/20/99	6.68	191.9
Great Swamp Branch 2nd (and 3rd) impoundments above Route 30	NGREAR30	10/13/99	6.51	73.2
Great Swamp Branch below Route 613	NGRMIDDL	06/09/99	6.30	119.2
Great Swamp Branch below Route 613	NGRMIDDL	07/15/99	6.25	109.7
Great Swamp Branch below Route 613	NGRMIDDL	08/20/99	5.78	150.7
Great Swamp Branch below Route 613	NGRMIDDL	10/13/99	6.73	117.2
Nescochague Creek at Pleasant Mills	NNEMILLS	06/09/99	6.71	53.0
Nescochague Creek at Pleasant Mills	NNEMILLS	07/20/99	6.69	52.2
Nescochague Creek at Pleasant Mills	NNEMILLS	08/19/99	6.74	70.5
Nescochague Creek at Pleasant Mills	NNEMILLS	10/14/99	6.47	66.2
Nescochague Creek near West Mill Road	NNEWESTM	06/11/99	6.69	54.4
Nescochague Creek near West Mill Road	NNEWESTM	07/20/99	6.73	52.1
Nescochague Creek near West Mill Road	NNEWESTM	08/19/99	6.83	69.4
Nescochague Creek near West Mill Road	NNEWESTM	10/14/99	6.51	59.4
Pump Branch impoundment at Ha-Lu-Wa-Sa	NPUHALUW	06/09/99	6.60	94.3
Pump Branch impoundment at Ha-Lu-Wa-Sa	NPUHALUW	07/15/99	6.62	89.8
Pump Branch impoundment at Ha-Lu-Wa-Sa	NPUHALUW	08/20/99	6.74	83.5
Pump Branch impoundment at Ha-Lu-Wa-Sa	NPUHALUW	10/13/99	7.19	89.1
Pump Branch impoundment near Cedar Avenue	NPUIMPNT	06/08/99	6.51	69.3
Pump Branch impoundment near Cedar Avenue	NPUIMPNT	07/15/99	6.54	73.4
Pump Branch impoundment near Cedar Avenue	NPUIMPNT	08/20/99	6.48	78.9
Pump Branch impoundment near Cedar Avenue	NPUIMPNT	10/13/99	7.16	74.6
Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	06/08/99	6.58	65.5
Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	07/15/99	6.72	71.8
Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	08/20/99	6.74	76.6
Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	10/13/99	7.04	72.4

Appendix 1.4.1. Water-quality monitoring sites in the Sleeper Branch drainage basin. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name, Location, and Listening Point	Site Code
Clark Branch above Burnt Mill Road Waterford Twp., Camden Co. (lat 39°42'48.47", long 74°46'40.16", Hammonton quad). *Latitude and longitude values were obtained using ArcView Software.	MCLBURNT
Clark Branch at Parkdale Waterford Twp., Camden Co. (lat 39°43'00.60", long 74°45'18.56", Hammonton quad).	MCLJOHNS
Cooper Branch impoundment near Tremont Avenue and Burnt Mill Road Waterford Twp., Camden Co. (lat 39°44'45.00", long 74°50'24.99", Hammonton quad).	MCOIMPNT
Atco Lake Waterford Twp., Camden Co. (lat 39°45'24.16", long 74°53'01.54", Clementon quad).	MHAATCOL
Hays Mill Creek above Tremont Avenue Waterford Twp., Camden Co. (lat 39°45'02.70", long 74°50'27.27", Medford Lakes quad).	MHATREMO
Price Branch below Burnt Mill Road Waterford Twp., Camden Co. (lat 39°43'19.53", long 74°47'48.02", Hammonton quad).	MPRBURNT
Sleeper Branch bogs at Route 206 Hammonton Twp., Atlantic Co. (lat 39°43'08.01", long 74°44'19.23", Atsion quad).	MSL206BG
Sleeper Branch at Parkdale Waterford Twp., Camden Co. (lat 39°43'10.05", long 74°45'02.71", Hammonton quad).	MSLEPARK
Sleeper Branch at Maple Island Waterford Twp., Camden Co. (lat 39°44'15.17", long 74°48'53.84", Hammonton quad).	MSLMAPLE
Sleeper Branch above Mullica River Mullica Twp., Atlantic Co. (lat 39°38'48.59", long 74°39'38.86", Atsion quad).	MSLPLEAS
Sleeper Branch diversion (Saltars Ditch) Waterford Twp., Camden Co. (lat 39°43'55.09", long 74°45'58.84", Hammonton quad).	MSLSALTD
Wildcat Branch below Burnt Mill Road Waterford Twp., Camden Co. (lat 39°44'21.08", long 74°49'58.00", Hammonton quad).	MWIBURNT

Appendix 1.4.2. Specific conductance (SC, μS cm^{-1}) and pH values for the Sleeper Branch drainage basin. Refer to Chapter 4 (Water Quality) for methodology.

Site Name	Site Code	Date	pH	SC
Clark Branch above Burnt Mill Road	MCLBURNT	06/08/99	4.80	49.7
Clark Branch above Burnt Mill Road	MCLBURNT	07/15/99	4.92	49.6
Clark Branch above Burnt Mill Road	MCLBURNT	08/20/99	4.92	109.1
Clark Branch above Burnt Mill Road	MCLBURNT	10/13/99	4.80	53.6
Clark Branch at Parkdale	MCLJOHNS	06/09/99	4.73	47.1
Clark Branch at Parkdale	MCLJOHNS	07/15/99	4.67	39.0
Clark Branch at Parkdale	MCLJOHNS	08/20/99	4.58	68.9
Clark Branch at Parkdale	MCLJOHNS	10/13/99	4.90	52.9
Cooper Branch impoundment near Tremont Avenue and Burnt Mill Road	MCOIMPNT	06/08/99	6.33	60.0
Cooper Branch impoundment near Tremont Avenue and Burnt Mill Road	MCOIMPNT	07/15/99	5.32	66.6
Cooper Branch impoundment near Tremont Avenue and Burnt Mill Road	MCOIMPNT	08/20/99	5.63	56.1
Cooper Branch impoundment near Tremont Avenue and Burnt Mill Road	MCOIMPNT	10/13/99	5.34	81.2
Atco Lake	MHAATCOL	06/08/99	6.42	106.0
Atco Lake	MHAATCOL	07/15/99	6.52	97.0
Atco Lake	MHAATCOL	08/20/99	6.31	98.2
Atco Lake	MHAATCOL	10/13/99	6.95	114.7
Hays Mill Creek above Tremont Avenue	MHATREMO	06/08/99	6.64	98.0
Hays Mill Creek above Tremont Avenue	MHATREMO	07/15/99	6.75	92.1
Hays Mill Creek above Tremont Avenue	MHATREMO	08/20/99	6.91	92.9
Hays Mill Creek above Tremont Avenue	MHATREMO	10/13/99	7.00	101.6
Price Branch below Burnt Mill Road	MPRBURNT	06/08/99	6.10	66.4
Price Branch below Burnt Mill Road	MPRBURNT	10/13/99	6.25	62.7
Sleeper Branch bogs at Route 206	MSL206BG	06/09/99	6.55	57.0
Sleeper Branch bogs at Route 206	MSL206BG	07/19/99	6.57	63.2
Sleeper Branch bogs at Route 206	MSL206BG	08/26/99	6.53	56.3
Sleeper Branch bogs at Route 206	MSL206BG	10/13/99	6.55	61.0
Sleeper Branch at Parkdale	MSLEPARK	06/09/99	6.68	62.7
Sleeper Branch at Parkdale	MSLEPARK	07/15/99	6.70	63.6
Sleeper Branch at Parkdale	MSLEPARK	08/20/99	6.96	63.7
Sleeper Branch at Parkdale	MSLEPARK	10/13/99	6.85	61.6
Sleeper Branch at Maple Island	MSLMAPLE	06/08/99	6.58	72.8
Sleeper Branch at Maple Island	MSLMAPLE	07/15/99	6.63	69.7
Sleeper Branch at Maple Island	MSLMAPLE	08/23/99	6.88	73.4
Sleeper Branch at Maple Island	MSLMAPLE	10/13/99	6.95	73.8
Sleeper Branch above Mullica River	MSLPLEAS	06/09/99	4.16	69.4
Sleeper Branch above Mullica River	MSLPLEAS	07/20/99	4.11	67.5
Sleeper Branch above Mullica River	MSLPLEAS	08/19/99	4.04	85.2
Sleeper Branch above Mullica River	MSLPLEAS	10/14/99	4.23	79.8
Sleeper Branch diversion (Saltars Ditch)	MSLSALTD	06/08/99	6.65	63.1
Sleeper Branch diversion (Saltars Ditch)	MSLSALTD	07/15/99	6.80	63.6
Sleeper Branch diversion (Saltars Ditch)	MSLSALTD	08/23/99	6.75	68.0
Sleeper Branch diversion (Saltars Ditch)	MSLSALTD	10/13/99	6.35	62.8
Wildcat Branch below Burnt Mill Road	MWIBURNT	06/08/99	6.57	59.3
Wildcat Branch below Burnt Mill Road	MWIBURNT	07/15/99	6.71	54.3
Wildcat Branch below Burnt Mill Road	MWIBURNT	08/20/99	6.80	55.5
Wildcat Branch below Burnt Mill Road	MWIBURNT	10/13/99	7.05	62.1

Appendix 1.5.1. Water-quality monitoring sites in the Upper Mullica River drainage basin. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name, Location, and Listening Point	Site Code
Northern Alquatka Branch tributary impoundment above Jackson-Medford Road Medford Twp., Burlington Co. (lat 39°48'19.52", long 74°51'15.28", Medford Lakes quad).	MALTRBOY
Atsion Lake Waterford Twp., Camden Co. (lat 39°44'25.97", long 74°43'35.66", Atsion quad).	MMUATSIO
Mullica River below Constable Bridge Mullica/Washington Twp., Atlantic/Burlington Co. (lat 39°39'33.19", long 74°39'30.84", Atsion quad).	MMUCONST
Mullica River above dike below Old Jackson-Atsion Road Waterford/Shamong Twp., Camden/Burlington Co. (lat 39°45'28.14", long 74°46'39.88", Medford Lakes quad).	MMUDIKES
Goshen Pond Waterford/Shamong Twp., Camden/Burlington Co. (lat 39°44'39.58", long 74°45'38.03", Hammonton quad).	MMUGOSHN
Mullica River below Jackson-Medford Road Waterford/Medford Twp., Camden/Burlington Co. (lat 39°47'09.39", long 74°51'36.53", Medford Lakes quad).	MMULADYS
Mullica River above Route 534 Waterford/Shamong Twp., Camden/Burlington Co. (lat 39°46'40.92", long 74°47'58.97", Medford Lakes quad).	MMULJACK
Mullica River above Central New Jersey/Conrail railroad bridge Shamong Twp., Burlington Co. (lat 39°44'19.35", long 74°43'18.75", Atsion quad).	MMURRBRG
Mullica River tributary above Quaker Bridge Road Shamong Twp., Burlington Co. (lat 39°43'54.88", long 74°41'50.80", Atsion quad).	MMUTRQUA
Mullica River at northern border of Wilderness Area Washington Twp., Burlington Co. (lat 39°42'03.28", long 74°40'48.11", Atsion quad).	MMUWILDR
Wesickaman Creek above Atsion Road Shamong Twp., Burlington Co. (lat 39°46'59.08", long 74°46'10.27", Medford Lakes quad).	MWEATSIO
Wesickaman Creek at Quaker Bridge Road Shamong Twp., Burlington Co. (lat 39°44'27.88", long 74°43'24.08", Atsion quad).	MWEQUAKR
Wesickaman Creek below Three Bridge Road Shamong Twp., Burlington Co. (lat 39°46'14.00", long 74°44'59.22", Indian Mills quad).	MWETHREE

Appendix 1.5.2. Specific conductance (SC, μS cm^{-1}) and pH values for the Upper Mullica River drainage basin. Refer to Chapter 4 (Water Quality) for methodology.

Site Name	Site Code	Date	pH	SC
Northern Alquatka Branch tributary impoundment above Jackson-Medford Road	MALTRBOY	06/08/99	3.94	69.8
Northern Alquatka Branch tributary impoundment above Jackson-Medford Road	MALTRBOY	10/13/99	3.79	101.5
Atsion Lake	MMUATSIO	06/09/99	4.85	39.0
Atsion Lake	MMUATSIO	07/19/99	5.33	32.0
Atsion Lake	MMUATSIO	08/26/99	5.99	28.1
Atsion Lake	MMUATSIO	10/13/99	4.91	64.9
Mullica River below Constable Bridge	MMUCONST	06/09/99	5.46	37.2
Mullica River below Constable Bridge	MMUCONST	07/20/99	5.98	33.9
Mullica River below Constable Bridge	MMUCONST	08/19/99	6.18	41.9
Mullica River below Constable Bridge	MMUCONST	10/14/99	5.53	60.8
Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	06/08/99	4.99	38.9
Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	07/15/99	5.36	34.1
Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	08/23/99	6.03	36.1
Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	10/14/99	4.12	85.0
Goshen Pond	MMUGOSHN	06/08/99	5.01	33.7
Goshen Pond	MMUGOSHN	07/19/99	5.33	30.5
Goshen Pond	MMUGOSHN	08/20/99	5.77	31.1
Goshen Pond	MMUGOSHN	10/14/99	4.26	72.5
Mullica River below Jackson-Medford Road	MMULADYS	06/08/99	6.56	121.4
Mullica River below Jackson-Medford Road	MMULADYS	07/15/99	6.76	108.0
Mullica River below Jackson-Medford Road	MMULADYS	08/23/99	6.19	137.2
Mullica River below Jackson-Medford Road	MMULADYS	10/13/99	6.88	105.6
Mullica River above Route 534	MMULJACK	06/08/99	4.33	54.4
Mullica River above Route 534	MMULJACK	07/15/99	4.96	31.0
Mullica River above Route 534	MMULJACK	08/23/99	5.55	30.6
Mullica River above Route 534	MMULJACK	10/13/99	3.99	110.4
Mullica River above Central New Jersey/Conrail railroad bridge	MMURRBRG	06/09/99	5.05	41.1
Mullica River above Central New Jersey/Conrail railroad bridge	MMURRBRG	07/19/99	5.48	31.2
Mullica River above Central New Jersey/Conrail railroad bridge	MMURRBRG	08/19/99	5.74	31.7
Mullica River above Central New Jersey/Conrail railroad bridge	MMURRBRG	10/13/99	5.01	65.0
Mullica River tributary above Quaker Bridge Road	MMUTRQUA	06/09/99	6.42	99.7
Mullica River tributary above Quaker Bridge Road	MMUTRQUA	07/19/99	6.51	95.9
Mullica River tributary above Quaker Bridge Road	MMUTRQUA	08/19/99	5.53	142.4
Mullica River tributary above Quaker Bridge Road	MMUTRQUA	10/13/99	5.95	131.2
Mullica River at northern border of Wilderness Area	MMUWILDR	06/09/99	5.24	38.4
Mullica River at northern border of Wilderness Area	MMUWILDR	07/20/99	5.57	30.7
Mullica River at northern border of Wilderness Area	MMUWILDR	08/19/99	5.44	40.1
Mullica River at northern border of Wilderness Area	MMUWILDR	10/13/99	4.98	67.5
Wesickaman Creek impoundment above Atsion Road	MWEATSIO	06/08/99	6.33	108.8
Wesickaman Creek impoundment above Atsion Road	MWEATSIO	07/15/99	6.49	99.2
Wesickaman Creek impoundment above Atsion Road	MWEATSIO	08/23/99	6.53	119.6
Wesickaman Creek impoundment above Atsion Road	MWEATSIO	10/13/99	6.88	113.5
Wesickaman Creek at Quaker Bridge Road	MWEQUAKR	06/24/99	4.40	85.3
Wesickaman Creek at Quaker Bridge Road	MWEQUAKR	07/19/99	5.46	52.2
Wesickaman Creek at Quaker Bridge Road	MWEQUAKR	08/26/99	4.18	124.0
Wesickaman Creek at Quaker Bridge Road	MWEQUAKR	10/14/99	4.19	112.9
Wesickaman Creek below Three Bridge Road	MWETHREE	06/11/99	6.60	98.7
Wesickaman Creek below Three Bridge Road	MWETHREE	07/19/99	6.47	113.2
Wesickaman Creek below Three Bridge Road	MWETHREE	08/23/99	6.16	214.0
Wesickaman Creek below Three Bridge Road	MWETHREE	10/14/99	6.58	122.6

Appendix 1.6.1. Water-quality monitoring sites in the Batsto River drainage basin. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name, Location, and Listening Point	Site Code
Batsto River above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°48'02.61", long 74°40'20.65", Indian Mills quad).	BBACARRZ
Batsto River at Lower Forge Washington Twp., Burlington Co. (lat 39°43'28.64", long 74°40'29.32", Atsion quad).	BBALFORG
Batsto River below Penn Swamp Branch Washington Twp., Burlington Co. (lat 39°40'27.81", long 74°39'14.95", Atsion quad). *Latitude and longitude values were obtained using ArcView Software.	BBAPENNS
Batsto River side channel below Quaker Bridge Road Washington Twp., Burlington Co. (lat 39°42'34.77", long 74°39'58.83", Atsion quad).	BBAQUAKR
Batsto River below Central New Jersey/Conrail railroad bridge Shamong Twp., Burlington Co. (lat 39°45'18.60", long 74°40'44.71", Indian Mills quad).	BBARRBRG
Batsto River below Route 532 Tabernacle Twp., Burlington Co. (lat 39°50'16.24", long 74°39'47.90", Indian Mills quad).	BBART532
Batsto River above Hampton Road Shamong Twp., Burlington Co. (lat 39°46'15.58", long 74°40'47.53", Indian Mills quad).	BBATHAMP
Batsto Lake Washington Twp., Burlington Co. (lat 39°39'12.21", long 74°39'14.65", Atsion quad).	BBATLAKE
Batsto River tributary above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°47'26.19", long 74°39'44.06", Indian Mills quad).	BBATRCAR
Batsto River tributary below Hay Road Shamong Twp., Burlington Co. (lat 39°44'19.52", long 74°40'34.11", Atsion quad).	BBATRMAN
Batsto River tributary near Moore's Meadow Road Tabernacle Twp., Burlington Co. (lat 39°47'50.09", long 74°40'08.07", Indian Mills quad).	BBATRMOO
Batsto River headwater impoundment below Route 532 Tabernacle Twp., Burlington Co. (lat 39°49'56.95", long 74°39'21.56", Indian Mills quad).	BBATS532
Deep Run below Hampton Road Shamong Twp., Burlington Co. (lat 39°45'36.62", long 74°41'27.05", Indian Mills quad).	BDEEPDKE
Horse Pond Stream below Butterworth's Bogs Road Tabernacle Twp., Burlington Co. (lat 3949'42.28", long 7440'47.54", Indian Mills quad).	BHOBUTTR
Indian Mills Brook impoundment above Old Schoolhouse Road Shamong Twp., Burlington Co. (lat 39°48'00.68", long 74°45'36.39", Medford Lakes quad).	BINSCHOO
Indian Mills Brook impoundment above Oakshade Road (Shadow Lake) Shamong Twp., Burlington Co. (lat 39°48'22.04", long 74°46'14.74", Medford Lakes quad).	BINSHADW
Indian Mills Lake at dam Shamong Twp., Burlington Co. (lat 39°47'44.04", long 74°44'24.29", Indian Mills quad).	BMULAKED
Muskingum Brook above Tuckerton Road Tabernacle Twp., Burlington Co. (lat 39°49'05.28", long 74°44'15.66", Indian Mills quad).	BMUSKTUC

Site Name, Location, and Listening Point	Site Code
Penn Swamp Branch above Batona Trail bridge Washington Twp., Burlington Co. (lat 39°41'03.08", long 74°39'01.26", Atsion quad).	BPEBRIDG
Skit Branch below Carranza Road Shamong Twp., Burlington Co. (lat 39°47'08.52", long 74°39'30.00", Indian Mills quad).	BSKITCAR
Skit Branch above Hampton Road Shamong Twp., Burlington Co. (lat 39°46'01.18", long 74°40'39.17", Indian Mills quad).	BSKITHAM
Skit Branch beaver pond above Batona Campground Tabernacle Twp., Burlington Co. (lat 39°46'55.72", long 74°37'38.15", Indian Mills quad).	BSKWIDEN
Springers Brook below Deep Run Shamong Twp., Burlington Co. (lat 39°44'26.67", long 74°41'03.01", Atsion quad).	BSPRDIKE
Springers Brook above Hampton Road Shamong Twp., Burlington Co. (lat 39°45'19.53", long 74°41'46.10", Indian Mills quad).	BSPRIHAM
Springers Brook at Route 206 Shamong Twp., Burlington Co. (lat 39°46'44.40", long 74°44 ' 20.40", Indian Mills quad). *Latitude and longitude values were obtained using ArcView Software.	BSPRT206
Roberts (Tom Roberts) Branch beaver pond above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°47'24.16", long 74°39'22.49", Indian Mills quad).	BTOIMPCA
Roberts (Tom Roberts) Branch above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°47'16.21", long 74°39'34.03", Indian Mills quad).	BTOMCARR

Appendix 1.6.2. Specific conductance (SC, μS cm^{-1}) and pH values for the Batsto River drainage basin. Refer to Chapter 4 (Water Quality) for methodology.

Site Name	Site Code	Date	pH	SC
Batsto River above Carranza Road	BBACARRZ	06/10/99	5.96	42.0
Batsto River above Carranza Road	BBACARRZ	07/15/99	6.04	40.7
Batsto River above Carranza Road	BBACARRZ	08/25/99	5.18	47.7
Batsto River above Carranza Road	BBACARRZ	10/14/99	4.68	54.8
Batsto River at Lower Forge	BBALFORG	06/11/99	5.87	30.6
Batsto River at Lower Forge	BBALFORG	07/19/99	5.96	32.7
Batsto River at Lower Forge	BBALFORG	08/26/99	4.66	56.7
Batsto River at Lower Forge	BBALFORG	10/13/99	5.45	46.0
Batsto River below Penn Swamp Branch	BBAPENNS	06/11/99	6.24	26.7
Batsto River below Penn Swamp Branch	BBAPENNS	07/20/99	4.80	34.6
Batsto River below Penn Swamp Branch	BBAPENNS	08/26/99	4.65	41.9
Batsto River below Penn Swamp Branch	BBAPENNS	10/14/99	4.83	43.4
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	06/11/99	5.76	28.8
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	07/20/99	5.83	24.7
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	08/26/99	4.50	51.3
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	10/13/99	5.69	43.7
Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	06/11/99	5.59	29.6
Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	07/19/99	5.77	26.9
Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	08/26/99	4.25	49.2
Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	10/14/99	4.63	40.5
Batsto River below Route 532	BBART532	06/11/99	5.27	30.2
Batsto River below Route 532	BBART532	07/20/99	5.14	30.4
Batsto River below Route 532	BBART532	08/26/99	4.17	74.4
Batsto River below Route 532	BBART532	10/14/99	4.05	85.4
Batsto River above Hampton Road	BBATHAMP	06/11/99	5.96	37.6
Batsto River above Hampton Road	BBATHAMP	07/19/99	6.25	36.3
Batsto River above Hampton Road	BBATHAMP	08/25/99	4.91	46.1
Batsto River above Hampton Road	BBATHAMP	10/14/99	4.73	47.9
Batsto Lake	BBATLAKE	06/09/99	6.46	28.6
Batsto Lake	BBATLAKE	07/20/99	5.61	22.4
Batsto Lake	BBATLAKE	08/19/99	4.32	56.7
Batsto Lake	BBATLAKE	10/14/99	5.01	41.3
Batsto River tributary above Carranza Road	BBATRCAR	06/10/99	5.01	50.2
Batsto River tributary above Carranza Road	BBATRCAR	07/15/99	4.36	60.7
Batsto River tributary above Carranza Road	BBATRCAR	08/26/99	4.01	82.3
Batsto River tributary above Carranza Road	BBATRCAR	10/14/99	4.69	41.8
Batsto River tributary below Hay Road	BBATRMAN	06/11/99	4.77	23.7
Batsto River tributary near Moore’s Meadow Road	BBATRMOO	06/10/99	4.20	49.2
Batsto River tributary near Moore’s Meadow Road	BBATRMOO	07/15/99	4.47	40.8
Batsto River tributary near Moore’s Meadow Road	BBATRMOO	08/26/99	3.71	115.6
Batsto River tributary near Moore’s Meadow Road	BBATRMOO	10/14/99	4.15	61.8
Batsto River headwater impoundment below Route 532	BBATS532	06/11/99	4.11	97.5
Batsto River headwater impoundment below Route 532	BBATS532	07/20/99	4.14	106.2
Batsto River headwater impoundment below Route 532	BBATS532	08/26/99	3.96	188.1
Batsto River headwater impoundment below Route 532	BBATS532	10/14/99	3.98	100.0
Deep Run below Hampton Road	BDEEPDKE	06/11/99	6.04	92.8
Deep Run below Hampton Road	BDEEPDKE	07/19/99	4.25	49.6
Deep Run below Hampton Road	BDEEPDKE	08/26/99	3.70	97.2
Deep Run below Hampton Road	BDEEPDKE	10/14/99	4.13	51.4
Horse Pond Stream below Butterworth’s Bogs Road	BHOBUTTR	06/11/99	6.54	98.9
Horse Pond Stream below Butterworth’s Bogs Road	BHOBUTTR	07/20/99	6.44	100.0
Horse Pond Stream below Butterworth’s Bogs Road	BHOBUTTR	08/26/99	5.34	505.0
Horse Pond Stream below Butterworth’s Bogs Road	BHOBUTTR	10/14/99	6.32	172.3

Site Name	Site Code	Date	pH	SC
Indian Mills Brook impoundment above Old Schoolhouse Road	BINSCHOO	06/08/99	6.08	87.0
Indian Mills Brook impoundment above Old Schoolhouse Road	BINSCHOO	07/19/99	6.49	85.8
Indian Mills Brook impoundment above Old Schoolhouse Road	BINSCHOO	08/23/99	6.64	95.8
Indian Mills Brook impoundment above Old Schoolhouse Road	BINSCHOO	10/13/99	6.86	104.5
Indian Mills Brook impoundment above Oakshade Road (Shadow Lake)	BINSHADW	06/08/99	6.54	67.6
Indian Mills Brook impoundment above Oakshade Road (Shadow Lake)	BINSHADW	07/19/99	6.60	63.6
Indian Mills Brook impoundment above Oakshade Road (Shadow Lake)	BINSHADW	08/23/99	6.85	59.5
Indian Mills Brook impoundment above Oakshade Road (Shadow Lake)	BINSHADW	10/13/99	6.77	67.3
Indian Mills Lake at dam	BMULAKED	06/11/99	8.96	194.3
Indian Mills Lake at dam	BMULAKED	07/19/99	8.86	183.4
Indian Mills Lake at dam	BMULAKED	08/23/99	7.11	207.0
Indian Mills Lake at dam	BMULAKED	10/14/99	6.60	211.0
Muskingum Brook above Tuckerton Road	BMUSKTUC	06/11/99	6.73	112.7
Muskingum Brook above Tuckerton Road	BMUSKTUC	07/19/99	6.49	102.7
Muskingum Brook above Tuckerton Road	BMUSKTUC	08/23/99	6.51	133.8
Muskingum Brook above Tuckerton Road	BMUSKTUC	10/14/99	6.46	142.6
Penn Swamp Branch above Batona Trail bridge	BPEBRIDG	06/11/99	4.48	32.0
Penn Swamp Branch above Batona Trail bridge	BPEBRIDG	07/20/99	4.61	31.7
Penn Swamp Branch above Batona Trail bridge	BPEBRIDG	08/26/99	3.97	66.4
Penn Swamp Branch above Batona Trail bridge	BPEBRIDG	10/14/99	4.32	40.2
Skit Branch below Carranza Road	BSKITCAR	06/10/99	4.82	22.1
Skit Branch below Carranza Road	BSKITCAR	07/19/99	4.95	20.4
Skit Branch below Carranza Road	BSKITCAR	08/25/99	4.50	34.3
Skit Branch below Carranza Road	BSKITCAR	10/14/99	4.54	29.0
Skit Branch above Hampton Road	BSKITHAM	06/11/99	4.79	24.6
Skit Branch above Hampton Road	BSKITHAM	07/19/99	4.79	22.4
Skit Branch above Hampton Road	BSKITHAM	08/25/99	4.33	49.8
Skit Branch above Hampton Road	BSKITHAM	10/14/99	4.51	35.0
Skit Branch beaver pond above Batona Campground	BSKWIDEN	06/10/99	4.78	23.9
Skit Branch beaver pond above Batona Campground	BSKWIDEN	07/19/99	4.50	26.2
Skit Branch beaver pond above Batona Campground	BSKWIDEN	08/26/99	4.37	30.6
Skit Branch beaver pond above Batona Campground	BSKWIDEN	10/14/99	4.37	32.8
Springers Brook below Deep Run	BSPRDIKE	06/11/99	6.47	69.1
Springers Brook below Deep Run	BSPRDIKE	07/19/99	6.26	42.4
Springers Brook below Deep Run	BSPRDIKE	08/26/99	5.31	91.4
Springers Brook below Deep Run	BSPRDIKE	10/13/99	5.32	84.6
Springers Brook above Hampton Road	BSPRIHAM	06/14/99	6.45	73.1
Springers Brook above Hampton Road	BSPRIHAM	07/19/99	6.46	55.1
Springers Brook above Hampton Road	BSPRIHAM	08/25/99	5.48	120.2
Springers Brook above Hampton Road	BSPRIHAM	10/14/99	6.27	103.9
Springers Brook at Route 206	BSPRT206	06/24/99	6.64	157.6
Springers Brook at Route 206	BSPRT206	07/19/99	6.75	150.1
Springers Brook at Route 206	BSPRT206	08/26/99	6.75	223.0
Springers Brook at Route 206	BSPRT206	10/14/99	6.40	181.7
Roberts (Tom Roberts) Branch beaver pond above Carranza Road	BTOIMPCA	06/11/99	4.33	42.0
Roberts (Tom Roberts) Branch beaver pond above Carranza Road	BTOIMPCA	07/19/99	4.51	46.7
Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	06/10/99	5.82	40.5
Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	07/19/99	5.25	23.4
Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	08/25/99	4.16	69.9
Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	10/14/99	4.30	46.3

APPENDIX 2. STREAM-VEGETATION DATA

Appendix 2.0. Mullica River Basin stream-vegetation monitoring sites and individuals who sampled on each date. Sites are arranged alphabetically by site code. Individuals who sampled are: KJL = Kim J. Laidig, RAZ = Robert A. Zampella, TMS = Tanya M. Sulikowski.

Site Name	Site Code	Sampler	Date
East Branch Bass River above Stage Road	AEASTAGE	KJL/TMS	05/27/98
East Branch Bass River above Stage Road	AEASTAGE	KJL/TMS	07/30/98
East Branch Bass River above Stage Road	AEASTAGE	KJL/TMS	09/29/98
West Branch Bass River above Stage Road	AWESTAGE	KJL/RAZ/TMS	05/13/99
West Branch Bass River above Stage Road	AWESTAGE	KJL/TMS	07/01/99
West Branch Bass River above Stage Road	AWESTAGE	KJL/TMS	09/13/99
Batsto River above Carranza Road	BBACARRZ	KJL	05/20/97
Batsto River above Carranza Road	BBACARRZ	KJL/RAZ	07/16/97
Batsto River above Carranza Road	BBACARRZ	KJL/TMS	09/08/97
Batsto River at Lower Forge	BBALFORG	KJL	05/20/97
Batsto River at Lower Forge	BBALFORG	KJL/RAZ	07/17/97
Batsto River at Lower Forge	BBALFORG	KJL/TMS	09/08/97
Batsto River below Penn Swamp Branch	BBAPENNS	KJL	05/20/97
Batsto River below Penn Swamp Branch	BBAPENNS	KJL/RAZ	07/23/97
Batsto River below Penn Swamp Branch	BBAPENNS	KJL/TMS	09/18/97
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	KJL/TMS	05/26/98
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	KJL/TMS	07/30/98
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	KJL/TMS	09/25/98
Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	KJL	05/30/97
Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	KJL/RAZ	07/17/97
Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	KJL/TMS	09/08/97
Batsto River below Route 532	BBART532	KJL/RAZ/TMS	05/13/99
Batsto River below Route 532	BBART532	KJL/TMS	07/02/99
Batsto River below Route 532	BBART532	KJL/TMS	09/13/99
Batsto River above Hampton Road	BBATHAMP	KJL/TMS	05/22/98
Batsto River above Hampton Road	BBATHAMP	KJL/TMS	07/28/98
Batsto River above Hampton Road	BBATHAMP	KJL/TMS	09/25/98
Batsto River tributary above Carranza Road	BBATRCAR	KJL	05/12/97
Batsto River tributary above Carranza Road	BBATRCAR	KJL/RAZ	07/16/97
Batsto River tributary above Carranza Road	BBATRCAR	KJL/TMS	09/05/97
Batsto River tributary below Hay Road	BBATRMAN	KJL	07/02/97
Batsto River tributary below Hay Road	BBATRMAN	KJL/TMS	08/20/97
Batsto River tributary near Moore’s Meadow Road	BBATRMOO	KJL	05/12/97
Batsto River tributary near Moore’s Meadow Road	BBATRMOO	KJL/RAZ	07/16/97
Batsto River tributary near Moore’s Meadow Road	BBATRMOO	KJL/TMS	09/05/97
Deep Run below Hampton Road	BDEEPDKE	KJL	05/12/97
Deep Run below Hampton Road	BDEEPDKE	KJL/RAZ	07/17/97
Deep Run below Hampton Road	BDEEPDKE	KJL/TMS	09/05/97
Horse Pond Stream below Butterworth’s Bogs Road	BHOBUTTR	KJL	07/02/97
Horse Pond Stream below Butterworth’s Bogs Road	BHOBUTTR	KJL/RAZ	07/23/97
Horse Pond Stream below Butterworth’s Bogs Road	BHOBUTTR	KJL/TMS	09/08/97
Indian Mills Brook above Oakshade Road (above Shadow Lake)	BINSHADS	KJL	05/30/97
Indian Mills Brook above Oakshade Road (above Shadow Lake)	BINSHADS	KJL/RAZ	07/23/97

Site Name	Site Code	Sampler	Date
Indian Mills Brook above Oakshade Road (above Shadow Lake)	BINSHADS	KJL/TMS	09/18/97
Muskingum Brook above Tuckerton Road	BMUSKTUC	KJL/TMS	05/15/98
Muskingum Brook above Tuckerton Road	BMUSKTUC	KJL/TMS	07/28/98
Muskingum Brook above Tuckerton Road	BMUSKTUC	KJL/TMS	09/24/98
Penn Swamp Branch above Batona Trail bridge	BPEBRIDG	KJL	05/07/97
Penn Swamp Branch above Batona Trail bridge	BPEBRIDG	KJL/RAZ	07/23/97
Penn Swamp Branch above Batona Trail bridge	BPEBRIDG	KJL/TMS	09/18/97
Skit Branch below Carranza Road	BSKITCAR	KJL	05/07/97
Skit Branch below Carranza Road	BSKITCAR	KJL/RAZ	07/16/97
Skit Branch below Carranza Road	BSKITCAR	KJL/TMS	09/05/97
Skit Branch above Hampton Road	BSKITHAM	KJL/TMS	05/22/98
Skit Branch above Hampton Road	BSKITHAM	KJL/TMS	07/28/98
Skit Branch above Hampton Road	BSKITHAM	KJL/TMS	09/25/98
Springers Brook below Deep Run	BSPRDIKE	KJL	05/12/97
Springers Brook below Deep Run	BSPRDIKE	KJL/RAZ	07/17/97
Springers Brook below Deep Run	BSPRDIKE	KJL/TMS	09/18/97
Springers Brook above Hampton Road	BSPRIHAM	KJL/TMS	05/22/98
Springers Brook above Hampton Road	BSPRIHAM	KJL/TMS	07/28/98
Springers Brook above Hampton Road	BSPRIHAM	KJL/TMS	09/25/98
Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	KJL	05/07/97
Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	KJL/RAZ	07/16/97
Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	KJL/TMS	09/05/97
Clarks Mill Stream at Leibig Street and Odessa Avenue	LCLODESS	KJL/RAZ/TMS	05/20/99
Clarks Mill Stream at Leibig Street and Odessa Avenue	LCLODESS	KJL/TMS	06/28/99
Clarks Mill Stream at Leibig Street and Odessa Avenue	LCLODESS	KJL/RAZ	09/29/99
Elliots Creek at Bremen Avenue	LELIOBRE	KJL/RAZ/TMS	05/20/99
Elliots Creek at Bremen Avenue	LELIOBRE	KJL/TMS	06/28/99
Elliots Creek at Bremen Avenue	LELIOBRE	KJL/TMS	07/02/99
Hammonton Creek above Chestnut Avenue	LHACHEST	KJL	06/06/97
Hammonton Creek above Chestnut Avenue	LHACHEST	KJL/RAZ	07/23/97
Hammonton Creek above Chestnut Avenue	LHACHEST	KJL	08/28/97
Indian Cabin Creek above Landing Creek	LINCABIN	KJL/RAZ/TMS	05/20/99
Indian Cabin Creek above Landing Creek	LINCABIN	KJL/TMS	06/28/99
Indian Cabin Creek above Landing Creek	LINCABIN	KJL/TMS	09/02/99
Landing Creek above Indian Cabin Road	LLANDIND	KJL/RAZ/TMS	05/20/99
Landing Creek above Indian Cabin Road	LLANDIND	KJL/TMS	06/28/99
Landing Creek above Indian Cabin Road	LLANDIND	KJL/TMS	09/02/99
Landing Creek below Alternate Route 561	LLANDMOS	KJL/TMS	05/12/99
Landing Creek below Alternate Route 561	LLANDMOS	KJL	07/07/99
Landing Creek below Alternate Route 561	LLANDMOS	KJL/RAZ	09/29/99
Morses Mill Stream below College Drive	LMORSESM	KJL/TMS	05/12/99
Morses Mill Stream below College Drive	LMORSESM	KJL/TMS	06/28/99
Morses Mill Stream below College Drive	LMORSESM	KJL/TMS	09/02/99
Union Creek above Alternate Route 561	LUNIOMOS	KJL/TMS	05/12/99
Union Creek above Alternate Route 561	LUNIOMOS	KJL	07/07/99
Union Creek above Alternate Route 561	LUNIOMOS	KJL/RAZ	09/29/99

Site Name	Site Code	Sampler	Date
Clark Branch above Burnt Mill Road	MCLBURNT	KJL	06/04/96
Clark Branch above Burnt Mill Road	MCLBURNT	KJL/RAZ	08/02/96
Clark Branch above Burnt Mill Road	MCLBURNT	KJL	09/26/96
Clark Branch at Parkdale	MCLJOHNS	KJL/TMS	05/15/98
Clark Branch at Parkdale	MCLJOHNS	KJL/TMS	07/29/98
Clark Branch at Parkdale	MCLJOHNS	KJL/TMS	09/24/98
Cooper Branch above Burnt Mill Road	MCOBURNT	KJL/RAZ	05/17/96
Cooper Branch above Burnt Mill Road	MCOBURNT	KJL/RAZ	08/02/96
Cooper Branch above Burnt Mill Road	MCOBURNT	KJL	09/26/96
Hays Mill Creek above Tremont Avenue	MHATREMO	KJL	05/20/96
Hays Mill Creek above Tremont Avenue	MHATREMO	KJL/RAZ	08/02/96
Hays Mill Creek above Tremont Avenue	MHATREMO	KJL	09/25/96
Mullica River below Constable Bridge	MMUCONST	KJL/TMS	06/05/98
Mullica River below Constable Bridge	MMUCONST	KJL/TMS	07/30/98
Mullica River below Constable Bridge	MMUCONST	KJL/TMS	09/29/98
Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	KJL/TMS	05/22/98
Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	KJL/TMS	07/23/98
Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	KJL/TMS	09/24/98
Mullica River below Jackson-Medford Road	MMULADYS	KJL/RAZ	05/17/96
Mullica River below Jackson-Medford Road	MMULADYS	KJL	08/14/96
Mullica River below Jackson-Medford Road	MMULADYS	KJL	09/25/96
Mullica River above Route 534	MMULJACK	KJL/TMS	05/22/98
Mullica River above Route 534	MMULJACK	KJL/TMS	07/29/98
Mullica River above Route 534	MMULJACK	KJL/TMS	09/24/98
Mullica River above Central New Jersey/Conrail railroad bridge	MMURRBRG	KJL/RAZ/TMS	05/20/99
Mullica River above Central New Jersey/Conrail railroad bridge	MMURRBRG	KJL/TMS	07/01/99
Mullica River above Central New Jersey/Conrail railroad bridge	MMURRBRG	KJL/TMS	09/09/99
Mullica River tributary above Quaker Bridge Road	MMUTRQUA	KJL	06/05/96
Mullica River tributary above Quaker Bridge Road	MMUTRQUA	KJL	08/12/96
Mullica River tributary above Quaker Bridge Road	MMUTRQUA	KJL	09/25/96
Mullica River at northern border of Wilderness Area	MMUWILDR	KJL/TMS	05/26/98
Mullica River at northern border of Wilderness Area	MMUWILDR	KJL/RAZ/TMS	07/21/98
Mullica River at northern border of Wilderness Area	MMUWILDR	KJL/RAZ/TMS	09/22/98
Price Branch below Burnt Mill Road	MPRBURNT	KJL	06/04/96
Price Branch below Burnt Mill Road	MPRBURNT	KJL/RAZ	08/02/96
Price Branch below Burnt Mill Road	MPRBURNT	KJL	09/26/96
Sleeper Branch at Parkdale	MSLEPARK	KJL/TMS	05/15/98
Sleeper Branch at Parkdale	MSLEPARK	KJL/TMS	07/29/98
Sleeper Branch at Parkdale	MSLEPARK	KJL/TMS	09/24/98
Sleeper Branch at Maple Island	MSLMAPLE	KJL	05/20/96
Sleeper Branch at Maple Island	MSLMAPLE	KJL	08/29/96
Sleeper Branch at Maple Island	MSLMAPLE	KJL	09/26/96
Sleeper Branch above Mullica River	MSLPLEAS	KJL/TMS	06/04/98
Sleeper Branch above Mullica River	MSLPLEAS	KJL/TMS	07/23/98
Sleeper Branch above Mullica River	MSLPLEAS	KJL/TMS	09/29/98
Sleeper Branch diversion (Saltars Ditch)	MSLSALTD	KJL	05/29/96

Site Name	Site Code	Sampler	Date
Sleeper Branch diversion (Saltars Ditch)	MSLSALTD	KJL	08/12/96
Sleeper Branch diversion (Saltars Ditch)	MSLSALTD	KJL	09/26/96
Wesickaman Creek below Three Bridge Road	MWETHREE	KJL/RAZ	05/17/96
Wesickaman Creek below Three Bridge Road	MWETHREE	KJL	08/28/96
Wesickaman Creek below Three Bridge Road	MWETHREE	KJL	09/25/96
Wildcat Branch below Burnt Mill Road	MWIBURNT	KJL	05/29/96
Wildcat Branch below Burnt Mill Road	MWIBURNT	KJL/RAZ	08/02/96
Wildcat Branch below Burnt Mill Road	MWIBURNT	KJL	09/26/96
Albertson Brook above Fleming Pike	NALBFLEM	KJL	05/24/96
Albertson Brook above Fleming Pike	NALBFLEM	KJL	08/29/96
Albertson Brook above derelict bridge below Route 206	NALDEREL	KJL/TMS	06/04/98
Albertson Brook above derelict bridge below Route 206	NALDEREL	KJL/TMS	07/23/98
Albertson Brook above derelict bridge below Route 206	NALDEREL	KJL/TMS	09/25/98
Blue Anchor Brook above Pump Branch	NBLCONFL	KJL	05/24/96
Blue Anchor Brook above Pump Branch	NBLCONFL	KJL	08/29/96
Cedar Brook near Hammonton Airport	NCEAIRPO	KJL	06/05/96
Cedar Brook near Hammonton Airport	NCEAIRPO	KJL	08/14/96
Cedar Brook near Hammonton Airport	NCEAIRPO	KJL	09/26/96
Great Swamp Branch below Route 613	NGRMIDDL	KJL/TMS	05/26/98
Great Swamp Branch below Route 613	NGRMIDDL	KJL/TMS	07/30/98
Great Swamp Branch below Route 613	NGRMIDDL	KJL/TMS	09/25/98
Nescochague Creek at Pleasant Mills	NNEMILLS	KJL/TMS	05/26/98
Nescochague Creek at Pleasant Mills	NNEMILLS	KJL/TMS	07/23/98
Nescochague Creek at Pleasant Mills	NNEMILLS	KJL/TMS	09/29/98
Nescochague Creek near West Mill Road	NNEWESTM	KJL/RAZ/TMS	05/21/99
Nescochague Creek near West Mill Road	NNEWESTM	KJL	07/07/99
Nescochague Creek near West Mill Road	NNEWESTM	KJL/RAZ	09/29/99
Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	KJL	05/29/96
Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	KJL	09/03/96
Buck Run below Old Martha Road	OBUCKRUN	KJL/RAZ/TMS	05/13/99
Buck Run below Old Martha Road	OBUCKRUN	KJL/TMS	07/01/99
Buck Run below Old Martha Road	OBUCKRUN	KJL/TMS	09/13/99
Oswego River below Beaver Dam Road	OOSBEAVR	KJL/RAZ/TMS	05/27/99
Oswego River below Beaver Dam Road	OOSBEAVR	KJL/TMS	07/01/99
Oswego River below Beaver Dam Road	OOSBEAVR	KJL/TMS	09/09/99
Oswego River below Route 679	OOSHARST	KJL/TMS	05/27/98
Oswego River below Route 679	OOSHARST	KJL/TMS	07/30/98
Oswego River below Route 679	OOSHARST	KJL/TMS	09/29/98
Oswego River above Oswego Lake	OOSLAKUP	KJL/RAZ/TMS	05/27/99
Oswego River above Oswego Lake	OOSLAKUP	KJL/TMS	07/01/99
Oswego River above Oswego Lake	OOSLAKUP	KJL/TMS	09/09/99
Oswego River above Martha	OOSOLMAR	KJL/RAZ/TMS	05/13/99
Oswego River above Martha	OOSOLMAR	KJL/TMS	07/01/99
Oswego River above Martha	OOSOLMAR	KJL/TMS	09/13/99
Papoose Branch below Jenkins Road	OPAPOOSE	KJL/RAZ/TMS	05/27/99
Papoose Branch below Jenkins Road	OPAPOOSE	KJL/TMS	07/01/99

Site Name	Site Code	Sampler	Date
Papoose Branch below Jenkins Road	OPAPOOSE	KJL/TMS	09/09/99
Featherbed Branch below Carranza Road	WFEACARR	KJL/TMS	05/06/98
Featherbed Branch below Carranza Road	WFEACARR	KJL/RAZ/TMS	07/21/98
Featherbed Branch below Carranza Road	WFEACARR	KJL/RAZ/TMS	09/22/98
Hospitality Brook below Route 563	WHOSPITA	KJL/RAZ/TMS	05/21/99
Hospitality Brook below Route 563	WHOSPITA	KJL	07/07/99
Hospitality Brook below Route 563	WHOSPITA	KJL/TMS	09/13/99
Little Hauken Run below Route 563	WLIHAUKN	KJL/RAZ/TMS	05/21/99
Little Hauken Run below Route 563	WLIHAUKN	KJL/TMS	07/01/99
Little Hauken Run below Route 563	WLIHAUKN	KJL/TMS	09/09/99
Shane Branch above fourth dike above Carranza Road	WSA4DIKE	KJL/TMS	05/06/98
Shane Branch above fourth dike above Carranza Road	WSA4DIKE	KJL/RAZ/TMS	07/17/98
Shane Branch above fourth dike above Carranza Road	WSA4DIKE	KJL/RAZ/TMS	09/16/98
Shane Branch above Carranza Road	WSACARRA	KJL/TMS	05/06/98
Shane Branch above Carranza Road	WSACARRA	KJL/RAZ/TMS	07/21/98
Shane Branch above Carranza Road	WSACARRA	KJL/RAZ/TMS	09/16/98
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	KJL/TMS	05/27/98
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	KJL/RAZ/TMS	07/21/98
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	KJL/RAZ/TMS	09/22/98
Wading River above Route 563	WWEEVANB	KJL	07/16/98
Wading River above Route 563	WWEEVANB	KJL/RAZ/TMS	09/22/98
Wading River below Ford Road	WWEFORDR	KJL/TMS	05/07/98
Wading River below Ford Road	WWEFORDR	KJL/RAZ/TMS	07/17/98
Wading River below Ford Road	WWEFORDR	KJL/RAZ/TMS	09/16/98
Wading River below Mile Run	WWEMILER	KJL/TMS	06/05/98
Wading River below Mile Run	WWEMILER	KJL/RAZ/TMS	07/17/98
Wading River below Mile Run	WWEMILER	KJL/RAZ/TMS	09/16/98
Wading River above Tulpehocken Creek	WWETULPC	KJL/TMS	05/07/98
Wading River above Tulpehocken Creek	WWETULPC	KJL/RAZ/TMS	07/17/98
Wading River above Tulpehocken Creek	WWETULPC	KJL/RAZ/TMS	09/16/98

Appendix 2.1.1. Stream-vegetation monitoring sites in the Wading River drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Refer to methods for sampling details. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered by site code.

Site Name and Description	Site Code
Featherbed Branch below Carranza Road Tabernacle Twp., Burlington Co. (lat 39°45'36.67", long 74°35'32.30", Chatsworth quad). Section 4 ends 3 m downstream from Carranza Road.	WFEACARR
Hospitality Brook below Route 563 Washington Twp., Burlington Co. (lat 39°42'56.29", long 74°32'33.07", Jenkins quad). Section 1 begins 43 m upstream from breached dike, approximately 1.7 km upstream from Wading River.	WHOSPITA
Little Hauken Run below Route 563 Washington Twp., Burlington Co. (lat 39°42'57.62", long 74°32'06.49", Jenkins quad). Section 4 ends 55 m downstream from Green Bank-Chatsworth Road (Route 563).	WLIHAUKN
Shane Branch above fourth dike above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°45'49.02", long 74°35'01.71", Chatsworth quad). Section 1 begins 10 m upstream from fourth dike above Carranza Road.	WSA4DIKE
Shane Branch above Carranza Road Washington Twp., Burlington Co. (lat 39°45'04.87", long 74°35'06.49", Chatsworth quad). Section 1 begins 15 m upstream from Carranza Road.	WSACARRA
Tulpehocken Creek above Maxwell-Friendship Road Washington Twp., Burlington Co. (lat 39°42'51.73", long 74°33'57.15", Jenkins quad). Section 1 begins 35 m upstream from Big Hawkin Bridge at Maxwell-Friendship Road.	WTUHAWKN
Wading River above Route 563 Washington Twp., Burlington Co. (lat 39°40'30.53", long 74°32'27.17", Jenkins quad). Section 1 begins 60 m upstream from Evans Bridge at Green Bank-Chatsworth Road (Route 563).	WWEEVANB
Wading River below Ford Road Washington Twp., Burlington Co. (lat 39°42'16.44", long 74°33'18.43", Jenkins quad). Section 4 ends just downstream from Ford Road.	WWEFORDR
Wading River below Mile Run Washington Twp., Burlington Co. (lat 39°44'22.17", long 74°32'54.72", Jenkins quad). Section 1 begins near unnamed sand road, approximately 1.2 km downstream from confluence with Mile Run.	WWEMILER
Wading River above Tulpehocken Creek Washington Twp., Burlington Co. (lat 39°43'01.10", long 74°33'43.87", Jenkins quad). Section 1 begins near unnamed sand road, approximately 0.8 km upstream from confluence with Tulpehocken Creek.	WWETULPC

Appendix 2.1.2 Plant species at stream-monitoring sites in the Wading River drainage basin. Circles indicate a species is present at a site. Filled circles indicate the 25-m section where it was found (e.g., "●○●○" means a species was located in the first and third sections of the 100-m study site). Refer to Appendix 2.1.1 for site descriptions and explanations of site codes. Plant common names are presented in Appendix 2.8.

Species	Sites and Survey Years									
	WFEACARR	WHOSPITA	WLIHAUKN	WSA4DIKE	WSACARRA	WTUHAWKN	WWEEVANB	WWEFORDR	WWEMILER	WWETULPC
	98	99	99	98	98	98	98	98	98	98
Herbaceous plants:										
Agrostis hyemalis	-	-	-	-	-	-	-	-	-	-
Agrostis hyemalis var. scabra	-	-	-	-	-	-	-	○○○●	-	-
Agrostis perennans	-	-	-	-	-	-	-	-	-	○○○●
Agrostis perennans var. elata	-	-	-	-	-	-	-	-	-	-
Agrostis sp.	-	-	-	-	-	-	-	-	-	-
Alisma subcordatum	-	-	-	-	-	-	-	-	-	-
Allium sp.	-	-	-	-	-	-	-	-	-	-
Amphicarpum purshii	-	-	-	○○○●	-	-	-	-	-	-
Andropogon virginicus var. abbreviatus	-	-	-	●●●●	-	●●●●	-	○○●○	-	-
Andropogon virginicus var. virginicus	-	-	-	-	-	-	-	-	-	-
Apios americana	-	-	-	-	-	-	-	-	-	-
Aralia nudicaulis	-	-	-	-	-	-	-	-	-	-
Arethusa bulbosa	-	-	-	-	-	-	-	-	-	-
Asclepias incarnata	-	-	-	-	-	-	-	-	-	-
Aster dumosus	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	-	-	-	-	-	●●○○	-	-	-	-
Aster novi-belgii	-	●●●●	-	-	-	-	-	-	-	○○●○
Aster pilosus var. pringlei	-	-	-	-	-	-	-	-	-	-
Aster racemosus	-	-	-	-	-	-	-	-	-	-
Bartonia paniculata	○●●○	-	-	-	-	●●○●	-	-	○○●●	●●●●
Bartonia virginica	-	-	-	○○○●	-	●●●●	-	-	-	-
Bidens connata	-	-	-	-	-	-	-	-	-	-
Bidens coronata	-	-	-	-	-	-	-	-	-	-
Bidens discoidea	-	-	-	-	-	-	-	-	-	-
Bidens frondosa	-	-	-	-	-	-	-	-	-	-
Bidens sp.	-	-	-	-	-	-	-	-	-	-
Boehmeria cylindrica	-	-	-	-	-	-	-	-	-	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	-	-	-	-	-	-	-	-	-	-
Callitriche heterophylla	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	WFEACARR	WHOSPITA	WLIHAUKN	WSA4DIKE	WSACARRA	WTUHAWKN	WWEEVANB	WWEFORDR	WWEMILER	WWETULPC
	98	99	99	98	98	98	98	98	98	98
Cardamine pensylvanica	-	-	-	-	-	-	-	-	-	-
Carex albolutescens	-	-	●○○●	-	-	-	-	-	-	-
Carex atlantica	●●●●	-	-	-	-	-	-	-	-	-
Carex atlantica var. capillacea	-	-	-	-	-	-	-	-	-	-
Carex bullata	-	-	●●○●	-	-	-	○○●●	●○●○	-	-
Carex canescens	-	●●●○	-	-	-	-	-	-	-	-
Carex collinsii	-	-	-	-	-	-	-	-	-	-
Carex crinita	-	-	-	-	-	-	-	-	-	-
Carex exilis	-	-	-	○○●○	-	●●●●	-	-	-	-
Carex folliculata	-	-	-	-	-	-	-	-	●●○●	●○●○
Carex intumescens	-	-	-	-	-	-	-	-	-	-
Carex livida	-	-	-	-	-	-	-	-	-	-
Carex longii	-	-	-	-	-	-	-	-	-	-
Carex lurida	-	-	-	-	-	-	-	-	-	-
Carex pensylvanica	-	-	-	-	-	-	-	-	-	-
Carex scoparia	-	-	-	-	-	-	-	-	-	-
Carex stipata	-	-	-	-	-	-	-	-	-	-
Carex striata	●●●●	●○●○	-	●●●●	●●●●	-	-	-	-	-
Carex stricta	-	-	-	-	-	-	-	●○○●	●●●●	●●●●
Carex tribuloides	-	-	-	-	-	-	-	-	-	-
Carex trisperma	-	-	-	-	-	-	-	-	-	-
Carex venusta	-	-	-	-	-	-	-	-	-	-
Ceratophyllum echinatum	-	-	-	-	-	-	-	-	-	-
Chasmanthium laxum	-	-	-	-	-	-	-	-	-	-
Cinna arundinacea	-	-	-	-	-	-	-	-	-	-
Cladium mariscoides	-	-	-	-	●●●●	-	-	○○●○	-	-
Cuscuta sp.	-	●○○●	○○○●	-	-	-	●●○○	-	-	-
Cyperus dentatus	-	-	-	-	-	●●●●	○●●○	●●●●	-	-
Cyperus erythrorhizos	-	-	-	-	-	-	-	-	-	-
Cyperus odoratus	-	-	-	-	-	-	-	-	-	-
Cyperus retrorsus	-	-	-	-	-	-	-	-	-	-
Cyperus strigosus	-	-	-	-	-	-	-	-	-	-
Danthonia sericea var. epilis	-	-	-	-	-	-	-	-	-	-
Decodon verticillatus	-	●●●●	●●○○	-	-	-	-	-	-	-
Dioscorea villosa	-	-	-	-	-	-	-	-	-	-
Drosera filiformis	-	-	-	-	-	●●●●	-	-	-	-

Species	Sites and Survey Years									
	WFEACARR 98	WHOSPITA 99	WLIHAUKN 99	WSA4DIKE 98	WSACARRA 98	WTUHAWKN 98	WWEEVANB 98	WWEFORDR 98	WWEMILER 98	WWETULPC 98
Drosera intermedia	●●●○	–	●●○●	●●●●	●●●●	●●●●	●○○○	●●●●	–	○○●○
Drosera rotundifolia	●●●●	–	–	●●●●	–	●●●●	–	–	–	–
Dryopteris carthusiana	–	–	–	–	–	–	–	–	○○●○	–
Dulichium arundinaceum	●●●●	●●●●	●●○○	●●●●	●●●●	●●●●	●●●●	●●●●	–	○○●●
Echinochloa muricata	–	–	–	–	–	–	–	–	–	–
Eleocharis acicularis	–	–	–	–	–	–	●○●●	–	–	–
Eleocharis flavescens var. olivacea	○●●○	○●○●	–	●●●●	●●●○	●●●●	○●○○	●●●●	–	–
Eleocharis microcarpa	–	–	–	–	–	–	–	–	–	–
Eleocharis ovata	–	○○●●	–	–	–	–	–	–	–	–
Eleocharis robbinsii	–	●●●●	–	–	●●●●	●●●●	–	–	–	–
Eleocharis tenuis	–	●●●●	–	●●○●	–	●●●●	●●●●	●●●●	●○○○	●●●●
Eleocharis tuberculosa	–	–	–	●●●●	–	●○●●	–	–	–	–
Elodea nuttallii	–	–	–	–	–	–	–	–	–	–
Epilobium coloratum	–	–	–	–	–	–	–	–	–	–
Erechtites hieracifolia	–	–	–	–	–	–	–	–	–	–
Erianthus giganteus	–	○●●○	–	–	–	–	–	–	–	–
Eriocaulon aquaticum	–	–	–	–	–	–	○●●●	–	–	●○●●
Eriocaulon compressum	–	–	–	–	–	–	–	–	–	–
Eriocaulon decangulare	–	–	–	–	–	–	–	–	–	–
Eriophorum virginicum	●○●●	–	–	○○●○	–	–	–	–	–	–
Eupatorium dubium	–	–	–	–	–	–	–	–	–	–
Eupatorium perfoliatum	–	–	–	–	–	–	–	–	–	–
Eupatorium pilosum	–	–	–	–	–	–	–	–	–	–
Eupatorium resinosum	–	○●○○	–	–	–	–	–	–	–	–
Eupatorium serotinum	–	–	–	–	–	–	–	–	–	–
Euphorbia ipecacuanhae	–	–	–	–	–	–	–	–	–	–
Euthamia tenuifolia	–	–	–	–	–	–	–	–	–	–
Galium tinctorium	–	–	–	–	–	–	–	–	–	–
Glechoma hederacea	–	–	–	–	–	–	–	–	–	–
Glyceria canadensis	–	–	–	–	–	–	–	–	–	–
Glyceria obtusa	●●○○	●●●●	●●●●	–	–	●●●○	●●●●	●●●●	–	●●●●
Glyceria striata	–	–	–	–	–	–	–	–	–	–
Glyceria x laxa	–	–	–	–	–	–	–	–	–	–
Habenaria clavellata	–	–	–	–	–	–	–	–	–	–
Habenaria lacera	–	–	–	–	–	–	–	–	–	–
Hibiscus moscheutos	–	–	–	–	–	–	–	–	–	–

Species	WFEACARR 98	WHOSPITA 99	WLIHAUKN 99	WSA4DIKE 98	WSACARRA 98	WTUHAWKN 98	WWEEVANB 98	WWEFORDR 98	WWEMILER 98	WWETULPC 98
Hypericum canadense	-	○●●●	-	-	-	●●●●	○●●○	●●●●	-	-
Hypericum denticulatum	-	○○●○	-	-	-	-	●●●○	○○●○	-	-
Hypericum mutilum	-	-	●○○○	-	-	-	-	●○●●	-	●●●●
Hypericum stragulum	-	-	-	-	-	-	-	-	-	-
Impatiens capensis	-	-	-	-	-	-	-	-	-	-
Iris prismatica	-	-	-	-	-	-	-	●○○○	-	-
Iris versicolor	-	-	-	-	-	-	-	-	-	-
Isoetes echinospora	-	-	-	-	-	-	-	-	-	-
Juncus acuminatus	-	-	-	-	-	-	-	-	-	-
Juncus biflorus	-	-	-	-	-	-	-	-	-	-
Juncus caesariensis	-	-	-	-	-	-	-	-	-	-
Juncus canadensis	●●●○	-	-	-	●●○●	●○○●	○●○○	○●○○	-	-
Juncus effusus	○●●●	●●●●	-	-	●○○○	-	-	-	-	-
Juncus militaris	-	-	-	-	-	●●●●	●●●○	●●●●	●○●●	○○●●
Juncus pelocarpus	●●●●	-	-	●●●●	●●●●	●●●●	○●●○	●●●●	-	-
Lachnanthes caroliniana	-	-	-	-	●●●●	●●●●	●●●○	●○●●	-	-
Leersia oryzoides	-	●●●●	●●●●	-	-	-	●●●●	●○●●	●○○○	●○●○
Lemna sp.	-	-	-	-	-	-	-	-	-	-
Lilium superbum	-	-	-	-	-	-	-	-	-	-
Lindernia dubia	-	-	-	-	-	-	-	-	-	-
Lobelia canbyi	-	-	-	-	-	-	-	-	-	-
Lobelia cardinalis	-	-	-	-	-	-	-	-	-	-
Lobelia nuttallii	-	-	-	-	-	-	-	○●○●	-	-
Lophiola aurea	-	-	-	-	-	-	-	-	-	-
Ludwigia alternifolia	-	-	-	-	-	-	-	-	-	-
Ludwigia palustris	-	-	-	-	-	-	-	-	-	-
Lycopodium alopecuroides	-	-	-	○●○○	-	-	-	-	-	-
Lycopodium appressum	-	-	-	-	-	-	-	-	-	-
Lycopodium obscurum	-	-	-	-	-	-	-	-	-	-
Lycopus uniflorus	-	-	-	-	-	-	-	-	-	-
Lycopus virginicus	-	-	-	-	-	-	-	-	-	-
Lysimachia terrestris	-	●●●●	●●●●	-	-	●○○●	●●●●	●○●●	●○○○	○●●●
Lythrum salicaria	-	-	-	-	-	-	-	-	-	-
Microstegium vimineum	-	-	-	-	-	-	-	-	-	-
Mikania scandens	-	-	-	-	-	-	-	-	-	-
Mimulus ringens	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	WFEACARR	WHOSPITA	WLIHAUKN	WSA4DIKE	WSACARRA	WTUHAWKN	WWEEVANB	WWEFORDR	WWEMILER	WWETULPC
	98	99	99	98	98	98	98	98	98	98
Mitchella repens	-	-	-	-	-	-	-	-	-	-
Monotropa uniflora	-	-	-	-	-	-	-	-	-	-
Muhlenbergia torreyana	-	-	-	-	-	-	-	●○●○	-	-
Muhlenbergia uniflora	-	-	-	-	-	●●●●	-	-	-	-
Nuphar variegata	●●●●	●●●●	○○●○	-	●●●●	-	-	-	-	-
Nymphaea odorata	●●●●	●○○○	-	●●●●	●●●●	●●●●	○●●○	●○●○	-	○○○●
Onoclea sensibilis	-	-	-	-	-	-	-	-	-	-
Orontium aquaticum	-	-	-	-	-	●●●●	○●○○	●○●●	-	-
Osmunda cinnamomea	●●●●	-	-	●●●●	-	-	-	-	-	-
Osmunda regalis	-	-	-	-	-	-	-	-	-	-
Oxalis stricta	-	-	-	-	-	-	-	-	-	-
Oxypolis rigidior	-	-	-	-	-	-	-	-	-	-
Panicum clandestinum	-	-	-	-	-	-	-	-	-	-
Panicum dichotomum	○○●○	-	-	-	-	●●○○	●●●●	-	●●●●	●●●●
Panicum ensifolium	-	-	-	-	-	-	-	●●●●	-	-
Panicum lanuginosum var. lindheimeri	-	-	-	-	-	-	-	-	-	-
Panicum longifolium	○○●●	●○○○	-	-	●○●●	○○●○	●●●○	●●●●	●○○○	●●●○
Panicum rigidulum	-	-	-	-	-	-	-	-	-	-
Panicum scabriusculum	-	-	-	-	-	-	●●●●	●●●●	-	●●●●
Panicum sp.	-	-	-	○●○○	-	-	-	-	-	-
Panicum spretum	-	-	-	-	-	-	-	-	-	-
Panicum verrucosum	-	-	-	○●○○	●○○○	●●●●	○●●○	●●●●	-	○○●○
Panicum virgatum	-	-	-	-	-	-	○●●●	●●●●	●○○○	●○○●
Peltandra virginica	●●●●	●●●●	●●●●	●●●●	●●●●	●○●●	○●●●	●●●●	○●○○	●●●●
Phalaris arundinacea	-	-	-	-	-	-	-	-	-	-
Phragmites australis	-	-	-	-	-	-	-	-	-	-
Phytolacca americana	-	-	-	-	-	-	-	-	-	-
Pilea pumila	-	-	-	-	-	-	-	-	-	-
Poa palustris	-	-	-	-	-	-	-	-	-	-
Poa pratensis	-	-	-	-	-	-	-	-	-	-
Pogonia ophioglossoides	-	-	-	-	-	-	-	-	-	-
Polygala brevifolia	-	-	-	-	-	-	-	-	-	-
Polygala cruciata	-	-	-	-	-	●●●●	-	-	-	-
Polygonum arifolium	-	-	-	-	-	-	-	-	-	-
Polygonum cespitosum	-	-	-	-	-	-	-	-	-	-
Polygonum hydropiperoides	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	WFEACARR	WHOSPITA	WLIHAUKN	WSA4DIKE	WSACARRA	WTUHAWKN	WWEEVANB	WWEFORDR	WWEMILER	WWETULPC
	98	99	99	98	98	98	98	98	98	98
Polygonum punctatum	-	-	-	-	-	-	-	-	-	-
Polygonum sagittatum	-	-	-	-	-	-	-	-	-	-
Polygonum sp.	-	-	-	-	-	-	-	-	-	-
Pontederia cordata	-	-	-	-	-	-	-	○○○●	-	○●○●
Potamogeton confervoides	-	○○○●	-	-	-	-	●○●○	●●●●	●○●●	-
Potamogeton diversifolius	-	-	-	-	-	-	-	-	-	-
Potamogeton epihydrus	-	-	-	-	-	-	-	-	-	-
Potamogeton oakesianus	-	-	-	-	-	-	-	-	-	-
Potamogeton pusillus	-	-	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	○○○●	-	-	-	-	-	-	-	-
Pteridium aquilinum	-	-	-	-	-	-	-	-	●○○○	-
Rhexia mariana	-	-	-	-	-	-	-	-	-	-
Rhexia virginica	●○○●	-	-	○○○●	-	●●●●	●●●●	●●●●	-	○○●○
Rhynchospora alba	●●●●	-	-	●●●●	○●●●	●●●●	-	-	-	-
Rhynchospora capitellata	-	-	-	-	-	-	-	-	-	-
Rhynchospora chalarocephala	-	-	-	-	-	-	-	-	-	-
Rorippa palustris	-	-	-	-	-	-	-	-	-	-
Sabatia difformis	-	-	-	○○●○	-	○○●○	-	●●●●	●○○○	○●●●
Sagittaria engelmanniana	-	●●○●	●●○○	●●○●	●●●●	●●●●	●●●●	●●●●	-	○○●○
Sarracenia purpurea	-	-	-	-	-	●●●●	-	-	-	-
Schizachyrium scoparium	-	-	-	-	-	-	-	-	-	-
Schizaea pusilla	-	-	-	-	-	●●●○	-	-	-	-
Scirpus cyperinus	●○●●	●●○●	●●○○	-	●●●○	-	○●○○	-	-	-
Scirpus pungens	-	-	-	-	-	-	-	-	-	-
Scirpus subterminalis	-	●●●●	-	●●●●	●●●●	●●●●	●●●●	●○●○	○○●●	○●●●
Scleria reticularis	-	-	-	-	-	-	-	-	-	-
Sclerolepis uniflora	-	-	-	-	-	-	-	-	-	-
Scutellaria lateriflora	-	-	-	-	-	-	-	-	-	-
Smilax herbacea	-	-	-	-	-	-	-	-	●●○●	-
Smilax pseudochina	-	-	-	-	-	-	-	●○○●	-	-
Solanum nigrum	-	-	-	-	-	-	-	-	-	-
Solidago canadensis	-	-	-	-	-	-	-	-	-	-
Solidago rugosa	-	-	-	-	-	-	-	-	-	-
Sparganium americanum	-	●●●●	-	-	-	-	-	-	○○○●	-
Spiranthes cernua	-	-	-	-	-	-	-	-	-	-
Stellaria graminea	-	-	-	-	-	-	-	-	-	-

Species	WFEACARR 98	WHOSPITA 99	WLIHAUKN 99	WSA4DIKE 98	WSACARRA 98	WTUHAWKN 98	WWEEVANB 98	WWEFORDR 98	WWEMILER 98	WWETULPC 98
Stellaria media	-	-	-	-	-	-	-	-	-	-
Taraxacum officinale	-	-	-	-	-	-	-	-	-	-
Thelypteris palustris	-	-	-	-	-	-	-	-	-	-
Thelypteris simulata	-	-	-	-	-	-	-	-	-	-
Triadenum virginicum	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	○●●●	●○●●	○○●●	○●●●
Trientalis borealis	-	-	-	-	-	-	-	-	-	-
Typha latifolia	-	-	-	-	-	-	-	-	-	-
Urtica dioica	-	-	-	-	-	-	-	-	-	-
Utricularia cornuta	-	-	-	-	-	●●●●	-	-	-	-
Utricularia fibrosa	-	-	-	●●●●	●●●●	●○○○	-	-	-	-
Utricularia geminiscapa	○○○●	-	-	-	-	-	-	○○●○	-	-
Utricularia inflata	-	-	-	-	-	-	-	-	-	-
Utricularia purpurea	-	-	-	-	-	-	-	-	-	-
Utricularia sp.	-	-	-	-	-	-	-	-	-	-
Utricularia subulata	-	-	-	-	-	-	-	-	-	-
Utricularia vulgaris	-	-	-	-	-	-	-	-	-	-
Verbena hastata	-	-	-	-	-	-	-	-	-	-
Vernonia noveboracensis	-	-	-	-	-	-	-	-	-	-
Viola lanceolata	-	-	●○○●	-	-	●○○●	●●●●	●●●●	●●●●	●●●●
Viola primulifolia	-	-	-	-	-	-	-	-	-	-
Viola sororia	-	-	-	-	-	-	-	-	-	-
Woodwardia areolata	-	-	-	○○○●	-	-	-	-	-	-
Woodwardia virginica	-	○○●●	-	●○○○	○○○●	-	-	-	○●○○	-
Xerophyllum asphodeloides	-	-	-	-	-	-	-	-	-	-
Xyris difformis	○●●○	-	-	-	-	●●○●	○●○○	-	-	-
Xyris smalliana	-	-	-	-	-	-	-	-	-	-
Zizania aquatica	-	-	-	-	-	-	●●●●	●●○○	-	-
Woody plants:										
Acer rubrum	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Ailanthus altissima	-	-	-	-	-	-	-	-	-	-
Alnus serrulata	-	-	-	-	-	-	-	○○○●	-	-
Amelanchier canadensis	-	-	-	-	-	●○●○	○○●○	●●●○	●○○○	-
Amelanchier obovalis	-	-	-	-	-	-	-	-	-	-
Aronia arbutifolia	●○●●	○●○○	-	-	-	●○●●	-	○○●○	-	-
Berberis thunbergii	-	-	-	-	-	-	-	-	-	-
Betula lenta	-	-	-	-	-	-	-	-	-	-

Species	WFEACARR	WHOSPITA	WLIHAUKN	WSA4DIKE	WSACARRA	WTUHAWKN	WWEEVANB	WWEFORDR	WWEMILER	WWETULPC
	98	99	99	98	98	98	98	98	98	98
Betula populifolia	-	-	-	-	-	-	-	-	-	-
Catalpa bignonioides	-	-	-	-	-	-	-	-	-	-
Cephalanthus occidentalis	-	-	-	-	-	-	-	-	-	-
Chamaecyparis thyoides	●●●●	-	○●●●	●●●●	○○●●	●●●●	●●●●	●●●●	●○○○	●●●●
Chamaedaphne calyculata	●●●●	●●●●	○●○●	●●●●	●●●●	●●●●	○○●●	●●●●	-	○○●○
Clematis terniflora	-	-	-	-	-	-	-	-	-	-
Clethra alnifolia	●●●●	●●●●	●●●●	●○●●	-	●●●●	●●●●	●●●●	●●●●	●●●●
Diospyros virginiana	-	-	-	-	-	-	-	-	-	-
Eubotrys racemosa	●●●●	-	-	-	-	○●●●	●●○●	●●●●	●●●●	●●●●
Gaultheria procumbens	-	-	-	-	-	-	-	-	●○○○	-
Gaylussacia baccata	-	-	-	-	-	-	-	○●○●	-	-
Gaylussacia dumosa	-	-	-	○●●●	-	○●●●	-	○○●●	●○○○	-
Gaylussacia frondosa	●●●●	-	-	○○○●	-	○●●○	-	-	-	-
Hudsonia ericoides	-	-	-	-	-	-	-	-	-	-
Hypericum densiflorum	-	-	-	-	-	-	○●●●	○○●○	○○●○	-
Ilex glabra	○●○●	-	○○○●	●○○●	-	●●●●	●●●●	●●●●	●○●●	●●●●
Ilex laevigata	○●●●	-	-	-	-	-	-	-	-	-
Ilex opaca	-	-	-	-	-	-	-	-	-	-
Ilex verticillata	-	-	-	-	-	-	-	-	●○○○	-
Itea virginica	●●●●	-	○●●●	-	-	-	-	-	-	○○○●
Juniperus virginiana	-	-	-	-	-	-	-	-	-	-
Kalmia angustifolia	●●●●	-	-	●●●●	-	○●●○	-	○○○●	-	-
Kalmia latifolia	-	-	-	-	-	-	-	-	-	-
Leiophyllum buxifolium	-	-	-	-	-	○●●○	-	-	-	-
Liquidambar styraciflua	-	-	-	-	-	-	-	-	○●●●	-
Lonicera japonica	-	-	-	-	-	-	-	-	-	-
Lyonia ligustrina	○○●○	○○●○	-	-	-	-	-	-	-	-
Lyonia mariana	-	-	-	-	-	○○●○	-	-	●○○○	-
Magnolia virginiana	-	-	-	-	-	-	-	●●○○	○●●○	○○○●
Myrica pensylvanica	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	-	●●○●	●●●●	●●●●	○●●●
Parthenocissus quinquefolia	-	-	-	-	-	-	-	-	-	-
Pinus echinata	-	-	-	-	-	-	-	-	-	-
Pinus rigida	-	-	-	○○●●	-	●●●○	●●●●	●●●●	●●●○	○●○●
Pinus strobus	-	-	-	-	-	-	-	-	-	-
Platanus occidentalus	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	WFEACARR	WHOSPITA	WLIHAUKN	WSA4DIKE	WSACARRA	WTUHAWKN	WWEEVANB	WWEFORDR	WWEMILER	WWETULPC
	98	99	99	98	98	98	98	98	98	98
Prunus serotina	-	-	-	-	-	-	-	-	-	-
Quercus alba	-	-	-	-	-	-	-	-	-	-
Quercus ilicifolia	-	-	-	-	-	-	-	○○○●	-	-
Quercus marilandica	-	-	-	-	-	-	-	-	-	-
Quercus sp. seedling	-	-	-	-	-	-	-	-	-	-
Quercus stellata	-	-	-	-	-	-	-	-	-	-
Quercus velutina	-	-	-	-	-	-	-	-	-	-
Rhododendron viscosum	●●●●	-	○○○●	-	-	○●●●	●○○○	○○●○	●●●●	○○●○
Rosa palustris	-	-	-	-	-	-	-	-	-	-
Rubus hispidus	-	-	-	-	-	-	-	-	-	-
Rubus sp.	-	-	-	-	-	-	-	-	-	-
Salix nigra	-	-	-	-	-	-	-	-	-	-
Sambucus canadensis	-	-	-	-	-	-	-	-	-	-
Sassafras albidum	-	-	●●●●	-	-	-	-	-	-	-
Smilax glauca	-	-	○○○●	-	-	-	●●○●	●○●●	●●●●	●●●●
Smilax laurifolia	-	-	-	-	-	-	-	-	-	-
Smilax rotundifolia	-	-	○○●●	○●○○	-	●○○○	○○○●	●●●●	●●●●	○●○●
Smilax walteri	-	-	●●○●	-	-	-	-	-	-	-
Spiraea alba var. latifolia	-	-	-	-	-	-	-	-	-	-
Spiraea tomentosa	-	-	-	-	-	-	-	-	-	-
Tilia americana	-	-	-	-	-	-	-	-	-	-
Toxicodendron radicans	-	-	-	-	-	-	-	-	-	-
Toxicodendron vernix	-	-	-	-	-	-	-	-	-	-
Ulmus americana	-	-	-	-	-	-	-	-	-	-
Vaccinium corymbosum	●●●●	○●●○	●●●●	●●●●	○●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Vaccinium macrocarpon	●●●●	○●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●○●○	●●●●
Vaccinium pallidum	-	-	-	-	-	-	-	○●○○	-	-
Viburnum dentatum	-	-	-	-	-	-	-	-	-	-
Viburnum nudum var. nudum	○○●●	-	-	-	-	-	-	-	-	-
Vitis labrusca	-	-	-	-	-	-	-	-	-	-

Appendix 2.2.1. Stream-vegetation monitoring sites in the Oswego River and Bass River drainage basins. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Refer to methods for sampling details. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered by site code.

Site Name and Description	Site Code
East Branch Bass River above Stage Road Bass River Twp., Burlington Co. (lat 39°37'24.00", long 74°26'27.95", New Gretna quad). Section 1 begins 5 m upstream from Stage Road.	AEASTAGE
West Branch Bass River above Stage Road Bass River Twp., Burlington Co. (lat 39°37'27.38", long 74°26'45.22", New Gretna quad). Section 1 begins 14 m upstream from Stage Road.	AWESTAGE
Buck Run below Old Martha Road Bass River Twp., Burlington Co. (lat 39°41'58.89", long 74°29'53.22", Oswego Lake quad). Section 4 ends 4 m downstream from Old Martha Road.	OBUCKRUN
Oswego River below Beaver Dam Road Little Egg Harbor Twp., Ocean Co. (lat 39°44'58.67", long 74°22'38.43", Oswego Lake quad). Section 4 ends 10 m downstream from Beaver Dam Road.	OOSBEAVR
Oswego River below Route 679 Washington/Bass River Twp., Burlington Co. (lat 39°39'48.45", long 74°31'24.44", Jenkins quad). Section 4 ends 42 m downstream from Harrisville-Chatsworth Road (Route 679).	OOSHARST
Oswego River above Oswego Lake Washington/Bass River Twp., Burlington Co. (lat 39°44'07.16", long 74°28'24.16", Oswego Lake quad). Section 4 ends near end of unnamed sand road, upstream from Oswego Lake.	OOSLAKUP
Oswego River above Martha Washington/Bass River Twp., Burlington Co. (lat 39°42'13.56", long 74°30'05.45", Jenkins quad). Section 1 begins near end of unnamed sand road, approximately 0.8 km upstream from confluence with Buck Run.	OOSOLMAR
Papoose Branch below Jenkins Road Washington/Bass River Twp., Burlington Co. (lat 39°44'31.93", long 74°27'09.67", Oswego Lake quad). Section 4 ends 19 m downstream from Jenkins Road.	OPAPOOSE

Appendix 2.2.2. Plant species at stream-monitoring sites in the Oswego River and Bass River drainage basins. Circles indicate a species is present at a site. Filled circles indicate the 25-m section where it was found (e.g., "•○•○" means a species was located in the first and third sections of the 100-m study site). Refer to Appendix 2.2.1 for site descriptions and explanations of site codes. Plant common names are presented in Appendix 2.8.

Species	Sites and Survey Years							
	AEASTAGE 98	AWESTAGE 99	OBUCKRUN 99	OOSBEAVR 99	OOSHARST 98	OOSLAKUP 99	OOSOLMAR 99	OPAPOOSE 99
Herbaceous plants:								
Agrostis hyemalis	-	-	-	-	○●●●	-	-	-
Agrostis hyemalis var. scabra	-	-	-	-	-	-	-	-
Agrostis perennans	-	-	-	-	-	-	-	-
Agrostis perennans var. elata	-	○○○●	-	-	-	-	-	-
Agrostis sp.	-	-	-	-	-	-	-	-
Alisma subcordatum	-	-	-	-	-	-	-	-
Allium sp.	-	-	-	-	-	-	-	-
Amphicarpum purshii	-	-	-	-	-	-	-	-
Andropogon virginicus var. abbreviatus	-	-	○●●●	○●●●	-	-	○○○●	-
Andropogon virginicus var. virginicus	-	○○○●	-	-	-	-	-	-
Apios americana	-	-	-	-	-	-	-	-
Aralia nudicaulis	-	-	-	-	-	-	-	-
Arethusa bulbosa	○●●○	-	-	-	-	-	-	-
Asclepias incarnata	-	-	-	-	-	-	-	-
Aster dumosus	-	-	-	-	●●●●	-	-	-
Aster nemoralis	○●●●	-	●●●●	●●●●	-	○○●○	-	-
Aster novi-belgii	○●○○	●○●●	●●●○	●●●●	-	●●○●	-	○○●●
Aster pilosus var. pringlei	-	-	-	-	-	-	-	-
Aster racemosus	-	-	-	-	-	-	-	-
Bartonia paniculata	○●●○	●●●●	●●●●	●●●●	●●○○	-	-	-
Bartonia virginica	○○●○	○○●●	-	○○●●	-	-	-	-
Bidens connata	-	-	-	-	-	-	-	-
Bidens coronata	-	-	-	-	-	-	-	-
Bidens discoidea	-	-	-	-	-	-	-	-
Bidens frondosa	-	-	-	-	-	-	-	-
Bidens sp.	-	-	-	-	-	-	-	-
Boehmeria cylindrica	-	-	-	-	-	-	-	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	-	-	-	-	●●●●	-	-	-
Callitriche heterophylla	-	-	-	-	-	-	-	-
Cardamine pensylvanica	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	AEASTAGE 98	AWESTAGE 99	OBUCKRUN 99	OOSBEAVR 99	OOSHARST 98	OOSLAKUP 99	OOSOLMAR 99	OPAPOOSE 99
Carex albolutescens	–	○○○●	–	–	–	–	–	–
Carex atlantica	●●●●	●●●●	●●●●	●●●●	○○○●	●●●○	●○○○	●●●●
Carex atlantica var. capillacea	–	●●●●	–	●○○○	–	–	–	–
Carex bullata	–	–	–	–	–	–	○○○●	–
Carex canescens	–	–	–	–	–	–	–	–
Carex collinsii	○●●●	–	●●○○	–	–	–	–	●●●●
Carex crinita	–	–	–	–	–	–	–	–
Carex exilis	–	●●○○	●●●●	○●●●	○○○●	–	–	○○○●
Carex folliculata	–	●●●○	●●●●	●●●●	–	○●●○	●○○●	●●●●
Carex intumescens	–	–	–	–	–	–	–	–
Carex livida	–	–	●●●●	–	–	●●○○	–	–
Carex longii	–	–	–	–	–	–	–	–
Carex lurida	–	–	–	–	–	–	–	–
Carex pensylvanica	–	○○○●	–	–	○●○○	–	–	–
Carex scoparia	–	–	–	–	–	–	–	–
Carex stipata	–	–	–	–	–	–	–	–
Carex striata	–	–	○○●●	●●●●	–	–	–	–
Carex stricta	–	–	–	–	–	●●●○	–	–
Carex tribuloides	–	–	–	–	–	–	–	–
Carex trisperma	–	–	●●●●	–	–	–	–	–
Carex venusta	–	–	–	–	–	–	–	–
Ceratophyllum echinatum	–	–	–	–	–	–	–	–
Chasmanthium laxum	–	–	–	–	–	–	–	–
Cinna arundinacea	–	–	–	–	–	–	–	–
Cladium mariscoides	–	–	–	–	–	–	–	–
Cuscuta sp.	○●○○	–	–	●●○●	–	●●●●	–	–
Cyperus dentatus	–	–	–	–	○●○○	–	○○●○	–
Cyperus erythrorhizos	–	–	–	–	–	–	–	–
Cyperus odoratus	–	–	–	–	–	–	–	–
Cyperus retrorsus	–	–	–	–	–	–	–	–
Cyperus strigosus	–	–	–	–	–	–	–	–
Danthonia sericea var. epilis	–	–	○●○○	–	–	–	–	–
Decodon verticillatus	–	●○○○	–	●●●●	–	–	–	–
Dioscorea villosa	–	–	–	–	–	–	–	○○○●
Drosera filiformis	–	○○○●	–	–	○●○○	–	–	–
Drosera intermedia	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	–

Species	Sites and Survey Years							
	AEASTAGE 98	AWESTAGE 99	OBUCKRUN 99	OOSBEAVR 99	OOSHARST 98	OOSLAKUP 99	OOSOLMAR 99	OPAPOOSE 99
Drosera rotundifolia	○●●●	●●●○	●●●●	●●●●	○●○●	●○●●	●●●●	●●●●
Dryopteris carthusiana	-	-	-	-	-	-	-	-
Dulichium arundinaceum	●○●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●○○●
Echinochloa muricata	-	-	-	-	-	-	-	-
Eleocharis acicularis	-	-	-	-	●●●●	-	●○○●	-
Eleocharis flavescens var. olivacea	-	○○●○	-	-	●●●●	-	○●●●	-
Eleocharis microcarpa	-	-	-	-	-	-	-	-
Eleocharis ovata	-	-	-	-	○○●○	-	-	-
Eleocharis robbinsii	-	●○○●	-	●●●●	●●●●	●●●●	●●●●	-
Eleocharis tenuis	-	●○●●	●○○●	○○○●	●●●○	●●●●	●●●●	-
Eleocharis tuberculosa	-	●○○○	-	○●○○	○●○●	-	-	-
Elodea nuttallii	-	-	-	-	-	-	-	-
Epilobium coloratum	-	-	-	-	-	-	-	-
Erechtites hieracifolia	-	-	-	-	-	-	-	-
Erianthus giganteus	-	-	-	-	-	-	-	-
Eriocaulon aquaticum	●●●●	●●●○	○○○●	-	●●●●	●●●○	●●●●	●●●●
Eriocaulon compressum	-	-	●●●●	○●●●	-	-	-	-
Eriocaulon decangulare	-	-	-	-	○●○○	-	-	-
Eriophorum virginicum	-	●●○○	○○●○	○●●○	-	-	-	-
Eupatorium dubium	-	-	-	-	-	-	-	-
Eupatorium perfoliatum	-	-	-	-	-	-	-	-
Eupatorium pilosum	-	○○○●	-	-	-	-	-	-
Eupatorium resinosum	-	-	-	-	-	-	-	-
Eupatorium serotinum	-	-	-	-	-	-	-	-
Euphorbia ipecacuanhae	-	-	-	-	○●●○	-	-	-
Euthamia tenuifolia	-	-	-	-	●○○●	-	-	-
Galium tinctorium	-	-	-	-	-	-	-	-
Glechoma hederacea	-	-	-	-	-	-	-	-
Glyceria canadensis	-	-	-	-	-	-	-	-
Glyceria obtusa	●○●○	-	○●○●	●●●●	○○●●	●●●●	●●●●	●○●●
Glyceria striata	-	-	-	-	-	-	-	-
Glyceria x laxa	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	○●○●	-	-	-	-	-
Habenaria lacera	-	-	-	-	-	-	-	-
Hibiscus moscheutos	-	-	-	-	-	-	-	-
Hypericum canadense	-	○○●●	○●○●	-	○●●●	○●○○	●●●○	-

Species	AEASTAGE 98	AWESTAGE 99	OBUCKRUN 99	OOSBEAVR 99	OOSHARST 98	OOSLAKUP 99	OOSOLMAR 99	OPAPOOSE 99
Hypericum denticulatum	-	-	-	-	-	-	-	-
Hypericum mutilum	-	-	-	-	-	-	-	-
Hypericum stragulum	-	-	-	-	○○●○	-	-	-
Impatiens capensis	-	-	-	-	-	-	-	-
Iris prismatica	-	-	-	-	-	-	-	-
Iris versicolor	-	-	-	-	-	-	-	-
Isoetes echinospora	-	-	-	-	-	-	-	-
Juncus acuminatus	-	-	-	-	-	-	-	-
Juncus biflorus	-	○●○●	-	-	-	-	-	-
Juncus caesariensis	-	-	-	-	-	-	-	-
Juncus canadensis	-	●●●●	-	●○●○	○●●●	-	○○●○	-
Juncus effusus	-	-	-	○●●○	-	-	-	-
Juncus militaris	-	-	-	○○●○	●●●●	●●●●	●●●●	-
Juncus pelocarpus	●●●○	●○●●	●●●●	○●●●	○●●●	●○○○	●●●●	●○●●
Lachnanthes caroliniana	-	●●●●	-	-	-	-	-	-
Leersia oryzoides	○●●○	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Lemna sp.	-	-	-	-	-	-	-	-
Lilium superbum	-	-	-	○○●●	-	-	-	-
Lindernia dubia	-	-	-	-	-	-	-	-
Lobelia canbyi	-	-	-	-	-	-	-	-
Lobelia cardinalis	-	-	-	-	-	-	-	-
Lobelia nuttallii	-	-	-	-	○○●○	-	-	-
Lophiola aurea	-	-	-	-	-	-	-	-
Ludwigia alternifolia	-	-	-	-	-	-	-	-
Ludwigia palustris	-	-	-	-	-	-	-	-
Lycopodium alopecuroides	-	-	-	-	-	-	-	-
Lycopodium appressum	-	-	-	-	-	-	-	-
Lycopodium obscurum	-	-	-	-	-	-	-	○○○●
Lycopus uniflorus	-	-	-	-	●○○○	-	-	-
Lycopus virginicus	-	-	-	-	-	-	-	-
Lysimachia terrestris	-	●○●●	●●○○	●●●●	●●●●	●●●●	●●●●	●●●●
Lythrum salicaria	-	-	-	-	-	-	-	-
Microstegium vimineum	-	-	-	-	-	-	-	-
Mikania scandens	-	-	-	-	-	-	-	-
Mimulus ringens	-	-	-	-	-	-	-	-
Mitchella repens	●●●●	○●●●	●●○○	-	-	-	-	○○●●

Species	AEASTAGE 98	AWESTAGE 99	OBUCKRUN 99	OOSBEAVR 99	OOSHARST 98	OOSLAKUP 99	OOSOLMAR 99	OPAPOOSE 99
Monotropa uniflora	-	-	○●○○	-	-	-	-	-
Muhlenbergia torreyana	-	-	-	-	○○●●	-	-	-
Muhlenbergia uniflora	-	-	-	-	○●●○	-	○●●●	-
Nuphar variegata	●○●○	-	○○●●	-	-	-	-	-
Nymphaea odorata	●○○○	-	○○●●	●●●●	●●●●	●●●●	●●●●	-
Onoclea sensibilis	-	-	-	-	●○○○	-	-	-
Orontium aquaticum	○○●○	-	●●●●	●●●●	○●●○	-	●●●●	●●●●
Osmunda cinnamomea	●●○●	●●●○	-	●○○○	●○○○	○○●●	-	●○○●
Osmunda regalis	●●●●	○○○●	-	-	-	○●●●	○○●●	●●●●
Oxalis stricta	-	-	-	-	-	-	-	-
Oxypolis rigidior	○○●○	-	○●●○	-	-	-	●○○○	-
Panicum clandestinum	-	●○○○	-	-	-	-	-	-
Panicum dichotomum	-	●●●●	●●●●	-	○●●●	○●○●	●●●●	●○●●
Panicum ensifolium	-	-	-	-	-	-	-	-
Panicum lanuginosum var. lindheimeri	-	-	-	-	-	-	-	-
Panicum longifolium	-	●●○○	-	-	○●●○	-	○●●●	-
Panicum rigidulum	-	-	-	-	-	-	-	-
Panicum scabriusculum	-	-	-	-	-	●●●●	●●●●	-
Panicum sp.	-	-	-	-	-	-	-	-
Panicum spretum	-	-	-	-	-	-	-	-
Panicum verrucosum	-	-	-	-	○●○○	-	○●●○	-
Panicum virgatum	●○○○	-	-	-	●●●●	-	-	-
Peltandra virginica	●●●●	-	-	●●●●	-	●●●●	●●●●	●●●●
Phalaris arundinacea	-	-	-	-	-	-	-	-
Phragmites australis	-	-	-	-	-	-	-	-
Phytolacca americana	-	-	-	-	-	-	-	-
Pilea pumila	-	-	-	-	-	-	-	-
Poa palustris	-	-	-	-	-	-	-	-
Poa pratensis	-	-	-	-	-	-	-	-
Pogonia ophioglossoides	○●●○	-	●●●●	○○●●	-	-	-	-
Polygala brevifolia	-	-	-	-	-	-	-	-
Polygala cruciata	-	-	-	-	○○○●	-	-	-
Polygonum arifolium	-	-	-	-	-	-	-	-
Polygonum cespitosum	-	-	-	-	-	-	-	-
Polygonum hydropiperoides	-	○○○●	-	-	-	-	-	-
Polygonum punctatum	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	AEASTAGE 98	AWESTAGE 99	OBUCKRUN 99	OOSBEAVR 99	OOSHARST 98	OOSLAKUP 99	OOSOLMAR 99	OPAPOOSE 99
Polygonum sagittatum	-	-	-	-	-	-	-	-
Polygonum sp.	-	-	-	-	-	-	-	-
Pontederia cordata	-	-	-	-	-	-	-	-
Potamogeton confervoides	○●●●	●●○○	○●○○	-	●●●○	-	●●●●	-
Potamogeton diversifolius	-	-	-	-	-	-	-	-
Potamogeton epihydrus	-	-	-	-	-	-	-	-
Potamogeton oakesianus	-	-	-	-	-	-	-	-
Potamogeton pusillus	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	○●●●	-	-	-	-	-	-
Pteridium aquilinum	-	-	-	-	-	-	-	-
Rhexia mariana	-	-	-	-	-	-	-	-
Rhexia virginica	-	●●●●	-	●○●●	○●●●	○●●●	●●●●	-
Rhynchospora alba	○○○●	-	●●●●	○●●●	○●○●	-	-	-
Rhynchospora capitellata	-	-	-	-	○●○○	-	-	-
Rhynchospora chalarocephala	-	○○○●	-	-	-	-	-	-
Rorippa palustris	-	-	-	-	-	-	-	-
Sabatia difformis	●●●●	-	○●○●	○●●●	○●○○	○○○●	-	○○○●
Sagittaria engelmanniana	-	-	-	●●●●	●●○●	○●○●	●●○●	-
Sarracenia purpurea	○●●●	●○○○	●●●●	●○●●	○○○●	○●●●	○○●●	○●○○
Schizachyrium scoparium	-	-	-	-	○●●○	-	-	-
Schizaea pusilla	-	-	-	-	-	-	-	-
Scirpus cyperinus	●○○○	●●●●	-	●○○○	-	○○○●	-	-
Scirpus pungens	-	-	-	-	●●●●	-	-	-
Scirpus subterminalis	●●●●	●●○●	●○●●	●●●●	●●●●	●●●○	●●●●	●○●●
Scleria reticularis	-	-	-	-	-	-	-	-
Sclerolepis uniflora	-	-	-	-	-	-	-	-
Scutellaria lateriflora	-	-	-	-	-	-	-	-
Smilax herbacea	-	-	-	-	-	-	-	-
Smilax pseudochina	-	-	-	-	-	-	-	-
Solanum nigrum	-	-	-	-	-	-	-	-
Solidago canadensis	-	-	-	-	-	-	-	-
Solidago rugosa	-	-	-	-	-	-	-	-
Sparganium americanum	●○●●	●●●●	●○●●	●○○●	○○●●	●○○○	●●●●	○○●●
Spiranthes cernua	-	-	-	-	-	-	-	-
Stellaria graminea	-	-	-	-	-	-	-	-
Stellaria media	-	-	-	-	-	-	-	-

Species	AEASTAGE 98	AWESTAGE 99	OBUCKRUN 99	OOSBEAVR 99	OOSHARST 98	OOSLAKUP 99	OOSOLMAR 99	OPAPOOSE 99
Taraxacum officinale	-	-	-	-	-	-	-	-
Thelypteris palustris	-	-	-	-	-	-	-	-
Thelypteris simulata	-	-	-	-	-	-	-	-
Triadenum virginicum	○●●●	●●●●	●●●○	●●●●	●●●●	●●●●	●●●●	●●○●
Trientalis borealis	○●○○	-	-	-	-	-	-	-
Typha latifolia	-	-	-	-	-	-	-	-
Urtica dioica	-	-	-	-	-	-	-	-
Utricularia cornuta	-	-	-	-	○○●●	-	-	-
Utricularia fibrosa	●●●●	-	●●●●	○●●●	○○○●	-	-	-
Utricularia geminiscapa	-	-	-	-	-	○○●●	-	-
Utricularia inflata	-	○○●●	-	-	-	-	-	-
Utricularia purpurea	-	-	-	-	-	-	-	-
Utricularia sp.	-	-	-	-	-	-	○●●○	●○○○
Utricularia subulata	-	-	-	-	-	-	-	-
Utricularia vulgaris	-	-	-	-	-	-	-	-
Verbena hastata	-	-	-	-	-	-	-	-
Vernonia noveboracensis	-	-	-	-	-	-	-	-
Viola lanceolata	○●○○	○○●●	●●○●	-	○●●●	-	●●●●	-
Viola primulifolia	-	-	-	-	-	-	-	-
Viola sororia	-	-	-	-	-	-	-	-
Woodwardia areolata	-	-	-	○○●○	●○○○	-	-	○●○○
Woodwardia virginica	○●●●	●●○○	-	●●○●	-	-	-	○●○○
Xerophyllum asphodeloides	-	-	-	-	-	-	-	-
Xyris difformis	-	○●●●	-	-	○●●○	-	-	-
Xyris smalliana	-	-	-	○●●●	●●●●	●●○○	●○●○	-
Zizania aquatica	-	-	-	-	-	-	-	-
Woody plants:								
Acer rubrum	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Ailanthus altissima	-	-	-	-	-	-	-	-
Alnus serrulata	-	●○○○	○○●○	-	●●●●	○●●○	-	○●○●
Amelanchier canadensis	●○○○	●●●●	●●○○	○●●●	○○●○	-	-	●●○○
Amelanchier obovalis	-	-	-	-	-	-	-	-
Aronia arbutifolia	○●●○	●●○○	-	-	-	●○●○	-	-
Berberis thunbergii	-	-	-	-	-	-	-	-
Betula lenta	-	-	-	-	-	-	-	-
Betula populifolia	-	-	-	○●○○	○○○●	-	-	-

Species	Sites and Survey Years							
	AEASTAGE 98	AWESTAGE 99	OBUCKRUN 99	OOSBEAVR 99	OOSHARST 98	OOSLAKUP 99	OOSOLMAR 99	OPAPOOSE 99
Catalpa bignonioides	-	-	-	-	●○●○	-	-	-
Cephalanthus occidentalis	-	-	-	-	-	-	-	-
Chamaecyparis thyoides	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Chamaedaphne calyculata	●●●●	-	●●●●	●●●●	●●●●	●●●●	●●●●	-
Clematis terniflora	-	-	-	-	-	-	-	-
Clethra alnifolia	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Diospyros virginiana	-	-	-	-	-	-	-	-
Eubotrys racemosa	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●○	●●●●
Gaultheria procumbens	-	-	-	-	○○●●	○○●●	-	●●○○
Gaylussacia baccata	-	○●○○	-	-	-	-	-	-
Gaylussacia dumosa	○●●○	-	●●●●	○○●○	-	●●○○	-	-
Gaylussacia frondosa	○●●●	●●●●	●○●●	●●●●	-	○●●●	●○●○	○●●●
Hudsonia ericoides	-	-	-	-	-	-	-	-
Hypericum densiflorum	-	○○○●	-	-	-	●○○○	○○●○	-
Ilex glabra	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Ilex laevigata	○●●●	○●○○	●○●●	●●●●	-	-	-	-
Ilex opaca	-	-	-	-	-	-	-	-
Ilex verticillata	-	-	○○●○	-	-	-	-	-
Itea virginica	-	-	-	-	-	-	-	-
Juniperus virginiana	-	-	-	-	●○●○	-	-	-
Kalmia angustifolia	●●●●	○○●○	●●●●	●●●●	○●○○	○●●●	-	●○○○
Kalmia latifolia	●●○○	-	-	-	-	-	-	-
Leiophyllum buxifolium	-	-	-	-	-	-	-	-
Liquidambar styraciflua	-	-	-	-	-	-	-	-
Lonicera japonica	-	-	-	-	-	-	-	-
Lyonia ligustrina	●○○○	○●○●	○●○○	-	○●○○	-	-	-
Lyonia mariana	-	-	-	-	●●○●	-	-	-
Magnolia virginiana	○●○○	●●●●	-	●●●●	-	-	-	-
Myrica pensylvanica	●●●●	-	●●●●	●●●●	●○○○	○●●●	-	-
Nyssa sylvatica	-	●●●●	-	-	○●○○	○○●●	●●○●	●●●●
Parthenocissus quinquefolia	●●○○	○○○●	-	-	●○○○	-	-	-
Pinus echinata	-	-	-	-	○●○○	-	-	-
Pinus rigida	-	●●●●	●●●●	-	●●●●	●●○●	○○●○	●●●○
Pinus strobus	○○○●	-	-	-	-	-	-	-
Platanus occidentalus	-	-	-	-	-	-	-	-
Prunus serotina	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	AEASTAGE 98	AWESTAGE 99	OBUCKRUN 99	OOSBEAVR 99	OOSHARST 98	OOSLAKUP 99	OOSOLMAR 99	OPAPOOSE 99
Quercus alba	●●○○	-	-	-	-	-	-	-
Quercus ilicifolia	-	-	-	-	-	○○●○	-	-
Quercus marilandica	-	-	-	-	●●●○	-	-	-
Quercus sp. seedling	○●●○	○○○●	○●○●	-	-	-	-	-
Quercus stellata	-	-	-	-	-	-	-	-
Quercus velutina	-	-	-	-	-	-	-	-
Rhododendron viscosum	●●●●	●●●●	●●●●	●●●●	●●○●	●●●●	●●●○	●●●●
Rosa palustris	-	-	-	-	-	-	-	-
Rubus hispidus	○●○○	●●●●	●●●●	●●○○	●●●○	○○●○	-	●●○●
Rubus sp.	-	-	-	-	○○●○	-	-	-
Salix nigra	-	-	-	-	-	-	-	-
Sambucus canadensis	-	-	-	-	-	-	-	-
Sassafras albidum	-	○●○○	-	-	-	-	-	●○○○
Smilax glauca	●●○○	○●●●	●●○○	-	●○○○	-	-	●●●○
Smilax laurifolia	○●●○	●●○○	-	-	-	-	-	○●○●
Smilax rotundifolia	●○○○	●●●●	●●●○	-	●●●●	○○●●	-	●●●●
Smilax walteri	-	-	-	○○○●	-	-	-	-
Spiraea alba var. latifolia	-	-	-	-	-	-	-	-
Spiraea tomentosa	-	-	-	-	-	-	-	-
Tilia americana	-	-	-	-	-	-	-	-
Toxicodendron radicans	○●○○	-	-	-	-	-	-	-
Toxicodendron vernix	-	-	-	-	-	-	-	-
Ulmus americana	-	-	-	-	-	-	-	-
Vaccinium corymbosum	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Vaccinium macrocarpon	●○○●	-	●●●●	●○●●	●●●●	●●●●	●●●●	○○○●
Vaccinium pallidum	-	-	-	-	○●○○	-	-	-
Viburnum dentatum	-	-	-	-	-	-	-	-
Viburnum nudum var. nudum	○●●●	-	-	●●●●	-	○○●●	-	○●○●
Vitis labrusca	●○○○	-	-	-	-	-	-	-

Appendix 2.3.1. Stream-vegetation monitoring sites in the Lower Mullica River drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Refer to methods for sampling details. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered by site code.

Site Name and Description	Site Code
Clarks Mill Stream at Leibig Street and Odessa Avenue Galloway Twp., Atlantic Co. (lat 39°30'47.48", long 74°33'10.33", Green Bank quad). Section 2 ends 32 m downstream from Leibig Street and Odessa Avenue intersection; section 3 begins 11 m upstream from intersection.	LCLODESS
Elliots Creek at Bremen Avenue Egg Harbor City Twp., Atlantic Co. (lat 39°32'41.01", long 74°36'22.90", Green Bank quad). Section 1 ends 21 m downstream from Bremen Avenue; section 2 begins 15 m upstream from Bremen Avenue.	LELIOBRE
Hammonton Creek above Chestnut Avenue Mullica Twp., Atlantic Co. (lat 39°38'02.07", long 74°43'03.70", Atsion quad). Section 1 begins 40 m upstream from Chestnut Avenue.	LHACHEST
Indian Cabin Creek above Landing Creek Egg Harbor City Twp., Atlantic Co. (lat 39°33'26.19", long 74°36'09.04", Green Bank quad). Section 1 begins 18 m from confluence with Landing Creek.	LINCABIN
Landing Creek above Indian Cabin Road Egg Harbor City Twp., Atlantic Co. (lat 39°33'24.32", long 74°36'10.22", Green Bank quad). Section 1 begins 14 m upstream from Indian Cabin Road.	LLANDIND
Landing Creek below Alternate Route 561 Egg Harbor City Twp., Atlantic Co. (lat 39°32'45.66", long 74°37'51.25", Egg Harbor City quad). Section 4 ends 35 m downstream from Moss Mill Road (Alternate Route 561).	LLANDMOS
Morses Mill Stream below College Drive Galloway Twp., Atlantic Co. (lat 39°29'44.82", long 74°31'40.83", Pleasantville quad). Section 4 ends 100 m downstream from College Drive.	LMORSESM
Union Creek above Alternate Route 561 Egg Harbor City Twp., Atlantic Co. (lat 39°32'39.77", long 74°37'38.68", Egg Harbor City quad). Section 1 begins 24 m upstream from Moss Mill Road (Alternate Route 561).	LUNIOMOS

Appendix 2.3.2 Plant species at stream-monitoring sites in Lower Mullica River tributaries. Circles indicate a species is present at a site. Filled circles indicate the 25-m section where it was found (e.g., "•○•○" means a species was located in the first and third sections of the 100-m study site). Refer to Appendix 2.3.1 for site descriptions and explanations of site codes. Plant common names are presented in Appendix 2.8.

Species	Sites and Survey Years							
	LCLODESS	LELIOBRE	LHACHEST	LINCABIN	LLANDIND	LLANDMOS	LMORSESM	LUNIOMOS
	99	99	97	99	99	99	99	99
Herbaceous plants:								
Agrostis hyemalis	-	-	-	-	-	-	-	-
Agrostis hyemalis var. scabra	-	-	-	-	-	-	-	-
Agrostis perennans	-	●●●●	-	-	●●●●	-	-	-
Agrostis perennans var. elata	-	-	-	-	-	-	-	-
Agrostis sp.	-	-	-	-	-	-	-	-
Alisma subcordatum	-	-	-	-	-	-	-	-
Allium sp.	-	-	-	-	-	-	-	●●●○
Amphicarpum purshii	-	-	-	-	-	-	-	-
Andropogon virginicus var. abbreviatus	○○●●	-	-	-	-	-	-	-
Andropogon virginicus var. virginicus	-	-	-	-	-	●○○○	-	-
Apios americana	-	-	-	-	○○●●	●○○○	-	-
Aralia nudicaulis	-	-	-	-	-	-	-	-
Arethusa bulbosa	-	-	-	-	-	-	-	-
Asclepias incarnata	-	-	-	-	-	-	-	-
Aster dumosus	-	-	-	-	-	-	-	-
Aster nemoralis	○○●●	-	-	○●●●	-	-	-	-
Aster novi-belgii	○○●●	●●●●	-	●●○●	●●●○	●●○●	○●●●	-
Aster pilosus var. pringlei	-	-	-	-	-	-	-	●●●●
Aster racemosus	-	-	-	-	-	-	-	-
Bartonia paniculata	●●○●	-	-	○○●○	-	-	-	-
Bartonia virginica	-	-	-	-	-	-	-	-
Bidens connata	-	-	-	-	-	●○○○	●●●●	-
Bidens coronata	-	-	-	-	-	-	-	-
Bidens discoidea	-	-	-	-	-	-	-	-
Bidens frondosa	-	-	-	●○○●	-	○●○○	○○○●	-
Bidens sp.	-	-	●●●●	-	-	-	-	●●●●
Boehmeria cylindrica	-	-	●●●●	-	-	○○●○	-	●●●○
Calamagrostis canadensis	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	-	-	-	-	-	-	-	-
Callitriche heterophylla	-	-	●●●●	-	●●●●	-	-	●●●●

Species	Sites and Survey Years							
	LCLODESS 99	LELIOBRE 99	LHACHEST 97	LINCABIN 99	LLANDIND 99	LLANDMOS 99	LMORSESM 99	LUNIOMOS 99
Cardamine pensylvanica	-	-	-	-	-	-	-	●●●●
Carex albolutescens	-	-	-	-	●○●●	●●●●	-	-
Carex atlantica	○○○●	-	-	○●●●	-	-	-	-
Carex atlantica var. capillacea	-	-	-	-	-	-	●●○●	-
Carex bullata	-	-	-	-	-	-	-	-
Carex canescens	-	-	-	-	-	-	-	-
Carex collinsii	-	-	-	-	-	-	-	-
Carex crinita	-	-	-	-	●○●●	●●●●	-	-
Carex exilis	-	-	-	-	-	-	-	-
Carex folliculata	●○○●	-	-	-	-	-	-	-
Carex intumescens	-	-	-	-	○●○○	●○○○	-	-
Carex livida	-	-	-	-	-	-	-	-
Carex longii	-	-	-	-	-	-	-	-
Carex lurida	-	-	●○●●	-	●○○○	●●●●	-	-
Carex pensylvanica	-	-	-	-	-	-	-	-
Carex scoparia	-	-	-	-	-	-	-	-
Carex stipata	-	-	-	-	-	-	-	-
Carex striata	-	-	-	-	-	-	-	-
Carex stricta	-	-	-	-	-	-	-	-
Carex tribuloides	-	-	●○●○	-	-	-	-	-
Carex trisperma	-	-	-	-	-	-	-	-
Carex venusta	-	-	-	-	-	-	-	-
Ceratophyllum echinatum	-	-	-	-	-	-	-	-
Chasmanthium laxum	-	-	-	-	-	-	-	-
Cinna arundinacea	-	-	-	-	●●●●	-	-	-
Cladium mariscoides	○○○●	-	-	-	-	-	-	-
Cuscuta sp.	-	●○●●	●○●○	●○○○	-	●●●○	○○○●	-
Cyperus dentatus	-	-	-	-	-	-	-	-
Cyperus erythrorhizos	-	-	-	-	-	-	-	-
Cyperus odoratus	-	-	-	-	-	-	-	-
Cyperus retrorsus	-	-	-	-	-	-	-	-
Cyperus strigosus	-	-	-	-	○○○●	-	-	-
Danthonia sericea var. epilis	-	-	-	-	-	-	-	-
Decodon verticillatus	-	-	-	○●○●	-	●●●●	●○○●	-
Dioscorea villosa	-	-	-	-	●○○●	-	-	-
Drosera filiformis	○○●●	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	LCLODESS 99	LELIOBRE 99	LHACHEST 97	LINCABIN 99	LLANDIND 99	LLANDMOS 99	LMORSESM 99	LUNIOMOS 99
Drosera intermedia	○○●●	-	-	-	-	-	-	-
Drosera rotundifolia	●●●●	-	-	-	-	-	-	-
Dryopteris carthusiana	-	-	-	-	-	-	-	○○●○
Dulichium arundinaceum	-	-	-	-	-	●●●●	-	-
Echinochloa muricata	-	-	-	-	-	-	-	-
Eleocharis acicularis	-	-	●●●●	-	-	-	○○○●	-
Eleocharis flavescens var. olivacea	○○○●	-	-	-	-	-	-	-
Eleocharis microcarpa	-	-	-	-	-	-	-	-
Eleocharis ovata	-	-	-	-	-	-	-	-
Eleocharis robbinsii	-	-	-	-	-	-	-	-
Eleocharis tenuis	-	-	-	●○○○	-	-	-	-
Eleocharis tuberculosa	○○○●	-	-	-	-	-	-	-
Elodea nuttallii	-	-	●●●●	-	-	-	-	-
Epilobium coloratum	-	-	-	-	-	-	-	-
Erechtites hieracifolia	-	-	-	-	○○●○	-	○●●●	-
Erianthus giganteus	-	-	-	-	-	-	-	-
Eriocaulon aquaticum	○○●●	-	-	-	-	-	-	-
Eriocaulon compressum	○○●●	-	-	-	-	-	-	-
Eriocaulon decangulare	-	-	-	-	-	-	-	-
Eriophorum virginicum	-	-	-	-	-	-	-	-
Eupatorium dubium	-	●●●●	-	-	●○○○	●●●●	-	-
Eupatorium perfoliatum	-	-	-	-	-	-	-	-
Eupatorium pilosum	○○●●	-	-	○●●○	-	-	-	-
Eupatorium resinosum	-	-	-	-	-	-	-	-
Eupatorium serotinum	-	-	-	-	-	-	-	-
Euphorbia ipecacuanhae	-	-	-	-	-	-	-	-
Euthamia tenuifolia	○○●●	-	-	-	-	●●○○	-	-
Galium tinctorium	-	-	○●●●	-	-	●●●●	●●●●	-
Glechoma hederacea	-	-	-	-	-	-	-	●●○○
Glyceria canadensis	-	-	-	-	-	●●●●	-	-
Glyceria obtusa	○○●●	●●○○	-	●●●●	○●●○	●●●●	●●●●	-
Glyceria striata	-	-	●○●●	-	-	-	-	-
Glyceria x laxa	-	-	●●●●	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-
Habenaria lacera	-	-	-	-	-	-	-	-
Hibiscus moscheutos	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	LCLODESS 99	LELIOBRE 99	LHACHEST 97	LINCABIN 99	LLANDIND 99	LLANDMOS 99	LMORSESM 99	LUNIOMOS 99
Hypericum canadense	○○○●	-	-	-	-	-	●●●●	-
Hypericum denticulatum	-	-	-	-	-	-	○○○●	-
Hypericum mutilum	-	-	-	-	●●●●	○○○●	○●●●	-
Hypericum stragulum	-	-	-	-	-	-	-	-
Impatiens capensis	-	-	●●●●	-	-	-	-	●●●●
Iris prismatica	-	-	-	-	-	-	-	-
Iris versicolor	-	-	-	-	-	-	-	-
Isoetes echinospora	-	-	-	-	-	-	-	-
Juncus acuminatus	-	-	-	-	-	-	-	-
Juncus biflorus	-	-	-	-	-	-	-	-
Juncus caesariensis	-	-	-	-	-	-	-	-
Juncus canadensis	○○○●	-	-	-	-	-	-	-
Juncus effusus	-	-	●○○●	-	-	●●●●	○○○●	-
Juncus militaris	○○○●	-	-	-	-	-	-	-
Juncus pelocarpus	○○●●	-	-	-	-	-	-	-
Lachnanthes caroliniana	-	-	-	-	-	-	-	-
Leersia oryzoides	-	○●○○	●○●○	●●●●	●●●●	●●●●	●●●●	-
Lemna sp.	-	-	-	-	-	-	-	-
Lilium superbum	-	-	-	-	-	-	-	-
Lindernia dubia	-	-	-	-	-	-	-	-
Lobelia canbyi	-	-	-	-	-	-	-	-
Lobelia cardinalis	-	-	-	-	-	-	-	-
Lobelia nuttallii	-	-	-	-	-	-	-	-
Lophiola aurea	-	-	-	-	-	-	-	-
Ludwigia alternifolia	-	-	-	-	-	-	-	-
Ludwigia palustris	-	-	●●●○	-	●●●○	○●●●	○○●●	●○○●
Lycopodium alopecuroides	○○●●	-	-	-	-	-	-	-
Lycopodium appressum	-	-	-	-	-	-	-	-
Lycopodium obscurum	-	-	-	-	-	-	-	-
Lycopus uniflorus	-	○○●●	-	-	○○●●	●●●●	-	-
Lycopus virginicus	-	○○○●	●●○○	-	●○●○	●○○○	○●○○	-
Lysimachia terrestris	-	-	-	-	●●○●	●●●○	●●●●	-
Lythrum salicaria	-	-	-	-	-	-	-	-
Microstegium vimineum	-	-	●●●●	●○○○	●●●●	●●●●	-	●●●●
Mikania scandens	-	-	●○○○	-	○●●○	○○○●	-	-
Mimulus ringens	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	LCLODESS 99	LELIOBRE 99	LHACHEST 97	LINCABIN 99	LLANDIND 99	LLANDMOS 99	LMORSESM 99	LUNIOMOS 99
Mitchella repens	●○○○	●○○○	-	○●●●	-	-	-	-
Monotropa uniflora	-	-	-	-	-	-	-	-
Muhlenbergia torreyana	-	-	-	-	-	-	-	-
Muhlenbergia uniflora	-	-	-	-	-	-	-	-
Nuphar variegata	-	-	-	-	-	-	-	-
Nymphaea odorata	-	-	-	●○○○	-	-	○○●○	-
Onoclea sensibilis	-	-	●○○○	-	-	○○○●	-	-
Orontium aquaticum	-	-	-	●○○○	-	-	-	-
Osmunda cinnamomea	●●○○	●●●●	-	-	-	●○●●	-	●○○○
Osmunda regalis	○●○○	●●●●	-	-	-	○○●○	-	●○○○
Oxalis stricta	-	-	●●○●	-	-	-	-	○●●●
Oxypolis rigidior	-	-	-	-	-	-	-	-
Panicum clandestinum	-	-	●○○○	-	●●●●	●●●●	-	●●●●
Panicum dichotomum	●○●●	●●●●	-	●●●●	●●●●	●●●●	○●●●	-
Panicum ensifolium	-	-	-	-	-	-	-	-
Panicum lanuginosum var. lindheimeri	-	-	-	-	-	-	-	-
Panicum longifolium	-	-	-	-	-	-	-	-
Panicum rigidulum	-	-	-	-	-	-	-	-
Panicum scabriusculum	-	-	-	-	●●●●	-	-	-
Panicum sp.	-	-	-	-	-	-	-	-
Panicum spretum	-	-	-	-	-	-	-	-
Panicum verrucosum	-	-	-	○○●○	-	○○○●	●●●●	-
Panicum virgatum	-	-	-	-	-	-	-	-
Peltandra virginica	●●○●	-	●●●●	●●●●	●●○●	●●●●	○●●●	-
Phalaris arundinacea	-	-	●●●●	-	-	-	-	-
Phragmites australis	-	-	-	-	-	-	-	-
Phytolacca americana	-	-	-	-	-	-	-	-
Pilea pumila	-	-	-	-	-	-	-	●●●●
Poa palustris	-	-	-	-	-	-	-	●●●●
Poa pratensis	-	-	-	-	-	-	-	-
Pogonia ophioglossoides	○○●●	-	-	-	-	-	-	-
Polygala brevifolia	-	-	-	-	-	-	-	-
Polygala cruciata	○○●○	-	-	-	-	-	-	-
Polygonum arifolium	-	-	●●●●	-	-	-	-	-
Polygonum cespitosum	-	-	●●●●	-	○○●○	-	-	●●●●
Polygonum hydropiperoides	-	-	-	-	-	●●●●	-	-

Species	Sites and Survey Years							
	LCLODESS 99	LELIOBRE 99	LHACHEST 97	LINCABIN 99	LLANDIND 99	LLANDMOS 99	LMORSESM 99	LUNIOMOS 99
Polygonum punctatum	-	○○○●	●●●●	-	●●●●	-	●○●●	-
Polygonum sagittatum	-	-	●●●●	-	●●●○	●●●●	○○●●	○○●○
Polygonum sp.	-	-	-	-	-	-	-	-
Pontederia cordata	-	-	-	-	-	●●●○	-	-
Potamogeton confervoides	-	○●○●	-	-	-	●●●●	-	-
Potamogeton diversifolius	-	-	-	-	-	-	●○●●	-
Potamogeton epihydrus	-	-	●●●●	-	-	-	-	-
Potamogeton oakesianus	-	-	-	-	-	-	-	-
Potamogeton pusillus	-	-	○●●●	-	-	-	-	-
Proserpinaca pectinata	○○●●	-	-	-	-	-	○○●○	-
Pteridium aquilinum	-	-	-	-	-	-	-	-
Rhexia mariana	-	-	-	-	-	-	-	-
Rhexia virginica	○○●●	-	-	●○●●	-	●○○○	-	-
Rhynchospora alba	○○○●	-	-	-	-	-	-	-
Rhynchospora capitellata	-	-	-	-	-	-	-	-
Rhynchospora chalarocephala	-	-	-	-	-	-	-	-
Rorippa palustris	-	-	-	-	-	-	-	-
Sabatia difformis	-	-	-	-	-	-	-	-
Sagittaria engelmanniana	-	-	-	-	-	●○○○	-	-
Sarracenia purpurea	○○●●	-	-	-	-	-	-	-
Schizachyrium scoparium	-	-	-	-	-	-	-	-
Schizaea pusilla	-	-	-	-	-	-	-	-
Scirpus cyperinus	-	-	-	-	-	-	-	-
Scirpus pungens	-	-	-	-	-	-	-	-
Scirpus subterminalis	-	-	-	-	-	-	-	-
Scleria reticularis	-	-	-	-	-	-	-	-
Sclerolepis uniflora	-	-	-	-	-	-	-	-
Scutellaria lateriflora	-	-	-	-	-	-	-	-
Smilax herbacea	-	-	-	-	-	-	-	-
Smilax pseudochina	-	-	-	-	-	-	-	-
Solanum nigrum	-	-	-	-	-	-	-	-
Solidago canadensis	-	-	-	-	-	-	-	-
Solidago rugosa	-	-	-	-	-	-	-	-
Sparganium americanum	-	●●●●	○●●○	●○●●	●●●●	●●●●	●●●●	-
Spiranthes cernua	-	-	-	-	-	-	-	-
Stellaria graminea	-	-	-	-	-	-	-	●●●●

Species	Sites and Survey Years							
	LCLODESS 99	LELIOBRE 99	LHACHEST 97	LINCABIN 99	LLANDIND 99	LLANDMOS 99	LMORSESM 99	LUNIOMOS 99
Stellaria media	-	-	●●○○	-	-	-	-	-
Taraxacum officinale	-	-	-	-	-	-	-	○○●○
Thelypteris palustris	-	-	-	-	-	○○○●	-	-
Thelypteris simulata	-	●●●●	-	-	●●●○	●●●●	-	-
Triadenum virginicum	○○●●	○○●●	-	●●●●	●●●●	●●●●	●●●●	-
Trientalis borealis	-	-	-	-	-	-	-	-
Typha latifolia	-	-	●○○○	-	-	-	-	-
Urtica dioica	-	-	-	-	-	-	-	○●○○
Utricularia cornuta	-	-	-	-	-	-	-	-
Utricularia fibrosa	○○●●	-	-	-	-	-	-	-
Utricularia geminiscapa	-	-	-	-	-	-	-	-
Utricularia inflata	-	-	-	-	-	-	-	-
Utricularia purpurea	-	-	-	-	-	-	-	-
Utricularia sp.	-	-	-	-	-	-	-	-
Utricularia subulata	-	-	-	-	-	-	-	-
Utricularia vulgaris	-	-	-	-	-	-	-	-
Verbena hastata	-	-	-	-	-	-	-	-
Vernonia noveboracensis	-	-	-	-	-	-	-	-
Viola lanceolata	-	-	-	●●●○	●●●●	●●●●	-	-
Viola primulifolia	-	○○○●	-	○○●●	●○●●	-	●●●●	-
Viola sororia	-	-	-	-	-	-	-	●●●●
Woodwardia areolata	-	●●○●	●○○○	○●○○	●●●●	●●●●	-	○○○●
Woodwardia virginica	●●○○	-	●○○○	●●●●	○○●○	○●○○	-	-
Xerophyllum asphodeloides	-	-	-	-	-	-	-	-
Xyris difformis	○○○●	-	-	-	-	-	-	-
Xyris smalliana	-	-	-	-	-	-	-	-
Zizania aquatica	-	-	-	-	-	-	-	-
Woody plants:								
Acer rubrum	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Ailanthus altissima	-	-	-	-	-	-	-	○○●○
Alnus serrulata	-	-	-	-	-	○○○●	-	-
Amelanchier canadensis	○●○○	○●●○	-	-	-	-	-	-
Amelanchier obovalis	-	-	-	-	-	-	-	-
Aronia arbutifolia	●○○○	-	-	-	-	-	●●●○	-
Berberis thunbergii	-	-	-	-	-	-	-	●●●●
Betula lenta	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	LCLODESS 99	LELIOBRE 99	LHACHEST 97	LINCABIN 99	LLANDIND 99	LLANDMOS 99	LMORSESM 99	LUNIOMOS 99
Betula populifolia	-	-	-	-	-	-	-	-
Catalpa bignonioides	-	-	-	-	-	-	-	-
Cephalanthus occidentalis	-	-	-	-	-	-	-	-
Chamaecyparis thyoides	●●●●	●●●●	-	●●●●	-	●●●●	●●●●	-
Chamaedaphne calyculata	○○●○	-	-	-	-	-	-	-
Clematis terniflora	-	-	-	-	-	-	-	●●●●
Clethra alnifolia	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Diospyros virginiana	-	-	-	-	-	-	-	○●○○
Eubotrys racemosa	●●●●	○●●●	○○○●	●●●●	●●●●	●●○●	●●●●	○●○○
Gaultheria procumbens	-	-	-	-	-	-	-	-
Gaylussacia baccata	-	-	-	-	-	-	-	-
Gaylussacia dumosa	-	-	-	-	-	-	-	-
Gaylussacia frondosa	●●○●	-	-	-	-	-	-	-
Hudsonia ericoides	-	-	-	-	-	-	-	-
Hypericum densiflorum	-	-	-	-	-	-	-	-
Ilex glabra	○○●●	-	-	○●●○	-	-	○●○●	-
Ilex laevigata	○●○○	-	-	-	-	-	-	-
Ilex opaca	-	●○○○	-	○●●●	○○○●	●○○●	●●●●	●○●●
Ilex verticillata	-	-	-	-	-	●○○●	-	-
Itea virginica	-	●●●○	-	-	-	-	-	●○○○
Juniperus virginiana	-	-	-	-	-	-	-	-
Kalmia angustifolia	-	-	-	-	-	-	-	-
Kalmia latifolia	-	-	-	-	-	-	-	-
Leiophyllum buxifolium	-	-	-	-	-	-	-	-
Liquidambar styraciflua	-	-	-	-	-	-	-	-
Lonicera japonica	-	-	-	-	-	○○○●	-	-
Lyonia ligustrina	-	-	-	-	-	-	-	-
Lyonia mariana	-	-	-	-	-	-	-	-
Magnolia virginiana	●●●●	○●●●	-	●●●●	-	-	●●●●	-
Myrica pensylvanica	-	-	-	-	-	-	-	-
Nyssa sylvatica	●○●●	●○○○	-	○●●●	●○○●	●●○●	●●●○	○●●●
Parthenocissus quinquefolia	-	●○●○	-	-	●●●●	○●○●	-	●●●●
Pinus echinata	-	-	-	-	-	-	-	-
Pinus rigida	○○●●	-	-	-	-	-	○●○●	-
Pinus strobus	-	-	-	-	-	-	-	-
Platanus occidentalus	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	LCLODESS 99	LELIOBRE 99	LHACHEST 97	LINCABIN 99	LLANDIND 99	LLANDMOS 99	LMORSESM 99	LUNIOMOS 99
Prunus serotina	-	-	-	-	-	-	-	-
Quercus alba	-	-	-	-	-	●○○○	-	-
Quercus ilicifolia	-	-	-	-	-	●○○○	-	-
Quercus marilandica	-	-	-	-	-	-	-	-
Quercus sp. seedling	-	-	-	○○●●	-	-	-	-
Quercus stellata	-	-	-	-	-	-	-	-
Quercus velutina	-	-	-	-	-	-	-	-
Rhododendron viscosum	●●●●	●●●○	-	●●●●	○○●○	○●○○	○●●●	-
Rosa palustris	-	-	-	-	-	-	-	-
Rubus hispidus	●●○●	●●●●	-	○○●●	●●●●	●●●●	●●●○	●○○○
Rubus sp.	-	-	-	-	-	-	-	●○○●
Salix nigra	-	-	-	-	-	-	-	-
Sambucus canadensis	-	-	●○○●	-	○●○○	-	-	●●●○
Sassafras albidum	-	-	-	○○●○	-	-	-	-
Smilax glauca	-	●●●●	-	●○●●	●○○○	-	●●●●	-
Smilax laurifolia	●○●○	-	-	-	-	-	-	-
Smilax rotundifolia	●●○○	●●○●	○●●○	●●●●	●●●●	●●●●	●●●●	●●●●
Smilax walteri	-	-	-	-	-	-	-	-
Spiraea alba var. latifolia	-	-	-	-	-	-	-	-
Spiraea tomentosa	-	-	-	-	-	●●●○	-	-
Tilia americana	-	-	-	-	-	-	-	○○●○
Toxicodendron radicans	-	-	-	-	-	●○○○	-	○●○●
Toxicodendron vernix	-	-	-	-	-	-	-	-
Ulmus americana	-	-	-	-	-	-	-	●○○○
Vaccinium corymbosum	●●●●	●●●●	-	●●●●	●●●●	●●●●	●●●●	●○●●
Vaccinium macrocarpon	○●●●	-	-	-	-	-	-	-
Vaccinium pallidum	-	-	-	-	-	-	-	-
Viburnum dentatum	-	-	-	-	-	●●●○	-	●○○○
Viburnum nudum var. nudum	-	-	-	-	-	-	-	●○○○
Vitis labrusca	-	-	-	-	-	-	-	-

Appendix 2.4.1. Stream-vegetation monitoring sites in the Nescochague Creek drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Refer to methods for sampling details. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered by site code.

Site Name and Description	Site Code
Albertson Brook above Fleming Pike Waterford Twp., Camden Co. (lat 39°41'35.12", long 74°48'22.58", Hammonton quad). Section 1 begins 30 m upstream from Fleming Pike.	NALBFLEM
Albertson Brook above derelict bridge below Route 206 Hammonton Twp., Atlantic Co. (lat 39°41'40.59", long 74°44'38.23", Atsion quad). Section 1 begins 10 m upstream from derelict bridge, downstream from Route 206.	NALDEREL
Blue Anchor Brook above Pump Branch Waterford Twp., Camden Co. (lat 39°41'33.65", long 74°48'42.87", Hammonton quad). Section 1 begins 15 m upstream from confluence with Pump Branch.	NBLCONFL
Cedar Brook near Hammonton Airport Hammonton Twp., Atlantic Co. (lat 39°40'09.64", long 74°45'42.61", Hammonton quad). Section 1 ends 85 m downstream from bridge near Wharton State Forest boundary (25-m site).	NCEAIRPO
Great Swamp Branch below Route 613 Hammonton Twp., Atlantic Co. (lat 39°41'03.76", long 74°45'45.93", Hammonton quad). Section 4 ends 9 m downstream from Middle Road (Route 613).	NGRMIDDL
Nescochague Creek at Pleasant Mills Mullica Twp., Atlantic Co. (lat 39°38'37.35", long 74°39'46.31", Atsion quad). Section 1 begins approximately 0.5 km upstream from sand road bridge near church at Pleasant Mills.	NNEMILLS
Nescochague Creek near West Mill Road Washington Twp., Burlington Co. (lat 39°39'49.35", long 74°41'51.93", Atsion quad). Section 1 begins near West Mill Road, midway between Pleasant Mills and the confluence of Great Swamp Branch and Albertson Brook.	NNEWESTM
Pump Branch above dike near Winslow/Waterford boundary Winslow Twp., Camden Co. (lat 39°41'38.64", long 74°49'15.68", Hammonton quad). Section 1 begins 15 m upstream from breached dike near Winslow Township/Waterford Township boundary.	NPUMDIKE

Appendix 2.4.2 Plant species at stream-monitoring sites in the Nescochague River drainage basin. Circles indicate a species is present at a site. Filled circles indicate the 25-m section where it was found (e.g., "•○•○" means a species was located in the first and third sections of the 100-m study site). Refer to Appendix 2.4.1 for site descriptions and explanations of site codes. Plant common names are presented in Appendix 2.8.

Species	Sites and Survey Years							
	NALBFLEM 95	NALDEREL 98	NBLCONFL 95	NCEAIRPO 96	NGRMIDDL 98	NNEMILLS 98	NNEWESTM 99	NPUMDIKE 95
Herbaceous plants:								
Agrostis hyemalis	-	-	-	-	-	-	-	-
Agrostis hyemalis var. scabra	•○○○	-	-	-	-	-	-	-
Agrostis perennans	-	-	-	-	-	-	-	••••
Agrostis perennans var. elata	-	-	-	-	-	-	-	-
Agrostis sp.	-	-	-	-	○•••	○•○○	-	-
Alisma subcordatum	-	-	-	-	-	-	-	-
Allium sp.	-	-	-	-	-	-	-	-
Amphicarpum purshii	-	-	-	-	-	-	-	-
Andropogon virginicus var. abbreviatus	-	-	-	-	-	-	-	••••
Andropogon virginicus var. virginicus	-	-	-	-	-	-	-	-
Apios americana	-	-	-	-	○•○○	••○•	-	-
Aralia nudicaulis	-	-	-	•	-	-	-	-
Arethusa bulbosa	-	-	-	-	-	-	-	-
Asclepias incarnata	-	-	-	-	-	-	-	○○•○
Aster dumosus	-	-	-	-	-	-	-	-
Aster nemoralis	-	-	-	-	-	-	-	○○••
Aster novi-belgii	•○○○	•○••	•○○○	-	•○○○	•○○•	-	••••
Aster pilosus var. pringlei	-	-	-	-	-	-	-	-
Aster racemosus	-	-	-	•	-	-	-	-
Bartonia paniculata	-	-	-	-	-	-	-	••○○
Bartonia virginica	-	-	-	-	-	-	-	○○•○
Bidens connata	-	-	•○••	•	-	-	-	-
Bidens coronata	-	-	-	-	-	-	-	••••
Bidens discoidea	-	-	-	•	-	-	-	-
Bidens frondosa	-	••••	-	-	•••○	○•○•	-	•○••
Bidens sp.	•○••	-	-	-	-	-	-	-
Boehmeria cylindrica	••••	○••○	••••	•	••••	○••○	-	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	-	-	-	-	-	-	-	-
Callitriche heterophylla	••••	••••	••••	•	••••	-	-	-

Species	Sites and Survey Years							
	NALBFLEM 95	NALDEREL 98	NBLCONFL 95	NCEAIRPO 96	NGRMIDDL 98	NNEMILLS 98	NNEWESTM 99	NPUMDIKE 95
Cardamine pensylvanica	–	–	–	–	–	–	–	–
Carex albolutescens	○●●○	–	●●○●	–	–	○●●○	–	–
Carex atlantica	○●○○	–	–	–	–	–	–	●●●●
Carex atlantica var. capillacea	●●○●	–	–	–	–	–	–	○○●●
Carex bullata	–	–	–	–	–	–	–	–
Carex canescens	–	○●○○	–	–	–	–	–	○○○●
Carex collinsii	–	–	–	–	–	–	–	–
Carex crinita	–	–	–	–	–	–	–	–
Carex exilis	–	–	–	–	–	–	–	–
Carex folliculata	–	●○○○	–	–	–	–	–	●○○○
Carex intumescens	–	–	–	–	–	–	–	–
Carex livida	–	–	–	–	–	–	–	–
Carex longii	–	–	–	–	●○○●	–	–	–
Carex lurida	–	–	–	●	●●●●	–	–	–
Carex pensylvanica	–	–	–	–	–	○●●○	–	–
Carex scoparia	–	–	–	–	–	–	–	–
Carex stipata	–	–	–	●	–	–	–	–
Carex striata	–	–	–	–	–	–	–	●●●●
Carex stricta	–	–	–	–	–	–	–	–
Carex tribuloides	–	–	–	–	–	–	–	–
Carex trisperma	–	–	–	–	–	–	–	–
Carex venusta	–	–	–	–	–	–	–	–
Ceratophyllum echinatum	–	–	–	●	–	–	–	–
Chasmanthium laxum	–	–	–	–	–	–	–	–
Cinna arundinacea	–	–	–	●	–	–	–	–
Cladium mariscoides	–	–	–	–	–	–	–	–
Cuscuta sp.	●●●●	●○●●	○○○●	●	○●●●	●○○●	–	○●●●
Cyperus dentatus	–	–	–	–	–	●○○○	–	–
Cyperus erythrorhizos	–	–	–	–	●○○●	–	–	–
Cyperus odoratus	–	–	–	–	●●●●	–	–	–
Cyperus retrorsus	–	–	–	–	–	●○○○	–	–
Cyperus strigosus	–	●○●●	–	–	–	–	–	–
Danthonia sericea var. epilis	–	–	–	–	–	–	–	–
Decodon verticillatus	●●●●	●●○●	○●○○	–	●●●●	–	–	●●●●
Dioscorea villosa	–	●●○●	–	–	–	○○●○	–	–
Drosera filiformis	–	–	–	–	–	–	–	–

Species	NALBFLEM 95	NALDEREL 98	NBLCONFL 95	NCEAIRPO 96	NGRMIDDL 98	NNEMILLS 98	NNEWESTM 99	NPUMDIKE 95
Drosera intermedia	-	-	-	-	-	●○○○	-	●●●●
Drosera rotundifolia	-	-	-	-	-	-	-	-
Dryopteris carthusiana	-	-	-	●	-	-	-	-
Dulichium arundinaceum	-	○●●●	-	-	○○○●	○●○○	●●●●	●●●●
Echinochloa muricata	-	-	-	-	○○○●	-	-	-
Eleocharis acicularis	●●●●	○●○●	-	-	●●●●	-	-	●●●○
Eleocharis flavescens var. olivacea	-	-	-	-	-	●○○○	-	●○●○
Eleocharis microcarpa	-	-	-	-	-	-	-	-
Eleocharis ovata	-	-	-	-	●●●○	-	-	-
Eleocharis robbinsii	●●●●	-	-	-	-	-	-	●●●●
Eleocharis tenuis	●○○○	-	-	-	-	●●●●	●○○○	●●●●
Eleocharis tuberculosa	-	-	-	-	-	-	-	●●●●
Elodea nuttallii	-	-	-	-	-	-	-	-
Epilobium coloratum	-	-	-	-	-	-	-	-
Erechtites hieracifolia	-	-	-	-	-	-	●○○○	-
Erianthus giganteus	-	-	-	-	-	-	-	-
Eriocaulon aquaticum	-	-	-	-	-	-	-	-
Eriocaulon compressum	-	-	-	-	-	-	-	-
Eriocaulon decangulare	-	-	-	-	-	-	-	-
Eriophorum virginicum	-	-	-	-	-	-	-	●●●●
Eupatorium dubium	-	-	-	-	●●●●	●●●○	●●●●	-
Eupatorium perfoliatum	-	-	-	-	-	-	-	-
Eupatorium pilosum	-	-	-	-	-	-	-	-
Eupatorium resinosum	-	-	-	-	-	-	-	●●●●
Eupatorium serotinum	-	-	-	-	-	-	-	-
Euphorbia ipecacuanhae	-	-	-	-	-	-	-	-
Euthamia tenuifolia	-	-	-	-	-	●●○●	-	●●●●
Galium tinctorium	●●●●	●●●●	●●●●	●	●●●●	-	●●●●	○○○●
Glechoma hederacea	-	-	-	-	-	-	-	-
Glyceria canadensis	-	-	-	-	-	-	-	-
Glyceria obtusa	●○○○	●●●●	-	-	●●●●	○●●○	●●●●	●●●●
Glyceria striata	-	-	-	●	-	-	-	-
Glyceria x laxa	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-
Habenaria lacera	-	-	-	-	-	-	-	-
Hibiscus moscheutos	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	NALBFLEM 95	NALDEREL 98	NBLCONFL 95	NCEAIRPO 96	NGRMIDDL 98	NNEMILLS 98	NNEWESTM 99	NPUMDIKE 95
Hypericum canadense	–	–	–	–	–	●●●●	●●●○	●●●●
Hypericum denticulatum	–	–	–	–	–	●●●○	●●●●	–
Hypericum mutilum	●●●●	●●●●	○○●●	●	●●●●	●●●○	●○○●	●●○○
Hypericum stragulum	–	–	–	–	–	–	–	–
Impatiens capensis	●●●○	–	●●●●	●	●●●●	–	○●○○	–
Iris prismatica	–	–	–	–	–	○○○●	–	–
Iris versicolor	–	–	–	–	–	–	○●○○	–
Isoetes echinospora	–	–	–	–	–	–	–	–
Juncus acuminatus	–	–	–	–	○●○○	–	–	–
Juncus biflorus	–	–	–	–	–	–	–	–
Juncus caesariensis	–	–	–	–	–	–	–	–
Juncus canadensis	–	–	–	–	–	●○○○	–	●●●●
Juncus effusus	●●●●	○○●●	○○○●	●	●●●●	○●○●	●○●○	●●●●
Juncus militaris	–	●●●●	–	–	–	●●○●	●●●●	–
Juncus pelocarpus	–	–	–	–	–	–	–	●●●●
Lachnanthes caroliniana	–	–	–	–	–	●●○●	–	●●●●
Leersia oryzoides	●●○●	●●●●	–	–	●●●●	●●●○	●●●●	●●●●
Lemna sp.	–	–	–	●	–	–	–	–
Lilium superbum	–	–	–	–	–	–	–	–
Lindernia dubia	●●○○	–	–	–	○○○●	●●○○	–	–
Lobelia canbyi	–	–	–	–	–	–	–	–
Lobelia cardinalis	–	–	–	–	–	–	–	–
Lobelia nuttallii	–	–	–	–	–	–	–	–
Lophiola aurea	–	–	–	–	–	–	–	–
Ludwigia alternifolia	–	–	–	–	–	–	–	●○○●
Ludwigia palustris	●●●○	●●●●	●●●●	●	●●●●	●●●○	●○●●	–
Lycopodium alopecuroides	–	–	–	–	–	–	–	–
Lycopodium appressum	–	–	–	–	–	–	–	–
Lycopodium obscurum	–	–	–	–	–	–	–	–
Lycopus uniflorus	●○○●	●●●●	–	–	●●○○	●●●●	●●●●	●●●○
Lycopus virginicus	●●●●	○○○●	●●○●	●	○●●●	–	○●○●	–
Lysimachia terrestris	●○○○	●●●●	○○●○	–	●●●●	●●●●	●●●●	●●●●
Lythrum salicaria	–	–	–	–	–	–	–	–
Microstegium vimineum	–	–	–	–	–	○●●○	●●●●	–
Mikania scandens	●○○○	●●●●	●○●●	●	●●●●	○●○○	●●○●	–
Mimulus ringens	–	–	–	–	–	–	–	–

Species	Sites and Survey Years							
	NALBFLEM 95	NALDEREL 98	NBLCONFL 95	NCEAIRPO 96	NGRMIDDL 98	NNEMILLS 98	NNEWESTM 99	NPUMDIKE 95
Mitchella repens	-	-	○○○●	-	-	-	-	-
Monotropa uniflora	-	-	-	-	-	-	-	-
Muhlenbergia torreyana	-	-	-	-	-	-	-	-
Muhlenbergia uniflora	-	-	-	-	-	-	-	○○●●
Nuphar variegata	-	-	-	-	-	-	○○●○	-
Nymphaea odorata	-	-	-	-	-	-	○○●○	●●●●
Onoclea sensibilis	●●●●	●●○●	○○○●	●	●●●●	-	●●○●	○●○○
Orontium aquaticum	-	-	-	-	-	-	-	-
Osmunda cinnamomea	-	○○●○	●●●●	-	○●○○	-	○●●●	-
Osmunda regalis	○○○●	-	●●●○	-	-	●○○○	○●●○	●●○○
Oxalis stricta	-	-	-	●	●○○○	-	-	-
Oxypolis rigidior	-	●○○○	-	-	-	-	-	-
Panicum clandestinum	-	-	-	●	●○○○	-	-	-
Panicum dichotomum	-	-	-	-	-	●●●●	-	-
Panicum ensifolium	-	-	-	-	-	-	-	-
Panicum lanuginosum var. lindheimeri	-	-	-	-	-	-	●●●●	-
Panicum longifolium	-	-	-	-	-	●●●●	●○●○	●●○○
Panicum rigidulum	-	-	-	-	-	-	-	-
Panicum scabriusculum	-	-	-	-	-	●●●●	●●●○	●●●●
Panicum sp.	-	-	-	-	-	-	-	-
Panicum spretum	-	-	-	-	-	-	-	-
Panicum verrucosum	-	-	-	-	-	●●●○	●○●○	●●●●
Panicum virgatum	-	-	-	-	-	-	-	-
Peltandra virginica	●●●●	●●●●	○○●○	-	●●●●	●●●●	●●●●	●●●●
Phalaris arundinacea	-	-	-	-	-	-	-	-
Phragmites australis	-	-	-	-	-	-	-	-
Phytolacca americana	-	-	-	●	-	-	-	-
Pilea pumila	-	-	-	●	-	-	-	-
Poa palustris	-	-	-	-	-	-	-	-
Poa pratensis	-	-	-	-	-	-	-	-
Pogonia ophioglossoides	-	-	-	-	-	-	-	-
Polygala brevifolia	-	-	-	-	-	-	-	-
Polygala cruciata	-	-	-	-	-	-	-	●●●●
Polygonum arifolium	●●●○	-	-	●	●●●●	-	-	-
Polygonum cespitosum	-	-	●○●○	-	-	-	-	-
Polygonum hydropiperoides	-	●○●●	-	●	●●●●	●●●○	●○○●	○●○○

Species	Sites and Survey Years							
	NALBFLEM 95	NALDEREL 98	NBLCONFL 95	NCEAIRPO 96	NGRMIDDL 98	NNEMILLS 98	NNEWESTM 99	NPUMDIKE 95
Polygonum punctatum	●●●●	-	-	-	-	-	-	-
Polygonum sagittatum	-	-	○○○●	●	●●●●	-	●○○●	●○○○
Polygonum sp.	-	-	-	-	-	-	-	-
Pontederia cordata	-	○○○●	-	-	-	●○●○	●●●●	●●○○
Potamogeton confervoides	-	-	-	-	-	-	-	-
Potamogeton diversifolius	-	-	-	-	-	-	-	-
Potamogeton epihydrus	●●○●	-	-	-	●●●●	-	○○●○	●●●●
Potamogeton oakesianus	-	-	-	-	-	-	-	●●●●
Potamogeton pusillus	○○○●	-	●●●○	●	○○●○	-	-	-
Proserpinaca pectinata	-	-	-	-	-	-	-	-
Pteridium aquilinum	-	-	-	-	-	-	-	-
Rhexia mariana	-	-	-	-	-	-	-	-
Rhexia virginica	●○○○	-	○○○●	-	-	●●●○	●○●●	●○●○
Rhynchospora alba	-	-	-	-	-	-	-	●●●●
Rhynchospora capitellata	-	-	-	-	-	-	-	●●●●
Rhynchospora chalarocephala	-	-	-	-	-	-	-	●●●●
Rorippa palustris	-	-	-	-	-	-	-	-
Sabatia difformis	-	-	-	-	-	●●○●	●○○○	●○○○
Sagittaria engelmanniana	-	-	-	-	-	●●○○	●●○○	●●●●
Sarracenia purpurea	-	-	-	-	-	-	-	-
Schizachyrium scoparium	-	-	-	-	-	-	-	-
Schizaea pusilla	-	-	-	-	-	-	-	-
Scirpus cyperinus	-	-	-	-	●●○○	○●○○	○○○●	●○●○
Scirpus pungens	-	-	-	-	-	-	-	-
Scirpus subterminalis	●●○○	-	-	-	-	●●○○	-	●●●●
Scleria reticularis	-	-	-	-	-	-	-	○○●○
Sclerolepis uniflora	-	-	-	-	-	-	-	-
Scutellaria lateriflora	●○○○	●○○○	-	-	●●●●	○●○○	-	-
Smilax herbacea	-	-	-	-	-	-	-	-
Smilax pseudochina	-	-	-	-	-	-	-	-
Solanum nigrum	-	-	-	-	-	-	-	-
Solidago canadensis	-	-	-	-	-	-	-	-
Solidago rugosa	-	-	-	-	●●○○	-	-	-
Sparganium americanum	●●●●	●●●●	●●●●	●	●●●●	●●●●	●●●●	●●●●
Spiranthes cernua	-	-	-	-	-	-	-	-
Stellaria graminea	-	-	-	-	-	-	-	-

Species	NALBFLEM 95	NALDEREL 98	NBLCONFL 95	NCEAIRPO 96	NGRMIDDL 98	NNEMILLS 98	NNEWESTM 99	NPUMDIKE 95
Stellaria media	-	-	-	-	-	-	-	-
Taraxacum officinale	○○○●	-	○●○○	-	-	-	-	-
Thelypteris palustris	●○○●	-	-	-	●●●●	-	-	●●●●
Thelypteris simulata	-	○●●○	○○●○	-	-	-	-	-
Triadenum virginicum	●●●●	●●●●	-	-	-	●●●○	●●○●	●●●●
Trientalis borealis	-	-	-	-	-	-	-	-
Typha latifolia	-	-	-	-	●●●●	-	-	-
Urtica dioica	-	-	-	-	-	-	-	-
Utricularia cornuta	-	-	-	-	-	-	-	-
Utricularia fibrosa	-	-	-	-	-	-	-	○○●●
Utricularia geminiscapa	-	-	-	-	-	-	-	-
Utricularia inflata	-	-	-	-	-	-	-	-
Utricularia purpurea	-	-	-	-	-	-	-	●●●●
Utricularia sp.	-	-	-	-	-	-	○○●○	-
Utricularia subulata	-	-	-	-	-	-	-	-
Utricularia vulgaris	-	-	-	-	-	-	-	-
Verbena hastata	-	-	-	-	-	-	-	-
Vernonia noveboracensis	-	-	-	-	-	-	-	-
Viola lanceolata	●●●○	-	-	-	-	●●●●	●●●●	●●○●
Viola primulifolia	-	-	-	-	-	-	●○○○	-
Viola sororia	-	-	-	-	-	-	-	-
Woodwardia areolata	○●○○	○●●○	●●●○	●	●●●●	○○●○	○○●●	-
Woodwardia virginica	●○○○	-	○○●●	-	-	-	●○○○	○●○●
Xerophyllum asphodeloides	-	-	-	-	-	-	-	-
Xyris difformis	-	-	-	-	-	-	-	●●●○
Xyris smalliana	-	-	-	-	-	-	-	-
Zizania aquatica	-	-	-	-	-	-	-	-
Woody plants:								
Acer rubrum	●●●●	●●●●	●●●●	●	●●●●	●●●●	●●●●	●●●●
Ailanthus altissima	-	-	-	-	-	-	-	-
Alnus serrulata	●○○○	●●●●	-	-	-	-	-	●●●●
Amelanchier canadensis	-	-	-	-	-	-	-	-
Amelanchier obovalis	-	-	-	-	-	-	-	-
Aronia arbutifolia	-	●●●○	-	-	-	○○○●	○●○○	○●○○
Berberis thunbergii	-	-	-	-	-	-	-	-
Betula lenta	-	-	-	-	-	-	-	-

Species	NALBFLEM 95	NALDEREL 98	NBLCONFL 95	NCEAIRPO 96	NGRMIDDL 98	NNEMILLS 98	NNEWESTM 99	NPUMDIKE 95
Betula populifolia	-	-	-	-	-	-	-	-
Catalpa bignonioides	-	-	-	-	-	-	-	-
Cephalanthus occidentalis	●●○○	-	-	-	●●●●	●●○●	-	●●●○
Chamaecyparis thyoides	●●○○	●●●●	●●●●	-	●○○○	●●●●	-	●●●●
Chamaedaphne calyculata	-	○●●○	-	-	-	●●●●	-	●○○●
Clematis terniflora	-	-	-	-	-	-	-	-
Clethra alnifolia	●●●●	●●●●	●●●●	●	●●●●	●●●●	●●●●	○●○○
Diospyros virginiana	●○○○	-	-	-	-	-	-	-
Eubotrys racemosa	●●●●	●●●●	●○●○	-	●○●●	●●●●	●●●●	●●●●
Gaultheria procumbens	-	-	-	-	-	-	-	-
Gaylussacia baccata	-	-	-	-	-	-	-	-
Gaylussacia dumosa	-	●○○○	-	-	-	-	-	-
Gaylussacia frondosa	-	-	-	-	-	-	-	-
Hudsonia ericoides	-	-	-	-	-	-	-	-
Hypericum densiflorum	-	-	-	-	-	-	-	●●●●
Ilex glabra	-	●●○○	-	-	-	○○○●	●●●○	●●●○
Ilex laevigata	-	○○○●	-	-	-	-	-	-
Ilex opaca	-	●○○○	-	-	●●○○	-	-	-
Ilex verticillata	-	-	-	-	●●●○	-	-	●○●○
Itea virginica	-	○●●●	-	-	-	-	-	-
Juniperus virginiana	-	-	-	-	-	-	-	-
Kalmia angustifolia	-	-	-	-	-	●○○○	-	-
Kalmia latifolia	-	-	-	-	-	-	-	-
Leiophyllum buxifolium	-	-	-	-	-	●○○○	-	-
Liquidambar styraciflua	-	-	-	-	-	-	-	-
Lonicera japonica	-	-	-	●	-	-	-	-
Lyonia ligustrina	-	○●●●	-	-	●○○○	-	-	-
Lyonia mariana	-	-	-	-	-	-	-	-
Magnolia virginiana	-	○○●○	-	-	-	-	-	-
Myrica pensylvanica	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	○○●●	●	○○○●	-	-	-
Parthenocissus quinquefolia	○●○○	-	●●○●	●	●●●●	-	-	-
Pinus echinata	-	-	-	-	-	-	-	-
Pinus rigida	-	○○○●	-	-	-	●●●●	-	-
Pinus strobus	-	-	-	-	-	-	-	-
Platanus occidentalus	-	-	-	●	-	-	-	-

Species	NALBFLEM 95	NALDEREL 98	NBLCONFL 95	NCEAIRPO 96	NGRMIDDL 98	NNEMILLS 98	NNEWESTM 99	NPUMDIKE 95
Prunus serotina	-	-	-	•	-	-	-	-
Quercus alba	-	-	-	-	-	-	-	-
Quercus ilicifolia	-	-	-	-	-	-	-	-
Quercus marilandica	-	-	-	-	-	-	-	-
Quercus sp. seedling	-	-	-	-	-	-	-	-
Quercus stellata	-	-	-	-	-	-	-	-
Quercus velutina	-	-	-	-	-	-	-	-
Rhododendron viscosum	○●○○	●●●●	-	-	-	●●●○	●●●●	-
Rosa palustris	-	-	○●○○	-	-	-	-	○○●○
Rubus hispidus	○●●○	○○○●	●●●●	-	○●○○	-	-	●●●●
Rubus sp.	-	-	-	•	●●●●	-	-	-
Salix nigra	-	-	-	-	-	-	-	-
Sambucus canadensis	-	-	-	-	●●●●	-	-	-
Sassafras albidum	-	-	-	-	-	-	-	-
Smilax glauca	-	●○○○	●○○●	-	-	○●○●	○○○●	●○○○
Smilax laurifolia	-	-	-	-	-	-	-	-
Smilax rotundifolia	●●●●	●○●●	●●●●	•	●●●●	●●●●	●●○●	○○○●
Smilax walteri	-	-	-	-	-	-	-	-
Spiraea alba var. latifolia	-	-	-	-	-	-	-	-
Spiraea tomentosa	-	-	-	-	●●○○	○○○●	-	●●●●
Tilia americana	-	-	-	-	-	-	-	-
Toxicodendron radicans	●○○○	●●●●	●●●●	•	○○●○	-	●●○○	-
Toxicodendron vernix	-	-	-	-	-	-	-	-
Ulmus americana	-	-	-	-	-	-	-	-
Vaccinium corymbosum	●●●●	●●○●	●●●●	•	●●●○	●●●●	●○●●	●●●●
Vaccinium macrocarpon	-	-	-	-	-	●●●●	-	●●●○
Vaccinium pallidum	-	-	-	-	-	-	-	-
Viburnum dentatum	●○○○	-	-	-	-	-	-	-
Viburnum nudum var. nudum	-	○●●●	-	-	-	-	●○●○	-
Vitis labrusca	-	-	-	•	○●●●	-	-	-

Appendix 2.5.1. Stream-vegetation monitoring sites in the Sleeper Branch drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Refer to methods for sampling details. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered by site code.

Site Name and Description	Site Code
Clark Branch above Burnt Mill Road Waterford Twp., Camden Co. (lat 39°42'48.47", long 74°46'40.16", Hammonton quad). Section 1 begins at culvert on upstream side of Burnt Mill Road (25-m site). *Latitude and longitude values were obtained using ArcView Software.	MCLBURNT
Clark Branch at Parkdale Waterford Twp., Camden Co. (lat 39°43'00.60", long 74°45'18.56", Hammonton quad). Section 4 ends 8 m downstream from Johnson Road, at Parkdale.	MCLJOHNS
Cooper Branch above Burnt Mill Road Waterford Twp., Camden Co. (lat 39°44'50.04", long 74°50'44.07", Hammonton quad). Section 1 ends approximately 80 m south of intersection of Burnt Mill Road and Tremont Avenue (25-m site).	MCOBURNT
Hays Mill Creek above Tremont Avenue Waterford Twp., Camden Co. (lat 39°45'02.70", long 74°50'27.27", Medford Lakes quad). Section 1 begins 5 m upstream from Tremont Avenue.	MHATREMO
Price Branch below Burnt Mill Road Waterford Twp., Camden Co. (lat 39°43'19.53", long 74°47'48.02", Hammonton quad). Section 1 ends 11 m downstream from Burnt Mill Road (25-m site).	MPRBURNT
Sleeper Branch at Parkdale Waterford Twp., Camden Co. (lat 39°43'10.05", long 74°45'02.71", Hammonton quad). Section 3 begins at breached dike near Parkdale, upstream from Camden County/Atlantic County boundary.	MSLEPARK
Sleeper Branch at Maple Island Waterford Twp., Camden Co. (lat 39°44'15.17", long 74°48'53.84", Hammonton quad). Section 4 ends at trail crossing near east end of Maple Island.	MSLMAPLE
Sleeper Branch above Mullica River Mullica Twp., Atlantic Co. (lat 39°38'48.59", long 74°39'38.86", Atsion quad). Section 4 ends 21 m downstream from small footbridge, upstream from confluence with Mullica River.	MSLPLEAS
Sleeper Branch diversion (Saltars Ditch) Waterford Twp., Camden Co. (lat 39°43'55.09", long 74°45'58.84", Hammonton quad). Section 1 ends at sand road crossing east of intersection of Burnt House and Maple Island Roads (25-m site).	MSLSALTD
Wildcat Branch below Burnt Mill Road Waterford Twp., Camden Co. (lat 39°44'21.08", long 74°49'58.00", Hammonton quad). Section 1 ends 7 m downstream from Burnt Mill Road (25-m site).	MWIBURNT

Appendix 2.5.2 Plant species at stream-monitoring sites in the Sleeper Branch drainage basin. Circles indicate a species is present at a site. Filled circles indicate the 25-m section where it was found (e.g., "●○●○" means a species was located in the first and third sections of the 100-m study site). Refer to Appendix 2.5.1 for site descriptions and explanations of site codes. Plant common names are presented in Appendix 2.8.

Species	Sites and Survey Years									
	MCLBURNT	MCLJOHNS	MCOBURNT	MHATREMO	MPRBURNT	MSLEPARK	MSLMAPLE	MSLPLEAS	MSLSALTD	MWIBURNT
	96	98	96	96	96	98	96	98	96	96
Herbaceous plants:										
Agrostis hyemalis	-	-	-	-	-	-	-	-	-	-
Agrostis hyemalis var. scabra	-	-	-	-	●	-	-	-	-	-
Agrostis perennans	-	-	-	-	-	-	-	-	-	-
Agrostis perennans var. elata	-	-	-	-	-	-	-	-	-	-
Agrostis sp.	-	-	-	-	-	-	-	-	-	-
Alisma subcordatum	-	-	-	-	-	-	-	-	-	-
Allium sp.	-	-	-	-	-	-	-	-	-	-
Amphicarpum purshii	-	-	-	-	-	-	-	-	-	-
Andropogon virginicus var. abbreviatus	-	-	●	-	-	-	-	-	●	-
Andropogon virginicus var. virginicus	-	-	-	-	-	-	-	-	-	-
Apios americana	-	-	-	○○●○	-	●○○●	●●○○	-	-	-
Aralia nudicaulis	-	-	-	-	-	-	-	-	-	-
Arethusa bulbosa	-	-	-	-	-	-	-	-	-	-
Asclepias incarnata	-	-	-	-	-	-	-	-	-	-
Aster dumosus	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	-	●○○●	-	-	-	○●●●	-	-	-	-
Aster novi-belgii	●	●●●●	-	○○●○	-	●●●●	○○○●	-	-	●
Aster pilosus var. pringlei	-	-	-	-	-	-	-	-	-	-
Aster racemosus	-	-	-	-	-	-	-	-	-	-
Bartonia paniculata	-	●●●●	●	-	-	●○○○	-	○●●○	-	-
Bartonia virginica	-	●○○○	●	-	-	●●○○	-	●●○●	-	-
Bidens connata	-	-	-	-	-	-	-	-	-	●
Bidens coronata	-	-	-	-	-	-	-	-	-	-
Bidens discoidea	-	-	-	-	-	-	-	-	-	-
Bidens frondosa	-	-	-	-	-	-	●○●●	-	-	-
Bidens sp.	-	-	-	-	-	-	-	-	-	-
Boehmeria cylindrica	-	-	-	-	-	-	-	-	-	-
Calamagrostis canadensis	-	-	-	-	-	○○○●	-	-	-	-
Calamagrostis cinnoides	-	-	-	-	-	-	-	-	-	-
Callitriche heterophylla	-	-	-	●●●●	-	-	●●●●	-	-	●

Species	MCLBURNT 96	MCLJOHNS 98	MCOBURNT 96	MHATREMO 96	MPRBURNT 96	MSLEPARK 98	MSLMAPLE 96	MSLPLEAS 98	MSLSALTD 96	MWIBURNT 96
Cardamine pensylvanica	–	–	–	–	–	–	–	–	–	–
Carex albolutescens	–	–	–	○○●○	–	–	–	–	–	–
Carex atlantica	●	–	●	–	–	–	–	○○●●	●	–
Carex atlantica var. capillacea	–	–	●	●○●○	–	–	●●●●	–	–	●
Carex bullata	–	●○○●	–	–	–	–	–	●●●●	–	–
Carex canescens	–	–	–	–	–	–	–	–	–	●
Carex collinsii	–	–	–	–	–	–	–	–	–	–
Carex crinita	–	–	–	–	–	–	–	–	–	–
Carex exilis	–	–	–	–	–	–	–	○○●●	–	–
Carex folliculata	–	–	●	–	–	–	●●○●	–	–	–
Carex intumescens	–	–	–	–	–	–	–	–	–	–
Carex livida	–	–	–	–	–	–	–	–	–	–
Carex longii	–	–	–	–	–	–	–	–	–	–
Carex lurida	–	–	–	–	–	–	–	–	–	●
Carex pensylvanica	–	–	–	–	–	–	–	–	–	–
Carex scoparia	–	–	●	–	–	–	–	–	–	–
Carex stipata	–	–	–	–	–	–	–	–	–	–
Carex striata	–	●●●●	–	–	–	○○●●	–	○○○●	●	–
Carex stricta	–	–	–	–	–	○●○○	–	○●○○	–	–
Carex tribuloides	–	–	–	–	–	–	–	–	–	–
Carex trisperma	–	–	–	–	–	–	–	–	–	–
Carex venusta	–	–	–	–	–	–	–	–	–	–
Ceratophyllum echinatum	–	–	–	–	–	–	–	–	–	–
Chasmanthium laxum	–	–	–	–	–	–	–	–	–	–
Cinna arundinacea	–	–	–	–	–	–	–	–	–	–
Cladium mariscoides	–	●●○○	–	–	–	–	–	–	–	–
Cuscuta sp.	–	–	–	●●○○	●	○○○●	●●○●	○○●●	–	●
Cyperus dentatus	–	–	–	–	–	–	–	●●○●	–	–
Cyperus erythrorhizos	–	–	–	–	–	–	–	–	–	–
Cyperus odoratus	–	–	–	–	–	–	–	–	–	–
Cyperus retrorsus	–	–	–	–	–	–	–	–	–	–
Cyperus strigosus	–	–	–	–	–	–	–	–	–	–
Danthonia sericea var. epilis	–	–	–	–	–	–	–	–	–	–
Decodon verticillatus	–	–	●	○○●●	–	●●○●	–	–	–	●
Dioscorea villosa	–	–	–	–	●	–	–	–	–	●
Drosera filiformis	–	–	–	–	–	–	–	○○●●	–	–

Species	MCLBURNT 96	MCLJOHNS 98	MCOBURNT 96	MHATREMO 96	MPRBURNT 96	MSLEPARK 98	MSLMAPLE 96	MSLPLEAS 98	MSLSALTD 96	MWIBURNT 96
Drosera intermedia	-	○●○●	-	-	-	-	-	●●●●	-	-
Drosera rotundifolia	-	-	-	-	-	-	-	○○●●	-	-
Dryopteris carthusiana	-	-	-	-	-	-	-	-	-	-
Dulichium arundinaceum	●	●●●●	●	-	-	●●●●	●○○○	●●●●	●	-
Echinochloa muricata	-	-	-	-	-	-	-	-	-	-
Eleocharis acicularis	-	-	-	-	-	-	-	-	-	-
Eleocharis flavescens var. olivacea	-	●●○○	-	-	-	○●●○	-	○●●●	-	-
Eleocharis microcarpa	-	-	-	-	-	●○○○	-	-	-	-
Eleocharis ovata	-	-	-	-	-	-	●○○○	-	-	-
Eleocharis robbinsii	-	●●●●	-	-	-	○●●●	-	○●●●	-	-
Eleocharis tenuis	-	●●●●	-	-	-	●●●●	-	●●●●	-	-
Eleocharis tuberculosa	-	-	-	-	-	●○●○	-	○●●●	-	-
Elodea nuttallii	-	-	-	-	-	-	-	-	-	-
Epilobium coloratum	-	-	-	-	-	-	-	-	-	-
Erechtites hieracifolia	-	-	-	-	-	-	-	-	-	-
Erianthus giganteus	-	-	-	-	-	-	-	-	-	-
Eriocaulon aquaticum	-	○○○●	-	-	-	-	-	-	-	-
Eriocaulon compressum	-	-	-	-	-	-	-	-	-	-
Eriocaulon decangulare	-	-	-	-	-	-	-	-	-	-
Eriophorum virginicum	-	-	-	-	-	-	-	-	-	-
Eupatorium dubium	-	-	-	○●○●	-	-	-	-	-	●
Eupatorium perfoliatum	-	-	-	-	-	-	-	-	-	-
Eupatorium pilosum	-	-	-	-	-	-	-	-	-	-
Eupatorium resinosum	-	-	-	-	-	○○○●	-	-	-	-
Eupatorium serotinum	-	-	-	-	-	-	-	-	-	-
Euphorbia ipecacuanhae	-	-	-	-	-	-	-	-	-	-
Euthamia tenuifolia	-	-	-	-	-	○○○●	-	○○○●	-	-
Galium tinctorium	-	-	-	-	●	●○○○	-	-	-	●
Glechoma hederacea	-	-	-	-	-	-	-	-	-	-
Glyceria canadensis	-	-	-	-	-	-	-	-	-	-
Glyceria obtusa	-	●●●●	-	-	-	●●●●	-	●●●●	●	-
Glyceria striata	-	-	-	-	●	-	-	-	-	●
Glyceria x laxa	-	-	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-	-	-
Habenaria lacera	-	-	-	-	-	-	-	-	-	●
Hibiscus moscheutos	-	-	-	-	-	-	-	-	-	-

Species	MCLBURNT 96	MCLJOHNS 98	MCOBURNT 96	MHATREMO 96	MPRBURNT 96	MSLEPARK 98	MSLMAPLE 96	MSLPLEAS 98	MSLSALTD 96	MWIBURNT 96
Hypericum canadense	–	○●○●	–	–	–	○●●●	○○●○	○●○○	–	–
Hypericum denticulatum	–	–	–	–	–	–	–	–	–	–
Hypericum mutilum	–	–	–	○●●○	–	–	○○●○	–	–	–
Hypericum stragulum	–	–	–	–	–	–	–	–	–	–
Impatiens capensis	–	–	–	●●●●	–	–	–	–	–	●
Iris prismatica	–	–	–	–	–	–	–	–	–	–
Iris versicolor	–	–	–	–	–	○○○●	●●●○	–	●	–
Isoetes echinospora	–	–	–	–	–	–	–	–	–	–
Juncus acuminatus	–	–	–	–	–	–	–	–	–	–
Juncus biflorus	–	–	–	–	–	–	–	–	–	–
Juncus caesariensis	–	–	–	–	–	–	–	–	–	–
Juncus canadensis	–	○●●○	●	–	–	○○●○	–	○○○●	–	–
Juncus effusus	–	●●○●	–	–	●	●○●●	–	–	–	–
Juncus militaris	–	–	–	–	–	○○●●	–	●●●●	–	–
Juncus pelocarpus	–	●○●●	–	–	●	○●●○	–	●●●●	–	–
Lachnanthes caroliniana	–	●●○○	–	–	–	○○●●	–	●●●●	–	–
Leersia oryzoides	–	●●●●	●	●○●●	●	●●●●	●●●●	●●●●	●	●
Lemna sp.	–	–	–	–	–	–	–	–	–	–
Lilium superbum	–	–	–	–	–	–	–	–	–	–
Lindernia dubia	–	–	–	○●○○	–	–	○○●○	–	–	–
Lobelia canbyi	–	–	–	–	–	–	–	–	–	–
Lobelia cardinalis	–	–	–	○●○○	–	–	–	–	–	–
Lobelia nuttallii	–	–	–	–	–	–	–	–	–	–
Lophiola aurea	–	–	–	–	–	–	–	–	–	–
Ludwigia alternifolia	–	–	–	–	–	–	–	–	–	–
Ludwigia palustris	–	–	–	○●●○	●	–	●●●●	–	●	●
Lycopodium alopecuroides	–	–	–	–	–	–	–	○○●●	–	–
Lycopodium appressum	–	–	–	–	–	–	–	–	–	–
Lycopodium obscurum	–	–	–	–	–	–	–	–	–	–
Lycopus uniflorus	–	●●●●	–	–	●	●●○●	●○○○	○●○○	●	–
Lycopus virginicus	–	–	–	○●●○	●	–	●●○○	–	–	●
Lysimachia terrestris	–	●●●●	–	–	–	●●●●	○○●○	●●●●	●	●
Lythrum salicaria	–	–	–	–	–	–	–	–	–	–
Microstegium vimineum	–	–	–	–	–	–	–	–	–	–
Mikania scandens	–	–	–	○●○○	–	–	●●●●	–	–	●
Mimulus ringens	–	–	–	–	–	–	–	–	–	–

Species	Sites and Survey Years									
	MCLBURNT	MCLJOHNS	MCOBURNT	MHATREMO	MPRBURNT	MSLEPARK	MSLMAPLE	MSLPLEAS	MSLSALTD	MWIBURNT
	96	98	96	96	96	98	96	98	96	96
Mitchella repens	–	–	–	○○●○	●	–	●○○○	–	–	●
Monotropa uniflora	–	–	–	–	–	–	–	–	–	–
Muhlenbergia torreyana	–	–	–	–	–	–	–	–	–	–
Muhlenbergia uniflora	–	–	–	–	–	–	–	○●○○	–	–
Nuphar variegata	●	●○○○	–	–	–	○●●●	–	●○●○	–	–
Nymphaea odorata	–	●●●●	●	–	–	○●●○	–	●●●●	–	–
Onoclea sensibilis	–	–	–	○●●○	–	–	–	–	–	–
Orontium aquaticum	●	–	–	–	–	–	–	–	●	–
Osmunda cinnamomea	●	●○○●	●	●●●●	●	●○○○	●●○●	○○●●	●	–
Osmunda regalis	–	–	–	–	–	–	–	○○○●	–	–
Oxalis stricta	–	–	–	–	–	–	–	–	–	–
Oxypolis rigidior	–	–	–	–	–	–	●○○○	–	–	–
Panicum clandestinum	–	–	–	–	–	–	–	–	–	●
Panicum dichotomum	–	–	–	–	–	–	–	–	–	●
Panicum ensifolium	–	–	–	–	–	–	–	–	–	–
Panicum lanunigosum var. lindheimeri	–	–	–	–	–	–	–	–	–	–
Panicum longifolium	–	●○○●	–	–	–	○○●●	–	●●●●	–	–
Panicum rigidulum	–	–	–	–	–	–	–	–	–	–
Panicum scabriusculum	–	–	–	–	–	–	–	●●●●	–	–
Panicum sp.	–	–	–	–	–	–	–	–	–	–
Panicum spretum	–	–	–	–	–	–	–	–	–	–
Panicum verrucosum	–	○●○○	●	○○●○	–	–	–	○●●○	–	–
Panicum virgatum	–	–	–	–	–	–	–	●○○○	–	–
Peltandra virginica	–	●●●●	–	●●●●	–	●●●●	●●●○	●●●●	●	–
Phalaris arundinacea	–	–	–	–	–	–	–	–	–	–
Phragmites australis	–	–	–	–	–	○●○○	–	–	–	–
Phytolacca americana	–	–	–	–	–	–	–	–	–	–
Pilea pumila	–	–	–	–	–	–	–	–	–	–
Poa palustris	–	–	–	–	–	–	–	–	–	–
Poa pratensis	–	–	–	–	–	–	–	–	–	–
Pogonia ophioglossoides	–	–	–	–	–	–	–	–	–	–
Polygala brevifolia	–	–	–	–	–	–	–	–	–	–
Polygala cruciata	–	–	–	–	–	–	–	○●●●	–	–
Polygonum arifolium	–	–	–	–	–	–	–	–	–	–
Polygonum cespitosum	–	–	–	–	–	–	–	–	–	–
Polygonum hydropiperoides	–	–	–	–	●	–	–	–	–	●

Species	Sites and Survey Years									
	MCLBURNT	MCLJOHNS	MCOBURNT	MHATREMO	MPRBURNT	MSLEPARK	MSLMAPLE	MSLPLEAS	MSLSALTD	MWIBURNT
	96	98	96	96	96	98	96	98	96	96
Polygonum punctatum	-	-	●	○○●○	-	-	●○○●	-	-	-
Polygonum sagittatum	-	-	-	-	-	-	●○○○	-	-	-
Polygonum sp.	-	-	-	-	-	-	-	-	-	-
Pontederia cordata	-	●●●●	-	-	-	●●●●	-	○●○○	-	-
Potamogeton confervoides	-	-	-	-	-	-	-	-	-	●
Potamogeton diversifolius	-	-	-	-	-	-	-	-	-	-
Potamogeton epihydrus	-	-	-	-	-	-	○○●●	-	-	-
Potamogeton oakesianus	-	-	-	-	-	-	-	-	-	-
Potamogeton pusillus	-	-	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	○○○●	-	-	-	-	-	-	-	-
Pteridium aquilinum	-	-	-	-	-	-	-	-	-	-
Rhexia mariana	-	-	-	-	-	-	-	-	-	-
Rhexia virginica	-	●●●●	-	-	-	●○○●	-	●●●●	-	-
Rhynchospora alba	-	-	●	-	-	○○●○	-	○●●●	-	-
Rhynchospora capitellata	-	-	●	-	-	●○●○	-	●●●●	-	-
Rhynchospora chalarocephala	-	-	-	-	-	-	-	-	-	-
Rorippa palustris	-	-	-	-	-	-	-	-	-	-
Sabatia difformis	-	-	-	-	-	-	-	-	-	-
Sagittaria engelmanniana	-	●●●●	-	-	-	○○●●	-	●●●●	-	-
Sarracenia purpurea	-	-	-	-	-	-	-	-	-	-
Schizachyrium scoparium	-	-	-	-	-	-	-	-	-	-
Schizaea pusilla	-	-	-	-	-	-	-	○○○●	-	-
Scirpus cyperinus	●	○○○●	●	-	●	●○●●	-	-	●	●
Scirpus pungens	-	-	-	-	-	-	-	-	-	-
Scirpus subterminalis	-	●●●●	-	●●○●	●	○○○●	○●○●	●●●●	-	-
Scleria reticularis	-	-	-	-	-	-	-	-	-	-
Sclerolepis uniflora	-	-	-	-	-	-	-	-	-	-
Scutellaria lateriflora	-	-	-	●●○○	-	-	○○○●	-	-	-
Smilax herbacea	-	-	-	-	-	-	-	-	-	-
Smilax pseudochina	-	-	-	-	-	-	-	-	-	-
Solanum nigrum	-	-	-	-	-	-	-	-	-	-
Solidago canadensis	-	-	-	-	-	-	-	-	-	-
Solidago rugosa	-	-	-	-	-	-	-	-	-	-
Sparganium americanum	-	●●●●	-	●●●●	●	●●●●	●●●●	-	●	●
Spiranthes cernua	-	-	-	-	-	-	-	-	-	-
Stellaria graminea	-	-	-	-	-	-	-	-	-	-

Species	MCLBURNT 96	MCLJOHNS 98	MCOBURNT 96	MHATREMO 96	MPRBURNT 96	MSLEPARK 98	MSLMAPLE 96	MSLPLEAS 98	MSLSALTD 96	MWIBURNT 96
Stellaria media	-	-	-	-	-	-	-	-	-	-
Taraxacum officinale	-	-	-	-	-	-	-	-	-	-
Thelypteris palustris	-	-	-	-	-	-	-	-	-	•
Thelypteris simulata	-	-	•	-	-	-	-	-	-	-
Triadenum virginicum	•	••••	-	-	-	••••	•••○	••••	•	•
Trientalis borealis	-	-	-	-	-	-	-	-	-	-
Typha latifolia	-	-	-	-	-	-	-	-	-	-
Urtica dioica	-	-	-	-	-	-	-	-	-	-
Utricularia cornuta	-	-	-	-	-	-	-	-	-	-
Utricularia fibrosa	-	•○○○	-	-	-	-	-	-	-	-
Utricularia geminiscapa	•	-	-	-	-	-	-	-	-	-
Utricularia inflata	-	-	-	-	-	-	-	-	-	-
Utricularia purpurea	-	-	-	-	-	-	-	-	-	-
Utricularia sp.	-	-	-	-	-	-	-	•○••	-	-
Utricularia subulata	-	-	-	-	-	-	-	-	-	-
Utricularia vulgaris	-	-	-	-	-	-	-	-	-	-
Verbena hastata	-	-	-	-	-	-	-	-	-	-
Vernonia noveboracensis	-	-	-	-	-	-	-	-	-	-
Viola lanceolata	-	••○•	-	-	•	••••	-	••••	-	-
Viola primulifolia	-	-	-	-	•	-	-	-	-	-
Viola sororia	-	-	-	-	-	-	-	-	-	-
Woodwardia areolata	-	•••○	•	••••	-	-	○•○○	○○○•	•	•
Woodwardia virginica	•	••••	•	○•○•	•	-	••••	-	-	-
Xerophyllum asphodeloides	-	-	-	-	-	-	-	-	•	-
Xyris difformis	-	-	-	-	-	-	-	○•••	-	-
Xyris smalliana	-	-	-	-	-	-	-	-	-	-
Zizania aquatica	-	-	-	-	-	-	-	-	-	-
Woody plants:										
Acer rubrum	•	••••	•	••••	•	•••○	••••	••••	-	•
Ailanthus altissima	-	-	-	-	-	-	-	-	-	-
Alnus serrulata	-	-	-	•○○○	-	-	○○••	-	-	-
Amelanchier canadensis	•	-	-	-	-	-	-	-	•	-
Amelanchier obovalis	-	-	-	-	-	-	-	-	•	-
Aronia arbutifolia	•	-	-	-	•	••○○	○○•○	-	-	•
Berberis thunbergii	-	-	-	-	-	-	-	-	-	-
Betula lenta	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	MCLBURNT 96	MCLJOHNS 98	MCOBURNT 96	MHATREMO 96	MPRBURNT 96	MSLEPARK 98	MSLMAPLE 96	MSLPLEAS 98	MSLSALTD 96	MWIBURNT 96
Betula populifolia	-	-	-	-	-	-	-	-	-	-
Catalpa bignonioides	-	-	-	-	-	-	-	-	-	-
Cephalanthus occidentalis	-	-	-	-	-	-	-	-	-	-
Chamaecyparis thyoides	●	●●●●	●	●○●○	●	○●○○	●●●●	●●●●	●	-
Chamaedaphne calyculata	-	●●●●	-	-	-	○●○○	-	●●●●	●	-
Clematis terniflora	-	-	-	-	-	-	-	-	-	-
Clethra alnifolia	●	●●●●	●	●●●●	●	●●●●	●●●●	●●●●	●	●
Diospyros virginiana	-	-	-	-	●	-	-	-	-	-
Eubotrys racemosa	●	○○●●	●	●●●○	●	●●●○	●●●●	○○●●	●	●
Gaultheria procumbens	-	-	-	-	-	-	-	○○●○	●	-
Gaylussacia baccata	-	-	-	-	-	-	-	-	●	-
Gaylussacia dumosa	-	-	-	-	-	-	-	○○○●	●	-
Gaylussacia frondosa	●	-	-	-	-	-	-	-	●	-
Hudsonia ericoides	-	-	-	-	-	-	-	-	●	-
Hypericum densiflorum	-	●○●○	-	-	-	-	-	○○○●	-	-
Ilex glabra	-	-	-	-	-	-	○○●○	○●●●	●	-
Ilex laevigata	-	-	-	-	-	-	-	-	-	-
Ilex opaca	-	-	-	●●●○	-	-	●○●○	○○○●	-	-
Ilex verticillata	-	-	●	●●●●	●	-	●●●○	-	-	●
Itea virginica	-	-	-	-	-	-	-	-	-	-
Juniperus virginiana	-	-	-	-	-	-	-	-	-	-
Kalmia angustifolia	-	●○○○	-	-	-	○●●○	-	○○●●	●	-
Kalmia latifolia	-	-	-	●●●○	●	-	●●●○	-	-	●
Leiophyllum buxifolium	-	-	-	-	-	-	-	○○○●	-	-
Liquidambar styraciflua	-	-	-	-	-	-	-	○●○○	-	-
Lonicera japonica	-	-	-	-	-	-	-	-	-	-
Lyonia ligustrina	-	○●○●	●	●●●●	●	●●○○	●●●○	-	-	-
Lyonia mariana	-	-	-	-	-	-	-	○○○●	●	-
Magnolia virginiana	●	●○○○	-	-	●	-	●●○○	-	-	●
Myrica pensylvanica	-	-	-	-	-	○●●○	-	-	●	-
Nyssa sylvatica	●	-	-	●●●●	●	●○○○	●●●●	-	●	●
Parthenocissus quinquefolia	-	-	-	○○○●	●	-	-	-	-	●
Pinus echinata	-	-	-	-	-	-	-	-	-	-
Pinus rigida	-	-	●	-	●	-	-	●○●●	●	-
Pinus strobus	-	-	-	-	-	-	-	-	-	-
Platanus occidentalus	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	MCLBURNT	MCLJOHNS	MCOBURNT	MHATREMO	MPRBURNT	MSLEPARK	MSLMAPLE	MSLPLEAS	MSLSALTD	MWIBURNT
	96	98	96	96	96	98	96	98	96	96
Prunus serotina	–	–	–	–	–	–	–	–	–	–
Quercus alba	–	–	–	–	–	–	–	–	–	–
Quercus ilicifolia	–	–	–	–	–	–	–	–	•	•
Quercus marilandica	–	–	–	–	–	–	–	–	–	–
Quercus sp. seedling	–	–	–	•○○○	•	–	–	–	–	–
Quercus stellata	–	–	–	–	–	–	–	–	–	–
Quercus velutina	–	–	–	–	–	–	–	–	–	–
Rhododendron viscosum	•	••••	–	••••	•	•••○	••••	○○••	•	•
Rosa palustris	–	–	–	–	–	–	–	–	–	–
Rubus hispidus	–	••○•	•	••••	•	••○○	•••○	–	–	•
Rubus sp.	–	–	–	–	•	–	–	–	–	–
Salix nigra	–	–	–	–	–	–	–	–	–	–
Sambucus canadensis	–	–	–	–	–	–	–	–	–	–
Sassafras albidum	–	–	–	–	–	○•○○	–	–	–	–
Smilax glauca	–	○○○•	–	•○•○	–	–	–	•○○○	•	•
Smilax laurifolia	–	–	–	–	–	–	–	–	–	–
Smilax rotundifolia	–	•○○•	•	••••	•	•••○	••••	••••	•	•
Smilax walteri	–	○••○	–	–	–	–	–	–	–	–
Spiraea alba var. latifolia	–	–	–	–	–	–	–	–	–	–
Spiraea tomentosa	–	–	–	–	–	–	–	–	–	–
Tilia americana	–	–	–	–	–	–	–	–	–	–
Toxicodendron radicans	–	○○○•	–	•○•○	•	–	•••○	–	•	•
Toxicodendron vernix	–	–	–	–	–	–	○•○○	–	–	•
Ulmus americana	–	–	–	–	–	–	–	–	–	–
Vaccinium corymbosum	•	••••	•	••••	•	•••○	••••	••••	•	•
Vaccinium macrocarpon	–	••○•	–	–	–	–	–	••••	–	–
Vaccinium pallidum	–	–	–	–	–	–	–	○○•○	–	–
Viburnum dentatum	–	–	–	–	–	–	–	–	–	–
Viburnum nudum var. nudum	–	–	–	–	•	○•○○	–	–	–	•
Vitis labrusca	–	–	–	–	–	••○○	–	–	–	–

Appendix 2.6.1. Stream-vegetation monitoring sites in the Upper Mullica River drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Refer to methods for sampling details. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered by site code.

Site Name and Description	Site Code
Mullica River below Constable Bridge Mullica/Washington Twp., Atlantic/Burlington Co. (lat 39°39'33.19", long 74°39'30.84", Atsion quad). Section 4 ends 175 m downstream from Constable Bridge.	MMUCONST
Mullica River above dike below Old Jackson-Atsion Road Waterford/Shamong Twp., Camden/Burlington Co. (lat 39°45'28.14", long 74°46'39.88", Medford Lakes quad). Section 1 begins 65 m upstream from breached dike, downstream from Old Jackson-Atsion Road.	MMUDIKES
Mullica River below Jackson-Medford Road Waterford/Medford Twp., Camden/Burlington Co. (lat 39°47'09.39", long 74°51'36.53", Medford Lakes quad). Section 4 ends 12 m downstream from Jackson-Medford Road.	MMULADYS
Mullica River above Route 534 Waterford/Shamong Twp., Camden/Burlington Co. (lat 39°46'40.92", long 74°47'58.97", Medford Lakes quad). Section 1 begins 40 m upstream from Jackson Road (Route 534).	MMULJACK
Mullica River above Central New Jersey/Conrail railroad bridge Shamong Twp., Burlington Co. (lat 39°44'19.35", long 74°43'18.75", Atsion quad). Section 1 begins 21 m upstream from railroad bridge.	MMURRBRG
Mullica River tributary above Quaker Bridge Road Shamong Twp., Burlington Co. (lat 39°43'54.88", long 74°41'50.80", Atsion quad). Section 1 begins near upstream end of impoundment, upstream from Quaker Bridge Road (25-m site).	MMUTRQUA
Mullica River at northern border of Wilderness Area Washington Twp., Burlington Co. (lat 39°42'03.28", long 74°40'48.11", Atsion quad). Section 1 begins near northern boundary of Mullica River Wilderness Area.	MMUWILDR
Wesickaman Creek below Three Bridge Road Shamong Twp., Burlington Co. (lat 39°46'14.00", long 74°44'59.22", Indian Mills quad). Section 4 ends 10 m downstream from Three Bridge Road.	MWETHREE

Appendix 2.6.2 Plant species at stream-monitoring sites in the Upper Mullica River drainage basin. Circles indicate a species is present at a site. Filled circles indicate the 25-m section where it was found (e.g., "●○●○" means a species was located in the first and third sections of the 100-m study site). Refer to Appendix 2.6.1 for site descriptions and explanations of site codes. Plant common names are presented in Appendix 2.8.

Species	Sites and Survey Years							
	MMUCONST	MMUDIKES	MMULADYS	MMULJACK	MMURRBRG	MMUTRQUA	MMUWILDR	MWETHREE
	98	98	96	98	99	96	98	96
Herbaceous plants:								
Agrostis hyemalis	-	-	-	-	-	-	-	○●●○
Agrostis hyemalis var. scabra	-	-	-	-	-	-	-	-
Agrostis perennans	-	-	-	-	○○●●	●	-	-
Agrostis perennans var. elata	-	-	-	-	-	-	-	-
Agrostis sp.	-	-	-	-	-	-	●○○○	-
Alisma subcordatum	-	-	-	-	-	-	-	-
Allium sp.	-	-	-	-	-	-	-	-
Amphicarpum purshii	-	-	-	-	-	-	-	-
Andropogon virginicus var. abbreviatus	○○●○	-	-	-	-	-	-	-
Andropogon virginicus var. virginicus	-	-	-	-	-	-	-	-
Apios americana	-	-	●●○○	-	-	●	-	○○●○
Aralia nudicaulis	-	-	-	-	-	-	-	●●●○
Arethusa bulbosa	-	-	-	-	-	-	-	-
Asclepias incarnata	-	-	-	-	-	-	-	-
Aster dumosus	-	-	-	-	-	-	-	-
Aster nemoralis	●○○○	-	-	-	●○○○	-	-	-
Aster novi-belgii	●●○●	-	-	-	○●○●	●	-	●●●○
Aster pilosus var. pringlei	-	-	-	-	-	-	-	-
Aster racemosus	-	-	-	-	-	-	-	○○○●
Bartonia paniculata	-	●●●○	-	●○○●	●○○○	-	-	-
Bartonia virginica	-	●○●○	-	-	-	-	-	-
Bidens connata	-	-	-	-	-	-	-	-
Bidens coronata	-	-	●○●●	-	-	-	○○●○	-
Bidens discoidea	-	-	-	-	-	-	-	●●●●
Bidens frondosa	-	-	○○○●	-	○○●●	-	-	●●●●
Bidens sp.	-	-	-	-	-	-	-	-
Boehmeria cylindrica	-	-	●●●○	-	-	-	-	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	○○●●	-	-	-	-	●	-	-
Callitriche heterophylla	-	-	●●●●	-	-	-	-	●●●●
Cardamine pensylvanica	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	MMUCONST 98	MMUDIKES 98	MMULADYS 96	MMULJACK 98	MMURRBRG 99	MMUTRQUA 96	MMUWILDR 98	MWETHREE 96
Carex albolutescens	–	–	–	–	–	●	–	–
Carex atlantica	–	–	–	–	–	●	–	●●●○
Carex atlantica var. capillacea	–	–	●○●○	–	–	●	–	–
Carex bullata	○●○○	●●○●	–	–	–	●	●○●●	–
Carex canescens	–	●○○○	●○●●	–	–	–	–	●○○○
Carex collinsii	–	–	–	–	–	–	–	–
Carex crinita	–	–	–	–	–	–	–	–
Carex exilis	●○○○	–	–	–	–	–	–	–
Carex folliculata	–	○●●●	–	–	–	●	–	–
Carex intumescens	–	–	–	–	–	–	–	–
Carex livida	–	–	–	–	–	–	–	–
Carex longii	–	–	–	–	–	–	–	–
Carex lurida	–	–	●○●○	–	–	–	–	●●●●
Carex pensylvanica	–	–	–	–	●●●●	–	–	–
Carex scoparia	–	–	–	–	–	–	–	–
Carex stipata	–	–	–	–	–	–	–	–
Carex striata	–	–	–	–	–	–	–	–
Carex stricta	○●○●	●●●●	–	●●●●	●●●●	–	●●●●	–
Carex tribuloides	–	–	–	–	–	–	–	–
Carex trisperma	–	–	–	–	–	–	–	–
Carex venusta	–	–	–	–	–	●	–	–
Ceratophyllum echinatum	–	–	–	–	–	–	–	–
Chasmanthium laxum	–	–	–	–	–	–	–	–
Cinna arundinacea	–	–	–	–	–	–	–	●○○○
Cladium mariscoides	●●●●	–	–	–	–	–	–	–
Cuscuta sp.	–	●○●●	–	●●●●	–	–	●○○○	–
Cyperus dentatus	–	–	–	–	–	–	○●○○	–
Cyperus erythrorhizos	–	–	–	–	–	–	–	–
Cyperus odoratus	–	–	–	–	–	–	–	–
Cyperus retrorsus	–	–	–	–	–	–	–	–
Cyperus strigosus	–	–	–	–	–	–	–	–
Danthonia sericea var. epilis	–	–	–	–	–	–	–	–
Decodon verticillatus	–	–	●●●●	–	–	–	–	●●●○
Dioscorea villosa	–	–	–	–	–	●	–	–
Drosera filiformis	●●●●	–	–	–	–	–	–	–
Drosera intermedia	●●●●	●●●●	–	○○○●	○○●○	–	○○●○	–

Species	Sites and Survey Years							
	MMUCONST 98	MMUDIKES 98	MMULADYS 96	MMULJACK 98	MMURRBRG 99	MMUTRQUA 96	MMUWILDR 98	MWETHREE 96
Drosera rotundifolia	-	●●●○	-	-	-	-	-	-
Dryopteris carthusiana	-	-	-	-	-	-	-	●○●○
Dulichium arundinaceum	●●●●	●●●●	●●●●	●●●○	-	●	●●●●	-
Echinochloa muricata	-	-	-	-	-	-	-	-
Eleocharis acicularis	-	-	●●●●	-	-	-	●●●●	-
Eleocharis flavescens var. olivacea	●●○●	○●●●	-	-	○○○●	-	●●●●	-
Eleocharis microcarpa	-	-	-	-	-	-	-	-
Eleocharis ovata	-	-	-	-	-	-	-	-
Eleocharis robbinsii	●○○○	-	-	-	-	-	●●●●	-
Eleocharis tenuis	●●●○	●●●●	-	-	-	●	●●●●	-
Eleocharis tuberculosa	○○○●	○○●○	-	-	-	-	-	-
Elodea nuttallii	-	-	-	-	-	-	-	-
Epilobium coloratum	-	-	-	-	-	-	-	●○○○
Erechtites hieracifolia	-	-	○●○○	-	○○●○	-	-	-
Erianthus giganteus	-	-	-	-	-	-	-	-
Eriocaulon aquaticum	●●●●	-	-	-	-	-	-	-
Eriocaulon compressum	-	-	-	-	-	-	-	-
Eriocaulon decangulare	●●●●	-	-	-	-	-	●○○○	-
Eriophorum virginicum	-	-	-	-	-	-	-	-
Eupatorium dubium	-	-	●●○●	-	●○○○	-	-	-
Eupatorium perfoliatum	-	-	-	-	-	-	-	-
Eupatorium pilosum	-	-	-	-	-	-	-	-
Eupatorium resinosum	-	-	-	-	-	-	-	-
Eupatorium serotinum	-	-	-	-	-	-	-	-
Euphorbia ipecacuanhae	-	-	-	-	-	-	-	-
Euthamia tenuifolia	●●●●	-	-	-	-	-	-	-
Galium tinctorium	-	-	●●●○	-	-	●	-	●●●●
Glechoma hederacea	-	-	-	-	-	-	-	-
Glyceria canadensis	-	-	-	-	-	-	-	-
Glyceria obtusa	-	●●●●	○●●○	●●●●	○○●●	●	●●●●	-
Glyceria striata	-	-	-	-	-	-	-	-
Glyceria x laxa	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-
Habenaria lacera	-	-	-	-	-	-	-	-
Hibiscus moscheutos	-	-	-	-	-	-	-	-
Hypericum canadense	●●●●	●○○○	-	-	○○○●	●	○●●●	-

Species	Sites and Survey Years							
	MMUCONST 98	MMUDIKES 98	MMULADYS 96	MMULJACK 98	MMURRBRG 99	MMUTRQUA 96	MMUWILDR 98	MWETHREE 96
Hypericum denticulatum	●●●●	-	-	-	-	-	-	-
Hypericum mutilum	-	-	●●○○	-	-	-	●○●●	○●○○
Hypericum stragulum	-	-	-	-	-	-	-	-
Impatiens capensis	-	-	●●○○	-	-	●	-	●●●●
Iris prismatica	○○○●	-	-	-	-	-	-	-
Iris versicolor	-	○●○●	-	-	-	-	○○●●	-
Isoetes echinospora	-	-	-	-	-	-	-	-
Juncus acuminatus	-	-	-	-	-	-	-	-
Juncus biflorus	-	-	-	-	-	-	-	-
Juncus caesariensis	-	-	-	-	-	-	-	-
Juncus canadensis	○●●●	●●●●	-	-	-	-	●●●●	-
Juncus effusus	-	●○●●	○●●●	-	-	-	-	-
Juncus militaris	●●●●	-	-	-	-	-	●●●●	-
Juncus pelocarpus	○●●●	●●●○	-	-	-	-	●○●●	-
Lachnanthes caroliniana	●●●●	-	-	-	-	●	●●●●	-
Leersia oryzoides	-	●●●●	●●●●	●●●●	●○○●	●	●●●●	●●●●
Lemna sp.	-	-	-	-	-	-	-	●●●●
Lilium superbum	-	-	-	-	○○●○	-	-	-
Lindernia dubia	-	-	-	-	-	-	-	●○○○
Lobelia canbyi	-	-	-	-	-	-	-	-
Lobelia cardinalis	-	-	●●○○	-	-	-	-	●●●●
Lobelia nuttallii	●●●●	-	-	-	-	-	●○○●	-
Lophiola aurea	○●●●	-	-	-	-	-	-	-
Ludwigia alternifolia	-	-	-	-	-	-	-	-
Ludwigia palustris	-	-	●●●●	-	-	●	-	●●●●
Lycopodium alopecuroides	-	-	-	-	-	-	-	-
Lycopodium appressum	-	-	-	-	-	-	-	-
Lycopodium obscurum	-	-	-	-	-	-	-	-
Lycopus uniflorus	-	-	●●●○	-	-	●	○○○●	-
Lycopus virginicus	-	-	●●●●	-	-	●	-	●●●●
Lysimachia terrestris	●●●●	●●●●	●●●○	●○●●	○○○●	●	●●●●	-
Lythrum salicaria	-	-	-	-	-	-	-	-
Microstegium vimineum	-	-	-	-	-	-	-	●○●●
Mikania scandens	-	-	●●●●	-	-	-	-	●●●●
Mimulus ringens	-	-	●●○○	-	-	-	-	-
Mitchella repens	-	-	-	-	○○●○	●	-	○○●○

Species	Sites and Survey Years							
	MMUCONST 98	MMUDIKES 98	MMULADYS 96	MMULJACK 98	MMURRBRG 99	MMUTRQUA 96	MMUWILDR 98	MWETHREE 96
Monotropa uniflora	-	-	-	-	-	-	-	-
Muhlenbergia torreyana	●●●●	-	-	-	-	-	-	-
Muhlenbergia uniflora	-	-	-	-	-	-	-	-
Nuphar variegata	-	○○○●	-	-	-	-	-	-
Nymphaea odorata	-	-	-	-	-	-	●●●●	●○○○
Onoclea sensibilis	-	-	○●○●	-	-	-	-	●●●●
Orontium aquaticum	●●●●	-	-	-	○○○●	-	●●●●	-
Osmunda cinnamomea	-	○●○○	●●○●	-	○●●●	-	-	●●●●
Osmunda regalis	-	-	-	-	-	-	●○○○	-
Oxalis stricta	-	-	-	-	-	-	-	-
Oxypolis rigidior	●○○○	-	-	-	-	-	●○●●	○○○●
Panicum clandestinum	-	-	●○○●	-	●○●○	-	-	-
Panicum dichotomum	-	○●●○	-	-	-	●	-	-
Panicum ensifolium	-	-	-	-	●●●●	-	-	-
Panicum lanuginosum var. lindheimeri	-	-	-	-	-	-	-	-
Panicum longifolium	●●●●	●●●●	-	-	-	●	●●●●	-
Panicum rigidulum	-	-	-	-	-	-	-	-
Panicum scabriusculum	●●●●	-	-	-	-	-	●●●●	-
Panicum sp.	-	-	●●○○	-	-	-	-	-
Panicum spretum	-	●●●○	-	-	-	-	●●●●	-
Panicum verrucosum	-	-	-	●○○○	-	-	●●●●	-
Panicum virgatum	●●●●	-	-	-	-	-	●●●●	-
Peltandra virginica	-	●●●●	-	●○○○	○○○●	-	●●●●	-
Phalaris arundinacea	-	-	-	-	-	-	-	-
Phragmites australis	-	-	-	-	-	-	-	●○○●
Phytolacca americana	-	-	-	-	-	-	-	-
Pilea pumila	-	-	-	-	-	-	-	●●●●
Poa palustris	-	-	-	-	-	-	-	-
Poa pratensis	-	-	-	-	-	-	-	●○○○
Pogonia ophioglossoides	●●●○	○○●○	-	-	-	-	-	-
Polygala brevifolia	-	-	-	-	-	-	-	-
Polygala cruciata	●○●○	●●○○	-	-	-	-	●○○○	-
Polygonum arifolium	-	-	-	-	-	-	-	●●○○
Polygonum cespitosum	-	-	-	-	-	-	-	○○○●
Polygonum hydropiperoides	-	-	-	-	-	-	-	-
Polygonum punctatum	-	-	○●○○	-	-	-	-	●●●●

Species	MMUCONST 98	MMUDIKES 98	MMULADYS 96	MMULJACK 98	MMURRBRG 99	MMUTRQUA 96	MMUWILDR 98	MWETHREE 96
Polygonum sagittatum	-	-	-	-	-	-	-	●○○○
Polygonum sp.	-	-	-	○●○○	-	-	-	-
Pontederia cordata	-	○●○○	-	●○○○	○○○●	-	●●●●	-
Potamogeton confervoides	-	-	-	-	-	-	-	-
Potamogeton diversifolius	-	-	-	-	-	-	-	-
Potamogeton epihydrus	-	-	●●●●	-	-	●	-	○●●○
Potamogeton oakesianus	-	-	-	-	-	-	-	-
Potamogeton pusillus	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	-	-	-	-	-	-	-
Pteridium aquilinum	-	-	-	-	-	-	-	-
Rhexia mariana	-	-	-	-	-	-	-	-
Rhexia virginica	●●●●	●●●●	-	-	●●●●	●	●●○○	-
Rhynchospora alba	-	○●●○	-	-	-	-	-	-
Rhynchospora capitellata	-	-	-	-	-	-	-	-
Rhynchospora chalarocephala	-	-	-	-	-	-	-	-
Rorippa palustris	-	-	-	-	-	-	-	-
Sabatia difformis	●●●●	●●●○	-	-	-	-	●●○○	-
Sagittaria engelmanniana	-	-	-	-	-	-	●●●●	-
Sarracenia purpurea	○●○○	○●●○	-	-	-	-	-	-
Schizachyrium scoparium	●●●●	○○●○	-	-	-	-	-	-
Schizaea pusilla	-	-	-	-	-	-	-	-
Scirpus cyperinus	-	●●●●	-	-	-	-	-	-
Scirpus pungens	-	-	-	-	-	-	-	-
Scirpus subterminalis	●●●●	-	-	-	-	-	●●●●	-
Scleria reticularis	-	-	-	-	-	-	-	-
Sclerolepis uniflora	-	-	-	-	-	-	-	-
Scutellaria lateriflora	-	-	-	-	-	-	-	●●●●
Smilax herbacea	-	-	-	○○○●	●●●○	-	-	-
Smilax pseudochina	-	-	-	●○○○	-	●	-	-
Solanum nigrum	-	-	○●○○	-	-	-	-	-
Solidago canadensis	-	-	-	-	-	-	-	-
Solidago rugosa	-	-	-	-	○○○●	-	-	-
Sparganium americanum	○●○○	●●●●	●●●●	●●○○	○○○●	●	●●●●	●○●○
Spiranthes cernua	-	-	-	-	-	-	-	-
Stellaria graminea	-	-	-	-	-	-	-	-
Stellaria media	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	MMUCONST 98	MMUDIKES 98	MMULADYS 96	MMULJACK 98	MMURRBRG 99	MMUTRQUA 96	MMUWILDR 98	MWETHREE 96
Taraxacum officinale	-	-	-	-	-	-	-	●○○○
Thelypteris palustris	-	-	●○○○	-	-	-	-	-
Thelypteris simulata	-	-	●●●○	-	-	-	-	●○●●
Triadenum virginicum	○●●○	●●●●	●●●○	●○○●	●●○●	●	●●●●	-
Trientalis borealis	-	-	-	-	-	-	-	-
Typha latifolia	-	-	-	-	-	-	-	-
Urtica dioica	-	-	-	-	-	-	-	-
Utricularia cornuta	●○●●	-	-	-	-	-	-	-
Utricularia fibrosa	-	-	-	-	-	-	-	-
Utricularia geminiscapa	-	-	-	-	-	-	-	-
Utricularia inflata	-	-	-	-	-	-	-	-
Utricularia purpurea	-	-	-	-	-	-	-	-
Utricularia sp.	●○●○	-	-	-	●●●●	-	-	-
Utricularia subulata	●○○○	-	-	-	-	-	-	-
Utricularia vulgaris	-	-	○●●●	-	-	-	-	-
Verbena hastata	-	-	-	-	-	-	-	-
Vernonia noveboracensis	-	-	-	-	-	-	-	-
Viola lanceolata	●●●●	●●●●	○○●○	-	●●●●	-	●●●●	-
Viola primulifolia	-	-	-	-	●○●●	●	-	-
Viola sororia	-	-	-	-	-	-	-	-
Woodwardia areolata	-	-	●○●●	-	-	●	-	●●●●
Woodwardia virginica	-	-	-	○○○●	-	-	-	○●○○
Xerophyllum asphodeloides	-	-	-	-	-	-	-	-
Xyris difformis	●●●●	○●●○	-	-	-	-	-	-
Xyris smalliana	-	-	-	-	-	-	-	-
Zizania aquatica	-	-	-	-	-	-	-	-
Woody plants:								
Acer rubrum	●●●●	●●●●	●●●●	●●●●	●●●●	●	●●●●	●●●●
Ailanthus altissima	-	-	-	-	-	-	-	-
Alnus serrulata	-	-	-	-	-	-	-	-
Amelanchier canadensis	-	-	-	○○○●	○●○○	-	-	-
Amelanchier obovalis	-	-	-	-	-	-	-	-
Aronia arbutifolia	○○●○	-	-	-	○●○○	-	-	-
Berberis thunbergii	-	-	-	-	-	-	-	-
Betula lenta	-	-	-	-	-	-	-	○●●●
Betula populifolia	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	MMUCONST 98	MMUDIKES 98	MMULADYS 96	MMULJACK 98	MMURRBRG 99	MMUTRQUA 96	MMUWILDR 98	MWETHREE 96
Catalpa bignonioides	-	-	-	-	-	-	-	-
Cephalanthus occidentalis	-	-	-	●●●●	-	-	●○○○	-
Chamaecyparis thyoides	●●●●	●●●●	●○○○	○○●●	●●○○	●	○○●○	○●●○
Chamaedaphne calyculata	●●●○	●●●●	-	●●○○	-	-	-	-
Clematis terniflora	-	-	-	-	-	-	-	-
Clethra alnifolia	●●●●	●●●●	●●●●	●●●●	●●●●	●	●●●●	●●●●
Diospyros virginiana	○○○●	-	-	-	-	-	-	-
Eubotrys racemosa	○○●○	-	●●○○	●●●●	●●●●	●	○○●○	●●●●
Gaultheria procumbens	-	-	-	-	-	-	-	-
Gaylussacia baccata	-	-	-	-	-	-	-	-
Gaylussacia dumosa	-	-	-	-	-	-	-	-
Gaylussacia frondosa	-	-	-	○○○●	-	-	-	-
Hudsonia ericoides	-	-	-	-	-	-	-	-
Hypericum densiflorum	○●●●	●●○○	-	-	-	-	-	-
Ilex glabra	●●●○	●○●○	-	-	-	-	○●●○	-
Ilex laevigata	-	-	-	-	-	-	-	-
Ilex opaca	-	●○●○	-	-	-	●	-	○○●○
Ilex verticillata	-	-	●●●○	●●●●	-	-	-	●●●●
Itea virginica	-	●○○○	●●●○	○○○●	-	●	-	○○●●
Juniperus virginiana	-	-	-	-	-	-	-	-
Kalmia angustifolia	○●●○	○●●○	-	○●○○	-	●	-	-
Kalmia latifolia	-	-	-	-	○○●○	-	-	○○●○
Leiophyllum buxifolium	-	-	-	-	-	-	-	-
Liquidambar styraciflua	-	-	-	-	●●●●	●	-	-
Lonicera japonica	-	-	-	-	-	-	-	○○○●
Lyonia ligustrina	-	-	-	●○○○	-	-	-	○●○○
Lyonia mariana	●●●○	-	-	-	-	-	-	-
Magnolia virginiana	-	○○●○	○○○●	●○●●	○○●○	-	○○○●	●○○○
Myrica pensylvanica	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	●○○●	○●●●	●●●●	-	-	-
Parthenocissus quinquefolia	-	-	●●●●	-	-	-	-	●●●●
Pinus echinata	-	-	-	-	-	-	-	-
Pinus rigida	●●●●	-	-	-	-	-	-	-
Pinus strobus	-	-	-	-	-	-	-	-
Platanus occidentalus	-	-	-	-	-	-	-	-
Prunus serotina	-	-	-	-	-	-	-	-

Species	Sites and Survey Years							
	MMUCONST	MMUDIKES	MMULADYS	MMULJACK	MMURRBRG	MMUTRQUA	MMUWILDR	MWETHREE
	98	98	96	98	99	96	98	96
Quercus alba	-	-	-	-	○●●●	-	-	-
Quercus ilicifolia	-	-	-	-	-	-	-	-
Quercus marilandica	-	-	-	-	-	-	-	-
Quercus sp. seedling	-	-	-	-	-	-	-	-
Quercus stellata	-	-	-	-	○●○○	-	-	-
Quercus velutina	-	-	-	-	○○●●	-	-	-
Rhododendron viscosum	-	-	○○●●	○●●●	○●●●	●	-	○●●○
Rosa palustris	-	-	-	-	-	-	-	●●●●
Rubus hispidus	-	-	○●○○	○○○●	○○●○	-	-	●○○○
Rubus sp.	-	-	○●●●	-	-	-	-	●●○○
Salix nigra	-	-	-	-	-	-	-	●●○○
Sambucus canadensis	-	-	-	-	-	-	-	-
Sassafras albidum	-	-	-	-	-	-	-	-
Smilax glauca	○○○●	-	-	-	○●●●	●	-	-
Smilax laurifolia	-	-	-	-	-	-	-	-
Smilax rotundifolia	○○○●	●●○○	●●●●	●●●●	●●●●	●	○○●○	●○○●
Smilax walteri	-	-	-	-	-	-	-	-
Spiraea alba var. latifolia	-	-	○○○●	-	-	-	-	-
Spiraea tomentosa	-	-	-	-	-	-	-	-
Tilia americana	-	-	-	-	-	-	-	-
Toxicodendron radicans	-	-	○○○●	-	○○●○	-	-	●●●●
Toxicodendron vernix	-	-	-	-	-	-	-	●●●○
Ulmus americana	-	-	-	-	-	-	-	-
Vaccinium corymbosum	○●●○	●●●●	●○●●	●●●●	●●●●	●	●○○●	●●○●
Vaccinium macrocarpon	●●●●	●●●●	-	-	-	●	○●○●	-
Vaccinium pallidum	-	-	-	-	-	-	-	-
Viburnum dentatum	-	-	-	-	-	-	-	-
Viburnum nudum var. nudum	-	-	-	○○○●	-	-	-	●○○○
Vitis labrusca	-	-	●●○●	-	-	-	-	●●●○

Appendix 2.7.1. Stream-vegetation monitoring sites in the Batsto River drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Refer to methods for sampling details. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered by site code.

Site Name and Description	Site Code
Batsto River above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°48'02.61", long 74°40'20.65", Indian Mills quad). Section 1 begins 25 m upstream from Carranza Road.	BBACARRZ
Batsto River at Lower Forge Washington Twp., Burlington Co. (lat 39°43'28.64", long 74°40'29.32", Atsion quad). Section 1 begins 50 m upstream from derelict bridge, at Lower Forge.	BBALFORG
Batsto River below Penn Swamp Branch Washington Twp., Burlington Co. (lat 39°40'27.81", long 74°39'14.95", Atsion quad). Section 1 begins approximately 0.8 km downstream from confluence with Penn Swamp Branch. *Latitude and longitude values were obtained using ArcView Software.	BBAPENNS
Batsto River side channel below Quaker Bridge Road Washington Twp., Burlington Co. (lat 39°42'34.77", long 74°39'58.83", Atsion quad). Section 4 ends 30 m downstream from Quaker Bridge Road, in Batsto River side channel below Quaker Bridge.	BBAQUAKR
Batsto River below Central New Jersey/Conrail railroad bridge Shamong Twp., Burlington Co. (lat 39°45'18.60", long 74°40'44.71", Indian Mills quad). Section 4 ends 5 m downstream from railroad bridge.	BBARRBRG
Batsto River below Route 532 Tabernacle Twp., Burlington Co. (lat 39°50'16.24", long 74°39'47.90", Indian Mills quad). Section 4 ends 85 m downstream from Tabernacle-Chatsworth Road (Route 532).	BBART532
Batsto River above Hampton Road Shamong Twp., Burlington Co. (lat 39°46'15.58", long 74°40'47.53", Indian Mills quad). Section 1 begins 20 m upstream from Hampton Road.	BBATHAMP
Batsto River tributary above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°47'26.19", long 74°39'44.06", Indian Mills quad). Section 1 begins 10 m upstream from Carranza Road, in abandoned cranberry bog near Glossy Spung Road.	BBATRCAR
Batsto River tributary below Hay Road Shamong Twp., Burlington Co. (lat 39°44'19.52", long 74°40'34.11", Atsion quad). Section 1 ends 8 m downstream from Hay Road, on unnamed tributary downstream from Mannis Duck Pond (25-m site).	BBATRMAN
Batsto River tributary near Moore's Meadow Road Tabernacle Twp., Burlington Co. (lat 39°47'50.09", long 74°40'08.07", Indian Mills quad). Section 1 begins 50 m upstream from Carranza Road, just west of intersection with Moore's Meadow Road.	BBATRMOO
Deep Run below Hampton Road Shamong Twp., Burlington Co. (lat 39°45'36.62", long 74°41'27.05", Indian Mills quad). Section 1 begins at first breached dike downstream from Hampton Road.	BDEEPDKE
Horse Pond Stream below Butterworth's Bogs Road Tabernacle Twp., Burlington Co. (lat 39°49'42.28", long 74°40'47.54", Indian Mills quad). Section 1 ends 15 m downstream from Butterworth's Bogs Road (25-m site).	BHOBUTTR
Indian Mills Brook above Oakshade Road (above Shadow Lake) Shamong Twp., Burlington Co. (lat 39°48'31.11", long 74°46'24.68", Medford Lakes quad). Section 1 begins at forest edge, upstream from inlet of Shadow Lake.	BINSHADS
Muskingum Brook above Tuckerton Road Tabernacle Twp., Burlington Co. (lat 39°49'05.28", long 74°44'15.66", Indian Mills quad). Section 1 begins 16 m upstream from Tuckerton Road.	BMUSKTUC

Site Name and Description	Site Code
Penn Swamp Branch above Batona Trail bridge Washington Twp., Burlington Co. (lat 39°41'03.08", long 74°39'01.26", Atsion quad). Section 1 begins 5 m upstream from bridge on unnamed sand road (Batona Trail).	BPEBRIDG
Skit Branch below Carranza Road Shamong Twp., Burlington Co. (lat 39°47'08.52", long 74°39'30.00", Indian Mills quad). Section 4 ends 55 m downstream from Carranza Road.	BSKITCAR
Skit Branch above Hampton Road Shamong Twp., Burlington Co. (lat 39°46'01.18", long 74°40'39.17", Indian Mills quad). Section 1 begins 32 m upstream from Hampton Road.	BSKITHAM
Springers Brook below Deep Run Shamong Twp., Burlington Co. (lat 39°44'26.67", long 74°41'03.01", Atsion quad). Section 1 begins near end of unnamed sand road, approximately 175 m downstream from confluence with Deep Run.	BSPRDIKE
Springers Brook above Hampton Road Shamong Twp., Burlington Co. (lat 39°45'19.53", long 74°41'46.10", Indian Mills quad). Section 1 begins 18 m upstream from Hampton Road.	BSPRIHAM
Roberts (Tom Roberts) Branch below Carranza Road Shamong Twp., Burlington Co. (lat 39°47'16.21", long 74°39'34.03", Indian Mills quad). Section 4 ends 35 m downstream from Carranza Road.	BTOMCARR

Appendix 2.7.2.a. Plant species at stream-monitoring sites in the Batsto River drainage basin. Circles indicate a species is present at a site. Filled circles indicate the 25-m section where it was found (e.g., "●○●○" means a species was located in the first and third sections of the 100-m study site). Refer to Appendix 2.7.1 for site descriptions and explanations of site codes. Plant common names are presented in Appendix 2.8.

Species	Sites and Survey Years									
	BBACARRZ 97	BBALFORG 97	BBAPENNS 97	BBAQUAKR 98	BBARRBRG 97	BBART532 99	BBATHAMP 98	BBATRCAR 97	BBATRMAN 97	BBATRMOO 97
Herbaceous plants:										
Agrostis hyemalis	-	-	-	○○●●	-	-	●●●○	-	-	-
Agrostis hyemalis var. scabra	-	-	-	-	-	-	-	-	-	-
Agrostis perennans	-	-	-	-	-	-	-	-	-	-
Agrostis perennans var. elata	-	-	○●●●	-	●●●●	-	-	-	-	-
Agrostis sp.	-	●●●○	-	-	-	-	-	-	-	-
Alisma subcordatum	-	-	-	-	-	-	-	-	-	-
Allium sp.	-	-	-	-	-	-	-	-	-	-
Amphicarpum purshii	-	-	-	-	-	-	-	-	-	-
Andropogon virginicus var. abbreviatus	-	-	-	-	○●●●	●○○○	●●●●	○○●○	-	-
Andropogon virginicus var. virginicus	-	-	-	-	-	○○○●	-	-	-	-
Apios americana	○○○●	-	-	-	-	-	-	-	-	-
Aralia nudicaulis	-	-	-	-	-	-	-	-	-	-
Arethusa bulbosa	-	-	-	-	-	-	-	-	-	-
Asclepias incarnata	-	-	-	-	-	-	-	-	-	-
Aster dumosus	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	-	-	○○●●	-	●●●●	-	-	-	-	-
Aster novi-belgii	-	●○○○	-	○○○●	○●●●	●○●●	●○○○	-	-	-
Aster pilosus var. pringlei	-	-	-	-	-	-	-	-	-	-
Aster racemosus	-	-	-	-	-	-	-	-	-	-
Bartonia paniculata	-	-	-	○○●○	-	○●○○	●●●●	○○●○	●	●●○●
Bartonia virginica	-	-	-	-	-	●●●○	●●●○	○●○○	-	●○○○
Bidens connata	-	-	-	-	-	-	-	-	-	-
Bidens coronata	-	-	-	-	-	-	-	-	-	-
Bidens discoidea	-	-	-	-	-	-	-	-	-	-
Bidens frondosa	-	-	-	-	-	●●●●	-	-	-	-
Bidens sp.	-	-	-	-	-	-	-	-	-	-
Boehmeria cylindrica	-	-	-	-	-	-	-	-	-	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	-	●●○○	○●●●	-	○○●○	●●●○	●○●●	-	-	-
Callitriche heterophylla	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	BBACARRZ	BBALFORG	BBAPENNS	BBAQUAKR	BBARRBRG	BBART532	BBATHAMP	BBATRCAR	BBATRMAN	BBATRMOO
	97	97	97	98	97	99	98	97	97	97
Cardamine pensylvanica	-	-	-	-	-	-	-	-	-	-
Carex albolutescens	-	-	-	-	-	●○●○	-	-	-	-
Carex atlantica	-	-	-	-	○●○●	●○○○	-	-	●	○●○○
Carex atlantica var. capillacea	-	-	-	-	-	-	-	-	●	○○●●
Carex bullata	-	○○○●	○●○●	●○○○	○○●●	-	●●●●	○○●○	●	-
Carex canescens	-	-	-	-	-	-	-	-	-	-
Carex collinsii	-	-	-	-	-	-	-	-	●	-
Carex crinita	-	○●●○	-	○●○○	-	-	-	-	-	-
Carex exilis	-	-	○○○●	-	-	-	-	-	-	○●○○
Carex folliculata	-	-	-	○○○●	-	-	-	-	●	●●●●
Carex intumescens	-	-	-	-	-	●●●●	-	-	-	-
Carex livida	-	-	●●●●	○○●○	-	-	-	-	-	○○●○
Carex longii	-	-	-	-	-	-	-	-	-	-
Carex lurida	-	-	-	-	-	○●●●	-	-	-	-
Carex pensylvanica	-	-	-	-	-	○●●●	-	-	-	-
Carex scoparia	-	-	-	-	-	-	-	-	-	-
Carex stipata	-	-	-	-	-	-	-	-	-	-
Carex striata	-	-	●●○○	-	-	-	-	○○●○	-	-
Carex stricta	●●●●	●●●●	-	○●●●	●●●●	-	●●●●	●●●●	-	-
Carex tribuloides	-	-	-	-	-	-	-	-	-	-
Carex trisperma	-	-	-	-	-	-	-	-	-	●●○●
Carex venusta	-	-	-	-	-	●●●○	-	-	-	-
Ceratophyllum echinatum	-	-	-	-	-	-	-	-	-	-
Chasmanthium laxum	-	-	-	-	-	●●●●	-	-	-	-
Cinna arundinacea	-	-	-	-	-	-	-	-	-	-
Cladium mariscoides	-	-	-	-	-	-	○○●○	-	-	-
Cuscuta sp.	●●●●	-	○●○○	●●●○	●○○○	●●●●	-	-	-	○●○○
Cyperus dentatus	-	-	-	-	●○○○	-	-	-	-	-
Cyperus erythrorhizos	-	-	-	-	-	-	-	-	-	-
Cyperus odoratus	-	-	-	-	-	-	-	-	-	-
Cyperus retrorsus	-	-	-	-	-	-	-	-	-	-
Cyperus strigosus	-	-	-	-	-	-	-	-	-	-
Danthonia sericea var. epilis	-	-	-	-	-	-	-	-	-	-
Decodon verticillatus	-	-	-	-	-	○○●○	-	-	-	-
Dioscorea villosa	●●○○	-	-	-	-	○○○●	-	-	-	-
Drosera filiformis	-	-	○●○○	-	-	-	-	-	-	-

Species	BBACARRZ 97	BBALFORG 97	BBAPENNS 97	BBAQUAKR 98	BBARRBRG 97	BBART532 99	BBATHAMP 98	BBATRCAR 97	BBATRMAN 97	BBATRMOO 97
Drosera intermedia	–	–	●○○○	●○●●	○●●●	–	●●●●	○○○●	–	–
Drosera rotundifolia	–	–	–	○○●●	●●●●	–	–	–	●	●●●●
Dryopteris carthusiana	–	–	–	–	–	–	–	–	–	–
Dulichium arundinaceum	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●	●●●●
Echinochloa muricata	–	–	–	–	–	–	–	–	–	–
Eleocharis acicularis	–	–	●●●○	–	–	–	–	–	–	–
Eleocharis flavescens var. olivacea	○●●●	–	–	●○○○	○●○○	–	–	○●○○	–	–
Eleocharis microcarpa	–	–	–	–	–	–	–	–	–	–
Eleocharis ovata	○○○●	–	–	–	–	○○○●	–	–	–	–
Eleocharis robbinsii	–	○○○●	●●●●	●●○●	●●●●	–	–	–	–	–
Eleocharis tenuis	–	○●●●	○●●●	●●●●	●●●●	●○○●	●●●●	●●●●	–	–
Eleocharis tuberculosa	–	–	–	–	–	–	–	–	–	–
Elodea nuttallii	–	–	–	–	–	–	–	–	–	–
Epilobium coloratum	–	–	–	–	–	–	–	–	–	–
Erechtites hieracifolia	–	–	–	–	–	–	–	–	–	–
Erianthus giganteus	–	–	–	–	–	–	–	–	–	–
Eriocaulon aquaticum	–	●●●●	●●●●	●●●●	–	–	–	–	●	–
Eriocaulon compressum	–	–	–	–	–	–	–	–	–	–
Eriocaulon decangulare	–	–	–	○○○●	–	–	–	–	–	–
Eriophorum virginicum	–	–	–	–	–	–	–	–	–	–
Eupatorium dubium	–	–	–	–	–	–	–	–	–	–
Eupatorium perfoliatum	–	–	–	–	–	–	–	–	–	–
Eupatorium pilosum	–	–	–	–	–	–	–	–	–	–
Eupatorium resinosum	–	–	–	–	–	–	–	–	–	–
Eupatorium serotinum	–	–	–	–	–	–	–	–	–	–
Euphorbia ipecacuanhae	–	–	–	–	–	–	–	–	–	–
Euthamia tenuifolia	–	–	–	–	–	–	●●●●	–	–	–
Galium tinctorium	–	–	–	–	–	–	–	–	–	–
Glechoma hederacea	–	–	–	–	–	–	–	–	–	–
Glyceria canadensis	–	–	–	–	–	–	–	–	–	–
Glyceria obtusa	●●●●	●●●●	●●●●	●●●●	●●●●	●○●●	●●●●	●●●●	●	●●○○
Glyceria striata	–	–	–	–	–	–	–	–	–	–
Glyceria x laxa	–	–	–	–	–	–	–	–	–	–
Habenaria clavellata	–	–	●○○●	○○●●	–	–	–	–	–	–
Habenaria lacera	–	–	–	–	–	–	–	–	–	–
Hibiscus moscheutos	–	–	–	–	–	–	–	–	–	–

Species	BBACARRZ 97	BBALFORG 97	BBAPENNS 97	BBAQUAKR 98	BBARRBRG 97	BBART532 99	BBATHAMP 98	BBATRCAR 97	BBATRMAN 97	BBATRMOO 97
Hypericum canadense	–	○○○●	–	–	●●●○	○○●○	●●●●	–	●	–
Hypericum denticulatum	–	–	●●●●	○○○●	–	–	–	–	–	–
Hypericum mutilum	○●●●	–	–	○●○○	–	–	–	–	–	–
Hypericum stragulum	–	–	–	–	–	–	–	–	–	–
Impatiens capensis	–	–	–	–	–	–	–	–	–	–
Iris prismatica	–	–	●○○○	–	–	–	–	–	–	–
Iris versicolor	–	●●○○	○●○●	○●●●	–	–	–	–	–	–
Isoetes echinospora	–	●●○○	–	○○●○	–	–	–	–	–	–
Juncus acuminatus	–	–	–	–	–	–	–	–	–	–
Juncus biflorus	–	–	–	–	–	–	–	–	–	–
Juncus caesariensis	–	–	–	–	–	–	–	–	–	–
Juncus canadensis	–	○○○●	–	○●○○	●●○●	○●●○	●●●●	–	–	–
Juncus effusus	–	–	–	–	●○○○	●●●●	●●○●	○●○●	–	–
Juncus militaris	–	○○●●	●●●●	●●○●	●●●●	–	●●○○	–	–	–
Juncus pelocarpus	–	○●●●	●●●●	●●○●	○●○●	–	–	–	●	–
Lachnanthes caroliniana	–	–	○●○○	–	○○○●	●●●○	●○●●	–	–	–
Leersia oryzoides	●●●●	●●●●	○○●○	●●●●	●●●●	●●●●	●●●●	●●●●	●	●●●●
Lemna sp.	–	–	–	–	–	–	–	–	–	–
Lilium superbum	–	–	–	–	–	–	–	–	–	–
Lindernia dubia	–	–	–	–	–	–	–	–	–	–
Lobelia canbyi	–	–	–	●○○○	–	–	–	–	–	–
Lobelia cardinalis	–	–	–	–	–	–	–	–	–	–
Lobelia nuttallii	–	–	○●●●	○○●●	○○●●	–	●●●●	–	–	–
Lophiola aurea	–	–	–	–	–	–	–	–	–	–
Ludwigia alternifolia	–	–	–	–	–	–	–	–	–	–
Ludwigia palustris	●●●●	○○●●	–	–	–	–	–	–	–	–
Lycopodium alopecuroides	–	–	–	–	–	–	–	–	–	–
Lycopodium appressum	–	–	–	–	–	–	–	–	–	–
Lycopodium obscurum	–	–	–	–	–	–	–	–	–	–
Lycopus uniflorus	●●●●	●●○●	–	○○○●	–	●○○○	●○●●	–	–	–
Lycopus virginicus	–	–	–	–	–	–	–	–	–	–
Lysimachia terrestris	●●●●	●●●●	●●●●	●●●●	●○○●	●●●●	●●●●	–	–	–
Lythrum salicaria	–	–	–	–	–	–	–	–	–	–
Microstegium vimineum	–	–	–	–	–	–	–	–	–	–
Mikania scandens	–	○○●○	–	–	–	–	–	–	–	–
Mimulus ringens	–	–	–	–	–	–	–	–	–	–

Species	BBACARRZ 97	BBALFORG 97	BBAPENNS 97	BBAQUAKR 98	BBARRBRG 97	BBART532 99	BBATHAMP 98	BBATRCAR 97	BBATRMAN 97	BBATRMOO 97
Mitchella repens	-	-	-	-	-	●●●●	-	-	-	-
Monotropa uniflora	-	-	-	-	-	-	-	-	-	-
Muhlenbergia torreyana	-	-	-	-	-	-	-	-	-	-
Muhlenbergia uniflora	-	-	-	-	●●●●	-	-	-	-	-
Nuphar variegata	●●○●	-	-	-	-	●●●●	●●○●	-	-	●●●●
Nymphaea odorata	-	○○○●	○●○●	●●○○	○○●●	●●●●	-	●●●●	-	-
Onoclea sensibilis	-	-	-	-	-	-	-	-	-	-
Orontium aquaticum	-	-	●○●●	-	-	-	-	-	●	-
Osmunda cinnamomea	-	-	-	-	-	○○●○	○●●○	●●●○	-	-
Osmunda regalis	●○○○	-	●○●●	-	-	-	-	-	-	●○●●
Oxalis stricta	-	-	-	-	-	-	-	-	-	-
Oxypolis rigidior	-	-	○●●●	○○○●	-	-	-	-	-	-
Panicum clandestinum	-	-	-	-	-	-	-	-	-	-
Panicum dichotomum	-	●○○●	○●○○	○○●●	●●●●	●●●●	●●●●	-	●	-
Panicum ensifolium	-	-	-	-	-	-	-	-	-	-
Panicum lanuginosum var. lindheimeri	-	-	-	-	-	-	-	-	-	-
Panicum longifolium	-	-	●●●●	-	-	●○○○	●●●●	-	-	-
Panicum rigidulum	-	-	-	-	-	-	-	-	-	-
Panicum scabriusculum	-	●○●●	●●●●	●●●●	-	-	-	-	-	-
Panicum sp.	-	-	-	-	-	-	-	-	-	-
Panicum spretum	-	-	-	-	-	-	-	-	-	-
Panicum verrucosum	-	○○○●	-	-	●●●●	●●●●	○○●●	●●●●	●	-
Panicum virgatum	-	-	-	-	○○●●	-	●●●●	-	-	-
Peltandra virginica	●●●●	●●●●	●●●●	●●●●	●●●●	-	●●●●	●●●●	●	●●●●
Phalaris arundinacea	-	-	-	-	-	-	-	-	-	-
Phragmites australis	-	-	-	-	-	-	-	-	-	-
Phytolacca americana	-	-	-	-	-	-	-	-	-	-
Pilea pumila	-	-	-	-	-	-	-	-	-	-
Poa palustris	-	-	-	-	-	-	-	-	-	-
Poa pratensis	-	-	-	-	-	-	-	-	-	-
Pogonia ophioglossoides	-	-	-	-	-	-	-	-	-	○○○●
Polygala brevifolia	-	-	-	-	-	-	-	-	-	-
Polygala cruciata	-	-	-	-	●○●●	-	○●●●	-	-	-
Polygonum arifolium	-	-	-	-	-	-	-	-	-	-
Polygonum cespitosum	-	-	-	-	-	-	-	-	-	-
Polygonum hydropiperoides	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	BBACARRZ 97	BBALFORG 97	BBAPENNS 97	BBAQUAKR 98	BBARRBRG 97	BBART532 99	BBATHAMP 98	BBATRCAR 97	BBATRMAN 97	BBATRMOO 97
Polygonum punctatum	○●●○	-	-	-	-	-	-	-	-	-
Polygonum sagittatum	-	-	-	-	-	-	-	-	-	-
Polygonum sp.	-	-	-	-	-	-	-	-	-	-
Pontederia cordata	-	-	○○●●	●●●●	●●●○	●●●●	○○●●	-	-	-
Potamogeton confervoides	-	○●●○	-	-	-	-	●●●●	-	-	-
Potamogeton diversifolius	-	-	-	-	-	-	-	-	-	-
Potamogeton epihydrus	-	-	-	-	-	-	-	-	-	-
Potamogeton oakesianus	-	-	○●●●	-	-	-	-	-	-	-
Potamogeton pusillus	-	-	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	-	-	-	-	-	-	-	-	-
Pteridium aquilinum	-	-	-	-	-	-	-	-	-	-
Rhexia mariana	-	-	-	-	-	-	○○●○	-	-	-
Rhexia virginica	-	-	-	●●●●	○●●●	●●●●	●●●●	●○○○	-	-
Rhynchospora alba	-	-	-	-	-	-	●○○●	-	●	-
Rhynchospora capitellata	-	-	-	-	-	-	-	-	-	-
Rhynchospora chalarocephala	-	-	-	-	-	-	-	-	-	-
Rorippa palustris	-	-	-	-	-	-	-	-	-	-
Sabatia difformis	-	○○●○	●●●●	○●●●	-	-	-	-	-	-
Sagittaria engelmanniana	○●●○	○○○●	●●●●	●●○○	●●●●	●●●●	-	-	-	-
Sarracenia purpurea	-	○○○●	-	-	●●○○	-	-	-	-	●○○○
Schizachyrium scoparium	-	-	-	-	○○●●	-	-	-	-	-
Schizaea pusilla	-	-	-	-	-	-	-	-	-	-
Scirpus cyperinus	○○○●	○○●○	-	-	●○○○	●○●●	○○●○	-	-	-
Scirpus pungens	-	-	-	-	-	-	-	-	-	-
Scirpus subterminalis	-	●●●●	●●●●	●●●●	●●●●	-	●●●●	-	●	-
Scleria reticularis	-	-	-	-	-	-	-	-	-	-
Sclerolepis uniflora	-	-	●●●●	-	-	-	-	-	-	-
Scutellaria lateriflora	-	-	-	-	-	-	-	-	-	-
Smilax herbacea	-	-	●○●○	-	-	-	-	-	-	-
Smilax pseudochina	-	-	-	-	-	●●○○	-	-	-	-
Solanum nigrum	-	-	-	-	-	-	-	-	-	-
Solidago canadensis	-	-	-	-	-	-	-	-	-	-
Solidago rugosa	-	-	-	-	-	-	-	-	-	-
Sparganium americanum	●●●●	●●●●	●●●○	●●●●	●●●●	-	●●●●	-	●	-
Spiranthes cernua	-	-	-	-	-	-	-	-	-	-
Stellaria graminea	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	BBACARRZ 97	BBALFORG 97	BBAPENNS 97	BBAQUAKR 98	BBARRBRG 97	BBART532 99	BBATHAMP 98	BBATRCAR 97	BBATRMAN 97	BBATRMOO 97
Stellaria media	-	-	-	-	-	-	-	-	-	-
Taraxacum officinale	-	-	-	-	-	-	-	-	-	-
Thelypteris palustris	-	-	-	-	-	-	-	-	-	-
Thelypteris simulata	-	-	-	-	-	○○●●	-	-	-	-
Triadenum virginicum	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●○○●	●	-
Trientalis borealis	-	-	-	-	-	-	-	-	-	-
Typha latifolia	-	-	-	-	-	-	-	-	-	-
Urtica dioica	-	-	-	-	-	-	-	-	-	-
Utricularia cornuta	-	-	-	-	-	-	-	-	-	-
Utricularia fibrosa	-	-	●●●●	-	-	-	-	-	-	-
Utricularia geminiscapa	-	-	-	-	-	●●●●	-	-	●	-
Utricularia inflata	-	-	-	-	-	-	-	-	-	-
Utricularia purpurea	-	-	○●○○	-	-	-	-	-	-	-
Utricularia sp.	-	-	-	-	-	-	-	-	-	-
Utricularia subulata	-	-	-	-	-	-	-	-	-	-
Utricularia vulgaris	-	-	-	-	-	-	-	-	-	-
Verbena hastata	-	-	-	-	-	-	-	-	-	-
Vernonia noveboracensis	-	-	-	○○○●	-	-	-	-	-	-
Viola lanceolata	-	●●●●	●●●●	●●●●	●●●●	-	●●●●	-	-	-
Viola primulifolia	-	-	-	○○○●	-	-	-	-	-	-
Viola sororia	-	-	-	-	-	-	-	-	-	-
Woodwardia areolata	-	-	-	-	-	-	-	-	●	-
Woodwardia virginica	-	-	-	-	-	-	●●○●	-	-	●●○○
Xerophyllum asphodeloides	-	-	-	-	-	-	-	-	-	-
Xyris difformis	-	-	●○○○	●●○○	○○○●	-	-	-	-	-
Xyris smalliana	-	-	-	-	-	-	-	-	-	-
Zizania aquatica	-	-	-	-	●●●●	-	-	-	-	-
Woody plants:										
Acer rubrum	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●	●●●●
Ailanthus altissima	-	-	-	-	-	-	-	-	-	-
Alnus serrulata	-	-	●○●●	●●○●	○○○●	-	-	-	●	-
Amelanchier canadensis	-	-	-	-	○●○○	○●●○	○●○○	-	-	-
Amelanchier obovalis	-	-	-	-	-	-	-	-	-	-
Aronia arbutifolia	-	-	-	-	●●○○	-	-	-	●	○○●○
Berberis thunbergii	-	-	-	-	-	-	-	-	-	-
Betula lenta	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	BBACARRZ 97	BBALFORG 97	BBAPENNS 97	BBAQUAKR 98	BBARRBRG 97	BBART532 99	BBATHAMP 98	BBATRCAR 97	BBATRMAN 97	BBATRMOO 97
Betula populifolia	-	-	-	-	-	-	-	-	-	●●●●
Catalpa bignonioides	-	-	-	-	-	-	-	-	-	-
Cephalanthus occidentalis	●●●○	-	-	-	-	-	-	○○●○	-	-
Chamaecyparis thyoides	-	○●●●	●●●●	○○●●	●●●●	●●●○	○○●○	●●○○	●	●●●●
Chamaedaphne calyculata	-	○○●●	-	○○●●	●●●●	○○○●	●●●○	●●●●	●	●●●●
Clematis terniflora	-	-	-	-	-	-	-	-	-	-
Clethra alnifolia	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●	●○●○	●○○○	●	●●●●
Diospyros virginiana	-	-	-	-	-	-	-	-	-	-
Eubotrys racemosa	●●●●	-	●●●○	●●●●	●○●●	○●●●	○○○●	-	●	●○○●
Gaultheria procumbens	-	-	-	-	-	-	-	-	-	●●●●
Gaylussacia baccata	-	-	-	-	-	-	-	-	●	-
Gaylussacia dumosa	-	-	-	-	-	-	-	-	-	●●○○
Gaylussacia frondosa	-	-	-	○○●●	-	●○○●	-	-	●	●●○●
Hudsonia ericoides	-	-	-	-	-	-	-	-	-	-
Hypericum densiflorum	-	-	○●●○	-	○○○●	-	●●●●	-	-	-
Ilex glabra	-	-	●●●●	○●●●	●○●●	-	○●●●	○●○○	-	○○○●
Ilex laevigata	-	-	-	-	-	-	-	-	-	-
Ilex opaca	-	-	-	-	-	●●●●	●○○○	-	●	-
Ilex verticillata	●●●●	-	-	●●○●	●○○●	-	-	-	●	-
Itea virginica	-	-	-	○●○○	○○○●	●●○●	-	-	-	●●●●
Juniperus virginiana	-	-	-	-	-	-	-	-	-	-
Kalmia angustifolia	○●○○	○○○●	●○○○	-	○○●○	-	-	○●●○	●	○●○○
Kalmia latifolia	-	-	-	-	-	-	-	-	-	-
Leiophyllum buxifolium	-	-	-	-	-	-	-	-	-	-
Liquidambar styraciflua	-	-	-	-	-	-	-	-	-	●●●○
Lonicera japonica	-	-	-	-	-	-	-	-	-	-
Lyonia ligustrina	●●●○	○●○○	-	-	○○●●	-	-	●●●○	●	●○○●
Lyonia mariana	-	-	-	-	-	-	-	-	-	-
Magnolia virginiana	-	○○○●	-	●○●●	-	●○○●	-	-	-	●○○○
Myrica pensylvanica	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	○○○●	-	●●●●	-	●●●●	-	-	●	●●●●
Parthenocissus quinquefolia	-	-	-	-	-	-	-	-	-	-
Pinus echinata	-	-	-	-	-	-	-	-	-	-
Pinus rigida	-	-	-	○○○●	○○●○	-	-	●○●●	●	●●●●
Pinus strobus	-	-	-	-	-	-	-	-	-	-
Platanus occidentalus	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	BBACARRZ 97	BBALFORG 97	BBAPENNS 97	BBAQUAKR 98	BBARRBRG 97	BBART532 99	BBATHAMP 98	BBATRCAR 97	BBATRMAN 97	BBATRMOO 97
Prunus serotina	-	-	-	-	-	-	-	-	-	-
Quercus alba	-	-	-	-	-	-	-	-	-	-
Quercus ilicifolia	-	-	-	-	-	-	-	-	-	-
Quercus marilandica	-	-	-	-	-	-	-	-	-	-
Quercus sp. seedling	-	-	-	-	-	-	-	-	-	-
Quercus stellata	-	-	-	-	-	-	-	-	-	-
Quercus velutina	-	-	-	-	-	-	-	-	-	-
Rhododendron viscosum	●●●●	○○○●	-	●○●○	●●●○	●●○○	-	-	●	●●●●
Rosa palustris	-	-	-	-	-	-	-	-	-	-
Rubus hispidus	-	-	-	○○●○	○○○●	●●●●	●○●●	-	-	-
Rubus sp.	-	-	-	-	-	-	-	-	-	-
Salix nigra	-	-	-	-	-	-	-	-	-	-
Sambucus canadensis	-	-	-	-	-	-	-	-	-	-
Sassafras albidum	-	-	-	-	-	-	-	-	-	-
Smilax glauca	-	-	-	-	-	●●●●	○○○●	-	-	○●●○
Smilax laurifolia	-	-	-	-	-	-	-	-	●	-
Smilax rotundifolia	●○○○	●○○●	-	●○●●	-	●●●●	○●●●	-	●	-
Smilax walteri	-	-	-	●●○●	-	-	-	-	-	-
Spiraea alba var. latifolia	-	-	-	-	-	-	-	-	-	-
Spiraea tomentosa	-	-	-	-	○○●○	-	●●●●	-	-	-
Tilia americana	-	-	-	-	-	-	-	-	-	-
Toxicodendron radicans	-	-	-	-	-	-	-	-	-	-
Toxicodendron vernix	-	-	-	-	-	-	-	-	-	-
Ulmus americana	-	-	-	-	-	-	-	-	-	-
Vaccinium corymbosum	●●●●	●●○●	●●○○	●○●●	●●○●	●●●●	●●●●	●●●●	●	●●●●
Vaccinium macrocarpon	-	-	●●●●	●○○●	●●●●	●○●●	●●●●	●●●●	-	●●●●
Vaccinium pallidum	-	-	-	-	-	-	-	-	-	-
Viburnum dentatum	●●●●	●○●●	-	○●○○	-	-	-	-	-	-
Viburnum nudum var. nudum	-	-	●○●●	●●●●	-	-	-	-	●	○○○●
Vitis labrusca	-	-	-	-	-	-	-	-	-	-

Appendix 2.7.2.b. Plant species at stream-monitoring sites in the Batsto River drainage basin. Circles indicate a species is present at a site. Filled circles indicate the 25-m section where it was found (e.g., "●○●○" means a species was located in the first and third sections of the 100-m study site). Refer to Appendix 2.7.1 for site descriptions and explanations of site codes. Plant common names are presented in Appendix 2.8.

Species	Sites and Survey Years									
	BDEEPDKE 97	BHOBUTTR 97	BINSHADS 97	BMUSKTUC 98	BPEBRIDG 97	BSKITCAR 97	BSKITHAM 98	BSPRDIKE 97	BSPRIHAM 98	BTOMCARR 97
Herbaceous plants:										
Agrostis hyemalis	-	-	-	-	-	-	●●○●	-	●●●●	-
Agrostis hyemalis var. scabra	-	-	-	-	-	-	-	●●●●	-	-
Agrostis perennans	-	-	-	-	-	-	-	-	-	-
Agrostis perennans var. elata	-	-	-	-	-	-	-	-	●●●●	-
Agrostis sp.	-	-	-	-	○○○●	-	-	-	-	-
Alisma subcordatum	-	-	-	●○○○	-	-	-	-	-	-
Allium sp.	-	-	-	-	-	-	-	-	-	-
Amphicarpum purshii	-	-	-	-	-	-	-	-	-	-
Andropogon virginicus var. abbreviatus	-	-	-	-	●○●●	●○○○	●●●●	-	-	-
Andropogon virginicus var. virginicus	-	-	-	-	-	-	-	-	-	-
Apios americana	-	●	-	-	-	-	-	-	●●●○	-
Aralia nudicaulis	-	-	-	-	-	-	-	-	-	-
Arethusa bulbosa	-	-	-	-	-	-	-	-	-	-
Asclepias incarnata	-	-	-	●○○●	-	-	-	-	○●○○	-
Aster dumosus	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	-	-	-	-	●●●●	●●●●	-	-	-	○○○●
Aster novi-belgii	-	-	-	-	○○○●	○○○●	-	-	-	○○○●
Aster pilosus var. pringlei	-	-	-	-	-	-	-	-	-	-
Aster racemosus	-	-	-	-	-	-	-	-	○●○○	-
Bartonia paniculata	-	-	-	-	●○○●	○●●○	●●●●	-	-	-
Bartonia virginica	-	-	-	-	-	●○○●	-	-	-	○●○●
Bidens connata	-	●	○●○○	●○○○	-	-	-	○●●○	○●●○	-
Bidens coronata	-	-	-	-	-	-	-	-	-	-
Bidens discoidea	-	●	-	○○●●	-	-	-	-	-	-
Bidens frondosa	-	-	-	-	-	-	-	-	-	-
Bidens sp.	-	-	-	-	-	-	-	-	-	-
Boehmeria cylindrica	-	●	-	-	-	-	-	-	●●●○	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	-	-	-	-	○○●●	●○○●	-	-	-	-
Callitriche heterophylla	-	●	●●●●	●●●●	-	-	-	●●●●	●●●●	-

Species	BDEEPDKE 97	BHOBUTTR 97	BINSHADS 97	BMUSKTUC 98	BPEBRIDG 97	BSKITCAR 97	BSKITHAM 98	BSPRDIKE 97	BSPRIHAM 98	BTOMCARR 97
Cardamine pensylvanica	-	-	-	●●○○	-	-	-	-	-	-
Carex albolutescens	-	-	●●●●	-	-	-	-	-	-	-
Carex atlantica	-	-	-	-	●○○○	○●●●	●●●●	-	-	○●●●
Carex atlantica var. capillacea	-	-	●●●●	-	-	-	-	-	-	●○●●
Carex bullata	●○○●	-	-	-	-	-	●●●●	○●●●	-	●○○●
Carex canescens	-	-	-	-	-	-	●○○○	-	-	-
Carex collinsii	-	-	-	-	-	-	-	-	-	-
Carex crinita	-	-	○○●○	-	-	-	-	●●●●	●●●●	-
Carex exilis	-	-	-	-	●●●●	●●●●	-	-	-	-
Carex folliculata	-	-	-	-	●●○●	●●●●	-	●●●●	○●●●	●●●●
Carex intumescens	-	-	-	-	-	-	-	-	-	-
Carex livida	-	-	-	-	●●●●	●●●●	-	-	-	-
Carex longii	-	-	-	-	-	-	-	-	-	-
Carex lurida	-	●	-	○●●●	-	-	-	-	-	-
Carex pensylvanica	-	-	-	-	-	-	-	●○○○	○●○○	-
Carex scoparia	-	-	-	-	-	-	-	-	-	-
Carex stipata	-	-	-	○○○●	-	-	-	-	-	-
Carex striata	-	-	-	-	●●●●	-	-	-	-	-
Carex stricta	●○●○	-	-	-	-	●●●○	-	●●●●	-	●○○●
Carex tribuloides	-	-	-	-	-	-	-	-	-	-
Carex trisperma	-	-	-	-	-	●●●○	-	-	-	-
Carex venusta	-	-	-	-	-	-	-	-	-	-
Ceratophyllum echinatum	-	●	-	-	-	-	-	-	-	-
Chasmanthium laxum	-	-	-	-	-	-	-	-	-	-
Cinna arundinacea	-	-	-	●●●●	-	-	-	-	-	-
Cladium mariscoides	●○●●	-	-	-	-	-	-	-	-	-
Cuscuta sp.	-	●	●●●●	-	-	-	-	-	○○●○	●●●●
Cyperus dentatus	-	-	-	-	-	-	-	-	-	-
Cyperus erythrorhizos	-	-	-	-	-	-	-	-	-	-
Cyperus odoratus	-	-	-	-	-	-	-	-	-	-
Cyperus retrorsus	-	-	-	-	-	-	-	-	-	-
Cyperus strigosus	-	-	-	●●○●	-	-	-	●●○○	●●●●	-
Danthonia sericea var. epilis	-	-	-	-	○●●●	○●○●	-	-	-	-
Decodon verticillatus	-	●	●●●●	○●●●	-	-	-	-	-	●○○○
Dioscorea villosa	-	-	-	-	-	-	-	-	-	-
Drosera filiformis	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	BDEEPDKE 97	BHOBUTTR 97	BINSHADS 97	BMUSKTUC 98	BPEBRIDG 97	BSKITCAR 97	BSKITHAM 98	BSPRDIKE 97	BSPRIHAM 98	BTOMCARR 97
Drosera intermedia	●●●●	-	-	-	●●●●	●●●●	●●●●	-	-	-
Drosera rotundifolia	-	-	-	-	●●●●	●●●●	●●●●	-	-	○○○●
Dryopteris carthusiana	-	-	-	-	-	-	-	-	-	-
Dulichium arundinaceum	●●●●	-	○●○○	-	●●●●	●●●●	●●●●	●●●○	●●●●	○○●●
Echinochloa muricata	-	-	-	-	-	-	-	●●●●	●○○●	-
Eleocharis acicularis	-	-	-	-	-	-	-	-	-	-
Eleocharis flavescens var. olivacea	●●●●	-	○○○●	-	○○●○	●○○●	-	●○●○	-	-
Eleocharis microcarpa	-	-	-	-	-	-	-	-	-	-
Eleocharis ovata	-	-	-	●●●●	-	-	-	○○●○	-	-
Eleocharis robbinsii	●●●●	-	-	-	-	●●●●	●●●●	-	-	-
Eleocharis tenuis	○●●●	-	-	-	-	○●●○	●●●●	-	-	-
Eleocharis tuberculosa	-	-	-	-	-	●●○●	-	-	-	-
Elodea nuttallii	-	-	-	-	-	-	-	-	○●○○	-
Epilobium coloratum	-	●	-	●●●●	-	-	-	-	-	-
Erechtites hieracifolia	-	-	-	●●●●	-	-	-	-	-	-
Erianthus giganteus	-	-	-	-	-	-	-	-	-	-
Eriocaulon aquaticum	-	-	-	-	-	-	●●●●	-	-	-
Eriocaulon compressum	-	-	-	-	-	-	-	-	-	-
Eriocaulon decangulare	-	-	-	-	-	○○○●	-	-	-	-
Eriophorum virginicum	-	-	-	-	-	○●●●	●●●●	-	-	-
Eupatorium dubium	-	-	-	-	-	-	-	●●●●	●●●●	-
Eupatorium perfoliatum	-	-	-	●○○○	-	-	-	-	-	-
Eupatorium pilosum	-	-	-	-	-	-	-	-	-	-
Eupatorium resinosum	-	-	-	-	-	-	-	-	-	-
Eupatorium serotinum	-	-	-	●●○○	-	-	-	-	-	-
Euphorbia ipecacuanhae	-	-	-	-	-	-	-	-	-	-
Euthamia tenuifolia	-	-	-	-	-	-	-	-	-	-
Galium tinctorium	-	●	●●●●	●●●●	-	-	-	●●●●	●●●●	-
Glechoma hederacea	-	-	-	-	-	-	-	-	-	-
Glyceria canadensis	-	●	-	-	-	-	-	-	-	-
Glyceria obtusa	●●●●	-	●●●●	-	●○○○	○○●●	●●●●	●●●●	○●○○	●●●●
Glyceria striata	-	-	-	-	-	-	-	-	-	-
Glyceria x laxa	-	-	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-	-	-
Habenaria lacera	-	-	-	-	-	-	-	-	-	-
Hibiscus moscheutos	-	-	-	●●○○	-	-	-	-	-	-

Species	Sites and Survey Years									
	BDEEPDKE 97	BHOBUTTR 97	BINSHADS 97	BMUSKTUC 98	BPEBRIDG 97	BSKITCAR 97	BSKITHAM 98	BSPRDIKE 97	BSPRIHAM 98	BTOMCARR 97
Hypericum canadense	–	–	●●●●	–	–	–	–	–	–	–
Hypericum denticulatum	–	–	–	–	–	–	–	●○○○	–	–
Hypericum mutilum	–	–	–	●●●●	–	–	–	●○●●	●●●●	–
Hypericum stragulum	–	–	–	–	–	–	–	–	–	–
Impatiens capensis	–	●	–	●●●●	–	–	–	–	–	–
Iris prismatica	–	–	–	–	○○●○	–	–	–	–	–
Iris versicolor	–	–	–	–	–	–	–	●●●●	–	–
Isoetes echinospora	–	–	–	–	–	–	–	–	–	–
Juncus acuminatus	–	–	–	–	–	–	–	–	–	–
Juncus biflorus	–	–	–	–	–	–	–	–	–	–
Juncus caesariensis	–	–	–	–	○●○○	–	–	–	–	–
Juncus canadensis	○○○●	–	–	–	–	●○○●	●●●●	–	○●●○	–
Juncus effusus	–	●	●●●●	●●●●	–	–	●●●○	○○●○	○●○○	–
Juncus militaris	–	–	–	–	–	–	●●●●	–	–	–
Juncus pelocarpus	●●●●	–	–	–	●●●●	●●●●	●●●●	○●○○	●●○○	–
Lachnanthes caroliniana	–	–	–	–	–	–	●○●○	–	–	–
Leersia oryzoides	–	●	●●●●	●●○○	–	○●●●	●●●●	●●●●	●●●●	●●●●
Lemna sp.	–	●	–	●●●●	–	–	–	–	–	–
Lilium superbum	–	–	–	–	–	–	–	–	–	–
Lindernia dubia	–	–	–	–	–	–	–	●●●●	●○●○	–
Lobelia canbyi	–	–	–	–	–	–	–	–	–	–
Lobelia cardinalis	–	–	–	○○○●	–	–	–	●●●●	●●●●	–
Lobelia nuttallii	–	–	–	–	–	○●●●	–	●●●○	–	–
Lophiola aurea	–	–	–	–	–	–	–	–	–	–
Ludwigia alternifolia	–	–	–	–	–	–	–	–	–	–
Ludwigia palustris	–	●	●●○●	●●●●	–	–	–	●●●●	●●●●	–
Lycopodium alopecuroides	–	–	–	–	–	–	–	–	–	–
Lycopodium appressum	–	–	–	–	–	–	●●●○	–	–	–
Lycopodium obscurum	–	–	–	–	–	–	–	–	–	–
Lycopus uniflorus	–	●	–	●○●○	–	–	–	●●●●	●●○○	–
Lycopus virginicus	–	●	●○●●	–	–	–	–	○●○○	●●●●	–
Lysimachia terrestris	–	–	–	–	–	–	●●●●	●●●●	–	○○○●
Lythrum salicaria	–	–	–	●●●○	–	–	–	–	–	–
Microstegium vimineum	–	–	–	●●●●	–	–	–	●●●●	●●●●	–
Mikania scandens	–	●	–	●●●○	–	–	–	●●●●	●●●●	–
Mimulus ringens	–	–	–	–	–	–	–	–	–	–

Species	Sites and Survey Years									
	BDEEPDKE 97	BHOBUTTR 97	BINSHADS 97	BMUSKTUC 98	BPEBRIDG 97	BSKITCAR 97	BSKITHAM 98	BSPRDIKE 97	BSPRIHAM 98	BTOMCARR 97
Mitchella repens	–	●	–	–	–	–	–	●○○●	–	–
Monotropa uniflora	–	–	–	–	–	–	–	–	–	–
Muhlenbergia torreyana	–	–	–	–	–	–	–	–	–	–
Muhlenbergia uniflora	–	–	–	–	–	○○○●	●●●●	–	–	–
Nuphar variegata	●●●●	–	●○●●	●○○○	–	–	●●●●	–	–	●○○○
Nymphaea odorata	–	●	–	–	○○●○	●●●●	●●●●	–	–	○○○●
Onoclea sensibilis	–	–	–	●●●●	–	–	–	–	●●○○	–
Orontium aquaticum	–	–	–	–	●●●●	●●●●	–	–	–	●○○○
Osmunda cinnamomea	–	–	○●○●	–	–	○●●●	●○○○	–	–	–
Osmunda regalis	–	–	–	–	–	○●●○	–	–	–	–
Oxalis stricta	–	–	–	–	–	–	–	–	–	–
Oxypolis rigidior	–	–	–	–	–	–	–	–	–	–
Panicum clandestinum	–	●	–	–	–	–	–	–	○○●●	–
Panicum dichotomum	–	–	–	–	●●●●	●●●●	–	●●●●	●●●●	○○○●
Panicum ensifolium	–	–	–	–	–	–	–	–	–	–
Panicum lanuginosum var. lindheimeri	–	–	–	–	–	–	–	–	–	–
Panicum longifolium	–	–	–	–	–	–	○○○●	–	○●○○	–
Panicum rigidulum	–	–	–	–	–	–	–	●●●●	–	–
Panicum scabriusculum	–	–	–	–	–	–	–	●●●●	–	–
Panicum sp.	–	–	–	–	–	–	–	–	–	–
Panicum spretum	–	–	–	–	–	–	–	–	–	–
Panicum verrucosum	–	–	○○●●	–	–	–	–	●●●○	–	–
Panicum virgatum	○●●●	–	–	–	–	–	○●○○	–	–	–
Peltandra virginica	–	–	–	●●●●	–	○●●●	–	●●●●	○○●○	●●●●
Phalaris arundinacea	–	–	–	●○○○	–	–	–	–	–	–
Phragmites australis	–	–	–	–	–	–	–	–	–	–
Phytolacca americana	–	–	–	–	–	–	–	–	–	–
Pilea pumila	–	●	–	●●●●	–	–	–	–	–	–
Poa palustris	–	–	–	–	–	–	–	–	–	–
Poa pratensis	–	–	–	–	–	–	–	–	–	–
Pogonia ophioglossoides	–	–	–	–	○●○●	○●○●	–	–	–	–
Polygala brevifolia	–	–	–	–	–	○○●●	–	–	–	–
Polygala cruciata	–	–	–	–	○○○●	○○○●	○○●○	–	–	–
Polygonum arifolium	–	●	●●●●	●●○○	–	–	–	–	–	–
Polygonum cespitosum	–	–	–	–	–	–	–	–	–	–
Polygonum hydropiperoides	–	●	–	●●●●	–	–	–	–	●●●●	–

Species	Sites and Survey Years									
	BDEEPDKE	BHOBUTTR	BINSHADS	BMUSKTUC	BPEBRIDG	BSKITCAR	BSKITHAM	BSPRDIKE	BSPRIHAM	BTOMCARR
	97	97	97	98	97	97	98	97	98	97
Polygonum punctatum	-	-	●●●●	○●●●	-	-	-	-	-	-
Polygonum sagittatum	-	-	●●●●	●●●●	-	-	-	-	○○●●	-
Polygonum sp.	-	-	-	-	-	-	-	●●●●	-	-
Pontederia cordata	-	-	-	-	-	-	-	-	○○●○	-
Potamogeton confervoides	-	-	-	-	-	-	○○●○	-	-	-
Potamogeton diversifolius	-	-	-	-	-	-	-	-	-	-
Potamogeton epihydrus	-	●	-	○○●●	-	-	-	-	-	-
Potamogeton oakesianus	-	-	-	-	-	-	-	-	-	-
Potamogeton pusillus	-	-	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	-	-	-	-	-	-	-	-	-
Pteridium aquilinum	-	-	-	-	-	-	-	-	-	-
Rhexia mariana	-	-	-	-	-	-	-	-	-	-
Rhexia virginica	-	-	-	-	●○●○	-	○●●●	-	-	-
Rhynchospora alba	-	-	-	-	●●●●	●●●●	●●●●	-	-	-
Rhynchospora capitellata	-	-	-	-	-	-	-	-	-	-
Rhynchospora chalarocephala	-	-	-	-	-	-	-	-	-	-
Rorippa palustris	-	-	-	●○●●	-	-	-	-	-	-
Sabatia difformis	-	-	-	-	-	○○○●	-	○●○○	-	-
Sagittaria engelmanniana	●●○○	-	-	-	-	○○●●	●●●●	-	-	●○○●
Sarracenia purpurea	-	-	-	-	●●●●	●●●●	-	-	-	○○○●
Schizachyrium scoparium	-	-	-	-	-	-	-	-	-	-
Schizaea pusilla	-	-	-	-	●○○●	-	●●○○	-	-	-
Scirpus cyperinus	-	-	●●●○	●●●●	-	-	○●●○	●●●○	-	-
Scirpus pungens	-	-	-	-	-	-	-	-	-	-
Scirpus subterminalis	○○○●	-	-	-	○●●●	●●●●	●●●●	○○●○	-	●○○●
Scleria reticularis	-	-	-	-	-	-	-	-	-	-
Sclerolepis uniflora	-	-	-	-	-	-	-	-	-	-
Scutellaria lateriflora	-	●	-	-	-	-	-	●●●●	○●●○	-
Smilax herbacea	-	-	-	-	-	-	-	-	-	-
Smilax pseudochina	-	-	-	-	-	-	-	-	-	-
Solanum nigrum	-	-	-	-	-	-	-	-	-	-
Solidago canadensis	-	-	-	●○○○	-	-	-	-	-	-
Solidago rugosa	-	-	-	-	-	-	-	-	-	-
Sparganium americanum	-	●	●●●●	●●●●	-	○○●●	-	●●●○	●●●●	○○●○
Spiranthes cernua	-	-	-	-	-	-	-	-	○●●○	-
Stellaria graminea	-	-	-	-	-	-	-	-	-	-

Species	BDEEPDKE 97	BHOBUTTR 97	BINSHADS 97	BMUSKTUC 98	BPEBRIDG 97	BSKITCAR 97	BSKITHAM 98	BSPRDIKE 97	BSPRIHAM 98	BTOMCARR 97
Stellaria media	-	-	-	-	-	-	-	-	-	-
Taraxacum officinale	-	-	-	-	-	-	-	-	-	-
Thelypteris palustris	-	●	-	●●●●	-	-	-	-	○○●○	-
Thelypteris simulata	-	-	●●●●	-	-	-	-	-	-	-
Triadenum virginicum	●●●●	-	○○●●	-	●●●●	●●●●	●●●●	●●●●	●●●○	●●●●
Trientalis borealis	-	-	-	-	-	-	-	-	-	-
Typha latifolia	-	-	-	●●●●	-	-	-	-	-	-
Urtica dioica	-	-	-	-	-	-	-	-	-	-
Utricularia cornuta	-	-	-	-	-	-	-	-	-	-
Utricularia fibrosa	●●●●	-	-	-	○●○○	●●●●	-	-	-	-
Utricularia geminiscapa	-	-	-	-	-	-	-	-	-	-
Utricularia inflata	-	-	-	-	-	-	-	-	-	-
Utricularia purpurea	-	-	-	-	-	-	-	-	-	-
Utricularia sp.	-	-	-	-	-	-	-	-	-	-
Utricularia subulata	-	-	-	-	-	-	-	-	-	-
Utricularia vulgaris	-	-	-	-	-	-	-	-	-	-
Verbena hastata	-	-	-	●●○●	-	-	-	-	-	-
Vernonia noveboracensis	-	-	-	-	-	-	-	-	-	-
Viola lanceolata	-	-	-	-	-	-	-	●●●●	●●●●	-
Viola primulifolia	-	-	-	-	-	-	-	●●●●	-	-
Viola sororia	-	-	-	-	-	-	-	-	-	-
Woodwardia areolata	-	-	●●●●	-	-	-	-	-	●●●●	-
Woodwardia virginica	-	-	-	-	-	-	-	-	●●○●	-
Xerophyllum asphodeloides	-	-	-	-	-	-	-	-	-	-
Xyris difformis	○○●○	-	-	-	-	-	○○●●	-	-	-
Xyris smalliana	-	-	-	-	-	-	-	-	-	-
Zizania aquatica	-	-	-	-	-	-	-	-	-	-
Woody plants:										
Acer rubrum	●●●●	●	●●●●	-	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
Ailanthus altissima	-	-	-	-	-	-	-	-	-	-
Alnus serrulata	-	-	-	●●●●	-	○○●○	-	-	-	-
Amelanchier canadensis	-	-	-	-	●○●○	●●●●	-	-	-	○●○●
Amelanchier obovalis	-	-	-	-	-	-	-	-	-	-
Aronia arbutifolia	-	●	-	-	●●●●	●●●●	-	-	-	●○○○
Berberis thunbergii	-	-	-	-	-	-	-	-	-	-
Betula lenta	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	BDEEPDKE 97	BHOBUTTR 97	BINSHADS 97	BMUSKTUC 98	BPEBRIDG 97	BSKITCAR 97	BSKITHAM 98	BSPRDIKE 97	BSPRIHAM 98	BTOMCARR 97
Betula populifolia	-	-	-	-	-	○○●○	-	-	-	-
Catalpa bignonioides	-	-	-	-	-	-	-	-	-	-
Cephalanthus occidentalis	-	-	-	●●○●	-	-	-	-	○○●○	-
Chamaecyparis thyoides	-	-	-	-	●●●●	●●●●	●●●●	-	-	●●●●
Chamaedaphne calyculata	●●○●	-	-	-	●●●●	●●●●	●●●●	-	-	●●●●
Clematis terniflora	-	-	-	-	-	-	-	-	-	-
Clethra alnifolia	-	●	●●●●	-	●●●●	●●●●	●●○○	●○●○	●●●●	●●●●
Diospyros virginiana	-	-	-	-	-	-	-	-	○○●○	-
Eubotrys racemosa	-	●	●●●●	-	●●●●	●●●○	○●○○	●●●●	○●●●	○●○●
Gaultheria procumbens	-	-	-	-	-	-	-	-	-	-
Gaylussacia baccata	-	-	-	-	○○●○	-	-	○●○○	-	-
Gaylussacia dumosa	-	-	-	-	●●●●	●●●●	-	-	-	-
Gaylussacia frondosa	-	-	-	-	●●●●	○●●○	-	-	-	-
Hudsonia ericoides	-	-	-	-	-	-	-	-	-	-
Hypericum densiflorum	-	-	-	-	-	○○●○	-	-	-	-
Ilex glabra	-	-	-	-	●●●●	●●●●	●○○○	-	-	●●●○
Ilex laevigata	-	-	-	-	-	●○○●	-	-	-	-
Ilex opaca	-	-	-	-	-	-	●●○○	●●○○	-	●○○○
Ilex verticillata	-	●	○○○●	-	-	-	-	-	-	-
Itea virginica	-	●	-	-	●●●●	-	-	○●●●	○●○○	●●●○
Juniperus virginiana	-	-	-	-	-	-	-	-	-	-
Kalmia angustifolia	-	-	-	-	●●●●	○●○●	●●○○	-	-	●○●●
Kalmia latifolia	-	-	-	-	-	-	-	-	-	-
Leiophyllum buxifolium	-	-	-	-	-	-	-	-	-	-
Liquidambar styraciflua	-	-	-	-	-	-	-	●●●●	●●●●	-
Lonicera japonica	-	-	-	-	-	-	-	-	-	-
Lyonia ligustrina	-	-	-	-	-	-	-	-	-	○●●○
Lyonia mariana	-	-	-	-	-	-	○●○○	-	-	-
Magnolia virginiana	-	-	-	-	-	○●○○	-	-	-	○○●○
Myrica pensylvanica	-	-	-	-	○●●●	-	-	-	-	-
Nyssa sylvatica	-	●	-	-	-	-	○●○○	●●●●	○○○●	-
Parthenocissus quinquefolia	-	-	○○●○	-	-	-	-	-	●●○●	-
Pinus echinata	-	-	-	-	-	-	-	-	-	-
Pinus rigida	○●○●	-	-	-	●●●●	●●●●	○●●○	○○○●	-	-
Pinus strobus	-	-	-	-	-	-	-	-	-	-
Platanus occidentalus	-	-	-	-	-	-	-	-	-	-

Species	Sites and Survey Years									
	BDEEPDKE	BHOBUTTR	BINSHADS	BMUSKTUC	BPEBRIDG	BSKITCAR	BSKITHAM	BSPRDIKE	BSPRIHAM	BTOMCARR
	97	97	97	98	97	97	98	97	98	97
Prunus serotina	-	-	-	-	-	-	-	-	-	-
Quercus alba	-	-	-	-	-	-	-	-	-	-
Quercus ilicifolia	-	-	-	-	-	-	-	-	-	-
Quercus marilandica	-	-	-	-	-	-	-	-	-	-
Quercus sp. seedling	-	-	-	-	-	-	-	-	-	-
Quercus stellata	-	-	-	-	-	-	-	-	-	-
Quercus velutina	-	-	-	-	-	-	-	-	-	-
Rhododendron viscosum	-	-	-	-	●○○○	●●●●	○●○○	○●●○	-	●●●●
Rosa palustris	-	-	-	●●●●	-	-	-	-	-	-
Rubus hispidus	-	-	-	-	-	○○●○	-	-	-	-
Rubus sp.	-	●	-	-	-	-	-	-	○●●●	-
Salix nigra	-	●	-	-	-	-	-	-	-	-
Sambucus canadensis	-	●	-	○○●●	-	-	-	-	○○○●	-
Sassafras albidum	-	-	-	-	-	-	-	-	-	-
Smilax glauca	-	-	-	-	○●●●	-	-	●●●●	○●○○	-
Smilax laurifolia	-	-	-	-	-	-	-	-	-	-
Smilax rotundifolia	-	●	○●●●	-	●●●○	-	-	●●●●	●●●●	-
Smilax walteri	-	-	-	-	-	-	-	-	-	-
Spiraea alba var. latifolia	-	-	-	-	-	-	-	-	-	-
Spiraea tomentosa	-	-	-	-	-	-	-	-	-	-
Tilia americana	-	-	-	-	-	-	-	-	-	-
Toxicodendron radicans	-	-	○●○○	-	-	-	-	-	○○○●	-
Toxicodendron vernix	-	-	-	-	-	-	-	-	-	-
Ulmus americana	-	-	-	-	-	-	-	-	-	-
Vaccinium corymbosum	-	●	●●●●	-	●●●●	●●●●	●●○○	●●●●	○●●○	●●●●
Vaccinium macrocarpon	●●●●	-	-	-	○●○●	●●●●	●●●●	-	-	-
Vaccinium pallidum	-	-	-	-	-	-	-	-	-	○○●○
Viburnum dentatum	-	-	-	-	-	-	-	-	-	-
Viburnum nudum var. nudum	-	-	-	-	-	○○●○	-	-	-	-
Vitis labrusca	-	●	-	-	-	-	-	-	-	-

Appendix 2.8. Scientific and common names of plants found at stream-vegetation sites in the Mullica River Basin. Taxonomic nomenclature follows Gleason and Cronquist (1991).

Scientific/Common Name | Scientific/Common Name | Scientific/Common Name

Herbaceous plants:

Agrostis hyemalis
ticklegrass

Agrostis hyemalis var. scabra
ticklegrass

Agrostis perennans
upland bent-grass

Agrostis perennans var. elata
upland bent-grass

Alisma subcordatum
small water plantain

Allium sp.
garlic

Amphicarpum purshii
Pursh's millet-grass

Andropogon virginicus var. abbreviatus
bushy beard-grass

Andropogon virginicus var. virginicus
broomsedge

Apios americana
groundnut

Aralia nudicaulis
wild sarsaparilla

Arethusa bulbosa
arethusa

Asclepias incarnata
swamp milkweed

Aster dumosus
bushy aster

Aster nemoralis
bog aster

Aster novi-belgii
New York aster

Aster pilosus var. pringlei
heath aster

Aster racemosus
small white aster

Bartonia paniculata
twining bartonia

Bartonia virginica
yellow bartonia

Bidens connata
purple-stemmed beggar ticks

Bidens coronata
northern tickseed-sunflower

Bidens discoidea
small beggar ticks

Bidens frondosa
beggar ticks

Boehmeria cylindrica
false nettle

Calamagrostis canadensis
blue-joint grass

Calamagrostis cinnoides
Nuttall's reed-grass

Callitriche heterophylla
larger water starwort

Cardamine pensylvanica
Pennsylvania bitter-cress

Carex albolutescens
greenish-white sedge

Carex atlantica
Atlantic sedge

Carex atlantica var. capillacea
Howe's sedge

Carex bullata
button sedge

Carex canescens
silvery sedge

Carex collinsii
Collins' sedge

Carex crinita
fringed sedge

Carex exilis
coast sedge

Carex folliculata
long sedge

Carex intumescens
bladder sedge

Carex livida
livid sedge

Carex longii
Long's sedge

Carex lurida
sallow sedge

Carex pensylvanica
Pennsylvania sedge

Carex scoparia
pointed broom sedge

Carex stipata
awl-fruited sedge

Carex striata
Walter's sedge

Carex stricta
tussock sedge

Carex tribuloides
blunt broom sedge

Carex trisperma
three-fruited sedge

Carex venusta
dark green sedge

Ceratophyllum echinatum
prickly hornwort

Chasmanthium laxum
slender spike-grass

Cinna arundinacea
wood-reed

Cladium mariscoides
twig-rush

Cuscuta sp.
dodder

Cyperus dentatus
toothed cyperus

Cyperus erythrorhizos
red-rooted cyperus

Cyperus odoratus
coarse cyperus

Cyperus retrorsus
Pine Barrens cyperus

Cyperus strigosus
straw-colored cyperus

Scientific/Common Name	Scientific/Common Name	Scientific/Common Name
Danthonia sericea var. epilis silky wild oat-grass	*Eriocaulon compressum* flattened pipewort	*Hypericum mutilum* dwarf Saint John's-wort
Decodon verticillatus swamp loosestrife	*Eriocaulon decangulare* ten-angled pipewort	*Hypericum stragulum* Saint Andrew's cross
Dioscorea villosa common wild yam	*Eriophorum virginicum* tawny cotton-grass	*Impatiens capensis* spotted touch-me-not
Drosera filiformis thread-leaved sundew	*Eupatorium dubium* eastern joe-pye weed	*Iris prismatica* slender blue flag
Drosera intermedia spatulate-leaved sundew	*Eupatorium perfoliatum* boneset	*Iris versicolor* larger blue flag
Drosera rotundifolia round-leaved sundew	*Eupatorium pilosum* rough boneset	*Isoetes echinospora* spiny-spored quillwort
Dryopteris carthusiana spinulose wood fern	*Eupatorium resinosum* pine barrens boneset	*Juncus acuminatus* sharp-fruited rush
Dulichium arundinaceum dulichium	*Eupatorium serotinum* late-flowering boneset	*Juncus biflorus* two-flowered rush
Echinochloa muricata American barnyard grass	*Euphorbia ipecacuanhae* ipecac spurge	*Juncus caesariensis* New Jersey rush
Eleocharis acicularis needle spike-rush	*Euthamia tenuifolia* slender-leaved goldenrod	*Juncus canadensis* Canada rush
Eleocharis flavescens var. olivacea green spike-rush	*Galium tinctorium* stiff marsh bedstraw	*Juncus effusus* common rush
Eleocharis microcarpa small-fruited spike-rush	*Glechoma hederacea* gill-over-the-ground	*Juncus militaris* bayonet rush
Eleocharis ovata blunt spike-rush	*Glyceria canadensis* rattlesnake grass	*Juncus pelocarpus* brown-fruited rush
Eleocharis robbinsii Robbin's spike-rush	*Glyceria obtusa* blunt manna-grass	*Lachnanthes caroliniana* redroot
Eleocharis tenuis slender spike-rush	*Glyceria striata* fowl manna-grass	*Leersia oryzoides* rice cut-grass
Eleocharis tuberculosa tubercled spike-grass	*Glyceria × laxa* northern manna-grass	*Lemna sp.* duckweed
Elodea nuttallii Nuttall's water-weed	*Habenaria clavellata* green wood orchid	*Lilium superbum* turk's-cap lily
Epilobium coloratum purple-leaved willow-herb	*Habenaria lacera* ragged fringed orchid	*Lindernia dubia* short-stalked false pimpernel
Erechtites hieracifolia pilewort	*Hibiscus moscheutos* swamp rose mallow	*Lobelia canbyi* Canby's lobelia
Erianthus giganteus plume-grass	*Hypericum canadense* Canada Saint John's-wort	*Lobelia cardinalis* cardinal flower
Eriocaulon aquaticum seven-angled pipewort	*Hypericum denticulatum* coppery Saint John's-wort	*Lobelia nuttallii* Nuttall's lobelia

Scientific/Common Name

Lophiola aurea
golden-crest

Ludwigia alternifolia
seedbox

Ludwigia palustris
water purslane

Lycopodium alopecuroides
foxtail-clubmoss

Lycopodium appressum
southern bog clubmoss

Lycopodium obscurum
tree clubmoss

Lycopus uniflorus
northern bugleweed

Lycopus virginicus
Virginia bugleweed

Lysimachia terrestris
swamp loosestrife

Lythrum salicaria
purple loosestrife

Microstegium vimineum
eulalia

Mikania scandens
climbing hempweed

Mimulus ringens
square-stemmed monkey-flower

Mitchella repens
partridge berry

Monotropa uniflora
indian pipe

Muhlenbergia torreyana
Torrey's dropseed

Muhlenbergia uniflora
late-flowering dropseed

Nuphar variegata
bullhead lily

Nymphaea odorata
white water lily

Onoclea sensibilis
sensitive fern

Orontium aquaticum
golden club

Scientific/Common Name

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 ensifolium
small-leaved panic-grass

Panicum lanuginosum
panic-grass

Panicum longifolium
long-leaved panic-grass

Panicum rigidulum
long-leaved panic-grass

Panicum scabriusculum
sheathed panic-grass

Panicum spretum
Eaton's panic-grass

Panicum verrucosum
warty panic-grass

Panicum virgatum
switchgrass

Peltandra virginica
arrow arum

Phalaris arundinacea
reed canary grass

Phragmites australis
reed

Phytolacca americana
pokeweed

Pilea pumila
clearweed

Poa palustris
fowl bluegrass

Poa pratensis
Kentucky bluegrass

Scientific/Common Name

Pogonia ophioglossoides
rose pogonia

Polygala brevifolia
short-leaved milkwort

Polygala cruciata
cross-leaved milkwort

Polygonum arifolium
halberd-leaved tearthumb

Polygonum cespitosum
cespitose knotweed

Polygonum hydropiperoides
mild water pepper

Polygonum punctatum
dotted smartweed

Polygonum sagittatum
arrow-leaved tearthumb

Pontederia cordata
pickerel-weed

Potamogeton confervoides
alga-like pondweed

Potamogeton diversifolius
hair-like pondweed

Potamogeton epihydrus
Nuttall's pondweed

Potamogeton oakesianus
Oakes' pondweed

Potamogeton pusillus
small pondweed

Proserpinaca pectinata
cut-leaved mermaid-weed

Pteridium aquilinum
bracken

Rhexia mariana
Maryland meadow beauty

Rhexia virginica
Virginia meadow beauty

Rhynchospora alba
white beaked-rush

Rhynchospora capitellata
small-headed beaked-rush

Rhynchospora chalarocephala
loose-headed beaked-rush

Scientific/Common Name

Rorippa palustris
marsh yellow cress

Sabatia difformis
lance-leaved sabatia

Sagittaria engelmanniana
Engelmann's arrowhead

Sarracenia purpurea
pitcher plant

Schizachyrium scoparium
little bluestem

Schizaea pusilla
curly-grass fern

Scirpus cyperinus
wool-grass

Scirpus pungens
three-square bulrush

Scirpus subterminalis
water club-rush

Scleria reticularis
reticulated nut-rush

Sclerolepis uniflora
Sclerolepis

Scutellaria lateriflora
mad-dog skullcap

Smilax herbacea
carrion flower

Smilax pseudochina
halberd-leaved greenbrier

Solanum nigrum
black nightshade

Solidago canadensis
Canada goldenrod

Solidago rugosa
rough-stemmed goldenrod

Sparganium americanum
slender bur-reed

Spiranthes cernua
nodding ladies'-tresses

Stellaria graminea
common stitchwort

Stellaria media
common chickweed

Taraxacum officinale
dandelion

Thelypteris palustris
marsh fern

Thelypteris simulata
bog fern

Triadenum virginicum
marsh Saint John's-wort

Trientalis borealis
starflower

Typha latifolia
broad-leaved cat-tail

Urtica dioica
stinging nettle

Utricularia cornuta
horned bladderwort

Utricularia fibrosa
fibrous bladderwort

Utricularia geminiscapa
hidden-fruited bladderwort

Utricularia inflata
floating bladderwort

Utricularia purpurea
purple bladderwort

Utricularia subulata
zig-zag bladderwort

Utricularia vulgaris
greater bladderwort

Verbena hastata
blue vervain

Vernonia noveboracensis
New York ironweed

Viola lanceolata
lance-leaved violet

Viola primulifolia
primrose-leaved violet

Viola sororia
woolly blue violet

Woodwardia areolata
netted chain fern

Woodwardia virginica
Virginia chain fern

Xerophyllum asphodeloides
turkey-beard

Xyris difformis
yellow-eyed grass

Xyris smalliana
Small's yellow-eyed grass

Zizania aquatica
wild rice

<u>Woody plants:</u>

Acer rubrum
red maple

Ailanthus altissima
ailanthus

Alnus serrulata
smooth alder

Amelanchier canadensis
oblongleaf juneberry

Amelanchier obovalis
coastal juneberry

Aronia arbutifolia
red chokeberry

Berberis thunbergii
Japanese barberry

Betula lenta
black birch

Betula populifolia
gray birch

Catalpa bignonioides
common catalpa

Cephalanthus occidentalis
buttonbush

Chamaecyparis thyoides
Atlantic white cedar

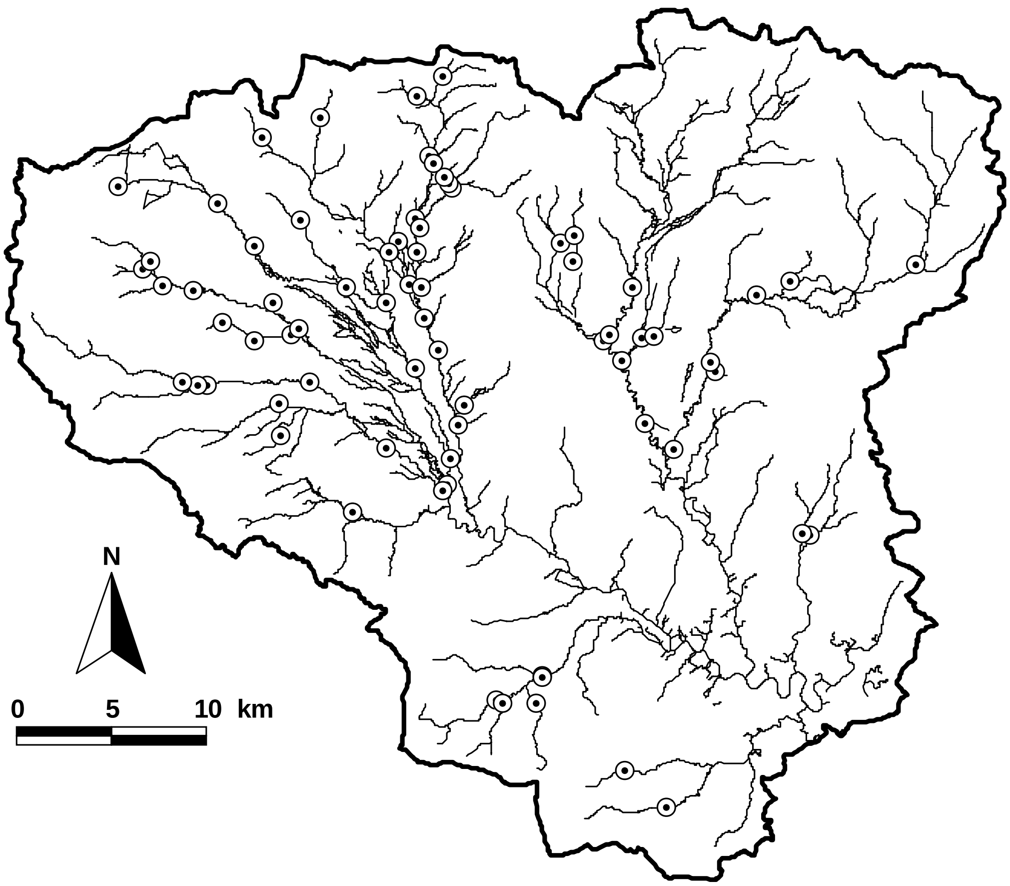
Chamaedaphne calyculata
leatherleaf

Clematis terniflora
yam-leaved clematis

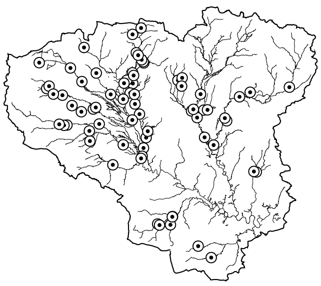
Clethra alnifolia
sweet pepperbush

Scientific/Common Name
Diospyros virginiana persimmon
Eubotrys racemosa fetterbush
Gaultheria procumbens wintergreen
Gaylussacia baccata black huckleberry
Gaylussacia dumosa dwarf huckleberry
Gaylussacia frondosa dangleberry
Hudsonia ericoides golden heather
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
Kalmia latifolia mountain laurel
Leiophyllum buxifolium sand myrtle
Liquidambar styraciflua sweet gum
Lonicera japonica Japanese honeysuckle
Lyonia ligustrina maleberry
Lyonia mariana staggerbush
Magnolia virginiana sweet bay
Myrica pensylvanica bayberry
Nyssa sylvatica black gum
Parthenocissus quinquefolia Virginia creeper
Pinus echinata shortleaf pine
Pinus rigida pitch pine
Pinus strobus white pine
Platanus occidentalus sycamore
Prunus serotina black cherry
Quercus alba white oak
Quercus ilicifolia scrub oak
Quercus marilandica black-jack oak
Quercus stellata post oak
Quercus velutina black oak
Rhododendron viscosum swamp azalea
Rosa palustris swamp rose
Rubus hispidus swamp dewberry
Rubus sp. blackberry
Salix nigra black willow
Sambucus canadensis common elder
Sassafras albidum sassafras
Smilax glauca glaucous greenbrier
Smilax laurifolia laurel-leaved greenbrier
Smilax rotundifolia common greenbrier
Smilax walteri red-berried greenbrier
Spiraea alba var. latifolia narrow-leaved meadowsweet
Spiraea tomentosa steeplebush
Tilia americana basswood
Toxicodendron radicans poison ivy
Toxicodendron vernix poison sumac
Ulmus americana American elm
Vaccinium corymbosum highbush blueberry
Vaccinium macrocarpon large cranberry
Vaccinium pallidum early low blueberry
Viburnum dentatum southern arrowwood
Viburnum nudum var. nudum naked withe-rod
Vitis labrusca fox grape

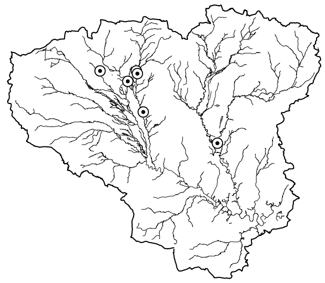
APPENDIX 2.9. PLANT-DISTRIBUTION MAPS



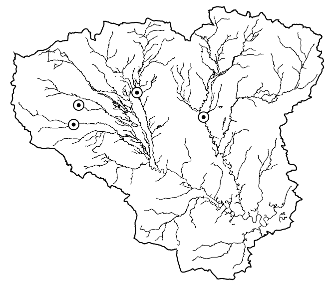
Location of 72 stream-vegetation survey sites. Distribution maps for plant species found at two or more sites are on the following pages.



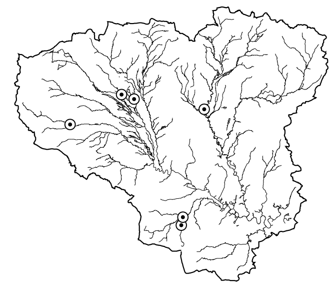
Acer rubrum
red maple



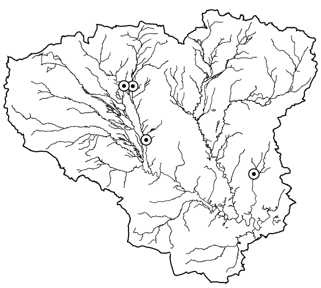
Agrostis hyemalis
ticklegrass



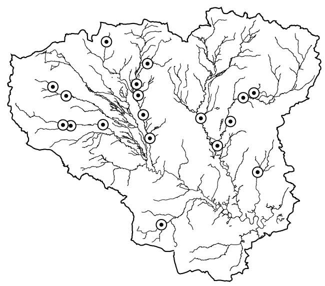
Agrostis hyemalis var. scabra
ticklegrass



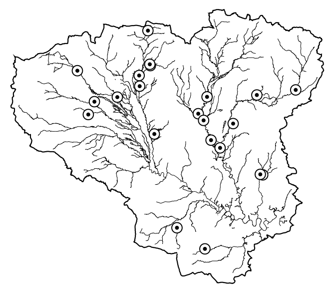
Agrostis perennans
upland bent-grass



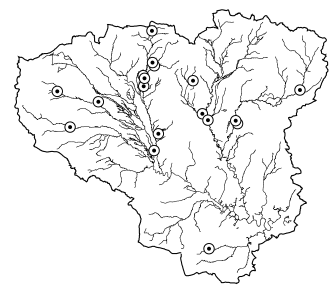
Agrostis perennans var. elata
upland bent-grass



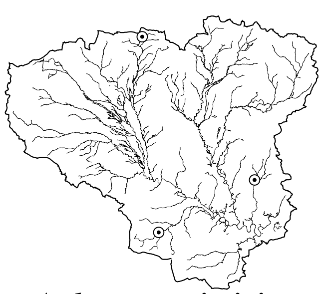
Alnus serrulata
smooth alder



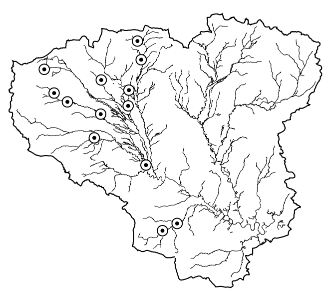
Amelanchier canadensis
oblongleaf juneberry



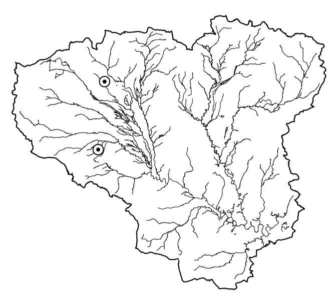
Andropogon virginicus var. abbreviatus
bushy beard-grass



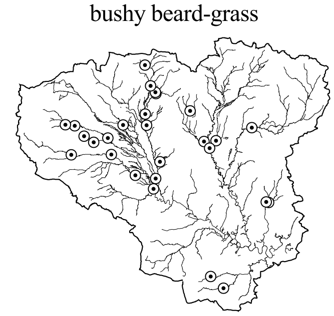
Andropogon virginicus var. virginicus
broomsedge



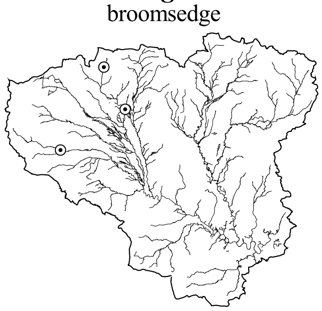
Apios americana
groundnut



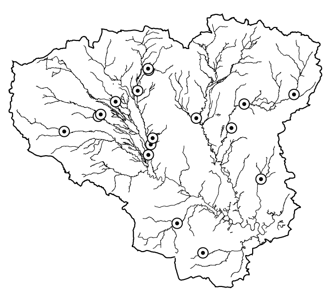
Aralia nudicaulis
wild sarsaparilla



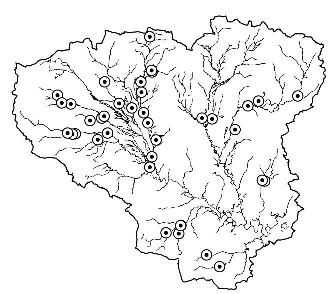
Aronia arbutifolia
red chokeberry



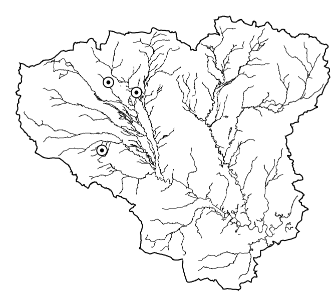
Asclepias incarnata
swamp milkweed



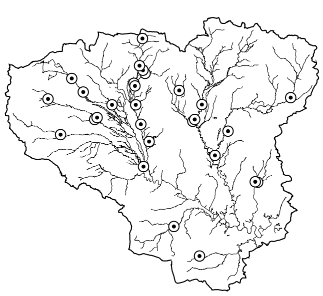
Aster nemoralis
bog aster



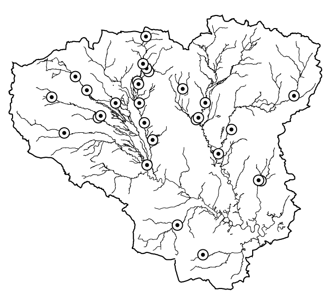
Aster novi-belgii
New York aster



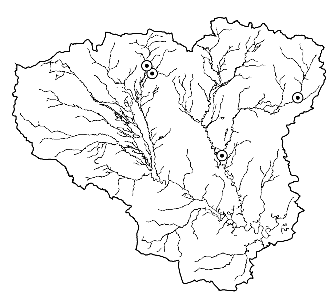
Aster racemosus
small white aster



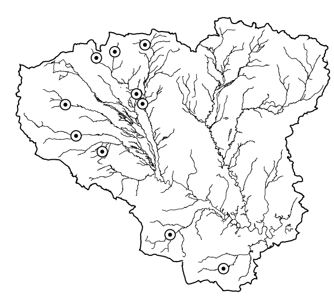
Bartonia paniculata
twining bartonia



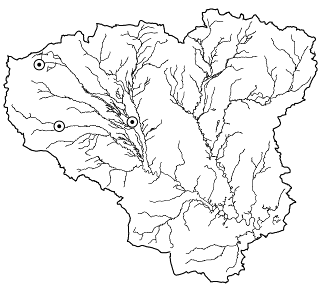
Bartonia virginica
yellow bartonia



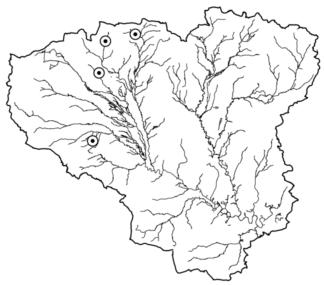
Betula populifolia
gray birch



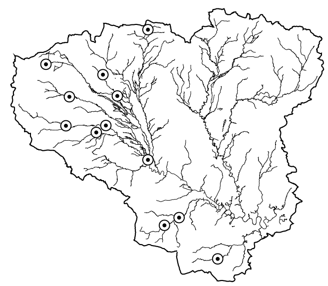
Bidens connata
purple-stemmed beggar ticks



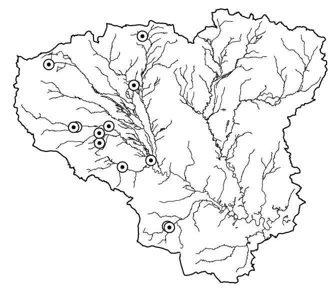
Bidens coronata
northern tickseed-sunflower



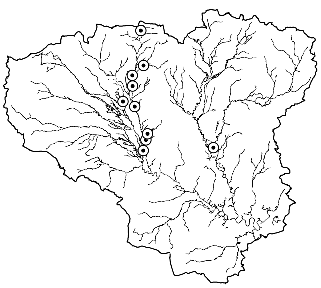
Bidens discoidea
small beggar ticks



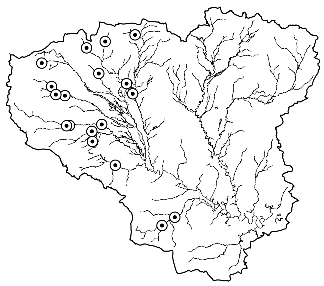
Bidens frondosa
beggar ticks



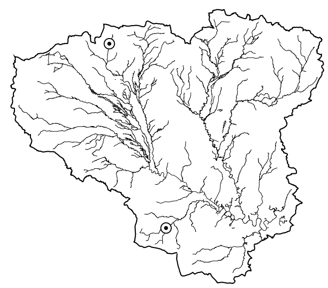
Boehmeria cylindrica
false nettle



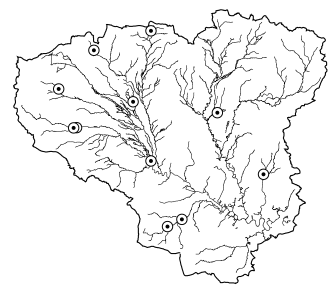
Calamagrostis cinnoides
Nuttall's reed-grass



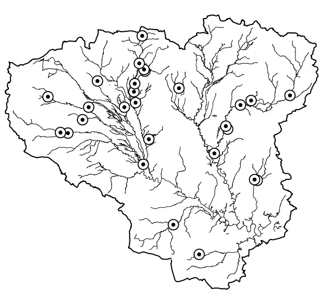
Callitriche heterophylla
larger water starwort



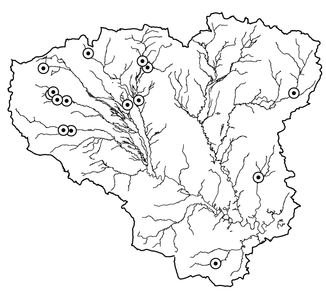
Cardamine pensylvanica
Pennsylvania bitter-cress



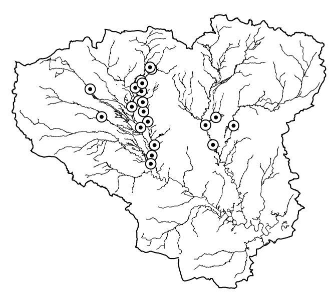
Carex albolutescens
greenish-white sedge



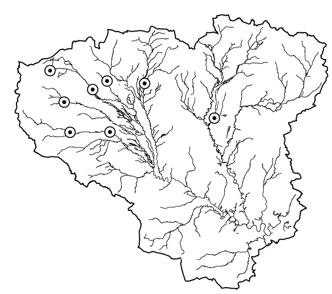
Carex atlantica
Atlantic sedge



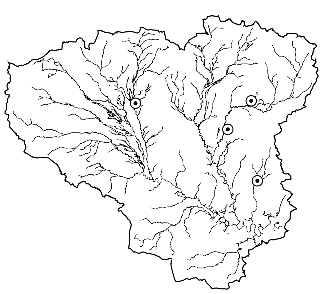
Carex atlantica var. capillacea
Howe's sedge



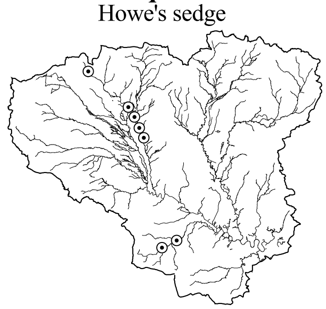
Carex bullata
button sedge



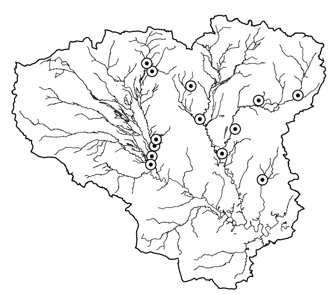
Carex canescens
silvery sedge



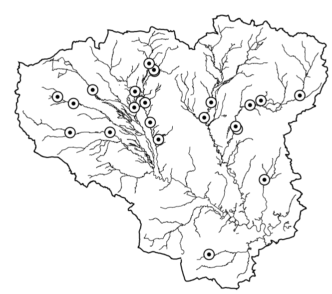
Carex collinsii
Collins' sedge



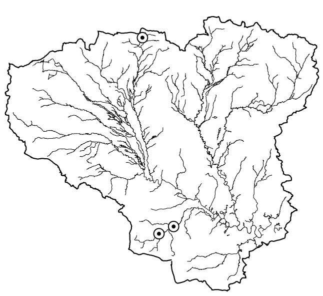
Carex crinita
fringed sedge



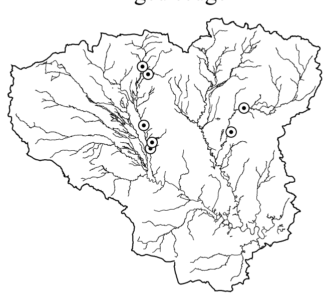
Carex exilis
coast sedge



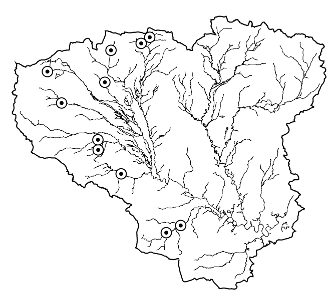
Carex folliculata
long sedge



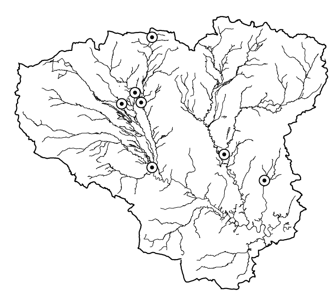
Carex intumescens
bladder sedge



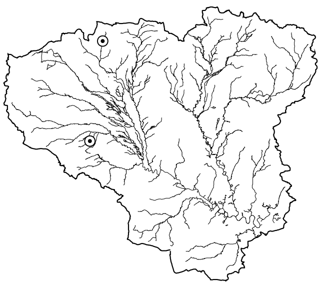
Carex livida
livid sedge



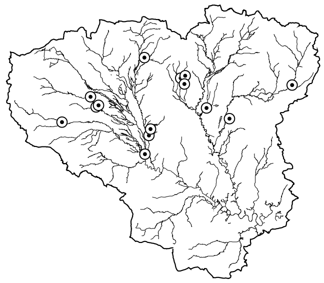
Carex lurida
sallow sedge



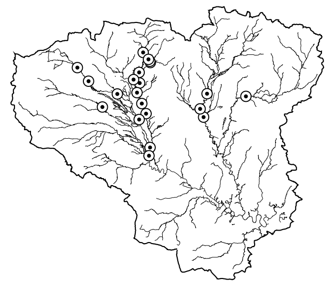
Carex pensylvanica
Pennsylvania sedge



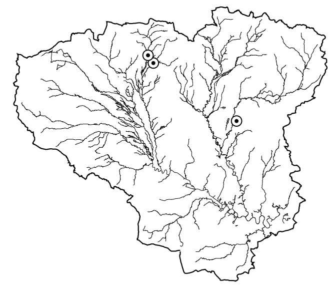
Carex stipata
awl-fruited sedge



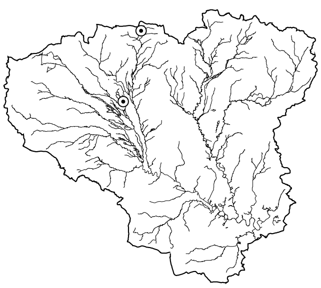
Carex striata
Walter's sedge



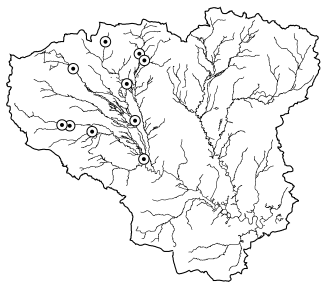
Carex stricta
tussock sedge



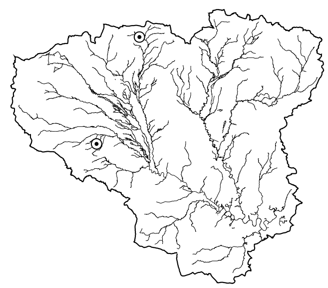
Carex trisperma
three-fruited sedge



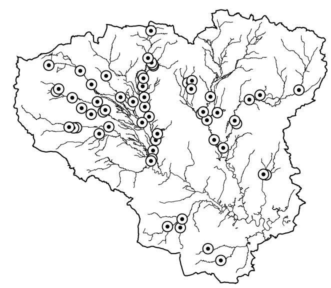
Carex venusta
dark green sedge



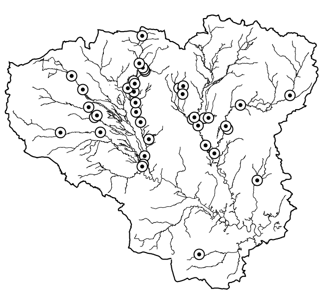
Cephalanthus occidentalis
buttonbush



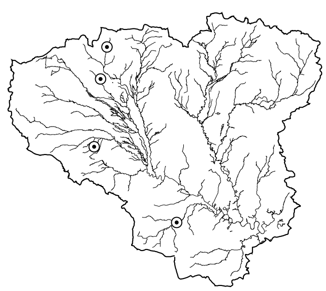
Ceratophyllum echinatum
prickly hornwort



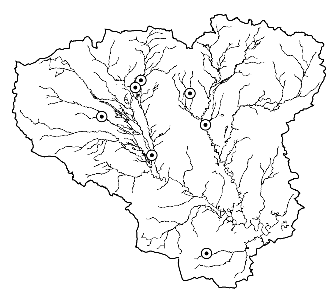
Chamaecyparis thyoides
Atlantic white cedar



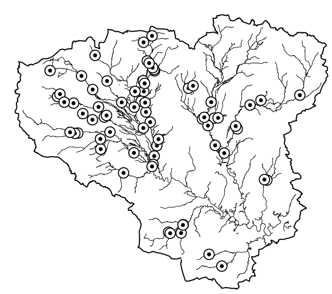
Chamaedaphne calyculata
leatherleaf



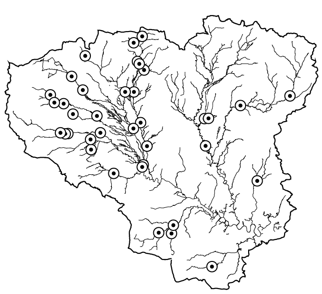
Cinna arundinacea
wood-reed



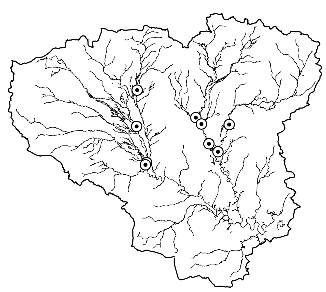
Cladium mariscoides
twig-rush



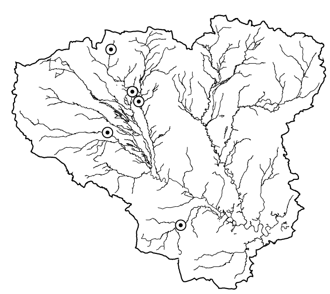
Clethra alnifolia
sweet pepperbush



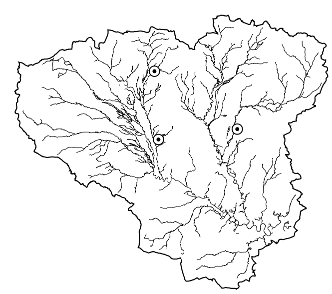
Cuscuta sp.
dodder



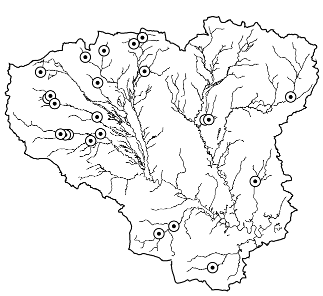
Cyperus dentatus
toothed cyperus



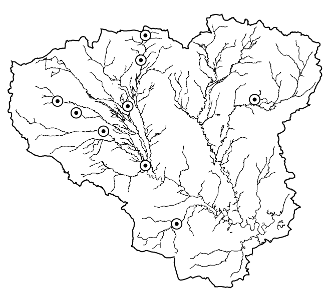
Cyperus strigosus
straw-colored cyperus



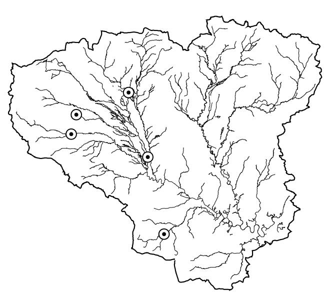
Danthonia sericea var. epilis
silky wild oat-grass



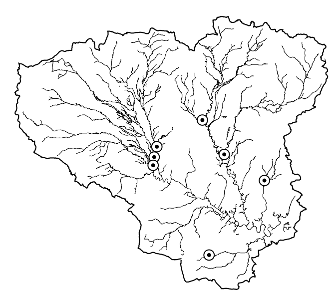
Decodon verticillatus
swamp loosestrife



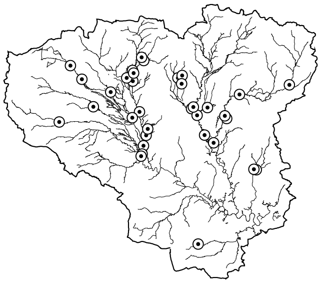
Dioscorea villosa
common wild yam



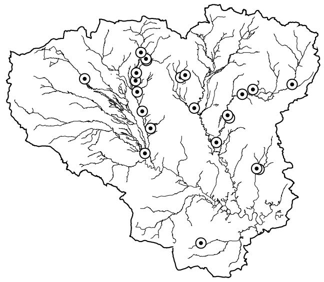
Diospyros virginiana
persimmon



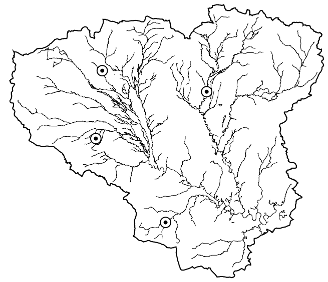
Drosera filiformis
thread-leaved sundew



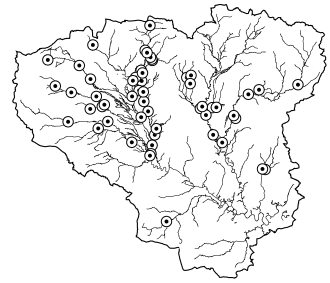
Drosera intermedia
spatulate-leaved sundew



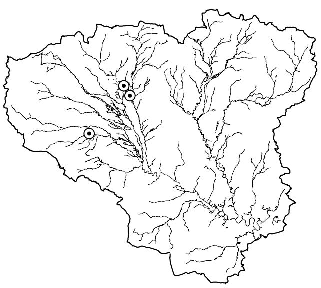
Drosera rotundifolia
round-leaved sundew



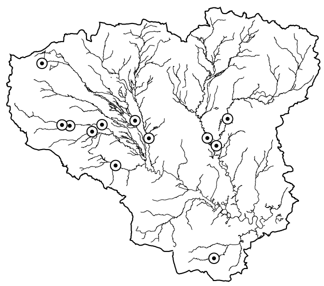
Dryopteris carthusiana
spinulose wood fern



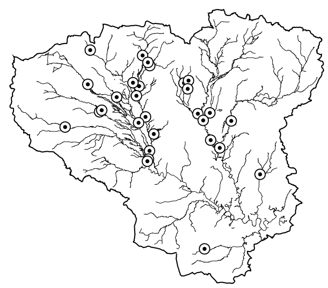
Dulichium arundinaceum
dulichium



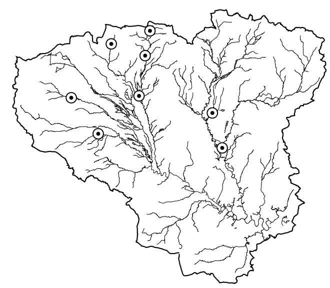
Echinochloa muricata
American barnyard grass



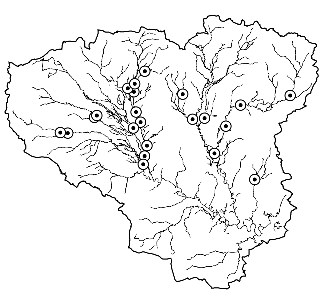
Eleocharis acicularis
needle spike-rush



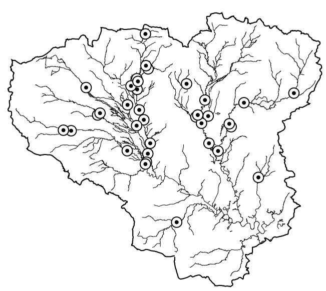
Eleocharis flavescens var. olivacea
green spike-rush



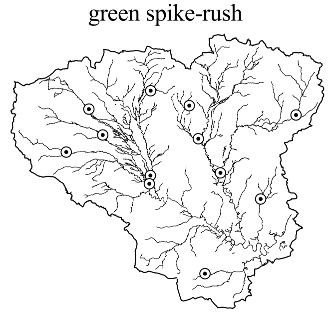
Eleocharis ovata
blunt spike-rush



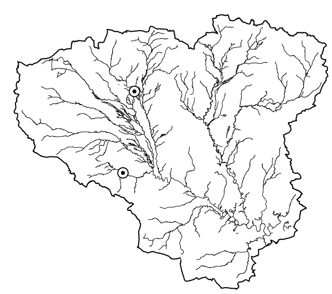
Eleocharis robbinsii
Robbin's spike-rush



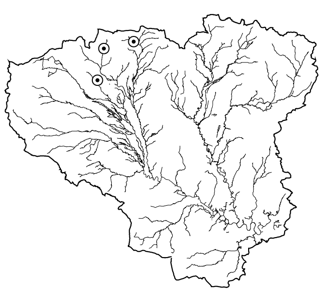
Eleocharis tenuis
slender spike-rush



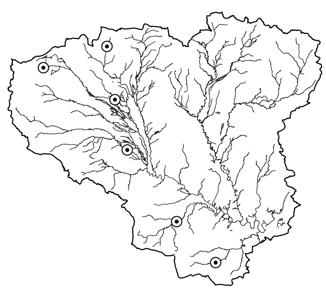
Eleocharis tuberculosa
tubercled spike-grass



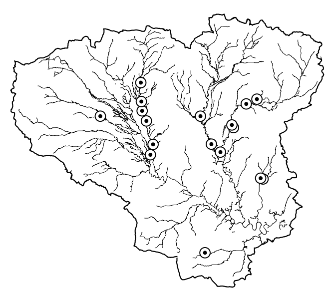
Elodea nuttallii
Nuttall's water-weed



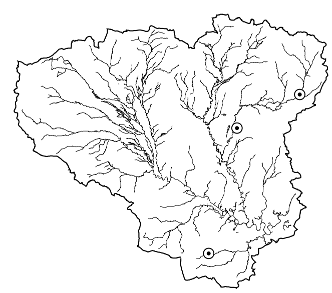
Epilobium coloratum
purple-leaved willow-herb



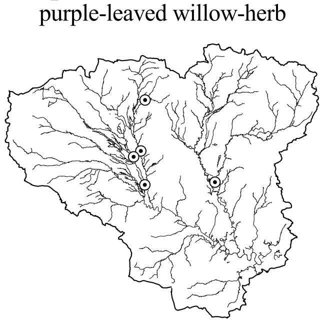
Erechtites hieracifolia
pilewort



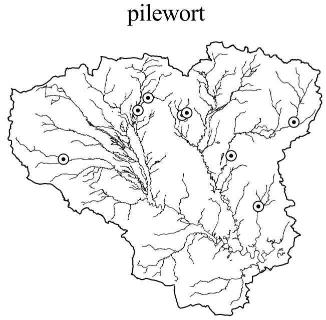
Eriocaulon aquaticum
seven-angled pipewort



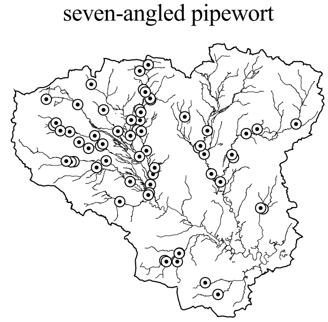
Eriocaulon compressum
flattened pipewort



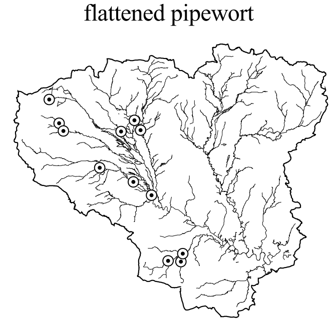
Eriocaulon decangulare
ten-angled pipewort



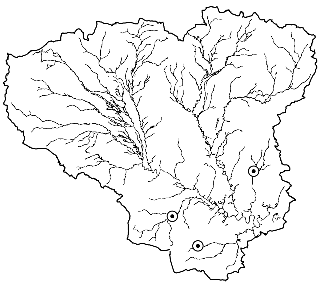
Eriophorum virginicum
tawny cotton-grass



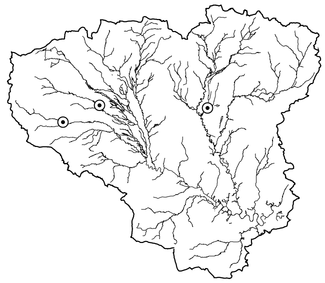
Eubotrys racemosa
fetterbush



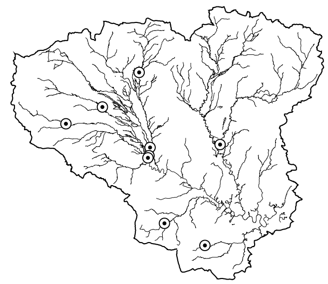
Eupatorium dubium
eastern joe-pye weed



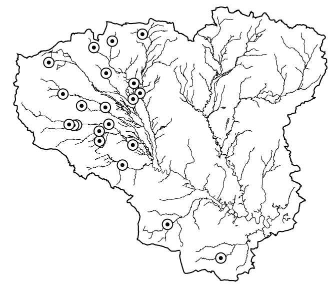
Eupatorium pilosum
rough boneset



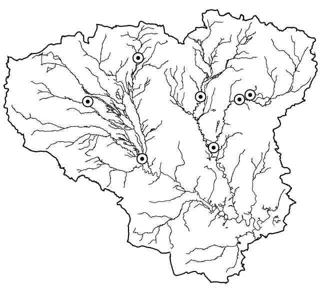
Eupatorium resinosum
pine barrens boneset



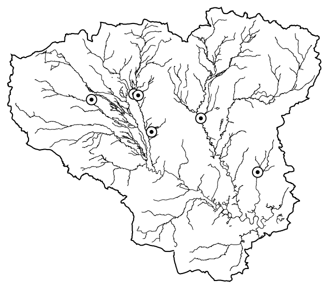
Euthamia tenuifolia
slender-leaved goldenrod



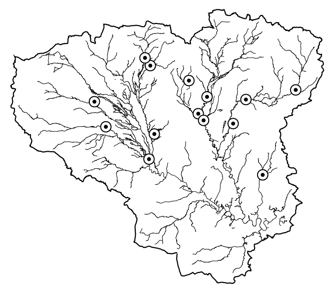
Galium tinctorium
stiff marsh bedstraw



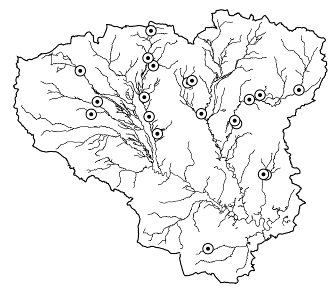
Gaultheria procumbens
wintergreen



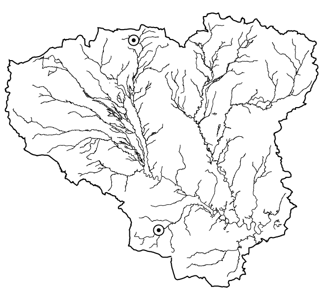
Gaylussacia baccata
black huckleberry



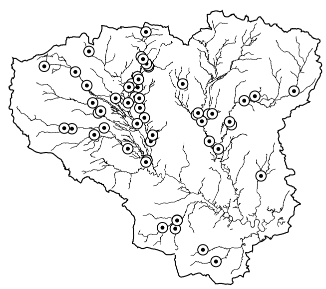
Gaylussacia dumosa
dwarf huckleberry



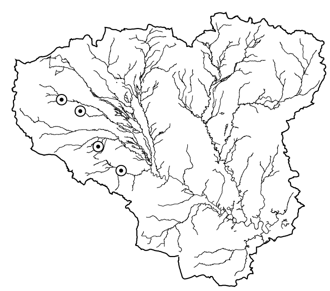
Gaylussacia frondosa
dangleberry



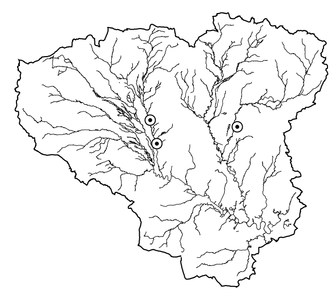
Glyceria canadensis
rattlesnake grass



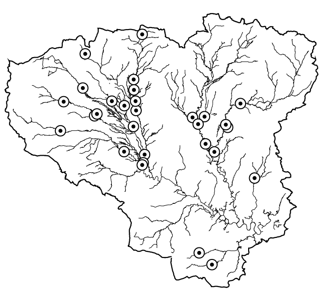
Glyceria obtusa
blunt manna-grass



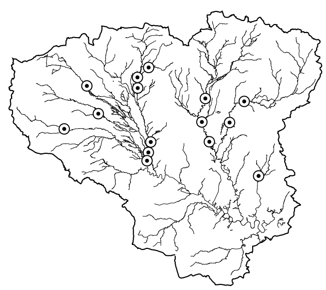
Glyceria striata
fowl manna-grass



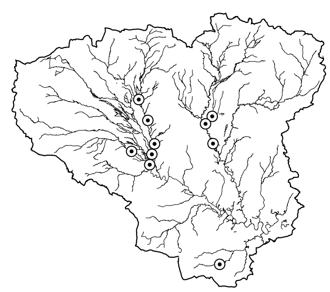
Habenaria clavellata
green wood orchid



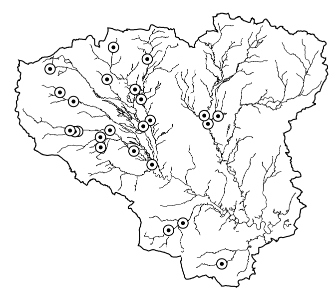
Hypericum canadense
Canada Saint John's-wort



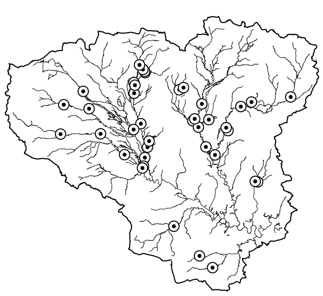
Hypericum densiflorum
bushy Saint John's-wort



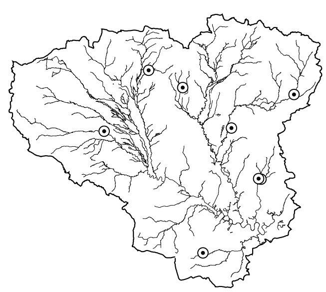
Hypericum denticulatum
coppery Saint John's-wort



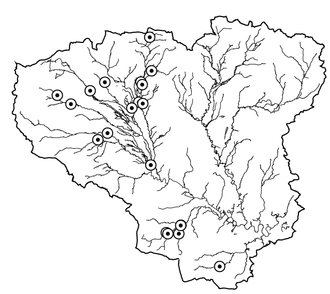
Hypericum mutilum
dwarf Saint John's-wort



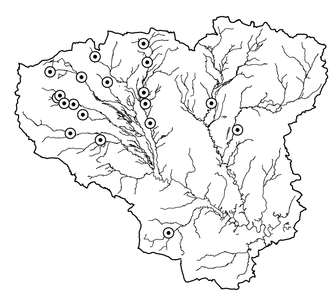
Ilex glabra
inkberry



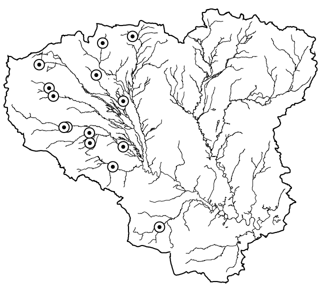
Ilex laevigata
smooth winterberry



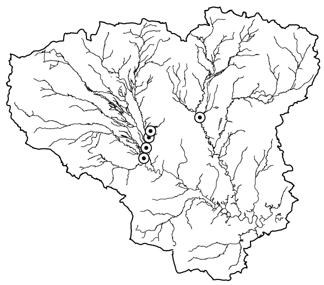
Ilex opaca
American holly



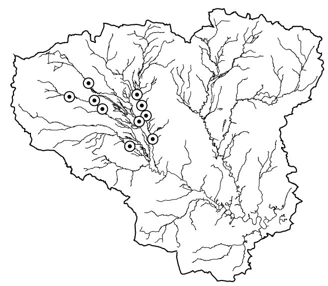
Ilex verticillata
winterberry



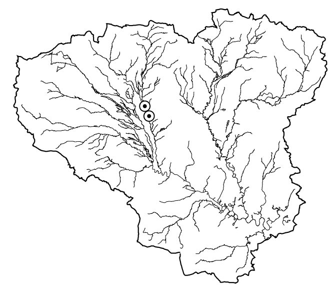
Impatiens capensis
spotted touch-me-not



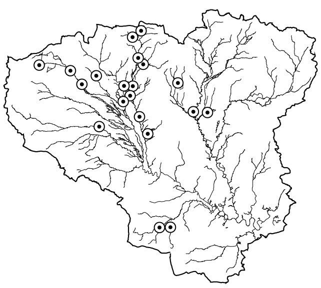
Iris prismatica
slender blue flag



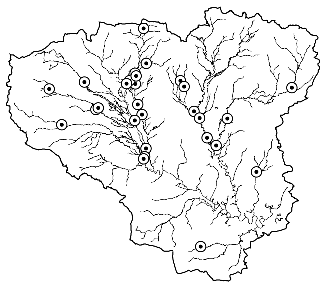
Iris versicolor
larger blue flag



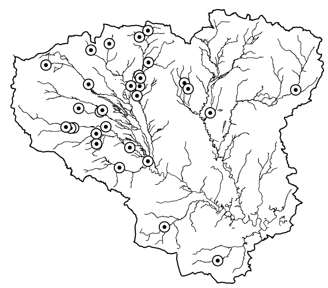
Isoetes echinospora
spiny-spored quillwort



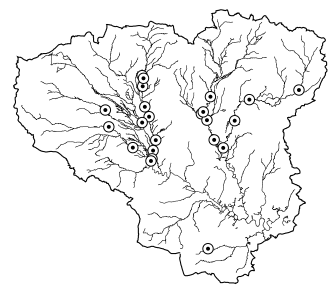
Itea virginica
Virginia willow



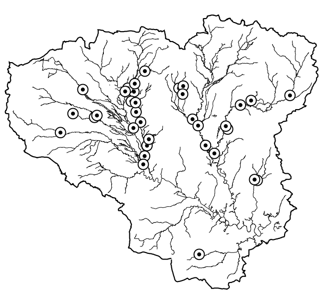
Juncus canadensis
Canada rush



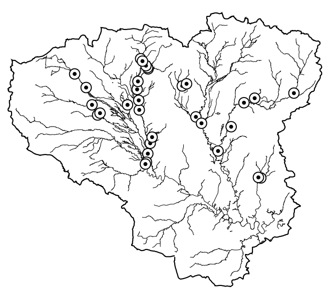
Juncus effusus
common rush



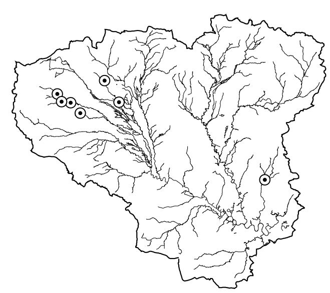
Juncus militaris
bayonet rush



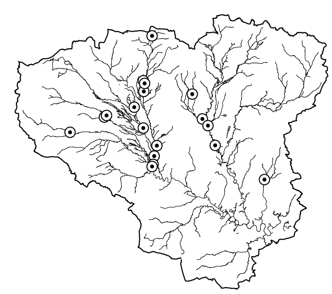
Juncus pelocarpus
brown-fruited rush



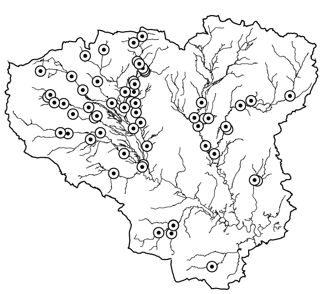
Kalmia angustifolia
sheep laurel



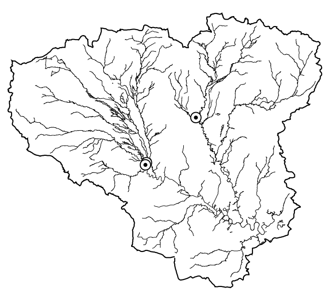
Kalmia latifolia
mountain laurel



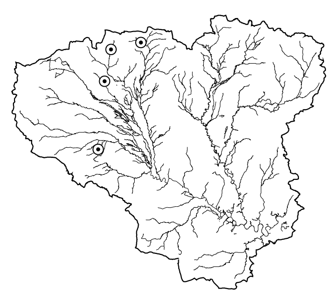
Lachnanthes caroliniana
redroot



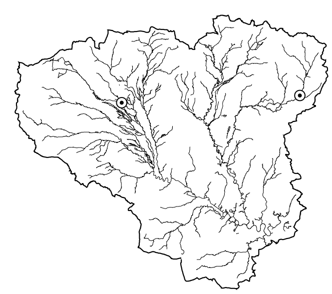
Leersia oryzoides
rice cut-grass



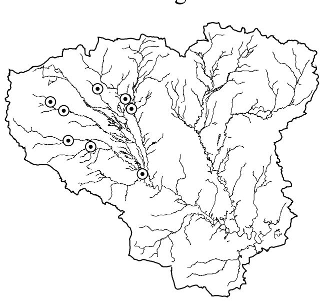
Leiophyllum buxifolium
sand myrtle



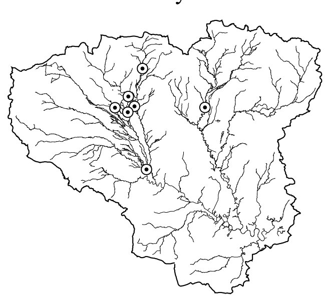
Lemna sp.
duckweed



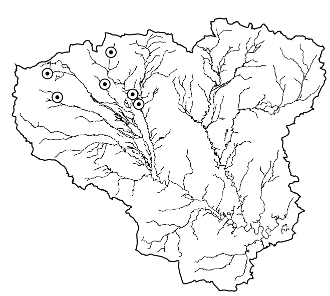
Lilium superbum
turk's-cap lily



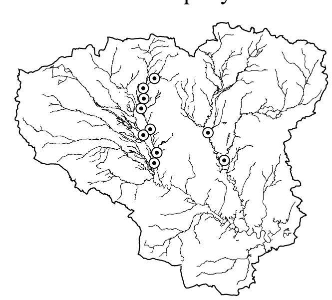
Lindernia dubia
short-stalked false pimpernel



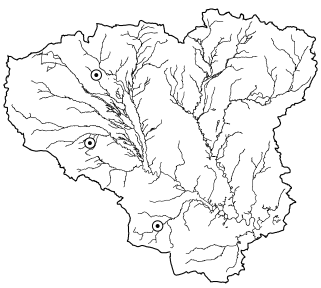
Liquidambar styraciflua
sweet gum



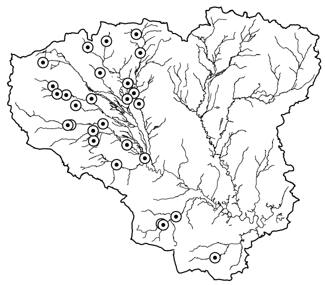
Lobelia cardinalis
cardinal flower



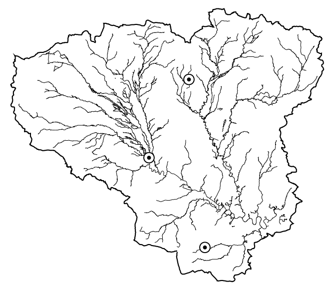
Lobelia nuttallii
Nuttall's lobelia



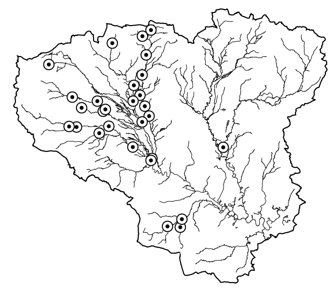
Lonicera japonica
Japanese honeysuckle



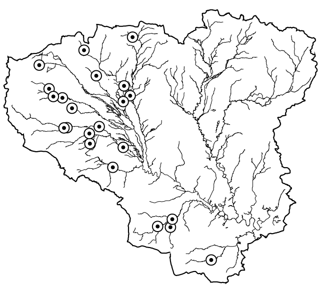
Ludwigia palustris
water purslane



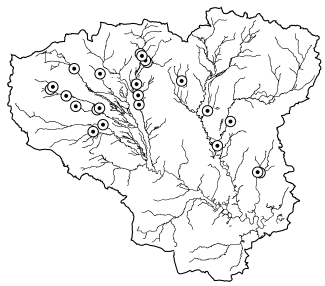
Lycopodium alopecuroides
foxtail-clubmoss



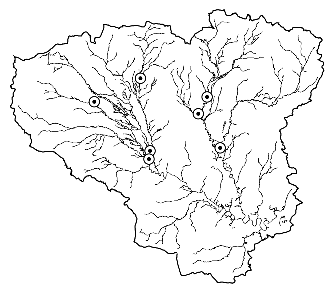
Lycopus uniflorus
northern bugleweed



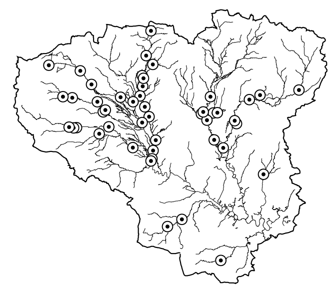
Lycopus virginicus
Virginia bugleweed



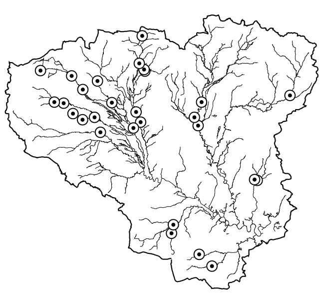
Lyonia ligustrina
maleberry



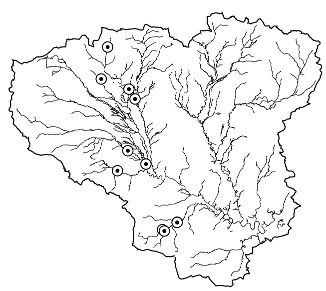
Lyonia mariana
staggerbush



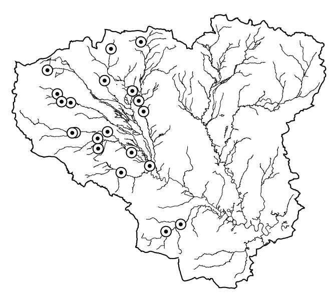
Lysimachia terrestris
swamp loosestrife



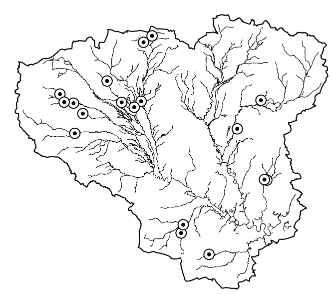
Magnolia virginiana
sweet bay



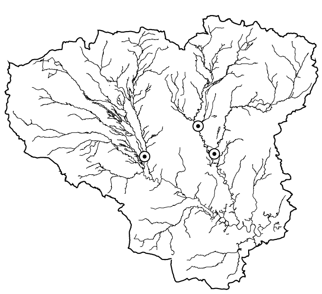
Microstegium vimineum
eulalia



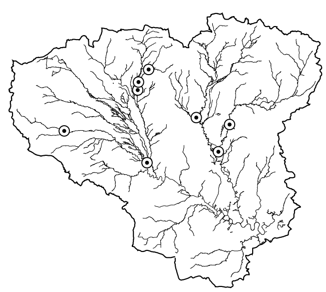
Mikania scandens
climbing hempweed



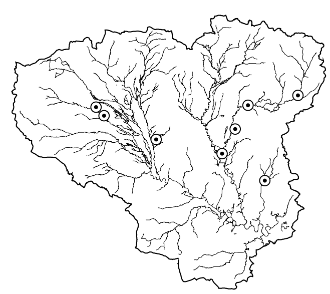
Mitchella repens
partridge berry



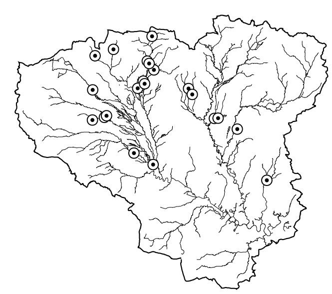
Muhlenbergia torreyana
Torrey's dropseed



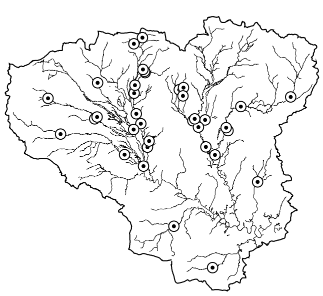
Muhlenbergia uniflora
late-flowering dropseed



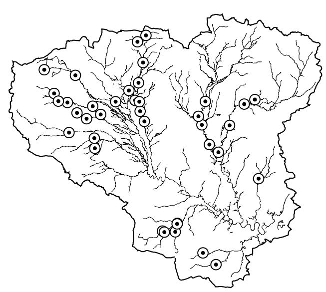
Myrica pensylvanica
bayberry



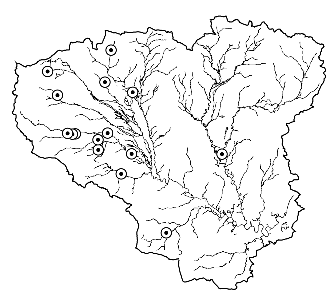
Nuphar variegata
bullhead lily



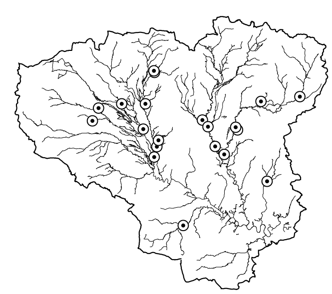
Nymphaea odorata
white water lily



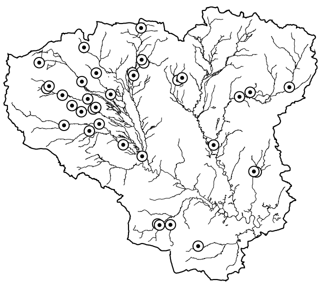
Nyssa sylvatica
black gum



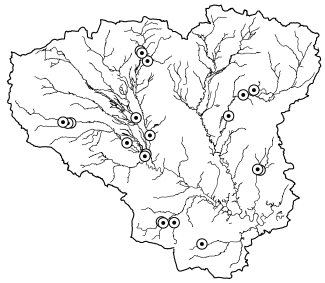
Onoclea sensibilis
sensitive fern



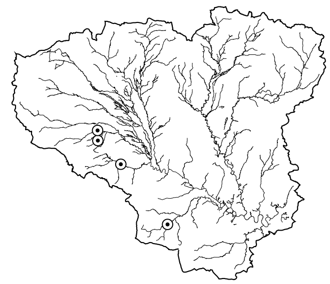
Orontium aquaticum
golden club



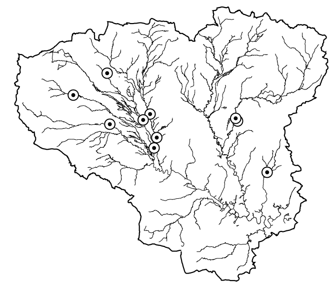
Osmunda cinnamomea
cinnamon fern



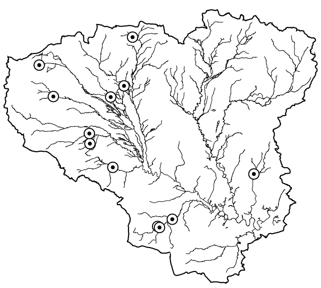
Osmunda regalis
royal fern



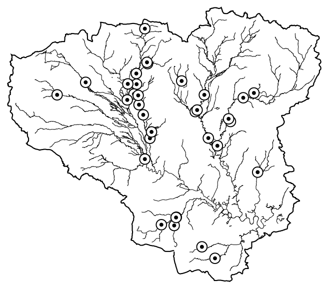
Oxalis stricta
upright yellow wood-sorrel



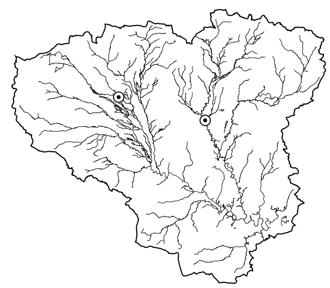
Oxypolis rigidior
cowbane



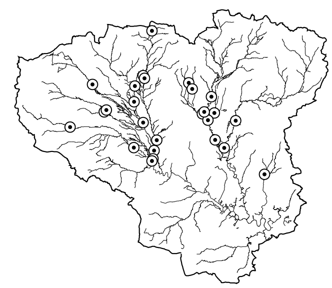
Panicum clandestinum
deertongue grass



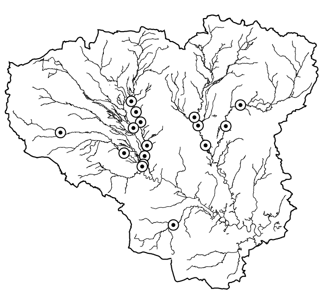
Panicum dichotomum
forked panic-grass



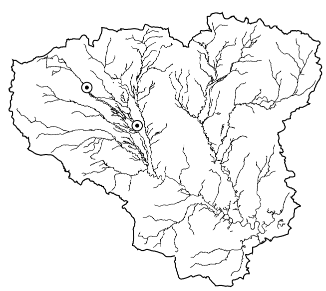
Panicum ensifolium
small-leaved panic-grass



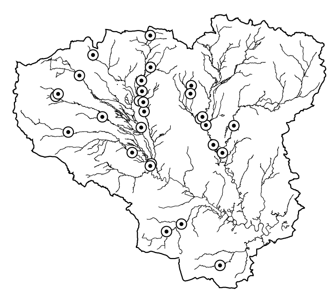
Panicum longifolium
long-leaved panic-grass



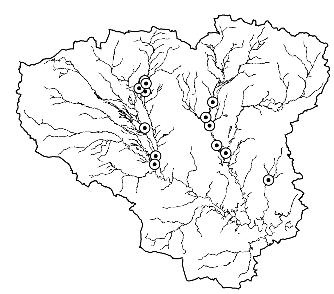
Panicum scabriusculum
sheathed panic-grass



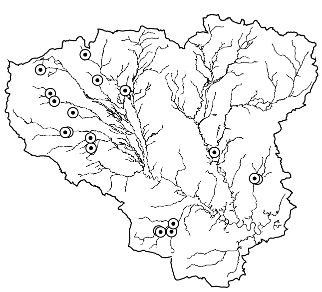
Panicum spretum
Eaton's panic-grass



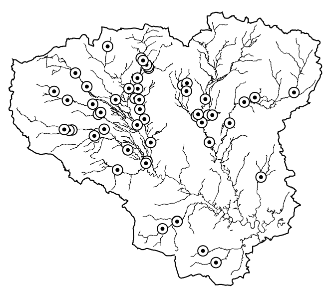
Panicum verrucosum
warty panic-grass



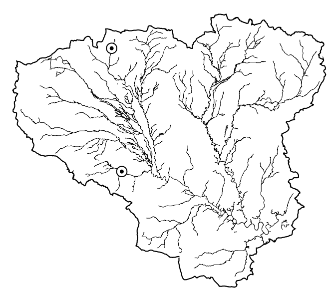
Panicum virgatum
switchgrass



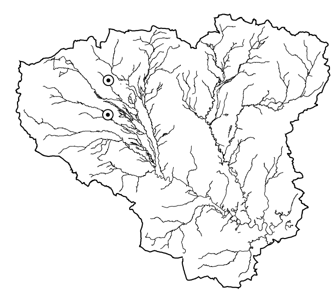
Parthenocissus quinquefolia
Virginia creeper



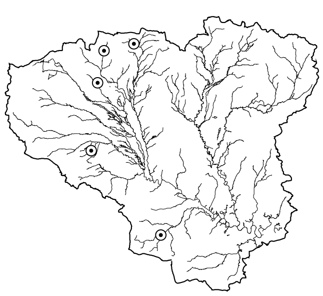
Peltandra virginica
arrow arum



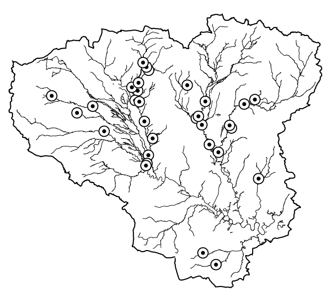
Phalaris arundinacea
reed canary grass



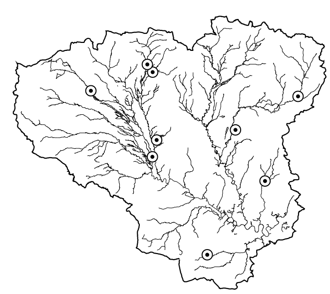
Phragmites australis
reed



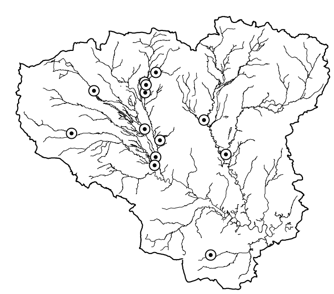
Pilea pumila
clearweed



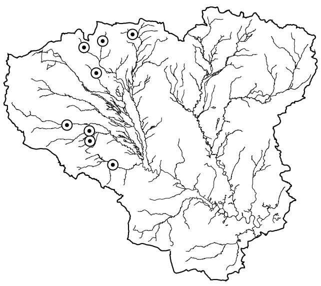
Pinus rigida
pitch pine



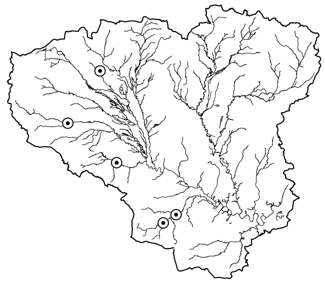
Pogonia ophioglossoides
rose pogonia



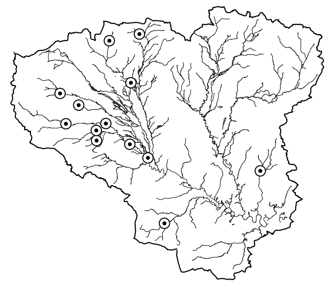
Polygala cruciata
cross-leaved milkwort



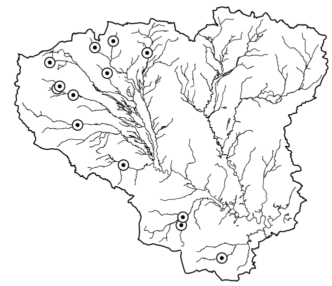
Polygonum arifolium
halberd-leaved tearthumb



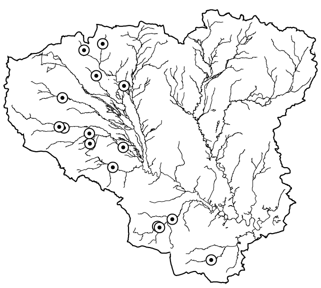
Polygonum cespitosum
cespitose knotweed



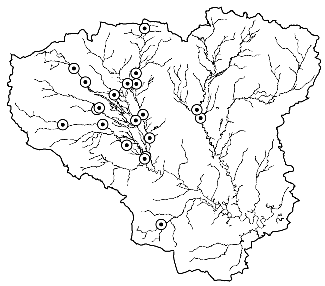
Polygonum hydropiperoides
mild water pepper



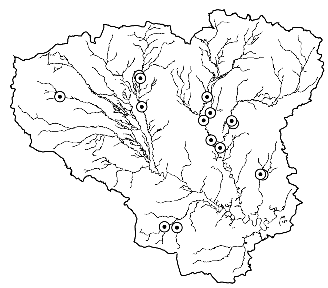
Polygonum punctatum
dotted smartweed



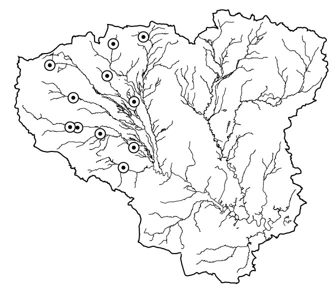
Polygonum sagittatum
arrow-leaved tearthumb



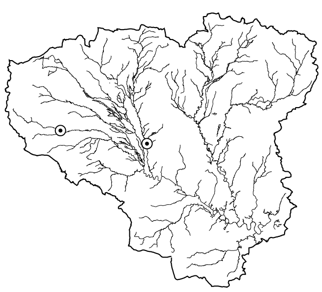
Pontederia cordata
pickerel-weed



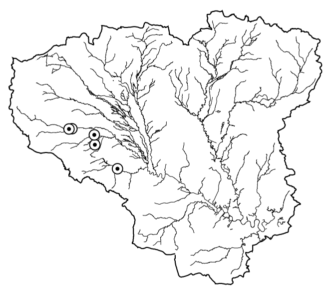
Potamogeton confervoides
alga-like pondweed



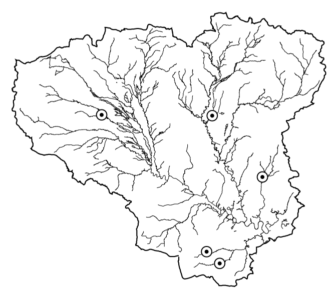
Potamogeton epihydrus
Nuttall's pondweed



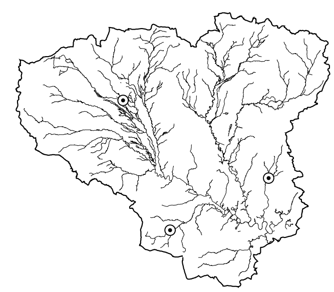
Potamogeton oakesianus
Oakes' pondweed



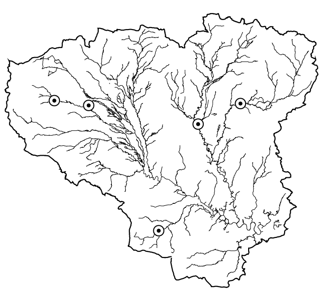
Potamogeton pusillus
small pondweed



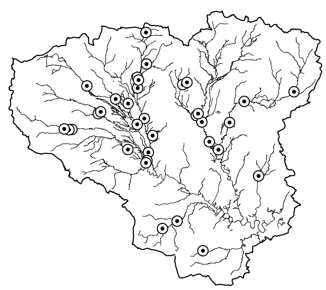
Proserpinaca pectinata
cut-leaved mermaid-weed



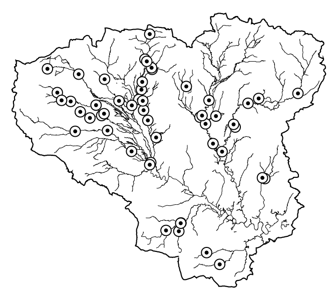
Quercus alba
white oak



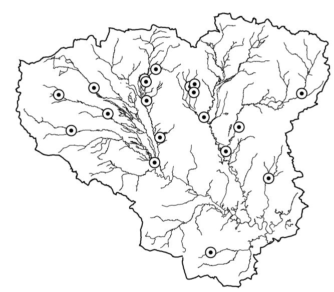
Quercus ilicifolia
scrub oak



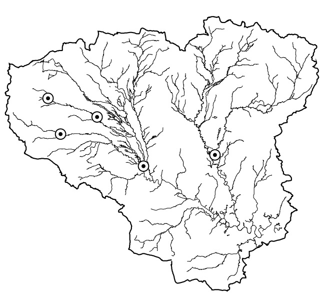
Rhexia virginica
Virginia meadow beauty



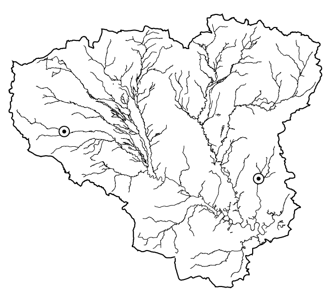
Rhododendron viscosum
swamp azalea



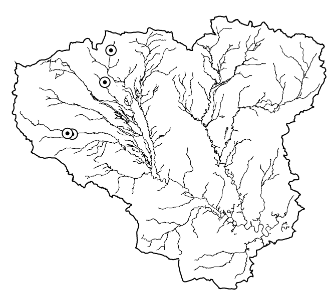
Rhynchospora alba
white beaked-rush



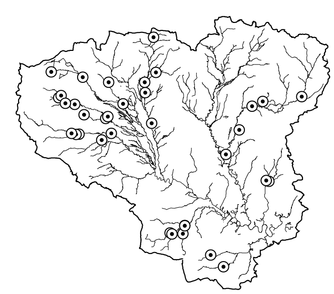
Rhynchospora capitellata
small-headed beaked-rush



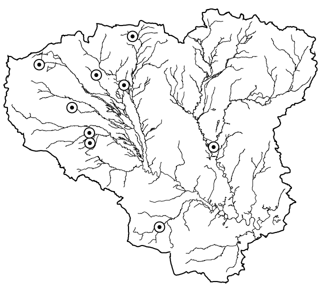
Rhynchospora chalarocephala
loose-headed beaked-rush



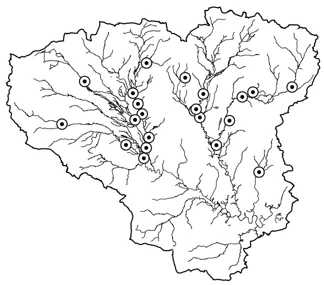
Rosa palustris
swamp rose



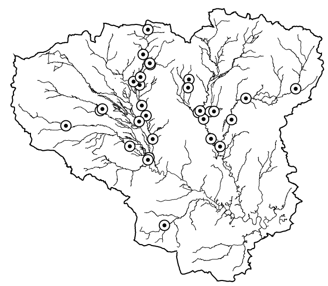
Rubus hispidus
swamp dewberry



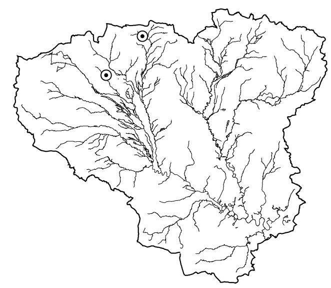
Rubus sp.
blackberry



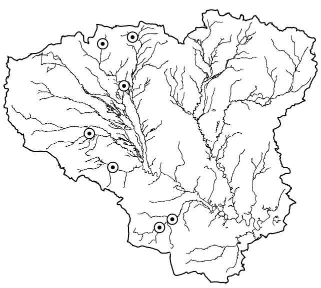
Sabatia difformis
lance-leaved sabatia



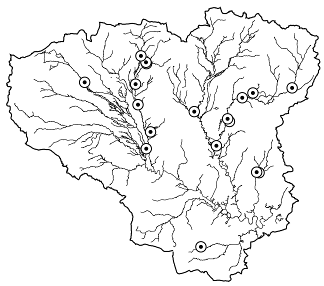
Sagittaria engelmanniana
Engelmann's arrowhead



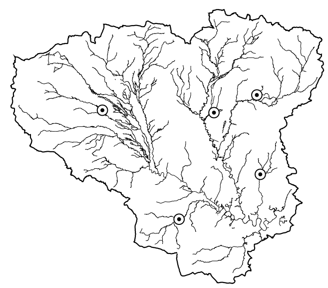
Salix nigra
black willow



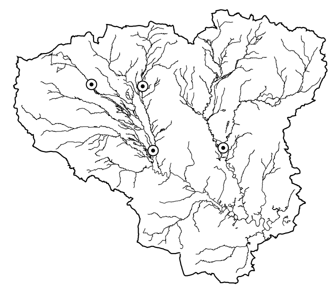
Sambucus canadensis
common elder



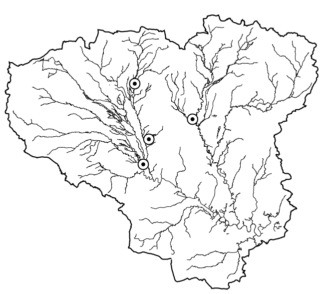
Sarracenia purpurea
pitcher plant



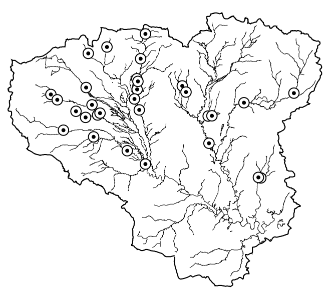
Sassafras albidum
sassafras



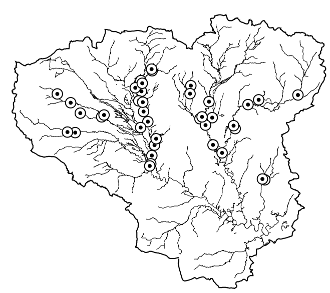
Schizachyrium scoparium
little bluestem



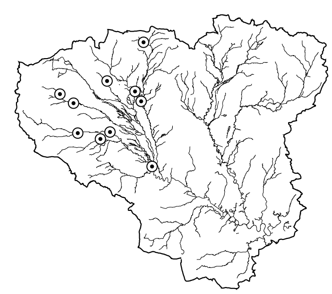
Schizaea pusilla
curly-grass fern



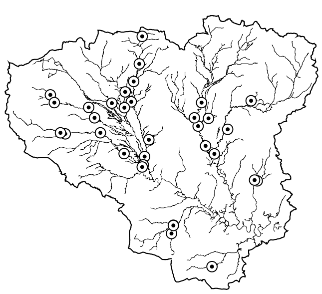
Scirpus cyperinus
wool-grass



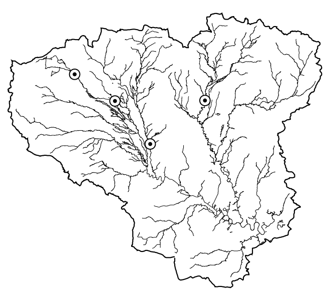
Scirpus subterminalis
water club-rush



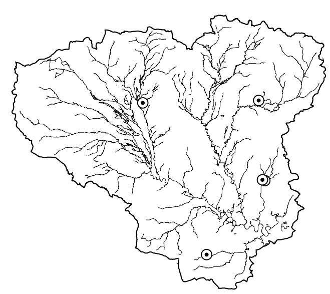
Scutellaria lateriflora
mad-dog skullcap



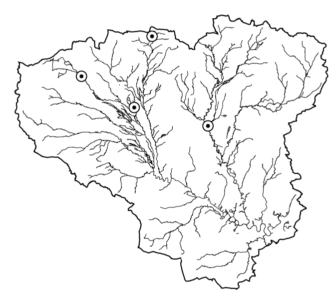
Smilax glauca
glaucous greenbrier



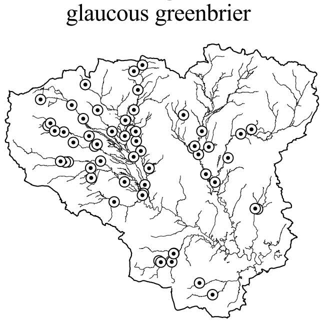
Smilax herbacea
carrion flower



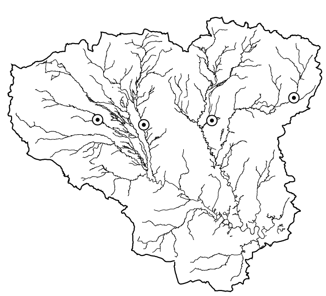
Smilax laurifolia
laurel-leaved greenbrier



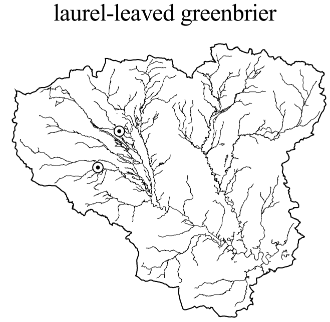
Smilax pseudochina
halberd-leaved greenbrier



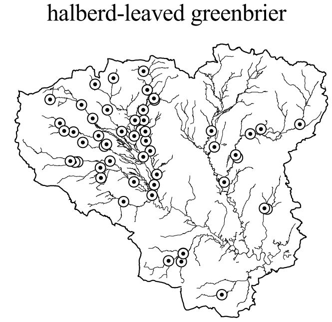
Smilax rotundifolia
common greenbrier



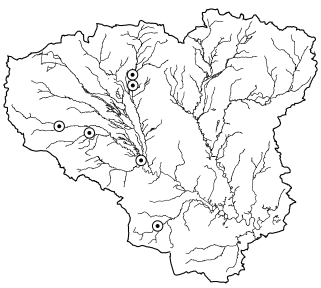
Smilax walteri
red-berried greenbrier



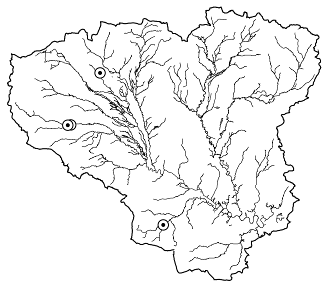
Solidago rugosa
rough-stemmed goldenrod



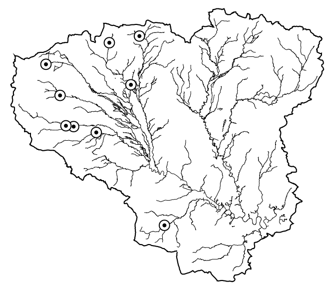
Sparganium americanum
slender bur-reed



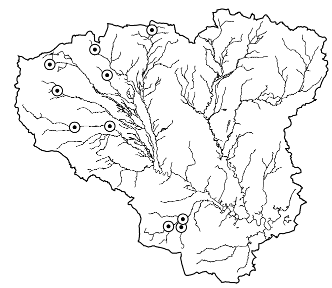
Spiraea tomentosa
steeplebush



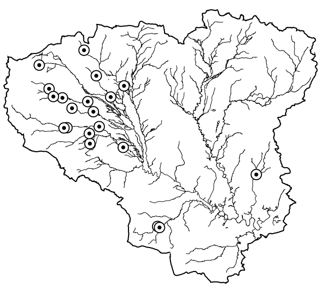
Taraxacum officinale
dandelion



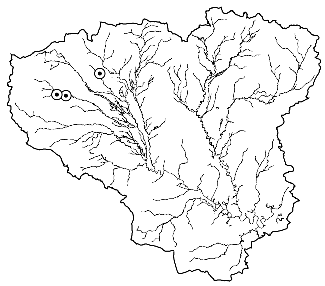
Thelypteris palustris
marsh fern



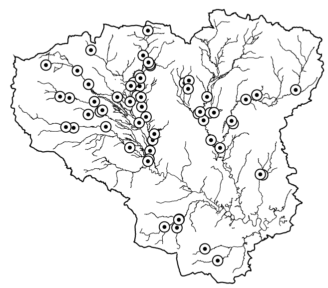
Thelypteris simulata
bog fern



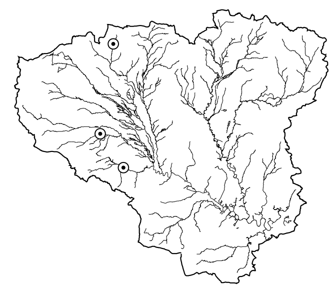
Toxicodendron radicans
poison ivy



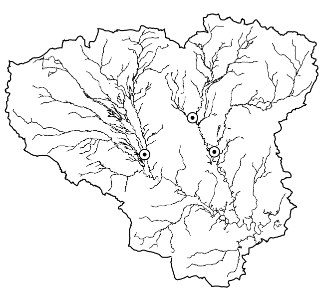
Toxicodendron vernix
poison sumac



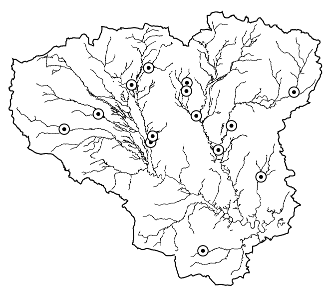
Triadenum virginicum
marsh Saint John's-wort



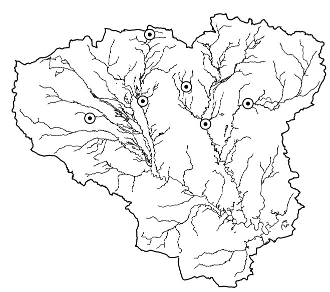
Typha latifolia
broad-leaved cat-tail



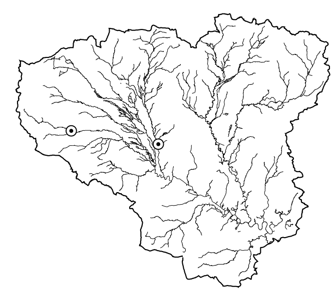
Utricularia cornuta
horned bladderwort



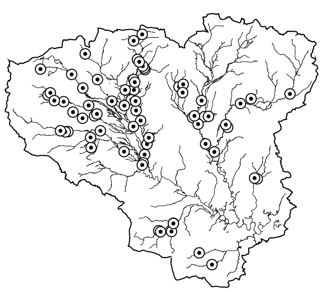
Utricularia fibrosa
fibrous bladderwort



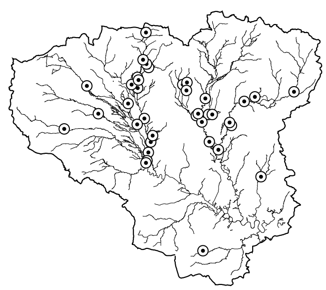
Utricularia geminiscapa
hidden-fruited bladderwort



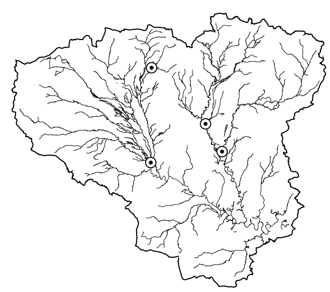
Utricularia purpurea
purple bladderwort



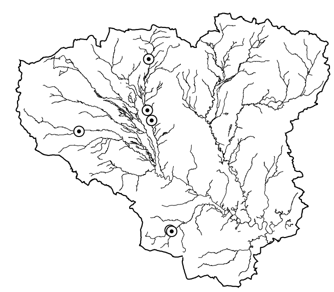
Vaccinium corymbosum
highbush blueberry



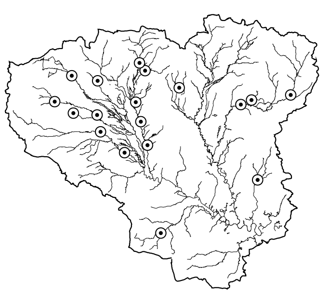
Vaccinium macrocarpon
large cranberry



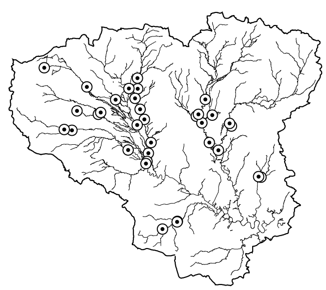
Vaccinium pallidum
early low blueberry



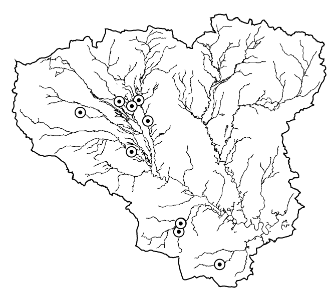
Viburnum dentatum
southern arrowwood



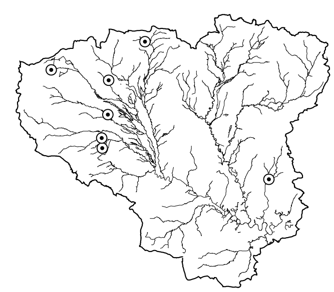
Viburnum nudum var. nudum
naked withe-rod



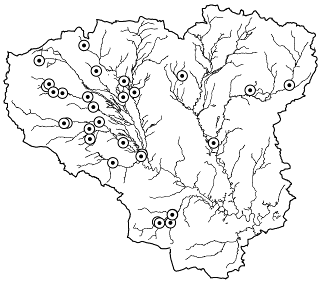
Viola lanceolata
lance-leaved violet



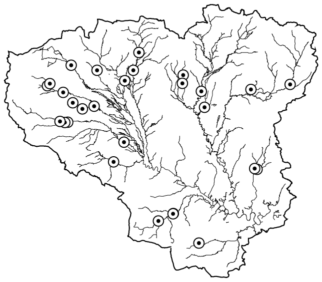
Viola primulifolia
primrose-leaved violet



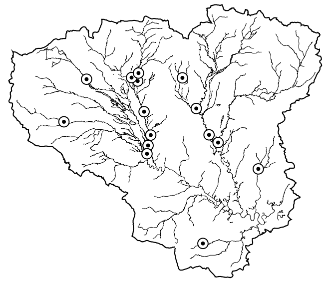
Vitis labrusca
fox grape



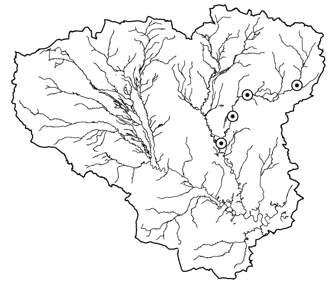
Woodwardia areolata
netted chain fern



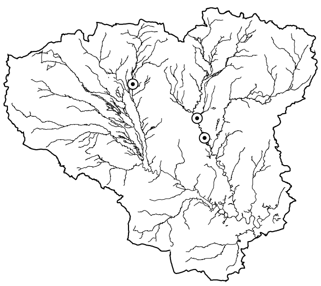
Woodwardia virginica
Virginia chain fern



Xyris difformis
yellow-eyed grass



Xyris smalliana
Small's yellow-eyed grass



Zizania aquatica
wild rice

APPENDIX 3. ATLANTIC WHITE CEDAR SWAMP DATA

Appendix 3.0. Cedar swamp permanent macroplot locations in the Mullica River Basin and individuals that sampled on each date. Species presence was determined during regular site visits during the growing seasons of 1995-1996. Species cover was estimated on the dates listed. Individuals who sampled are: KJL = Kim J. Laidig and RAZ = Robert A. Zampella. Coordinates were determined with a global positioning system.

Watershed and site	Sampler	Date	Downstream metal stake		Upstream metal stake	
			Latitude	Longitude	Latitude	Longitude
Albertson Brook						
A1	KJL	06/29/95	39°41'33.648"	74°44'28.844"	39°41'34.506"	74°44'30.616"
A2	KJL	06/22, 06/23/95	39°41'38.594"	74°44'29.532"	39°41'38.776"	74°44'31.598"
A3	KJL	06/15, 06/16/95	39°41'31.758"	74°48'24.800"	39°41'30.831"	74°48'26.567"
A4	KJL	06/16, 06/19/95	39°41'34.632"	74°48'29.250"	39°41'33.495"	74°48'30.862"
Pump Branch						
P1	KJL	07/25/96	39°41'32.829"	74°48'50.042"	39°41'33.573"	74°48'51.768"
P2	KJL/RAZ	07/24/96	39°41'34.443"	74°48'46.366"	39°41'34.455"	74°48'48.396"
P3	KJL	07/25/96	39°41'33.904"	74°48'53.351"	39°41'34.625"	74°48'55.185"
P4	KJL/RAZ	07/24/96	39°41'37.288"	74°48'55.287"	39°41'38.092"	74°48'57.161"
Mullica River						
M1	KJL	08/22/95	39°43'46.383"	74°42'30.492"	39°43'47.896"	74°42'30.164"
M2	KJL	08/28/95	39°44'08.380"	74°43'13.344"	39°44'09.114"	74°43'15.188"
M3	KJL	08/29/95	39°45'08.325"	74°46'19.996"	39°45'10.011"	74°46'20.631"
M4	KJL	08/31/95	39°45'42.048"	74°46'55.183"	39°45'43.400"	74°46'56.647"
Batsto River						
B1	KJL/RAZ	07/13/95	39°42'28.811"	74°39'59.889"	39°42'30.433"	74°40'00.356"
B2	KJL	07/05/95	39°42'19.503"	74°39'53.694"	39°42'20.870"	74°39'54.104"
B3	KJL	08/02/95	39°42'51.835"	74°40'10.859"	39°42'52.682"	74°40'12.678"
B4	KJL/RAZ	07/28/95	39°42'59.346"	74°40'12.834"	39°43'00.980"	74°40'13.273"
Wading River						
W1	KJL	07/31/96	39°42'54.601"	74°33'46.826"	39°42'54.252"	74°33'44.905"
W2	KJL/RAZ	08/22/96	39°43'08.592"	74°33'43.680"	39°43'10.175"	74°33'44.244"
W3	KJL/RAZ	08/22/96	39°43'10.964"	74°33'44.711"	39°43'11.989"	74°33'43.188"
W4	KJL	07/31, 08/28/96	39°44'17.296"	74°33'03.149"	39°44'18.719"	74°33'03.946"
East Branch Bass River						
E1	KJL/RAZ	08/16/96	39°37'17.859"	74°26'28.850"	39°37'19.348"	74°26'27.947"
E2	KJL/RAZ	08/16/96	39°37'36.652"	74°26'09.576"	39°37'37.819"	74°26'08.069"
E3	KJL	08/08/96	39°37'45.991"	74°25'59.014"	39°37'47.229"	74°25'57.864"
E4	KJL	08/07/96	39°37'43.486"	74°25'54.782"	39°37'44.638"	74°25'53.365"

Appendix 3.1. Detailed understory and canopy plant species inventory in permanent cedar macroplots in the Mullica River Basin. Locations of macroplots are given in Appendix 3.0. For understory data, Braun-Blanquet cover values (r = one, + = rare, 1 = 1-5%, 2 = 5-25%, 3 = 25-50%, 4 = 50-75%, 5 = 75-100%) are presented for each 5 x 5 m subplot; presence data (+) are given for each 10 x 10 m plot and for the overall 20 x 50 m macroplot (M). For canopy and subcanopy species, Braun-Blanquet cover values are presented for 10 x 10 m plots; presence data (+) are given for the overall 20 x 50 m macroplot (M).

Albertson Brook	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Understory																												
Herbaceous plants:																												
Agrostis hyemalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Andropogon virginicus var. *abbreviatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	-	-	-	-	-	-	-	+	+	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster novi-belgii	-	-	-	-	+	+	+	+	-	r	+	-	+	+	-	-	-	-	-	-	-	+	-	-	+	+	-	+
Bartonia paniculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+
Bartonia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex atlantica	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex atlantica var. *capillacea*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex bullata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Carex collinsii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+
Carex exilis	-	-	-	-	-	-	-	+	r	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex folliculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+
Carex livida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex stricta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex trisperma	r	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	+	+
Cuscuta sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Danthonia sericea var. *epilis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decodon verticillatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	+	-	-	+
Drosera intermedia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drosera rotundifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	+	-	+	+	-	+
Dulichium arundinaceum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriocaulon aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriocaulon decangulare	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriophorum virginicum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glyceria obtusa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypericum mutilum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris prismatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris versicolor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus caesariensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus canadensis	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus pelocarpus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lachnanthes caroliniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Albertson Brook	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Leersia oryzoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lobelia nuttallii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium alopecuroides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium appressum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Lysimachia terrestris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+
Mitchella repens	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	r	-	+	+	+	+	-	r	-	-	+	-	+
Narthecium americanum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orontium aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Osmunda cinnamomea	-	+	1	+	+	+	+	-	-	+	+	-	+	+	-	-	-	-	-	-	+	2	4	1	+	+	+	+
Osmunda regalis	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	2	1	-	+	+	+	+
Oxypolis rigidior	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum ensifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peltandra virginica	-	r	-	+	+	-	+	-	-	-	-	-	-	-	r	-	-	+	-	-	+	-	-	-	-	-	-	+
Pogonia ophioglossoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygala brevifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhexia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+
Rhynchospora alba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatia difformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sagittaria engelmanniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarracenia purpurea	-	-	-	-	-	-	+	-	-	-	+	+	-	+	-	-	-	-	-	-	+	-	-	-	+	-	+	+
Smilax psuedochina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thelypteris simulata	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	+
Triadenum virginicum	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	+	+	-	+
Trientalis borealis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	+	-	-	+
Viola lanceolata var. *lanceolata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woodwardia areolata	-	+	-	-	+	-	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	+	-	-	+
Woodwardia virginica	r	+	-	+	+	-	+	-	r	-	-	+	+	+	-	-	-	-	-	-	+	-	r	-	+	+	-	+
Xyris torta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woody plants:																												
Acer rubrum seedling	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Amelanchier sp. seedling	-	-	-	-	-	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	+	-	-	+	-	+
Aronia arbutifolia	-	+	r	-	+	+	+	1	-	r	+	+	+	+	-	-	-	+	-	+	+	-	-	-	-	-	-	+
Chamaecyparis thyoides seedling	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Chamaedaphne calyculata	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clethra alnifolia	2	2	1	+	+	+	+	2	3	+	+	+	+	+	2	3	3	+	+	+	+	+	2	2	+	+	+	+
Eubotrys racemosa	2	+	r	+	+	+	+	+	r	+	+	+	+	+	+	-	-	+	-	+	+	-	-	-	-	+	-	+
Gaylussacia baccata	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gaylussacia dumosa	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-	+	-	-	+	-	-	+
Gaylussacia frondosa	+	+	1	+	+	+	+	+	1	1	+	+	+	+	-	-	-	-	+	-	+	-	-	-	+	+	-	+

Albertson Brook	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Ilex glabra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilex laevigata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+
Ilex opaca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-
Kalmia angustifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalmia latifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Lyonia ligustrina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnolia virginiana seedling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	r	-	+	+	+	-	-	-	-	-	-	-
Myrica pensylvanica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica seedling	+	+	+	+	+	+	+	-	-	+	-	-	+	+	-	-	-	-	+	+	+	r	-	-	+	-	-	+
Parthenocissus quinquefolia	r	-	-	+	+	-	+	-	-	+	-	-	+	+	-	+	+	+	+	+	+	r	r	-	+	+	-	+
Pinus rigida seedling	r	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp. seedling	r	r	r	+	+	+	+	-	r	-	-	+	+	+	r	-	-	+	-	-	+	r	+	-	+	+	+	+
Rhododendron viscosum	-	r	+	-	+	+	+	+	r	-	+	+	+	+	-	+	-	-	+	+	+	+	-	+	+	+	+	+
Rhus vernix	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	+	-	-	+
Rubus hispidus	-	-	r	+	-	+	+	-	-	-	-	-	-	-	-	+	r	-	+	+	+	+	+	+	+	+	+	+
Sassafras albidum seedling	-	r	r	+	+	+	+	r	-	-	+	+	+	+	-	-	+	+	-	+	+	r	r	r	+	+	+	+
Smilax glauca	-	-	-	-	-	-	-	r	r	r	+	+	+	+	-	-	-	+	+	-	+	r	-	-	+	+	-	+
Smilax laurifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Smilax rotundifolia	+	r	+	+	+	+	+	r	r	r	+	+	+	+	+	+	+	+	+	+	+	r	-	-	+	+	+	+
Smilax walteri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toxicodendron radicans	-	-	-	-	+	-	+	-	-	-	-	-	-	+	-	-	-	+	+	+	+	-	-	-	+	+	-	+
Vaccinium corymbosum	+	1	2	+	+	+	+	+	r	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Vaccinium macrocarpon	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Viburnum nudum var. *nudum*	-	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	+	-	-	+
Canopy																												
Acer rubrum	-	-	-	+	1	1	+	-	-	-	-	-	-	-	-	-	-	-	2	2	+	-	-	-	2	2	3	+
Chamaecyparis thyoides	-	-	-	5	5	5	+	-	-	-	5	5	5	+	-	-	-	5	5	4	+	-	-	-	5	4	3	+
Magnolia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus rigida	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	1	-	+	-	-	-	-	-	-	+
Subcanopy																												
Acer rubrum	-	-	-	1	1	1	+	-	-	-	1	-	1	+	-	-	-	-	-	-	+	-	-	-	2	2	2	+
Chamaecyparis thyoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnolia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	1	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Batsto River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Understory																												
Herbaceous plants:																												
Agrostis hyemalis	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Andropogon virginicus var. *abbreviatus*	-	-	-	-	-	-	+	+	-	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	+	-	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	+	+	-	-	+	-	-	+
Aster novi-belgii	-	+	-	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	-	-	-	-	-	-	-
Bartonia paniculata	+	+	+	+	+	+	+	-	-	r	+	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+
Bartonia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	+	+	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	-	-	-	-	-	-
Carex atlantica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+
Carex atlantica var. *capillacea*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex bullata	-	-	-	-	+	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	+	+	-	+
Carex collinsii	+	-	-	+	+	-	+	1	+	+	+	+	+	+	-	-	+	-	-	+	+	+	1	1	+	+	+	+
Carex exilis	-	+	-	-	+	-	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	-	-	-	-	+	-	+
Carex folliculata	+	+	-	+	+	+	+	-	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Carex livida	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	1	+	+	+	+	-	-	-	-	-	-	-
Carex stricta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Carex trisperma	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Cuscuta sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Danthonia sericea var. *epilis*	-	-	-	-	-	-	-	+	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decodon verticillatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drosera intermedia	+	-	-	+	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drosera rotundifolia	+	+	+	+	+	+	+	+	-	-	+	-	-	+	+	-	+	+	-	+	+	+	+	+	+	+	+	+
Dulichium arundinaceum	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	-	+	+	-	+	+
Eriocaulon aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriocaulon decangulare	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriophorum virginicum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glyceria obtusa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	+	-	-	-	-	-	-	-
Hypericum mutilum	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris prismatica	-	+	-	+	+	-	+	-	-	-	-	-	+	+	-	-	-	-	+	-	+	-	-	-	-	-	-	-
Iris versicolor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	+
Juncus caesariensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	-
Juncus pelocarpus	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	+
Lachnanthes caroliniana	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leersia oryzoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Lobelia nuttallii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium alopecuroides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium appressum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lysimachia terrestris	+	-	-	+	-	-	+	-	-	-	-	-	-	-	+	+	-	+	+	+	+	-	-	+	+	+	+	+

Batsto River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Mitchella repens	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	+	-	+	+	-	+	+	+	-	+	+	-	+
Narthecium americanum	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orontium aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Osmunda cinnamomea	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+	-	-	-	-	-	-	-
Osmunda regalis	-	+	-	-	+	+	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Oxypolis rigidior	+	-	-	+	-	-	+	-	-	+	-	-	+	+	-	-	-	-	-	-	+	r	-	-	+	-	-	+
Panicum ensifolium	2	+	2	+	+	+	+	-	-	+	-	-	+	+	+	+	1	+	+	+	+	+	+	+	+	+	+	+
Panicum sp.	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Peltandra virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	r	+	-	+	+
Pogonia ophioglossoides	+	+	+	+	+	+	+	r	+	-	+	+	-	+	+	-	-	+	-	-	+	-	-	+	-	-	+	+
Polygala brevifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-
Rhexia virginica	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhynchospora alba	+	+	-	+	+	+	+	+	-	+	+	-	+	+	+	-	-	+	-	+	+	-	-	-	-	-	-	-
Sabatia difformis	+	+	-	+	+	-	+	-	r	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sagittaria engelmanniana	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarracenia purpurea	-	+	-	+	+	-	+	+	+	+	+	1	+	+	+	+	-	+	+	-	+	-	-	+	-	-	-	+
Smilax psuedochina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thelypteris simulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triadenum virginicum	-	+	-	+	+	-	+	+	-	-	+	-	-	+	-	+	+	+	+	+	+	+	-	+	+	+	+	+
Trientalis borealis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viola lanceolata var. *lanceolata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Woodwardia areolata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woodwardia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+
Xyris torta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woody plants:																												
Acer rubrum seedling	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Amelanchier sp. seedling	+	-	r	+	-	+	+	r	-	r	+	-	+	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-
Aronia arbutifolia	-	+	-	-	+	-	+	-	-	+	-	-	+	+	-	+	-	-	+	-	+	-	-	-	-	-	-	-
Chamaecyparis thyoides seedling	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Chamaedaphne calyculata	+	+	+	+	+	+	+	+	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Clethra alnifolia	1	1	+	+	+	-	+	+	+	+	+	+	+	+	+	1	+	+	+	+	+	+	+	2	+	+	+	+
Eubotrys racemosa	2	+	2	+	+	+	+	3	2	2	+	+	+	+	+	+	1	+	+	+	+	2	1	+	+	+	+	+
Gaylussacia baccata	+	-	-	+	+	+	+	-	-	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gaylussacia dumosa	1	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Gaylussacia frondosa	2	2	1	+	+	+	+	2	2	2	+	+	+	+	1	+	2	+	+	+	+	1	2	2	+	+	+	+
Ilex glabra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	+	+
Ilex laevigata	2	-	-	+	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilex opaca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalmia angustifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalmia latifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lyonia ligustrina	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Batsto River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Magnolia virginiana seedling	-	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	+	+
Myrica pensylvanica	1	+	-	+	-	-	+	+	+	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica seedling	-	+	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parthenocissus quinquefolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus rigida seedling	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+
Quercus sp. seedling	-	+	-	+	-	+	+	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhododendron viscosum	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1	+	+	+	+	+	+	+	+	+	+	+	+	+
Rhus vernix	-	-	-	-	-	-	-	-	r	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubus hispidus	-	-	-	+	+	-	+	+	+	-	+	+	-	+	-	-	+	-	+	+	+	+	+	-	+	+	-	+
Sassafras albidum seedling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
Smilax glauca	+	+	+	+	+	+	+	-	r	-	-	+	-	+	+	+	-	+	+	-	+	-	-	-	-	-	-	-
Smilax laurifolia	-	-	-	+	-	-	+	r	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Smilax rotundifolia	+	+	+	+	+	+	+	+	r	-	+	+	-	+	-	+	+	-	+	+	+	-	r	-	-	+	-	+
Smilax walteri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toxicodendron radicans	-	-	-	-	-	-	-	r	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium corymbosum	1	2	2	+	+	-	+	2	2	2	+	+	+	+	1	1	+	+	+	+	+	1	2	1	+	+	+	+
Vaccinium macrocarpon	+	+	-	+	+	+	+	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-
Viburnum nudum var. *nudum*	r	+	+	+	+	-	+	r	-	-	+	-	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-
Canopy																												
Acer rubrum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Chamaecyparis thyoides	-	-	-	5	5	5	+	-	-	-	5	5	5	+	-	-	-	5	5	5	+	-	-	-	5	5	5	+
Magnolia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	1	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus rigida	-	-	-	-	1	1	+	-	-	-	-	-	-	-	-	-	-	-	-	1	+	-	-	-	-	-	-	+
Subcanopy																												
Acer rubrum	-	-	-	-	1	-	+	-	-	-	-	-	-	-	-	-	-	1	3	3	+	-	-	-	-	2	2	+
Chamaecyparis thyoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnolia virginica	-	-	-	-	2	+	+	-	-	-	-	-	-	-	-	-	-	1	1	-	+	-	-	-	1	-	-	+
Nyssa sylvatica	-	-	-	2	2	2	+	-	-	-	2	-	-	+	-	-	-	2	1	3	+	-	-	-	2	1	1	+

Bass River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Understory																												
Herbaceous plants:																												
Agrostis hyemalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Andropogon virginicus var. *abbreviatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+
Aster novi-belgii	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bartonia paniculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	+	+	+	+	+	+	+	+
Bartonia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex atlantica	-	-	-	-	-	-	-	-	-	+	-	-	+	+	+	+	-	+	+	-	+	-	-	-	-	-	-	-
Carex atlantica var. *capillacea*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex bullata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	+	+	-	-	-	+	-	-	+
Carex collinsii	r	3	1	+	+	+	+	5	4	1	+	+	+	+	2	2	1	+	+	+	+	2	2	1	+	+	+	+
Carex exilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	+	1	2	+	+	+	+
Carex folliculata	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	+	-	+	-	-	+	-	+
Carex livida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Carex stricta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex trisperma	-	-	-	-	-	-	-	-	-	+	-	-	+	+	1	+	1	+	+	+	+	-	-	-	+	-	-	+
Cuscuta sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Danthonia sericea var. *epilis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decodon verticillatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drosera intermedia	-	-	-	-	-	-	-	-	+	-	-	+	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-	+
Drosera rotundifolia	-	-	-	-	-	-	+	+	-	+	+	-	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+
Dulichium arundinaceum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Eriocaulon aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriocaulon decangulare	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriophorum virginicum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-
Glyceria obtusa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypericum mutilum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris prismatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris versicolor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus caesariensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-
Juncus canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Juncus pelocarpus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Lachnanthes caroliniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leersia oryzoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lobelia nuttallii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium alopecuroides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium appressum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lysimachia terrestris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Bass River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Mitchella repens	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	+	-	-	+
Narthecium americanum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orontium aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Osmunda cinnamomea	1	2	2	+	+	+	+	+	+	-	+	+	+	+	-	+	-	+	+	+	+	-	-	+	+	+	+	+
Osmunda regalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	-	+
Oxypolis rigidior	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum ensifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peltandra virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	+	+
Pogonia ophioglossoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	-	+	+	-	+	+	+	+	+
Polygala brevifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhexia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhynchospora alba	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	-	-	+	+	-	-	+	-	+	+
Sabatia difformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Sagittaria engelmanniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarracenia purpurea	-	-	-	-	-	-	-	-	r	-	-	+	-	+	+	-	-	+	-	-	+	+	+	+	+	+	+	+
Smilax psuedochina	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thelypteris simulata	+	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triadenum virginicum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trientalis borealis	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+
Viola lanceolata var. *lanceolata*	-	-	-	-	-	-	-	-	r	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woodwardia areolata	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woodwardia virginica	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xyris torta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woody plants:																												
Acer rubrum seedling	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Amelanchier sp. seedling	r	-	r	+	-	+	+	r	r	-	+	+	-	+	-	-	+	-	-	+	+	-	-	-	-	-	-	-
Aronia arbutifolia	1	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	+
Chamaecyparis thyoides seedling	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+
Chamaedaphne calyculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clethra alnifolia	2	+	1	+	+	+	+	1	+	-	+	+	-	+	1	1	1	+	+	+	+	-	+	+	+	+	+	+
Eubotrys racemosa	+	-	-	+	+	-	+	1	+	1	+	+	+	+	1	1	1	+	+	+	+	1	1	1	+	+	+	+
Gaylussacia baccata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gaylussacia dumosa	-	+	-	-	+	-	+	-	+	+	-	+	+	+	-	-	-	-	-	-	-	+	+	1	+	+	+	+
Gaylussacia frondosa	2	+	1	+	+	+	+	2	2	2	+	+	+	+	2	2	2	+	+	+	+	2	2	2	+	+	+	+
Ilex glabra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-
Ilex laevigata	-	-	-	-	-	-	-	-	+	-	-	+	-	+	1	-	1	+	-	+	+	-	-	-	-	-	-	+
Ilex opaca	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalmia angustifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalmia latifolia	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	2	3	-	+	+	+	-	-	-	-	-	-	-
Lyonia ligustrina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	+	+	+	-	-	-	-	-	-	-

Bass River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Magnolia virginiana seedling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
Myrica pensylvanica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	+	+	+	-	-	+	-	-	+
Nyssa sylvatica seedling	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parthenocissus quinquefolia	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus rigida seedling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp. seedling	r	r	-	+	+	-	+	-	+	+	+	+	+	+	r	-	-	+	-	-	+	r	+	r	+	+	+	+
Rhododendron viscosum	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1	+	+	+	+	+	+	+	+	+	+	+
Rhus vernix	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubus hispidus	-	+	+	-	+	+	+	-	+	+	+	+	+	+	-	-	+	-	-	+	+	-	-	-	-	-	-	-
Sassafras albidum seedling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	r	-	+	+	+
Smilax glauca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Smilax laurifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Smilax rotundifolia	-	+	+	-	+	+	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	r	-	-	+	-	-	+
Smilax walteri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toxicodendron radicans	1	+	+	+	+	+	+	-	+	+	-	+	+	+	-	r	r	-	+	+	+	-	-	-	-	-	-	-
Vaccinium corymbosum	2	2	2	+	+	+	+	2	1	1	+	+	+	+	+	1	-	+	+	+	+	+	1	+	+	+	+	+
Vaccinium macrocarpon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	+	+
Viburnum nudum var. *nudum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canopy																												
Acer rubrum	-	-	-	-	2	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chamaecyparis thyoides	-	-	-	4	4	5	+	-	-	-	5	5	5	+	-	-	-	4	5	5	+	-	-	-	5	5	5	+
Magnolia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus rigida	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subcanopy																												
Acer rubrum	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chamaecyparis thyoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-
Magnolia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Mullica River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Understory																												
Herbaceous plants:																												
Agrostis hyemalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Andropogon virginicus var. *abbreviatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+
Aster novi-belgii	-	-	-	-	-	+	+	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	-	r	-	-	+	+
Bartonia paniculata	+	+	+	+	+	+	+	r	+	+	+	+	+	+	r	+	+	+	+	+	+	+	+	+	+	+	+	+
Bartonia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex atlantica	+	-	+	+	+	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Carex atlantica var. *capillacea*	1	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	+	+	-	+	+	-	+
Carex bullata	+	-	-	+	-	-	+	-	-	-	-	-	-	-	1	-	-	+	-	-	+	-	-	-	-	-	-	-
Carex collinsii	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	+	r	+	+	+	+	-	-	-	-	-	-	-
Carex exilis	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex folliculata	+	+	+	+	+	+	+	+	+	+	+	+	+	+	r	+	+	+	+	+	+	+	+	1	+	+	+	+
Carex livida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex stricta	-	-	-	-	-	-	-	-	2	1	-	+	+	+	-	-	-	-	-	-	-	-	-	+	+	+	+	+
Carex trisperma	2	1	1	+	+	+	+	+	+	1	+	+	+	+	+	+	-	+	+	-	+	-	-	-	-	-	-	-
Cuscuta sp.	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Danthonia sericea var. *epilis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decodon verticillatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drosera intermedia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+
Drosera rotundifolia	+	+	+	+	+	+	+	-	+	-	-	+	-	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+
Dulichium arundinaceum	-	-	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriocaulon aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+
Eriocaulon decangulare	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriophorum virginicum	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Glyceria obtusa	-	-	-	+	+	-	+	-	r	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypericum mutilum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris prismatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris versicolor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus caesariensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus canadensis	+	-	1	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Juncus pelocarpus	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	+	+
Lachnanthes caroliniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leersia oryzoides	-	1	-	-	+	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Lobelia nuttallii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium alopecuroides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium appressum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Lycopus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lysimachia terrestris	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+

Mullica River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Mitchella repens	-	-	-	-	-	-	-	+	+	+	+	+	+	+	-	-	+	-	-	+	+	-	-	-	-	-	-	-
Narthecium americanum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orontium aquaticum	-	-	-	-	-	-	-	-	r	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Osmunda cinnamomea	-	-	-	+	-	+	+	-	-	-	-	+	+	+	-	-	+	-	-	+	+	-	-	-	-	+	-	+
Osmunda regalis	-	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxypolis rigidior	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum ensifolium	-	-	1	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+
Panicum sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peltandra virginica	-	-	+	+	-	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Pogonia ophioglossoides	-	-	-	-	-	-	+	-	r	-	-	+	-	+	-	-	-	-	-	-	-	r	-	-	+	-	-	+
Polygala brevifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Rhexia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+
Rhynchospora alba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+
Sabatia difformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+
Sagittaria engelmanniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Sarracenia purpurea	-	-	+	-	-	+	+	-	-	-	-	+	-	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+
Smilax psuedochina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thelypteris simulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+
Triadenum virginicum	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	+	-	-	+	-	+
Trientalis borealis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viola lanceolata var. *lanceolata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	+	+
Woodwardia areolata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woodwardia virginica	-	-	+	-	-	+	+	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Xyris torta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woody plants:																												
Acer rubrum seedling	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Amelanchier sp. seedling	-	r	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aronia arbutifolia	-	-	-	-	-	-	+	+	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Chamaecyparis thyoides seedling	1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Chamaedaphne calyculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+
Clethra alnifolia	1	3	1	+	+	+	+	3	2	2	+	+	+	+	2	2	2	+	+	+	+	+	+	+	+	+	+	+
Eubotrys racemosa	+	-	-	+	+	-	+	2	1	1	+	+	+	+	1	1	2	+	+	+	+	+	-	+	+	+	+	+
Gaylussacia baccata	-	+	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	+	+	+	+	+	+
Gaylussacia dumosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	+
Gaylussacia frondosa	2	1	+	+	+	+	+	-	+	+	+	+	+	+	-	1	-	-	+	-	+	-	-	2	+	+	+	+
Ilex glabra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilex laevigata	-	2	1	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilex opaca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	+	-	+	-	-	-	-	-	-	-
Kalmia angustifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+
Kalmia latifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lyonia ligustrina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	+	-	+	-	-	-	-	-	-	-

Mullica River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Magnolia virginiana seedling	-	+	+	-	+	+	+	+	-	-	+	-	+	+	-	-	r	-	-	+	+	-	-	-	-	-	-	-
Myrica pensylvanica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	-	+
Nyssa sylvatica seedling	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	-	r	-	-	+	-	r	-	-	+	-	-	+
Parthenocissus quinquefolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus rigida seedling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	+	+	+	+	+	+
Quercus sp. seedling	r	-	-	+	-	-	+	r	-	r	+	-	+	+	-	-	r	-	-	+	+	+	+	+	+	+	+	+
Rhododendron viscosum	2	+	+	+	+	+	+	+	1	1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Rhus vernix	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubus hispidus	-	-	+	-	-	+	+	-	-	-	+	+	-	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
Sassafras albidum seedling	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Smilax glauca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	r	-	+	+	+	-	r	-	-	+	-	+
Smilax laurifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Smilax rotundifolia	-	-	-	-	-	-	-	+	-	r	+	-	+	+	r	-	-	+	-	-	+	+	-	+	+	-	+	+
Smilax walteri	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toxicodendron radicans	-	r	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium corymbosum	1	1	2	+	+	+	+	1	1	1	+	+	+	+	2	1	1	+	+	+	+	+	1	+	+	+	+	+
Vaccinium macrocarpon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+
Viburnum nudum var. *nudum*	-	-	-	-	-	-	+	+	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canopy																												
Acer rubrum	-	-	-	-	-	1	+	-	-	-	1	2	-	+	-	-	-	2	1	2	+	-	-	-	-	-	-	-
Chamaecyparis thyoides	-	-	-	5	5	5	+	-	-	-	5	5	5	+	-	-	-	4	5	4	+	-	-	-	5	5	5	+
Magnolia virginica	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Pinus rigida	-	-	-	-	-	1	+	-	-	-	-	-	1	+	-	-	-	-	-	-	-	-	-	-	1	1	-	+
Subcanopy																												
Acer rubrum	-	-	-	-	-	1	+	-	-	-	1	-	3	+	-	-	-	2	2	2	+	-	-	-	-	-	-	-
Chamaecyparis thyoides	-	-	-	1	+	-	+	-	-	-	-	-	-	-	-	-	-	1	1	1	+	-	-	-	1	1	1	+
Magnolia virginica	-	-	-	-	-	-	-	-	-	-	1	1	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	-	-	-	-	-	2	-	1	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-

Pump Branch	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Understory																												
Herbaceous plants:																												
Agrostis hyemalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Andropogon virginicus var. *abbreviatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	-	-	-	-	-	-	-	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Aster novi-belgii	-	-	-	-	-	-	-	+	-	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	+	+	-	+
Bartonia paniculata	-	-	-	-	-	-	-	-	r	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Bartonia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+
Calamagrostis cinnoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex atlantica	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	+	+	-	+
Carex atlantica var. *capillacea*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex bullata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex collinsii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex exilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex folliculata	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	+	-	-	+	-	-	+
Carex livida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex stricta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex trisperma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cuscuta sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Danthonia sericea var. *epilis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decodon verticillatus	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	+	-	+	+	-	+
Drosera intermedia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drosera rotundifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dulichium arundinaceum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriocaulon aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriocaulon decangulare	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriophorum virginicum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glyceria obtusa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypericum mutilum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris prismatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris versicolor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus caesariensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus pelocarpus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lachnanthes caroliniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leersia oryzoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+
Lobelia nuttallii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium alopecuroides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium appressum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Lysimachia terrestris	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	+	-	+	+	-	+

Pump Branch	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Mitchella repens	+	-	-	+	+	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Narthecium americanum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orontium aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Osmunda cinnamomea	+	2	1	+	+	+	+	2	3	3	+	+	+	+	1	1	1	+	+	+	+	1	2	2	+	+	+	+
Osmunda regalis	-	-	-	+	-	-	+	1	+	-	+	+	+	+	-	-	-	-	-	-	-	1	1	1	+	+	+	+
Oxypolis rigidior	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum ensifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+
Panicum sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peltandra virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	+	+
Pogonia ophioglossoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygala brevifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Proserpinaca pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhexia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhynchospora alba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatia difformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sagittaria engelmanniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarracenia purpurea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+
Smilax psuedochina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thelypteris simulata	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triadenum virginicum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trientalis borealis	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viola lanceolata var. *lanceolata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woodwardia areolata	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woodwardia virginica	+	+	+	+	+	+	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+	-	-	-	-	+	+	+
Xyris torta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woody plants:																												
Acer rubrum seedling	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Amelanchier sp. seedling	-	-	-	-	-	-	-	-	r	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aronia arbutifolia	-	-	-	-	-	-	-	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	r	-	-	+	-	+
Chamaecyparis thyoides seedling	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+
Chamaedaphne calyculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clethra alnifolia	3	2	3	+	+	+	+	2	4	3	+	+	+	+	3	2	3	+	+	+	+	2	3	3	+	+	+	+
Eubotrys racemosa	1	-	-	+	-	-	+	-	r	r	-	+	+	+	-	-	-	-	-	-	-	-	+	+	-	+	+	+
Gaylussacia baccata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gaylussacia dumosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gaylussacia frondosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	+	-	+
Ilex glabra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	r	-	-	+	-	-	+
Ilex laevigata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilex opaca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	r	-	-	+	+
Kalmia angustifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalmia latifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Lyonia ligustrina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Pump Branch	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Magnolia virginiana seedling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myrica pensylvanica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica seedling	-	r	-	-	+	-	+	+	+	-	+	+	-	+	-	r	-	-	+	-	+	-	-	r	+	-	+	+
Parthenocissus quinquefolia	-	-	r	-	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+
Pinus rigida seedling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp. seedling	-	-	-	-	-	-	-	-	r	-	-	+	+	+	-	+	-	-	+	-	+	-	r	-	-	+	-	+
Rhododendron viscosum	+	+	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	1	+	+	+	+
Rhus vernix	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubus hispidus	+	1	+	+	+	+	+	1	1	1	+	+	+	+	+	-	-	+	+	-	+	+	1	-	+	+	-	+
Sassafras albidum seedling	-	r	-	-	+	-	+	+	r	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	+	+	-	+
Smilax glauca	-	+	r	-	+	+	+	+	+	-	+	+	-	+	r	+	-	+	+	+	+	+	-	+	+	-	+	+
Smilax laurifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Smilax rotundifolia	+	-	+	+	-	+	+	-	-	+	-	-	+	+	r	+	+	+	+	+	+	-	-	-	-	-	-	+
Smilax walteri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toxicodendron radicans	+	+	-	+	+	-	+	+	+	1	+	+	+	+	-	-	-	+	+	-	+	-	-	+	-	+	+	+
Vaccinium corymbosum	1	+	1	+	+	+	+	+	1	+	+	+	+	+	+	2	1	+	+	+	+	1	+	-	+	+	-	+
Vaccinium macrocarpon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viburnum nudum var. *nudum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canopy																												
Acer rubrum	-	-	-	2	2	3	+	-	-	-	1	2	1	+	-	-	-	3	3	2	+	-	-	-	2	2	2	+
Chamaecyparis thyoides	-	-	-	5	5	4	+	-	-	-	5	5	5	+	-	-	-	4	3	3	+	-	-	-	5	5	5	+
Magnolia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	+	-	-	-	2	-	-	+
Pinus rigida	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	1	1	+	-	-	-	1	1	2	+
Subcanopy																												
Acer rubrum	-	-	-	2	2	-	+	-	-	-	-	1	1	+	-	-	-	+	2	1	+	-	-	-	1	1	1	+
Chamaecyparis thyoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnolia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2	-	+	-	-	-	1	-	-	+

Wading River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Understory																												
Herbaceous plants:																												
Agrostis hyemalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Andropogon virginicus var. *abbreviatus*	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster nemoralis	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+	-	-	+	-	+	+	+
Aster novi-belgii	-	-	-	-	-	-	-	-	-	-	-	-	-	+	r	-	-	+	-	-	+	-	-	-	-	-	-	-
Bartonia paniculata	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+
Bartonia virginica	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamagrostis cinnoides	+	+	+	+	+	+	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex atlantica	-	-	-	-	-	-	-	-	+	+	-	+	+	+	+	-	-	+	-	-	+	+	+	-	+	+	+	+
Carex atlantica var. *capillacea*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex bullata	-	-	-	-	-	-	-	+	-	-	+	+	-	+	-	-	-	-	-	-	-	+	+	-	+	+	+	+
Carex collinsii	+	+	-	+	+	+	+	-	+	2	+	+	+	+	1	+	+	+	+	+	+	+	+	1	+	+	+	+
Carex exilis	+	+	+	+	+	+	+	+	-	-	+	-	-	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+
Carex folliculata	-	-	-	-	-	-	-	-	-	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex livida	+	+	+	+	+	+	+	+	-	-	+	-	-	+	-	+	+	-	+	+	+	-	-	r	-	-	+	+
Carex stricta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex trisperma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Cuscuta sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Danthonia sericea var. *epilis*	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Decodon verticillatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drosera intermedia	-	-	-	-	+	-	+	-	+	-	-	+	-	+	-	+	+	-	+	+	+	-	r	+	-	+	+	+
Drosera rotundifolia	-	r	-	-	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+
Dulichium arundinaceum	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Eriocaulon aquaticum	+	-	-	+	-	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eriocaulon decangulare	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Eriophorum virginicum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glyceria obtusa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Habenaria clavellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypericum mutilum	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris prismatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iris versicolor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus caesariensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Juncus canadensis	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus pelocarpus	-	-	-	-	-	-	-	-	+	-	+	+	-	+	-	-	-	-	+	-	+	-	-	-	-	-	-	-
Lachnanthes caroliniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leersia oryzoides	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lobelia nuttallii	-	-	-	-	-	-	+	r	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium alopecuroides	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium appressum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycopus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lysimachia terrestris	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Wading River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Mitchella repens	-	-	-	-	-	-	-	-	-	+	-	-	+	+	+	+	-	+	+	+	+	-	-	-	-	-	-	+
Narthecium americanum	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orontium aquaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Osmunda cinnamomea	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	-	+	+	-	+	+	-	-	-	-	+	-	+
Osmunda regalis	-	-	-	-	-	-	-	+	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxypolis rigidior	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panicum ensifolium	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+
Panicum sp.	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peltandra virginica	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-	+	-	+	+	+	+	+
Pogonia ophioglossoides	-	-	r	-	+	+	+	+	-	-	+	-	-	+	-	+	-	-	+	+	+	-	-	-	-	-	-	-
Polygala brevifolia	-	-	-	-	+	-	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+	-	-	-	-	-	-	-
Proserpinaca pectinata	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhexia virginica	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhynchospora alba	-	+	+	+	+	+	+	-	-	-	-	-	-	+	+	+	+	+	+	+	+	-	-	+	-	+	+	+
Sabatia difformis	-	+	-	-	+	-	+	+	+	-	+	+	-	+	-	-	+	-	+	+	+	-	-	+	-	-	+	+
Sagittaria engelmanniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarracenia purpurea	-	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+
Smilax psuedochina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thelypteris simulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triadenum virginicum	-	-	-	-	-	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	+	+
Trientalis borealis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viola lanceolata var. *lanceolata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woodwardia areolata	-	-	-	-	-	-	-	-	+	+	-	+	+	+	-	-	-	+	-	-	+	-	-	-	-	-	-	-
Woodwardia virginica	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+
Xyris torta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
Woody plants:																												
Acer rubrum seedling	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Amelanchier sp. seedling	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	+	r	-	+	+	+	-	-	-	-	+	-	+
Aronia arbutifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	+	-	-	-	-	-	-	-
Chamaecyparis thyoides seedling	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Chamaedaphne calyculata	-	+	-	-	+	+	+	+	+	-	+	+	-	+	-	+	+	-	+	+	+	-	-	-	-	-	-	-
Clethra alnifolia	-	-	+	-	-	+	+	+	+	1	+	+	+	+	-	1	-	-	+	-	+	2	3	2	+	+	+	+
Eubotrys racemosa	-	-	-	-	-	-	+	+	+	+	+	+	+	+	1	-	1	+	-	+	+	-	-	-	-	-	-	-
Gaylussacia baccata	-	2	2	-	+	+	+	-	-	-	-	-	-	-	+	-	r	+	-	+	+	-	-	+	-	+	+	+
Gaylussacia dumosa	+	+	+	+	+	+	+	+	+	-	+	+	-	+	1	1	+	+	+	+	+	+	+	+	+	+	+	+
Gaylussacia frondosa	+	1	1	+	+	+	+	1	2	3	+	+	+	+	2	-	2	+	-	+	+	1	+	-	+	+	-	+
Ilex glabra	2	+	-	+	+	+	+	+	-	-	+	-	-	+	+	2	2	+	+	+	+	-	-	-	-	-	-	-
Ilex laevigata	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilex opaca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalmia angustifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalmia latifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lyonia ligustrina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Wading River	Macroplot 1							Macroplot 2							Macroplot 3							Macroplot 4						
	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M	Subplot			Plot			M
	1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3		1	2	3	1	2	3	
Magnolia virginiana seedling	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myrica pensylvanica	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	+	+	-	+	+	+	-	-	-	-	-	-	-
Nyssa sylvatica seedling	-	-	-	-	-	-	-	r	r	r	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parthenocissus quinquefolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus rigida seedling	-	r	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus sp. seedling	-	-	-	-	-	-	-	r	-	r	+	-	+	+	-	-	r	-	-	+	+	-	-	r	-	-	+	+
Rhododendron viscosum	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1	+	+	+	+	+
Rhus vernix	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubus hispidus	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+
Sassafras albidum seedling	-	r	-	-	+	-	+	-	-	r	-	+	+	+	-	r	-	+	+	+	+	-	-	-	-	+	-	+
Smilax glauca	+	-	-	+	-	-	+	1	-	-	+	-	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-
Smilax laurifolia	-	-	-	-	-	+	+	-	-	-	-	+	-	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-
Smilax rotundifolia	r	+	+	+	+	+	+	1	r	-	+	+	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-
Smilax walteri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toxicodendron radicans	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium corymbosum	+	+	+	+	+	+	+	1	+	1	+	+	+	+	1	1	1	+	+	+	+	+	1	2	+	+	+	+
Vaccinium macrocarpon	+	+	+	+	+	+	+	+	+	-	+	+	-	+	-	+	+	+	+	+	+	-	-	-	-	-	-	+
Viburnum nudum var. *nudum*	-	-	-	-	-	-	-	-	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	r	-	-	+	+
Canopy																												
Acer rubrum	-	-	-	-	-	-	-	-	-	-	-	-	2	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chamaecyparis thyoides	-	-	-	5	5	5	+	-	-	-	5	5	5	+	-	-	-	5	4	5	+	-	-	-	5	5	5	+
Magnolia virginica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Pinus rigida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subcanopy																												
Acer rubrum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	+	-	-	-	+	1	1	+
Chamaecyparis thyoides	-	-	-	1	+	+	+	-	-	-	-	-	-	-	-	-	-	-	1	1	+	-	-	-	-	-	-	-
Magnolia virginica	-	-	-	1	-	+	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nyssa sylvatica	-	-	-	-	+	-	+	-	-	-	-	2	2	+	-	-	-	2	-	-	-	-	-	-	-	-	-	-

Appendix 3.2. Summary of understory plant species present in cedar swamp study sites. Species without a symbol were not used in ordinations. Wetland affinity classification (Wet) is based on Reed (1997): O = obligate wetland, W = facultative wetland, F = facultative, FU = facultative upland. Biogeographic classification (Bio) is based on Stone (1911): P = Pine Barrens, M = Middle District, P/M = Pine Barrens and Middle District. Values represent number of macroplots (maximum of four) in each drainage basin in which species is present. Listed tree species are present as seedlings.

Species	Symbol	Wet	Bio	Albertson Brook	Pump Branch	Mullica River	Batsto River	Wading River	Bass River	Total
Herbaceous plants:										
Agrostis hyemalis	-	F	P/M	-	-	1	1	-	-	2
Andropogon virginicus var. *abbreviatus*	-	W	P/M	-	-	-	2	1	-	3
Aster nemoralis	AN	W	P	1	2	2	4	4	2	15
Aster novi-belgii	ANv	W	P/M	3	2	3	3	2	1	14
Bartonia paniculata	BP	O	P/M	1	2	4	4	4	2	17
Bartonia virginica	-	W	P/M	-	1	-	-	1	-	2
Calamagrostis cinnoides	CCn	O	P/M	-	-	1	3	2	-	6
Carex atlantica	CAt	W	P	1	2	3	1	3	2	12
Carex atlantica var. *capillacea*	CAc	O	-	-	-	3	-	-	-	3
Carex bullata	CB	O	P	1	-	2	4	2	2	11
Carex collinsii	CCl	O	P/M	1	-	2	4	4	4	15
Carex exilis	CE	O	P	1	-	1	4	4	2	12
Carex folliculata	CF	O	P/M	1	2	4	4	1	3	15
Carex livida	CL	O	P	-	-	-	3	4	1	8
Carex stricta	-	O	-	-	-	2	1	-	-	3
Carex trisperma	CTr	O	P	2	-	3	1	1	3	10
Cuscuta sp.	-	-	-	-	-	1	-	-	-	1
Danthonia sericea var. *epilis*	-	-	P	-	-	-	1	2	-	3
Decodon verticillatus	-	O	P/M	1	2	-	-	-	-	3
Drosera intermedia	DI	O	P/M	-	-	1	2	4	3	10
Drosera rotundifolia	DR	O	P/M	1	-	3	4	4	4	16
Dulichium arundinaceum	DA	O	-	-	-	1	4	2	1	8
Eriocaulon aquaticum	EA	O	P	-	-	1	-	2	-	3
Eriocaulon decangulare	-	O	P	-	-	-	-	2	-	2
Eriophorum virginicum	-	O	P/M	-	-	2	-	-	1	3
Glyceria obtusa	-	O	P/M	-	-	2	-	-	-	2
Habenaria clavellata	-	W	P/M	-	-	-	2	-	-	2
Hypericum mutilum	-	W	M	-	-	-	1	1	-	2
Iris prismatica	-	O	P/M	-	-	-	3	-	-	3
Iris versicolor	-	O	-	-	-	-	2	-	-	2
Juncus caesariensis	-	O	P	-	-	-	-	1	1	2
Juncus canadensis	JC	O	P/M	1	-	2	1	1	1	6
Juncus pelocarpus	JP	O	P/M	-	-	2	3	2	1	8
Lachnanthes caroliniana	-	O	P	-	-	-	1	-	-	1
Leersia oryzoides	-	O	-	-	1	3	2	1	-	7
Lobelia nuttallii	-	W	P	-	-	-	-	2	-	2

Species	Symbol	Wet	Bio	Albertson Brook	Pump Branch	Mullica River	Batsto River	Wading River	Bass River	Total
Lycopodium alopecuroides	-	W	P	-	-	-	-	1	-	1
Lycopodium appressum	-	W	P	-	-	1	-	-	-	1
Lycopus sp.	-	-	-	1	1	-	-	-	-	2
Lysimachia terrestris	LT	O	P/M	1	2	2	3	1	-	9
Mitchella repens	MR	FU	M	3	3	2	4	3	4	19
Narthecium americanum	-	W	P	-	-	-	1	1	-	2
Orontium aquaticum	-	O	P	-	1	1	-	-	-	2
Osmunda cinnamomea	OC	W	P/M	4	4	4	2	3	4	21
Osmunda regalis	OR	O	P/M	3	3	1	3	1	1	12
Oxypolis rigidior	ORx	O	P/M	-	-	-	4	-	-	4
Panicum ensifolium	PE	-	P	1	1	2	4	4	-	12
Panicum sp.	-	-	-	-	-	-	2	1	-	3
Peltandra virginica	PV	O	M	3	1	3	2	2	2	13
Pogonia ophioglossoides	PO	O	P/M	-	-	3	4	3	2	12
Polygala brevifolia	-	O	P	-	-	-	-	2	-	2
Proserpinaca pectinata	-	O	P	-	-	1	1	1	-	3
Rhexia virginica	-	O	P/M	1	-	1	1	1	-	4
Rhynchospora alba	RA	O	P	-	-	1	3	4	3	11
Sabatia difformis	SD	O	P	-	-	1	2	4	1	8
Sagittaria engelmanniana	-	O	P	-	-	1	1	-	-	2
Sarracenia purpurea	SP	O	P	4	1	3	4	4	3	19
Smilax psuedochina	-	F	P	-	-	-	-	-	1	1
Sphagnum spp.	SPH	-	-	4	3	4	4	4	4	23
Thelypteris simulata	TS	W	P	2	1	1	-	-	1	5
Triadenum virginicum	TV	O	P/M	3	-	2	4	3	-	12
Trientalis borealis	TB	F	P/M	2	1	-	-	-	4	7
Viola lanceolata var. *lanceolata*	-	O	P/M	-	-	1	1	-	1	3
Woodwardia areolata	-	W	P/M	3	1	-	-	2	1	7
Woodwardia virginica	WV	O	P/M	4	3	3	1	2	2	15
Xyris torta	-	O	P/M	-	-	-	-	1	-	1
Woody plants:										
Acer rubrum	AR	W	P	4	4	4	4	4	4	24
Amelanchier sp.	AM	-	-	3	1	1	3	3	3	14
Aronia arbutifolia	AA	W	P/M	4	2	3	3	1	3	16
Chamaecyparis thyoides	CT	O	P	4	4	4	4	4	4	24
Chamaedaphne calyculata	CC	O	P	1	-	1	3	3	-	8
Clethra alnifolia	CA	F	P/M	4	4	4	4	4	4	24
Eubotrys racemosa	ER	W	P/M	4	3	4	4	3	4	22
Gaylussacia baccata	GB	FU	P/M	1	-	2	2	3	-	8
Gaylussacia dumosa	GD	F	P	2	-	1	4	4	3	14
Gaylussacia frondosa	GF	F	P/M	4	1	4	4	4	4	21
Ilex glabra	IG	F	P	-	1	-	1	3	1	6

Species	Symbol	Wet	Bio	Albertson Brook	Pump Branch	Mullica River	Batsto River	Wading River	Bass River	Total
Ilex laevigata	IL	O	P/M	1	-	1	2	1	3	8
Ilex opaca	-	F	M	1	2	1	-	-	1	5
Kalmia angustifolia	-	F	P	-	-	1	-	-	-	1
Kalmia latifolia	-	FU	P/M	1	1	-	-	-	2	4
Lyonia ligustrina	-	W	P/M	-	-	1	1	-	1	3
Magnolia virginiana	MV	W	P/M	1	-	3	3	1	1	9
Myrica pensylvanica	MP	F	-	-	-	1	2	2	2	7
Nyssa sylvatica	NS	F	P/M	4	4	2	1	1	1	13
Parthenocissus quinquefolia	PQ	FU	M	4	3	-	-	-	1	8
Pinus rigida	PR	F	P	1	-	1	2	1	-	5
Quercus sp.	QU	-	-	4	3	4	2	3	4	20
Rhododendron viscosum	RVs	W	P	4	4	4	4	4	4	24
Rhus vernix	-	O	P/M	1	-	-	1	-	1	3
Rubus hispidus	RH	W	P/M	3	4	3	4	3	3	20
Sassafras albidum	SA	FU	P/M	4	3	1	1	4	1	14
Smilax glauca	SG	FU	P/M	3	4	2	3	3	-	15
Smilax laurifolia	-	O	P	-	-	-	2	3	-	5
Smilax rotundifolia	SR	F	P/M	4	4	3	4	3	3	21
Smilax walteri	-	O	P	-	-	1	-	-	-	1
Toxicodendron radicans	TR	F	M	4	4	1	1	1	3	14
Vaccinium corymbosum	VC	W	P	4	4	4	4	4	4	24
Vaccinium macrocarpon	VM	O	P	2	-	1	3	4	1	11
Viburnum nudum var. *nudum*	VN	O	P/M	2	-	2	3	2	-	9

APPENDIX 4. POND-VEGETATION DATA

Appendix 4.0. Pond-vegetation study sites in the Mullica River Basin. Refer to Methods for survey details. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name, Location, and Listening Point	Site Code
Hampton Furnace pond (Furnace) Shamong Twp., Burlington Co. (lat 39°46'07.15", long 74°40'57.67", Indian Mills quad). Northern side of Hampton Road, near Hampton Furnace.	BBAFURNP
Hampton Road pond (Hampton) Shamong Twp., Burlington Co. (lat 39°45'56.83", long 74°41'16.29", Indian Mills quad). Southern side of Hampton Road, between Deep Run tributary and Hampton Furnace.	BDEHAMPD
Skit Branch headwater pond (Skit) Tabernacle Twp., Burlington Co. (lat 39°47'51.53", long 74°36'51.42", Chatsworth quad). South of Tabernacle-Chatsworth Road (Route 532), north of railroad, east of Skit Branch.	BSKIHEAD
Skit Sphagnum pond (Sphagnum) Shamong Twp., Burlington Co. (lat 39°46'22.15", long 74°40'20.70", Indian Mills quad). Upstream from Hampton Road, adjacent to dike, on eastern side of Skit Branch.	BSKSPHGM
Roberts (Tom Roberts) pond (Roberts) Tabernacle Twp., Burlington Co. (lat 39°47'16.86", long 74°39'21.64", Indian Mills quad). Northern side of middle sand road between Skit and Roberts (Tom Roberts) Branches, upstream from Carranza Road.	BTOMSKIT
Chew pond (Chew) Waterford Twp., Camden Co. (lat 39°42'22.88", long 74°46'52.74", Hammonton quad). Northern side of Chew Road (Route 536), between Sandy Causeway Road and railroad.	MCLRUSNK
Sandy Causeway pond (Sandy) Waterford Twp., Camden Co. (lat 39°42'35.35", long 74°46'36.80", Hammonton quad). Western side of Sandy Causeway Road, between Chew Road (Route 536) and railroad.	MCLSANDY
Hays Mill pond (Hays) Waterford Twp., Camden Co. (lat 39°45'17.65", long 74°51'06.62", Medford Lakes quad). Southern side of sand road on southern side of Hays Mill Creek, west of Tremont Avenue.	MHASPRAY
Gravel pond (Gravel) Shamong Twp., Burlington Co. (lat 39°44'49.13", long 74°43'15.80", Atsion quad). Northern side of Hampton Road, near excavated area between Route 206 and Stokes Road (Route 541).	MMUGRAVL
Isolated Mullica pond (Mullica) Waterford Twp., Camden Co. (lat 39°45'39.37", long 74°48'09.27", Medford Lakes quad). South of Old Jackson-Atsion Road, between powerline and Mullica River.	MMULISOL
Price Branch pond (Price) Waterford Twp., Camden Co. (lat 39°42'51.74", long 74°49'20.20", Hammonton quad). South of Chew Road (Route 536), between Pestleton Road and Clark Branch.	MPRICEPD
Isolated Sleeper pond (Sleeper) Waterford Twp., Camden Co. (lat 39°43'16.89", long 74°46'09.29", Hammonton quad). North of Fleming Pike, east of Burnt House Road, south of Sleeper Branch.	MSLEISOL
Albertson pond (Albertson) Hammonton Twp., Atlantic Co. (lat 39°41'10.44", long 74°44'22.75", Atsion quad). South of Abandoned Albertson bog site.	NALBPOND

Appendix 4.1. Plant species present at 13 ponds in the Mullica River Basin, 1998. Filled circles indicate a species is present at a site. Refer to Appendix 4.0 for site descriptions.

Scientific Name	Common Name	Albertson	Chew	Furnace	Gravel	Hampton	Hays	Mullica	Price	Roberts	Sandy	Skit	Sleeper	Sphagnum
Herbaceous plants:														
Andropogon virginicus var. abbreviatus	bushy beard-grass	-	•	-	-	-	-	-	-	-	-	-	-	-
Aristida longespica	slender three-awn	-	•	-	-	-	-	-	-	-	-	-	-	-
Carex striata	Walter's sedge	•	-	-	•	-	-	•	•	-	•	•	•	-
Cladium mariscoides	twig-rush	-	-	-	-	-	-	-	-	-	-	-	-	•
Cyperus dentatus	toothed cyperus	-	•	-	-	-	-	-	-	-	-	-	-	•
Cyperus retrorsus	Pine Barrens cyperus	-	-	-	-	-	-	-	-	•	-	-	-	-
Decodon verticillatus	swamp loosestrife	-	-	-	•	-	•	•	-	-	-	-	-	-
Drosera filiformis	thread-leaved sundew	-	•	-	-	-	-	-	-	-	-	-	-	-
Drosera intermedia	spatulate-leaved sundew	•	•	•	-	•	-	-	-	•	-	•	-	•
Drosera rotundifolia	round-leaved sundew	-	-	-	-	-	-	-	-	•	-	-	-	-
Dulichium arundinaceum	Dulichium	•	-	-	•	-	•	-	•	-	-	•	•	•
Eleocharis flavescens var. olivacea	green spike-rush	-	-	-	•	-	•	•	•	•	-	-	•	-
Eleocharis microcarpa	small-fruited spike-rush	-	•	•	-	•	-	•	•	-	-	-	-	-
Eleocharis robbinsii	Robbin's spike-rush	-	-	-	-	-	-	-	-	-	-	-	-	•
Eleocharis tenuis	slender spike-rush	-	-	•	-	•	-	-	-	-	-	-	-	-
Eleocharis tricostata	three-ribbed spike-rush	-	•	-	-	-	•	-	-	-	-	-	-	-
Eleocharis tuberculosa	tubercled spike-grass	-	-	-	-	-	-	-	-	-	-	-	-	•
Erianthus giganteus	plume-grass	-	-	-	-	•	-	-	-	-	-	-	-	-
Euthamia tenuifolia	slender-leaved goldenrod	-	•	-	-	-	-	-	-	-	-	-	-	-
Gratiola aurea	golden hedge hyssop	-	•	-	-	-	-	-	-	-	-	-	-	-
Hypericum canadense	Canada Saint John's-wort	-	•	-	-	-	-	-	-	-	-	-	-	-
Hypericum mutilum	dwarf Saint John's-wort	-	•	-	-	-	-	-	-	-	-	-	-	-
Juncus pelocarpus	brown-fruited rush	-	•	•	-	•	-	-	•	-	-	-	•	•
Lachnanthes caroliniana	redroot	-	-	-	-	-	-	-	-	-	•	-	-	•
Lycopodium appressum	southern bog clubmoss	-	•	-	-	•	-	-	-	-	-	-	-	-
Muhlenbergia torreyana	Torrey's dropseed	-	•	-	-	-	-	-	-	-	-	-	-	-
Nuphar variegata	bullhead lily	-	-	-	-	-	-	-	-	-	-	-	-	•
Nymphaea odorata	white water lily	-	-	-	-	-	-	-	-	-	-	-	•	•
Orontium aquaticum	golden club	-	-	-	-	-	-	-	-	-	-	-	-	•
Osmunda regalis	royal fern	-	•	-	-	-	-	-	-	-	-	-	-	-
Panicum longifolium	long-leaved panic-grass	-	•	•	-	-	-	-	•	-	-	-	-	-
Panicum spretum	Eaton's panic-grass	-	•	•	-	-	-	-	-	-	-	-	-	-
Panicum verrucosum	warty panic-grass	•	•	•	-	•	•	•	•	•	-	•	•	•
Panicum virgatum	switchgrass	-	-	-	-	•	-	-	-	-	-	-	-	-
Peltandra virginica	arrow arum	-	-	-	-	-	-	-	-	-	-	-	-	•
Proserpinaca pectinata	cut-leaved mermaid-weed	•	•	•	-	•	-	-	-	-	-	-	-	-
Rhexia virginica	Virginia meadow beauty	•	•	-	-	•	-	-	•	•	-	-	-	•
Rhynchospora alba	white beaked-rush	-	-	-	•	-	-	-	-	-	-	•	-	-
Rhynchospora capitellata	small-headed beaked-rush	-	•	-	-	-	-	-	-	-	-	-	-	-
Rhynchospora chalarocephala	loose-headed beaked-rush	-	•	-	-	-	-	-	-	-	-	-	-	-
Sarracenia purpurea	pitcher plant	-	-	-	•	-	-	-	-	-	-	-	-	-
Scirpus cyperinus	wool-grass	-	-	-	-	•	-	-	•	-	-	-	-	-
Scirpus subterminalis	water club-rush	-	-	-	-	-	-	-	-	-	-	-	-	•

Scientific Name	Common Name	Albertson	Chew	Furnace	Gravel	Hampton	Hays	Mullica	Price	Roberts	Sandy	Skit	Sleeper	Sphagnum
Triadenum virginicum	marsh Saint John's-wort	-	-	•	-	-	-	•	•	-	-	-	-	•
Utricularia fibrosa	fibrous bladderwort	-	-	-	•	-	-	-	•	-	•	-	-	-
Utricularia geminiscapa	hidden-fruited bladderwort	•	•	-	-	-	-	-	•	-	-	-	•	-
Utricularia purpurea	purple bladderwort	-	-	-	-	-	-	-	-	-	-	-	-	•
Utricularia sp.	bladderwort species	-	-	•	-	-	•	-	-	-	-	-	-	-
Viola lanceolata	lance-leaved violet	-	•	-	-	-	-	-	-	-	-	-	-	-
Woodwardia virginica	Virginia chain fern	•	-	-	•	-	-	•	-	•	•	-	•	-
Xyris difformis	yellow-eyed grass	-	•	•	-	-	-	-	-	-	-	-	•	•
Xyris smalliana	Small's yellow-eyed grass	-	-	-	-	•	-	-	-	-	-	-	-	-
Woody plants:														
Acer rubrum	red maple	•	•	•	•	•	•	•	•	•	•	•	•	-
Amelanchier canadensis	oblongleaf juneberry	-	•	-	•	-	-	-	-	-	-	-	-	-
Aronia arbutifolia	red chokeberry	•	•	-	•	•	•	-	-	-	•	•	-	-
Betula populifolia	gray birch	-	•	-	•	-	-	-	-	-	-	-	-	-
Cephalanthus occidentalis	buttonbush	-	-	-	-	-	-	-	•	-	-	-	-	-
Chamaecyparis thyoides	Atlantic white cedar	-	-	-	•	-	-	-	-	•	•	-	-	•
Chamaedaphne calyculata	leatherleaf	•	•	•	•	•	•	•	•	•	•	-	•	•
Clethra alnifolia	sweet pepperbush	•	-	•	-	-	-	-	•	-	•	-	•	-
Comptonia peregrina	sweet fern	-	•	-	-	-	-	-	-	-	-	-	-	-
Eubotrys racemosa	fetterbush	•	•	•	•	•	•	-	•	•	•	•	•	•
Gaultheria procumbens	wintergreen	-	•	•	-	•	-	-	-	-	-	-	-	-
Gaylussacia baccata	black huckleberry	-	•	•	-	•	-	-	-	-	-	-	-	-
Gaylussacia dumosa	dwarf huckleberry	-	-	-	-	-	-	-	-	-	-	-	-	•
Gaylussacia frondosa	dangleberry	•	-	•	•	•	-	•	-	-	-	•	•	•
Hudsonia ericoides	golden heather	-	-	-	-	•	-	-	-	-	-	-	-	-
Ilex glabra	inkberry	-	•	•	-	•	-	-	-	-	-	-	•	-
Ilex opaca	American holly	-	-	•	•	-	-	-	-	-	-	-	-	-
Kalmia angustifolia	sheep laurel	•	•	•	•	•	-	•	•	•	•	•	•	•
Kalmia latifolia	mountain laurel	-	•	-	-	-	-	-	-	-	-	-	-	-
Leiophyllum buxifolium	sand myrtle	-	•	•	-	•	-	-	-	-	-	-	-	-
Lyonia mariana	staggerbush	•	•	•	-	•	•	•	•	-	-	-	•	-
Magnolia virginiana	sweet bay	-	-	-	•	-	-	-	-	-	-	-	-	-
Myrica pensylvanica	bayberry	-	-	•	-	•	-	-	-	-	-	-	-	-
Nyssa sylvatica	sour gum	•	•	•	-	•	•	-	-	-	-	-	•	-
Pinus rigida	pitch pine	•	•	•	•	•	•	•	•	•	•	•	•	-
Quercus ilicifolia	scrub oak	-	•	•	-	•	-	-	-	-	-	-	-	-
Quercus marilandica	black-jack oak	-	-	•	-	•	-	-	-	-	-	-	-	-
Rhododendron viscosum	swamp azalea	-	-	•	•	-	-	-	-	-	-	-	-	-
Sassafras albidum	sassafras	-	•	-	-	-	-	-	-	-	-	-	-	-
Smilax glauca	glaucous greenbrier	-	-	•	-	•	-	-	-	•	-	-	•	-
Smilax rotundifolia	common greenbrier	•	•	•	-	-	•	•	•	-	•	-	•	•
Toxicodendron radicans	poison ivy	-	-	-	-	-	-	•	-	-	-	-	-	-
Vaccinium corymbosum	highbush blueberry	•	•	•	•	•	•	•	•	•	•	•	•	•
Vaccinium macrocarpon	large cranberry	-	•	•	•	•	-	-	-	-	•	-	-	•

APPENDIX 5. FISH-ASSEMBLAGE DATA

Appendix 5.0. Mullica River Basin fish-monitoring sites and individuals who sampled on each date. Sites are arranged alphabetically by site code. Individuals that sampled are: JFB = John F. Bunnell, FD = Fred Doughitt, CLD = Charles L. Dow, JG = John Graham, DMG = Dennis M. Gray, RGH = Robert G. Howell, KJL = Kim J. Laidig, RGL = Richard G. Lathrop, CKM = Carleton K. Montgomery, TMS = Tanya M. Sulikowski, BW = Bob Wood, and RAZ = Robert A. Zampella.

Site Name	Site Code	Sampler	Date
Lake Absegami	AEAABSDW	JFB/RAZ	08/26/98
East Branch Bass River above Stage Road	AEASTAGE	JFB/RAZ	07/02/93
East Branch Bass River above Stage Road	AEASTAGE	JFB/RAZ	07/23/93
East Branch Bass River above Stage Road	AEASTAGE	JFB/RAZ	09/24/93
East Branch Bass River above Stage Road	AEASTAGE	JFB/TMS	06/30/99
West Branch Bass River impoundment above Stage Road (Pilgrim Lake)	AWEPILGL	JFB/RAZ	10/15/99
West Branch Bass River above Stage Road	AWESTAGE	JFB/RAZ	07/08/99
West Branch Bass River above Stage Road	AWESTAGE	JFB/RAZ	09/22/99
Batsto River above Carranza Road	BBACARRZ	JFB/RAZ	07/02/97
Batsto River above Carranza Road	BBACARRZ	RAZ/RGL	10/02/97
Batsto River at Lower Forge	BBALFORG	JFB/RAZ	06/26/97
Batsto River at Lower Forge	BBALFORG	JFB/CLD/TMS	10/02/97
Batsto River below Penn Swamp Branch	BBAPENNS	JFB/RAZ	08/07/97
Batsto River below Penn Swamp Branch	BBAPENNS	RAZ/RGL	10/02/97
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	JFB/RAZ	09/17/92
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	JFB/RAZ	10/15/92
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	JFB/RAZ	05/17/93
Batsto River side channel below Quaker Bridge Road	BBAQUAKR	JFB/KJL/TMS	10/08/97
Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	JFB/RAZ/TMS	07/25/97
Batsto River below Central New Jersey/Conrail railroad bridge	BBARRBRG	JFB/CLD/TMS	10/02/97
Batsto River below Route 532	BBART532	JFB/RAZ	06/02/99
Batsto River below Route 532	BBART532	JFB/TMS	09/28/99
Batsto River above Hampton Road	BBATHAMP	JFB/RAZ	06/18/92
Batsto River above Hampton Road	BBATHAMP	JFB/RAZ	07/17/92
Batsto River above Hampton Road	BBATHAMP	JFB/RAZ	05/14/93
Batsto River above Hampton Road	BBATHAMP	JFB/CLD/TMS	10/27/97
Batsto Lake	BBATLAKE	JFB/RAZ	06/26/97
Batsto Lake	BBATLAKE	JFB/RAZ	09/02/98
Batsto River tributary above Carranza Road	BBATRCAR	JFB/TMS	06/12/97
Batsto River tributary above Carranza Road	BBATRCAR	JFB/TMS	10/21/97
Batsto River tributary below Hay Road	BBATRMAN	JFB/TMS	08/28/97
Batsto River tributary below Hay Road	BBATRMAN	JFB/TMS	10/29/97
Batsto River headwater impoundment below Route 532	BBATS532	JFB/RAZ	07/14/97
Batsto River headwater impoundment below Route 532	BBATS532	JFB/RGH	09/08/97
Deep Run below Hampton Road	BDEEPDKE	JFB/RAZ/JG	06/06/97
Deep Run below Hampton Road	BDEEPDKE	JFB/RGH	09/08/97
Deep Run below Hampton Road	BDEEPDKE	JFB/KJL/TMS	10/08/97
Deep Run impoundment below Hampton Road	BDEEPIMP	JFB/RAZ	06/19/97
Deep Run impoundment below Hampton Road	BDEEPIMP	JFB/RGH	09/08/97
Horse Pond Stream below Butterworths Bogs Road	BHOBUTTR	JFB/RAZ	07/02/97
Horse Pond Stream below Butterworths Bogs Road	BHOBUTTR	JFB/RAZ/TMS	10/27/97
Indian Mills Brook impoundment above Old Schoolhouse Road	BINSCHOO	JFB/RAZ/TMS	07/25/97
Indian Mills Brook above Oakshade Road (above Shadow Lake)	BINSHADS	JFB/RAZ/TMS	10/16/97
Indian Mills Brook above Oakshade Road (above Shadow Lake)	BINSHADS	JFB/RAZ/TMS	07/25/97

Site Name	Site Code	Sampler	Date
Indian Mills Brook impoundment above Oakshade Road (Shadow Lake)	BINSHADW	JFB/RAZ	06/19/97
Indian Mills Lake at dam	BMULAKED	JFB/RAZ	07/14/97
Muskingum Brook above Tuckerton Road	BMUSKTUC	JFB/RAZ	06/13/93
Muskingum Brook above Tuckerton Road	BMUSKTUC	JFB/RAZ	08/18/93
Muskingum Brook above Tuckerton Road	BMUSKTUC	JFB/RAZ	10/07/93
Muskingum Brook above Tuckerton Road	BMUSKTUC	JFB/RAZ/TMS	10/27/97
Penn Swamp Branch above Batona Trail bridge	BPEBRIDG	JFB/RAZ	07/02/97
Penn Swamp Branch above Batona Trail bridge	BPEBRIDG	RAZ/RGL	10/02/97
Skit Branch below Carranza Road	BSKITCAR	JFB/RAZ/JG	06/06/97
Skit Branch below Carranza Road	BSKITCAR	JFB/CLD/TMS	10/02/97
Skit Branch above Hampton Road	BSKITHAM	JFB/RAZ	06/18/92
Skit Branch above Hampton Road	BSKITHAM	JFB/RAZ	07/17/92
Skit Branch above Hampton Road	BSKITHAM	JFB/RAZ	05/14/93
Skit Branch above Hampton Road	BSKITHAM	JFB/KJL/TMS	10/08/97
Skit Branch beaver pond above Batona Campground	BSKWIDEN	JFB/RAZ	10/15/98
Springers Brook below Deep Run	BSPRDIKE	JFB/RAZ/JG	06/06/97
Springers Brook below Deep Run	BSPRDIKE	JFB/RAZ/TMS	10/16/97
Springers Brook above Hampton Road	BSPRIHAM	JFB/RAZ	06/18/92
Springers Brook above Hampton Road	BSPRIHAM	JFB/RAZ	07/16/92
Springers Brook above Hampton Road	BSPRIHAM	JFB/RAZ	05/14/93
Springers Brook above Hampton Road	BSPRIHAM	JFB/RAZ/TMS	10/16/97
Roberts (Tom Roberts) Branch beaver pond above Carranza Road	BTOIMPCA	JFB/RAZ	06/19/97
Roberts (Tom Roberts) Branch beaver pond above Carranza Road	BTOIMPCA	JFB/RGH	09/08/97
Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	JFB/TMS	08/12/97
Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	JFB/TMS	09/23/97
Roberts (Tom Roberts) Branch below Carranza Road	BTOMCARR	JFB/TMS	10/21/97
Elliots Creek at Bremen Avenue	LELIOBRE	JFB/RAZ	07/08/99
Elliots Creek at Bremen Avenue	LELIOBRE	JFB/RAZ	09/23/99
Hammonton Creek above Chestnut Avenue	LHACHEST	JFB/RAZ	08/05/98
Hammonton Creek above Chestnut Avenue	LHACHEST	JFB/RAZ	10/15/98
Hammonton Lake	LHAMLAKE	JFB/RAZ	09/02/98
Indian Cabin Creek above Landing Creek	LINCABIN	JFB/RAZ	06/18/99
Indian Cabin Creek above Landing Creek	LINCABIN	JFB/RAZ	09/23/99
Egg Harbor City Lake below Route 563	LINLAKED	JFB/RAZ/TMS	09/08/99
Landing Creek above Indian Cabin Road	LLANDIND	JFB/RAZ	07/28/99
Landing Creek above Indian Cabin Road	LLANDIND	JFB/RAZ	09/10/99
Landing Creek below Alternate Route 561	LLANDMOS	JFB/RAZ	07/14/99
Landing Creek below Alternate Route 561	LLANDMOS	JFB/RAZ	10/08/99
Morses Mill Stream below College Drive	LMORSESM	JFB/RAZ	06/18/99
Morses Mill Stream below College Drive	LMORSESM	JFB/RAZ	09/10/99
Lake Fred	LMOSTOCK	JFB/RAZ/TMS	09/08/99
Union Creek above Alternate Route 561	LUNIOMOS	JFB/RAZ	07/14/99
Union Creek above Alternate Route 561	LUNIOMOS	JFB/RAZ	10/08/99
Clark Branch at Parkdale	MCLJOHNS	JFB/RAZ	07/16/92
Clark Branch at Parkdale	MCLJOHNS	JFB/RAZ	08/14/92
Clark Branch at Parkdale	MCLJOHNS	JFB/RAZ	05/14/93
Clark Branch at Parkdale	MCLJOHNS	JFB/DMG	07/31/96

Site Name	Site Code	Sampler	Date
Cooper Branch impoundment near Tremont Avenue and Burnt Mill Road	MCOIMPNT	JFB/RAZ/CKM	07/22/98
Atco Lake	MHAATCOL	JFB/RAZ	08/04/99
Hays Mill Creek above Tremont Avenue	MHATREMO	JFB/RAZ	07/25/96
Hays Mill Creek above Tremont Avenue	MHATREMO	JFB/KJL	08/30/96
Hays Mill Creek above Tremont Avenue	MHATREMO	JFB/FD	09/29/96
Atsion Lake	MMUATSIO	JFB/RAZ	08/25/99
Mullica River below Constable Bridge	MMUCONST	JFB/RAZ	08/27/92
Mullica River below Constable Bridge	MMUCONST	JFB/RGH	09/17/92
Mullica River below Constable Bridge	MMUCONST	JFB/RAZ	05/17/93
Mullica River below Constable Bridge	MMUCONST	JFB/DMG	08/12/96
Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	JFB/RAZ/CKM	07/22/98
Mullica River above dike below Old Jackson-Atsion Road	MMUDIKES	JFB/TMS	10/07/98
Goshen Pond	MMUGOSHN	JFB/RAZ	07/14/97
Mullica River impoundment above Jackson-Medford Road (Ladys Lake)	MMULADYL	JFB/RAZ/CKM	07/22/98
Mullica River below Jackson-Medford Road	MMULADYS	JFB/RAZ	07/25/96
Mullica River below Jackson-Medford Road	MMULADYS	JFB/KJL	08/30/96
Mullica River below Jackson-Medford Road	MMULADYS	JFB/FD	09/26/96
Mullica River above Route 534	MMULJACK	JFB/RAZ	07/16/92
Mullica River above Route 534	MMULJACK	JFB/RAZ	08/14/92
Mullica River above Route 534	MMULJACK	JFB/RAZ	05/14/93
Mullica River above Route 534	MMULJACK	JFB/RGH	06/24/96
Mullica River above Central New Jersey/Conrail railroad bridge	MMURRBRG	JFB/RAZ	07/26/99
Mullica River above Central New Jersey/Conrail railroad bridge	MMURRBRG	JFB/RAZ	09/23/99
Mullica River at northern border of Wilderness Area	MMUWILDR	JFB/RAZ	08/07/97
Mullica River at northern border of Wilderness Area	MMUWILDR	JFB/CLD	10/27/97
Sleeper Branch bogs at Route 206	MSL206BG	JFB/RAZ	08/05/98
Sleeper Branch at Parkdale	MSLEPARK	JFB/RAZ	07/16/92
Sleeper Branch at Parkdale	MSLEPARK	JFB/RAZ	08/14/92
Sleeper Branch at Parkdale	MSLEPARK	JFB/RAZ	05/14/93
Sleeper Branch at Parkdale	MSLEPARK	JFB/DMG	07/31/96
Sleeper Branch above Mullica River	MSLPLEAS	JFB/RAZ	08/27/92
Sleeper Branch above Mullica River	MSLPLEAS	JFB/RGH	09/17/92
Sleeper Branch above Mullica River	MSLPLEAS	JFB/RAZ	05/17/93
Sleeper Branch above Mullica River	MSLPLEAS	JFB/DMG	08/12/96
Wesickaman Creek below Three Bridge Road	MWETHREE	JFB/RAZ	07/25/96
Wesickaman Creek below Three Bridge Road	MWETHREE	JFB/KJL	08/30/96
Wesickaman Creek below Three Bridge Road	MWETHREE	JFB/FD	09/26/96
Albertson Brook above Fleming Pike	NALBFLEM	JFB/DMG	08/28/95
Albertson Brook above Fleming Pike	NALBFLEM	JFB/RGH	06/24/96
Albertson Brook above Fleming Pike	NALBFLEM	JFB/DMG	08/12/96
Albertson Brook above derelict bridge below Route 206	NALDEREL	JFB/RAZ	07/02/92
Albertson Brook above derelict bridge below Route 206	NALDEREL	JFB/RAZ	07/17/92
Albertson Brook above derelict bridge below Route 206	NALDEREL	JFB/RAZ	05/17/93
Albertson Brook above derelict bridge below Route 206	NALDEREL	JFB/DMG	08/28/95
Albertson Brook impoundment below Route 206 (Paradise Lakes)	NALPARAD	JFB/RAZ	08/25/99
Blue Anchor Brook impoundment above Spring Garden-Winslow Road	NBLSPRNG	JFB/RAZ	08/19/98
Cedar Brook near Hammonton Airport	NCEAIRPO	JFB/RAZ	08/05/98

Site Name	Site Code	Sampler	Date
Great Swamp Branch 2nd (and 3rd) impoundments above Route 30	NGREAR30	JFB/RAZ	08/04/99
Great Swamp Branch below Route 613	NGRMIDDL	JFB/RAZ	09/24/94
Great Swamp Branch below Route 613	NGRMIDDL	JFB/BW	08/18/95
Great Swamp Branch below Route 613	NGRMIDDL	JFB/RAZ	10/27/95
Great Swamp Branch below Route 613	NGRMIDDL	JFB/RGH	06/24/96
Nescochague Creek at Pleasant Mills	NNEMILLS	JFB/RAZ	08/27/92
Nescochague Creek at Pleasant Mills	NNEMILLS	JFB/RGH	09/17/92
Nescochague Creek at Pleasant Mills	NNEMILLS	JFB/RAZ	05/17/93
Nescochague Creek at Pleasant Mills	NNEMILLS	JFB/DMG	08/28/95
Nescochague Creek near West Mill Road	NNEWESTM	JFB/RAZ	07/26/99
Nescochague Creek near West Mill Road	NNEWESTM	JFB/RAZ	10/18/99
Pump Branch impoundment at Ha-Lu-Wa-Sa	NPUHALUW	JFB/RAZ	07/28/99
Pump Branch impoundment near Cedar Avenue	NPUIMPNT	JFB/RAZ	08/07/97
Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	JFB/BW	08/18/95
Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	JFB/RAZ	10/27/95
Pump Branch above dike near Winslow/Waterford boundary	NPUMDIKE	JFB/RGH	06/24/96
Buck Run below Old Martha Road	OBUCKRUN	JFB/RAZ	06/07/99
Buck Run below Old Martha Road	OBUCKRUN	JFB/RAZ	09/13/99
Oswego River below Beaver Dam Road	OOSBEAVR	JFB/RAZ	06/02/99
Oswego River below Beaver Dam Road	OOSBEAVR	JFB/RAZ	09/22/99
Oswego River impoundment above Old Cedar Bridge-Barnegat Road	OOSCEDRI	JFB/RAZ	08/06/99
Harrisville Pond	OOSHARLK	JFB/RAZ	08/06/99
Oswego River below Route 679	OOSHARST	JFB/RAZ	06/02/93
Oswego River below Route 679	OOSHARST	JFB/RAZ	07/23/93
Oswego River below Route 679	OOSHARST	JFB/RAZ	09/24/93
Oswego River below Route 679	OOSHARST	JFB/TMS	06/30/99
Oswego River impoundment at Howardsville	OOSHOWIM	JFB/RAZ	08/11/98
Oswego River below Oswego Lake	OOSLAKDW	JFB/RAZ	06/02/93
Oswego River below Oswego Lake	OOSLAKDW	JFB/RAZ	07/23/93
Oswego River below Oswego Lake	OOSLAKDW	JFB/RAZ	09/24/93
Oswego River above Oswego Lake	OOSLAKUP	JFB/RAZ/TMS	06/23/99
Oswego River above Oswego Lake	OOSLAKUP	JFB/RAZ	10/15/99
Oswego River above Martha	OOSOLMAR	JFB/RAZ	06/07/99
Oswego River above Martha	OOSOLMAR	JFB/RAZ	09/13/99
Oswego Lake	OOSWLAKE	JFB/RAZ	08/26/98
Papoose Branch below Jenkins Road	OPAPOOSE	JFB/RAZ/TMS	06/23/99
Papoose Branch below Jenkins Road	OPAPOOSE	JFB/RAZ	09/22/99
Bulls Branch impoundment (Otter Pond)	WBUOTTER	JFB/RAZ	08/11/98
Featherbed Branch below Carranza Road	WFEACARR	JFB/RAZ/TMS	06/08/98
Featherbed Branch below Carranza Road	WFEACARR	JFB/TMS	10/07/98
Featherbed Branch impoundment below Carranza Road	WFEIMPD1	JFB/RAZ	08/11/98
Hospitality Brook below Route 563	WHOSPITA	JFB/RAZ/TMS	06/23/99
Hospitality Brook below Route 563	WHOSPITA	JFB/TMS	09/28/99
Little Hauken Run below Route 563	WLIHAUKN	JFB/RAZ	07/28/99
Little Hauken Run below Route 563	WLIHAUKN	JFB/TMS	09/28/99
Shane Branch above fourth dike above Carranza Road	WSA4DIKE	JFB/RAZ	06/03/98
Shane Branch above fourth dike above Carranza Road	WSA4DIKE	JFB/TMS	09/18/98

Site Name	Site Code	Sampler	Date
Shane Branch above Carranza Road	WSACARRA	JFB/RAZ	06/03/98
Shane Branch above Carranza Road	WSACARRA	JFB/TMS	10/07/98
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	JFB/RAZ	06/02/93
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	JFB/RAZ	07/23/93
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	JFB/RAZ	09/24/93
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	JFB/RAZ/TMS	06/08/98
Tulpehocken Creek above Maxwell-Friendship Road	WTUHAWKN	JFB/RAZ/TMS	10/02/98
Wading River above Route 563	WWEEVANB	JFB/RAZ	06/12/98
Wading River above Route 563	WWEEVANB	JFB/RAZ/TMS	10/02/98
Wading River below Ford Road	WWEFORDR	JFB/RAZ/TMS	06/08/98
Wading River below Ford Road	WWEFORDR	JFB/RAZ	09/18/98
Wading River below Mile Run	WWEMILER	JFB/RAZ	06/12/98
Wading River below Mile Run	WWEMILER	JFB/RAZ/TMS	10/02/98
Wading River above Tulpehocken Creek	WWETULPC	JFB/RAZ	06/03/98
Wading River above Tulpehocken Creek	WWETULPC	JFB/RAZ	09/18/98
Wading River above Route 563 at Tumbling Dam	WWETUMBL	JFB/RAZ	06/02/93
Wading River above Route 563 at Tumbling Dam	WWETUMBL	JFB/RAZ	07/23/93
Wading River above Route 563 at Tumbling Dam	WWETUMBL	JFB/RAZ	09/24/93
Wading River above Route 563 at Tumbling Dam	WWETUMBL	JFB/RAZ	06/12/98

Appendix 5.1.1. Fish-monitoring sites (streams and impoundments) in the Wading River drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Sections were not assigned in impoundments. Refer to Methods for sampling details. 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
Bulls Branch impoundment (Otter Pond) Washington Twp., Burlington Co. (lat 39°44'39.05", long 74°34'49.95", Jenkins quad). Impoundment on Bulls Branch, upstream from fourth dike above from East Sandy Ridge Road	WBUOTTER
Featherbed Branch below Carranza Road Tabernacle Twp., Burlington Co. (lat 39°45'36.67", long 74°35'32.30", Chatsworth quad). Section 4 ends 3 m downstream from Carranza Road.	WFEACARR
Featherbed Branch impoundment below Carranza Road Tabernacle Twp., Burlington Co. (lat 39°45'29.37", long 74°35'36.59", Chatsworth quad). Impoundment between Carranza Road and first downstream dike	WFEIMPD1
Hospitality Brook below Route 563 Washington Twp., Burlington Co. (lat 39°42'56.29", long 74°32'33.07", Jenkins quad). Section 1 begins 43 m upstream from breached dike, approximately 1.7 km upstream from Wading River.	WHOSPITA
Little Hauken Run below Route 563 Washington Twp., Burlington Co. (lat 39°42'57.62", long 74°32'06.49", Jenkins quad). Section 4 ends 55 m downstream from Green Bank-Chatsworth Road (Route 563).	WLIHAUKN
Shane Branch above fourth dike above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°45'49.02", long 74°35'01.71", Chatsworth quad). Section 1 begins 10 m upstream from fourth dike above Carranza Road.	WSA4DIKE
Shane Branch above Carranza Road Washington Twp., Burlington Co. (lat 39°45'04.87", long 74°35'06.49", Chatsworth quad). Section 1 begins 15 m upstream from Carranza Road.	WSACARRA
Tulpehocken Creek above Maxwell-Friendship Road Washington Twp., Burlington Co. (lat 39°42'51.73", long 74°33'57.15", Jenkins quad). Section 1 begins 35 m upstream from Big Hawkin Bridge at Maxwell-Friendship Road.	WTUHAWKN
Wading River above Route 563 Washington Twp., Burlington Co. (lat 39°40'30.53", long 74°32'27.17", Jenkins quad). Section 1 begins 60 m upstream from Evans Bridge at Green Bank-Chatsworth Road (Route 563).	WWEEVANB
Wading River below Ford Road Washington Twp., Burlington Co. (lat 39°42'16.44", long 74°33'18.43", Jenkins quad). Section 4 ends just downstream from Ford Road.	WWEFORDR
Wading River below Mile Run Washington Twp., Burlington Co. (lat 39°44'22.17", long 74°32'54.72", Jenkins quad). Section 1 begins near unnamed sand road, approximately 1.2 km downstream from confluence with Mile Run.	WWEMILER
Wading River above Tulpehocken Creek Washington Twp., Burlington Co. (lat 39°43'01.10", long 74°33'43.87", Jenkins quad). Section 1 begins near unnamed sand road, approximately 0.8 km upstream from confluence with Tulpehocken Creek.	WWETULPC
Wading River above Route 563 at Tumbling Dam Washington Twp., Burlington Co. (lat 39°40'41.33", long 74°32'27.77", Chatsworth quad). Section 1 begins approximately 75 m downstream from Tumbling Dam, west of Green Bank-Chatsworth Road (Route 563), upstream from Evans Bridge.	WWETUMBL

Appendix 5.1.2. Total number collected for each fish species at monitoring sites in the Wading River drainage basin. A dash (-) indicates that a species was not collected at a site. Refer to the Methods section for survey methodology. Refer to Appendix 5.1.1 for detailed site information, Appendix 5.0 for individuals that participated in sampling, and Appendix 5.8 for common names for each species.

	Site Code (Date)																
Species	WBUOTTER (08/11/98)	WFEACARR (06/08/98)	WFEACARR (10/07/98)	WFEIMPD1 (08/11/98)	WHOSPITA (06/23/99)	WHOSPITA (09/28/99)	WLIHAUKN (07/28/99)	WLIHAUKN (09/28/99)	WSA4DIKE (06/03/98)	WSA4DIKE (09/18/98)	WSACARRA (06/03/98)	WSACARRA (10/07/98)	WTUHAWKN (06/02/93)	WTUHAWKN (07/23/93)	WTUHAWKN (09/24/93)	WTUHAWKN (06/08/98)	WTUHAWKN (10/02/98)
Acantharchus pomotis	4	4	16	2	8	1	3	-	-	5	1	4	-	2	3	1	2
Ameiurus natalis	-	-	-	-	10	10	4	-	-	-	-	-	-	3	-	-	-
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	-	-	-	-	1	1	-	-	-	-	-	-	-	1	1	-	3
Aphredoderus sayanus	-	-	6	4	-	-	35	-	-	-	-	-	3	2	1	-	3
Enneacanthus chaetodon	-	-	-	-	2	7	-	-	-	-	-	-	-	1	-	1	-
Enneacanthus gloriosus	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Enneacanthus obesus	70	23	404	43	78	35	11	14	-	15	17	36	5	3	6	28	16
Enneacanthus species	3	-	2	-	-	-	-	-	-	-	-	1	1	-	1	-	-
Erimyzon oblongus	-	-	-	-	3	1	-	-	-	-	-	-	-	-	-	1	4
Esox americanus	1	-	17	-	2	-	3	1	2	-	6	10	-	-	-	3	-
Esox niger	7	7	-	-	-	-	-	-	8	4	-	1	1	2	1	1	1
Esox species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Etheostoma fusiforme	-	4	-	6	3	10	10	1	-	-	-	-	6	-	2	10	7
Etheostoma olmstedi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis macrochirus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	4	9	288	9	72	14	57	5	26	204	16	136	1	1	2	9	13

Species	WWEEVANB (06/12/98)	WWEEVANB (10/02/98)	WWEFORDR (06/08/98)	WWEFORDR (09/18/98)	WWEMILER (06/12/98)	WWEMILER (10/02/98)	WWETULPC (06/03/98)	WWETULPC (09/18/98)	WWETUMBL (06/02/93)	WWETUMBL (07/23/93)	WWETUMBL (09/24/93)	WWETUMBL (06/12/98)
	Site Code (Date)											
Acantharchus pomotis	1	-	1	-	-	-	2	1	2	-	1	2
Ameiurus natalis	-	3	-	1	-	2	-	3	5	4	2	-
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	2	3	1	3	-	-	2	2	-	2	1	1
Aphredoderus sayanus	1	10	1	11	6	19	-	7	12	7	3	2
Enneacanthus chaetodon	6	12	1	1	-	4	-	1	6	15	8	6
Enneacanthus gloriosus	5	2	-	-	-	-	-	-	-	-	-	4
Enneacanthus obesus	24	8	3	2	15	10	2	-	19	5	2	6
Enneacanthus species	3	1	-	-	-	2	-	-	-	1	-	-
Erimyzon oblongus	-	4	-	7	-	15	-	-	-	6	-	-
Esox americanus	1	2	2	-	1	-	-	-	-	-	-	1
Esox niger	5	3	2	1	1	-	1	1	2	3	-	3
Esox species	-	-	-	-	-	-	-	-	-	-	-	-
Etheostoma fusiforme	11	26	22	21	48	53	14	31	23	7	25	13
Etheostoma olmstedi	-	-	-	-	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis macrochirus	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis species	-	-	-	-	-	-	-	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	-	-	-	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	59	16	6	10	28	22	9	11	61	6	3	43

Appendix 5.2.1. Fish-monitoring sites (streams and impoundments) in the Bass River and Oswego River drainage basins. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Sections were not assigned in impoundments. Refer to Methods for sampling details. 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
Lake Absegami Bass River Twp., Burlington Co. (lat 39°37'19.49", long 74°25'21.61", New Gretna quad). Impoundment on Tommys Branch downstream from Phillip Road, near main entrance to Bass River State Park	AEAABSDW
East Branch Bass River above Stage Road Bass River Twp., Burlington Co. (lat 39°37'24.00", long 74°26'27.95", New Gretna quad). Section 4 ends at U.S.G.S. gaging station, upstream from Stage Road.	AEASTAGE
West Branch Bass River impoundment above Stage Road (Pilgrim Lake) Bass River Twp., Burlington Co. (lat 39°37'34.34", long 74°26'35.00", Oswego Lake quad). Impoundment upstream from Stage Road	AWEPILGL
West Branch Bass River above Stage Road Bass River Twp., Burlington Co. (lat 39°37'27.38", long 74°26'45.22", New Gretna quad). Section 1 begins 14 m upstream from Stage Road.	AWESTAGE
Buck Run below Old Martha Road Bass River Twp., Burlington Co. (lat 39°41'58.89", long 74°29'53.22", Oswego Lake quad). Section 4 ends 4 m downstream from Old Martha Road.	OBUCKRUN
Oswego River below Beaver Dam Road Little Egg Harbor Twp., Ocean Co. (lat 39°44'58.67", long 74°22'38.43", Oswego Lake quad). Section 4 ends 10 m downstream from Beaver Dam Road.	OOSBEAVR
Oswego River impoundment above Old Cedar Bridge-Barnegat Road Union Twp., Ocean Co. (lat 39°47'05.05", long 74°21'38.29", Brookville quad). Impoundment upstream from Old Cedar Bridge-Barnegat Road, south of Barnegat Road (Route 72)	OOSCEDRI
Harrisville Pond Bass River Twp., Burlington Co. (lat 39°39'53.11", long 74°31'26.44", Jenkins quad). Impoundment on Oswego River, upstream of Harrisville-Chatsworth Road (Route 679)	OOSHARLK
Oswego River below Route 679 Washington/Bass River Twp., Burlington Co. (lat 39°39'48.45", long 74°31'24.44", Jenkins quad). Section 4 ends 42 m downstream from Harrisville-Chatsworth Road (Route 679).	OOSHARST
Oswego River impoundment at Howardsville Union Twp., Ocean Co. (lat 39°49'01.32", long 74°21'59.86", Brookville quad). Uppermost impoundment at Howardsville, east of Howardsville Road	OOSHOWIM
Oswego River below Oswego Lake Washington/Bass River Twp., Burlington Co. (lat 39°43'53.59", long 74°29'21.49", Oswego Lake quad). Section 4 ends just below Oswego Lake spillway. *lat/long calculated from USGS quad	OOSLAKDW
Oswego River above Oswego Lake Washington/Bass River Twp., Burlington Co. (lat 39°44'07.16", long 74°28'24.16", Oswego Lake quad). Section 4 ends near end of unnamed sand road, upstream from Oswego Lake.	OOSLAKUP
Oswego River above Martha Washington/Bass River Twp., Burlington Co. (lat 39°42'13.56", long 74°30'05.45", Jenkins quad). Section 1 begins near end of unnamed sand road, approximately 0.8 km upstream from confluence with Buck Run.	OOSOLMAR

Site Name and Description	Site Code
Oswego Lake Washington Twp., Burlington Co. (lat 39°44'04.11", long 74°29'31.46", Oswego Lake quad). Impoundment south of Jenkins Road	OOSWLAKE
Papoose Branch below Jenkins Road Washington/Bass River Twp., Burlington Co. (lat 39°44'31.93", long 74°27'09.67", Oswego Lake quad). Section 4 ends 19 m downstream from Jenkins Road.	OPAPOOSE

Appendix 5.2.2. Total number collected for each fish species at monitoring sites in the Bass River and Oswego River drainage basins. A dash (-) indicates that a species was not collected at a site. Refer to the Methods section for survey methodology. Refer to Appendix 5.2.1 for detailed site information, Appendix 5.0 for individuals that participated in sampling, and Appendix 5.8 for common names for each species.

	Site Code (Date)							
Species	AEAABSDW (08/26/98)	AEASTAGE (07/02/93)	AEASTAGE (07/23/93)	AEASTAGE (09/24/93)	AEASTAGE (06/30/99)	AWEPILGL (10/15/99)	AWESTAGE (07/08/99)	AWESTAGE (09/22/99)
Acantharchus pomotis	-	8	5	1	5	-	-	1
Ameiurus natalis	2	-	-	5	-	-	4	-
Ameiurus nebulosus	-	-	-	-	-	-	-	-
Anguilla rostrata	-	4	-	3	10	-	5	2
Aphredoderus sayanus	1	7	4	9	16	2	-	-
Enneacanthus chaetodon	-	1	5	2	8	81	2	9
Enneacanthus gloriosus	-	7	1	6	2	10	1	-
Enneacanthus obesus	109	12	8	9	9	21	5	1
Enneacanthus species	6	-	-	-	-	7	-	-
Erimyzon oblongus	16	-	1	1	1	-	-	-
Esox americanus	-	-	-	-	-	-	-	-
Esox niger	8	3	3	2	5	5	1	-
Esox species	-	1	-	-	-	-	-	-
Etheostoma fusiforme	36	25	6	12	15	8	4	1
Etheostoma olmstedi	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	-	-	-	7
Lepomis macrochirus	-	-	-	-	-	-	-	-
Lepomis species	-	-	-	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-
Noturus gyrinus	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-
Umbra pygmaea	2	4	2	8	1	1	-	-

Species	OBUCKRUN (06/07/99)	OBUCKRUN (09/13/99)	OOSBEAVR (06/02/99)	OOSBEAVR (09/22/99)	OOSCEDRI (08/06/99)	OOSHARLK (08/06/99)	OOSHARST (06/02/93)	OOSHARST (07/23/93)	OOSHARST (09/24/93)	OOSHARST (06/30/99)	OOSHOWIM (08/11/98)
Acantharchus pomotis	-	2	5	1	-	1	-	-	2	3	-
Ameiurus natalis	-	-	4	-	1	1	3	10	10	11	-
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	-	-	-	-	-	-	3	-	-	1	-
Aphredoderus sayanus	-	-	3	1	1	1	2	-	-	1	-
Enneacanthus chaetodon	-	1	4	46	80	74	14	10	28	15	31
Enneacanthus gloriosus	-	-	-	-	-	94	4	1	2	10	-
Enneacanthus obesus	18	13	14	16	74	7	15	2	4	14	82
Enneacanthus species	-	-	-	7	22	1	6	1	7	-	4
Erimyzon oblongus	-	2	-	-	-	28	-	-	-	-	-
Esox americanus	-	-	2	-	3	-	-	-	-	-	1
Esox niger	1	1	2	3	-	12	-	1	2	7	4
Esox species	1	-	2	-	-	-	-	-	-	-	-
Etheostoma fusiforme	9	5	1	7	33	15	38	6	14	74	21
Etheostoma olmstedi	-	-	-	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	-	-	-	-	-	-	-
Lepomis macrochirus	-	-	-	-	-	-	-	-	-	-	-
Lepomis species	-	-	-	-	-	-	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	-	-	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	25	30	12	7	10	-	-	-	-	1	4

Site Code (Date) spans all site columns.

Species	Site Code (Date)									
	OOSLAKDW (06/02/93)	OOSLAKDW (07/23/93)	OOSLAKDW (09/24/93)	OOSLAKUP (06/23/99)	OOSLAKUP (10/15/99)	OOSOLMAR (06/07/99)	OOSOLMAR (09/13/99)	OOSWLAKE (08/26/98)	OPAPOOSE (06/23/99)	OPAPOOSE (09/22/99)
Acantharchus pomotis	-	1	2	4	1	4	1	-	-	-
Ameiurus natalis	-	-	1	1	1	-	1	1	-	2
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	-	-	-	-	-	-	-	-	-	-
Aphredoderus sayanus	-	-	1	5	7	1	1	4	-	13
Enneacanthus chaetodon	22	29	38	1	29	3	8	107	-	-
Enneacanthus gloriosus	3	1	5	10	4	6	2	37	-	-
Enneacanthus obesus	6	3	5	3	-	60	22	13	2	1
Enneacanthus species	-	1	11	-	-	-	1	3	-	-
Erimyzon oblongus	-	124	213	1	-	-	7	5	-	-
Esox americanus	-	-	-	-	-	-	-	-	-	-
Esox niger	4	14	6	6	7	2	4	2	2	-
Esox species	-	-	-	1	-	3	-	-	2	-
Etheostoma fusiforme	8	-	18	17	26	16	28	21	-	2
Etheostoma olmstedi	-	-	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	-	-	-	-	-	-
Lepomis macrochirus	-	-	-	-	-	-	-	-	-	-
Lepomis species	-	-	-	-	-	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	-	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	-	-	-	10	2	-	3	4	15	35

Appendix 5.3.1. Fish-monitoring sites (streams and impoundments) in the Lower Mullica River tributaries. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Sections were not assigned in impoundments. Refer to Methods for sampling details. 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
Elliots Creek at Bremen Avenue Egg Harbor City Twp., Atlantic Co. (lat 39°32'41.01", long 74°36'22.90", Green Bank quad). Section 1 ends 21 m downstream from Bremen Avenue; section 2 begins 15 m upstream from Bremen Avenue.	LELIOBRE
Hammonton Creek above Chestnut Avenue Mullica Twp., Atlantic Co. (lat 39°38'02.07", long 74°43'03.70", Atsion quad). Section 1 begins 40 m upstream from Chestnut Avenue.	LHACHEST
Hammonton Lake Hammonton Twp., Atlantic Co. (lat 39°37'38.84", long 74°47'20.61", Hammonton quad). Impoundment on Hammonton Creek, upstream from White Horse Pike (Route 30)	LHAMLAKE
Indian Cabin Creek above Landing Creek Egg Harbor City Twp., Atlantic Co. (lat 39°33'26.19", long 74°36'09.04", Green Bank quad). Section 1 begins 18 m from confluence with Landing Creek.	LINCABIN
Egg Harbor City Lake below Route 563 Egg Harbor City Twp., Atlantic Co. (lat 39°33'37.58", long 74°36'36.88", Green Bank quad). Impoundment on Indian Cabin Creek, downstream from Egg Harbor-Green Bank Road (Route 563)	LINLAKED
Landing Creek above Indian Cabin Road Egg Harbor City Twp., Atlantic Co. (lat 39°33'24.32", long 74°36'10.22", Green Bank quad). Section 1 begins 14 m upstream from Indian Cabin Road.	LLANDIND
Landing Creek below Alternate Route 561 Egg Harbor City Twp., Atlantic Co. (lat 39°32'45.66", long 74°37'51.25", Egg Harbor City quad). Section 4 ends 35 m downstream from Moss Mill Road (Alternate Route 561).	LLANDMOS
Morses Mill Stream below College Drive Galloway Twp., Atlantic Co. (lat 39°29'44.82", long 74°31'40.83", Pleasantville quad). Section 4 ends 100 m downstream from College Drive.	LMORSESM
Lake Fred Galloway Twp., Atlantic Co. (lat 39°29'46.41", long 74°31'43.47", Green Bank quad). Impoundment on Morses Mill Stream, upstream from College Drive	LMOSTOCK
Union Creek above Alternate Route 561 Egg Harbor City Twp., Atlantic Co. (lat 39°32'39.77", long 74°37'38.68", Egg Harbor City quad). Section 1 begins 24 m upstream from Moss Mill Road (Alternate Route 561).	LUNIOMOS

Appendix 5.3.2. Total number collected for each fish species at monitoring sites in the Lower Mullica River drainage basin. A dash (-) indicates that a species was not collected at a site. Refer to the Methods section for survey methodology. Refer to Appendix 5.3.1 for detailed site information, Appendix 5.0 for individuals that participated in sampling, and Appendix 5.8 for common names for each species.

Species	LELIOBRE (07/08/99)	LELIOBRE (09/23/99)	LHACHEST (08/05/98)	LHACHEST (10/15/98)	LHAMLAKE (09/02/98)	LINCABIN (06/18/99)	LINCABIN (09/23/99)	LINLAKED (09/08/99)	LLANDIND (07/28/99)	LLANDIND (09/10/99)	LLANDMOS (07/14/99)	LLANDMOS (10/08/99)	LMORSESM (06/18/99)	LMORSESM (09/10/99)	LMOSTOCK (09/08/99)	LUNIOMOS (07/14/99)	LUNIOMOS (10/08/99)
Acantharchus pomotis	1	1	-	-	-	-	-	1	1	-	8	4	-	3	-	-	-
Ameiurus natalis		-	2	1	-	2	-	-	-	-	-	-	15	7	1	-	-
Ameiurus nebulosus	-	-	2	2	-	-	-	-	-	-	-	-	-	-	1	-	-
Anguilla rostrata	2	-	-	1	-	2	-	-	19	5	18	11	2	1	-	2	1
Aphredoderus sayanus	5	2	22	1	-	-	-	-	-	-	11	9	-	-	-	9	10
Enneacanthus chaetodon	-	3	-	-	-	13	1	177	13	3	5	-	3	1	92	4	1
Enneacanthus gloriosus	-	-	-	1	-	3	1	2	-	-	-	-	-	-	-	-	-
Enneacanthus obesus	-	1	-	3	-	-	-	22	-	1	-	-	-	-	50	-	-
Enneacanthus species	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Erimyzon oblongus	-	-	11	6	-	2	-	245	3	-	1	-	1	2	-	27	1
Esox americanus	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Esox niger	1	4	6	9	2	-	1	12	4	1	4	6	-	2	11	27	8
Esox species	1	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Etheostoma fusiforme	10	8	11	20	7	41	8	37	25	19	4	29	2	3	23	14	29
Etheostoma olmstedi	4	-	-	-	-	15	-	-	10	3	2	2	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	1	2	1	-	-	-	-	-	-	-	2	5	66	-	-
Lepomis macrochirus	-	-	-	1	83	-	-	-	-	-	-	-	-	2	8	-	-
Lepomis species	-	-	-	-	60	-	-	-	-	-	-	-	-	-	9	-	-
Micropterus salmoides	-	-	-	-	4	-	-	-	-	-	-	-	5	5	18	-	-
Notemigonus crysoleucas	-	-	-	7	15	-	-	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	2	5	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	7	16	54	30	-	1	-	-	-	1	8	23	-	-	-	31	5

Appendix 5.4.1. Fish-monitoring sites (streams and impoundments) in the Nescochague Creek drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Sections were not assigned in impoundments. Refer to Methods for sampling details. 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
Albertson Brook above Fleming Pike Waterford Twp., Camden Co. (lat 39°41'35.12", long 74°48'22.58", Hammonton quad). Section 1 begins 30 m upstream from Fleming Pike.	NALBFLEM
Albertson Brook above derelict bridge below Route 206 Hammonton Twp., Atlantic Co. (lat 39°41'40.59", long 74°44'38.23", Atsion quad). Section 1 begins 10 m upstream from derelict bridge, downstream from Route 206.	NALDEREL
Albertson Brook impoundment below Route 206 (Paradise Lakes) Hammonton Twp., Atlantic Co. (lat 39°41'22.44", long 74°43'46.64", Atsion quad). Impoundment on Albertson Brook, downstream from Route 206	NALPARAD
Blue Anchor Brook impoundment above Spring Garden-Winslow Road Winslow Twp., Camden Co. (lat 39°41'16.70", long 74°50'58.08", Hammonton quad). Impoundment upstream from Spring Garden-Winslow Road	NBLSPRNG
Cedar Brook near Hammonton Airport Hammonton Twp., Atlantic Co. (lat 39°40'09.64", long 74°45'42.61", Hammonton quad). Section 1 ends 85 m downstream from bridge near Wharton State Forest boundary.	NCEAIRPO
Great Swamp Branch impoundment above Route 30 Winslow Twp., Camden Co. (lat 39°40'15.59", long 74°49'32.78", Hammonton quad). Second and third impoundments upstream from White Horse Pike (Route 30)	NGREAR30
Great Swamp Branch below Route 613 Hammonton Twp., Atlantic Co. (lat 39°41'03.76", long 74°45'45.93", Hammonton quad). Section 4 ends 9 m downstream from Middle Road (Route 613).	NGRMIDDL
Nescochague Creek at Pleasant Mills Mullica Twp., Atlantic Co. (lat 39°38'37.35", long 74°39'46.31", Atsion quad). Section 1 begins approximately 0.5 km upstream from sand road bridge near church at Pleasant Mills.	NNEMILLS
Nescochague Creek near West Mill Road Washington Twp., Burlington Co. (lat 39°39'49.35", long 74°41'51.93", Atsion quad). Section 1 begins near West Mill Road, midway between Pleasant Mills and the confluence of Great Swamp Branch and Albertson Brook.	NNEWESTM
Pump Branch impoundment at Ha-Lu-Wa-Sa Winslow Twp., Camden Co. (lat 39°42'10.49", long 74°51'31.90", Hammonton quad). Middle impoundment between White Horse Pike (Route 30) and Waterford Road	NPUHALUW
Pump Branch impoundment near Cedar Avenue Winslow Twp., Camden Co. (lat 39°41'50.31", long 74°49'43.48", Hammonton quad). Upper and lower impoundment near Cedar Avenue, east of White Horse Pike (Route 30)	NPUIMPNT
Pump Branch above dike at Winslow/Waterford boundary Winslow Twp., Camden Co. (lat 39°41'38.64", long 74°49'15.68", Hammonton quad). Section 1 begins 15 m upstream from breached dike near Winslow Township/Waterford Township boundary.	NPUMDIKE

Appendix 5.4.2. Total number collected for each fish species at monitoring sites in the Nescochague Creek drainage basin. A dash (-) indicates that a species was not collected at a site. Refer to the Methods section for survey methodology. Refer to Appendix 5.4.1 for detailed site information, Appendix 5.0 for individuals that participated in sampling, and Appendix 5.8 for common names for each species.

	Site Code (Date)												
Species	NALBFLEM (08/28/95)	NALBFLEM (06/24/96)	NALBFLEM (08/12/96)	NALDEREL (07/02/92)	NALDEREL (07/17/92)	NALDEREL (05/17/93)	NALDEREL (08/28/95)	NALPARAD (08/25/99)	NBLSPRNG (08/19/98)	NCEAIRPO (08/05/98)	NGREAR30 (08/04/99)	NGRMIDDL (09/24/94)	NGRMIDDL (08/18/95)
Acantharchus pomotis	-	-	-	-	2	1	-	-	-	2	-	-	2
Ameiurus natalis	-	-	-	-	-	1	-	-	-	-	-	-	-
Ameiurus nebulosus	-	1	-	-	-	1	-	-	1	5	9	-	1
Anguilla rostrata	-	1	3	3	1	5	1	-	1	-	-	4	-
Aphredoderus sayanus	-	1	2	1	-	-	1	-	-	62	-	7	2
Enneacanthus chaetodon	-	-	-	-	-	1	-	25	-	-	-	3	-
Enneacanthus gloriosus	2	2	4	-	-	-	-	5	-	-	1	7	1
Enneacanthus obesus	-	-	-	-	-	-	-	14	-	5	11	6	5
Enneacanthus species	1	2	1	-	-	-	-	-	-	-	3	6	5
Erimyzon oblongus	-	-	8	2	27	-	41	47	-	4	-	10	3
Esox americanus	-	-	-	2	-	-	-	-	-	12	-	-	-
Esox niger	2	6	3	-	7	1	2	3	15	22	1	2	4
Esox species	-	-	-	-	-	2	-	-	-	-	-	-	-
Etheostoma fusiforme	4	2	2	1	-	1	7	4	-	6	-	3	3
Etheostoma olmstedi	-	2	-	-	1	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	-	-	-	-	1	-	3	-	-
Lepomis macrochirus	4	2	-	-	1	-	1	-	26	2	10	-	-
Lepomis species	-	-	-	-	-	-	-	-	17	-	225	-	-
Micropterus salmoides	-	-	-	-	-	-	1	3	-	1	4	1	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	15	1	-	-	-
Noturus gyrinus	24	-	-	2	3	-	5	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	3	-	2	-	-
Umbra pygmaea	2	-	-	-	-	-	-	-	-	40	4	6	6

Species	Site Code (Date)												
	NGRMIDDL (10/27/95)	NGRMIDDL (06/24/96)	NNEMILLS (08/27/92)	NNEMILLS (09/17/92)	NNEMILLS (05/17/93)	NNEMILLS (08/28/95)	NNEWESTM (07/26/99)	NNEWESTM (10/18/99)	NPUHALUW (07/28/99)	NPUIMPNT (08/07/97)	NPUMDIKE (08/18/95)	NPUMDIKE (10/27/95)	NPUMDIKE (06/24/96)
Acantharchus pomotis	-	-	2	-	1	-	-	-	-	-	-	-	-
Ameiurus natalis	-	-	-	-	-	-	1	-	-	-	1	5	-
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	1	-	19	14	6	4	18	6	-	-	-	1	4
Aphredoderus sayanus	4	2	-	-	-	-	1	-	-	-	-	-	-
Enneacanthus chaetodon	4	-	-	-	-	2	2	2	-	-	2	-	-
Enneacanthus gloriosus	2	3	-	-	-	-	10	2	41	36	1	9	4
Enneacanthus obesus	5	2	7	8	5	-	1	1	-	-	-	-	1
Enneacanthus species	3	-	-	-	1	-	-	-	2	-	1	3	1
Erimyzon oblongus	-	-	-	3	-	1	4	-	-	1	-	3	1
Esox americanus	-	-	-	-	-	-	-	-	-	-	-	-	-
Esox niger	3	9	2	-	4	-	6	1	-	3	1	-	1
Esox species	-	-	-	-	2	-	-	-	-	-	-	-	-
Etheostoma fusiforme	-	-	1	1	-	-	6	6	-	-	-	1	-
Etheostoma olmstedi	-	-	1	2	6	14	32	5	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	1	1	-	-	-	-	-	-	3	1	-	-	-
Lepomis macrochirus	4	1	-	-	-	-	-	-	85	2	3	3	2
Lepomis species	-	-	-	-	-	-	-	-	8	-	-	-	-
Micropterus salmoides	-	-	-	-	-	-	1	-	19	8	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	10	-	-	1	1	-	-
Noturus gyrinus	1	-	-	-	-	-	1	-	-	-	11	8	1
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	1	3	-	1	1	-	-	-	-	-	-	-	-

Appendix 5.5.1. Fish-monitoring sites (streams and impoundments) in the Sleeper Branch drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Sections were not assigned in impoundments. Refer to Methods for sampling details. 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
Clark Branch at Parkdale Waterford Twp., Camden Co. (lat 39°43'00.60", long 74°45'18.56", Hammonton quad). Section 4 ends 8 m downstream from Johnson Road, at Parkdale.	MCLJOHNS
Cooper Branch impoundment near Tremont Avenue and Burnt Mill Road Waterford Twp., Camden Co. (lat 39°44'45.00", long 74°50'24.99", Hammonton quad). Impoundment upstream from first dike above Burnt Mill Road	MCOIMPNT
Atco Lake Waterford Twp., Camden Co. (lat 39°45'24.16", long 74°53'01.54", Clementon quad). Impoundment on Hays Mill Creek, upstream from White Horse Pike (Route 30)	MHAATCOL
Hays Mill Creek above Tremont Avenue Waterford Twp., Camden Co. (lat 39°45'02.70", long 74°50'27.27", Medford Lakes quad). Section 1 begins 5 m upstream from Tremont Avenue.	MHATREMO
Sleeper Branch bogs at Route 206 Hammonton Twp., Atlantic Co. (lat 39°43'08.01", long 74°44'19.23", Atsion quad). Northernmost impoundment, upstream from Route 206	MSL206BG
Sleeper Branch at Parkdale Waterford Twp., Camden Co. (lat 39°43'10.05", long 74°45'02.71", Hammonton quad). Section 3 begins at breached dike near Parkdale, upstream from Camden County/Atlantic County boundary.	MSLEPARK
Sleeper Branch above Mullica River Mullica Twp., Atlantic Co. (lat 39°38'48.59", long 74°39'38.86", Atsion quad). Section 1 begins at small footbridge, upstream from confluence with Mullica River.	MSLPLEAS

Appendix 5.5.2. Total number collected for each fish species at monitoring sites in the Sleeper Branch drainage basin. A dash (-) indicates that a species was not colleccted at a site. Refer to the Methods section for survey methodology. Refer to Appendix 5.5.1 for detailed site information, Appendix 5.0 for individuals that participated in sampling, and Appendix 5.8 for common names for each species.

	Site Code (Date)																	
Species	MCLJOHNS (07/16/92)	MCLJOHNS (08/14/92)	MCLJOHNS (05/14/93)	MCLJOHNS (07/31/96)	MCOIMPNT (07/22/98)	MHAATCOL (08/04/99)	MHATREMO (07/25/96)	MHATREMO (08/30/96)	MHATREMO (09/29/96)	MSL206BG (08/05/98)	MSLEPARK (07/16/92)	MSLEPARK (08/14/92)	MSLEPARK (05/14/93)	MSLEPARK (07/31/96)	MSLPLEAS (08/27/92)	MSLPLEAS (09/17/92)	MSLPLEAS (05/17/93)	MSLPLEAS (08/12/96)
Acantharchus pomotis	2	1	1	1	-	-	2	-	-	-	2	2	-	2	-	2	5	3
Ameiurus natalis	1	3	-	2	1	-	-	-	-	-	-	1	-	1	8	6	10	6
Ameiurus nebulosus	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	-	-	-	1	-	-	1	-	-	-	-	1	1	2	-	1	4	-
Aphredoderus sayanus	-	3	-	-	1	-	2	3	11	1	1	-	-	2	4	2	8	4
Enneacanthus chaetodon	5	11	4	4	30	16	-	-	-	76	6	5	8	7	11	9	5	4
Enneacanthus gloriosus	-	-	-	-	-	48	-	-	-	-	-	-	-	-	-	-	-	-
Enneacanthus obesus	-	12	1	1	27	2	-	-	-	29	11	2	1	-	4	6	29	10
Enneacanthus species	-	2	-	1	2	-	-	-	-	3	1	-	-	-	1	-	-	-
Erimyzon oblongus	16	1	-	-	6	-	-	-	1	-	24	-	2	12	-	-	-	-
Esox americanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Esox niger	19	3	4	2	6	1	-	4	2	7	12	3	2	4	1	-	4	1
Esox species	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	1	-
Etheostoma fusiforme	2	6	8	10	17	5	6	12	20	1	1	1	1	3	11	7	10	13
Etheostoma olmstedi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	-	39	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis macrochirus	-	-	-	-	1	6	-	-	-	-	-	-	1	-	-	-	-	-
Lepomis species	-	-	-	-	14	7	-	1	-	-	-	-	-	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	29	-	-	-	-	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	2	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	-	-	-	8	1	-	10	20	16	3	2	-	-	-	2	-	3	1

Appendix 5.6.1. Fish-monitoring sites (streams and impoundments) in the Upper Mullica River drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Sections were not assigned in impoundments. Refer to Methods for sampling details. Latitude, longitude, and USGS 7.5 minute topographic quadrangle names are given in parentheses. Sites are ordered alphabetically by site code.

Site Name and Location	Site Code
Atsion Lake Waterford Twp., Camden Co. (lat 39°44'25.97", long 74°43'35.66", Atsion quad). Impoundment upstream from Route 206	MMUATSIO
Mullica River below Constable Bridge Mullica/Washington Twp., Atlantic/Burlington Co. (lat 39°39'33.19", long 74°39'30.84", Atsion quad). Section 4 ends 175 m downstream from Constable Bridge.	MMUCONST
Mullica River above dike below Old Jackson-Atsion Road Waterford/Shamong Twp., Camden/Burlington Co. (lat 39°45'28.14", long 74°46'39.88", Medford Lakes quad). Section 1 begins 65 m upstream from breached dike, downstream from Old Jackson-Atsion Road.	MMUDIKES
Goshen Pond Waterford/Shamong Twp., Camden/Burlington Co. (lat 39°44'39.58", long 74°45'38.03", Hammonton quad). Impoundment on Mullica River at Goshen Pond campground	MMUGOSHN
Mullica River impoundment above Jackson-Medford Road (Lady's Lake) Waterford/Medford Twp., Camden/Burlington Co. (lat 39°47'03.61", long 74°51'38.74", Medford Lakes quad). Impoundment on Mullica River, upstream from Jackson-Medford Road	MMULADYL
Mullica River below Jackson-Medford Road Waterford/Medford Twp., Camden/Burlington Co. (lat 39°47'09.39", long 74°51'36.53", Medford Lakes quad). Section 4 ends 12 m downstream from Jackson-Medford Road.	MMULADYS
Mullica River above Route 534 Waterford/Shamong Twp., Camden/Burlington Co. (lat 39°46'40.92", long 74°47'58.97", Medford Lakes quad). Section 1 begins 40 m upstream from Jackson Road (Route 534).	MMULJACK
Mullica River above Central New Jersey/Conrail railroad bridge Shamong Twp., Burlington Co. (lat 39°44'19.35", long 74°43'18.75", Atsion quad). Section 1 begins 21 m upstream from railroad bridge.	MMURRBRG
Mullica River at northern border of Wilderness Area Washington Twp., Burlington Co. (lat 39°42'03.28", long 74°40'48.11", Atsion quad). Section 1 begins near northern boundary of Mullica River Wilderness Area.	MMUWILDR
Wesickaman Creek below Three Bridge Road Shamong Twp., Burlington Co. (lat 39°46'14.00", long 74°44'59.22", Indian Mills quad). Section 4 ends 10 m downstream from Three Bridge Road.	MWETHREE

Appendix 5.6.2. Total number collected for each fish species at monitoring sites in the Upper Mullica River drainage basin. A dash (-) indicates that a species was not collected at a site. Refer to the Methods section for survey methodology. Refer to Appendix 5.6.1 for detailed site information, Appendix 5.0 for individuals that participated in sampling, and Appendix 5.8 for common names for each species.

	Site Code (Date)											
Species	MMUATSIO (08/25/99)	MMUCONST (08/27/92)	MMUCONST (09/17/92)	MMUCONST (05/17/93)	MMUCONST (08/12/96)	MMUDIKES (07/22/98)	MMUDIKES (10/07/98)	MMUGOSHN (07/14/97)	MMULADYL (07/22/98)	MMULADYS (07/25/96)	MMULADYS (08/30/96)	MMULADYS (09/26/96)
Acantharchus pomotis	-	-	-	1	1	1	2	2	-	-	2	2
Ameiurus natalis	-	2	1	-	4	-	-	1	-	7	1	4
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	-	4	4	10	1	2	1	1	-	1	-	-
Aphredoderus sayanus	3	-	1	-	1	5	10	13	-	-	-	-
Enneacanthus chaetodon	73	-	1	-	-	3	2	7	29	6	3	6
Enneacanthus gloriosus	2	-	-	-	-	-	-	18	1	-	-	-
Enneacanthus obesus	2	17	17	15	-	3	3	1	12	-	-	1
Enneacanthus species	1	-	-	-	-	-	-	-	-	-	-	-
Erimyzon oblongus	249	-	4	1	-	-	-	-	8	-	-	-
Esox americanus	-	-	-	-	-	-	2	-	-	1	-	-
Esox niger	5	2	2	1	2	2	3	8	4	-	2	3
Esox species	-	-	-	2	-	-	-	-	-	-	-	-
Etheostoma fusiforme	6	3	10	7	4	9	1	3	9	15	11	17
Etheostoma olmstedi	-	1	-	-	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	55	-	-	-	-	-	-	-	1	2	1	3
Lepomis macrochirus	-	-	-	-	-	-	-	-	11	7	2	6
Lepomis species	57	-	-	-	-	-	-	-	9	-	-	2
Micropterus salmoides	-	-	-	-	-	-	-	-	5	-	1	1
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	5	-	3	1
Noturus gyrinus	-	-	-	-	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	1	-	-	-
Umbra pygmaea	-	-	1	-	1	55	55	2	-	8	8	3

Species	Site Code (Date)										
	MMULJACK (07/16/92)	MMULJACK (08/14/92)	MMULJACK (05/14/93)	MMULJACK (06/24/96)	MMURRBRG (07/26/99)	MMURRBRG (09/23/99)	MMUWILDR (08/07/97)	MMUWILDR (10/27/97)	MWETHREE (07/25/96)	MWETHREE (08/30/96)	MWETHREE (09/26/96)
Acantharchus pomotis	2	-	-	1	2	-	2	1	1	4	6
Ameiurus natalis	-	-	-	-	4	-	-	1	-	7	4
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	-	-	1	-	3	-	3	3	1	1	-
Aphredoderus sayanus	1	3	1	-	-	-	1	-	-	-	-
Enneacanthus chaetodon	-	-	-	2	31	8	1	-	-	-	-
Enneacanthus gloriosus	-	-	-	-	1	-	-	-	-	-	-
Enneacanthus obesus	1	1	-	-	-	1	-	4	-	1	1
Enneacanthus species	-	-	-	-	-	-	-	-	-	-	-
Erimyzon oblongus	-	-	-	-	16	-	-	1	-	1	4
Esox americanus	-	1	-	-	-	-	-	-	8	7	14
Esox niger	8	1	2	3	1	-	1	-	-	-	-
Esox species	-	-	-	1	-	-	-	-	-	-	-
Etheostoma fusiforme	10	10	3	7	10	22	2	4	-	2	-
Etheostoma olmstedi	-	-	-	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	2	-	-	-	-	-	-
Lepomis macrochirus	-	-	-	-	-	-	-	-	-	-	-
Lepomis species	-	-	-	-	11	2	-	-	-	1	-
Micropterus salmoides	-	-	-	-	-	-	-	-	-	1	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	-	-	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	2	5	1	7	-	-	3	-	18	15	22

Appendix 5.7.1. Fish-monitoring sites (streams and impoundments) in the Batsto River drainage basin. Stream sections 1 through 4 (25 m each) were established while facing and moving upstream. Sections were not assigned in impoundments. Refer to Methods for sampling details. 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
Batsto River above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°48'02.61", long 74°40'20.65", Indian Mills quad). Section 1 begins 25 m upstream from Carranza Road.	BBACARRZ
Batsto River at Lower Forge Washington Twp., Burlington Co. (lat 39°43'28.64", long 74°40'29.32", Atsion quad). Section 1 begins 50 m upstream from derelict bridge, at Lower Forge.	BBALFORG
Batsto River below Penn Swamp Branch Washington Twp., Burlington Co. (lat 39°40'27.81", long 74°39'14.95", Atsion quad). Section 1 begins approximately 0.8 km downstream from confluence with Penn Swamp Branch. *Latitude and longitude values were obtained using ArcView Software.	BBAPENNS
Batsto River side channel below Quaker Bridge Road Washington Twp., Burlington Co. (lat 39°42'34.77", long 74°39'58.83", Atsion quad). Section 4 ends 30 m downstream from Quaker Bridge Road, in Batsto River side channel below Quaker Bridge.	BBAQUAKR
Batsto River below Central New Jersey/Conrail railroad bridge Shamong Twp., Burlington Co. (lat 39°45'18.60", long 74°40'44.71", Indian Mills quad). Section 4 ends 5 m downstream from railroad bridge.	BBARRBRG
Batsto River below Route 532 Tabernacle Twp., Burlington Co. (lat 39°50'16.24", long 74°39'47.90", Indian Mills quad). Section 4 ends 85 m downstream from Tabernacle-Chatsworth Road (Route 532).	BBART532
Batsto River above Hampton Road Shamong Twp., Burlington Co. (lat 39°46'15.58", long 74°40'47.53", Indian Mills quad). Section 1 begins 20 m upstream from Hampton Road.	BBATHAMP
Batsto Lake Washington Twp., Burlington Co. (lat 39°39'12.21", long 74°39'14.65", Atsion quad). Impoundment upstream from Pleasant Mills Road (Route 542)	BBATLAKE
Batsto River tributary above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°47'26.19", long 74°39'44.06", Indian Mills quad). Section 1 begins 10 m upstream from Carranza Road, in abandoned cranberry bog near Glossy Spung Road.	BBATRCAR
Batsto River tributary below Hay Road Shamong Twp., Burlington Co. (lat 39°44'19.52", long 74°40'34.11", Atsion quad). Section 1 ends 8 m downstream from Hay Road, on unnamed tributary downstream from Mannis Duck Pond (75-m site).	BBATRMAN
Batsto River headwater impoundment below Route 532 Tabernacle Twp., Burlington Co. (lat 39°49'56.95", long 74°39'21.56", Indian Mills quad). Impoundment upstream from second dike (sand road) below Tabernacle-Chatsworth Road (Route 532), on eastern tributary of Batsto River	BBATS532
Deep Run below Hampton Road Shamong Twp., Burlington Co. (lat 39°45'36.62", long 74°41'27.05", Indian Mills quad). Section 1 begins at first breached dike downstream from Hampton Road.	BDEEPDKE
Deep Run impoundment below Hampton Road Shamong Twp., Burlington Co. (lat 39°45'22.02", long 74°41'23.70", Indian Mills quad). Lowermost impoundment, downstream from Hampton Road	BDEEPIMP

Site Name and Description	Site Code
Horse Pond Stream below Butterworth’s Bogs Road Tabernacle Twp., Burlington Co. (lat 3949’42.28", long 7440’47.54", Indian Mills quad). Section 1 ends 15 m downstream from Butterworth’s Bogs Road (25-m site).	BHOBUTTR
Indian Mills Brook impoundment above Old Schoolhouse Road Shamong Twp., Burlington Co. (lat 39°48'00.68", long 74°45'36.39", Medford Lakes quad). Impoundment upstream from Old Schoolhouse Road	BINSCHOO
Indian Mills Brook above Oakshade Road (above Shadow Lake) Shamong Twp., Burlington Co. (lat 39°48'31.11", long 74°46'24.68", Medford Lakes quad). Section 1 begins at forest edge, upstream from inlet of Shadow Lake.	BINSHADS
Indian Mills Brook impoundment above Oakshade Road (Shadow Lake) Shamong Twp., Burlington Co. (lat 39°48'22.04", long 74°46'14.74", Medford Lakes quad). Impoundment on Indian Mills Brook, upstream from Oakshade Road (Route 534)	BINSHADW
Indian Mills Lake at dam Shamong Twp., Burlington Co. (lat 39°47'44.04", long 74°44'24.29", Indian Mills quad). Impoundment on Muskingum Brook, upstream from Indian Mills Road (Route 648)	BMULAKED
Muskingum Brook above Tuckerton Road Tabernacle Twp., Burlington Co. (lat 39°49'05.28", long 74°44'15.66", Indian Mills quad). Section 1 begins 16 m upstream from Tuckerton Road.	BMUSKTUC
Penn Swamp Branch above Batona Trail bridge Washington Twp., Burlington Co. (lat 39°41'03.08", long 74°39'01.26", Atsion quad). Section 1 begins 5 m upstream from bridge on unnamed sand road (Batona Trail).	BPEBRIDG
Skit Branch below Carranza Road Shamong Twp., Burlington Co. (lat 39°47'08.52", long 74°39'30.00", Indian Mills quad). Section 4 ends 55 m downstream from Carranza Road.	BSKITCAR
Skit Branch above Hampton Road Shamong Twp., Burlington Co. (lat 39°46'01.18", long 74°40'39.17", Indian Mills quad). Section 1 begins 32 m upstream from Hampton Road.	BSKITHAM
Skit Branch beaver pond above Batona Campground Tabernacle Twp., Burlington Co. (lat 39°46'55.72", long 74°37'38.15", Indian Mills quad). Impoundment adjacent to Batona Trail, upstream from Batona campground	BSKWIDEN
Springers Brook below Deep Run Shamong Twp., Burlington Co. (lat 39°44'26.67", long 74°41'03.01", Atsion quad). Section 1 begins near end of unnamed sand road, approximately 175 m downstream from confluence with Deep Run.	BSPRDIKE
Springers Brook above Hampton Road Shamong Twp., Burlington Co. (lat 39°45'19.53", long 74°41'46.10", Indian Mills quad). Section 1 begins 18 m upstream from Hampton Road.	BSPRIHAM
Roberts (Tom Roberts) Branch beaver pond above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°47'24.16", long 74°39'22.49", Indian Mills quad). Impoundment upstream from Carranza Road	BTOIMPCA
Roberts (Tom Roberts) Branch below Carranza Road Shamong Twp., Burlington Co. (lat 39°47'16.21", long 74°39'34.03", Indian Mills quad). Section 4 ends 35 m downstream from Carranza Road.	BTOMCARR

Appendix 5.7.2. Total number collected for each fish species at monitoring sites in the Batsto River drainage basin. A dash (-) indicates that a species was not collected at a site. Refer to the Methods section for survey methodology. Refer to Appendix 5.7.1 for detailed site information, Appendix 5.0 for individuals that participated in sampling, and Appendix 5.8 for common names for each species.

	Site Code (Date)													
Species	BBACARRZ (07/02/97)	BBACARRZ (10/02/97)	BBALFORG (06/26/97)	BBALFORG (10/02/97)	BBAPENNS (08/07/97)	BBAPENNS (10/02/97)	BBAQUAKR (09/17/92)	BBAQUAKR (10/15/92)	BBAQUAKR (05/17/93)	BBAQUAKR (10/08/97)	BBARRBRG (07/25/97)	BBARRBRG (10/02/97)	BBART532 (06/02/99)	BBART532 (09/28/99)
Acantharchus pomotis	-	-	1	2	1	2	-	3	2	3	2	6	3	3
Ameiurus natalis	-	-	1	1	2	-	2	1	5	-	2	3	-	-
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	-	1	3	4	-	1	2	4	-	2	2	-	-	-
Aphredoderus sayanus	4	13	14	30	29	26	8	12	1	14	12	13	-	-
Enneacanthus chaetodon	-	-	-	-	1	1	1	4	7	2	3	2	-	-
Enneacanthus gloriosus	1	-	6	4	4	1	8	10	1	12	5	2	-	-
Enneacanthus obesus	10	4	-	2	11	6	-	-	1	-	3	7	140	92
Enneacanthus species	-	-	-	-	-	-	-	4	8	-	-	-	-	-
Erimyzon oblongus	-	-	-	2	-	1	3	3	-	-	-	-	-	-
Esox americanus	-	-	-	-	-	-	-	-	-	-	-	-	5	6
Esox niger	5	3	6	2	2	2	3	8	2	5	4	3	1	6
Esox species	1	-	7	-	-	-	-	-	2	-	-	-	6	-
Etheostoma fusiforme	19	15	7	9	12	22	12	23	42	11	5	15	-	-
Etheostoma olmstedi	-	-	-	-	-	-	-	10	2	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis macrochirus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis species	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	-	2	3	1	-	5	5	10	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	9	3	15	24	28	18	7	5	-	54	5	6	91	80

Species	BBATHAMP (06/18/92)	BBATHAMP (07/17/92)	BBATHAMP (05/14/93)	BBATHAMP (10/27/97)	BBATLAKE (06/26/97)	BBATLAKE (09/02/98)	BBATRCAR (06/12/97)	BBATRCAR (10/21/97)	BBATRMAN (08/28/97)	BBATRMAN (10/29/97)	BBATS532 (07/14/97)	BBATS532 (09/08/97)	BDEEPDKE (06/06/97)	BDEEPDKE (09/08/97)	BDEEPDKE (10/08/97)	BDEEPIMP (06/19/97)	BDEEPIMP (09/08/97)
	Site Code (Date)																
Acantharchus pomotis	2	2	4	-	-	1	-	-	-	-	4	1	-	-	-	-	-
Ameiurus natalis	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	3	1	1	1	1	3	-	-	-	-	-	-	-	-	-	-	-
Aphredoderus sayanus	4	13	3	4	6	1	-	-	-	1	-	-	-	-	-	-	-
Enneacanthus chaetodon	-	-	-	-	4	26	-	-	-	-	-	-	-	-	-	-	-
Enneacanthus gloriosus	-	-	-	-	28	20	-	-	-	-	-	-	-	-	-	-	-
Enneacanthus obesus	-	4	6	14	1	15	7	1	3	-	50	86	183	100	101	175	268
Enneacanthus species	-	-	-	-	6	5	-	-	-	-	-	-	-	-	-	-	-
Erimyzon oblongus	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-
Esox americanus	-	-	-	-	-	-	1	-	-	1	19	2	2	3	2	3	2
Esox niger	2	3	1	-	7	9	-	-	3	1	-	-	-	-	-	-	-
Esox species	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-
Etheostoma fusiforme	3	1	10	11	2	5	-	-	20	5	-	-	-	-	-	-	-
Etheostoma olmstedi	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis macrochirus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	2	7	8	8	-	5	181	58	19	10	7	19	61	9	17	2	1

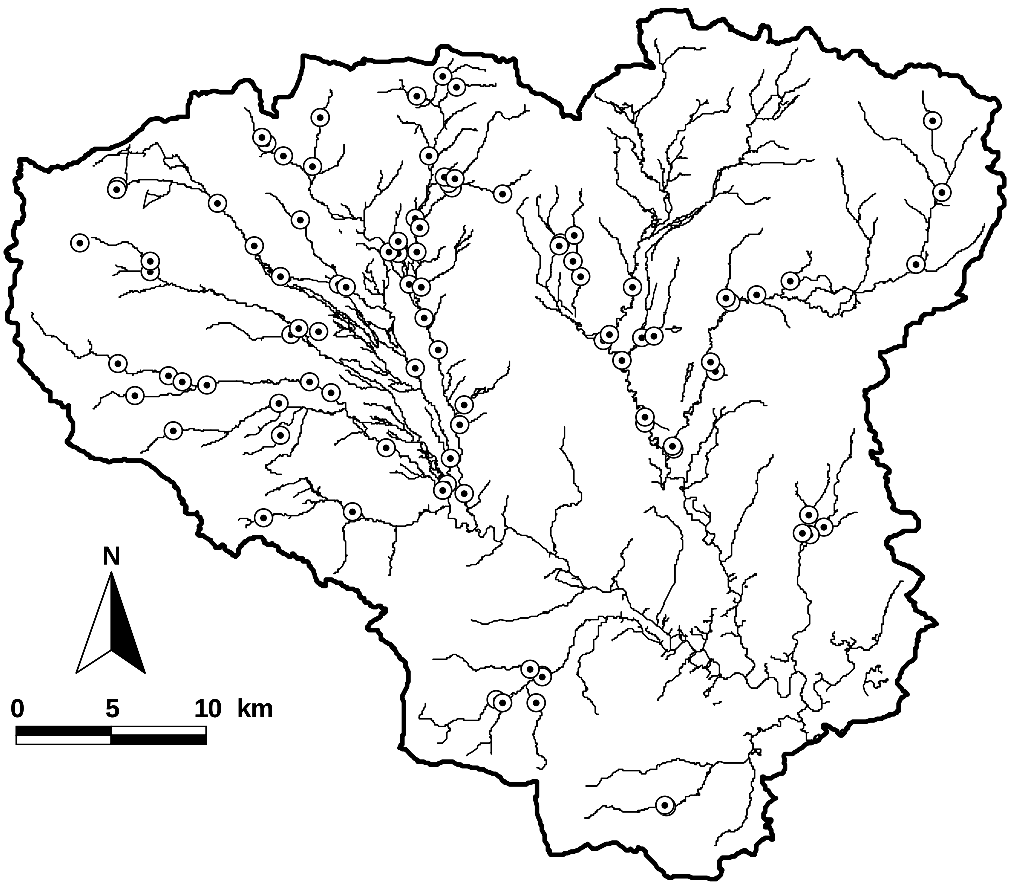
Species	Site Code (Date)														
	BHOBUTTR (07/02/97)	BHOBUTTR (10/27/97)	BINSCHOO (07/25/97)	BINSHADS (07/25/97)	BINSHADS (10/16/97)	BINSHADW (06/19/97)	BMULAKED (07/14/97)	BMUSKTUC (06/13/93)	BMUSKTUC (08/18/93)	BMUSKTUC (10/07/93)	BMUSKTUC (10/27/97)	BPEBRIDG (07/02/97)	BPEBRIDG (10/02/97)	BSKITCAR (06/06/97)	BSKITCAR (10/02/97)
Acantharchus pomotis	3	2	-	-	-	-	-	3	2	3	-	1	-	1	2
Ameiurus natalis	8	-	3	-	-	-	-	-	-	-	-	-	-	1	8
Ameiurus nebulosus	-	-	1	1	-	-	75	-	1	-	2	-	-	-	-
Anguilla rostrata	-	-	-	-	-	1	-	-	2	1	-	-	-	-	-
Aphredoderus sayanus	11	9	8	72	6	1	-	-	20	10	7	-	-	-	2
Enneacanthus chaetodon	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Enneacanthus gloriosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Enneacanthus obesus	19	35	20	5	7	2	-	6	10	19	7	4	6	2	3
Enneacanthus species	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Erimyzon oblongus	1	-	-	-	-	-	-	2	22	13	-	-	-	-	-
Esox americanus	17	4	-	-	-	-	-	-	-	-	-	2	2	-	-
Esox niger	-	-	2	38	19	4	1	-	-	1	4	5	2	1	-
Esox species	-	-	-	3	-	1	-	-	-	-	-	1	-	-	-
Etheostoma fusiforme	-	-	-	14	38	2	10	3	3	3	9	-	-	28	21
Etheostoma olmstedi	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	1	2	11	1	6	6	-	-	-	-	-
Lepomis macrochirus	-	-	5	-	-	8	17	-	2	3	-	-	-	-	-
Lepomis species	-	-	-	-	-	-	53	-	-	-	-	-	-	-	-
Micropterus salmoides	-	-	2	-	1	-	9	-	-	-	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	1	6	3	-	-	-	-	-
Noturus gyrinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	4	8	-	38	49	-	-	-	10	17	31	37	43	3	8

Species	Site Code (Date)															
	BSKITHAM (06/18/92)	BSKITHAM (07/17/92)	BSKITHAM (05/14/93)	BSKITHAM (10/08/97)	BSKWIDEN (10/15/98)	BSPRDIKE (06/06/97)	BSPRDIKE (10/16/97)	BSPRIHAM (06/18/92)	BSPRIHAM (07/16/92)	BSPRIHAM (05/14/93)	BSPRIHAM (10/16/97)	BTOIMPCA (06/19/97)	BTOIMPCA (09/08/97)	BTOMCARR (08/12/97)	BTOMCARR (09/23/97)	BTOMCARR (10/21/97)
Acantharchus pomotis	1	3	3	-	-	-	1	-	-	-	-	-	-	2	-	-
Ameiurus natalis	2	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Ameiurus nebulosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anguilla rostrata	2	-	-	-	-	1	3	1	2	1	4	-	-	-	-	-
Aphredoderus sayanus	1	2	1	1	2	6	4	-	-	-	1	-	13	-	-	-
Enneacanthus chaetodon	-	-	-	1	15	-	-	-	-	-	-	14	32	-	-	-
Enneacanthus gloriosus	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Enneacanthus obesus	2	3	2	16	58	9	-	-	2	10	-	45	44	-	1	-
Enneacanthus species	4	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Erimyzon oblongus	-	-	-	-	-	-	1	-	7	-	-	-	-	-	-	-
Esox americanus	-	-	3	-	-	6	-	-	-	1	-	-	-	-	-	-
Esox niger	-	1	1	2	2	7	3	-	2	4	-	5	2	-	-	-
Esox species	-	-	-	-	-	-	-	-	-	3	-	4	-	-	-	-
Etheostoma fusiforme	3	3	16	27	1	7	22	-	-	1	15	3	2	8	6	8
Etheostoma olmstedi	-	-	-	-	-	-	4	-	1	-	5	-	-	-	-	-
Fundulus diaphanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis gibbosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis macrochirus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepomis species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noturus gyrinus	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Perca flavescens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomoxis nigromaculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Umbra pygmaea	5	8	3	9	13	11	3	1	-	3	-	28	14	8	5	3

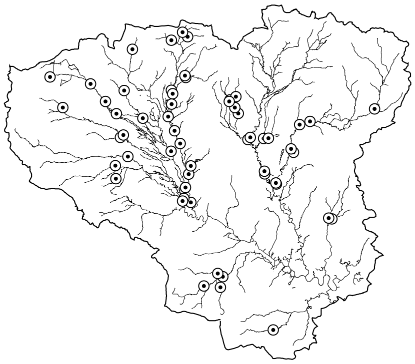
Appendix 5.8. Common and scientific names for 22 fish species collected in the Mullica River Basin. Nomenclature follows Fuller et al. (1999).

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 americanus	redfin pickerel
Esox niger	chain 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

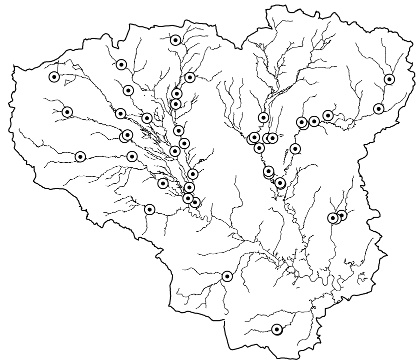
APPENDIX 5.9. FISH-DISTRIBUTION MAPS



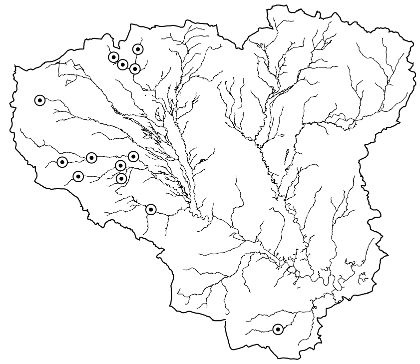
Location of 64 stream-fish and 30 impoundment-fish survey sites. Distribution maps on the following pages show where each fish species was present.



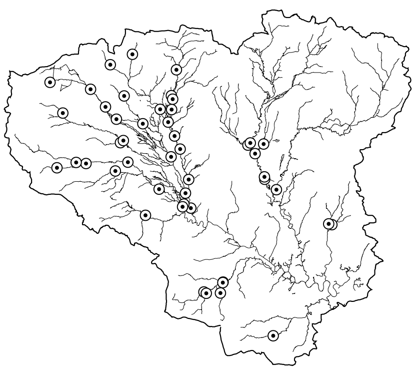
Acantharchus pomotis
mud sunfish



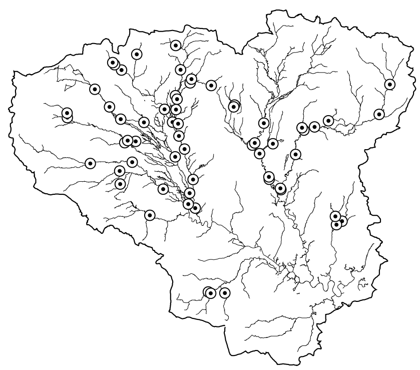
Ameiurus natalis
yellow bullhead



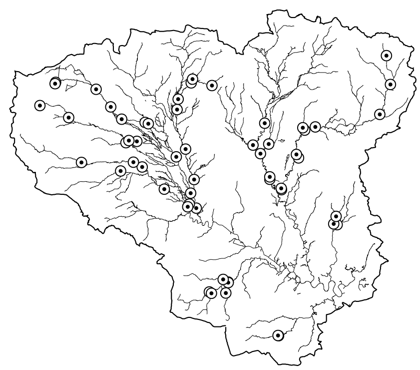
Ameiurus nebulosus
brown bullhead



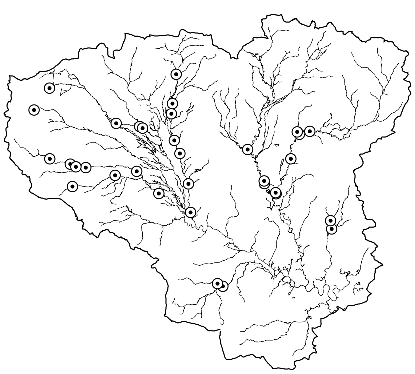
Anguilla rostrata
American eel



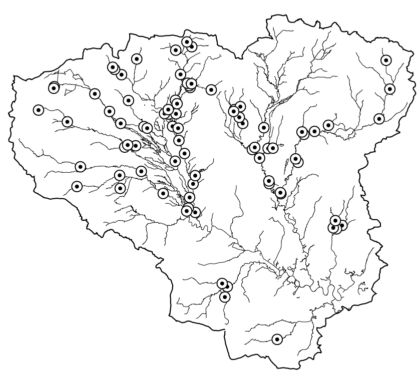
Aphredoderus sayanus
pirate perch



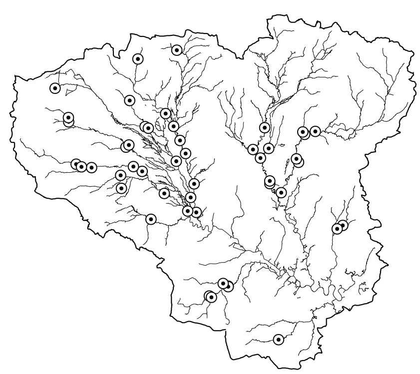
Enneacanthus chaetodon
blackbanded sunfish



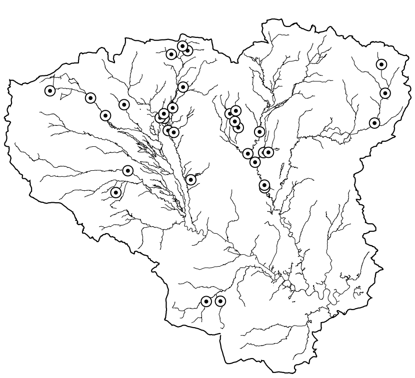
Enneacanthus gloriosus
bluespotted sunfish



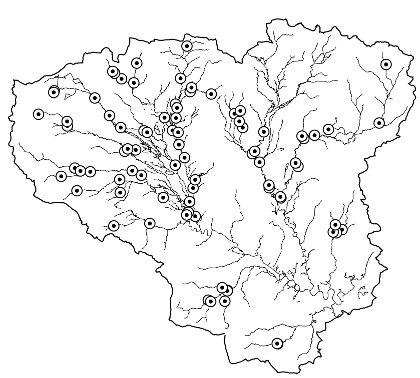
Enneacanthus obesus
banded sunfish



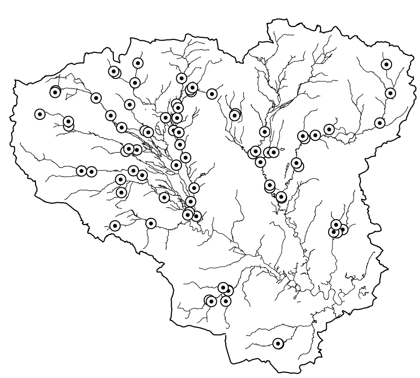
Erimyzon oblongus
creek chubsucker



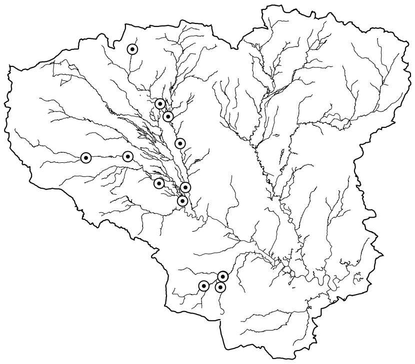
Esox americanus
redfin pickerel



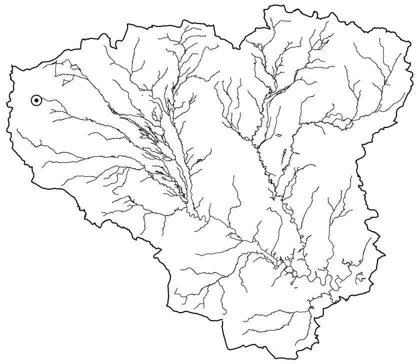
Esox niger
chain pickerel



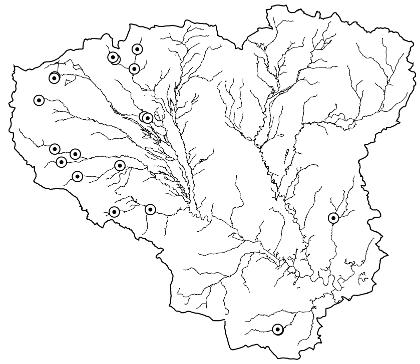
Etheostoma fusiforme
swamp darter



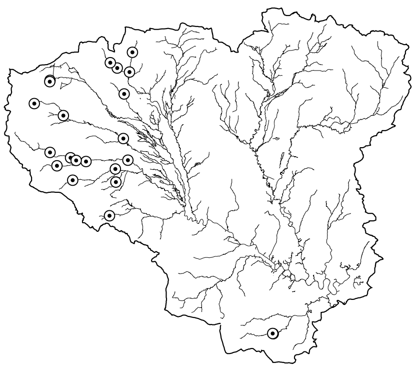
Etheostoma olmstedi
tessellated darter



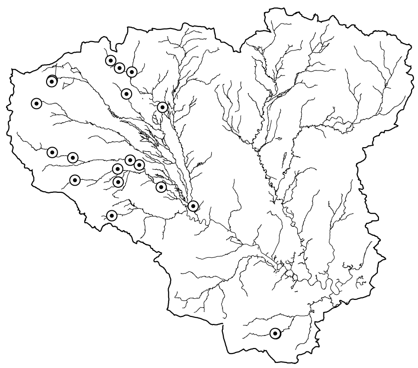
Fundulus diaphanus
banded killifish



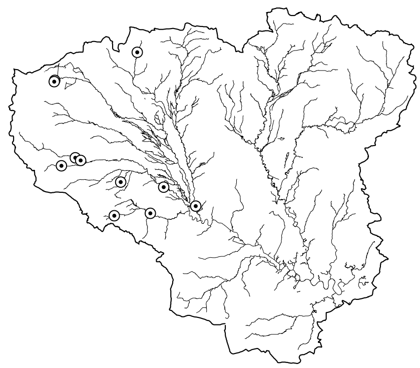
Lepomis gibbosus
pumpkinseed



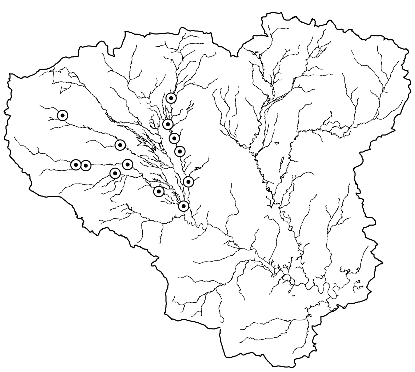
Lepomis macrochirus
bluegill



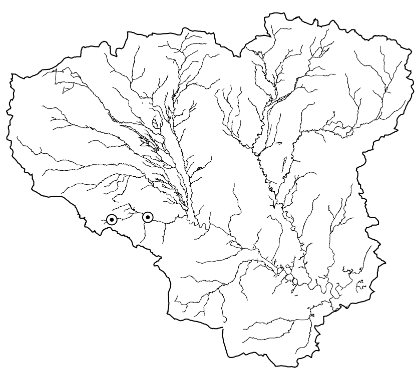
Micropterus salmoides
largemouth bass



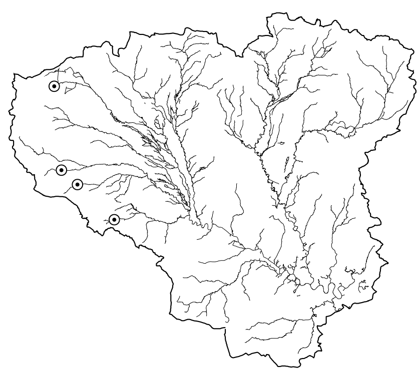
Notemigonus crysoleucas
golden shiner



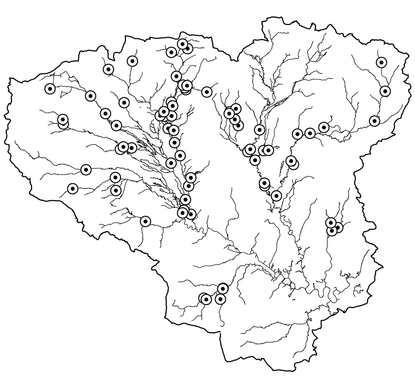
Noturus gyrinus
tadpole madtom



Perca flavescens
yellow perch



Pomoxis nigromaculatus
black crappie



Umbra pygmaea
eastern mudminnow

APPENDIX 6. ANURAN-ASSEMBLAGE DATA

Appendix 6.0.1. Anuran-vocalization monitoring sites in the Wading River drainage basin. Refer to Methods for survey details. 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, Location, and Listening Point	Site Code
Herbaceous pond at Route 679 Bass River Twp., Burlington Co. (lat 39°39'05.36", long 74°30'43.62", Jenkins quad). Southern side of intersection of Harrisville-Chatsworth Road (Route 679) and unnamed sand road, south of Beaver Run [Route 679].	WBE679HB
Square pond at Route 679 Bass River Twp., Burlington Co. (lat 39°39'05.88", long 74°30'43.41", Jenkins quad). Eastern corner of intersection of Harrisville-Chatsworth Road (Route 679) and unnamed sand road, south of Beaver Run [Route 679].	WBE679SQ
Biddle Branch impoundment above Route 72 Woodland Twp., Burlington Co. (lat 39°50'17.47", long 74°28'12.16", Woodmansie quad). Upstream from Barnegat Road (Route 72), west of Tabernacle-Chatsworth Road (Route 532) intersection [Route 72 at outlet].	WBIDDL72
Northern Bulls Branch borrow pit Washington Twp., Burlington Co. (lat 39°44'15.02", long 74°34'57.55", Jenkins quad). North of sand trail that leads west from East Sandy Ridge Road, just north of Bulls Branch [sand trail].	WBUBORON
Southern Bulls Branch borrow pit Washington Twp., Burlington Co. (lat 39°44'14.74", long 74°34'57.53", Jenkins quad). South of sand trail that leads west from East Sandy Ridge Road, just north of Bulls Branch [sand trail].	WBUBOROS
Bulls Branch dike pond Washington Twp., Burlington Co. (lat 39°44'19.63", long 74°34'47.81", Jenkins quad). Eastern side of sand trail/dike northeast of East Sandy Ridge Road [sand trail/dike].	WBUDIKEP
Bulls Branch bog upstream of first dike above East Sandy Ridge Road Washington Twp., Burlington Co. (lat 39°44'14.01", long 74°34'53.23", Jenkins quad). Impoundment upstream from first dike above from East Sandy Ridge Road [dike].	WBUHERBI
Bulls Branch impoundment (Otter Pond) Washington Twp., Burlington Co. (lat 39°44'39.05", long 74°34'49.95", Jenkins quad). Impoundment on Bulls Branch, upstream from fourth dike above East Sandy Ridge Road [dike/sand road].	WBUOTTER
Bulls Branch above East Sandy Ridge Road Washington Twp., Burlington Co. (lat 39°44'10.77", long 74°34'54.04", Jenkins quad). Upstream from East Sandy Ridge Road [East Sandy Ridge Road at culvert].	WBUSANDY
Featherbed Branch impoundment below Carranza Road Tabernacle Twp., Burlington Co. (lat 39°45'29.37", long 74°35'36.59", Chatsworth quad). Impoundment between Carranza Road and first downstream dike [sand road].	WFEIMPD1
Featherbed Branch above Carranza Road-first impoundment Tabernacle Twp., Burlington Co. (lat 39°45'40.75", long 74°35'38.37", Chatsworth quad). Impoundment upstream from first dike above Carranza Road [dike near outlet].	WFEIMPU1
Featherbed Branch above Carranza Road-second impoundment Tabernacle Twp., Burlington Co. (lat 39°45'53.83", long 74°35'48.39", Chatsworth quad). Impoundment downstream from third dike above Carranza Road [western side of dike].	WFEIMPU2
Featherbed Branch above Carranza Road-third impoundment Tabernacle Twp., Burlington Co. (lat 39°45'53.83", long 74°35'48.39", Chatsworth quad). Impoundment upstream from third dike above Carranza Road [western side of dike].	WFEIMPU3
Featherbed Branch above Carranza Road-second and third impoundments Tabernacle Twp., Burlington Co. (lat 39°45'53.83", long 74°35'48.39", Chatsworth quad). Impoundments upstream and downstream from third dike above Carranza Road [western side of dike].	WFEIMPUP

Site Name, Location, and Listening Point	Site Code
Ives Branch impoundment below Route 679 Bass River Twp., Burlington Co. (lat 39°38'02.54", long 74°28'53.02", Oswego Lake quad). Impoundment downstream from Harrisville-Chatsworth Road (Route 679) [Route 679].	WIVE679D
Ives Branch impoundment above Route 679 Bass River Twp., Burlington Co. (lat 39°38'02.54", long 74°28'53.02", Oswego Lake quad). Impoundment upstream from Harrisville-Chatsworth Road (Route 679) [Route 679].	WIVE679U
Hidden pond at Route 679 Bass River Twp., Burlington Co. (lat 39°38'29.98", long 74°29'43.76", Oswego Lake quad). Northern side of Harrisville-Chatsworth Road (Route 679), between Tub Mill Branch and Ives Branch [Route 679].	WIVHIDEN
Little Hauken Run above Route 563 Tabernacle Twp., Burlington Co. (lat 39°42'57.62", long 74°32'06.49", Jenkins quad). Upstream from Greenbank-Chatsworth Road (Route 563) [Route 563].	WLIHAUKN
Mile Run impoundment above Speedwell-Friendship Road Washington Twp., Burlington Co. (lat 39°45'46.98", long 74°33'36.80", Chatsworth quad). Impoundment upstream from Speedwell-Friendship Road [Speedwell-Friendship Road].	WMILIMPU
Pope Branch impoundment below Route 72 Woodland Twp., Burlington Co. (lat 39°49'39.22", long 74°27'24.49", Woodmansie quad). Impoundment downstream from Barnegat Road (Route 72) [dike/sand road near outlet].	WPO72MM9
Decou Pond Woodland Twp., Burlington Co. (lat 39°48'56.74", long 74°27'23.91", Woodmansie quad). West of Sooy Road (Crawley Road), between Sykes Branch and Barnegat Road (Route 72) [northern shoreline].	WPODECOU
Isolated Pope Branch pond Woodland Twp., Burlington Co. (lat 39°50'14.44", long 74°27'46.17", Woodmansie quad). Northeast of the intersection of Barnegat Road (Route 72) and Tabernacle-Chatsworth Road (Route 532) [southeastern shoreline].	WPOPISOL
Superfund long-thin pond Woodland Twp., Burlington Co. (lat 39°48'58.19", long 74°27'36.37", Woodmansie quad). West of Decou Pond, between Sykes Branch and Barnegat Road (Route 72) [northeastern shoreline].	WPOPTHIN
Northern superfund pond Woodland Twp., Burlington Co. (lat 39°49'09.33", long 74°27'12.81", Woodmansie quad). West of Sooy Road (Crawley Road), northeast of Decou Pond, between Sykes Branch and Barnegat Road (Route 72) [southeastern shoreline].	WPOSUPRN
Southern superfund pond Woodland Twp., Burlington Co. (lat 39°49'04.37", long 74°27'19.50", Woodmansie quad). West of Sooy Road (Crawley Road), north of Decou Pond, on Pope Branch tributary between Sykes Branch and Barnegat Road (Route 72) [northwestern shoreline].	WPOSUPRS
Reeds Branch bog above Route 563 Woodland Twp., Burlington Co. (lat 39°49'36.28", long 74°32'15.76", Chatsworth quad). Impoundment upstream from Greenbank-Chatsworth Road (Route 563), on eastern side of Reeds Branch [Route 563].	WRE563PD
Reeds Branch above Route 563 Woodland Twp., Burlington Co. (lat 39°49'36.22", long 74°32'16.00", Chatsworth quad). Upstream from Greenbank-Chatsworth Road (Route 563) [Route 563].	WRE563ST
Eastern Savoy Boulevard pond Woodland Twp., Burlington Co. (lat 39°49'42.02", long 74°31'17.93", Chatsworth quad). Eastern pond, northern side of Savoy Boulevard, between Chatsworth and Barnegat Road (Route 72) [Savoy Boulevard].	WRESAVYE
Western Savoy Boulevard pond Woodland Twp., Burlington Co. (lat 39°49'35.28", long 74°31'27.98", Chatsworth quad). Western pond, northern side of Savoy Boulevard, between Chatsworth and Barnegat Road (Route 72) [Savoy Boulevard].	WRESAVYW

Site Name, Location, and Listening Point	Site Code
Shane Branch above Carranza Road Washington Twp., Burlington Co. (lat 39°45'04.87", long 74°35'06.59", Chatsworth quad). Upstream from Carranza Road [Carranza Road at bridge].	WSACARRA
Shane Branch impoundment above Carranza Road Washington Twp., Burlington Co. (lat 39°45'07.07", long 74°34'59.39", Chatsworth quad). Upstream from first dike above from Carranza Road [dike].	WSAUPIMP
Shoal Branch above Chatsworth-Tuckerton Road Woodland Twp., Burlington Co. (lat 39°46'31.23", long 74°30'27.58", Chatsworth quad). Upstream from Chatsworth-Tuckerton Road, between middle and southernmost bridge [Chatsworth-Tuckerton Road].	WSODUKES
Shoal Branch impoundment Woodland Twp., Burlington Co. (lat 39°47'37.13", long 74°29'21.92", Woodmansie quad). Impoundment upstream from Baptist Road/dike [southeastern corner near outlet].	WSOLGIMP
Shoal Branch tributary dry spong Woodland Twp., Burlington Co. (lat 39°47'06.34", long 74°27'49.14", Woodmansie quad). Southern side of Baptist Road, between of tributary that flows into Goose Pond and Sooy Road (Crawley Road) [northeastern shoreline].	WSOTRDRY
Shoal Branch tributary impoundment above Baptist Road Woodland Twp., Burlington Co. (lat 39°47'08.89", long 74°28'00.09", Woodmansie quad). Impoundment upstream from Baptist Road, on tributary that flows into Goose Pond [Baptist Road near outlet].	WSOTRIMP
Shreve Branch above Sooy Road Woodland Twp., Burlington Co. (lat 39°47'50.02", long 74°27'18.53", Woodmansie quad). Upstream from Sooy Road (Crawley Road) [Sooy Road at culvert].	WSRESOOY
Shreve Branch spong Woodland Twp., Burlington Co. (lat 39°47'59.85", long 74°27'37.68", Woodmansie quad). Northern side of sand road that leads west from Sooy Road (Crawley Road), between Sykes and Shreve Branches [northeastern shoreline].	WSRSPONG
Sykes Branch above Sooy Road Woodland Twp., Burlington Co. (lat 39°48'31.58", long 74°27'04.85", Woodmansie quad). Upstream from Sooy Road (Crawley Road) [Sooy Road at culvert].	WSYKSOOY
Sykes Branch pond near stream above Sooy Road Woodland Twp., Burlington Co. (lat 39°48'29.85", long 74°27'02.64", Woodmansie quad). Eastern side of Sooy Road (Crawley Road), just south of Sykes Branch [Sooy Road].	WSYSOOPD
Isolated Tibbs Branch pond Woodland Twp., Burlington Co. (lat 39°51'58.70", long 74°31'44.51", Chatsworth quad). North of Barnegat Road (Route 72), near intersection with Sooy Place Road [southern shoreline].	WTIBPOND
Tulpehocken Creek above Big Hawkin Bridge Washington Twp., Burlington Co. (lat 39°42'51.73", long 74°33'57.15", Jenkins quad). Upstream from Big Hawkin Bridge on Maxwell-Friendship Road [Big Hawkin Bridge].	WTUHAWKN
Tulpehocken Creek parking area spong Washington Twp., Burlington Co. (lat 39°42'56.43", long 74°33'56.29", Jenkins quad). Eastern side of Maxwell-Friendship Road, just north of Tulpehocken Creek [cleared area adjacent to East Sandy Ridge Road].	WTUPARKG
Tulpehocken Creek downstream pond Washington Twp., Burlington Co. (lat 39°42'53.18", long 74°33'56.88", Jenkins quad). Eastern side of Maxwell-Friendship Road, just north of Tulpehocken Creek [East Sandy Ridge Road].	WTUPONDD
Tulpehocken Creek upstream pond Washington Twp., Burlington Co. (lat 39°42'53.18", long 74°33'56.88", Jenkins quad). Western side of Maxwell-Friendship Road, just north of Tulpehocken Creek [East Sandy Ridge Road].	WTUPONDU

Site Name, Location, and Listening Point	Site Code
Tulpehocken Creek eastern tributary-northeast of railroad Tabernacle Twp., Burlington Co. (lat 39°46'51.60", long 74°36'56.68", Chatsworth quad). Northern side of railroad, between eastern and western tributaries of Tulpehocken Creek (easternmost site) [railroad right-of-way].	WTUTRENE
Tulpehocken Creek eastern tributary-north of railroad Tabernacle Twp., Burlington Co. (lat 39°46'49.92", long 74°37'00.28", Chatsworth quad). Northern side of railroad, between eastern and western tributaries of Tulpehocken Creek [railroad right-of-way].	WTUTRENO
Tulpehocken Creek eastern tributary-south of railroad Tabernacle Twp., Burlington Co. (lat 39°46'49.31", long 74°37'01.22", Chatsworth quad). Southern side of railroad, between eastern and western tributaries of Tulpehocken Creek [railroad right-of-way].	WTUTRESO
Western Tulpehocken Creek tributary-north of Central New Jersey/Conrail railroad Tabernacle Twp., Burlington Co. (lat 39°46'42.58", long 74°37'16.57", Chatsworth quad). Upstream from railroad, on western headwater tributary of Tulpehocken Creek [railroad right-of-way].	WTUTRWNO
Western Tulpehocken Creek tributary-south of Central New Jersey/Conrail railroad Tabernacle Twp., Burlington Co. (lat 39°46'42.40", long 74°37'16.53", Chatsworth quad). Downstream from railroad, on western headwater tributary of Tulpehocken Creek [railroad right-of-way].	WTUTRWSO
Chatsworth Lake canal Woodland Twp., Burlington Co. (lat 39°48'54.45", long 74°33'08.48", Chatsworth quad). Upstream from Tabernacle-Chatsworth Road (Route 532), west of Chatsworth Lake outflow [Route 532].	WWE532CA
Chatsworth Lake Woodland Twp., Burlington Co. (lat 39°49'00.06", long 74°32'38.77", Chatsworth quad). Impoundment upstream from Tabernacle-Chatsworth Road (Route 532) [eastern corner at Route 532].	WWE532LK
Wading River below Route 563 Woodland Twp., Burlington Co. (lat 39°47'23.56", long 74°32'09.13", Chatsworth quad). Downstream from Green Bank-Chatsworth Road (Route 563), first crossing south of Chatsworth [Route 563 at bridge].	WWE563DW
Wading River above Route 563 Woodland Twp., Burlington Co. (lat 39°47'23.56", long 74°32'09.13", Chatsworth quad). Upstream from Green Bank-Chatsworth Road (Route 563), first crossing south of Chatsworth [Route 563 at bridge].	WWE563UP
Batona Trail dike pond Washington Twp., Burlington Co. (lat 39°40'38.03", long 74°32'14.84", Jenkins quad). Along Batona Trail, east of Green Bank-Chatsworth Road (Route 563), west of Spur 563 (Alternate Route 679) [dike along southern shoreline].	WWEDIKEP
Wading River backwater pond at Evans Bridge Washington Twp., Burlington Co. (lat 39°40'30.53", long 74°32'27.17", Jenkins quad). Southern side of Wading River, upstream from Evans Bridge at Green Bank-Chatsworth Road (Route 563)[Route 563].	WWEEVANP
Wading river seep Woodland Twp., Burlington Co. (lat 39°47'38.60", long 74°32'04.51", Chatsworth quad). Western side of Green Bank-Chatsworth Road (Route 563), just north of first Wading River crossing south of Chatsworth [Route 563].	WWESE563
Wading River above Route 563 at Speedwell Washington Twp., Burlington Co. (lat 39°45'49.00", long 74°32'31.80", Jenkins quad). Upstream from Green Bank-Chatsworth Road (Route 563) at Speedwell [Route 563 at bridge].	WWESPEED
Wading River above Route 563 at Tumbling Dam Washington Twp., Burlington Co. (lat 39°40'41.33", long 74°32'27.77", Chatsworth quad). Just downstream from Tumbling Dam, west of Green Bank-Chatsworth Road (Route 563), upstream from Evans Bridge [southern end of dam].	WWETUMBL

Appendix 6.0.2. Maximum calling ranks for 12 anuran species at monitoring sites in the Wading River drainage basin. Data type is F = formal survey or S = supplemental data. Observers are JFB = John F. Bunnell, DMG = Dennis M. Gray, and RAZ = Robert A. Zampella. 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 calling ranks are 1 = 1, 2 = 2-5, 3 = 6-10, and 4 > 10 individuals calling. A plus sign (+) indicates that a species was vocalizing at a site, but no calling rank was recorded. The letter " v " refers to the visual observation of a species that was not 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 6.0.1 for detailed site information and Appendix 6.7 for full scientific and common names.

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
WBE679HB	S	JFB	03/18/99	02:40 PM	0,4	21.0	29	-	-	-	-	-	-	-	-	-	4	-	-
WBE679HB	F	JFB/DMG	03/24/99	06:23 PM	2	14.5	79	-	-	-	-	2	-	-	-	-	2	-	-
WBE679HB	F	JFB/DMG	04/07/99	09:30 PM	0	9.5	64	-	-	-	-	-	-	-	-	-	-	-	-
WBE679HB	F	JFB/RAZ	05/26/99	09:46 PM	2	19.0	56	-	-	-	-	-	-	-	-	-	-	-	-
WBE679HB	F	JFB	06/28/99	10:47 PM	1	24.0	92	-	-	-	-	-	-	-	-	-	-	-	-
WBE679SQ	S	JFB	03/11/99	02:43 PM	0,4	9.0	56	-	-	-	-	-	-	-	-	-	1	-	-
WBE679SQ	S	JFB	03/18/99	02:35 PM	0,4	21.0	29	-	-	-	-	-	-	-	-	-	1	-	-
WBE679SQ	F	JFB/DMG	03/24/99	06:23 PM	2	14.5	79	-	-	-	-	-	-	-	-	-	1	-	-
WBE679SQ	F	JFB/DMG	04/07/99	09:30 PM	0	9.5	64	-	-	-	-	-	-	-	-	-	-	-	-
WBE679SQ	F	JFB/RAZ	05/26/99	09:46 PM	2	19.0	56	-	-	-	-	-	-	-	-	-	-	-	-
WBE679SQ	F	JFB	06/28/99	10:47 PM	1	24.0	92	-	-	-	-	-	-	-	2	-	-	-	-
WBIDDL72	F	JFB/RAZ	04/08/93	11:18 PM	0	7.0	-	-	-	-	-	-	-	-	-	-	-	-	-
WBIDDL72	F	JFB	05/04/93	08:13 PM	2,3,4	16.5	90	-	-	2	-	4	-	-	-	-	-	-	2
WBIDDL72	F	JFB/RAZ	06/03/93	08:49 PM	1	18.0	73	-	-	2	-	-	-	-	1	-	-	-	2
WBIDDL72	S	JFB/RAZ	02/28/98	11:08 AM	1,4	15.5	44	-	-	-	-	-	-	-	-	-	-	-	-
WBIDDL72	F	JFB	03/27/98	06:44 PM	2	23.0	42	-	-	-	-	-	-	-	-	-	-	-	-
WBIDDL72	F	JFB/RAZ	04/15/98	08:12 PM	2	16.0	79	-	-	-	-	-	-	-	-	-	-	2	1
WBIDDL72	F	JFB	05/06/98	08:14 PM	2	15.0	95	-	-	3	-	2	-	-	-	-	-	-	2
WBIDDL72	F	JFB/DMG	06/25/98	01:10 AM	0	22.0	96	-	-	1	-	-	-	-	-	-	-	-	1
WBUBORON	S	JFB/RAZ	02/28/98	03:21 PM	1,4	13.0	66	-	-	-	-	-	-	-	-	-	-	-	-
WBUBORON	F	JFB	03/19/98	08:51 PM	2	10.0	100	-	-	-	-	4	-	-	-	-	-	-	-
WBUBORON	F	JFB/DMG	04/14/98	09:36 PM	2,5	14.0	94	-	-	-	-	4	-	-	-	-	-	-	-
WBUBORON	F	JFB/DMG	05/20/98	09:19 PM	1	22.0	74	-	-	2	-	-	-	-	1	-	-	1	2
WBUBORON	F	JFB/RAZ	06/24/98	10:00 PM	0	22.5	96	-	-	1	-	-	-	-	2	-	-	-	2
WBUBORON	S	JFB	03/18/99	04:54 PM	0,4	15.0	46	-	-	-	-	2	-	-	-	-	-	-	-
WBUBOROS	S	JFB/RAZ	02/28/98	03:21 PM	1,4	13.0	66	-	-	-	-	-	-	-	-	-	-	-	-
WBUBOROS	F	JFB	03/19/98	08:51 PM	2	10.0	100	-	-	-	-	4	-	-	-	-	-	1	-
WBUBOROS	F	JFB/DMG	04/14/98	09:36 PM	2,5	14.0	94	-	-	1	-	4	-	-	-	-	-	-	-
WBUBOROS	F	JFB/DMG	05/20/98	09:19 PM	1	22.0	74	-	-	4	-	-	-	-	1	-	-	1	2
WBUBOROS	F	JFB/RAZ	06/24/98	10:00 PM	0	22.5	96	-	-	-	-	-	-	-	1	-	-	-	-
WBUBOROS	S	JFB	03/18/99	04:54 PM	0,4	15.0	46	-	-	-	-	-	-	-	-	-	-	-	-
WBUDIKEP	S	JFB/RAZ	02/28/98	03:27 PM	1,4	13.0	65	-	-	-	-	-	-	-	-	-	-	-	-
WBUDIKEP	F	JFB	03/19/98	09:12 PM	2	9.5	91	-	-	-	-	-	-	-	-	-	-	-	-
WBUDIKEP	F	JFB/DMG	04/14/98	10:05 PM	2	14.5	89	-	-	-	-	-	-	-	-	-	-	-	-
WBUDIKEP	F	JFB/DMG	05/20/98	09:02 PM	1	22.0	68	-	-	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
WBUDIKEP	F	JFB/RAZ	06/24/98	09:41 PM	2	24.0	96	-	-	-	-	-	-	-	-	-	-	-	-
WBUHERBI	S	JFB/RAZ	02/28/98	03:26 PM	1,4	13.5	75	-	-	-	-	-	-	-	-	-	-	-	-
WBUHERBI	F	JFB	03/19/98	08:58 PM	2	10.0	100	-	-	-	-	-	-	-	-	-	-	-	-
WBUHERBI	F	JFB/DMG	04/14/98	09:47 PM	2,5	15.0	89	-	-	-	-	2	-	-	-	-	-	2	-
WBUHERBI	F	JFB/DMG	05/20/98	09:10 PM	1	22.0	74	-	-	-	-	-	-	-	2	-	-	-	2
WBUHERBI	F	JFB/RAZ	06/24/98	09:50 PM	2	23.5	100	-	-	-	-	-	-	-	2	-	-	-	2
WBUOTTER	S	JFB/RAZ	02/28/98	03:09 PM	1,4	12.5	66	-	-	-	-	-	-	-	-	-	-	-	-
WBUOTTER	F	JFB	03/19/98	08:43 PM	2,4	9.5	91	-	-	-	-	-	-	-	-	-	-	-	-
WBUOTTER	F	JFB/DMG	04/14/98	09:25 PM	2,5	13.0	94	-	-	-	-	1	-	-	-	-	-	-	4
WBUOTTER	F	JFB/DMG	05/20/98	09:31 PM	1	20.5	82	-	-	-	-	-	-	-	2	-	-	-	4
WBUOTTER	F	JFB/RAZ	06/24/98	10:09 PM	0	22.5	96	-	-	-	-	-	-	-	2	-	-	-	4
WBUSANDY	F	JFB/RAZ	04/08/93	08:40 PM	0	12.0	-	-	-	-	-	4	-	-	-	-	-	2	-
WBUSANDY	F	JFB	05/04/93	10:15 PM	2,4	17.0	90	-	-	1	-	2	-	-	-	-	-	-	1
WBUSANDY	F	JFB/RAZ	06/03/93	10:29 PM	1	16.0	90	-	-	+	-	-	-	-	-	-	-	-	4
WBUSANDY	S	JFB/RAZ	02/28/98	03:29 PM	1,4	13.5	75	-	-	-	-	-	-	-	-	-	-	-	-
WBUSANDY	F	JFB	03/19/98	09:04 PM	2	9.5	100	-	-	-	-	-	-	-	-	-	-	-	-
WBUSANDY	F	JFB/DMG	04/14/98	09:55 PM	2	14.0	94	-	-	-	-	3	-	-	-	-	-	-	-
WBUSANDY	F	JFB/DMG	05/20/98	09:09 PM	1	22.0	74	-	-	-	-	-	-	-	1	-	-	-	2
WBUSANDY	F	JFB/RAZ	06/24/98	09:50 PM	2	23.5	100	-	-	-	-	-	-	-	2	-	-	-	-
WFEIMPD1	F	JFB/RAZ	04/08/93	08:15 PM	0	12.0	-	-	-	-	-	-	-	-	-	-	-	2	1
WFEIMPD1	F	JFB	05/04/93	10:37 PM	2,3,5	15.5	100	-	1	-	-	-	-	-	-	-	-	-	4
WFEIMPD1	F	JFB/RAZ	06/03/93	10:42 PM	1	17.0	85	-	-	-	-	-	-	-	1	-	-	-	4
WFEIMPD1	S	JFB/RAZ	02/28/98	02:48 PM	0,4	15.0	58	-	-	-	-	-	-	-	-	-	-	-	-
WFEIMPD1	F	JFB	03/19/98	08:23 PM	2	10.0	91	-	-	-	-	-	-	-	-	-	-	-	-
WFEIMPD1	F	JFB/DMG	04/14/98	08:43 PM	2,5	15.0	89	-	-	-	-	-	-	-	-	-	-	-	4
WFEIMPD1	F	JFB/DMG	05/20/98	10:17 PM	1,2	21.0	82	-	-	-	-	-	-	-	-	-	-	-	4
WFEIMPD1	F	JFB/RAZ	06/24/98	10:47 PM	0	22.5	91	-	-	-	-	-	-	-	2	-	-	-	4
WFEIMPU1	S	JFB/RAZ	02/28/98	02:26 PM	1,4	18.0	50	-	-	-	-	-	-	-	-	-	-	-	-
WFEIMPU1	F	JFB	03/19/98	08:04 PM	2	10.0	91	-	-	-	-	-	-	-	-	-	-	2	-
WFEIMPU1	F	JFB/DMG	04/14/98	08:53 PM	2,5	15.0	94	-	-	-	-	2	-	-	-	-	-	-	4
WFEIMPU1	F	JFB/DMG	05/20/98	10:11 PM	1	20.0	87	-	-	-	-	-	-	-	-	-	-	-	4
WFEIMPU1	F	JFB/RAZ	06/24/98	10:40 PM	0	22.5	100	-	-	-	-	-	-	-	2	-	-	-	3
WFEIMPU2	F	JFB	03/19/98	08:13 PM	2,4	10.0	91	-	-	-	-	-	-	-	-	-	-	1	-
WFEIMPU2	F	JFB/DMG	04/14/98	08:28 PM	2,5	14.0	94	-	-	-	-	2	-	-	-	-	-	-	3
WFEIMPU2	F	JFB/DMG	05/20/98	10:25 PM	2	20.0	78	-	-	-	-	-	-	-	1	-	-	-	4
WFEIMPU2	F	JFB/RAZ	06/24/98	10:56 PM	0	22.0	100	-	-	-	-	-	-	-	1	-	-	-	4
WFEIMPU3	S	JFB/RAZ	02/28/98	02:40 PM	1,4	14.0	53	-	-	-	-	-	-	-	-	-	-	-	-
WFEIMPU3	F	JFB	03/19/98	08:13 PM	2,4	10.0	91	-	-	-	-	-	-	-	-	-	-	2	-
WFEIMPU3	F	JFB/DMG	04/14/98	08:28 PM	2,5	14.0	94	-	-	-	-	-	-	-	-	-	-	1	3
WFEIMPU3	F	JFB/DMG	05/20/98	10:25 PM	2	20.0	78	-	-	-	-	-	-	-	2	-	-	2	4
WFEIMPU3	F	JFB/RAZ	06/24/98	10:56 PM	0	22.0	100	-	-	-	-	-	-	-	2	-	-	-	4
WFEIMPUP	F	JFB/RAZ	04/08/93	08:06 PM	0	14.0	-	-	-	-	-	-	-	-	-	-	-	2	2
WFEIMPUP	F	JFB	05/04/93	10:45 PM	2,4	16.0	95	-	-	-	-	1	-	-	2	-	-	1	4
WFEIMPUP	F	JFB/RAZ	06/03/93	10:49 PM	1	16.0	90	-	-	-	-	-	-	-	2	-	-	1	4
WIVE679D	F	JFB/DMG	03/24/99	06:44 PM	2	14.0	79	-	-	-	-	-	-	-	-	-	-	-	-
WIVE679D	F	JFB/DMG	04/07/99	09:35 PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
WIVE679D	F	JFB/RAZ	05/26/99	10:03 PM	2	18.5	57	-	-	-	-	-	-	-	1	-	-	1	2
WIVE679D	F	JFB	06/28/99	10:32 PM	0	24.0	92	-	-	-	-	-	-	-	-	-	-	-	2
WIVE679U	F	JFB/RAZ	05/25/93	09:58 PM	1	23.0	69	-	-	-	-	-	-	-	-	-	-	4	4
WIVE679U	F	JFB/RAZ	06/29/93	10:34 PM	2	23.0	87	-	-	-	-	-	-	-	1	-	-	-	3
WIVE679U	F	JFB/DMG	03/24/99	06:44 PM	2	14.0	79	-	-	-	-	-	-	-	-	-	-	-	-
WIVE679U	F	JFB/DMG	04/07/99	09:35 PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WIVE679U	F	JFB/RAZ	05/26/99	10:03 PM	2	18.5	57	-	-	-	-	-	-	-	1	-	-	2	2
WIVE679U	F	JFB	06/28/99	10:32 PM	0	24.0	92	-	2	-	-	-	-	-	-	-	-	-	2
WIVHIDEN	F	JFB	04/28/93	09:12 PM	0	9.0	73	-	-	-	-	-	-	-	-	-	-	1	-
WIVHIDEN	F	JFB/RAZ	05/25/93	10:05 PM	1	22.0	72	-	-	3	-	-	-	-	3	-	-	2	2
WIVHIDEN	F	JFB/RAZ	06/29/93	10:30 PM	2	23.0	87	-	-	1	-	-	-	-	-	-	-	-	-
WIVHIDEN	S	JFB	03/11/99	02:52 PM	0,4	7.0	41	-	-	-	-	-	-	-	-	-	-	-	-
WIVHIDEN	S	JFB	03/18/99	02:48 PM	0,4	22.0	28	-	-	-	-	-	-	-	-	-	-	-	-
WIVHIDEN	F	JFB/DMG	03/24/99	06:36 PM	2	14.5	84	-	-	-	-	4	-	-	-	-	1	-	-
WIVHIDEN	F	JFB/DMG	04/07/99	09:42 PM	0	9.5	74	-	-	-	-	2	-	-	-	-	-	2	-
WIVHIDEN	F	JFB/RAZ	05/26/99	09:54 PM	2	18.5	56	-	-	1	-	-	-	-	2	-	-	1	2
WIVHIDEN	F	JFB	06/28/99	10:39 PM	0	24.0	92	-	-	2	-	-	-	-	2	-	-	-	-
WLIHAUKN	F	JFB/RAZ	04/08/93	09:39 PM	0	10.0	-	-	-	-	-	-	-	-	-	-	-	-	-
WLIHAUKN	F	JFB	05/04/93	09:19 PM	2,4	16.5	90	-	-	-	-	-	-	-	-	-	-	-	-
WLIHAUKN	F	JFB/RAZ	06/03/93	09:45 PM	1	17.0	85	-	-	-	-	-	-	-	-	-	-	-	-
WLIHAUKN	F	JFB	03/27/98	10:39 PM	2,4	19.5	65	-	-	-	-	-	-	-	-	-	-	-	-
WLIHAUKN	F	JFB	04/29/98	08:24 PM	0	15.5	66	-	-	-	-	-	-	-	-	-	-	-	-
WLIHAUKN	F	JFB	05/28/98	10:27 PM	0	18.0	85	-	-	-	-	-	-	-	-	-	-	-	-
WLIHAUKN	F	JFB/DMG	06/25/98	09:56 PM	0	26.0	84	-	-	-	-	-	-	-	-	-	-	-	1
WMILIMPU	S	JFB/RAZ	02/28/98	04:51 PM	1,4,5	14.0	80	-	-	-	-	-	-	-	-	-	-	-	-
WMILIMPU	F	JFB	03/27/98	10:53 PM	2	17.5	77	-	-	-	-	-	-	-	-	-	-	-	-
WMILIMPU	F	JFB/DMG	04/14/98	10:40 PM	2	16.5	95	-	-	-	-	2	-	-	-	-	-	-	-
WMILIMPU	F	JFB/DMG	05/20/98	09:45 PM	1	21.5	79	-	-	-	-	-	-	-	2	-	-	-	-
WMILIMPU	F	JFB/RAZ	06/24/98	10:30 PM	0	23.0	92	-	-	-	-	-	-	-	2	-	-	-	-
WPO72MM9	F	JFB/RAZ	04/08/93	10:51 PM	0	8.0	-	-	-	-	-	-	-	-	-	-	-	2	-
WPO72MM9	F	JFB	05/04/93	08:01 PM	2,3,4	15.0	95	-	-	-	-	-	-	-	-	-	-	1	4
WPO72MM9	F	JFB/RAZ	06/03/93	08:36 PM	1	17.0	77	-	-	+	-	-	-	-	2	-	-	-	4
WPO72MM9	F	JFB	03/27/98	07:10 PM	2,4	22.0	44	-	-	-	-	-	-	-	-	-	-	-	-
WPO72MM9	F	JFB/RAZ	04/15/98	08:42 PM	2	14.0	83	-	-	-	-	-	-	-	-	-	-	2	2
WPO72MM9	F	JFB	05/06/98	08:45 PM	2	15.5	94	-	-	-	-	-	-	-	-	-	-	1	4
WPO72MM9	F	JFB/DMG	06/25/98	12:33 AM	0	22.0	96	-	-	-	-	-	-	-	-	-	-	-	4
WPODECOU	F	JFB	03/27/98	07:52 PM	0,4	20.5	49	-	-	-	-	3	-	-	-	-	-	2	-
WPODECOU	F	JFB/RAZ	04/15/98	09:10 PM	0	12.5	83	-	-	2	-	4	-	-	-	-	-	2	2
WPODECOU	F	JFB	05/06/98	09:18 PM	2,3	15.0	100	-	2	4	-	2	-	-	2	-	-	2	3
WPODECOU	F	JFB/DMG	06/25/98	12:02 AM	0	22.0	96	-	-	3	-	-	-	-	2	-	-	1	4
WPOPISOL	S	JFB/RAZ	02/28/98	11:25 AM	0,4	16.0	48	-	-	-	-	-	-	-	-	-	-	-	-
WPOPISOL	F	JFB	03/27/98	06:56 PM	2	20.5	52	-	-	-	-	4	-	-	-	-	-	-	-
WPOPISOL	F	JFB/RAZ	04/15/98	08:25 PM	2	14.0	83	-	-	2	-	4	-	-	-	-	-	2	2
WPOPISOL	F	JFB	05/06/98	08:28 PM	2	15.5	90	-	-	4	-	4	-	-	1	-	-	2	2
WPOPISOL	F	JFB/DMG	06/25/98	12:51 AM	0	22.5	96	-	-	3	-	-	-	-	1	-	-	-	2
WPOPISOL	S	JFB	03/18/99	11:10 AM	0,4	23.5	35	-	-	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
WPOPTHIN	F	JFB	03/27/98	08:03 PM	0,4	20.5	55	-	-	-	-	2	-	-	-	-	-	3	-
WPOPTHIN	F	JFB/RAZ	04/15/98	09:18 PM	0	12.0	83	-	-	2	-	4	-	-	1	-	-	2	2
WPOPTHIN	F	JFB	05/06/98	09:28 PM	2,3	16.0	90	-	-	4	-	2	-	-	2	-	-	2	2
WPOPTHIN	F	JFB/DMG	06/25/98	12:13 AM	0	22.5	96	-	-	3	-	-	-	-	2	-	-	-	3
WPOSUPRN	F	JFB	03/27/98	07:33 PM	0	21.0	52	-	-	-	-	4	-	-	-	-	-	2	-
WPOSUPRN	F	JFB/RAZ	04/15/98	08:53 PM	0	12.0	83	-	-	2	-	2	-	-	-	-	-	2	-
WPOSUPRN	F	JFB	05/06/98	09:00 PM	2	15.5	94	-	-	2	-	1	-	-	-	-	-	2	1
WPOSUPRN	F	JFB/DMG	06/25/98	11:51 PM	0	22.5	100	-	-	2	-	-	-	-	2	-	-	-	2
WPOSUPRN	S	JFB	03/18/99	12:25 PM	0,4	23.0	32	-	-	-	-	-	-	-	-	-	-	-	-
WPOSUPRS	F	JFB	03/27/98	07:40 PM	0	21.5	44	-	-	-	-	2	-	-	-	-	-	2	-
WPOSUPRS	F	JFB/RAZ	04/15/98	09:01 PM	0	12.5	83	-	-	2	-	2	-	-	1	-	-	2	-
WPOSUPRS	F	JFB	05/06/98	09:08 PM	2,3	15.0	95	-	-	-	-	1	-	-	-	-	-	3	-
WPOSUPRS	F	JFB/DMG	06/25/98	11:57 PM	0	23.0	100	-	-	3	-	-	-	-	1	-	-	-	2
WPOSUPRS	S	JFB	03/18/99	12:33 PM	0,4	23.0	32	-	-	-	-	-	-	-	-	-	-	-	-
WRE563PD	F	JFB/RAZ	04/08/93	10:19 PM	0	8.0	-	-	-	-	-	4	-	-	-	-	-	-	-
WRE563PD	F	JFB	05/04/93	08:40 PM	2,4	16.5	100	-	4	4	-	4	-	-	-	-	-	-	-
WRE563PD	F	JFB/RAZ	06/03/93	09:07 PM	1	20.0	77	-	-	-	-	-	-	-	2	-	-	-	-
WRE563PD	F	JFB	03/27/98	11:21 PM	2	18.5	65	-	-	-	-	-	-	-	-	-	-	-	-
WRE563PD	F	JFB	04/29/98	09:02 PM	0,4	15.0	65	-	-	-	-	-	-	-	-	-	-	-	-
WRE563PD	F	JFB	05/28/98	10:53 PM	0,4	18.0	81	-	-	-	-	-	-	-	-	-	-	-	-
WRE563PD	F	JFB/DMG	06/25/98	08:59 PM	0	26.0	84	-	-	-	-	-	-	-	-	-	-	-	-
WRE563ST	F	JFB/RAZ	04/08/93	10:19 PM	0	8.0	-	-	-	-	-	-	-	-	-	-	-	-	-
WRE563ST	F	JFB	05/04/93	08:40 PM	2,4	16.5	100	-	-	-	-	-	-	-	-	-	-	-	2
WRE563ST	F	JFB/RAZ	06/03/93	09:07 PM	1	20.0	77	-	-	-	-	-	-	-	-	-	-	-	3
WRE563ST	F	JFB	03/27/98	11:21 PM	2	18.5	65	-	-	-	-	-	-	-	-	-	-	-	-
WRE563ST	F	JFB	04/29/98	09:02 PM	0,4	15.0	65	-	-	-	-	-	-	-	-	-	-	-	-
WRE563ST	F	JFB	05/28/98	10:53 PM	0,4	18.0	81	-	-	-	-	-	-	-	-	-	-	-	-
WRE563ST	F	JFB/DMG	06/25/98	08:59 PM	0	26.0	84	-	-	-	-	-	-	-	-	-	-	-	-
WRESAVYE	F	JFB/RAZ	04/08/93	10:37 PM	0	10.0	-	-	-	-	-	2	-	-	-	-	-	-	-
WRESAVYE	F	JFB	05/04/93	08:25 PM	2,3,4	16.0	90	-	4	4	-	4	-	-	-	-	-	-	-
WRESAVYE	F	JFB/RAZ	06/03/93	08:58 PM	1	22.0	77	-	-	-	-	-	-	-	-	-	-	-	-
WRESAVYE	F	JFB	04/29/98	08:55 PM	0,5	15.0	59	-	-	-	-	2	-	-	-	-	-	-	-
WRESAVYE	F	JFB	05/28/98	10:45 PM	0	17.0	90	-	2	2	1	-	-	-	2	-	-	-	1
WRESAVYE	F	JFB/DMG	06/25/98	09:12 PM	0	26.5	75	-	1	-	2	-	-	-	-	-	-	-	-
WRESAVYE	S	JFB	03/10/99	10:01 AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRESAVYE	S	JFB	03/11/99	01:00 PM	0,4	7.0	41	-	-	-	-	-	-	-	-	-	-	-	-
WRESAVYE	S	JFB	03/18/99	12:05 PM	0,4	24.0	33	-	-	-	-	-	-	-	-	-	-	-	-
WRESAVYW	F	JFB	05/04/93	08:25 PM	2,3,4	16.0	90	-	4	4	-	4	-	-	-	-	-	-	-
WRESAVYW	F	JFB/RAZ	06/03/93	09:01 PM	1	22.0	77	-	-	2	-	-	-	-	-	-	-	-	-
WRESAVYW	F	JFB	04/29/98	08:48 PM	0	14.0	69	-	1	2	-	4	-	-	-	-	-	-	-
WRESAVYW	F	JFB	05/28/98	10:39 PM	0	17.0	90	-	-	3	2	-	-	-	2	-	-	2	2
WRESAVYW	F	JFB/DMG	06/25/98	09:07 PM	0	27.0	75	-	1	3	-	-	-	-	1	-	-	-	-
WRESAVYW	S	JFB	03/10/99	10:06 AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRESAVYW	S	JFB	03/11/99	01:00 PM	0,4	7.0	41	-	-	-	-	-	-	-	-	-	-	-	-
WRESAVYW	S	JFB	03/18/99	12:11 PM	0,4	24.0	33	-	-	-	-	-	-	-	-	-	-	-	-
WSACARRA	F	JFB/RAZ	04/08/93	08:27 PM	0	12.0	-	-	-	-	-	-	-	-	-	-	-	2	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
WSACARRA	F	JFB	05/04/93	10:28 PM	2,4	16.0	95	-	-	-	-	1	-	-	-	-	-	2	3
WSACARRA	F	JFB/RAZ	06/03/93	10:36 PM	1	15.0	90	-	-	-	-	-	-	-	-	-	-	1	2
WSACARRA	S	JFB/RAZ	02/28/98	02:57 PM	1,4	14.0	58	-	-	-	-	-	-	-	-	-	-	-	-
WSACARRA	F	JFB	03/19/98	08:30 PM	2,4	9.5	91	-	-	-	-	-	-	-	-	-	-	-	-
WSACARRA	F	JFB/DMG	04/14/98	09:04 PM	2,5	15.0	94	-	-	-	-	-	-	-	-	-	-	-	1
WSACARRA	F	JFB/DMG	05/20/98	10:01 PM	1	21.5	75	-	-	-	-	-	-	-	-	-	-	1	3
WSACARRA	F	JFB/RAZ	06/24/98	10:20 PM	0	23.0	96	-	-	-	-	-	-	-	2	-	-	-	3
WSAUPIMP	S	JFB/RAZ	02/28/98	02:57 PM	1,4	14.0	58	-	-	-	-	-	-	-	-	-	-	-	-
WSAUPIMP	F	JFB	03/19/98	08:36 PM	2,4	9.5	91	-	-	-	-	-	-	-	-	-	-	-	-
WSAUPIMP	F	JFB/DMG	04/14/98	09:16 PM	2,5	14.0	89	-	-	-	-	-	-	-	-	-	-	2	2
WSAUPIMP	F	JFB/DMG	05/20/98	09:55 PM	1	21.0	79	-	-	-	-	-	-	-	1	-	-	1	2
WSAUPIMP	F	JFB/RAZ	06/24/98	10:20 PM	0	23.0	96	-	-	-	-	-	-	-	2	-	-	-	3
WSODUKES	F	JFB	03/27/98	09:57 PM	0	17.5	72	-	-	-	-	-	-	-	-	-	-	-	-
WSODUKES	F	JFB	04/29/98	07:40 PM	0	15.5	69	-	-	-	-	-	-	-	-	-	-	-	-
WSODUKES	F	JFB	05/06/98	11:06 PM	2,3	14.0	100	-	-	-	-	-	-	-	-	-	-	-	-
WSODUKES	F	JFB/DMG	06/25/98	10:12 PM	0	26.0	92	-	-	-	-	-	-	-	2	-	-	-	-
WSOLGIMP	F	JFB	03/27/98	09:35 PM	2	19.5	58	-	-	-	-	-	-	-	-	-	-	-	-
WSOLGIMP	F	JFB/RAZ	04/15/98	10:28 PM	0	10.0	91	-	-	-	-	-	-	-	-	-	-	-	3
WSOLGIMP	F	JFB	05/06/98	10:42 PM	2,3	14.0	100	-	-	-	-	-	-	-	-	-	-	-	4
WSOLGIMP	F	JFB/DMG	06/25/98	10:38 PM	0	25.0	92	-	-	-	-	-	-	-	-	-	-	-	4
WSOTRDRY	F	JFB	03/27/98	09:09 PM	0	20.0	58	-	-	-	-	2	-	-	-	-	-	4	-
WSOTRDRY	F	JFB/RAZ	04/15/98	10:13 PM	0	10.5	86	-	-	2	-	4	-	-	-	-	-	4	2
WSOTRDRY	F	JFB	05/06/98	10:24 PM	2,3	14.0	90	-	-	3	-	2	-	-	2	-	-	4	2
WSOTRDRY	F	JFB/DMG	06/25/98	10:58 PM	0	24.0	92	-	-	4	-	-	-	-	4	-	-	1	2
WSOTRIMP	F	JFB	03/27/98	09:20 AM	0	19.0	65	-	-	-	-	-	-	-	-	-	-	4	-
WSOTRIMP	F	JFB/RAZ	04/15/98	10:20 PM	0	10.5	85	-	-	-	-	-	-	-	-	-	-	2	2
WSOTRIMP	F	JFB	05/06/98	10:32 PM	2,3	14.0	100	-	-	2	-	-	-	-	2	-	-	2	4
WSOTRIMP	F	JFB/DMG	06/25/98	10:49 PM	0	24.5	92	-	-	-	-	-	-	-	2	-	-	-	3
WSRESOOY	F	JFB	03/27/98	08:56 PM	0,4	19.0	62	-	-	-	-	-	-	-	-	-	-	-	-
WSRESOOY	F	JFB/RAZ	04/15/98	09:55 PM	0	12.0	85	-	-	-	-	-	-	-	-	-	-	-	-
WSRESOOY	F	JFB	05/06/98	09:56 PM	2,3	15.0	100	-	-	-	-	-	-	-	2	-	-	-	2
WSRESOOY	F	JFB/DMG	06/25/98	11:12 PM	0	24.5	96	-	-	-	-	-	-	-	2	-	-	-	2
WSRSPONG	F	JFB	03/27/98	08:49 PM	0	19.0	52	-	-	-	-	4	-	-	-	-	-	4	-
WSRSPONG	F	JFB/RAZ	04/15/98	10:01 PM	0	12.0	91	-	-	4	-	4	-	-	-	-	-	4	-
WSRSPONG	F	JFB	05/06/98	10:10 PM	2,3	15.0	90	-	-	4	-	1	-	-	2	-	-	4	1
WSRSPONG	F	JFB/DMG	06/25/98	11:29 PM	0	24.0	92	-	-	4	-	-	-	-	2	-	-	-	1
WSYKSOOY	F	JFB/RAZ	04/08/93	11:04 PM	0	9.0	-	-	-	-	-	-	-	-	-	-	-	-	-
WSYKSOOY	F	JFB	05/04/93	07:48 PM	2,3,4	16.5	100	-	-	4	-	-	-	-	-	-	-	1	1
WSYKSOOY	F	JFB/RAZ	06/03/93	08:24 PM	1	20.0	77	-	-	4	-	-	-	-	-	-	-	-	2
WSYKSOOY	F	JFB	03/27/98	08:17 PM	0	18.5	65	-	-	-	-	-	-	-	-	-	-	-	-
WSYKSOOY	F	JFB/RAZ	04/15/98	08:35 PM	0	13.0	94	-	-	-	-	-	-	-	-	-	-	-	-
WSYKSOOY	F	JFB	05/06/98	09:46 PM	2,3	15.0	90	-	-	-	-	-	-	-	-	-	-	-	-
WSYKSOOY	F	JFB/DMG	06/25/98	11:42 PM	0	22.0	96	-	-	-	-	-	-	-	2	-	-	-	1
WSYSOOPD	F	JFB	03/27/98	08:17 PM	0	18.5	65	-	-	-	-	-	-	-	-	-	-	1	-
WSYSOOPD	F	JFB/RAZ	04/15/98	08:35 PM	0	13.0	94	-	-	-	-	-	-	-	-	-	-	2	1
WSYSOOPD	F	JFB	05/06/98	09:46 PM	2,3	15.0	90	-	-	3	-	1	-	-	1	-	-	2	2

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
WSYSOOPD	F	JFB/DMG	06/25/98	11:42 PM	0	22.0	96	-	-	-	-	-	-	-	3	-	-	-	2
WTIBPOND	S	JFB/RAZ	02/28/98	11:00 AM	1,4	16.0	52	-	-	-	-	-	-	-	-	-	-	-	-
WTIBPOND	F	JFB	03/27/98	06:29 PM	2	22.0	44	-	-	-	-	4	-	-	-	-	-	-	-
WTIBPOND	F	JFB/RAZ	04/15/98	08:00 PM	2	17.0	80	-	-	4	-	4	-	-	-	-	-	-	-
WTIBPOND	F	JFB	05/06/98	08:00 PM	2	15.5	94	-	-	4	-	2	-	-	1	-	-	2	-
WTIBPOND	F	JFB/DMG	06/25/98	01:22 AM	0	22.0	96	-	-	2	-	-	-	-	1	-	-	-	-
WTIBPOND	S	JFB	03/18/99	11:51 AM	0,4	25.0	31	-	-	-	-	1	-	-	-	-	-	-	-
WTUHAWKN	S	JFB/RAZ	02/28/98	03:57 PM	1,4	12.0	65	-	-	-	-	-	-	-	-	-	-	-	-
WTUHAWKN	F	JFB	03/19/98	09:34 PM	2	9.5	91	-	-	-	-	-	-	-	-	-	-	-	-
WTUHAWKN	F	JFB/DMG	04/14/98	10:20 PM	2	15.0	94	-	-	-	-	-	-	-	-	-	-	-	-
WTUHAWKN	F	JFB/DMG	05/20/98	08:47 PM	1	23.0	64	-	-	-	-	-	-	-	-	-	-	-	-
WTUHAWKN	F	JFB/RAZ	06/24/98	09:18 PM	2	24.0	87	-	-	-	-	-	-	-	-	-	-	-	-
WTUPARKG	S	JFB/RAZ	02/28/98	03:57 PM	1,4	12.0	65	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDD	F	JFB/RAZ	04/08/93	08:54 PM	0	14.0	-	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDD	F	JFB	05/04/93	10:00 PM	2,4	17.0	95	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDD	F	JFB/RAZ	06/03/93	10:22 PM	1	17.0	90	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDD	S	JFB/RAZ	02/28/98	03:57 PM	1,4	12.0	65	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDD	F	JFB	03/19/98	09:28 PM	2	9.5	91	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDD	F	JFB/DMG	04/14/98	10:20 PM	2	15.0	94	-	-	-	-	-	-	-	-	-	-	1	-
WTUPONDD	F	JFB/DMG	05/20/98	08:47 PM	1	23.0	64	-	-	-	-	-	-	-	2	-	-	-	-
WTUPONDD	F	JFB/RAZ	06/24/98	09:18 PM	2	24.0	87	-	-	-	-	-	-	-	2	-	-	-	-
WTUPONDD	S	JFB	03/18/99	04:30 PM	0,4	17.0	43	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDU	F	JFB/RAZ	04/08/93	08:54 PM	0	14.0	-	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDU	F	JFB	05/04/93	10:00 PM	2,4	17.0	95	-	-	2	-	1	-	-	-	-	-	-	1
WTUPONDU	F	JFB/RAZ	06/03/93	10:22 PM	1	17.0	90	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDU	S	JFB/RAZ	02/28/98	03:57 PM	1,4	12.0	65	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDU	F	JFB	03/19/98	09:28 PM	2	9.5	91	-	-	-	-	-	-	-	-	-	-	-	-
WTUPONDU	F	JFB/DMG	04/14/98	10:20 PM	2	15.0	94	-	-	-	-	-	-	-	-	-	-	1	-
WTUPONDU	F	JFB/DMG	05/20/98	08:47 PM	1	23.0	64	-	-	-	-	-	-	-	2	-	-	-	-
WTUPONDU	F	JFB/RAZ	06/24/98	09:18 PM	2	24.0	87	-	-	-	-	-	-	-	1	-	-	-	-
WTUPONDU	S	JFB	03/18/99	04:35 PM	0,4	17.0	43	-	-	-	-	-	-	-	-	-	-	-	-
WTUTRENE	S	JFB/RAZ	02/28/98	02:00 PM	1,4	25.5	44	-	-	-	-	-	-	-	-	-	-	-	-
WTUTRENE	F	JFB	03/19/98	07:39 PM	2	9.0	91	-	-	-	-	-	-	-	-	-	-	3	-
WTUTRENE	F	JFB	04/17/98	10:51 PM	2	18.0	95	-	2	4	-	4	-	-	1	-	-	3	-
WTUTRENE	F	JFB/DMG	05/20/98	10:59 PM	2	19.0	82	-	2	3	-	-	-	-	1	-	-	3	-
WTUTRENE	F	JFB/RAZ	06/24/98	11:29 PM	0	21.5	96	-	-	1	-	-	-	-	2	-	-	-	2
WTUTRENO	S	JFB/RAZ	02/28/98	01:50 PM	1,4	25.5	44	-	-	-	-	-	-	-	-	-	-	-	-
WTUTRENO	F	JFB	03/19/98	07:33 PM	2	9.0	91	-	-	-	-	-	-	-	-	-	-	2	-
WTUTRENO	F	JFB	04/17/98	10:42 PM	2	17.0	95	-	2	4	-	4	-	-	-	-	-	2	-
WTUTRENO	F	JFB/DMG	05/20/98	10:51 PM	2	19.5	82	-	-	2	-	-	-	-	2	-	-	3	1
WTUTRENO	F	JFB/RAZ	06/24/98	11:22 PM	0	21.5	96	-	-	-	-	-	-	-	2	-	-	2	2
WTUTRESO	S	JFB/RAZ	02/28/98	01:50 PM	1,4	25.5	44	-	-	-	-	-	-	-	-	-	-	-	-
WTUTRESO	F	JFB	03/19/98	07:33 PM	2	9.0	91	-	-	-	-	1	-	-	-	-	-	1	-
WTUTRESO	F	JFB	04/17/98	10:42 PM	2	17.0	95	-	1	2	-	4	-	-	-	-	-	2	-
WTUTRESO	F	JFB/DMG	05/20/98	10:51 PM	2	19.5	82	-	-	2	-	-	-	-	1	-	-	4	1
WTUTRESO	F	JFB/RAZ	06/24/98	11:22 PM	0	21.5	96	-	-	-	-	-	-	-	2	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
WTUTRWNO	S	JFB/RAZ	02/28/98	01:40 PM	1,4	25.5	44	-	-	-	-	-	-	-	-	-	-	-	-
WTUTRWNO	F	JFB	03/19/98	07:20 PM	2	9.0	91	-	-	-	-	-	-	-	-	-	-	1	-
WTUTRWNO	F	JFB	04/17/98	10:34 PM	2	18.0	95	-	-	-	-	2	-	-	-	-	-	1	-
WTUTRWNO	F	JFB/DMG	05/20/98	10:40 PM	2	22.0	82	-	-	-	-	-	-	-	1	-	-	3	1
WTUTRWNO	F	JFB/RAZ	06/24/98	11:11 PM	0	22.5	96	-	-	-	-	-	-	-	1	-	-	-	-
WTUTRWSO	S	JFB/RAZ	02/28/98	01:40 PM	1,4	25.5	44	-	-	-	-	-	-	-	-	-	-	-	-
WTUTRWSO	F	JFB	03/19/98	07:20 PM	2	9.0	91	-	-	-	-	2	-	-	-	-	-	1	-
WTUTRWSO	F	JFB	04/17/98	10:34 PM	2	18.0	95	-	-	2	-	4	-	-	1	-	-	2	2
WTUTRWSO	F	JFB/DMG	05/20/98	10:40 PM	2	22.0	82	-	-	3	-	-	-	-	2	-	-	2	2
WTUTRWSO	F	JFB/RAZ	06/24/98	11:11 PM	0	21.5	96	-	-	1	-	-	-	-	2	-	-	-	2
WWE532CA	S	JFB/RAZ	02/28/98	11:52 AM	1,4	18.0	39	-	-	-	-	-	-	-	-	-	-	-	-
WWE532CA	F	JFB	03/27/98	11:10 PM	2	19.0	65	-	-	-	-	1	-	-	-	-	-	-	-
WWE532CA	F	JFB	04/29/98	09:14 PM	0,4	14.5	60	-	-	-	-	-	-	-	-	-	-	-	-
WWE532CA	F	JFB	05/28/98	09:48 PM	0	19.5	77	-	-	-	-	-	-	-	-	-	-	-	1
WWE532CA	F	JFB/DMG	06/25/98	09:20 PM	0	26.0	78	-	-	-	-	-	-	-	-	-	-	-	1
WWE532LK	F	JFB/RAZ	04/08/93	10:28 PM	0	8.0	-	-	-	-	-	-	-	-	-	-	-	-	-
WWE532LK	S	JFB	05/04/93	08:33 PM	2,3,4	16.0	90	-	-	-	-	-	-	-	-	-	-	-	-
WWE532LK	F	JFB/RAZ	05/25/93	10:40 PM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	4
WWE532LK	F	JFB/RAZ	06/03/93	09:19 PM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	4
WWE532LK	S	JFB/RAZ	02/28/98	11:45 AM	1,4	18.0	39	-	-	-	-	-	-	-	-	-	-	-	-
WWE532LK	F	JFB	03/27/98	11:15 PM	2,4	19.0	65	-	-	-	-	-	-	-	-	-	-	-	-
WWE532LK	F	JFB	04/29/98	09:08 PM	0,4	14.5	60	-	-	-	-	-	-	-	-	-	-	-	1
WWE532LK	F	JFB	05/28/98	09:55 PM	0	18.0	73	-	-	-	-	-	-	-	1	-	-	-	4
WWE532LK	F	JFB/DMG	06/25/98	09:27 PM	0	26.0	78	-	1	-	-	-	-	-	2	-	-	-	2
WWE563DW	F	JFB/RAZ	04/08/93	09:58 PM	0	8.0	-	-	-	-	-	1	-	-	-	-	-	1	-
WWE563DW	F	JFB	05/04/93	08:56 PM	2,4	16.5	95	-	4	4	-	4	-	-	-	-	-	1	-
WWE563DW	F	JFB/RAZ	06/03/93	09:28 PM	1	17.0	81	-	+	+	-	-	-	-	2	-	-	-	2
WWE563DW	F	JFB	03/27/98	11:01 PM	2	19.0	58	-	-	-	-	-	-	-	-	-	-	-	-
WWE563DW	F	JFB	04/29/98	08:39 PM	0,4	15.5	60	-	-	-	-	-	-	-	-	-	-	-	-
WWE563DW	F	JFB	05/28/98	10:10 PM	0	18.0	81	-	-	-	-	-	-	-	-	-	-	-	1
WWE563DW	F	JFB/DMG	06/25/98	09:37 PM	0	26.0	81	-	-	-	-	-	-	-	-	-	-	-	-
WWE563UP	F	JFB/RAZ	04/08/93	09:58 PM	0	8.0	-	-	-	-	-	-	-	-	-	-	-	-	-
WWE563UP	F	JFB	05/04/93	08:56 PM	2,4	16.5	95	-	-	-	-	-	-	-	1	-	-	-	2
WWE563UP	F	JFB/RAZ	06/03/93	09:28 PM	1	17.0	81	-	-	-	-	-	-	-	2	-	-	-	2
WWE563UP	F	JFB	03/27/98	11:01 PM	2	19.0	58	-	-	-	-	-	-	-	-	-	-	-	-
WWE563UP	F	JFB	04/29/98	08:39 PM	0,4	15.5	60	-	-	-	-	1	-	-	-	-	-	-	1
WWE563UP	F	JFB	05/28/98	10:10 PM	0	18.0	81	-	-	-	-	-	-	-	2	-	-	-	2
WWE563UP	F	JFB/DMG	06/25/98	09:37 PM	0	26.0	81	-	-	-	-	-	-	-	1	-	-	-	1
WWEDIKEP	F	JFB/RAZ	04/08/93	09:27 PM	0	8.0	-	-	-	-	-	4	-	-	-	-	-	3	-
WWEDIKEP	F	JFB	05/04/93	09:29 PM	2,4	14.5	95	-	1	4	-	4	-	-	-	-	-	4	2
WWEDIKEP	F	JFB/RAZ	06/03/93	10:01 PM	1	15.0	95	-	-	1	-	-	-	-	2	-	-	2	2
WWEDIKEP	S	JFB/RAZ	02/28/98	04:30 PM	1,4,5	13.0	86	-	-	-	-	-	-	-	-	-	-	-	-
WWEDIKEP	F	JFB	03/27/98	10:22 PM	2	18.5	65	-	-	-	-	-	-	-	-	-	-	4	-
WWEDIKEP	F	JFB	04/29/98	08:08 PM	0	16.0	69	-	-	-	-	-	-	-	-	-	-	-	3
WWEDIKEP	F	JFB/DMG	05/20/98	08:18 PM	1	23.0	68	-	-	2	-	-	-	-	3	-	-	-	2
WWEDIKEP	F	JFB/RAZ	06/24/98	08:53 PM	2	23.5	87	-	-	1	-	-	-	-	2	-	-	-	4

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
WWEEVANP	F	JFB/RAZ	04/08/93	09:21 PM	0	14.0	-	-	-	-	-	-	-	-	-	-	-	-	-
WWEEVANP	F	JFB	05/04/93	09:41 PM	2,4	17.0	95	-	-	-	-	-	-	-	-	-	-	-	-
WWEEVANP	F	JFB/RAZ	06/03/93	09:53 PM	1	17.0	95	-	-	-	-	-	-	-	-	-	-	-	-
WWESE563	F	JFB/RAZ	04/08/93	10:10 PM	0	8.0	-	-	-	-	-	2	-	-	-	-	-	-	-
WWESE563	F	JFB	05/04/93	08:50 PM	2,4	17.0	95	-	-	-	-	-	-	-	-	-	-	-	-
WWESE563	F	JFB/RAZ	06/03/93	09:24 PM	1	17.0	90	-	-	-	-	-	-	-	-	-	-	-	-
WWESPEED	F	JFB/RAZ	04/08/93	09:50 PM	0	10.0	-	-	-	-	-	-	-	-	-	-	-	-	-
WWESPEED	F	JFB	05/04/93	09:06 PM	2,4	15.5	90	-	-	-	-	-	-	-	-	-	-	-	1
WWESPEED	F	JFB/RAZ	06/03/93	09:37 PM	1	18.0	85	-	-	-	-	-	-	-	-	-	-	-	-
WWESPEED	F	JFB	03/27/98	10:47 PM	2	19.0	65	-	-	-	-	-	-	-	1	-	-	-	-
WWESPEED	F	JFB	04/29/98	08:32 PM	0	16.0	61	-	-	-	-	-	-	-	-	-	-	-	-
WWESPEED	F	JFB	05/28/98	10:19 PM	0	18.5	81	-	-	-	-	-	-	-	-	-	-	-	-
WWESPEED	F	JFB/DMG	06/25/98	09:47 PM	0	26.0	81	-	-	-	-	-	-	-	-	-	-	-	-
WWETUMBL	S	JFB/RAZ	02/28/98	04:31 PM	1,4,5	13.0	86	-	-	-	-	-	-	-	-	-	-	-	-
WWETUMBL	F	JFB	03/27/98	10:28 PM	2	19.5	58	-	-	-	-	-	-	-	-	-	-	-	-
WWETUMBL	F	JFB	04/29/98	08:16 PM	0	15.5	66	-	-	-	-	-	-	-	-	-	-	-	-
WWETUMBL	F	JFB/DMG	05/20/98	08:26 PM	1	23.0	68	-	-	-	-	-	-	-	-	-	-	-	-
WWETUMBL	F	JFB/RAZ	06/24/98	09:03 PM	2	24.0	96	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 6.1.1. Anuran-vocalization monitoring sites in the Bass River and Oswego River drainage basins. Refer to Methods for survey details. 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, Location, and Listening Point	Site Code
Allen pond Bass River Twp., Burlington Co. (lat 39°38'56.89", long 74°26'38.21", Oswego Lake quad). Eastern side of Allen Road, between Bartletts Branch and Oswego Road [western shoreline].	ABAALLEN
Dans Bridge Branch above Dans Bridge Road Bass River Twp., Burlington Co. (lat 39°38'11.97", long 74°25'34.70", Oswego Lake quad). Upstream from Dans Bridge Road [Dans Bridge Road at bridge].	ADADANRD
Dans Bridge Branch tributary above Dans Bridge Road Bass River Twp., Burlington Co. (lat 39°37'57.67", long 74°25'53.99", Oswego Lake quad). Upstream from Dans Bridge Road, between Stage Road and Dans Bridge Branch [Dans Bridge Road at outlet].	ADATRDED
Lake Absegami below bridge Bass River Twp., Burlington Co. (lat 39°37'19.49", long 74°25'21.61", New Gretna quad). Impoundment on Tommys Branch downstream from Phillip Road, near main entrance to Bass River State Park [Phillip Road at bridge].	AEAABSDW
East Branch Bass River above Dans Bridge Road Bass River Twp., Burlington Co. (lat 39°38'27.68", long 74°25'11.91", Oswego Lake quad). Upstream from Dans Bridge Road [sand road on southern side of stream].	AEADANRD
East Branch Bass River above Stage Road Bass River Twp., Burlington Co. (lat 39°37'24.00", long 74°26'27.95", New Gretna quad). Upstream from Stage Road [Stage Road at bridge].	AEASTAGE
Lake Absegami above bridge Bass River Twp., Burlington Co. (lat 39°37'19.49", long 74°25'21.61", New Gretna quad). Unnamed tributary upstream from Phillip Road, near main entrance to Bass River State Park [Phillip Road at bridge].	AEATRLUP
Tommys Branch impoundment above Dans Bridge Road Bass River Twp., Burlington Co. (lat 39°38'22.70", long 74°24'19.07", Oswego Lake quad). Upstream from Dans Bridge Road [Dans Bridge Road at outlet].	ATOMMYIM
West Branch Bass River upstream of second dike above Stage Road Bass River Twp., Burlington Co. (lat 39°37'57.72", long 74°26'32.83", Oswego Lake quad). Downstream from second dike above Stage Road [near center of dike].	AWEPILGD
West Branch Bass River above Pilgrim Lake-upper Bass River Twp., Burlington Co. (lat 39°37'57.72", long 74°26'32.83", Oswego Lake quad). Upstream from second dike above Stage Road [near center of dike].	AWEPILGU
Small Allen pond Bass River Twp., Burlington Co. (lat 39°37'50.24", long 74°26'47.21", Oswego Lake quad). West of intersection of Martha and Allen Roads [Martha Road].	AWESMALL
West Branch Bass River above Stage Road Bass River Twp., Burlington Co., (lat 39°37'27.38", long 74°26'45.22", New Gretna quad). Upstream from Stage Road [Stage Road at bridge].	AWESTAGE

Site Name, Location, and Listening Point	Site Code
Breeches Branch impoundment above Jenkins Road Washington Twp., Burlington Co. (lat 39°44'04.86", long 74°29'31.36", Oswego Lake quad). Impoundment upstream from Jenkins Road [Jenkins Road at bridge].	OBRESTRM
Dry Branch impoundment above Route 539 Stafford Twp., Ocean Co. (lat 39°44'49.95", long 74°22'12.08", West Creek quad). Adjacent to restaurant parking area, just west of intersection of Warren Grove-Whiting (Route 539) and Sim Place Roads [western shoreline].	ODRYLUCY
Oswego River impoundment above Beaver Dam Road Stafford Twp., Ocean Co. (lat 39°44'59.02", long 74°22'38.45", Oswego Lake quad). Impoundment on secondary channel, upstream from Beaver Dam Road, near Sim Place Road [Beaver Dam Road near outlet].	OOSBEAVI
Oswego River above Beaver Dam Road Stafford Twp., Ocean Co. (lat 39°44'54.62", long 74°22'32.79", Oswego Lake quad). Upstream from Beaver Dam Road [Beaver Dam Road at bridge].	OOSBEAVR
Oswego Lake borrow pit Washington Twp., Burlington Co. (lat 39°44'02.62", long 74°29'35.93", Oswego Lake quad). Western side of intersection of Jenkins and Little Hawkin Roads [Jenkins Road].	OOSBOROW
Oswego River impoundment above Old Cedar Bridge-Barnegat Road Union Twp., Ocean Co. (lat 39°47'05.05", long 74°21'38.29", Brookville quad). Impoundment upstream from Old Cedar Bridge-Barnegat Road, south of Barnegat Road (Route 72) [southeastern shoreline].	OOSCEDRI
Harrisville Pond canal Bass River Twp., Burlington Co. (lat 39°39'42.73", long 74°31'14.91", Jenkins quad). Western side of Harrisville-Martha Road, at first road bend east of Harrisville-Chatsworth Road (Route 679) [Harrisville-Martha Road near bend].	OOSHARCA
Harrisville Pond Washington/Bass River Twp., Burlington Co. (lat 39°39'53.11", long 74°31'26.44", Jenkins quad). Impoundment on Oswego River, upstream from Harrisville-Chatsworth Road (Route 679) [western shoreline between outlets].	OOSHARLK
Oswego River tributary impoundment above Cabin Road Washington Twp., Burlington Co. (lat 39°44'27.56", long 74°28'00.90", Oswego Lake quad). Impoundment upstream from Cabin Road, south of Penn Place (Deer Run) Road [Cabin Road].	OOSHERBI
Oswego River tributary below Cabin Road Washington Twp., Burlington Co. (lat 39°44'30.13", long 74°28'04.41", Oswego Lake quad). Downstream from Cabin Road, south of Penn Place (Deer Run) Road [Cabin Road].	OOSHERBP
Eastern hidden pond on Jenkins Road Bass River Twp., Burlington Co. (lat 39°44'55.00", long 74°26'23.22", Oswego Lake quad). Eastern pond on southern side of Jenkins Road, east of Papoose Branch [Jenkins Road].	OOSHIDEE
Western hidden pond on Jenkins Road Bass River Twp., Burlington Co. (lat 39°44'50.17", long 74°26'33.19", Oswego Lake quad). Western pond on southern side of Jenkins Road, east of Papoose Branch [Jenkins Road].	OOSHIDEW
Oswego River impoundment at Howardsville Union Twp., Ocean Co. (lat 39°49'01.32", long 74°21'59.86", Brookville quad). Uppermost impoundment at Howardsville, east of Howardsville Road [dike near outlet].	OOSHOWIM
Howardsville pond Union Twp., Ocean Co. (lat 39°48'59.53", long 74°22'09.26", Brookville quad). Just west of the northern end of Howardsville Road [Howardsville Road].	OOSHOWPD
Northern Sim Place bog Bass River Twp., Burlington Co. (lat 39°44'31.35", long 74°27'04.86", Oswego Lake quad). Northern side of Jenkins Road, just east of Papoose Branch [southeast corner at Jenkins Road].	OOSSIMNO

Site Name, Location, and Listening Point	Site Code
Cranberry bogs on Jenkins Road Bass River Twp., Burlington Co. (lat 39°44'31.35", long 74°27'04.86", Oswego Lake quad). Northern and southern side of Jenkins Road, just east of Papoose Branch [Jenkins Road].	OOSSIMPL
Southern Sim Place bog Bass River Twp., Burlington Co. (lat 39°44'31.35", long 74°27'04.86", Oswego Lake quad). Southern side of Jenkins Road, just east of Papoose Branch [northeast corner at Jenkins Road].	OOSSIMSO
Oswego Lake Washington/Bass River Twp., Burlington Co. (lat 39°44'04.11", long 74°29'31.46", Oswego Lake quad). Impoundment south of Jenkins Road [Jenkins Road at bridge].	OOSWLAKE
Oswego River pockmark pond Washington Twp., Burlington Co. (lat 39°44'32.69", long 74°28'08.06", Oswego Lake quad). Eastern side of intersection of Cabin and Penn Place (Deer Run) Roads [Cabin Road].	OOSWPOCK
Plains Branch impoundment above Beaver Dam Road Bass River Twp., Burlington Co. (lat 39°45'45.58", long 74°24'10.92", Woodmansie quad). Impoundment upstream from Beaver Dam Road [just east of outlet at Beaver Dam Road].	OPLBEAVR
Large Plains Branch tributary impoundment above Baptist Road Bass River Twp., Burlington Co. (lat 39°46'05.07", long 74°24'44.81", Woodmansie quad). Impoundment upstream from intersection of unnamed sand road and Long Causeway Road [western shoreline].	OPLTRIMP
Plains Branch tributary impoundment above Jenkins Road Woodland Twp., Burlington Co. (lat 39°46'53.89", long 74°24'15.19", Woodmansie quad). Impoundment upstream from Jenkins Road (Stevenson Road) [Stevenson Road at outlet].	OPLTRMOR
Yellow Dam Branch impoundment on western side of Old Half Way Road Union Twp., Ocean Co. (lat 39°47'16.17", long 74°21'50.14", Brookville quad). Western side of Old Half Way Road, south of Barnegat Road (Route 72) [Old Half Way Road].	OYEHALFI
Old Half Way Road pond Union Twp., Ocean Co. (lat 39°47'27.20", long 74°21'59.00", Brookville quad). East of intersection of Barnegat Road (Route 72) and Old Half Way Road [Old Half Way Road].	OYEHALFP

Appendix 6.1.2. Maximum calling ranks for 12 anuran species at monitoring sites in the Bass River and Oswego River drainage basins. Data type is F = formal survey or S = supplemental data. Observers are JFB = John F. Bunnell, DMG = Dennis M. Gray, and RAZ = Robert A. Zampella. 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 calling ranks are 1 = 1, 2 = 2-5, 3 = 6-10, and 4 > 10 individuals calling. A plus sign (+) indicates that a species was vocalizing at a site, but no calling rank was recorded. The letter " v " refers to the visual observation of a species that was not 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 6.1.1 for detailed site information and Appendix 6.7 for full scientific and common names.

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
ABAALLEN	F	JFB	04/28/93	08:38 PM	0	10.5	57	-	-	-	-	4	-	-	-	-	-	4	-
ABAALLEN	F	JFB/RAZ	05/25/93	08:27 PM	1	23.0	69	-	-	4	-	-	-	-	4	-	-	2	2
ABAALLEN	F	JFB/RAZ	06/29/93	11:15 PM	2,5	23.0	83	-	-	-	-	-	-	-	2	-	-	-	-
ABAALLEN	S	JFB	03/18/99	03:04 PM	0,4	22.0	28	-	-	-	-	-	-	-	-	-	-	2	-
ABAALLEN	F	JFB/DMG	03/24/99	07:02 PM	2	12.5	94	-	-	-	-	-	-	-	-	-	1	3	-
ABAALLEN	F	JFB/DMG	04/07/99	07:52 PM	0	12.0	61	-	-	-	-	1	-	-	-	-	-	3	2
ABAALLEN	F	JFB/RAZ	05/26/99	11:19 PM	2	17.5	64	-	-	-	-	-	-	-	-	-	-	2	1
ABAALLEN	F	JFB	06/28/99	09:12 PM	0	24.0	92	-	-	2	-	-	-	-	-	-	-	-	-
ADADANRD	F	JFB	04/28/93	08:02 PM	0	10.0	53	-	-	-	-	-	-	-	-	-	-	-	-
ADADANRD	F	JFB/RAZ	05/25/93	09:28 PM	1	21.0	75	-	-	-	-	-	-	-	-	-	-	-	-
ADADANRD	F	JFB/RAZ	06/29/93	11:03 PM	2	23.0	83	-	-	-	-	-	-	-	-	-	-	-	1
ADADANRD	F	JFB/DMG	03/24/99	07:32 PM	2	12.0	100	-	-	-	-	-	-	-	-	-	-	-	-
ADADANRD	F	JFB/DMG	04/07/99	08:30 PM	0	11.0	75	-	-	-	-	-	-	-	-	-	-	-	-
ADADANRD	F	JFB/RAZ	05/26/99	10:39 PM	2	17.5	56	-	-	-	-	-	-	-	-	-	-	-	-
ADADANRD	F	JFB	06/28/99	10:01 PM	0	24.0	92	-	-	-	-	-	-	-	-	-	-	-	-
ADATRDED	F	JFB	04/28/93	08:11 PM	0	11.0	63	-	-	-	-	-	-	-	-	-	-	-	-
ADATRDED	F	JFB/RAZ	05/25/93	09:33 PM	1	20.0	79	-	-	-	-	-	-	-	1	-	-	-	-
ADATRDED	F	JFB/RAZ	06/29/93	11:06 PM	2,5	23.0	83	-	-	-	-	-	-	-	-	-	-	-	-
ADATRDED	F	JFB/DMG	03/24/99	07:26 PM	2	13.0	94	-	-	-	-	-	-	-	-	-	-	-	-
ADATRDED	F	JFB/DMG	04/07/99	08:24 PM	0	11.0	80	-	-	-	-	3	-	-	-	-	-	2	-
ADATRDED	F	JFB/RAZ	05/26/99	10:33 PM	2	18.0	55	-	-	-	-	-	-	-	-	-	-	-	-
ADATRDED	F	JFB	06/28/99	09:55 PM	0	24.0	92	-	-	-	-	-	-	-	-	-	-	-	-
AEAABSDW	F	JFB	04/28/93	07:25 PM	0	12.0	47	-	-	-	-	-	-	-	-	-	-	-	-
AEAABSDW	F	JFB/RAZ	05/25/93	08:54 PM	1	24.0	63	-	-	-	-	-	-	-	2	-	-	-	3
AEAABSDW	F	JFB/RAZ	06/29/93	10:43 PM	2	24.5	91	-	-	-	-	-	-	-	3	-	-	-	3
AEAABSDW	F	JFB/DMG	03/24/99	08:10 PM	2	12.0	100	-	-	-	-	-	-	-	-	-	-	-	-
AEAABSDW	F	JFB/DMG	04/07/99	09:10 PM	0	12.0	80	-	-	-	-	-	-	-	-	-	-	2	-
AEAABSDW	F	JFB/RAZ	05/26/99	10:24 PM	2	18.5	57	-	-	-	-	-	-	-	2	-	-	-	2
AEAABSDW	F	JFB	06/28/99	09:38 PM	0	24.0	92	-	1	-	-	-	-	-	2	-	-	-	2
AEADANRD	F	JFB	04/28/93	07:53 PM	0	13.0	50	-	-	-	-	-	-	-	-	-	-	-	2
AEADANRD	F	JFB/RAZ	05/25/93	09:17 PM	1	22.5	75	-	2	4	-	-	-	-	4	-	-	-	4
AEADANRD	F	JFB/RAZ	06/29/93	10:57 PM	2	22.0	91	-	-	-	-	-	-	-	4	-	-	-	3
AEADANRD	F	JFB/DMG	03/24/99	07:39 PM	2	11.5	100	-	-	-	-	-	-	-	-	-	-	-	-
AEADANRD	F	JFB/DMG	04/07/99	08:37 PM	0	10.0	80	-	-	-	-	-	-	-	-	-	-	1	-
AEADANRD	F	JFB/RAZ	05/26/99	10:45 PM	2	18.0	57	-	-	-	-	-	-	-	2	-	-	-	2

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
AEADANRD	F	JFB	06/28/99	10:08 PM	0	24.0	92	-	-	-	-	-	-	-	2	-	-	-	1
AEASTAGE	F	JFB	04/28/93	07:35 PM	0	14.0	48	-	-	-	-	-	-	-	-	-	-	-	-
AEASTAGE	F	JFB/RAZ	05/25/93	09:03 PM	1	22.0	76	-	-	-	-	-	-	-	-	-	-	-	-
AEASTAGE	F	JFB/RAZ	06/29/93	10:49 PM	2	22.0	87	-	-	-	-	-	-	-	1	-	-	-	-
AEASTAGE	F	JFB/DMG	03/24/99	08:02 PM	2	11.5	100	-	-	-	-	-	-	-	-	-	-	-	-
AEASTAGE	F	JFB/DMG	04/07/99	08:59 PM	0	12.0	62	-	-	-	-	-	-	-	-	-	-	-	-
AEASTAGE	F	JFB/RAZ	05/26/99	10:15 PM	2	18.5	60	-	-	-	-	-	-	-	-	-	-	-	-
AEASTAGE	F	JFB	06/28/99	09:46 PM	0	24.0	96	-	-	-	-	-	-	-	-	-	-	-	-
AEATRLUP	F	JFB	04/28/93	07:25 PM	0	12.0	47	-	-	-	-	-	-	-	-	-	-	-	-
AEATRLUP	F	JFB/RAZ	05/25/93	08:54 PM	1	24.0	63	-	-	-	-	-	-	-	1	-	-	1	2
AEATRLUP	F	JFB/RAZ	06/29/93	10:43 PM	2	24.5	91	-	-	-	-	-	-	-	2	-	-	-	-
AEATRLUP	F	JFB/DMG	03/24/99	08:10 PM	2	12.0	100	-	-	-	-	-	-	-	-	-	-	-	-
AEATRLUP	F	JFB/DMG	04/07/99	09:10 PM	0	12.0	80	-	-	-	-	-	-	-	-	-	-	1	-
AEATRLUP	F	JFB/RAZ	05/26/99	10:24 PM	2	18.5	57	-	-	-	-	-	-	-	2	-	-	-	-
AEATRLUP	F	JFB	06/28/99	09:38 PM	0	24.0	92	-	-	-	-	-	-	-	1	-	-	-	1
ATOMMYIM	F	JFB/DMG	03/24/99	07:48 PM	2	12.0	100	-	-	-	-	-	-	-	-	-	-	2	-
ATOMMYIM	F	JFB/DMG	04/07/99	08:44 PM	0	10.0	65	-	-	-	-	-	-	-	-	-	-	3	2
ATOMMYIM	F	JFB/RAZ	05/26/99	10:55 PM	2	17.5	56	-	-	-	-	-	-	-	3	-	-	2	2
ATOMMYIM	F	JFB	06/28/99	10:14 PM	0	24.0	96	-	4	-	-	-	-	-	2	-	-	-	3
AWEPILGD	F	JFB/DMG	03/24/99	07:13 PM	2	13.0	94	-	-	-	-	-	-	-	-	-	-	2	-
AWEPILGD	F	JFB/DMG	04/07/99	08:06 PM	0	14.0	54	-	-	-	-	1	-	-	-	-	-	3	-
AWEPILGD	F	JFB/RAZ	05/26/99	11:29 PM	2	17.5	64	-	-	-	-	-	-	-	1	-	-	1	3
AWEPILGD	F	JFB	06/28/99	09:23 PM	0	23.5	96	-	-	-	-	-	-	-	-	-	-	1	2
AWEPILGU	F	JFB/DMG	03/24/99	07:13 PM	2	13.0	94	-	-	-	-	-	-	-	-	-	-	-	-
AWEPILGU	F	JFB/DMG	04/07/99	08:06 PM	0	14.0	54	-	-	-	-	-	-	-	-	-	-	-	-
AWEPILGU	F	JFB/RAZ	05/26/99	11:29 PM	2	17.5	64	-	-	-	-	-	-	-	2	-	-	-	1
AWEPILGU	F	JFB	06/28/99	09:23 PM	0	23.5	96	-	-	-	-	-	-	-	2	-	-	-	1
AWESMALL	F	JFB	04/28/93	08:30 PM	0	12.0	62	-	-	+	-	4	-	-	-	-	-	-	-
AWESMALL	F	JFB/RAZ	05/25/93	08:46 PM	1	23.0	72	-	-	+	-	-	-	-	-	-	-	-	-
AWESMALL	F	JFB/RAZ	06/29/93	11:21 PM	2	24.0	87	-	-	-	-	-	-	-	-	-	-	-	-
AWESMALL	S	JFB	03/18/99	02:57 PM	0,4	22.0	28	-	-	-	-	-	-	-	-	-	-	-	-
AWESMALL	F	JFB/DMG	03/24/99	06:53 PM	2	14.5	89	-	-	-	-	-	-	-	-	-	-	-	-
AWESMALL	F	JFB/DMG	04/07/99	08:13 PM	0	13.0	65	-	-	-	-	2	-	-	-	-	-	-	-
AWESMALL	F	JFB/RAZ	05/26/99	11:08 PM	2	17.5	56	-	-	-	-	-	-	-	-	-	-	-	-
AWESMALL	F	JFB	06/28/99	09:30 PM	0	23.5	96	-	-	1	-	-	-	-	-	-	-	-	-
AWESTAGE	F	JFB	04/28/93	08:21 PM	0	11.0	54	-	-	-	-	-	-	-	-	-	-	-	-
AWESTAGE	F	JFB/RAZ	06/29/93	11:09 PM	2,5	23.0	84	-	-	-	-	-	-	-	-	-	-	-	-
OBRESTRM	F	JFB/RAZ	04/20/93	09:47 PM	0,4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OBRESTRM	F	JFB/RAZ	05/11/93	08:50 PM	0	26.0	71	-	-	-	-	-	-	-	-	-	-	-	-
OBRESTRM	F	JFB/RAZ	06/29/93	09:59 PM	2	23.0	80	-	-	-	-	-	-	-	1	-	-	-	4
OBRESTRM	F	JFB	03/23/99	08:12 PM	2,4	9.0	68	-	-	-	-	-	-	-	-	-	-	-	-
OBRESTRM	F	JFB	04/08/99	10:34 PM	0	14.5	77	-	-	-	-	-	-	-	-	-	-	3	2
OBRESTRM	F	JFB/DMG	05/12/99	11:11 PM	2	15.5	90	-	2	-	-	-	-	-	1	-	-	1	3
OBRESTRM	F	JFB/RAZ	06/14/99	08:41 PM	7	21.0	100	-	-	-	-	-	-	-	-	-	-	-	2
ODRYLUCY	F	JFB	03/23/99	06:48 PM	2,4	7.5	68	-	-	-	-	-	-	-	-	-	-	-	-
ODRYLUCY	F	JFB	04/08/99	08:53 PM	0	18.0	56	-	-	-	-	2	-	-	-	-	-	2	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
ODRYLUCY	F	JFB/DMG	05/12/99	09:27 PM	2	17.0	85	-	2	-	-	-	-	-	-	-	-	1	-
ODRYLUCY	F	JFB/RAZ	06/14/99	09:58 PM	2	20.0	100	-	2	-	-	-	-	-	-	-	-	-	-
OOSBEAVI	S	JFB/RAZ	05/11/93	10:26 PM	0	23.5	83	-	-	-	-	-	-	-	-	-	-	-	4
OOSBEAVI	F	JFB	03/23/99	06:55 PM	2	8.5	73	-	-	-	-	-	-	-	-	-	-	3	-
OOSBEAVI	F	JFB	04/08/99	08:59 PM	0	16.0	76	-	-	-	-	-	-	-	-	-	-	4	3
OOSBEAVI	F	JFB/DMG	05/12/99	09:33 PM	2	17.0	80	-	-	-	-	-	-	-	2	-	-	2	3
OOSBEAVI	F	JFB/RAZ	06/14/99	09:53 PM	2	20.0	100	-	-	1	-	-	-	-	-	-	-	-	-
OOSBEAVR	F	JFB/RAZ	04/20/93	08:53 PM	0,4	15.0	80	-	-	-	-	-	-	-	-	-	-	-	2
OOSBEAVR	F	JFB/RAZ	05/11/93	10:13 PM	0	23.0	73	-	-	-	-	-	-	-	4	-	-	-	4
OOSBEAVR	F	JFB/RAZ	06/29/93	09:14 PM	2	23.0	80	-	-	-	-	-	-	-	3	-	-	-	3
OOSBEAVR	F	JFB	03/23/99	07:01 PM	2	8.5	73	-	-	-	-	-	-	-	-	-	-	-	-
OOSBEAVR	F	JFB	04/08/99	09:05 PM	0	16.0	76	-	-	-	-	-	-	-	-	-	-	-	-
OOSBEAVR	F	JFB/DMG	05/12/99	09:39 PM	2	17.0	80	-	-	-	-	-	-	-	-	-	-	-	-
OOSBEAVR	F	JFB/RAZ	06/14/99	09:48 PM	2	20.0	100	-	-	-	-	-	-	-	-	-	-	-	2
OOSBOROW	F	JFB/RAZ	04/20/93	09:56 PM	0,4	15.0	71	-	-	-	-	+	-	-	-	-	-	+	-
OOSBOROW	F	JFB/RAZ	05/11/93	08:42 PM	0	26.0	67	-	1	3	-	-	-	-	2	-	-	1	2
OOSBOROW	F	JFB/RAZ	06/29/93	10:06 PM	2	22.0	76	-	-	-	-	-	-	-	2	-	-	-	-
OOSBOROW	S	JFB	03/18/99	02:11 PM	0,4	23.0	25	-	-	-	-	-	-	-	-	-	-	-	-
OOSBOROW	F	JFB	03/23/99	08:18 PM	2,4	9.0	68	-	-	-	-	2	-	-	-	-	-	-	-
OOSBOROW	F	JFB	04/08/99	10:43 PM	0	14.5	77	-	-	-	-	2	-	-	-	-	-	1	-
OOSBOROW	F	JFB/DMG	05/12/99	11:22 PM	2	15.5	90	-	-	-	-	-	-	-	2	-	-	1	-
OOSBOROW	F	JFB/RAZ	06/14/99	08:35 PM	7	21.0	100	-	1	-	-	-	-	-	-	-	-	-	-
OOSCEDRI	F	JFB	03/23/99	06:32 PM	2	7.5	78	-	-	-	-	-	-	-	-	-	-	-	-
OOSCEDRI	F	JFB	04/08/99	08:35 PM	0	16.5	58	-	-	-	-	-	-	-	-	-	-	4	-
OOSCEDRI	F	JFB/DMG	05/12/99	09:12 PM	2	16.5	85	-	-	-	-	-	-	-	-	-	-	-	3
OOSCEDRI	F	JFB/RAZ	06/14/99	10:20 PM	2	20.0	100	-	2	-	-	-	-	-	-	-	-	-	3
OOSHARCA	S	JFB	03/11/99	01:45 PM	0,4	8.5	55	-	-	-	-	-	-	-	-	-	4	-	-
OOSHARCA	F	JFB	03/18/99	02:25 PM	0,4	21.0	29	-	-	-	-	-	-	-	-	-	4	-	-
OOSHARCA	S	JFB	03/23/99	08:33 PM	2	10.0	68	-	-	-	-	-	-	-	-	-	-	-	-
OOSHARCA	F	JFB/DMG	04/07/99	09:50 PM	0	8.0	64	-	-	-	-	3	-	-	-	-	-	-	-
OOSHARCA	F	JFB/RAZ	05/26/99	09:35 PM	2	19.0	56	-	-	-	-	-	-	-	-	-	-	-	-
OOSHARCA	F	JFB	06/28/99	10:57 PM	1	24.0	92	-	-	-	-	-	-	-	-	-	-	-	-
OOSHARLK	F	JFB/RAZ	05/25/93	10:19 PM	1	22.5	76	-	2	-	-	-	-	-	-	-	-	-	4
OOSHARLK	F	JFB/RAZ	06/29/93	10:23 PM	2	24.0	83	-	-	-	-	-	-	-	-	-	-	-	3
OOSHARLK	F	JFB	03/23/99	08:27 PM	2	10.0	68	-	-	-	-	-	-	-	-	-	-	-	-
OOSHARLK	F	JFB/DMG	04/07/99	10:03 PM	0	9.0	74	-	-	-	-	-	-	-	-	-	-	-	-
OOSHARLK	F	JFB/RAZ	05/26/99	09:29 PM	2	19.0	53	-	-	-	-	-	-	-	-	-	-	-	3
OOSHARLK	F	JFB	06/28/99	11:03 PM	1	24.0	92	-	-	-	-	-	-	-	-	-	-	-	3
OOSHERBI	S	JFB	03/18/99	01:52 PM	0,4	24.5	33	-	-	-	-	-	-	-	-	-	-	-	-
OOSHERBI	F	JFB	03/23/99	07:58 PM	2	8.5	78	-	-	-	-	-	-	-	-	-	-	-	-
OOSHERBI	F	JFB	04/08/99	10:14 PM	0	14.0	82	-	-	-	-	-	-	-	-	-	-	-	-
OOSHERBI	F	JFB/DMG	05/12/99	10:55 PM	2	16.0	89	-	-	-	-	-	-	-	-	-	-	-	-
OOSHERBI	F	JFB/RAZ	06/14/99	08:55 PM	5	21.0	100	-	-	-	-	-	-	-	-	-	-	-	-
OOSHERBP	S	JFB	03/18/99	01:59 PM	0,4	24.5	33	-	-	-	-	-	-	-	-	-	-	-	-
OOSHERBP	F	JFB	04/08/99	10:20 PM	0	14.0	82	-	-	-	-	-	-	-	-	-	-	-	-
OOSHERBP	F	JFB/RAZ	06/14/99	08:55 PM	5	21.0	100	-	-	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
OOSHIDEE	F	JFB/RAZ	04/20/93	09:29 PM	0,4	-	-	-	-	+	-	-	-	-	-	-	-	-	-
OOSHIDEE	F	JFB/RAZ	05/11/93	09:31 PM	0	26.0	74	-	2	4	-	2	-	-	-	-	-	2	2
OOSHIDEE	S	JFB	03/18/99	01:20 PM	0,4	26.0	31	-	-	-	-	-	-	-	-	-	-	-	-
OOSHIDEE	F	JFB	03/23/99	07:38 PM	2	7.0	66	-	-	-	-	-	-	-	-	-	-	3	-
OOSHIDEE	F	JFB	04/08/99	09:45 PM	0	14.5	71	-	-	-	-	2	-	-	-	-	-	4	1
OOSHIDEE	F	JFB/DMG	05/12/99	10:26 PM	2	15.0	84	-	1	-	-	-	-	-	-	-	-	-	4
OOSHIDEE	F	JFB/RAZ	06/14/99	09:12 PM	9	20.0	100	-	-	-	-	-	-	-	-	-	-	-	-
OOSHIDEW	F	JFB/RAZ	04/20/93	09:35 PM	0,4	-	-	-	-	+	-	-	-	-	-	-	-	-	-
OOSHIDEW	F	JFB/RAZ	05/11/93	09:37 PM	0	26.0	74	-	2	4	-	2	-	-	-	-	-	2	2
OOSHIDEW	S	JFB	03/18/99	01:28 PM	0,4	26.0	31	-	-	-	-	-	-	-	-	-	-	-	-
OOSHIDEW	F	JFB	03/23/99	07:44 PM	2	7.0	66	-	-	-	-	2	-	-	-	-	-	2	-
OOSHIDEW	F	JFB	04/08/99	09:57 PM	0	14.0	71	-	-	-	-	4	-	-	-	-	-	4	2
OOSHIDEW	F	JFB/DMG	05/12/99	10:33 PM	2	15.0	84	-	-	2	-	1	-	-	-	-	-	-	4
OOSHIDEW	F	JFB/RAZ	06/14/99	09:08 PM	9	20.0	100	-	-	-	-	-	-	-	-	-	-	-	-
OOSHOWIM	F	JFB	03/23/99	06:13 PM	2,4	7.0	59	-	-	-	-	-	-	-	-	-	-	-	-
OOSHOWIM	F	JFB	04/08/99	07:54 PM	0	17.5	46	-	-	-	-	-	-	-	-	-	-	3	2
OOSHOWIM	F	JFB/DMG	05/12/99	08:36 PM	2,4	16.5	85	-	2	-	-	-	-	-	1	-	-	2	2
OOSHOWIM	F	JFB/RAZ	06/14/99	10:36 PM	2	20.0	100	-	1	-	-	-	-	-	1	-	-	2	4
OOSHOWPD	F	JFB	03/18/99	12:47 PM	0,4	24.5	32	-	-	-	-	1	-	-	-	-	-	-	-
OOSHOWPD	S	JFB	03/23/99	06:00 PM	2,4	7.0	59	-	-	-	-	-	-	-	-	-	-	-	-
OOSHOWPD	F	JFB	04/08/99	08:06 PM	0	16.0	54	-	-	-	-	2	-	-	-	-	-	2	-
OOSHOWPD	F	JFB/DMG	05/12/99	08:46 PM	2	15.5	80	-	-	2	-	1	-	-	1	-	-	-	2
OOSHOWPD	F	JFB/RAZ	06/14/99	10:45 PM	2	20.0	100	-	-	1	-	-	-	-	-	-	-	-	1
OOSSIMNO	F	JFB	03/23/99	07:51 PM	2	7.5	73	-	-	-	-	-	-	-	-	-	-	2	-
OOSSIMNO	F	JFB	04/08/99	10:07 PM	0	14.0	75	-	-	-	-	2	-	-	-	-	-	4	2
OOSSIMNO	F	JFB/DMG	05/12/99	10:43 PM	2	14.5	89	-	-	-	-	-	-	-	2	-	-	-	1
OOSSIMNO	F	JFB/RAZ	06/14/99	09:02 PM	5	20.0	100	-	-	-	-	-	-	-	-	-	-	-	-
OOSSIMPL	F	JFB/RAZ	05/11/93	09:22 PM	0	25.0	74	-	3	-	-	-	-	-	-	-	-	3	3
OOSSIMPL	F	JFB/RAZ	06/29/93	09:44 PM	2	23.0	83	-	-	+	-	-	-	-	4	-	-	2	-
OOSSIMSO	F	JFB	03/23/99	07:51 PM	2	7.5	73	-	-	-	-	-	-	-	-	-	-	-	-
OOSSIMSO	F	JFB	04/08/99	10:07 PM	0	14.0	75	-	-	-	-	2	-	-	-	-	-	2	1
OOSSIMSO	F	JFB/DMG	05/12/99	10:43 PM	2	14.5	89	-	-	-	-	1	-	-	-	-	-	-	2
OOSSIMSO	F	JFB/RAZ	06/14/99	09:02 PM	5	20.0	100	-	-	-	-	-	-	-	-	-	-	-	-
OOSWLAKE	F	JFB/RAZ	04/20/93	09:47 PM	0,4	15.0	72	-	-	-	-	-	-	-	-	-	-	1	-
OOSWLAKE	F	JFB/RAZ	05/11/93	08:50 PM	0	26.0	71	-	-	-	-	-	-	-	1	-	-	-	4
OOSWLAKE	F	JFB/RAZ	06/29/93	09:59 PM	2	23.0	80	-	-	-	-	-	-	-	2	-	-	-	4
OOSWLAKE	F	JFB	03/23/99	08:12 PM	2,4	9.0	68	-	-	-	-	-	-	-	-	-	-	-	-
OOSWLAKE	F	JFB	04/08/99	10:34 PM	0	14.5	77	-	-	-	-	-	-	-	-	-	-	-	1
OOSWLAKE	F	JFB/DMG	05/12/99	11:11 PM	2	15.5	90	-	2	-	-	-	-	-	2	-	-	-	2
OOSWLAKE	F	JFB/RAZ	06/14/99	08:41 PM	7	21.0	100	-	2	-	-	-	-	-	1	-	-	-	2
OOSWPOCK	F	JFB	03/18/99	01:40 PM	0,4	25.0	28	-	-	-	-	-	-	-	-	-	2	-	-
OOSWPOCK	S	JFB	03/23/99	08:04 PM	2	8.5	78	-	-	-	-	-	-	-	-	-	-	-	-
OOSWPOCK	F	JFB	04/08/99	10:26 PM	0	14.0	82	-	-	-	-	2	-	-	-	-	-	-	-
OOSWPOCK	F	JFB/DMG	05/12/99	11:00 PM	2	16.0	89	-	-	-	-	-	-	-	-	-	-	-	-
OOSWPOCK	F	JFB/RAZ	06/14/99	08:51 PM	7	21.0	100	-	-	1	-	-	-	-	-	-	-	-	-
OPLBEAVR	F	JFB/RAZ	04/20/93	09:02 PM	0,4	15.0	80	-	-	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
OPLBEAVR	F	JFB/RAZ	05/11/93	10:03 PM	0	22.0	83	-	-	-	-	-	-	-	-	-	-	-	-
OPLBEAVR	F	JFB/RAZ	06/29/93	09:22 PM	2	23.0	80	-	-	-	-	-	-	-	1	-	-	-	-
OPLBEAVR	F	JFB	03/23/99	07:08 PM	2	9.5	78	-	-	-	-	-	-	-	-	-	-	-	-
OPLBEAVR	F	JFB	04/08/99	09:11 PM	0	14.0	78	-	-	-	-	-	-	-	-	-	-	2	-
OPLBEAVR	F	JFB/DMG	05/12/99	09:48 PM	2	16.5	85	-	-	-	-	-	-	-	-	-	-	-	2
OPLBEAVR	F	JFB/RAZ	06/14/99	09:35 PM	5	20.0	96	-	-	-	-	-	-	-	1	-	-	-	2
OPLTRIMP	F	JFB	03/23/99	07:28 PM	2	9.0	84	-	-	-	-	-	-	-	-	-	-	-	-
OPLTRIMP	F	JFB	04/08/99	09:30 PM	0	12.0	80	-	-	-	-	-	-	-	-	-	-	3	-
OPLTRIMP	F	JFB/DMG	05/12/99	10:10 PM	2	15.5	90	-	-	3	-	1	-	-	-	-	-	2	4
OPLTRIMP	F	JFB/RAZ	06/14/99	09:18 PM	5	20.0	100	-	-	2	-	-	-	-	-	-	-	-	4
OPLTRMOR	F	JFB/RAZ	04/20/93	09:14 PM	0,4	15.0	75	-	-	1	-	4	-	-	-	-	-	3	-
OPLTRMOR	F	JFB/RAZ	05/11/93	09:47 PM	0	22.0	72	-	4	4	-	-	-	-	-	-	-	4	-
OPLTRMOR	F	JFB/RAZ	06/29/93	09:30 PM	2	23.0	76	-	-	-	-	-	-	-	-	-	-	-	-
OPLTRMOR	F	JFB	03/23/99	07:16 PM	2	9.5	78	-	-	-	-	2	-	-	-	-	-	2	-
OPLTRMOR	F	JFB	04/08/99	09:20 PM	0	11.0	80	-	-	-	-	2	-	-	-	-	-	2	1
OPLTRMOR	F	JFB/DMG	05/12/99	10:00 PM	2	15.5	89	-	-	-	-	-	-	-	-	-	-	-	-
OPLTRMOR	F	JFB/RAZ	06/14/99	09:27 PM	5	20.0	100	-	-	-	-	-	-	-	-	-	-	-	-
OYEHALFI	F	JFB/RAZ	04/20/93	08:29 PM	0,4	15.0	75	-	-	-	-	3	-	-	-	-	-	3	3
OYEHALFI	F	JFB/RAZ	05/11/93	10:51 PM	0	23.0	76	-	4	2	-	-	-	-	4	-	-	-	4
OYEHALFI	F	JFB/RAZ	06/29/93	08:56 PM	2	22.0	80	-	+	-	-	-	-	-	-	-	-	-	+
OYEHALFI	F	JFB	03/23/99	06:39 PM	2	7.5	78	-	-	-	-	-	-	-	-	-	-	-	-
OYEHALFI	F	JFB	04/08/99	08:24 PM	0	16.5	80	-	-	-	-	4	-	-	-	-	-	2	2
OYEHALFI	F	JFB/DMG	05/12/99	09:05 PM	2	16.0	80	-	-	-	-	-	-	-	1	-	-	2	4
OYEHALFI	F	JFB/RAZ	06/14/99	10:12 PM	2	20.0	100	-	2	-	-	-	-	-	2	-	-	-	3
OYEHALFP	F	JFB/RAZ	04/20/93	08:26 PM	0,4	15.0	75	-	-	-	-	-	-	-	-	-	-	-	-
OYEHALFP	F	JFB/RAZ	05/11/93	10:47 PM	0	23.0	73	-	4	-	-	-	-	-	1	-	-	-	-
OYEHALFP	F	JFB/RAZ	06/29/93	08:52 PM	2	22.0	80	-	1	-	-	-	-	-	-	-	-	-	-
OYEHALFP	F	JFB	03/23/99	06:20 PM	2,4	7.5	78	-	-	-	-	-	-	-	-	-	-	-	-
OYEHALFP	F	JFB	04/08/99	08:18 PM	0	19.5	54	-	-	-	-	-	-	-	-	-	-	3	-
OYEHALFP	F	JFB/DMG	05/12/99	08:59 PM	2	17.0	80	-	2	-	-	1	-	-	-	-	-	2	-
OYEHALFP	F	JFB/RAZ	06/14/99	10:07 PM	2	20.0	100	-	1	-	-	-	-	-	-	-	-	-	2

Appendix 6.2.1. Anuran-vocalization monitoring sites in the Lower Mullica River tributaries. Refer to Methods for survey details. 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, Location, and Listening Point	Site Code
Brockaways Branch below Route 623 Mullica Twp., Atlantic Co. (lat 39°36'02.86", long 74°41'11.81", Egg Harbor City quad). Flooded area downstream from Elwood-Pleasant Mills Road (Route 623) [Route 623].	LBR623DW
Nature Conservancy pond Galloway Twp., Atlantic Co. (lat 39°30'08.70", long 74°35'07.71", Green Bank quad). Northern side of Duerer Street (Route 561), between Mannheim and Leipzig Avenues [Route 561].	LCL561NC
Herbaceous area near Route 602 retention basin Hammonton Twp., Atlantic Co. (lat 39°37'20.08", long 74°47'04.84", Hammonton quad). Eastern side of sand road that leads south from Egg Harbor Road (Route 602), just south of intersection with Moss Mill Road (Route 561) [sand road].	LHAMHERB
Hammonton Lake Hammonton Twp., Atlantic Co. (lat 39°37'38.84", long 74°47'20.61", Hammonton quad). Impoundment on Hammonton Creek, upstream from White Horse Pike (Route 30) [western shoreline near ballfield].	LHAMLAKE
Retention basin near Hammonton Lake Hammonton Twp., Atlantic Co. (lat 39°37'24.04", long 74°47'02.27", Hammonton quad). Southern side of Egg Harbor Road (Route 602), just south of Moss Mill Road (Route 561) [Route 602 at outlet].	LHARETEN
Hammonton Creek tributary impoundment above Plymouth Road Hammonton Twp., Atlantic Co. (lat 39°39'10.17", long 74°45'59.95", Hammonton quad). Upstream from Plymouth Road, just south of Laurel Road [Plymouth Road at outlet].	LHATRPLY
Egg Harbor City Lake below Route 563 Egg Harbor City Twp., Atlantic Co. (lat 39°33'37.58", long 74°36'36.88", Green Bank quad). Impoundment on Indian Cabin Creek, downstream from Egg Harbor-Green Bank Road (Route 563) [southeastern shoreline near Route 563].	LINLAKED
Egg Harbor City Lake above Route 563 Egg Harbor City Twp., Atlantic Co. (lat 39°33'38.41", long 74°36'38.67", Green Bank quad). Impoundment on Indian Cabin Creek, upstream from Egg Harbor-Green Bank Road (Route 563) [southwestern shoreline near Route 563].	LINLAKEU
Egg Harbor City Lake outlet pond Egg Harbor City Twp., Atlantic Co. (lat 39°33'31.92", long 74°36'22.39", Green Bank quad). Between two branches of Indian Cabin Creek, downstrream from lower Egg Harbor City Lake [southeastern shoreline].	LINOUTLE
Big Goose Pond borrow pit Hamilton Twp., Atlantic Co. (lat 39°31'20.53", long 74°41'05.95", Egg Harbor City quad). South of intersection of Walnut and Joseph Streets, west of Big Goose Pond [borrow pit entrance].	LLAGOOBP
Big Goose Pond Hamilton Twp., Atlantic Co. (lat 39°31'34.01", long 74°40'50.30", Egg Harbor City quad). Southeast of intersection of Joseph and Chestnut Streets, west of Egg Harbor City [ditch at pond edge].	LLATRGOO
Smilax pond ditch Washington Twp., Burlington Co. (lat 39°37'23.64", long 74°34'27.38", Green Bank quad). Ditch along eastern side of Greenbank-Chatsworth Road (Route 563), north of intersection with Pleasant Mills Road (Route 542) [Route 563, just north of Smilax pond].	LLBDITCH
Smilax pond Washington Twp., Burlington Co. (lat 39°37'18.76", long 74°34'28.43", Green Bank quad). East of Greenbank-Chatsworth Road (Route 563), north of intersection with Pleasant Mills Road (Route 542) [western shoreline].	LLBSMILX

Site Name, Location, and Listening Point	Site Code
Morses Mill Stream impoundment below Route 561 Galloway Twp., Atlantic Co. (lat 39°29'32.72", long 74°34'15.97", Green Bank quad). Downstream of Duerer Street (Route 561), between Odessa and Genoa Avenues [Route 561 at inlet].	LMO561IM
Morses Mill Stream flooded swamp above Route 561 Galloway Twp., Atlantic Co. (lat 39°29'32.51", long 74°34'16.34", Green Bank quad). Upstream of Duerer Street (Route 561), between Odessa and Genoa Avenues [Route 561 near culvert].	LMO561UP
Lake Fred Galloway Twp., Atlantic Co. (lat 39°29'46.41", long 74°31'43.47", Green Bank quad). Impoundment on Morses Mill Stream, upstream from College Drive [northeastern corner].	LMOSTOCK
Rusty car seat pond Washington Twp., Burlington Co. (lat 39°38'12.20", long 74°33'10.17", Jenkins quad). Northern side of Seaf Weeks Road, east of Greenbank-Chatsworth Road (Route 563) [southern shoreline].	LMURUSTY
Nortons Branch impoundment above Sailor Boy Road Mullica Twp., Atlantic Co. (lat 39°35'51.23", long 74°42'00.47", Egg Harbor City quad). Upstream from Sailor Boy Road, between Columbia Road (Route 693) and Elwood-Pleasant Mills Road (Route 623) [Sailor Boy Road at outlet].	LNOSALOR
Pine Creek impoundment above Seventh Avenue Mullica Twp., Atlantic Co. (lat 39°35'12.80", long 74°39'44.02", Egg Harbor City quad). Upstream from Seventh Avenue, between intersection with Indian Cabin Road and Elwood-Weekstown Road (Route 612) [Seventh Avenue at outlet].	LPINE7TH
Rubins Run lower impoundment Galloway Twp., Atlantic Co. (lat 39°33'06.02", long 74°34'32.76", Green Bank quad). Downstream from Frankfurt Avenue [Frankfurt Avenue near outlet].	LRUFRAND
Rubins Run impoundment below Frankfurt Avenue Galloway Twp., Atlantic Co. (lat 39°33'06.00", long 74°34'32.79", Green Bank quad). Upstream from Frankfurt Avenue [Frankfurt Avenue near inlet].	LRUFRANU
Rubins Run impoundment below Pestalozzi Street Galloway Twp., Atlantic Co. (lat 39°33'11.33", long 74°35'09.40", Green Bank quad). Downstream from Pestalozzi Street, between Bremen and Frankfurt Avenues [Pestalozzi Street].	LRUPESTA
Union Creek tributary impoundment above Antwerp Avenue Egg Harbor City Twp., Atlantic Co. (lat 39°32'06.65", long 74°37'21.51", Green Bank quad). Upstream from Antwerp Avenue, between Duerer Street (Route 561) and Moss Mill Road (Alternate Route 561) [Antwerp Avenue].	LUNTRANT

Appendix 6.2.2. Maximum calling ranks for 12 anuran species at monitoring sites in the Lower Mullica River tributaries. Data type is F = formal survey or S = supplemental data. Observers are JFB = John F. Bunnell, DMG = Dennis M. Gray, and RAZ = Robert A. Zampella. 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 calling ranks are 1 = 1, 2 = 2-5, 3 = 6-10, and 4 > 10 individuals calling. A plus sign (+) indicates that a species was vocalizing at a site, but no calling rank was recorded. The letter " v " refers to the visual observation of a species that was not 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 6.2.1 for detailed site information and Appendix 6.7 for full scientific and common names.

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
LBR623DW	F	JFB	03/29/99	08:55 PM	0	8.5	79	-	-	-	-	4	2	-	-	-	-	-	-
LBR623DW	F	JFB	04/22/99	11:18 PM	2,4	14.0	100	-	-	-	-	4	1	-	-	-	-	-	-
LBR623DW	F	JFB	06/03/99	11:55 PM	0	18.0	91	-	-	1	-	-	-	-	2	-	-	-	-
LBR623DW	F	JFB	06/24/99	12:10 AM	0	13.0	100	-	-	-	-	-	-	1	3	-	-	-	-
LCL561NC	S	JFB	03/17/99	11:52 AM	0	20.5	31	-	-	-	-	-	4	-	-	-	2	-	-
LCL561NC	F	JFB	03/29/99	10:40 PM	0	8.5	64	-	-	-	-	2	4	-	-	-	-	2	-
LCL561NC	F	JFB	04/22/99	10:04 PM	2	12.0	93	-	-	-	-	4	-	-	-	-	-	2	-
LCL561NC	F	JFB	06/03/99	09:26 PM	0	22.0	79	-	-	-	-	-	-	-	-	-	-	-	-
LCL561NC	F	JFB	06/24/99	10:12 PM	0	20.0	95	-	-	-	-	-	-	-	-	-	-	-	-
LHAMHERB	F	JFB	03/29/99	08:39 PM	0	12.5	49	-	-	-	-	4	-	-	-	-	-	-	-
LHAMHERB	F	JFB	04/22/99	11:46 PM	2,4	13.0	100	-	-	-	-	4	-	-	-	-	-	-	-
LHAMHERB	F	JFB	06/01/99	10:56 PM	2	22.5	76	-	-	-	2	-	-	1	-	-	-	-	-
LHAMHERB	F	JFB/RAZ	06/25/99	10:42 PM	0,4	21.0	96	-	-	-	-	-	-	-	-	-	-	-	-
LHAMLAKE	F	JFB	03/29/99	08:30 PM	0	12.5	53	-	-	-	-	-	-	-	-	-	-	-	-
LHAMLAKE	F	JFB	04/22/99	11:52 PM	2,4	13.0	100	-	v	-	-	-	-	-	-	-	-	-	-
LHAMLAKE	F	JFB	06/01/99	10:37 PM	2	22.0	75	2	2	-	-	-	-	3	1	-	-	-	-
LHAMLAKE	F	JFB/RAZ	06/25/99	10:29 PM	0,4	21.5	91	1	1	-	-	-	-	2	1	-	-	-	-
LHARETEN	F	JFB	03/29/99	08:39 PM	0	12.5	49	-	-	-	-	-	-	-	-	-	-	-	-
LHARETEN	F	JFB	04/22/99	11:40 PM	2,4	13.0	100	-	-	-	-	-	-	-	-	-	-	-	-
LHARETEN	F	JFB	06/01/99	10:50 PM	2	22.5	76	-	-	-	-	-	-	1	-	-	-	-	-
LHARETEN	F	JFB/RAZ	06/25/99	10:37 PM	0,4	21.0	96	-	-	-	-	-	-	2	-	-	-	-	-
LHATRPLY	F	JFB	03/29/99	07:58 PM	0	16.5	46	-	-	-	-	2	-	-	-	-	-	4	-
LHATRPLY	F	JFB	04/14/99	09:34 PM	0	14.5	38	-	-	-	-	2	-	-	-	-	-	2	-
LHATRPLY	F	JFB	06/01/99	09:45 PM	2,4	24.0	73	-	-	-	-	-	-	2	-	-	-	-	-
LHATRPLY	F	JFB/RAZ	06/25/99	09:50 PM	0,4	22.0	83	-	-	-	-	-	-	2	2	-	-	-	-
LINLAKED	F	JFB	03/29/99	09:45 PM	0	10.5	64	-	-	-	-	-	-	-	-	-	-	-	-
LINLAKED	F	JFB	04/22/99	08:53 PM	2,4	12.5	93	-	-	-	-	-	-	-	-	-	-	-	-
LINLAKED	F	JFB	06/03/99	11:10 PM	0,4	21.5	75	-	-	-	-	-	-	2	-	-	-	-	1
LINLAKED	F	JFB	06/24/99	10:50 PM	0	16.5	89	-	2	-	-	-	-	2	-	-	-	-	-
LINLAKEU	F	JFB	03/29/99	09:40 PM	0	10.5	64	-	-	-	-	-	-	-	-	-	-	-	-
LINLAKEU	F	JFB	04/22/99	08:53 PM	2,4	12.5	93	-	-	-	-	-	-	-	-	-	-	-	-
LINLAKEU	F	JFB	06/03/99	11:15 PM	0,4	21.5	75	-	-	-	-	-	-	1	2	-	-	-	4
LINLAKEU	F	JFB	06/24/99	10:50 PM	0	16.5	89	-	-	-	-	-	-	1	2	-	-	-	2
LINOUTLE	F	JFB	04/22/99	09:03 PM	2	13.5	83	-	-	-	-	4	-	-	-	-	-	-	-
LINOUTLE	F	JFB	06/03/99	11:02 PM	0	21.0	75	-	-	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
LINOUTLE	F	JFB	06/24/99	10:56 PM	0	16.5	89	-	-	-	-	-	-	-	-	-	-	-	-
LLAGOOBP	F	JFB	03/29/99	11:27 PM	0	8.0	84	-	-	-	-	2	4	-	-	-	-	-	-
LLAGOOBP	F	JFB	04/22/99	10:39 PM	2,4	12.0	100	-	-	-	-	4	2	-	-	-	-	-	-
LLAGOOBP	F	JFB	06/03/99	09:46 PM	0	21.0	83	-	-	1	-	-	-	v	-	-	-	-	-
LLAGOOBP	F	JFB	06/24/99	09:06 PM	0	20.0	81	-	2	1	2	-	-	-	-	-	-	-	-
LLATRGOO	F	JFB	03/29/99	11:39 PM	0	7.0	84	-	-	-	-	1	1	-	-	-	-	4	-
LLATRGOO	F	JFB	04/22/99	10:45 PM	2,4	12.0	100	-	-	-	-	4	-	-	-	-	-	-	2
LLATRGOO	F	JFB	06/03/99	09:55 PM	0	21.0	78	-	-	2	-	-	-	-	-	-	-	-	-
LLATRGOO	F	JFB	06/24/99	08:56 PM	0	20.0	81	-	-	4	-	-	-	-	-	-	-	-	-
LLBDITCH	S	JFB/DMG	03/24/99	09:00 PM	2	11.5	88	-	-	-	-	2	2	-	-	-	1	-	-
LLBSMILX	S	JFB	03/18/99	03:33 PM	0,4	19.0	30	-	-	-	-	-	-	-	-	-	2	-	-
LLBSMILX	F	JFB/DMG	03/24/99	08:55 PM	2	11.5	88	-	-	-	-	-	1	-	-	-	1	-	-
LLBSMILX	F	JFB	04/22/99	08:29 PM	2	12.0	100	-	-	-	-	4	-	-	-	-	-	2	2
LLBSMILX	F	JFB/RAZ	05/26/99	09:12 PM	2	19.0	60	-	-	-	-	-	-	-	-	-	-	-	1
LLBSMILX	F	JFB	06/24/99	11:24 PM	0	15.0	95	-	-	-	-	-	-	-	-	-	-	-	-
LMO561IM	F	JFB	03/29/99	10:32 PM	0	7.5	79	-	-	-	-	-	-	-	-	-	-	-	-
LMO561IM	F	JFB	04/22/99	09:56 PM	2,4	12.0	100	-	-	-	-	-	-	-	-	-	-	-	-
LMO561IM	F	JFB	06/03/99	09:16 PM	0,4	22.0	79	-	1	-	-	-	-	2	-	-	-	-	-
LMO561IM	F	JFB	06/24/99	10:03 PM	0	20.0	95	-	-	-	-	-	-	2	-	-	-	-	-
LMO561UP	F	JFB	03/29/99	10:32 PM	0	7.5	79	-	-	-	-	2	1	-	-	-	-	-	-
LMO561UP	F	JFB	04/22/99	09:56 PM	2,4	12.0	100	-	-	-	-	3	-	-	-	-	-	-	-
LMO561UP	F	JFB	06/03/99	09:16 PM	0,4	22.0	79	-	-	-	-	-	-	-	-	-	-	-	-
LMO561UP	F	JFB	06/24/99	10:03 PM	0	20.0	95	-	-	-	-	-	-	-	-	-	-	-	-
LMOSTOCK	F	JFB	03/29/99	10:18 PM	0	13.0	48	-	-	-	-	-	-	-	-	-	-	-	-
LMOSTOCK	F	JFB	04/22/99	09:41 PM	2	13.0	100	-	-	-	-	-	-	-	-	-	-	-	-
LMOSTOCK	F	JFB	06/03/99	09:01 PM	1,4	23.5	69	-	2	-	-	-	-	-	-	-	-	-	-
LMOSTOCK	F	JFB	06/24/99	09:50 PM	0	20.0	100	-	2	-	-	-	-	2	2	-	-	-	-
LMURUSTY	S	JFB	03/18/99	03:48 PM	0,4	18.0	30	-	-	-	-	-	-	-	-	-	2	-	-
LMURUSTY	F	JFB/DMG	03/24/99	08:37 PM	2	12.0	100	-	-	-	-	-	-	-	-	-	1	1	-
LMURUSTY	F	JFB	04/22/99	08:14 PM	2,4	13.0	100	-	-	-	-	4	1	-	-	-	-	-	-
LMURUSTY	F	JFB/RAZ	05/26/99	08:58 PM	2	18.0	56	-	-	-	-	-	-	-	-	-	-	1	-
LMURUSTY	F	JFB	06/24/99	11:14 PM	0	14.0	95	-	-	-	-	-	-	-	-	-	-	-	-
LNOSALOR	F	JFB	03/29/99	09:08 PM	0	8.0	79	-	-	-	-	-	-	-	-	-	-	-	-
LNOSALOR	F	JFB	04/22/99	11:25 PM	2,4	13.0	100	-	-	-	-	-	-	-	-	-	-	-	-
LNOSALOR	F	JFB	06/03/99	11:44 PM	0	18.0	91	-	-	-	-	-	-	2	4	-	-	-	-
LNOSALOR	F	JFB	06/24/99	11:56 PM	0	15.5	90	-	-	3	-	-	-	2	4	-	-	-	-
LPINE7TH	F	JFB	03/29/99	09:21 PM	0	9.5	62	-	-	-	-	-	-	-	-	-	-	-	-
LPINE7TH	F	JFB	04/22/99	11:08 PM	2	13.0	100	-	-	-	-	4	-	-	1	-	-	-	-
LPINE7TH	F	JFB	06/03/99	11:30 PM	0	20.0	86	-	-	1	-	-	-	-	3	-	-	-	-
LPINE7TH	F	JFB	06/24/99	11:39 PM	0	15.5	90	-	-	-	-	-	-	-	4	-	-	-	-
LRUFRAND	F	JFB	03/29/99	10:00 PM	0	8.5	80	-	-	-	-	-	-	-	-	-	2	2	-
LRUFRAND	F	JFB	04/22/99	09:21 PM	2,4	12.0	88	-	-	-	-	-	-	-	-	-	-	2	1
LRUFRAND	F	JFB	06/03/99	10:39 PM	0	22.0	72	-	-	-	-	-	-	2	2	-	-	1	2
LRUFRAND	F	JFB	06/24/99	10:23 PM	0	20.0	82	-	-	-	-	-	-	2	2	-	-	-	2
LRUFRANU	F	JFB	03/29/99	10:00 PM	0	8.5	80	-	-	-	-	-	-	-	-	-	-	2	-
LRUFRANU	F	JFB	04/22/99	09:21 PM	2,4	12.0	88	-	-	-	-	-	-	-	-	-	-	2	2

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
LRUFRANU	F	JFB	06/03/99	10:39 PM	0	22.0	72	-	-	-	-	-	-	1	2	-	-	-	2
LRUFRANU	F	JFB	06/24/99	10:23 PM	0	20.0	82	-	-	-	-	-	-	3	2	-	-	-	2
LRUPESTA	F	JFB	03/29/99	09:53 PM	0	9.0	73	-	-	-	-	4	-	-	-	-	-	1	-
LRUPESTA	F	JFB	04/22/99	09:14 PM	2,4	11.5	93	-	-	-	-	4	-	-	-	-	-	2	-
LRUPESTA	F	JFB	06/03/99	10:50 PM	0	20.0	78	-	-	-	-	-	-	-	3	-	-	-	1
LRUPESTA	F	JFB	06/24/99	10:33 PM	0	16.5	90	-	-	1	-	-	-	2	4	-	-	-	-
LUNTRANT	F	JFB	03/29/99	11:00 PM	0	10.5	64	-	-	-	-	4	4	-	-	-	-	2	-
LUNTRANT	F	JFB	04/22/99	10:22 PM	2	13.0	100	-	-	-	-	4	-	-	-	-	-	2	-
LUNTRANT	F	JFB	06/03/99	10:25 PM	0,4	21.0	79	-	-	2	-	-	-	1	3	-	-	-	2
LUNTRANT	F	JFB	06/24/99	09:30 PM	0	20.0	100	-	-	2	-	-	-	2	4	-	-	-	2

Appendix 6.3.1. Anuran-vocalization monitoring sites in the Nescochague Creek drainage basin. Refer to Methods for survey details. 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, Location, and Listening Point	Site Code
Abandoned Albertson bog Hammonton Twp., Atlantic Co. (lat 39°41'19.93", long 74°44'22.39", Atsion quad). Southern side of sand road, between Great Swamp Branch and Albertson Brook, east of Route 206 [northern shoreline].	NALABBOG
Albertson pond (Albertson) Hammonton Twp., Atlantic Co. (lat 39°41'10.44", long 74°44'22.75", Atsion quad). South of Abandoned Albertson bog site [southern shoreline].	NALBPOND
Albertson Brook impoundment below Route 206 (Paradise Lakes) Hammonton Twp., Atlantic Co. (lat 39°41'22.44", long 74°43'46.64", Atsion quad). Impoundment on Albertson Brook, downstream from Route 206 [northwestern shoreline].	NALPARAD
Blue Anchor Brook impoundment above Route 30 Winslow Twp., Camden Co. (lat 39°41'16.83", long 74°50'29.56", Hammonton quad). First impoundment upstream from White Horse Pike (Route 30) [northwestern corner]. *Latitude and longitude values were obtained using ArcView Software.	NBLABBOG
Elm retention basin Winslow Twp., Camden Co. (lat 39°41'06.55", long 74°50'14.09", Hammonton quad). Retention basin at intersection of Pine and Poplar Avenues [northern shoreline].	NBLELMRE
Blue Anchor Brook impoundment above Spring Garden-Winslow Road Winslow Twp., Camden Co. (lat 39°41'16.70", long 74°50'58.08", Hammonton quad). Impoundment upstream from Spring Garden-Winslow Road [northeastern corner].	NBLSPRNG
Drivers Branch impoundment below Columbia Road Hammonton Twp., Atlantic Co. (lat 39°39'36.65", long 74°45'23.88", Hammonton quad). First impoundment downstream from Columbia Road (Route 693) [southern shoreline].	NDRCOLUM
Great Swamp Branch impoundment above Route 30 Winslow Twp., Camden Co. (lat 39°40'15.59", long 74°49'32.78", Hammonton quad). Impoundment upstream from White Horse Pike (Route 30) [southeastern corner].	NGREAR30
Thin finger pond Winslow Twp., Camden Co. (lat 39°40'12.66", long 74°50'51.27", Hammonton quad). Northern side of Fleming Pike, just east of railroad [Fleming Pike].	NGRFINGR
Flooded hardwoods on Fleming Pike Winslow Twp., Camden Co. (lat 39°40'12.66", long 74°50'51.27", Hammonton quad). Southern side of Fleming Pike, just east of railroad [Fleming Pike].	NGRFLOOD
Middle Road pond Hammonton Twp., Atlantic Co. (lat 39°41'09.76", long 74°45'44.12", Hammonton quad). Western side of Route 206, just north of Middle Road (Route 613) [Route 206].	NGRMIDPD
Great Swamp Branch impoundment above Myrtle Street Hammonton Twp., Atlantic Co. (lat 39°40'35.07", long 74°46'49.98", Hammonton quad). Impoundment upstream from Myrtle Street, near Pine Road [southeastern corner at Pine Street].	NGRMYRTL
Great Swamp Branch tributary impoundment above Route 30 Winslow Twp., Camden Co. (lat 39°39'52.77", long 74°48'54.97", Hammonton quad). Upstream from White Horse Pike (Route 30), south of Great Swamp Branch [southeastern corner].	NGRTRI30

Site Name, Location, and Listening Point	Site Code
Great Swamp Branch tributary impoundment above Myrtle Street Hammonton Twp., Atlantic Co. (lat 39°40'20.84", long 74°46'23.26", Hammonton quad). Upstream from Myrtle Street, near Route 206 [Myrtle Street near outlet].	NGRTRRED
Great Swamp tributary above Walker Road Winslow Twp., Camden Co. (lat 39°40'44.21", long 74°48'08.64", Hammonton quad). Flooded swamp upstream from Walker Road [Walker Road].	NGRTRWAL
Great Swamp Branch below Union Road Hammonton Twp., Atlantic Co. (lat 39°40'16.99", long 74°47'45.07", Hammonton quad). Impoundment downstream from Union Road [Union Road at inlet].	NGRUNION
Great Swamp impoundment below Walker Road Winslow Twp., Camden Co. (lat 39°40'19.14", long 74°48'36.19", Hammonton quad). Impoundment downstream from Walker Road [Walker Road at inlet].	NGRWALKD
Great Swamp impoundment above Walker Road Winslow Twp., Camden Co. (lat 39°40'19.14", long 74°48'36.19", Hammonton quad). Impoundment upstream from Walker Road [Walker Road at outlet].	NGRWALKU
Columbia Road irrigation pond Hammonton Twp., Atlantic Co. (lat 39°39'20.70", long 74°44'35.51", Atsion quad). Northern side of Columbia Road (Route 693), between Drivers Branch and Laurel Road [Route 693].	NNEIRRIG
Nescochague Lake at Jackson Road Mullica Twp., Atlantic Co. (lat 39°37'57.45", long 74°39'56.05", Atsion quad). Impoundment on northern side of Jackson Road [Jackson Road].	NNEJACKS
Nescochague Lake at Route 623 Mullica Twp., Atlantic Co. (lat 39°38'20.16", long 74°39'39.70", Atsion quad). Impoundment on western side of Elwood-Pleasant Mills Road (Route 623), just south of Pleasant Mills Road (Route 542) [Route 623, near Route 542].	NNESLAKE
Panther Branch impoundment on northern side of Richards Road Mullica Twp., Atlantic Co. (lat 39°39'09.00", long 74°41'19.24", Atsion quad). Impoundment on Panther Branch, northern side of Richards Road [southeastern shoreline, near Richards Road].	NPACRANB
Pump Branch borrow pit Winslow Twp., Camden Co. (lat 39°41'46.53", long 74°50'39.87", Hammonton quad). Western side of Spring Garden-Winslow Road, just south of White Horse Pike (Route 30) [Spring Garden-Winslow Road].	NPUBOROW
Pump Branch impoundment at Ha-Lu-Wa-Sa Campground Winslow Twp., Camden Co. (lat 39°42'10.49", long 74°51'31.90", Hammonton quad). Middle impoundment between White Horse Pike (Route 30) and Waterford Road [sand road/dike along northwestern shoreline].	NPUHALUW
Pump Branch impoundment near Cedar Avenue Winslow Twp., Camden Co. (lat 39°41'50.31", long 74°49'43.48", Hammonton quad). Lower impoundment near Cedar Avenue, east of White Horse Pike (Route 30) [sand road/dike just south of outlet].	NPUIMPNT
Pump Branch irrigation pond Winslow Twp., Camden Co. (lat 39°41'39.64", long 74°49'53.69", Hammonton quad). On edge of old field between Cedar Avenue and Pump Branch, east of White Horse Pike (Route 30) [southern shoreline].	NPUMISOL
Flooded swamp near Pump Branch Winslow Twp., Camden Co. (lat 39°41'46.53", long 74°50'39.87", Hammonton quad). Eastern side of Spring Garden-Winslow Road, just south of White Horse Pike (Route 30) [Spring Garden-Winslow Road].	NPUSWAMP

Appendix 6.3.2. Maximum calling ranks for 12 anuran species at monitoring sites in the Nescochague Creek drainage basin. Data type is F = formal survey or S = supplemental data. Observers are JFB = John F. Bunnell, DMG = Dennis M. Gray, and RAZ = Robert A. Zampella. 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 calling ranks are 1 = 1, 2 = 2-5, 3 = 6-10, and 4 > 10 individuals calling. A plus sign (+) indicates that a species was vocalizing at a site, but no calling rank was recorded. The letter " v " refers to the visual observation of a species that was not 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 6.3.1 for detailed site information and Appendix 6.7 for full scientific and common names.

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
NALABBOG	F	JFB/RAZ	04/27/93	09:20 PM	0	8.0	74	-	-	2	-	4	-	-	-	-	-	4	2
NALABBOG	F	JFB/RAZ	05/24/93	10:31 PM	1	21.0	79	-	-	4	-	-	-	-	4	-	-	-	4
NALABBOG	F	JFB/RAZ	06/16/93	10:15 PM	0	20.0	90	-	-	2	-	-	-	-	4	-	-	-	2
NALABBOG	F	JFB	03/13/96	08:03 PM	0	8.0	63	-	-	-	-	-	-	-	-	-	-	-	-
NALABBOG	F	JFB/RAZ	03/25/96	08:14 PM	0	15.0	70	-	-	-	-	4	2	-	-	-	1	4	-
NALABBOG	F	JFB	04/15/96	09:27 PM	2,4,5	9.5	86	-	-	-	-	4	1	-	-	-	-	4	-
NALABBOG	F	JFB	04/28/96	08:36 PM	1	20.0	45	-	-	4	-	4	-	-	2	-	-	2	2
NALABBOG	F	JFB/DMG	05/20/96	10:58 PM	0	26.5	65	-	-	4	-	-	-	-	4	-	-	2	2
NALABBOG	F	JFB	06/10/96	09:45 PM	2	23.5	87	-	-	4	-	-	-	-	4	-	-	4	4
NALABBOG	F	JFB	07/07/96	09:52 PM	0	27.0	84	-	-	4	-	-	-	-	4	-	-	-	2
NALABBOG	S	JFB/RAZ	03/08/97	07:34 PM	0,4	10.5	59	-	-	-	-	-	-	-	-	-	1	2	-
NALABBOG	F	JFB/DMG	03/26/97	07:52 PM	0,4	11.0	49	-	-	-	-	-	-	-	-	-	-	1	-
NALABBOG	F	JFB/DMG	04/29/97	10:03 PM	0	12.0	88	-	-	2	-	4	-	-	2	-	-	4	1
NALABBOG	F	JFB/RAZ	05/29/97	11:08 PM	0	13.0	88	-	-	2	-	-	-	1	4	-	-	-	4
NALABBOG	F	JFB	06/24/97	11:52 PM	0	21.5	91	-	-	3	-	-	-	-	4	-	-	-	-
NALABBOG	S	JFB/DMG	02/19/98	08:38 PM	2	9.5	79	-	-	-	-	-	-	-	-	-	-	-	-
NALABBOG	S	JFB/DMG	02/25/98	07:16 PM	0,4	10.0	46	-	-	-	-	-	-	-	-	-	1	-	-
NALABBOG	S	JFB	02/26/98	02:13 PM	0,4	19.0	30	-	-	-	-	-	-	-	-	-	-	-	-
NALABBOG	F	JFB/RAZ	03/26/98	07:39 PM	0	17.0	58	-	-	-	-	4	-	-	-	-	-	4	-
NALABBOG	F	JFB	04/17/98	08:19 PM	2,5	20.0	91	-	-	4	-	-	-	-	2	-	-	1	4
NALABBOG	F	JFB	05/19/98	08:18 PM	1	23.0	71	-	-	4	-	-	-	-	4	-	-	-	2
NALABBOG	F	JFB	06/16/98	10:06 PM	2,4,6	22.5	100	-	-	4	-	-	-	-	4	-	-	-	1
NALABBOG	S	JFB	03/06/99	03:45 PM	0	-	-	-	-	-	-	-	-	-	-	-	2	-	-
NALABBOG	S	JFB	03/09/99	09:15 AM	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NALABBOG	S	JFB	03/10/99	09:00 AM	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NALABBOG	S	JFB	03/13/99	11:17 AM	0,4	8.0	49	-	-	-	-	-	-	-	-	-	-	-	-
NALABBOG	F	JFB	03/17/99	09:52 PM	0,4	16.0	50	-	-	-	-	-	-	-	-	-	-	-	-
NALABBOG	F	JFB	04/01/99	09:21 PM	2,3,5	15.5	93	-	-	-	-	-	-	-	-	-	-	3	-
NALABBOG	F	JFB	05/08/99	10:16 PM	0	18.0	81	-	2	4	-	2	-	-	2	-	-	2	4
NALABBOG	F	JFB	06/08/99	11:20 PM	0	21.5	82	-	-	-	-	-	-	-	2	-	-	-	-
NALBPOND	F	JFB	03/13/96	08:12 PM	0	8.0	63	-	-	-	-	-	-	-	-	-	-	-	-
NALBPOND	F	JFB/RAZ	03/25/96	08:26 PM	2	15.0	66	-	-	-	-	2	-	-	-	-	-	-	-
NALBPOND	F	JFB	04/15/96	09:41 PM	2,4,5	12.0	74	-	-	-	-	3	-	-	-	-	-	-	-
NALBPOND	F	JFB	04/28/96	08:48 PM	1	18.5	43	-	-	1	-	1	-	-	-	-	-	-	-
NALBPOND	F	JFB/DMG	05/20/96	11:15 PM	0	26.5	66	-	-	2	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
NALBPOND	F	JFB	06/10/96	09:56 PM	0	23.0	91	-	-	2	-	-	-	-	1	-	-	-	-
NALBPOND	F	JFB	06/26/96	10:17 PM	1	21.5	66	-	-	1	-	-	-	-	-	-	-	-	-
NALBPOND	F	JFB	07/07/96	10:02 PM	0	25.5	87	-	-	1	-	-	-	-	-	-	-	-	-
NALBPOND	F	JFB/DMG	03/26/97	08:04 PM	0,4	10.5	46	-	-	-	-	-	-	-	-	-	-	2	-
NALBPOND	F	JFB/DMG	04/29/97	10:15 PM	0	14.0	86	-	-	1	-	-	-	-	-	-	-	4	-
NALBPOND	F	JFB/RAZ	05/29/97	11:18 PM	1	11.0	88	-	-	-	-	-	-	-	-	-	-	2	-
NALBPOND	F	JFB	06/24/97	12:07 AM	0	21.0	91	-	-	1	-	-	-	-	-	-	-	-	-
NALBPOND	S	JFB/DMG	02/19/98	08:49 PM	2	8.5	79	-	-	-	-	-	-	-	-	-	-	-	-
NALBPOND	S	JFB	02/26/98	02:20 PM	0,4	19.0	30	-	-	-	-	-	-	-	-	-	4	-	-
NALBPOND	F	JFB/RAZ	03/26/98	07:50 PM	0	16.5	58	-	-	-	-	-	-	-	-	-	-	-	-
NALBPOND	F	JFB	04/17/98	08:30 PM	2,5	18.5	100	-	-	2	-	-	-	-	-	-	-	2	-
NALBPOND	F	JFB	05/19/98	08:29 PM	1	23.0	71	-	-	2	-	-	-	-	-	-	-	-	-
NALBPOND	F	JFB	06/16/98	10:00 PM	2,6	24.0	100	-	-	2	-	-	-	-	-	-	-	-	-
NALBPOND	S	JFB	03/10/99	09:10 AM	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NALBPOND	S	JFB	03/13/99	11:25 AM	0,4	8.0	53	-	-	-	-	-	-	-	-	-	-	-	-
NALBPOND	F	JFB	03/17/99	10:00 PM	0,4	16.0	50	-	-	-	-	-	-	-	-	-	-	-	-
NALBPOND	F	JFB	04/01/99	09:28 PM	2,3,5	15.5	93	-	-	-	-	-	-	-	-	-	-	-	-
NALBPOND	F	JFB	05/08/99	10:25 PM	0	16.5	90	-	-	2	-	-	-	-	-	-	-	-	-
NALBPOND	F	JFB	06/08/99	11:27 PM	0	21.0	82	-	-	-	-	-	-	-	-	-	-	-	-
NALPARAD	F	JFB	03/17/99	10:23 PM	0,4	16.0	50	-	-	-	-	-	-	-	-	-	-	-	-
NALPARAD	F	JFB	04/01/99	09:02 PM	2,3,5	16.0	100	-	-	-	-	-	-	-	-	-	-	-	-
NALPARAD	F	JFB	05/08/99	10:46 PM	0	17.0	90	-	2	-	-	1	-	-	-	-	-	-	2
NALPARAD	F	JFB	06/08/99	11:01 PM	0	22.0	75	-	-	-	-	-	-	2	-	-	-	-	3
NBLABBOG	F	JFB/RAZ	04/14/93	10:31 PM	1,5	12.0	-	-	-	-	-	-	-	-	-	-	-	-	-
NBLABBOG	F	JFB/RAZ	05/05/93	09:09 PM	2	21.0	87	-	4	-	-	4	-	2	-	-	-	-	-
NBLABBOG	F	JFB/RAZ	06/16/93	09:31 PM	0	23.0	76	1	2	-	-	-	-	1	-	-	-	-	-
NBLELMRE	F	JFB	04/14/99	08:53 PM	0	17.0	30	-	-	-	-	-	-	-	-	-	-	-	-
NBLELMRE	F	JFB	06/01/99	11:25 PM	2	23.0	79	-	-	-	-	-	-	2	-	-	-	-	-
NBLELMRE	F	JFB/RAZ	06/25/99	11:32 PM	0	21.0	96	-	1	-	-	-	-	2	-	-	-	-	-
NBLSPRNG	F	JFB	04/11/96	09:48 PM	1	15.5	61	-	-	-	-	-	-	-	-	-	-	-	-
NBLSPRNG	F	JFB/DMG	04/23/96	11:12 PM	2	19.0	77	-	1	-	-	-	-	-	-	-	-	-	-
NBLSPRNG	F	JFB	05/18/96	10:05 PM	2,3	21.0	100	-	4	-	-	-	-	2	2	-	-	-	-
NBLSPRNG	F	JFB	06/07/96	10:10 PM	0,4	24.0	83	-	3	-	-	-	-	2	2	-	-	-	-
NBLSPRNG	F	JFB	07/16/96	09:29 PM	2	27.0	70	-	2	-	-	-	-	1	-	-	-	-	-
NDRCOLUM	F	JFB/DMG	03/24/99	10:27 PM	2	11.0	100	-	-	-	-	-	-	-	-	-	-	-	-
NDRCOLUM	F	JFB	04/14/99	09:42 PM	0	14.0	49	-	-	-	-	-	-	-	-	-	-	-	-
NDRCOLUM	F	JFB	06/01/99	10:00 PM	2,4	24.0	73	-	1	-	-	-	-	2	-	-	-	-	-
NDRCOLUM	F	JFB/RAZ	06/25/99	10:05 PM	0,4	22.5	83	-	-	-	-	-	-	2	-	-	-	-	-
NGREAR30	F	JFB	03/29/99	07:29 PM	0	15.5	33	-	-	-	-	-	-	-	-	-	-	-	-
NGREAR30	F	JFB	04/14/99	09:00 PM	0	15.0	28	-	-	-	-	-	-	-	-	-	-	-	-
NGREAR30	F	JFB	06/01/99	11:17 PM	1	22.0	79	4	1	-	-	-	-	2	-	-	-	-	-
NGREAR30	F	JFB/RAZ	06/25/99	11:23 PM	0	21.0	96	2	2	-	-	-	-	2	-	-	-	-	-
NGRFINGR	F	JFB	03/15/96	08:02 PM	2	20.0	89	-	-	-	-	-	-	-	-	-	-	-	-
NGRFINGR	F	JFB	04/11/96	10:08 PM	1	14.0	70	-	-	-	-	-	-	-	-	-	-	-	-
NGRFINGR	F	JFB/DMG	04/23/96	11:30 PM	2	19.0	80	-	-	-	-	2	-	-	-	-	-	-	-
NGRFINGR	F	JFB	05/18/96	09:53 PM	2,3	19.0	95	-	-	-	-	-	-	-	2	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
NGRFINGR	F	JFB	06/07/96	10:54 PM	0,4	24.0	82	-	-	-	-	-	-	2	3	-	-	-	-
NGRFINGR	F	JFB	07/16/96	09:17 PM	2	27.0	70	-	-	-	-	-	-	1	2	-	-	-	-
NGRFLOOD	F	JFB	04/11/96	10:13 PM	1	14.0	60	-	-	-	-	4	-	-	-	-	-	-	-
NGRFLOOD	F	JFB/DMG	04/23/96	11:30 PM	2	19.0	81	-	-	-	-	4	-	-	-	-	-	-	-
NGRFLOOD	F	JFB	05/18/96	09:53 PM	2,3	19.0	95	-	-	-	-	1	-	-	-	-	-	-	-
NGRMIDPD	F	JFB	03/17/99	09:40 PM	0	15.0	50	-	-	-	-	-	-	-	-	-	4	-	-
NGRMIDPD	F	JFB	04/01/99	09:42 PM	2,3,5	16.5	100	-	-	-	-	4	-	-	-	-	2	-	-
NGRMIDPD	F	JFB	05/08/99	10:05 PM	1	19.0	85	-	-	4	-	2	-	-	-	-	-	1	-
NGRMIDPD	F	JFB	06/08/99	11:35 PM	0	22.0	82	-	-	1	-	-	-	-	-	-	-	-	-
NGRMYRTL	F	JFB/RAZ	04/27/93	09:35 PM	0	11.0	76	-	-	-	-	-	-	-	-	-	-	-	-
NGRMYRTL	F	RAZ	05/31/93	08:52 PM	8	21.0	-	-	-	-	-	-	-	-	-	-	-	-	-
NGRMYRTL	F	JFB/RAZ	06/16/93	10:03 PM	0	22.0	79	-	2	-	-	-	-	+	-	-	-	-	-
NGRTRI30	F	JFB	03/29/99	07:36 PM	0	15.5	33	-	-	-	-	-	-	-	-	-	-	-	-
NGRTRI30	F	JFB	04/14/99	09:06 PM	0	15.5	28	-	-	-	-	-	-	-	-	-	-	-	-
NGRTRI30	F	JFB	06/01/99	11:10 PM	1	22.5	79	-	2	-	-	-	-	3	-	-	-	-	-
NGRTRI30	F	JFB/RAZ	06/25/99	11:15 PM	0	22.0	96	-	2	-	-	-	-	2	-	-	-	-	-
NGRTRRED	F	JFB	03/29/99	07:48 PM	0	13.0	65	-	-	-	-	-	-	-	-	-	-	-	-
NGRTRRED	F	JFB	04/14/99	09:17 PM	0	14.5	34	-	-	-	-	-	-	-	-	-	-	-	-
NGRTRRED	F	JFB	06/01/99	10:06 PM	2	24.0	67	-	2	-	-	-	-	2	-	-	-	-	-
NGRTRRED	F	JFB/RAZ	06/25/99	10:12 PM	0,4	22.0	91	-	2	-	-	-	-	2	-	-	-	-	-
NGRTRWAL	F	JFB	03/15/96	08:13 PM	2	17.0	84	-	-	-	-	4	-	-	-	-	-	-	-
NGRTRWAL	F	JFB	04/11/96	10:20 PM	1	16.0	61	-	-	-	-	4	-	-	-	-	-	-	-
NGRTRWAL	F	JFB/DMG	04/23/96	11:40 PM	2,4	19.5	65	-	1	-	-	4	-	-	1	-	-	-	-
NGRTRWAL	F	JFB	05/18/96	09:30 PM	2,3	19.0	95	-	2	-	4	1	-	-	2	-	-	-	-
NGRTRWAL	F	JFB	06/07/96	11:15 PM	0,4	23.5	83	-	1	-	4	-	-	-	2	-	-	-	-
NGRTRWAL	F	JFB	07/16/96	08:49 PM	2,4	26.0	74	-	-	-	4	-	-	-	2	-	-	-	-
NGRUNION	F	JFB/RAZ	04/27/93	09:50 PM	0	10.0	64	-	-	-	-	4	-	-	-	-	-	-	-
NGRUNION	F	RAZ	05/31/93	08:45 PM	8	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-
NGRUNION	F	JFB/RAZ	06/16/93	09:56 PM	0	22.0	79	-	2	-	-	-	-	-	-	-	-	-	-
NGRWALKD	F	JFB	03/15/96	08:20 PM	2,4	15.5	80	-	-	-	-	2	-	-	-	-	-	-	-
NGRWALKD	F	JFB	04/11/96	10:28 PM	1,4	14.0	53	-	-	-	-	4	-	-	-	-	-	-	-
NGRWALKD	F	JFB/DMG	04/23/96	11:48 PM	4	18.0	53	-	-	-	-	2	-	-	-	-	-	-	-
NGRWALKD	F	JFB	05/18/96	09:20 PM	2,3,4	19.0	95	-	2	-	-	-	-	2	-	-	-	-	-
NGRWALKD	F	JFB	06/07/96	11:05 PM	0,4	24.0	83	-	4	-	-	-	-	2	-	-	-	-	-
NGRWALKD	F	JFB	07/16/96	08:57 PM	2,4	27.0	70	-	-	-	-	-	-	-	-	-	-	-	-
NGRWALKU	F	JFB/RAZ	06/16/93	09:42 PM	0	22.0	79	-	4	-	-	-	-	2	4	-	-	-	-
NGRWALKU	F	JFB	03/15/96	08:20 PM	2,4	15.5	80	-	-	-	-	4	-	-	-	-	-	-	-
NGRWALKU	F	JFB	04/11/96	10:28 PM	1,4	14.0	53	-	-	-	-	4	-	-	-	-	-	-	-
NGRWALKU	F	JFB/DMG	04/23/96	11:48 PM	4	18.0	53	-	1	-	-	3	-	-	-	-	-	-	-
NGRWALKU	F	JFB	05/18/96	09:20 PM	2,3,4	19.0	95	-	3	-	-	1	-	-	2	-	-	-	-
NGRWALKU	F	JFB	06/07/96	11:05 PM	0,4	24.0	83	-	4	-	-	-	-	-	2	-	-	-	-
NGRWALKU	F	JFB	07/16/96	08:57 PM	2,4	27.0	70	-	1	-	-	-	-	-	-	-	-	-	-
NNEIRRIG	F	JFB/DMG	03/24/99	10:21 PM	2	11.0	100	-	-	-	-	2	4	-	-	-	-	2	-
NNEIRRIG	F	JFB	04/14/99	09:48 PM	0	13.5	30	-	-	-	-	-	-	-	-	-	-	1	-
NNEIRRIG	F	JFB	06/01/99	09:53 PM	2,4	23.5	76	-	4	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
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NNEIRRIG	F	JFB/RAZ	06/25/99	09:59 PM	0,4	22.5	87	-	2	-	-	-	-	-	-	-	-	-	-
NNEJACKS	F	JFB/DMG	03/24/99	09:46 PM	2	12.5	100	-	-	-	-	-	-	-	-	-	-	-	-
NNEJACKS	F	JFB	04/14/99	10:17 PM	0	11.0	55	-	-	-	-	4	-	-	-	-	-	-	-
NNEJACKS	F	JFB	06/01/99	09:10 PM	2	24.0	76	-	1	-	-	-	-	-	2	-	-	-	-
NNEJACKS	F	JFB/RAZ	06/25/99	09:18 PM	0	22.5	91	-	-	-	-	-	-	-	2	-	-	-	-
NNESLAKE	F	JFB	06/01/99	09:16 PM	2	24.0	76	-	3	-	-	-	-	3	1	-	-	-	-
NNESLAKE	F	JFB/RAZ	06/25/99	09:25 PM	0	22.0	87	-	2	-	-	-	-	1	-	-	-	-	-
NPACRANB	F	JFB/DMG	03/24/99	10:00 PM	2	11.5	100	-	-	-	-	4	-	-	-	-	1	4	-
NPACRANB	F	JFB	04/14/99	10:01 PM	0	10.0	64	-	-	-	-	4	-	-	-	-	1	4	2
NPACRANB	F	JFB	06/01/99	09:28 PM	2	24.0	73	-	-	2	-	-	-	2	2	-	-	1	2
NPACRANB	F	JFB/RAZ	06/25/99	09:35 PM	0	22.0	87	-	1	2	-	-	-	2	2	-	-	-	2
NPUBOROW	F	JFB/RAZ	04/14/93	10:07 PM	1,5	14.0	-	-	-	-	-	4	-	-	-	-	-	-	-
NPUBOROW	F	JFB/RAZ	05/05/93	08:50 PM	2	20.0	83	-	4	-	-	4	-	2	1	-	-	-	-
NPUBOROW	F	JFB/RAZ	06/16/93	09:13 PM	0	25.0	76	4	-	-	-	-	-	-	-	-	-	-	-
NPUBOROW	F	JFB	03/15/96	07:53 PM	2	18.0	89	-	-	-	-	2	-	-	-	-	-	-	-
NPUBOROW	F	JFB	04/11/96	10:00 PM	1	15.0	62	-	-	-	-	3	-	-	-	-	-	-	-
NPUBOROW	F	JFB/DMG	04/23/96	11:19 PM	2	18.5	81	-	-	-	-	2	-	3	-	-	-	-	-
NPUBOROW	F	JFB	05/18/96	10:14 PM	2,3	19.0	100	-	1	-	-	-	-	3	2	-	-	-	-
NPUBOROW	F	JFB	06/07/96	10:19 PM	0,4	23.0	83	-	-	-	-	-	-	2	2	-	-	-	-
NPUBOROW	F	JFB	07/16/96	09:38 PM	2	26.0	76	-	-	-	-	-	-	-	3	-	-	-	-
NPUHALUW	F	JFB	03/29/99	07:17 PM	0	15.5	43	-	-	-	-	2	-	-	-	-	-	-	-
NPUHALUW	F	JFB	04/14/99	08:42 PM	0,4	17.0	24	-	-	-	-	-	-	-	-	-	-	-	-
NPUHALUW	F	JFB	06/01/99	11:36 PM	2	23.0	76	-	1	-	-	-	-	2	-	-	-	-	-
NPUHALUW	F	JFB/RAZ	06/25/99	11:42 PM	0	22.0	91	-	-	-	-	-	-	2	-	-	-	-	-
NPUIMPNT	F	JFB/RAZ	04/14/93	10:23 PM	1,5	14.0	-	-	-	-	-	1	-	-	-	-	-	1	-
NPUIMPNT	F	JFB/RAZ	05/05/93	09:01 PM	2	19.0	87	-	4	-	-	2	-	2	-	-	-	1	-
NPUIMPNT	F	JFB/RAZ	06/16/93	09:21 PM	0	22.0	83	2	-	-	-	-	-	1	1	-	-	-	-
NPUIMPNT	F	JFB	03/15/96	07:33 PM	2,4	17.0	80	-	-	-	-	-	-	-	-	-	-	-	-
NPUIMPNT	F	JFB	04/11/96	09:27 PM	2	16.0	60	-	-	-	-	4	-	-	-	-	-	4	-
NPUIMPNT	F	JFB/DMG	04/23/96	10:50 PM	2	20.0	82	-	4	-	-	-	-	1	-	-	-	3	-
NPUIMPNT	F	JFB	05/18/96	10:37 PM	2,3	18.0	95	-	2	-	-	-	-	4	2	-	-	1	-
NPUIMPNT	F	JFB	06/07/96	10:42 PM	0,4	24.5	83	-	1	1	-	-	-	2	2	-	-	2	-
NPUIMPNT	F	JFB	07/16/96	10:00 PM	2	25.5	83	-	-	-	-	-	-	2	4	-	-	-	1
NPUMISOL	F	JFB	03/15/96	07:40 PM	2,4	18.0	84	-	-	-	-	2	-	-	-	-	-	-	-
NPUMISOL	F	JFB	04/11/96	09:36 PM	1,2	15.0	66	-	-	-	-	4	1	-	-	-	-	-	-
NPUMISOL	F	JFB/DMG	04/23/96	10:58 PM	2	19.0	85	-	-	-	-	4	-	-	2	-	-	-	-
NPUMISOL	F	JFB	05/18/96	10:28 PM	2,3	17.0	90	-	-	2	-	-	-	1	3	-	-	-	-
NPUMISOL	F	JFB	06/07/96	10:30 PM	0,4	24.5	83	-	1	2	2	-	-	2	2	-	-	-	-
NPUMISOL	F	JFB	07/16/96	09:50 PM	2	26.0	84	-	1	2	1	-	-	v	4	-	-	2	-
NPUSWAMP	F	JFB	03/15/96	07:53 PM	2	18.0	89	-	-	-	-	-	-	-	-	-	-	-	-
NPUSWAMP	F	JFB	04/11/96	09:55 PM	1	15.0	62	-	-	-	-	4	-	-	-	-	-	-	-
NPUSWAMP	F	JFB/DMG	04/23/96	11:19 PM	2	18.5	81	-	-	-	-	2	-	-	-	-	-	-	-
NPUSWAMP	F	JFB	05/18/96	10:14 PM	2,3	19.0	100	-	1	-	-	-	-	-	-	-	-	-	-
NPUSWAMP	F	JFB	06/07/96	10:19 PM	0,4	23.0	83	-	-	-	-	-	-	-	-	-	-	-	-
NPUSWAMP	F	JFB	07/16/96	09:38 PM	2	26.0	76	-	-	-	-	-	-	-	2	-	-	-	-

Appendix 6.4.1. Anuran-vocalization monitoring sites in the Sleeper Branch drainage basin. Refer to Methods for survey details. 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, Location, and Listening Point	Site Code
Clark Branch bogs at Route 206 Hammonton Twp., Atlantic Co. (lat 39°42'42.14", long 74°44'37.79", Atsion quad). Southernmost impoundment, upstream from Route 206 [southeastern corner at Route 206].	MCL206BG
Chew Road spong Waterford Twp., Camden Co. (lat 39°42'34.81", long 74°47'51.22", Hammonton quad). Southern side of Chew Road (Route 536), between railroad and Clark Branch [Route 536].	MCLCHEWS
Sandy Causeway ditch Waterford Twp., Camden Co. (lat 39°42'42.81", long 74°46'31.06", Hammonton quad). Eastern side of Sandy Causeway Road, between Chew Road (Route 536) and railroad [Sandy Causeway Road].	MCLDITCH
Forbidden pond Waterford Twp., Camden Co. (lat 39°42'34.81", long 74°47'51.22", Hammonton quad). North of Chew Road (Route 536), west of Sandy Causeway Road, between Chew and Sandy Causeway ponds [Chew pond].	MCLFORBI
Clark Branch impoundment above Johnson Road Waterford Twp., Camden Co. (lat 39°42'57.28", long 74°45'28.65", Hammonton quad). Impoundment upstream from first breached dike above Johnson Road [dike near outlet].	MCLIMPNT
Clark Branch above Johnson Road Waterford Twp., Camden Co. (lat 39°43'00.57", long 74°45'18.67", Hammonton quad). Upstream from Johnson Road [Johnson Road].	MCLJOHNS
Johnson pond Hammonton Twp., Atlantic Co. (lat 39°42'36.04", long 74°44'47.43", Atsion quad). Northern side of Johnson Road near Route 206 [Johnson Road].	MCLJPOND
Sandy Causeway puddle Waterford Twp., Camden Co. (lat 39°42'35.70", long 74°46'32.89", Hammonton quad). Western side of Sandy Causeway Road, between Chew Road (Route 536) and railroad [Sandy Causeway Road].	MCLPUDDL
Clark Branch above Route 536 Waterford Twp., Camden Co. (lat 39°42'38.83", long 74°48'07.82", Hammonton quad). Upstream from Chew Road (Route 536) [Route 536 near outlet].	MCLRK536
Chew pond (Chew) Waterford Twp., Camden Co. (lat 39°42'22.88", long 74°46'52.74", Hammonton quad). Northern side of Chew Road (Route 536), between Sandy Causeway Road and railroad [southern shoreline].	MCLRUSNK
Sandy Causeway pond (Sandy) Waterford Twp., Camden Co. (lat 39°42'35.35", long 74°46'36.80", Hammonton quad). Western side of Sandy Causeway Road, between Chew Road (Route 536) and railroad [eastern shoreline].	MCLSANDY
Cooper Branch impoundment near Tremont Avenue and Burnt Mill Road Waterford Twp., Camden Co. (lat 39°44'45.00", long 74°50'24.99", Hammonton quad). Impoundment upstream from first dike above Burnt Mill Road [dike near outlet].	MCOIMPNT
Gun Branch below railroad Waterford Twp., Camden Co. (lat 39°42'09.66", long 74°47'40.16", Hammonton quad). Downstream from railroad [railroad right-of-way].	MGUHEADD
Gun Branch above Central New Jersey/Conrail railroad Waterford Twp., Camden Co. (lat 39°42'11.16", long 74°47'37.45", Hammonton quad). Upstream from railroad [railroad right-of-way].	MGUHEADU

Site Name, Location, and Listening Point	Site Code
Gun Branch above West Mill Road	MGUNWEST
Hammonton Twp., Atlantic Co. (lat 39°41'51.88", long 74°44'42.51", Atsion quad). Upstream from West Mill Road [West Mill Road at outlet].	
Gun Branch tributary above Route 536	MGUTR536
Hammonton Twp., Atlantic Co. (lat 39°42'06.35", long 74°45'50.90", Hammonton quad). Upstream from Chew Road (Route 536) [Route 536].	
Atco Lake	MHAATCOL
Waterford Twp., Camden Co. (lat 39°45'24.16", long 74°53'01.54", Clementon quad). Impoundment on Hays Mill Creek, upstream from White Horse Pike (Route 30) [southeastern shoreline].	
Hays Mill Creek impoundment above Cooper Folly Road	MHAFOLLY
Winslow Twp., Camden Co. (lat 39°45'26.40", long 74°53'48.10", Clementon quad). Impoundment upstream from Cooper Folly Road (Route 712) [Route 712 near outlet].	
Hays Mill retention basin	MHARETEN
Waterford Twp., Camden Co. (lat 39°45'08.18", long 74°49'57.27", Medford Lakes quad). Southern end of Columbia Avenue, south of Jackson Road (Route 534) [northern shoreline].	
Hays Mill pond (Hays)	MHASPRAY
Waterford Twp., Camden Co. (lat 39°45'17.65", long 74°51'06.62", Medford Lakes quad). Southern side of sand road on southern side of Hays Mill Creek, west of Tremont Avenue [northeastern shoreline].	
Flooded swamp on Route 536	MPR536JK
Waterford Twp., Camden Co. (lat 39°42'57.57", long 74°49'21.49", Hammonton quad). Northern side of Chew Road (Route 536), between Pestleton Road and Clark Branch [Route 536].	
Price Branch pond (Price)	MPRICEPD
Waterford Twp., Camden Co. (lat 39°42'51.74", long 74°49'20.20", Hammonton quad). South of Chew Road (Route 536), between Pestleton Road and Clark Branch [northwestern shoreline].	
Pestleton Road borrow pit	MPRPESTL
Waterford Twp., Camden Co. (lat 39°42'47.42", long 74°49'32.85", Hammonton quad). Western side of Pestleton Road, between Clark Branch and Chew Road (Route 536) [western shoreline].	
Sleeper Branch bogs at Route 206	MSL206BG
Hammonton Twp., Atlantic Co. (lat 39°43'08.01", long 74°44'19.23", Atsion quad). Northernmost impoundment, upstream from Route 206 [northeastern corner at Route 206].	
4x4 pond	MSL4X4PD
Waterford Twp., Camden Co. (lat 39°43'02.78", long 74°46'30.32", Hammonton quad). Eastern side of Burnt House Road, just north of Fleming Pike [western shoreline].	
Blueberry field pond	MSLBLUEB
Hammonton Twp., Atlantic Co. (lat 39°42'17.24", long 74°44'25.22", Atsion quad). Southern side of Rockwood Road, east of Route 206 [northern shoreline].	
Pine lowland near Blueberry field pond	MSLBLUPL
Hammonton Twp., Atlantic Co. (lat 39°42'18.35", long 74°44'27.08", Atsion quad). Northern side of Rockwood Road, just west of Blueberry field pond [Rockwood Road].	
Isolated Sleeper pond (Sleeper)	MSLEISOL
Waterford Twp., Camden Co. (lat 39°43'16.89", long 74°46'09.29", Hammonton quad). North of Fleming Pike, east of Burnt House Road, south of Sleeper Branch [southeastern shoreline].	
Fire Warden pond	MSLWARDN
Waterford Twp., Atlantic Co. (lat 39°43'16.99", long 74°44'16.70", Atsion quad). Southern side of sand road west of Route 206 and Dutchtown [western shoreline].	

Site Name, Location, and Listening Point	Site Code
Beaverdam Lake	MWIBEAVR
Waterford Twp., Camden Co. (lat 39°44'26.89", long 74°50'05.05", Hammonton quad). Impoundment on Wildcat Branch, upstream from Burnt Mill Road [northeastern corner].	
Wildcat Branch impoundment below Route 30	MWILD30D
Winslow Twp., Camden Co. (lat 39°44'12.68", long 74°52'12.33", Hammonton quad). Impoundment downstream from White Horse Pike (Route 30) [Route 30].	
Wildcat Branch flooded swamp	MWILD30U
Winslow Twp., Camden Co. (lat 39°44'12.68", long 74°52'12.33", Hammonton quad). Flooded swamp upstream from White Horse Pike (Route 30) [Route 30].	

Appendix 6.4.2. Maximum calling ranks for 12 anuran species at monitoring sites in the Sleeper Branch drainage basin. Data type is F = formal survey or S = supplemental data. Observers are JFB = John F. Bunnell, DMG = Dennis M. Gray, and RAZ = Robert A. Zampella. 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 calling ranks are 1 = 1, 2 = 2-5, 3 = 6-10, and 4 > 10 individuals calling. A plus sign (+) indicates that a species was vocalizing at a site, but no calling rank was recorded. The letter " v " refers to the visual observation of a species that was not 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 6.4.1 for detailed site information and Appendix 6.7 for full scientific and common names.

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MCL206BG	F	JFB/RAZ	04/27/93	08:05 PM	0	10.5	61	-	-	-	-	3	-	-	-	-	-	-	2
MCL206BG	F	JFB/RAZ	05/24/93	10:06 PM	1	23.0	72	-	-	-	-	-	-	-	-	-	-	-	4
MCL206BG	F	JFB/RAZ	06/16/93	10:30 PM	0	19.5	86	-	-	-	-	-	-	-	+	-	-	-	+
MCLCHEWS	F	JFB/RAZ	04/14/93	10:51 PM	1,5	12.0	-	-	-	-	-	4	-	-	-	-	-	1	-
MCLCHEWS	F	JFB/RAZ	05/05/93	08:20 PM	2	20.0	87	-	-	4	-	4	-	-	3	-	-	-	-
MCLCHEWS	F	JFB/RAZ	06/09/93	10:13 PM	2	25.0	96	-	-	2	-	-	-	-	4	-	-	-	-
MCLCHEWS	F	JFB	03/13/96	08:28 PM	0	8.0	66	-	-	-	-	-	-	-	-	-	-	-	-
MCLCHEWS	F	JFB	03/31/96	08:20 PM	0	10.0	71	-	-	-	-	4	-	-	-	-	-	-	-
MCLCHEWS	F	JFB	04/15/96	09:11 PM	2,4,5	11.0	80	-	-	-	-	4	-	-	-	-	-	1	-
MCLCHEWS	F	JFB	04/28/96	09:42 PM	1	15.0	47	-	-	1	-	2	-	-	1	-	-	-	-
MCLCHEWS	F	JFB	05/19/96	10:40 PM	0	25.0	83	-	-	4	2	-	-	-	4	-	-	1	-
MCLCHEWS	F	JFB	06/07/96	09:51 PM	0,4	22.0	83	-	-	2	-	-	-	-	2	-	-	1	-
MCLCHEWS	F	JFB	07/07/96	09:31 PM	2	26.0	87	-	-	-	-	-	-	-	2	-	-	-	-
MCLDITCH	S	JFB	02/26/98	01:41 PM	0,4	15.5	34	-	-	-	-	-	-	-	-	-	4	-	-
MCLDITCH	S	JFB	03/06/99	03:30 PM	0	-	-	-	-	-	-	-	-	-	-	-	4	-	-
MCLDITCH	S	JFB	03/09/99	09:00 AM	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MCLDITCH	S	JFB	03/11/99	04:55 PM	0,4	6.0	50	-	-	-	-	-	-	-	-	-	-	-	-
MCLDITCH	S	JFB	03/13/99	10:45 AM	0,4	8.0	49	-	-	-	-	-	-	-	-	-	-	-	-
MCLFORBI	S	JFB	02/19/98	07:40 PM	2	10.5	74	-	-	-	-	-	-	-	-	-	4	-	-
MCLFORBI	S	JFB/DMG	05/19/98	08:57 PM	2	23.5	75	-	-	-	-	-	-	2	-	-	-	-	-
MCLFORBI	S	JFB	03/17/99	08:07 PM	0	8.5	74	-	-	-	-	-	4	-	-	-	4	-	-
MCLFORBI	S	JFB	04/01/99	09:52 PM	2,3,5	14.5	93	-	-	-	-	4	-	-	-	-	-	4	-
MCLFORBI	S	JFB	05/06/99	10:20 PM	2	13.0	94	-	+	-	-	-	-	-	-	-	-	-	-
MCLIMPNT	F	JFB/RAZ	03/25/96	07:41 PM	2	11.0	62	-	-	-	-	-	-	-	-	-	-	-	-
MCLIMPNT	F	JFB/RAZ	04/18/96	09:39 PM	0	8.5	59	-	-	-	-	1	-	-	-	-	-	2	-
MCLIMPNT	F	JFB	04/28/96	09:23 PM	1	16.5	47	-	-	-	-	1	-	-	-	-	-	1	2
MCLIMPNT	F	JFB	05/19/96	11:20 PM	1	25.0	70	-	-	-	-	-	-	-	2	-	-	1	2
MCLIMPNT	F	JFB	06/10/96	10:27 PM	0	22.0	91	-	-	-	-	-	-	-	2	-	-	1	3
MCLIMPNT	F	JFB/DMG	07/17/96	10:58 PM	1	24.0	87	-	-	-	-	-	-	-	2	-	-	2	2
MCLJOHNS	F	JFB/RAZ	04/27/93	08:31 PM	0	11.0	62	-	-	-	-	-	-	-	-	-	-	+	2
MCLJOHNS	F	JFB/RAZ	05/24/93	10:50 PM	1	22.0	83	-	-	-	-	-	-	-	2	-	-	-	2
MCLJOHNS	F	JFB/RAZ	06/09/93	10:41 PM	5	25.0	96	-	-	-	-	-	-	-	2	-	-	-	2
MCLJPOND	F	JFB/RAZ	04/27/93	08:16 PM	0	11.0	60	-	-	-	-	4	-	-	-	-	-	1	4
MCLJPOND	F	JFB/RAZ	05/24/93	10:09 PM	1	21.0	72	-	-	4	-	-	-	-	3	-	-	-	4
MCLJPOND	F	JFB/RAZ	06/09/93	10:49 PM	5	24.0	92	-	-	4	-	-	-	-	-	-	-	-	+

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MCLJPOND	F	JFB	03/13/96	07:42 PM	0	9.0	55	-	-	-	-	-	-	-	-	-	-	-	-
MCLJPOND	F	JFB/RAZ	03/25/96	07:50 PM	2	14.0	66	-	-	-	-	2	-	-	-	-	-	1	-
MCLJPOND	F	JFB	04/15/96	10:07 PM	2,4,5	9.0	85	-	-	-	-	4	-	-	-	-	-	1	-
MCLJPOND	F	JFB	04/28/96	09:14 PM	1	16.0	43	-	-	-	-	1	-	-	-	-	-	2	3
MCLJPOND	F	JFB	05/19/96	11:29 PM	1	25.0	73	-	1	4	-	-	-	2	2	-	-	2	4
MCLJPOND	F	JFB	06/10/96	10:36 PM	0	22.0	91	-	-	4	-	-	-	-	-	-	-	2	3
MCLJPOND	F	JFB/DMG	07/17/96	11:08 PM	1	24.0	83	-	-	2	-	-	-	-	2	-	-	-	4
MCLJPOND	S	JFB	03/17/97	07:03 PM	2	9.0	54	-	-	-	-	-	-	-	-	-	-	-	-
MCLJPOND	F	JFB/DMG	03/26/97	08:38 PM	0,4	10.0	49	-	-	-	-	-	-	-	-	-	-	1	-
MCLJPOND	F	JFB/DMG	04/29/97	10:40 PM	0	12.0	80	-	-	-	-	2	-	-	-	-	-	1	3
MCLJPOND	F	JFB/RAZ	05/29/97	10:59 PM	0	13.0	88	-	-	2	-	-	-	1	2	-	-	-	2
MCLJPOND	F	JFB	06/24/97	11:40 PM	0	22.0	83	-	-	-	-	-	-	-	-	-	-	-	-
MCLJPOND	S	JFB/DMG	02/19/98	09:13 PM	2	10.0	74	-	-	-	-	-	-	-	-	-	-	-	-
MCLJPOND	S	JFB	02/26/98	02:43 PM	0,4	21.0	35	-	-	-	-	-	-	-	-	-	-	-	-
MCLJPOND	F	JFB/RAZ	03/26/98	08:19 PM	0	16.5	54	-	-	-	-	-	-	-	-	-	-	-	-
MCLJPOND	F	JFB	04/17/98	08:58 PM	2	19.0	95	-	1	4	-	4	-	1	-	-	-	1	2
MCLJPOND	F	JFB	05/07/98	10:07 PM	2	15.5	83	-	-	3	-	1	-	1	2	-	-	1	4
MCLJPOND	F	JFB	06/16/98	10:14 PM	2,4,6	22.5	100	-	-	3	-	-	-	1	2	-	-	1	2
MCLJPOND	F	JFB	03/17/99	09:22 PM	0,4	14.0	50	-	-	-	-	-	-	-	-	-	-	-	-
MCLJPOND	F	JFB	04/01/99	08:30 PM	2,3,5	16.0	100	-	-	-	-	2	-	-	-	-	-	1	-
MCLJPOND	F	JFB	05/08/99	09:56 PM	1	19.0	91	-	2	4	-	2	-	-	-	-	-	2	3
MCLJPOND	F	JFB	06/08/99	09:36 PM	0	25.0	63	-	-	3	-	-	-	-	-	-	-	-	1
MCLPUDDL	S	JFB	02/26/98	01:41 PM	0,4	15.5	34	-	-	-	-	-	-	-	-	-	4	-	-
MCLPUDDL	S	JFB	03/17/99	08:28 PM	-	-	-	-	-	-	-	-	-	-	-	-	v	-	-
MCLRK536	F	JFB/RAZ	04/14/93	10:58 PM	1,5	10.0	-	-	-	-	-	4	-	-	-	-	-	-	-
MCLRK536	F	JFB/RAZ	05/05/93	08:36 PM	2	22.0	87	-	2	-	-	2	-	-	1	-	-	-	-
MCLRK536	F	JFB/RAZ	06/09/93	10:10 PM	2	25.0	96	-	1	-	-	-	-	-	2	-	-	-	-
MCLRK536	S	JFB	05/19/98	08:48 PM	2	23.0	75	-	-	-	-	-	-	2	-	-	-	-	-
MCLRK536	F	JFB	04/03/99	08:24 PM	0,4	13.0	86	-	-	-	-	4	-	-	-	-	-	-	-
MCLRK536	F	JFB	05/06/99	10:05 PM	2	13.0	94	-	-	2	-	4	-	2	-	-	-	-	-
MCLRK536	F	JFB	06/08/99	10:00 PM	0	23.0	76	-	-	-	-	-	-	1	3	-	-	-	-
MCLRUSNK	S	JFB/RAZ	04/14/93	11:05 PM	1,5	11.0	-	-	-	-	-	-	-	-	-	-	-	-	-
MCLRUSNK	F	JFB/RAZ	04/27/93	08:55 PM	0	10.0	69	-	-	-	-	4	-	-	-	-	-	-	-
MCLRUSNK	F	JFB/RAZ	05/05/93	08:09 PM	2	20.0	87	-	3	4	-	4	-	-	2	-	-	-	-
MCLRUSNK	F	JFB/RAZ	06/09/93	10:21 PM	2	25.0	88	-	4	2	-	-	-	-	2	-	-	-	-
MCLRUSNK	F	JFB/RAZ	03/25/96	06:46 PM	2	15.0	62	-	-	-	-	-	2	-	-	-	-	-	-
MCLRUSNK	F	JFB	03/31/96	08:27 PM	0	10.0	71	-	-	-	-	2	2	-	-	-	-	1	-
MCLRUSNK	F	JFB/DMG	04/08/96	09:34 PM	0	3.0	-	-	-	-	-	-	2	-	-	-	-	-	-
MCLRUSNK	F	JFB	04/19/96	08:11 PM	2	19.5	55	-	-	2	-	4	2	-	-	-	-	1	-
MCLRUSNK	F	JFB	05/10/96	11:14 PM	1	18.0	90	-	-	4	-	-	-	-	-	-	-	2	-
MCLRUSNK	F	JFB	06/07/96	09:20 PM	0,4	23.0	75	-	1	4	2	-	-	-	2	-	-	2	-
MCLRUSNK	F	JFB	06/26/96	09:43 PM	1	22.0	58	-	-	2	-	-	-	-	1	-	-	-	-
MCLRUSNK	F	JFB	07/07/96	09:11 PM	2	26.0	80	-	-	4	1	-	-	-	-	-	-	-	-
MCLRUSNK	S	JFB	03/05/97	06:18 PM	2	8.0	74	-	-	-	-	-	2	-	-	-	-	-	-
MCLRUSNK	S	JFB	03/17/97	06:54 PM	2	9.0	54	-	-	-	-	-	3	-	-	-	-	-	-
MCLRUSNK	F	JFB/DMG	03/26/97	07:15 PM	0,4	7.5	60	-	-	-	-	1	3	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MCLRUSNK	F	JFB/DMG	04/29/97	09:27 PM	0	14.0	88	-	-	-	-	4	-	-	-	-	-	1	-
MCLRUSNK	F	JFB/RAZ	05/29/97	10:14 PM	0	11.5	89	-	-	2	-	-	-	-	-	-	-	2	-
MCLRUSNK	F	JFB	06/24/97	10:48 PM	0	22.0	83	-	-	3	-	-	-	-	1	-	-	-	-
MCLRUSNK	S	JFB/DMG	02/19/98	07:40 PM	2	10.5	74	-	-	-	-	-	-	-	-	-	2	-	-
MCLRUSNK	S	JFB	02/26/98	01:27 PM	0,4	15.0	30	-	-	-	-	-	-	-	-	-	2	-	-
MCLRUSNK	S	JFB	03/19/98	06:38 PM	2,4	9.5	91	-	-	-	-	-	4	-	-	-	-	-	-
MCLRUSNK	F	JFB	03/19/98	10:03 PM	2	9.5	100	-	-	-	-	-	4	-	-	-	-	-	-
MCLRUSNK	S	JFB/RAZ	03/25/98	07:53 PM	0	6.0	56	-	-	-	-	-	3	-	-	-	-	-	-
MCLRUSNK	S	JFB/DMG	04/14/98	07:50 PM	2,5	15.5	100	-	-	3	-	4	-	-	-	-	-	-	-
MCLRUSNK	F	JFB	04/17/98	08:06 PM	2	17.5	90	-	-	4	-	4	-	-	-	-	-	-	-
MCLRUSNK	S	JFB/DMG	04/22/98	09:57 PM	2	10.5	74	-	-	2	-	4	-	-	-	-	-	-	-
MCLRUSNK	F	JFB	05/19/98	08:48 PM	2	23.0	75	-	-	4	1	2	-	-	-	-	-	-	-
MCLRUSNK	F	JFB/DMG	06/15/98	11:05 PM	2	21.0	96	-	-	3	-	-	-	-	2	-	-	2	-
MCLRUSNK	S	JFB	03/11/99	04:45 PM	0,4	6.5	50	-	-	-	-	-	1	-	-	-	-	-	-
MCLRUSNK	S	JFB	03/13/99	11:04 AM	0,4	8.0	44	-	-	-	-	-	-	-	-	-	-	-	-
MCLRUSNK	F	JFB	03/17/99	08:07 PM	0	8.5	74	-	-	-	-	-	2	-	-	-	2	-	-
MCLRUSNK	S	JFB	04/01/99	09:52 PM	2,3,5	14.5	93	-	-	-	-	2	2	-	-	-	-	-	-
MCLRUSNK	F	JFB	04/03/99	09:00 PM	0,4	13.0	86	-	-	-	-	-	3	-	-	-	-	1	-
MCLRUSNK	F	JFB	05/06/99	10:20 PM	2	13.0	94	-	-	3	-	4	-	-	-	-	-	1	-
MCLRUSNK	F	JFB	06/08/99	10:30 PM	0	20.5	82	-	-	4	-	-	-	-	1	-	-	2	-
MCLSANDY	F	JFB/RAZ	04/14/93	11:11 PM	1,5	11.0	-	-	-	-	-	4	-	-	-	-	-	1	-
MCLSANDY	F	JFB/RAZ	05/05/93	07:58 PM	2	21.0	91	-	-	4	1	1	-	-	2	-	-	-	2
MCLSANDY	F	JFB/RAZ	06/09/93	10:26 PM	2,5	25.0	96	-	-	-	-	-	-	-	+	-	-	-	+
MCLSANDY	F	JFB	03/13/96	09:07 PM	0	7.5	54	-	-	-	-	-	-	-	-	-	-	-	-
MCLSANDY	F	JFB/RAZ	03/25/96	06:57 PM	2	15.0	66	-	-	-	-	2	2	-	-	-	1	-	-
MCLSANDY	F	JFB/DMG	04/08/96	09:46 PM	0	3.5	-	-	-	-	-	2	-	-	-	-	-	2	-
MCLSANDY	F	JFB	04/19/96	08:25 PM	2	20.0	59	-	-	-	-	4	1	-	-	-	-	1	-
MCLSANDY	F	JFB	05/19/96	10:50 PM	1	26.0	80	-	-	4	-	-	-	-	3	-	-	3	3
MCLSANDY	F	JFB	06/10/96	09:30 PM	0	24.5	91	-	-	4	-	-	-	-	1	-	-	-	1
MCLSANDY	F	JFB	06/26/96	09:51 PM	1	23.0	55	-	-	1	-	-	-	-	-	-	-	-	-
MCLSANDY	F	JFB	07/07/96	09:02 PM	2	26.5	84	-	-	4	-	-	-	-	-	-	-	-	-
MCLSANDY	S	JFB	03/05/97	06:28 PM	2	8.5	91	-	-	-	-	-	-	-	-	-	-	-	-
MCLSANDY	S	JFB	03/17/97	06:47 PM	2	10.0	64	-	-	-	-	-	-	-	-	-	-	-	-
MCLSANDY	F	JFB/DMG	03/26/97	07:32 PM	0,4	8.0	46	-	-	-	-	-	-	-	-	-	-	-	-
MCLSANDY	F	JFB/DMG	04/29/97	09:45 PM	0	15.0	86	-	-	2	-	4	-	-	-	-	-	4	-
MCLSANDY	F	JFB/RAZ	05/29/97	10:23 PM	0	12.0	88	-	-	2	-	-	-	-	-	-	-	1	2
MCLSANDY	F	JFB	06/24/97	10:59 PM	0	21.0	91	-	-	1	-	-	-	-	-	-	-	-	-
MCLSANDY	S	JFB/DMG	02/19/98	07:53 PM	2	9.5	74	-	-	-	-	-	-	-	-	-	-	-	-
MCLSANDY	S	JFB/DMG	02/25/98	07:51 PM	0,4	10.0	41	-	-	-	-	-	-	-	-	-	2	-	-
MCLSANDY	S	JFB	02/26/98	01:36 PM	0,4	15.5	34	-	-	-	-	-	-	-	-	-	1	-	-
MCLSANDY	S	JFB/RAZ	02/28/98	05:37 PM	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
MCLSANDY	F	JFB/RAZ	03/25/98	08:05 PM	0	6.0	55	-	-	-	-	1	-	-	-	-	-	-	-
MCLSANDY	F	JFB/DMG	04/22/98	10:08 PM	2	11.0	74	-	-	2	-	4	-	-	2	-	-	1	2
MCLSANDY	F	JFB	05/19/98	08:57 PM	2	23.5	75	-	-	4	-	-	-	-	2	-	-	1	2
MCLSANDY	F	JFB/DMG	06/15/98	11:11 PM	2	20.5	95	-	-	3	-	-	-	-	3	-	-	1	2
MCLSANDY	S	JFB	03/13/99	10:52 AM	0,4	7.5	49	-	-	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MCLSANDY	F	JFB	03/17/99	08:20 PM	0	8.5	74	-	-	-	-	-	-	-	-	-	-	-	-
MCLSANDY	F	JFB	04/01/99	10:04 PM	2,3,5	14.5	93	-	-	-	-	3	-	-	-	-	-	2	-
MCLSANDY	F	JFB	05/06/99	10:28 PM	2	13.0	94	-	-	4	-	-	-	-	-	-	-	2	2
MCLSANDY	F	JFB	06/08/99	10:40 PM	0	20.0	74	-	-	1	-	-	-	-	-	-	-	-	-
MCOIMPNT	F	JFB/RAZ	04/14/93	09:46 PM	1,5	12.0	-	-	-	-	-	2	-	-	-	-	-	4	-
MCOIMPNT	F	JFB/RAZ	05/05/93	09:26 PM	2	20.0	91	-	2	-	-	1	-	-	-	-	-	3	-
MCOIMPNT	F	JFB/RAZ	06/09/93	09:53 PM	8	25.0	92	-	-	-	-	-	-	-	-	-	-	1	-
MCOIMPNT	F	JFB/RAZ	06/16/93	08:44 PM	0	21.0	83	1	-	-	-	-	-	-	2	-	-	-	-
MCOIMPNT	F	JFB	03/15/96	07:04 PM	2	17.0	92	-	-	-	-	1	-	-	-	-	-	-	-
MCOIMPNT	F	JFB	03/31/96	07:49 PM	0,4	10.5	49	-	-	-	-	-	-	-	-	-	-	2	-
MCOIMPNT	F	JFB	04/15/96	08:55 PM	2,4	9.0	74	-	-	-	-	-	-	-	-	-	-	3	-
MCOIMPNT	F	JFB	04/28/96	10:02 PM	1	17.0	48	-	-	-	-	2	-	-	-	-	-	3	-
MCOIMPNT	F	JFB	05/19/96	10:12 PM	1	25.0	76	-	-	-	-	-	-	-	2	-	-	2	1
MCOIMPNT	F	JFB	06/08/96	11:35 PM	0	23.0	91	1	-	-	-	-	-	-	-	-	-	2	-
MCOIMPNT	F	JFB/DMG	07/17/96	10:34 PM	1	24.5	87	-	-	-	-	-	-	v	2	-	-	-	-
MGUHEADD	F	JFB	04/19/96	08:52 PM	0	20.0	59	-	-	-	-	-	1	-	-	-	-	-	-
MGUHEADD	F	JFB	05/10/96	11:29 PM	1	17.0	90	-	-	-	-	-	2	-	-	-	-	-	-
MGUHEADU	F	JFB	03/13/96	08:37 PM	0	8.0	60	-	-	-	-	-	-	-	-	-	-	-	-
MGUHEADU	F	JFB/DMG	04/08/96	09:21 PM	0	3.0	-	-	-	-	-	3	-	-	-	-	-	-	-
MGUHEADU	F	JFB	04/19/96	08:52 PM	0	20.0	59	-	-	-	-	4	-	-	-	-	-	-	-
MGUHEADU	F	JFB	05/10/96	11:29 PM	1	17.0	90	-	-	4	-	2	-	-	1	-	-	-	-
MGUHEADU	F	JFB	06/07/96	09:41 PM	0,4	23.0	75	-	-	4	1	-	-	-	2	-	-	-	-
MGUHEADU	F	JFB	07/07/96	09:21 PM	2	26.0	80	-	-	2	-	-	-	-	-	-	-	-	-
MGUNWEST	F	JFB/RAZ	04/27/93	09:07 PM	0	9.0	74	-	-	-	-	-	-	-	-	-	-	-	-
MGUNWEST	F	JFB/RAZ	05/24/93	10:19 PM	1	22.0	75	-	-	-	-	-	-	-	-	-	-	-	2
MGUNWEST	F	JFB/RAZ	06/16/93	10:24 PM	0	20.0	91	-	-	-	-	-	-	-	-	-	-	-	1
MGUTR536	S	JFB	02/26/98	01:21 PM	0,4	17.5	43	-	-	-	-	-	-	-	-	-	4	-	-
MHAATCOL	F	JFB	03/29/99	06:48 PM	0,4	17.0	37	-	-	-	-	-	-	-	-	-	-	-	-
MHAATCOL	F	JFB	04/14/99	08:24 PM	0,4	17.5	30	-	-	-	-	-	-	-	-	-	-	-	-
MHAATCOL	F	JFB	06/01/99	12:00 AM	2,5	22.0	79	-	-	-	-	-	-	3	-	-	-	-	-
MHAATCOL	F	JFB/RAZ	06/25/99	12:03 AM	0	21.0	100	-	2	-	-	-	-	3	-	-	-	-	-
MHAFOLLY	F	JFB	03/29/99	06:55 PM	0	16.0	40	-	-	-	-	4	-	-	-	-	-	-	-
MHAFOLLY	F	JFB	04/14/99	08:15 PM	0,4	16.0	36	-	-	-	-	2	-	-	-	-	-	-	-
MHAFOLLY	F	JFB	06/01/99	12:08 AM	2	21.0	91	-	-	-	-	-	-	2	2	-	-	-	-
MHAFOLLY	F	JFB/RAZ	06/25/99	12:13 AM	0	20.0	100	-	1	-	-	-	-	1	1	-	-	-	-
MHARETEN	F	JFB	03/17/99	07:05 PM	0	11.5	69	-	-	-	-	-	-	-	-	-	-	-	-
MHARETEN	F	JFB	04/03/99	07:32 PM	0,4	13.0	83	-	-	-	-	4	-	-	-	-	-	-	-
MHARETEN	F	JFB	05/08/99	08:58 PM	2	19.5	81	-	4	-	-	3	-	1	-	-	-	-	-
MHARETEN	F	JFB	06/07/99	10:35 PM	0	25.0	92	-	-	-	-	-	-	1	2	-	-	-	-
MHASPRAY	F	JFB	03/15/96	06:52 PM	2,3	17.0	92	-	-	-	-	4	-	-	-	-	2	-	-
MHASPRAY	F	JFB	03/31/96	07:29 PM	0	12.0	53	-	-	-	-	4	2	-	-	-	2	1	-
MHASPRAY	F	JFB	04/15/96	08:29 PM	2,4	9.0	74	-	-	-	-	4	-	-	-	-	1	2	-
MHASPRAY	F	JFB	04/28/96	10:19 PM	1	17.5	52	-	-	1	-	4	-	-	1	-	-	1	-
MHASPRAY	F	JFB	05/19/96	09:54 PM	2	24.0	84	1	-	4	-	2	-	-	-	-	-	2	-
MHASPRAY	F	JFB	06/08/96	11:16 PM	0	24.0	91	-	-	3	-	-	-	-	-	-	-	-	-
MHASPRAY	F	JFB	06/26/96	09:08 PM	1	22.0	59	-	-	1	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MHASPRAY	F	JFB	07/06/96	09:35 PM	0	23.0	90	-	-	4	-	-	-	-	-	-	-	-	-
MHASPRAY	S	JFB/RAZ	03/08/97	06:34 PM	0,4	10.5	64	-	-	-	-	-	-	-	-	-	-	-	-
MHASPRAY	F	JFB/DMG	03/26/97	09:31 PM	0,4	9.0	49	-	-	-	-	4	-	-	-	-	-	1	-
MHASPRAY	F	JFB/DMG	04/29/97	08:43 PM	0	17.0	68	-	-	-	-	4	-	-	-	-	-	2	-
MHASPRAY	F	JFB/RAZ	05/29/97	09:26 PM	0	11.5	78	-	-	2	-	-	-	-	-	-	-	-	-
MHASPRAY	F	JFB	06/24/97	10:04 PM	0	24.0	84	-	-	1	-	-	-	-	1	-	-	-	-
MHASPRAY	S	JFB/DMG	02/19/98	07:00 PM	1,4	10.0	75	-	-	-	-	-	-	-	-	-	-	-	-
MHASPRAY	S	JFB/DMG	02/25/98	06:40 PM	0,4	10.0	41	-	-	-	-	-	-	-	-	-	-	-	-
MHASPRAY	S	JFB	02/26/98	12:54 PM	0,4	18.0	32	-	-	-	-	-	-	-	-	-	-	-	-
MHASPRAY	F	JFB/RAZ	03/25/98	07:22 PM	0	5.0	62	-	-	-	-	-	-	-	-	-	-	-	-
MHASPRAY	F	JFB/DMG	04/22/98	09:16 PM	2	13.0	60	-	-	-	-	4	-	-	-	-	-	2	-
MHASPRAY	F	JFB	05/07/98	09:25 PM	2	16.0	90	-	-	2	-	4	-	-	2	-	-	2	-
MHASPRAY	F	JFB/DMG	06/15/98	10:22 PM	2	21.5	96	-	-	2	-	-	-	-	2	-	-	-	-
MHASPRAY	F	JFB	03/17/99	07:20 PM	0	12.0	70	-	-	-	-	-	-	-	-	-	-	-	-
MHASPRAY	F	JFB	04/03/99	07:43 PM	0,4	13.0	88	-	-	-	-	4	2	-	-	-	-	2	-
MHASPRAY	F	JFB	05/06/99	09:14 PM	2	14.5	94	-	-	2	-	2	-	-	-	-	-	-	-
MHASPRAY	F	JFB	06/07/99	10:52 PM	0	26.0	87	-	-	2	-	-	-	-	-	-	-	-	-
MPR536JK	S	JFB	02/26/98	01:33 PM	0,4	17.5	43	-	-	-	-	-	-	-	-	-	4	-	-
MPR536JK	S	JFB	03/17/99	08:00 PM	0	9.0	79	-	-	-	-	-	-	-	-	-	2	-	-
MPRICEPD	F	JFB	03/15/96	07:20 PM	2	18.0	89	-	-	-	-	1	-	-	-	-	1	-	-
MPRICEPD	F	JFB	03/31/96	08:05 PM	0	11.0	72	-	-	-	-	4	-	-	-	-	-	-	-
MPRICEPD	F	JFB/DMG	04/08/96	09:01 PM	0	1.0	54	-	-	-	-	4	-	-	-	-	-	2	-
MPRICEPD	F	JFB/DMG	04/23/96	10:30 PM	2	19.5	90	-	-	2	-	4	-	-	2	-	-	2	-
MPRICEPD	F	JFB	05/19/96	10:26 PM	1	25.0	83	-	1	2	1	1	-	-	4	-	-	2	-
MPRICEPD	F	JFB	06/08/96	11:55 PM	0	21.0	91	-	-	2	-	-	-	-	2	-	-	2	-
MPRICEPD	F	JFB	06/26/96	09:32 PM	1	22.5	60	-	-	2	-	-	-	-	2	-	-	-	-
MPRICEPD	F	JFB	07/06/96	10:02 PM	0	21.0	90	-	-	3	-	-	-	-	3	-	-	-	-
MPRICEPD	S	JFB/RAZ	03/08/97	07:16 PM	0,4	10.0	56	-	-	-	-	-	-	-	-	-	1	-	-
MPRICEPD	F	JFB/DMG	03/26/97	06:56 PM	1,4	9.0	60	-	-	-	-	2	-	-	-	-	1	1	-
MPRICEPD	F	JFB/DMG	04/29/97	09:13 PM	0	17.0	88	-	-	-	-	4	-	-	-	-	-	3	-
MPRICEPD	F	JFB/RAZ	05/29/97	10:03 PM	0	11.5	78	-	-	2	-	-	-	-	2	-	-	2	-
MPRICEPD	F	JFB	06/24/97	10:33 PM	0	23.5	84	-	-	-	-	-	-	-	2	-	-	-	-
MPRICEPD	S	JFB/DMG	02/19/98	07:25 PM	2	8.0	85	-	-	-	-	-	-	-	-	-	4	-	-
MPRICEPD	S	JFB	02/26/98	01:15 PM	0,4	17.5	43	-	-	-	-	-	-	-	-	-	4	-	-
MPRICEPD	F	JFB/RAZ	03/25/98	07:42 PM	0	5.0	61	-	-	-	-	1	-	-	-	-	-	-	-
MPRICEPD	F	JFB/DMG	04/22/98	09:44 PM	2	10.5	64	-	-	2	-	4	-	-	2	-	-	2	-
MPRICEPD	F	JFB	05/07/98	09:52 PM	2	15.5	84	-	-	2	-	2	-	1	4	-	-	2	-
MPRICEPD	F	JFB/DMG	06/15/98	10:51 PM	2	22.0	96	-	-	2	1	-	-	-	4	-	-	2	-
MPRICEPD	F	JFB	03/17/99	07:50 PM	0	9.0	79	-	-	-	-	-	-	-	-	-	-	1	-
MPRICEPD	F	JFB	04/03/99	08:34 PM	0,4	10.0	92	-	-	-	-	4	-	-	-	-	-	3	-
MPRICEPD	F	JFB	05/06/99	09:51 PM	2	14.0	88	-	-	3	-	2	-	-	-	-	-	2	-
MPRICEPD	F	JFB	06/07/99	11:35 PM	0	24.5	88	-	-	-	-	-	-	v	-	-	-	-	-
MPRPESTL	F	JFB	03/17/99	07:43 PM	0	13.5	56	-	-	-	-	-	-	-	-	-	-	-	-
MPRPESTL	F	JFB	04/03/99	08:18 PM	0,4	13.0	88	-	-	-	-	2	-	-	-	-	-	-	-
MPRPESTL	F	JFB	05/06/99	09:42 PM	2	15.5	89	-	-	-	-	-	-	v	-	-	-	-	-
MPRPESTL	F	JFB	06/08/99	10:17 PM	0	24.5	62	-	-	-	-	-	-	2	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MSL206BG	F	JFB/RAZ	04/27/93	08:05 PM	0	10.5	61	-	-	-	-	-	-	-	-	-	-	-	3
MSL206BG	F	JFB/RAZ	05/24/93	09:59 PM	1	23.0	72	-	-	-	-	-	-	-	1	-	-	-	4
MSL206BG	F	JFB/RAZ	06/16/93	10:36 PM	0	20.0	82	-	-	-	-	-	-	-	+	-	-	-	+
MSL206BG	F	JFB	03/17/99	10:33 PM	0,4	16.0	50	-	-	-	-	-	-	-	-	-	-	-	-
MSL206BG	F	JFB	04/01/99	08:24 PM	2,3,5	16.0	100	-	-	-	-	-	-	-	-	-	-	-	-
MSL206BG	F	JFB	05/08/99	11:12 PM	0	17.0	90	-	2	-	-	-	-	1	-	-	-	1	4
MSL206BG	F	JFB	06/08/99	09:27 PM	0	24.0	84	-	-	-	-	-	-	-	-	-	-	-	1
MSL4X4PD	F	JFB/RAZ	04/27/93	08:43 PM	0	12.0	64	-	-	-	-	4	-	-	-	-	-	3	-
MSL4X4PD	F	JFB/RAZ	05/24/93	11:01 PM	1	21.0	75	-	2	3	-	-	-	-	2	-	-	-	-
MSL4X4PD	F	JFB/RAZ	06/09/93	10:32 PM	5	25.0	92	-	-	4	2	-	-	-	-	-	-	-	-
MSL4X4PD	F	JFB/RAZ	03/25/96	07:09 PM	2,4	14.0	66	-	-	-	-	4	2	-	-	-	2	-	-
MSL4X4PD	F	JFB/DMG	04/08/96	09:59 PM	0	2.0	-	-	-	-	-	2	-	-	-	-	-	2	-
MSL4X4PD	F	JFB	04/19/96	08:37 PM	2	19.0	63	-	-	-	-	4	-	-	-	-	-	4	-
MSL4X4PD	F	JFB	05/10/96	11:43 PM	1	17.0	90	-	-	4	-	-	-	1	3	-	-	4	-
MSL4X4PD	F	JFB	06/10/96	09:20 PM	2	24.0	91	-	-	4	2	-	-	-	2	-	-	-	-
MSL4X4PD	F	JFB	07/07/96	08:50 PM	2	27.0	77	-	-	4	-	-	-	-	2	-	-	-	-
MSL4X4PD	S	JFB	03/05/97	06:37 PM	2	8.0	85	-	-	-	-	-	-	-	-	-	-	-	-
MSL4X4PD	F	JFB	03/17/97	06:40 PM	2	8.0	54	-	-	-	-	-	-	-	-	-	-	-	-
MSL4X4PD	F	JFB	04/16/97	09:06 PM	0,4	16.5	41	-	-	-	-	2	-	-	-	-	-	3	-
MSL4X4PD	F	JFB/RAZ	05/29/97	10:30 PM	0	12.5	88	-	-	2	-	-	-	-	2	-	-	2	-
MSL4X4PD	F	JFB	06/24/97	11:08 PM	0	21.5	83	-	-	1	-	-	-	v	2	-	-	-	-
MSL4X4PD	S	JFB/DMG	02/19/98	07:59 PM	2	10.5	79	-	-	-	-	-	-	-	-	-	-	-	-
MSL4X4PD	S	JFB	02/26/98	01:43 PM	0,4	18.0	36	-	-	-	-	-	-	-	-	-	-	-	-
MSL4X4PD	F	JFB/RAZ	03/25/98	08:15 PM	0	6.0	68	-	-	-	-	2	-	-	-	-	-	2	-
MSL4X4PD	F	JFB/DMG	04/22/98	10:20 PM	2	12.5	74	-	-	-	-	4	-	-	2	-	-	2	-
MSL4X4PD	F	JFB	05/19/98	09:05 PM	2	23.0	75	-	-	4	-	-	-	1	4	-	-	2	-
MSL4X4PD	F	JFB/DMG	06/15/98	11:19 PM	2	21.0	95	-	-	3	-	-	-	1	2	-	-	2	-
MSL4X4PD	F	JFB	03/17/99	08:35 PM	0	11.0	64	-	-	-	-	-	-	-	-	-	2	-	-
MSL4X4PD	F	JFB	04/01/99	10:20 PM	2,3,5	16.5	100	-	-	-	-	3	2	-	-	-	-	-	-
MSL4X4PD	F	JFB	05/06/99	10:45 PM	2	13.0	100	-	-	2	-	4	-	-	-	-	-	-	-
MSL4X4PD	F	JFB	06/07/99	11:57 PM	0	23.5	87	-	-	1	-	-	-	-	-	-	-	-	-
MSLBLUEB	F	JFB	03/13/96	07:53 PM	0	11.0	49	-	-	-	-	-	-	-	-	-	-	-	-
MSLBLUEB	F	JFB/RAZ	03/25/96	08:00 PM	2	14.0	66	-	-	-	-	4	-	-	-	-	-	2	-
MSLBLUEB	F	JFB	04/15/96	09:56 PM	2,4,5	14.0	92	-	-	-	-	4	-	-	-	-	-	2	-
MSLBLUEB	F	JFB	04/28/96	09:04 PM	1	15.5	43	-	-	2	-	2	-	-	2	-	-	2	1
MSLBLUEB	F	JFB/DMG	05/20/96	11:30 PM	0	25.0	70	-	1	4	2	-	-	-	4	-	-	4	2
MSLBLUEB	F	JFB	06/10/96	10:13 PM	0	22.5	91	-	2	4	-	-	-	-	2	-	-	4	2
MSLBLUEB	F	JFB	07/07/96	10:18 PM	0	24.5	87	-	-	4	-	-	-	-	2	-	-	1	2
MSLBLUEB	F	JFB/DMG	03/26/97	08:27 PM	0,4	10.5	49	-	-	-	-	4	-	-	-	-	-	2	-
MSLBLUEB	F	JFB/DMG	04/29/97	10:30 PM	0	15.0	75	-	-	-	-	4	-	-	1	-	-	4	2
MSLBLUEB	F	JFB/RAZ	05/29/97	11:34 PM	1	12.5	84	-	-	2	-	-	-	1	4	-	-	2	2
MSLBLUEB	F	JFB	06/24/97	12:24 AM	0	25.0	77	-	-	-	-	-	-	2	3	-	-	-	3
MSLBLUEB	S	JFB/DMG	02/19/98	09:06 PM	2	9.0	74	-	-	-	-	-	-	-	-	-	-	-	-
MSLBLUEB	S	JFB	02/26/98	02:35 PM	0,4	21.0	31	-	-	-	-	-	-	-	-	-	-	-	-
MSLBLUEB	F	JFB/RAZ	03/26/98	08:08 PM	0	16.5	58	-	-	-	-	-	-	-	-	-	-	4	-
MSLBLUEB	F	JFB	04/17/98	08:47 PM	2,5	18.5	95	-	2	1	-	4	-	-	-	-	-	2	3

Survey Information: Site Code	Data Type	Observer(s) Initials	Date	Time	Conditions: Weather Code	Air Temp. (°C)	Rel. Hum. (%)	Species: *A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MSLBLUEB	F	JFB	05/19/98	09:33 PM	2	24.5	72	-	2	-	-	-	-	2	4	-	-	2	2
MSLBLUEB	F	JFB	06/16/98	10:24 PM	2,4,6	22.5	100	-	-	2	-	-	-	2	4	-	-	1	2
MSLBLUEB	F	JFB	03/17/99	09:30 PM	0,4	14.0	50	-	-	-	-	-	-	-	-	-	-	1	-
MSLBLUEB	F	JFB	04/01/99	08:36 PM	2,3,5	15.0	93	-	-	-	-	3	-	-	-	-	-	3	-
MSLBLUEB	F	JFB	05/08/99	11:05 PM	0	17.0	90	-	1	2	-	-	-	1	2	-	-	3	2
MSLBLUEB	F	JFB	06/08/99	09:48 PM	0	23.5	76	-	2	2	-	-	-	-	2	-	-	1	1
MSLBLUPL	S	JFB/RAZ	03/26/98	08:08 PM	0	16.5	58	-	-	-	-	-	+	-	-	-	+	-	-
MSLBLUPL	S	JFB	03/17/99	09:30 PM	0,4	14.0	50	-	-	-	-	-	-	-	-	-	2	-	-
MSLBLUPL	S	JFB	04/01/99	08:36 PM	2,3,5	15.0	93	-	-	-	-	-	1	-	-	-	-	-	-
MSLEISOL	F	JFB	03/13/96	08:50 PM	0	8.0	60	-	-	-	-	-	-	-	-	-	-	-	-
MSLEISOL	F	JFB/RAZ	03/25/96	07:26 PM	2	12.0	62	-	-	-	-	-	2	-	-	-	1	-	-
MSLEISOL	F	JFB/DMG	04/08/96	10:13 PM	0	2.0	-	-	-	-	-	2	1	-	-	-	-	1	-
MSLEISOL	F	JFB/RAZ	04/18/96	09:23 PM	0	13.0	64	-	-	-	-	4	1	-	-	-	-	3	-
MSLEISOL	F	JFB	05/19/96	11:04 PM	1	22.0	83	-	-	4	-	-	-	-	2	-	-	4	-
MSLEISOL	F	JFB	06/10/96	09:05 PM	2	25.0	91	-	-	4	1	-	-	-	-	-	-	1	-
MSLEISOL	F	JFB	06/21/96	09:48 PM	1	21.0	54	-	-	3	-	-	-	-	1	-	-	-	-
MSLEISOL	F	JFB	07/07/96	08:35 PM	2	26.5	77	-	-	3	-	-	-	-	-	-	-	-	-
MSLEISOL	F	JFB	03/17/97	06:28 PM	2	8.0	54	-	-	-	-	-	-	-	-	-	-	-	-
MSLEISOL	F	JFB	04/16/97	09:18 PM	0	13.0	48	-	-	-	-	3	-	-	-	-	-	2	-
MSLEISOL	F	JFB/RAZ	05/29/97	10:43 PM	0	10.0	88	-	-	1	-	-	-	-	2	-	-	2	-
MSLEISOL	F	JFB	06/24/97	11:23 PM	0	21.0	83	-	-	2	-	-	-	-	1	-	-	-	-
MSLEISOL	S	JFB/DMG	02/19/98	08:13 PM	2	7.0	85	-	-	-	-	-	-	-	-	-	-	-	-
MSLEISOL	S	JFB	02/26/98	01:55 PM	0,4	17.0	36	-	-	-	-	-	-	-	-	-	-	-	-
MSLEISOL	F	JFB/RAZ	03/25/98	08:30 PM	0	3.0	67	-	-	-	-	-	-	-	-	-	-	1	-
MSLEISOL	F	JFB/DMG	04/22/98	10:34 PM	2	8.5	74	-	-	2	-	4	-	-	2	-	-	-	1
MSLEISOL	F	JFB	05/19/98	09:18 PM	2	23.0	75	-	-	4	-	-	-	-	2	-	-	2	-
MSLEISOL	F	JFB/DMG	06/15/98	11:33 PM	2	21.0	96	-	-	3	-	-	-	-	2	-	-	1	-
MSLEISOL	F	JFB	03/17/99	09:00 PM	0	10.0	64	-	-	-	-	-	1	-	-	-	-	-	-
MSLEISOL	F	JFB	04/03/99	09:15 PM	0,4	12.0	88	-	-	-	-	3	-	-	-	-	-	-	-
MSLEISOL	F	JFB	05/08/99	09:39 PM	1,2	18.0	76	-	-	4	-	3	-	-	-	-	-	3	-
MSLEISOL	F	JFB	06/07/99	12:15 AM	0	23.0	88	-	-	-	-	-	-	-	-	-	-	-	-
MSLWARDN	F	JFB/RAZ	04/27/93	07:56 PM	0	12.0	63	-	-	-	-	-	-	-	-	-	-	1	3
MSLWARDN	F	JFB/RAZ	05/24/93	09:52 PM	1	22.0	72	-	4	-	-	-	-	-	1	-	-	-	4
MSLWARDN	F	JFB/RAZ	06/16/93	10:40 PM	0	18.0	86	-	-	-	-	-	-	-	-	-	-	-	4
MSLWARDN	F	JFB	03/13/96	07:31 PM	0	14.0	56	-	-	-	-	-	-	-	-	-	-	-	-
MSLWARDN	F	JFB	04/03/96	08:58 PM	0	12.5	68	-	-	-	-	2	-	-	-	-	-	2	-
MSLWARDN	F	JFB/RAZ	04/18/96	09:50 PM	0	10.5	64	-	-	-	-	-	-	-	-	-	-	2	-
MSLWARDN	F	JFB	05/10/96	11:02 PM	1	18.0	86	-	2	-	-	-	-	-	-	-	-	3	4
MSLWARDN	F	JFB	06/10/96	10:47 PM	0	22.5	91	-	-	-	-	-	-	1	-	-	-	2	4
MSLWARDN	F	JFB/DMG	07/17/96	11:18 PM	1	24.0	80	-	-	-	-	-	-	-	-	-	-	-	3
MSLWARDN	S	JFB	03/17/97	07:05 PM	2	9.0	54	-	-	-	-	-	-	-	-	-	-	-	-
MSLWARDN	F	JFB/DMG	03/26/97	08:48 PM	0,4	9.0	49	-	-	-	-	-	-	-	-	-	-	2	-
MSLWARDN	F	JFB/DMG	04/29/97	10:57 PM	0	12.5	70	-	-	-	-	-	-	-	-	-	-	2	3
MSLWARDN	F	JFB/RAZ	05/29/97	11:42 PM	1	12.0	88	-	-	-	-	-	-	-	1	-	-	2	4
MSLWARDN	F	JFB	06/24/97	12:35 AM	0	24.0	71	-	-	-	-	-	-	1	2	-	-	-	4

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MSLWARDN	S	JFB/DMG	02/19/98	09:22 PM	2	10.0	64	-	-	-	-	-	-	-	-	-	-	-	-
MSLWARDN	S	JFB	02/26/98	02:51 PM	0,4	19.0	30	-	-	-	-	-	-	-	-	-	-	-	-
MSLWARDN	F	JFB/RAZ	03/26/98	08:26 PM	0	16.0	58	-	-	-	-	-	-	-	-	-	-	3	-
MSLWARDN	F	JFB	04/17/98	09:11 PM	2	18.5	90	-	-	-	-	-	-	-	-	-	-	2	4
MSLWARDN	F	JFB	05/19/98	09:41 PM	2	24.5	66	-	-	-	-	-	-	-	-	-	-	-	4
MSLWARDN	F	JFB	06/16/98	10:33 PM	2,4,6	21.5	100	-	-	-	-	-	-	-	-	-	-	-	3
MSLWARDN	F	JFB	03/17/99	10:11 PM	0,4	16.0	50	-	-	-	-	-	-	-	-	-	-	-	-
MSLWARDN	F	JFB	04/01/99	08:18 PM	2,3,5	16.0	93	-	-	-	-	2	-	-	-	-	-	2	-
MSLWARDN	F	JFB	05/08/99	11:23 PM	0	17.5	95	-	2	1	-	1	-	-	-	-	-	2	4
MSLWARDN	F	JFB	06/08/99	09:20 PM	0	26.0	67	-	-	-	-	-	-	-	-	-	-	-	2
MWIBEAVR	F	JFB	03/17/99	07:30 PM	0	11.5	70	-	-	-	-	-	-	-	-	-	-	-	-
MWIBEAVR	F	JFB	04/03/99	08:03 PM	0,4	12.5	82	-	-	-	-	1	-	-	-	-	-	-	-
MWIBEAVR	F	JFB	05/08/99	09:14 PM	2	19.0	74	-	2	-	-	4	-	-	-	-	-	-	-
MWIBEAVR	F	JFB	06/07/99	11:15 PM	0	26.5	77	2	-	-	-	-	-	3	-	-	-	-	-
MWILD30D	F	JFB	03/29/99	07:06 PM	0	16.0	43	-	-	-	-	2	-	-	-	-	-	-	-
MWILD30D	F	JFB	04/14/99	08:30 PM	0,4	16.0	26	-	-	-	-	-	-	-	1	-	-	-	-
MWILD30D	F	JFB	06/01/99	11:52 PM	2,5	22.0	91	-	1	-	-	-	-	2	2	-	-	-	-
MWILD30D	F	JFB/RAZ	06/25/99	11:54 PM	0	21.0	91	2	-	-	-	-	-	2	1	-	-	-	-
MWILD30U	F	JFB	03/29/99	07:06 PM	0	16.0	43	-	-	-	-	4	-	-	-	-	-	-	-
MWILD30U	F	JFB	04/14/99	08:30 PM	0,4	16.0	26	-	-	-	-	4	-	-	-	-	-	-	-
MWILD30U	F	JFB	06/01/99	11:52 PM	2,5	22.0	91	-	-	-	-	-	-	-	-	-	-	-	-
MWILD30U	F	JFB/RAZ	06/25/99	11:54 PM	0	21.0	91	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 6.5.1 Anuran-vocalization monitoring sites in the Upper Mullica River drainage basin. Refer to Methods for survey details. 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, Location, and Listening Point	Site Code
Northern Alquatka Branch tributary impoundment above Jackson-Medford Road Medford Twp., Burlington Co. (lat 39°48'19.52", long 74°51'15.28", Medford Lakes quad). Northern tributary of Alquatka Branch, upstream from Jackson-Medford Road [Jackson-Medford Road near outlet].	MALTRBOY
Southern Alquatka Branch tributary impoundment above Jackson-Medford Road Medford Twp., Burlington Co. (lat 39°47'28.09", long 74°51'19.83", Medford Lakes quad). Impoundment on southern tributary of Alquatka Branch, east of Jackson-Meford Road [southeastern shoreline near dike].	MALTRFRI
Atco Raceway pond Waterford Twp., Camden Co. (lat 39°46'48.67", long 74°49'33.87", Medford Lakes quad). Beneath powerline near Atco Raceway, north of Jackson Road (Route 534) [northern shoreline].	MMUATCOR
Atsion railroad pond Waterford Twp., Camden Co. (lat 39°44'06.46", long 74°43'48.46", Atsion quad). Southern side of railroad near Atsion, west of Route 206 [railroad right-of-way].	MMUATSRR
Goshen Pond Shamong Twp., Burlington Co. (lat 39°44'39.58", long 74°45'38.03", Hammonton quad). Impoundment on Mullica River at Goshen Pond campground [northeastern shoreline near outlet].	MMUGOSHN
Gravel pond (Gravel) Shamong Twp., Burlington Co. (lat 39°44'49.13", long 74°43'15.80", Atsion quad). Northern side of Hampton Road, near excavated area between Route 206 and Stokes Road (Route 541) [Hampton Road].	MMUGRAVL
Mullica River impoundment above Jackson-Medford Road (Lady's Lake) Waterford/Medford Twp., Camden/Burlington Co. (lat 39°47'03.61", long 74°51'38.74", Medford Lakes quad). Impoundment on Mullica River, upstream from Jackson-Medford Road [southeastern corner at Jackson-Medford Road].	MMULADYL
Isolated Mullica pond (Mullica) Waterford Twp., Camden Co. (lat 39°45'39.37", long 74°48'09.27", Medford Lakes quad). South of Old Jackson-Atsion Road, between powerline and Mullica River [northeastern shoreline].	MMULISOL
Mullica River tributary above Route 206 Waterford Twp., Camden Co. (lat 39°43'49.44", long 74°43'48.33", Atsion quad). Upstream from Route 206, between Atsion Lake and Dutchtown [Route 206].	MMUTR206
Hampton Road trail borrow pit Shamong Twp., Burlington Co. (lat 39°45'02.13", long 74°42'34.78", Indian Mills quad). On northwestern corner of intersection of Hampton Road and sand trail that leads north to Stokes Road (Route 541) [Hampton Road].	MMUTRBOR
Eastern Mullica River tributary above Hampton Road Shamong Twp., Burlington Co. (lat 39°45'14.92", long 74°42'00.50", Indian Mills quad). Upstream from Hampton Road, between Stokes Road (Route 541) and Springers Brook [Hampton Road at bridge].	MMUTRHAM
Western Mullica River tributary above Hampton Road Shamong Twp., Burlington Co. (lat 39°45'07.84", long 74°42'19.24", Indian Mills quad). Upstream from northeastern corner of intersection of Hampton and Stokes (Route 541) Roads [Hampton Road near Stokes Road].	MMUTRSTO
Wesickaman Creek above Atsion Road Shamong Twp., Burlington Co. (lat 39°46'59.08", long 74°46'10.27", Medford Lakes quad). Impoundment upstream from Atsion Road [Atsion Road near outlet].	MWEATSIO
Wesickaman Creek headwater borrow pit Shamong Twp., Burlington Co. (lat 39°47'40.02", long 74°47'16.54", Medford Lakes quad). Northern side of Austin's Causeway Road, just west of Wesickaman Creek [Austin's Causeway Road].	MWEBOROW

Site Name, Location, and Listening Point	Site Code
Uppermost Wesickaman Creek reservoir above Route 534 Shamong Twp., Burlington Co. (lat 39°47'38.42", long 74°47'13.72", Medford Lakes quad). Cranberry bog reservior downstream from Austin's Causeway Road [northwestern shoreline].	MWEHDBOG
Wesickaman Creek downstream pond Shamong Twp., Burlington Co. (lat 39°47'34.11", long 74°47'18.98", Medford Lakes quad). Southern pond, west of Wesickaman Creek cranberry bogs [sand road].	MWEHEADD
Wesickaman Creek upstream pond Shamong Twp., Burlington Co. (lat 39°47'35.32", long 74°47'21.16", Medford Lakes quad). Northern pond, west of Wesickaman Creek cranberry bogs [sand road].	MWEHEADU
Wesickaman pond (Wesickaman) Shamong Twp., Burlington Co. (lat 39°46'52.40", long 74°46'13.49", Medford Lakes quad). West of Atsion Road, just south of Wesickaman Creek [western shoreline].	MWESPOND
Northern Willow Grove Road Lake Shamong Twp., Burlington Co. (lat 39°47'04.93", long 74°46'02.70", Medford Lakes quad). North of Willow Grove Road (Route 534), near Atsion Road [Route 534].	MWEWILLN
Southern Willow Grove Road Lake Shamong Twp., Burlington Co. (lat 39°47'04.93", long 74°46'02.70", Medford Lakes quad). South of Willow Grove Road (Route 534), near Atsion Road [Route 534].	MWEWILLS

Appendix 6.5.2. Maximum calling ranks for 12 anuran species at monitoring sites in the Upper Mullica River drainage basin. Data type is F = formal survey or S = supplemental data. Observers are JFB = John F. Bunnell, DMG = Dennis M. Gray, and RAZ = Robert A. Zampella. 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 calling ranks are 1 = 1, 2 = 2-5, 3 = 6-10, and 4 > 10 individuals calling. A plus sign (+) indicates that a species was vocalizing at a site, but no calling rank was recorded. The letter " v " refers to the visual observation of a species that was not 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 6.5.1 for detailed site information and Appendix 6.7 for full scientific and common names.

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MALTRBOY	F	JFB/RAZ	04/14/93	08:48 PM	1	11.0	-	-	-	-	-	-	-	-	-	-	-	4	-
MALTRBOY	F	JFB/RAZ	05/05/93	09:48 PM	2	22.0	87	-	4	2	-	3	-	-	3	-	-	4	4
MALTRBOY	F	JFB/RAZ	06/09/93	09:00 PM	2	27.0	78	-	4	-	-	-	-	-	-	-	-	-	1
MALTRBOY	F	JFB	03/14/96	07:47 PM	1	12.0	62	-	-	-	-	-	-	-	-	-	-	-	-
MALTRBOY	F	JFB	04/11/96	08:40 PM	1,2	18.0	54	-	-	-	-	4	-	-	-	-	-	2	-
MALTRBOY	F	JFB/DMG	04/23/96	09:46 PM	2,4	19.5	95	-	3	2	-	4	-	-	-	-	-	3	2
MALTRBOY	F	JFB/DMG	05/20/96	10:16 PM	0	26.5	65	-	2	4	-	-	-	-	-	-	-	2	2
MALTRBOY	F	JFB	06/14/96	09:11 PM	1	23.0	87	-	4	4	-	-	-	-	-	-	-	1	1
MALTRBOY	F	JFB/DMG	07/24/96	09:12 PM	0	25.0	83	-	-	2	-	-	-	-	1	-	-	-	2
MALTRFRI	F	JFB/RAZ	04/14/93	09:12 PM	1,5	11.0	-	-	-	-	-	-	-	-	-	-	-	2	-
MALTRFRI	F	JFB/RAZ	05/05/93	10:08 PM	2,5	21.0	87	-	4	2	-	2	-	-	-	-	-	4	2
MALTRFRI	F	JFB/RAZ	06/09/93	09:13 PM	5,8	27.0	73	-	4	+	-	-	-	-	-	-	-	-	4
MALTRFRI	F	JFB/RAZ	06/16/93	08:23 PM	0	22.0	75	-	-	2	-	-	-	-	-	-	-	-	-
MALTRFRI	F	JFB	03/14/96	07:36 PM	1	10.5	59	-	-	-	-	1	-	-	-	-	-	-	-
MALTRFRI	F	JFB	04/11/96	08:25 PM	2	17.5	47	-	-	-	-	-	-	-	-	-	-	3	-
MALTRFRI	F	JFB/DMG	04/23/96	09:30 PM	4,5	19.0	90	-	2	2	-	2	-	-	-	-	-	3	1
MALTRFRI	F	JFB/DMG	05/20/96	09:58 PM	0	25.5	65	-	3	3	-	-	-	1	2	-	-	2	3
MALTRFRI	F	JFB	06/14/96	08:56 PM	1	25.0	80	-	1	4	-	-	-	-	-	-	-	1	2
MALTRFRI	F	JFB/DMG	07/24/96	08:58 PM	0	23.0	80	-	-	2	-	-	-	-	2	-	-	1	2
MMUATCOR	F	JFB/RAZ	04/14/93	08:18 PM	1,4,5	11.0	-	-	-	-	-	4	1	-	-	-	-	4	-
MMUATCOR	F	JFB/RAZ	05/05/93	10:41 PM	2,4	20.0	87	-	4	4	-	3	-	-	2	-	-	4	1
MMUATCOR	F	JFB/RAZ	06/09/93	08:38 PM	1,4	25.0	81	-	-	3	-	-	-	-	-	-	-	-	-
MMUATCOR	S	JFB	03/13/96	06:47 PM	0	8.0	68	-	-	-	-	4	-	-	-	-	-	2	-
MMUATCOR	S	JFB	03/13/96	09:27 PM	0	7.0	54	-	-	-	-	4	-	-	-	-	-	2	-
MMUATCOR	S	JFB	03/14/96	07:00 PM	0	16.0	72	-	-	-	-	4	-	-	-	-	-	2	-
MMUATCOR	S	JFB	03/14/96	08:26 PM	1	10.0	45	-	-	-	-	4	-	-	-	-	-	2	-
MMUATCOR	F	JFB	03/15/96	06:32 PM	2,5	16.0	92	-	-	-	-	4	-	-	-	-	3	2	-
MMUATCOR	S	JFB	03/15/96	08:42 PM	2,4	15.0	88	-	-	-	-	4	-	-	-	-	3	2	-
MMUATCOR	S	JFB	03/18/96	06:39 PM	0	11.5	73	-	-	-	-	4	-	-	-	-	-	3	-
MMUATCOR	F	JFB	03/31/96	07:05 PM	0,4	11.0	49	-	-	-	-	4	-	-	-	-	-	3	-
MMUATCOR	S	JFB/DMG	04/08/96	07:37 PM	0	7.0	67	-	-	-	-	4	-	-	-	-	-	2	-
MMUATCOR	S	JFB	04/11/96	08:09 PM	2	17.0	47	-	-	-	-	4	-	-	-	-	-	3	-
MMUATCOR	F	JFB	04/15/96	08:11 PM	2,4,5	9.0	80	-	-	-	-	4	-	-	-	-	-	3	-
MMUATCOR	F	JFB/DMG	04/23/96	09:10 PM	4,5	19.0	95	-	3	4	-	4	-	-	-	-	-	3	-
MMUATCOR	F	JFB	05/19/96	09:29 PM	2	26.0	64	-	4	4	1	-	-	v	3	-	-	4	1

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MMUATCOR	F	JFB	06/08/96	10:46 PM	0	21.5	87	-	2	4	1	-	-	-	1	-	-	-	-
MMUATCOR	F	JFB	06/14/96	08:40 PM	1	23.5	87	-	-	4	-	-	-	-	-	-	-	-	-
MMUATCOR	F	JFB/DMG	07/24/96	09:37 PM	0,4	23.0	84	-	-	3	2	-	-	-	2	-	-	1	-
MMUATCOR	S	JFB/RAZ	03/08/97	06:00 PM	0,4	12.0	48	-	-	-	-	-	-	-	-	-	-	-	-
MMUATCOR	F	JFB/DMG	03/26/97	09:07 PM	0,4	10.0	49	-	-	-	-	4	-	-	-	-	-	-	-
MMUATCOR	F	JFB/DMG	04/29/97	08:21 PM	0	17.5	70	-	-	2	-	4	-	-	-	-	-	2	-
MMUATCOR	F	JFB/RAZ	05/29/97	09:09 PM	0	14.0	79	-	-	2	-	-	-	-	2	-	-	2	-
MMUATCOR	F	JFB	06/24/97	09:41 PM	2	22.0	84	-	-	2	-	-	-	-	2	-	-	-	-
MMUATCOR	S	JFB/DMG	02/19/98	06:36 PM	1,4	12.0	60	-	-	-	-	-	-	-	-	-	4	-	-
MMUATCOR	S	JFB	02/26/98	12:40 PM	0,4	16.0	38	-	-	-	-	-	-	-	-	-	-	-	-
MMUATCOR	F	JFB/RAZ	03/25/98	07:03 PM	0,4	6.0	56	-	-	-	-	4	-	-	-	-	-	2	-
MMUATCOR	F	JFB/DMG	04/22/98	08:50 PM	2	11.0	69	-	-	2	-	4	-	-	2	-	-	3	2
MMUATCOR	F	JFB	05/07/98	08:55 PM	2	16.0	90	-	2	4	-	2	-	-	2	-	-	4	1
MMUATCOR	F	JFB/DMG	06/15/98	10:01 PM	2,4	22.0	96	-	2	2	-	-	-	-	2	-	-	2	2
MMUATCOR	F	JFB	03/17/99	06:53 PM	0	11.0	75	-	-	-	-	4	-	-	-	-	2	-	-
MMUATCOR	F	JFB	04/03/99	07:20 PM	0,4	12.5	78	-	-	-	-	4	-	-	-	-	-	2	-
MMUATCOR	S	JFB	04/14/99	08:05 PM	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-
MMUATCOR	F	JFB	05/06/99	08:50 PM	2	13.5	94	-	4	4	-	4	-	-	-	-	-	2	1
MMUATCOR	F	JFB	06/07/99	10:22 PM	0	27.5	71	-	-	-	-	-	-	-	-	-	-	-	-
MMUATSRR	F	JFB	03/13/96	07:23 PM	0	8.0	73	-	-	-	-	-	-	-	-	-	-	-	-
MMUATSRR	F	JFB	04/11/96	10:57 PM	1,4	13.5	44	-	-	-	-	-	-	-	-	-	-	-	-
MMUATSRR	F	JFB/DMG	04/23/96	08:20 PM	2,4	24.0	67	-	-	2	-	2	-	-	-	-	-	-	-
MMUATSRR	F	JFB	05/18/96	09:01 PM	2,3	18.0	100	-	-	4	-	-	-	-	1	-	-	-	1
MMUATSRR	F	JFB	06/10/96	10:56 PM	0	21.0	95	-	-	2	-	-	-	-	-	-	-	-	-
MMUATSRR	F	JFB/DMG	07/17/96	11:36 PM	1	23.0	86	-	-	2	-	-	-	-	-	-	-	-	-
MMUGOSHN	F	JFB/RAZ	04/27/93	10:13 PM	0	9.0	74	-	-	-	-	1	-	-	-	-	-	1	3
MMUGOSHN	F	JFB/RAZ	05/24/93	09:26 PM	1	22.0	69	-	4	-	-	-	-	-	4	-	-	-	4
MMUGOSHN	F	JFB/RAZ	06/09/93	11:00 PM	0	23.0	88	-	4	-	-	-	-	-	4	-	-	-	4
MMUGOSHN	F	JFB	03/13/96	07:11 PM	0	10.5	74	-	-	-	-	-	-	-	-	-	-	-	-
MMUGOSHN	F	JFB	04/11/96	11:05 PM	1	13.0	74	-	-	-	-	2	-	-	-	-	-	-	-
MMUGOSHN	F	JFB/DMG	04/23/96	08:35 PM	4,7	23.5	100	-	2	-	-	1	-	-	-	-	-	-	2
MMUGOSHN	F	JFB	05/18/96	08:44 PM	2,3,4	17.0	90	-	4	-	-	1	-	-	2	-	-	-	2
MMUGOSHN	F	JFB/RAZ	06/05/96	11:06 PM	0	16.5	90	-	-	-	-	-	-	1	2	-	-	2	4
MMUGOSHN	F	JFB	07/07/96	10:34 PM	0	25.0	91	-	-	-	-	-	-	-	2	-	-	-	4
MMUGOSHN	F	JFB/DMG	07/17/96	08:57 PM	1	25.0	77	-	-	-	-	-	-	-	-	-	-	-	2
MMUGRAVL	F	JFB/RAZ	03/31/93	07:01 PM	2	10.0	88	-	-	-	-	3	-	-	-	-	-	4	-
MMUGRAVL	S	JFB/RAZ	04/14/93	11:25 PM	1,5	-	-	-	-	-	-	-	-	-	-	-	-	+	+
MMUGRAVL	F	JFB/RAZ	05/24/93	09:13 PM	1	21.0	75	-	-	4	-	-	-	-	2	-	-	1	3
MMUGRAVL	F	JFB/RAZ	06/16/93	10:49 PM	0	19.0	90	-	-	1	-	-	-	-	-	-	-	-	2
MMUGRAVL	F	JFB	03/18/96	07:24 PM	0	11.5	73	-	-	-	-	-	-	-	-	-	-	-	-
MMUGRAVL	F	JFB/RAZ	03/25/96	08:47 PM	2	14.0	70	-	-	-	-	-	-	-	-	-	-	-	-
MMUGRAVL	F	JFB	04/03/96	08:44 PM	0	11.0	67	-	-	-	-	2	-	-	-	-	-	3	-
MMUGRAVL	F	JFB/RAZ	04/18/96	10:00 PM	0	9.0	73	-	-	-	-	2	-	-	-	-	-	3	-
MMUGRAVL	F	JFB	05/10/96	10:49 PM	1	18.0	90	-	-	2	-	-	-	-	2	-	-	2	2
MMUGRAVL	F	JFB/RAZ	06/05/96	10:40 PM	0	17.0	94	-	-	2	-	-	-	-	2	-	-	2	3
MMUGRAVL	F	JFB	06/21/96	10:14 PM	1	21.0	54	-	-	2	-	-	-	-	1	-	-	-	1

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MMUGRAVL	F	JFB/DMG	07/01/96	10:16 PM	2	22.5	90	-	-	2	-	-	-	-	1	-	-	-	2
MMUGRAVL	S	JFB	03/05/97	06:56 PM	2	8.5	85	-	-	-	-	-	-	-	-	-	-	-	-
MMUGRAVL	S	JFB	03/17/97	07:11 PM	2	9.0	62	-	-	-	-	-	-	-	-	-	-	-	-
MMUGRAVL	F	JFB	03/21/97	09:25 PM	0	9.0	73	-	-	-	-	-	-	-	-	-	-	-	-
MMUGRAVL	F	JFB/DMG	04/03/97	06:46 PM	1	15.0	57	-	-	-	-	-	-	-	-	-	-	2	-
MMUGRAVL	F	JFB/RAZ	05/20/97	09:28 PM	0	16.0	60	-	-	1	-	-	-	-	1	-	-	-	1
MMUGRAVL	F	JFB/DMG	06/12/97	08:55 PM	0	19.5	91	-	-	2	-	-	-	-	-	-	-	-	2
MMUGRAVL	S	JFB	02/26/98	02:59 PM	0,4	17.5	30	-	-	-	-	-	-	-	-	-	-	-	-
MMUGRAVL	F	JFB/RAZ	03/26/98	08:34 PM	0	15.0	52	-	-	-	-	-	-	-	-	-	-	-	-
MMUGRAVL	F	JFB	04/17/98	09:21 PM	2	18.0	95	-	-	2	-	2	-	-	-	-	-	2	2
MMUGRAVL	F	JFB	05/28/98	08:22 PM	0	20.5	73	-	-	2	-	-	-	-	-	-	-	-	1
MMUGRAVL	F	JFB	06/16/98	09:34 PM	2,5	25.0	87	-	-	2	-	-	-	-	1	-	-	-	2
MMUGRAVL	S	JFB	03/11/99	04:27 PM	0,4	7.0	56	-	-	-	-	-	-	-	-	-	-	-	-
MMUGRAVL	F	JFB	03/18/99	05:36 PM	0,4	12.5	48	-	-	-	-	2	-	-	-	-	-	-	-
MMUGRAVL	F	JFB	04/01/99	08:06 PM	2,3,5	16.5	100	-	-	-	-	2	-	-	-	-	-	-	-
MMUGRAVL	F	JFB	05/10/99	09:43 PM	0	12.5	61	-	-	-	-	-	-	-	-	-	-	-	-
MMUGRAVL	F	JFB	06/13/99	10:32 PM	0	21.0	91	-	-	2	-	-	-	-	-	-	-	-	2
MMULADYL	F	JFB/RAZ	04/14/93	09:24 PM	1,5	11.0	-	-	-	-	-	3	-	-	-	-	-	-	-
MMULADYL	F	JFB/RAZ	05/05/93	10:18 PM	2	20.0	83	-	4	-	-	4	-	2	1	-	-	-	-
MMULADYL	F	JFB/RAZ	06/09/93	09:25 PM	5,8	26.0	85	-	4	-	-	-	-	2	2	-	-	-	-
MMULADYL	F	JFB	03/14/96	08:10 PM	1	10.0	60	-	-	-	-	-	-	-	-	-	-	-	-
MMULADYL	F	JFB	04/11/96	08:54 PM	2	16.0	46	-	-	-	-	4	-	-	-	-	-	-	-
MMULADYL	F	JFB/DMG	04/23/96	10:02 PM	2,4	19.0	90	-	3	-	-	4	-	-	-	-	-	-	-
MMULADYL	F	JFB/DMG	05/20/96	10:27 PM	0	26.5	65	-	2	-	-	-	-	2	2	-	-	-	-
MMULADYL	F	JFB	06/14/96	09:24 PM	1	24.0	87	-	2	-	-	-	-	1	1	-	-	-	-
MMULADYL	F	JFB/DMG	07/24/96	09:24 PM	0	23.0	83	-	2	-	-	-	-	2	2	-	-	-	-
MMULISOL	F	JFB	03/15/96	09:08 PM	2	14.0	94	-	-	-	-	-	-	-	-	-	-	-	-
MMULISOL	F	JFB	03/31/96	08:56 PM	0	9.0	70	-	-	-	-	-	-	-	-	-	-	-	-
MMULISOL	F	JFB/DMG	04/08/96	08:06 PM	0	2.0	80	-	-	-	-	1	-	-	-	-	-	-	-
MMULISOL	F	JFB/RAZ	04/18/96	08:27 PM	0	14.0	56	-	-	-	-	4	-	-	-	-	-	-	-
MMULISOL	F	JFB	05/19/96	09:00 PM	2	25.0	77	-	4	4	1	-	-	-	1	-	-	-	1
MMULISOL	F	JFB	06/08/96	09:53 PM	0	24.0	83	-	2	4	2	-	-	-	1	-	-	-	-
MMULISOL	F	JFB	06/21/96	09:00 PM	1	22.0	47	-	-	2	1	-	-	-	1	-	-	-	-
MMULISOL	F	JFB/DMG	07/01/96	09:24 PM	2	24.0	92	-	2	4	2	-	-	-	1	-	-	-	-
MMULISOL	F	JFB/DMG	07/17/96	09:45 PM	1	22.5	88	-	-	4	2	-	-	-	-	-	-	-	-
MMULISOL	F	JFB	03/17/97	08:05 PM	2	9.0	62	-	-	-	-	-	-	-	-	-	-	-	-
MMULISOL	F	JFB	04/16/97	07:58 PM	0,4	14.0	42	-	-	-	-	4	-	-	-	-	-	2	-
MMULISOL	F	JFB/RAZ	05/29/97	08:34 PM	0	15.0	79	-	-	4	-	-	-	-	-	-	-	1	-
MMULISOL	F	JFB	06/24/97	09:07 PM	2	25.0	76	-	-	4	-	-	-	-	-	-	-	-	-
MMULISOL	S	JFB/DMG	02/25/98	06:13 PM	0,4	10.0	38	-	-	-	-	-	-	-	-	-	-	-	-
MMULISOL	S	JFB	02/26/98	11:48 AM	0,4	15.5	37	-	-	-	-	-	-	-	-	-	-	-	-
MMULISOL	F	JFB/RAZ	03/26/98	06:55 PM	0	16.0	54	-	-	-	-	4	-	-	-	-	2	-	-
MMULISOL	F	JFB/DMG	04/22/98	08:12 PM	2	12.0	60	-	-	3	-	4	-	-	-	-	-	-	-
MMULISOL	F	JFB	05/07/98	08:16 PM	2	17.5	85	-	1	4	1	2	-	-	1	-	-	2	-
MMULISOL	F	JFB/DMG	06/15/98	09:22 PM	2	25.0	96	-	-	4	-	-	-	-	-	-	-	1	-
MMULISOL	F	JFB	03/18/99	05:57 PM	0,4	11.5	50	-	-	-	-	4	-	-	-	-	2	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MMULISOL	F	JFB	04/03/99	06:50 PM	0	13.0	69	-	-	-	-	4	-	-	-	-	-	2	-
MMULISOL	F	JFB	05/06/99	08:16 PM	2	13.5	100	-	-	4	-	4	-	-	-	-	-	1	-
MMULISOL	F	JFB	06/07/99	09:47 PM	0	25.0	92	-	-	4	-	-	-	-	-	-	-	-	-
MMUTR206	F	JFB/RAZ	04/27/93	07:38 PM	0	15.0	34	-	-	-	-	-	-	-	-	-	-	1	1
MMUTR206	F	JFB/RAZ	05/24/93	09:40 PM	1	22.0	72	-	2	-	-	-	-	-	-	-	-	-	-
MMUTRBOR	F	JFB/RAZ	03/31/93	07:14 PM	2	12.0	58	-	-	-	-	4	-	-	-	-	-	1	-
MMUTRBOR	F	JFB/RAZ	05/24/93	09:04 PM	1	21.0	76	-	-	-	-	-	-	-	+	-	-	-	-
MMUTRBOR	F	JFB/RAZ	06/16/93	10:53 PM	0	19.0	90	-	-	-	-	-	-	-	-	-	-	-	-
MMUTRBOR	F	JFB/DMG	04/03/97	06:57 PM	1	17.0	57	-	-	-	-	4	-	-	-	-	-	-	-
MMUTRBOR	F	JFB/RAZ	05/20/97	09:37 PM	0	14.0	68	-	-	-	-	-	-	-	1	-	-	-	-
MMUTRHAM	F	JFB/RAZ	03/31/93	07:29 PM	2	10.0	77	-	-	-	-	4	-	-	-	-	-	-	-
MMUTRHAM	F	JFB/RAZ	05/24/93	08:41 PM	1	20.5	68	-	-	-	-	-	-	-	2	-	-	-	-
MMUTRHAM	F	JFB/RAZ	06/16/93	10:59 PM	0	16.0	86	-	-	-	-	-	-	-	1	-	-	-	-
MMUTRHAM	F	JFB/RAZ	03/27/97	08:37 PM	0	12.5	74	-	-	-	-	4	-	-	-	-	-	-	-
MMUTRHAM	F	JFB/DMG	04/29/97	11:50 PM	0	11.0	80	-	-	-	-	4	-	-	-	-	-	-	-
MMUTRHAM	F	JFB/RAZ	05/20/97	09:10 PM	0	15.0	79	-	-	-	-	-	-	1	2	-	-	-	-
MMUTRHAM	F	JFB/DMG	06/12/97	09:15 PM	0	21.0	82	-	2	-	-	-	-	-	2	-	-	-	1
MMUTRSTO	F	JFB/RAZ	03/31/93	07:20 PM	2	10.0	77	-	-	-	-	3	-	-	-	-	-	2	-
MMUTRSTO	F	JFB/RAZ	05/24/93	08:47 PM	1	21.0	83	-	-	-	-	-	-	-	2	-	-	-	2
MMUTRSTO	F	JFB/RAZ	06/16/93	10:55 PM	0	18.0	86	-	-	-	-	-	-	-	2	-	-	-	-
MMUTRSTO	S	JFB	03/05/97	07:10 PM	2,5	8.0	85	-	-	-	-	-	-	-	-	-	-	-	-
MMUTRSTO	S	JFB	03/17/97	07:20 PM	2	9.0	54	-	-	-	-	-	-	-	-	-	-	-	-
MMUTRSTO	F	JFB	03/21/97	09:17 PM	0	9.0	73	-	-	-	-	-	-	-	-	-	-	-	-
MMUTRSTO	F	JFB/DMG	04/03/97	07:02 PM	0	15.0	57	-	-	-	-	4	-	-	-	-	-	2	-
MMUTRSTO	S	JFB/DMG	04/29/97	11:14 PM	0	13.5	80	-	-	-	-	3	-	-	1	-	-	2	1
MMUTRSTO	F	JFB/RAZ	05/20/97	09:19 PM	0	14.0	78	-	-	-	-	-	-	-	2	-	-	1	-
MMUTRSTO	F	JFB/DMG	06/12/97	09:08 PM	0	21.5	79	-	2	-	-	-	-	-	2	-	-	-	-
MMUTRSTO	S	JFB	02/26/98	03:07 PM	0,4	18.0	30	-	-	-	-	-	-	-	-	-	4	-	-
MMUTRSTO	S	JFB	03/11/99	04:20 PM	0,4	7.0	56	-	-	-	-	-	-	-	-	-	-	-	-
MMUTRSTO	S	JFB	03/18/99	05:30 PM	0,4	12.5	48	-	-	-	-	-	-	-	-	-	-	-	-
MWEATSIO	F	JFB/RAZ	04/14/93	07:33 PM	1,5	12.0	-	-	-	-	-	4	-	-	1	1	-	-	-
MWEATSIO	F	JFB/RAZ	05/05/93	11:45 PM	2,4,5	20.0	87	-	4	-	-	3	-	-	1	2	-	-	-
MWEATSIO	F	JFB/RAZ	06/09/93	08:21 PM	1	26.0	85	-	1	-	-	-	-	-	-	-	-	-	-
MWEATSIO	S	JFB/RAZ	06/09/93	11:12 PM	0	24.0	96	-	+	-	-	-	-	-	+	-	-	-	-
MWEATSIO	F	JFB	03/13/96	07:00 PM	0	9.0	56	-	-	-	-	-	-	-	-	-	-	-	-
MWEATSIO	F	JFB	03/18/96	06:53 PM	0	12.0	69	-	-	-	-	4	-	-	-	-	-	-	-
MWEATSIO	F	JFB	04/11/96	07:56 PM	2	17.0	40	-	-	-	-	4	-	-	-	-	-	-	-
MWEATSIO	F	JFB/DMG	04/23/96	08:54 PM	4,7	19.0	95	-	4	-	-	2	-	-	-	-	-	-	-
MWEATSIO	F	JFB/DMG	05/20/96	08:55 PM	0	28.0	65	-	2	-	-	1	-	-	2	-	-	-	-
MWEATSIO	F	JFB	06/14/96	10:08 PM	1	24.5	87	-	4	-	-	-	-	2	3	-	-	-	-
MWEATSIO	F	JFB/DMG	07/17/96	09:11 PM	1	25.5	84	-	1	-	-	-	-	-	2	-	-	-	-
MWEATSIO	S	JFB/RAZ	05/20/97	10:35 PM	-	-	-	-	+	-	-	-	-	+	+	-	-	-	-
MWEBOROW	F	JFB/RAZ	04/14/93	08:05 PM	1,5	9.0	-	-	-	-	-	4	-	-	-	-	-	-	-
MWEBOROW	F	JFB/RAZ	05/05/93	11:08 PM	2,4	20.0	83	-	2	2	-	-	-	-	2	-	-	2	2
MWEBOROW	F	JFB/RAZ	06/09/93	08:02 PM	1	26.0	92	-	-	-	-	-	-	-	-	-	-	-	-
MWEBOROW	F	JFB	03/14/96	07:24 PM	0	10.5	55	-	-	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MWEBOROW	F	JFB	03/31/96	06:40 PM	0	11.0	49	-	-	-	-	4	-	-	-	-	-	-	-
MWEBOROW	F	JFB	04/15/96	08:01 PM	2,4,5	9.0	80	-	-	-	-	2	-	-	-	-	-	-	-
MWEBOROW	F	JFB	04/28/96	11:21 PM	1	16.5	52	-	-	-	-	2	-	-	-	-	-	-	-
MWEBOROW	F	JFB/DMG	05/20/96	09:14 PM	0	24.0	76	-	2	2	1	-	-	-	1	-	-	1	-
MWEBOROW	F	JFB	06/14/96	09:53 PM	1	24.5	87	-	2	-	-	-	-	-	-	-	-	-	-
MWEBOROW	F	JFB/DMG	07/24/96	09:54 PM	0	25.0	83	-	-	-	-	-	-	v	1	-	-	-	-
MWEBOROW	S	JFB	03/18/99	06:30 PM	0,4	11.0	58	-	-	-	-	-	-	-	-	-	-	-	-
MWEHDBOG	F	JFB/RAZ	04/14/93	08:05 PM	1,5	9.0	-	-	-	-	-	4	-	-	-	-	-	3	-
MWEHDBOG	F	JFB/RAZ	05/05/93	11:08 PM	2,4	20.0	83	-	4	4	-	2	-	-	2	-	-	4	1
MWEHDBOG	F	JFB/RAZ	06/09/93	08:02 PM	1	26.0	92	-	-	1	-	-	-	-	2	-	-	1	-
MWEHEADD	F	JFB/RAZ	04/14/93	07:46 PM	1,5	9.0	-	-	-	-	-	-	-	-	-	-	-	1	-
MWEHEADD	F	JFB/RAZ	05/05/93	11:19 PM	2,4	20.0	91	-	-	2	-	-	-	-	-	-	-	1	-
MWEHEADD	F	JFB/RAZ	06/09/93	08:10 PM	1	25.0	88	-	-	1	-	-	-	-	-	-	-	-	-
MWEHEADD	F	JFB	03/14/96	07:17 PM	0	11.0	51	-	-	-	-	-	-	-	-	-	-	-	-
MWEHEADD	F	JFB	03/31/96	06:57 PM	0,4	11.5	45	-	-	-	-	-	-	-	-	-	-	-	-
MWEHEADD	F	JFB	04/15/96	07:51 PM	2,4,5	10.0	85	-	-	-	-	-	-	-	-	-	-	-	-
MWEHEADD	F	JFB	04/28/96	11:13 PM	1	16.5	54	-	-	-	-	-	-	-	-	-	-	-	-
MWEHEADD	F	JFB/DMG	05/20/96	09:25 PM	0	24.5	70	-	-	2	-	-	-	-	-	-	-	-	-
MWEHEADD	F	JFB	06/14/96	09:44 PM	1	23.0	87	-	-	3	-	-	-	-	-	-	-	-	-
MWEHEADD	F	JFB/DMG	07/24/96	10:09 PM	0	22.5	87	-	-	1	-	-	-	-	-	-	-	-	-
MWEHEADD	S	JFB	03/18/99	06:40 PM	0,4	11.0	58	-	-	-	-	-	-	-	-	-	-	-	-
MWEHEADU	F	JFB/RAZ	04/14/93	07:46 PM	1,5	9.0	-	-	-	-	-	1	-	-	-	-	-	-	-
MWEHEADU	F	JFB/RAZ	05/05/93	11:19 PM	2,4	20.0	91	-	-	1	-	1	-	-	-	-	-	-	-
MWEHEADU	F	JFB/RAZ	06/09/93	08:10 PM	1	25.0	88	-	-	-	-	-	-	-	-	-	-	-	-
MWEHEADU	F	JFB	03/14/96	07:17 PM	0	11.0	51	-	-	-	-	-	-	-	-	-	-	-	-
MWEHEADU	F	JFB	03/31/96	06:51 PM	0,4	11.5	45	-	-	-	-	3	-	-	-	-	-	-	-
MWEHEADU	F	JFB	04/15/96	07:51 PM	2,4,5	10.0	85	-	-	-	-	2	-	-	-	-	-	-	-
MWEHEADU	F	JFB	04/28/96	11:13 PM	1	16.5	54	-	-	-	-	2	-	-	-	-	-	-	-
MWEHEADU	F	JFB/DMG	05/20/96	09:25 PM	0	24.5	70	-	-	4	-	-	-	-	1	-	-	-	-
MWEHEADU	F	JFB	06/14/96	09:44 PM	1	23.0	87	-	-	-	-	-	-	-	-	-	-	-	-
MWEHEADU	F	JFB/DMG	07/24/96	10:09 PM	0	22.5	87	-	-	-	-	-	-	-	-	-	-	-	-
MWEHEADU	S	JFB	03/18/99	06:40 PM	0,4	11.0	58	-	-	-	-	1	-	-	-	-	-	-	-
MWESPOND	F	JFB	03/18/96	07:05 PM	0	11.5	73	-	-	-	-	-	-	-	-	-	-	-	-
MWESPOND	F	JFB	03/31/96	06:25 PM	0,4	12.0	45	-	-	-	-	-	-	-	-	-	-	-	-
MWESPOND	F	JFB	04/11/96	07:44 PM	2	18.5	43	-	-	-	-	4	-	-	-	-	-	-	-
MWESPOND	F	JFB	04/28/96	10:48 PM	1	17.0	52	-	-	-	-	-	-	-	2	-	-	-	-
MWESPOND	F	JFB/DMG	05/20/96	08:43 PM	0	28.5	60	-	-	-	-	1	-	-	1	-	-	-	-
MWESPOND	F	JFB	06/14/96	10:20 PM	1	22.5	90	-	-	-	-	-	-	-	-	-	-	-	-
MWESPOND	F	JFB	06/26/96	10:46 PM	1	20.0	66	-	-	-	-	-	-	-	1	-	-	-	-
MWESPOND	F	JFB	07/06/96	09:05 PM	0	23.0	79	-	-	-	-	-	-	-	2	-	-	-	-
MWESPOND	F	JFB/RAZ	03/27/97	09:31 PM	0	9.0	64	-	-	-	-	4	-	-	-	-	-	-	-
MWESPOND	F	JFB/DMG	04/29/97	12:06 AM	0	10.5	74	-	-	-	-	1	-	-	2	-	-	-	-
MWESPOND	F	JFB/RAZ	05/20/97	10:43 PM	0	11.0	68	-	-	-	-	-	-	-	-	-	-	-	-
MWESPOND	F	JFB	06/24/97	12:48 AM	0	25.0	71	-	-	-	-	-	-	-	1	-	-	-	-
MWESPOND	S	JFB/DMG	02/19/98	06:22 PM	1,4	11.0	64	-	-	-	-	-	-	-	-	-	-	-	-
MWESPOND	S	JFB	02/26/98	12:23 PM	0,4	15.0	34	-	-	-	-	-	-	-	-	-	2	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
MWESPOND	F	JFB/RAZ	03/25/98	06:51 PM	0	5.0	52	-	-	-	-	-	-	-	-	-	-	-	-
MWESPOND	F	JFB	04/29/98	10:04 PM	0	14.0	62	-	-	-	-	2	-	-	-	-	-	-	-
MWESPOND	F	JFB	05/19/98	10:10 PM	2	24.5	76	-	-	-	-	-	-	-	2	-	-	-	-
MWESPOND	F	JFB	06/16/98	10:50 PM	2,4,6	21.5	100	-	-	-	-	-	-	-	2	-	-	-	-
MWESPOND	S	JFB	03/13/99	10:30 AM	0,4	8.0	49	-	-	-	-	-	-	-	-	-	-	-	-
MWESPOND	F	JFB	03/18/99	07:01 PM	0,4	9.0	54	-	-	-	-	-	-	-	-	-	2	-	-
MWESPOND	F	JFB	04/03/99	09:35 PM	0,4	11.0	85	-	-	-	-	3	-	-	-	-	-	-	-
MWESPOND	F	JFB	05/08/99	08:30 PM	2	20.0	77	-	-	-	-	4	-	-	1	-	-	-	-
MWESPOND	F	JFB	06/07/99	08:55 PM	2	27.0	85	-	-	-	-	-	-	-	-	-	-	-	-
MWEWILLN	F	JFB/RAZ	03/25/98	06:43 PM	0,4	7.0	52	-	-	-	-	-	-	-	-	-	-	-	-
MWEWILLN	F	JFB	04/29/98	10:11 PM	0,4	13.5	66	-	-	-	-	2	-	-	-	-	-	-	-
MWEWILLN	F	JFB	05/19/98	10:00 PM	2	24.0	76	-	-	-	-	-	-	2	2	-	-	-	-
MWEWILLN	F	JFB	06/16/98	10:57 PM	2,4,6	21.0	100	-	-	-	-	-	-	2	2	-	-	-	-
MWEWILLS	F	JFB/RAZ	03/25/98	06:43 PM	0,4	7.0	52	-	-	-	-	-	-	-	-	-	-	-	-
MWEWILLS	F	JFB	04/29/98	10:11 PM	0,4	13.5	66	-	-	-	-	2	-	-	-	-	-	-	-
MWEWILLS	F	JFB	05/19/98	10:00 PM	2	24.0	76	-	1	-	-	-	-	2	1	-	-	-	-
MWEWILLS	F	JFB	06/16/98	10:57 PM	2,4,6	21.0	100	-	2	-	-	-	-	2	2	-	-	-	-

Appendix 6.6.1. Anuran-vocalization monitoring sites in the Batsto River drainage basin. Refer to Methods for survey details. 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, Location, and Listening Point	Site Code
Batsto River above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°48'02.59", long 74°40'20.79", Indian Mills quad). Upstream from Carranza Road [Carranza Road at bridge].	BBACARRZ
Hampton Furnace pond (Furnace) Shamong Twp., Burlington Co. (lat 39°46'07.15", long 74°40'57.67", Indian Mills quad). Northern side of Hampton Road, near Hampton Furnace [Hampton Road].	BBAFURNP
Shotgun site Tabernacle Twp., Burlington Co. (lat 39°48'16.02", long 74°40'49.02", Indian Mills quad). Abandoned cranberry bogs on northern side of Carranza Road, just west of Hampton Gate [Carranza Road, just west of house].	BBASHOTG
Batsto Lake Washington Twp., Burlington Co. (lat 39°39'12.21", long 74°39'14.65", Atsion quad). Impoundment upstream from Pleasant Mills Road (Route 542) [southernmost canoe access on western shoreline].	BBATLAKE
Batsto River impoundment above Route 532 Tabernacle Twp., Burlington Co. (lat 39°50'21.29", long 74°39'54.34", Indian Mills quad). Impoundment on northern side of Tabernacle-Chatsworth Road (Route 532), just west of Goose Pond [southwestern shoreline near Route 532].	BBATN532
Batsto River tributary above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°47'26.13", long 74°39'44.10", Indian Mills quad). Abandoned cranberry bog upstream from Carranza Road, near Glossy Spung Road [Carranza Road].	BBATRCAR
High Crossing flooded area Shamong Twp., Burlington Co. (lat 39°46'06.79", long 74°38'39.00", Indian Mills quad). Southern side of intersection of sand road and railroad at High Crossing [railroad right-of-way].	BBATRHIX
Mannis Duck Pond tributary above Hampton Road Shamong Twp., Burlington Co. (lat 39°46'06.24", long 74°38'57.35", Indian Mills quad). Unnamed tributary that flows into Mannis Duck Pond, upstream from Hampton Road [Hampton Road].	BBATRMAH
Mannis Duck Pond tributary impoundment near High Crossing Shamong Twp., Burlington Co. (lat 39°45'46.31", long 74°38'47.55", Indian Mills quad). Along middle tributary of unnamed stream that flows into Mannis Duck Pond, south of railroad [western shoreline near sand road].	BBATRMAI
Batsto River headwater impoundment below Route 532 Tabernacle Twp., Burlington Co. (lat 39°49'56.95", long 74°39'21.56", Indian Mills quad). Impoundment upstream from second dike (sand road) below Tabernacle-Chatsworth Road (Route 532), on eastern tributary of Batsto River [dike/sand road at outlet].	BBATS532
Deep Run impoundment above Hampton Road Shamong Twp., Burlington Co. (lat 39°45'46.34", long 74°41'31.99", Indian Mills quad). Upstream from Hampton Road [Hampton Road at outlet].	BDEEPRUN
Hampton Road pond (Hampton) Shamong Twp., Burlington Co. (lat 39°45'56.83", long 74°41'16.29", Indian Mills quad). Southern side of Hampton Road, between Deep Run tributary and Hampton Furnace [Hampton Road].	BDEHAMPD
Deep Run tributary above Hampton Road Shamong Twp., Burlington Co. (lat 39°45'55.37", long 74°41'20.27", Indian Mills quad). Herbaceous area upstream from Hampton Road, just east of Deep Run [Hampton Road at culvert].	BDETRHAM

Site Name, Location, and Listening Point	Site Code
Horse Pond Stream above Butterworth's Bogs Road	BHOBUTTR
Tabernacle Twp., Burlington Co. (lat 39°49'42.27", long 74°40'47.69", Indian Mills quad). Between Butterworth's Bogs Road and impoundment [Butterworth's Bogs Road at bridge].	
Cranberry bog on Butterworth's Bogs Road	BHOCRBOG
Tabernacle Twp., Burlington Co. (lat 39°49'31.01", long 74°40'56.80", Indian Mills quad). Southern side of Butterworth's Bogs Road between Brace Lane and Horse Pond Stream [Butterworth's Bogs Road].	
Cranberry ditch on Butterworth's Bogs Road	BHODITCH
Tabernacle Twp., Burlington Co. (lat 39°49'31.01", long 74°40'56.80", Indian Mills quad). Northern side of Butterworth's Bogs Road between Brace Lane and Horse Pond Stream [Butterworth's Bogs Road].	
Abandoned bog on Oakshade Road	BINOAKBG
Shamong Twp., Burlington Co. (lat 39°48'38.07", long 74°45'50.53", Medford Lakes quad). Eastern side of Oakshade Road (Route 534), between Medford-Indian Mills Road (Route 620) and Stokes Road (Route 541) [Route 534].	
Indian Mills Brook impoundment above Old Schoolhouse Road	BINSCHOO
Shamong Twp., Burlington Co. (lat 39°48'00.68", long 74°45'36.39", Medford Lakes quad). Impoundment upstream from Old Schoolhouse Road [Old Schoolhouse Road near outlet].	
Indian Mills Brook Impoundment above Oakshade Road (Shadow Lake)	BINSHADW
Shamong Twp., Burlington Co. (lat 39°48'22.04", long 74°46'14.74", Medford Lakes quad). Impoundment on Indian Mills Brook, upstream from Oakshade Road (Route 534) [western end of dam].	
Stokes Road pond near shooting range	BINSTOKE
Shamong Twp., Burlington Co. (lat 39°48'47.12", long 74°46'16.16", Medford Lakes quad). Western side of Stokes Road (Route 541), between shooting range and Oakshade Road (Route 534) [southeastern shoreline].	
Concord Ridge pond	BMUCONCD
Shamong Twp., Burlington Co. (lat 39°49'23.62", long 74°44'45.53", Indian Mills quad). Southeastern side of intersection of Princeton and Yorktown Drives in Concord Ridge development [Princeton Drive].	
Indian Mills Lake	BMULAKED
Shamong Twp., Burlington Co. (lat 39°47'44.04", long 74°44'24.29", Indian Mills quad). Impoundment on Muskingum Brook, upstream from Indian Mills Road (Route 648) [eastern end of dam].	
Private pond on Tuckerton Road	BMUPRIVA
Shamong Twp., Burlington Co. (lat 39°49'06.35", long 74°44'21.76", Indian Mills quad). Southern side of Tuckerton Road, just west of Muskingum Brook [Tuckerton Road].	
Skit Branch beaver impoundment between Hampton and Carranza Roads	BSKBEAVD
Tabernacle Twp., Burlington Co. (lat 39°47'05.13", long 74°38'12.94", Indian Mills quad). Upstream from breached dike, midway between Hampton and Carranza Roads [western end of dike].	
Skit Branch beaver pond between Carranza Road and Batona Campground	BSKBEAVU
Tabernacle Twp., Burlington Co. (lat 39°46'39.34", long 74°40'12.25", Indian Mills quad). Between Batona campground and Carranza Road [southern shoreline near sand road].	
Skit Branch headwater pond (Skit)	BSKIHEAD
Tabernacle Twp., Burlington Co. (lat 39°47'51.53", long 74°36'51.42", Chatsworth quad). South of Tabernacle-Chatsworth Road (Route 532), north of railroad, east of Skit Branch [southern shoreline].	
Skit Branch above Carranza Road	BSKITCAR
Tabernacle Twp., Burlington Co. (lat 39°47'08.47", long 74°39'29.79", Indian Mills quad). Upstream from Carranza Road [Carranza Road at bridge].	
Skit Sphagnum pond (Sphagnum)	BSKSPHGM
Shamong Twp., Burlington Co. (lat 39°46'22.15", long 74°40'20.70", Indian Mills quad). Upstream from Hampton Road, adjacent to dike, on eastern side of Skit Branch [eastern shoreline].	

Site Name, Location, and Listening Point	Site Code
Skit Branch tributary below Carranza Road Shamong Twp., Burlington Co. (lat 39°46'49.82", long 74°39'24.29", Indian Mills quad). Upstream from sand road, on first eastern tributary south of Carranza Road [sand road].	BSKTRBRN
Southern Skit Branch herbaceous area Shamong Twp., Burlington Co. (lat 39°46'00.26", long 74°40'29.23", Indian Mills quad). East of eastern Skit Branch tributary at Hampton Road, south of Hampton Road [Hampton Road at culvert].	BSKTRHAD
Skit Branch herbaceous area Shamong Twp., Burlington Co. (lat 39°46'00.26", long 74°40'29.23", Indian Mills quad). East of eastern Skit Branch tributary at Hampton Road, north and south of Hampton Road [Hampton Road at culvert].	BSKTRHAM
Northern Skit Branch herbaceous area Shamong Twp., Burlington Co. (lat 39°46'00.26", long 74°40'29.23", Indian Mills quad). East of eastern Skit Branch tributary at Hampton Road, north of Hampton Road [Hampton Road at culvert].	BSKTRHAU
Skit Branch beaver pond above Batona Campground Tabernacle Twp., Burlington Co. (lat 39°46'55.72", long 74°37'38.15", Indian Mills quad). Impoundment adjacent to Batona Trail, upstream from Batona campground [southern shoreline near Batona Trail].	BSKWIDEN
Cranberry ditch on Stokes Road Shamong Twp., Burlington Co. (lat 39°45'31.54", long 74°42'57.32", Indian Mills quad). Cranberry ditch on eastern side of Stokes Road (Route 541), downstream from cranberry bogs [no listening point, visual observation only]. *Latitude and longitude values were obtained using ArcView Software.	BSPDITCH
Hot dog stand pond Shamong Twp., Burlington Co. (lat 39°46'03.31", long 74°44'18.11", Indian Mills quad). Eastern side of Route 206, just south of intersection with Stokes Road (Route 541) [southwestern shoreline at parking area].	BSPHOTDG
Springers Brook mud puddle Shamong Twp., Burlington Co. (lat 39°45'16.95", long 74°41'50.69", Indian Mills quad). Excavated area on southern side of Hampton Road, just west of Springers Brook [northern shoreline].	BSPPUDDL
Springers Brook railroad pond Shamong Twp., Burlington Co. (lat 39°44'57.67", long 74°41'38.20", Atsion quad). Southern side of railroad, just west of Springers Brook [railroad right-of-way].	BSPRRPND
Springers Brook impoundment on northern side of Indian Ann Trail Shamong Twp., Burlington Co. (lat 39°46'26.20", long 74°43'58.08", Indian Mills quad). Northern side of Indian Ann Trail in Fawn Lake trailer park [end of Indian Ann Trail].	BSPTRAIL
Roberts (Tom Roberts) Branch below Birches Road Tabernacle Twp., Burlington Co. (lat 39°49'04.59", long 74°38'00.10", Indian Mills quad). Downstream from Birches Road [Birches Road at bridge].	BTOBIRCD
Roberts (Tom Roberts) Branch above Birches Road Tabernacle Twp., Burlington Co. (lat 39°49'04.59", long 74°38'00.10", Indian Mills quad). Upstream from Birches Road [Birches Road at bridge].	BTOBIRCU
Roberts (Tom Roberts) Branch impoundment below Route 532 Tabernacle Twp., Burlington Co. (lat 39°49'15.80", long 74°36'22.78", Chatsworth quad). Second impoundment downstream from Tabernacle-Chatsworth Road (Route 532) [sand road south of impoundment].	BTOIM532
Roberts (Tom Roberts) Branch beaver pond above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°47'24.16", long 74°39'22.49", Indian Mills quad). Impoundment upstream from Carranza Road [southern shoreline].	BTOIMPCA
Roberts (Tom Roberts) Branch above Carranza Road Tabernacle Twp., Burlington Co. (lat 39°47'16.21", long 74°39'34.03", Indian Mills quad). Upstream from Carranza Road [Carranza Road at bridge].	BTOMCARR

Site Name, Location, and Listening Point	Site Code
Roberts (Tom Roberts) cripple	BTOMCRIP
Tabernacle Twp., Burlington Co. (lat 39°47'21.19", long 74°39'20.12", Indian Mills quad). Southeastern side of sand road that parallels Roberts (Tom Roberts) Branch, upstream from Carranza Road [northern shoreline].	
Pond at Birches and Moores Meadow Roads	BTOMMPND
Tabernacle Twp., Burlington Co. (lat 39°49'26.92", long 74°38'01.96", Indian Mills quad). Eastern side of intersection of Birches and Moores Meadow Roads [Moores Meadow Road].	
Roberts (Tom Roberts) Branch above Route 532	BTOMR532
Tabernacle Twp., Burlington Co. (lat 39°49'28.51", long 74°36'11.20", Chatsworth quad). Upstream from Tabernacle-Chatsworth Road (Route 532) [Route 532 at culvert].	
Roberts (Tom Roberts) pond (Roberts)	BTOMSKIT
Tabernacle Twp., Burlington Co. (lat 39°47'16.86", long 74°39'21.64", Indian Mills quad). Northern side of middle sand road between Skit and Roberts (Tom Roberts) Branches, upstream from Carranza Road [southern shoreline].	

Appendix 6.6.2. Maximum calling ranks for 12 anuran species at monitoring sites in the Batsto River drainage basin. Data type is F = formal survey or S = supplemental data. Observers are JFB = John F. Bunnell, DMG = Dennis M. Gray, and RAZ = Robert A. Zampella. 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 calling ranks are 1 = 1, 2 = 2-5, 3 = 6-10, and 4 > 10 individuals calling. A plus sign (+) indicates that a species was vocalizing at a site, but no calling rank was recorded. The letter " v " refers to the visual observation of a species that was not 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 6.6.1 for detailed site information and Appendix 6.7 for full scientific and common names.

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
BBACARRZ	F	RAZ	05/08/93	08:06 PM	0	16.5	-	-	-	-	-	-	-	-	-	-	-	-	1
BBACARRZ	F	JFB/RAZ	06/03/93	11:23 PM	1	13.0	95	-	-	-	-	-	-	-	-	-	-	-	-
BBACARRZ	F	JFB/RAZ	03/27/97	08:10 PM	0	9.0	64	-	-	-	-	-	-	-	-	-	-	-	-
BBACARRZ	F	JFB/RAZ	04/21/97	09:15 PM	1	9.5	92	-	-	-	-	2	-	-	-	-	-	-	-
BBACARRZ	F	JFB/RAZ	05/12/97	08:29 PM	0	18.0	69	-	-	-	-	-	-	-	-	-	-	-	-
BBACARRZ	F	JFB	06/09/97	11:02 PM	0	11.0	94	-	-	-	-	-	-	-	-	-	-	-	-
BBAFURNP	F	JFB/RAZ	03/31/93	08:11 PM	2	8.0	-	-	-	-	-	4	-	-	-	-	-	1	-
BBAFURNP	F	JFB/RAZ	05/24/93	08:16 PM	1	21.5	83	-	-	4	-	-	-	-	2	-	-	-	-
BBAFURNP	F	JFB/RAZ	06/16/93	11:17 PM	0	16.0	90	-	-	-	-	-	-	-	-	-	-	-	-
BBAFURNP	F	JFB	04/03/96	08:04 PM	0	12.0	58	-	-	-	-	3	-	-	-	-	-	-	-
BBAFURNP	F	JFB	04/19/96	09:30 PM	0	20.0	73	-	-	-	-	4	-	-	-	-	-	-	-
BBAFURNP	F	JFB	05/10/96	10:07 PM	1	19.0	90	-	-	2	-	2	-	-	-	-	-	1	-
BBAFURNP	F	JFB/RAZ	06/05/96	10:10 PM	0	19.0	90	-	-	3	-	-	-	-	1	-	-	2	1
BBAFURNP	F	JFB	06/21/96	10:33 PM	1	20.5	50	-	-	1	-	-	-	-	1	-	-	-	1
BBAFURNP	F	JFB/DMG	07/01/96	10:39 PM	2	22.5	90	-	-	3	-	-	-	-	2	-	-	-	1
BBAFURNP	F	JFB	03/21/97	08:50 PM	0	10.0	73	-	-	-	-	-	-	-	-	-	-	-	-
BBAFURNP	F	JFB/DMG	04/03/97	07:36 PM	0	16.0	56	-	-	-	-	4	-	-	-	-	-	1	-
BBAFURNP	F	JFB/RAZ	05/12/97	11:10 PM	0	16.5	71	-	-	2	-	-	-	-	-	-	-	-	-
BBAFURNP	F	JFB/DMG	06/12/97	10:10 PM	0	18.5	91	-	-	2	-	-	-	-	-	-	-	-	-
BBAFURNP	S	JFB	02/26/98	03:23 PM	0,4	18.5	31	-	-	-	-	-	-	-	-	-	-	-	-
BBAFURNP	F	JFB/RAZ	03/26/98	09:05 PM	0	13.5	68	-	-	-	-	4	-	-	-	-	-	-	-
BBAFURNP	F	JFB	04/17/98	09:47 PM	2	17.5	95	-	-	2	-	2	-	-	-	-	-	2	-
BBAFURNP	F	JFB	05/28/98	08:44 PM	0	20.5	73	-	-	1	-	-	-	-	-	-	-	-	-
BBAFURNP	F	JFB	06/16/98	09:19 PM	2	25.0	100	-	-	3	-	-	-	-	-	-	-	-	-
BBAFURNP	S	JFB	03/11/99	04:05 PM	0,4	7.5	46	-	-	-	-	-	-	-	-	-	-	-	-
BBAFURNP	F	JFB	03/18/99	05:15 PM	0,4	13.0	61	-	-	-	-	2	-	-	-	-	2	-	-
BBAFURNP	F	JFB	04/01/99	07:42 PM	2,3,5	16.0	93	-	-	-	-	3	-	-	-	-	-	-	-
BBAFURNP	F	JFB	05/10/99	09:14 PM	0	13.0	66	-	-	-	-	-	-	-	-	-	-	-	-
BBAFURNP	F	JFB	06/13/99	10:07 PM	2	21.0	96	-	1	-	-	-	-	-	-	-	-	-	-
BBASHOTG	F	JFB/RAZ	03/31/93	09:07 PM	2	10.0	-	-	-	-	-	3	-	-	-	-	-	1	-
BBASHOTG	F	JFB/RAZ	04/08/93	07:41 PM	0	18.0	-	-	-	-	-	4	-	-	-	-	-	-	2
BBASHOTG	F	RAZ	05/08/93	08:00 PM	0	18.0	-	-	-	4	-	-	-	-	1	-	-	-	-
BBASHOTG	F	JFB/RAZ	03/22/97	07:37 PM	0,4	6.5	49	-	-	-	-	-	-	-	-	-	-	-	-
BBASHOTG	F	JFB/RAZ	04/21/97	09:22 PM	1	9.5	92	-	-	-	-	4	-	-	-	-	-	-	-
BBASHOTG	F	JFB/RAZ	05/12/97	08:20 PM	0	20.0	69	-	1	2	-	-	-	-	2	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
BBASHOTG	F	JFB	06/09/97	11:09 PM	0	11.0	94	-	-	-	-	-	-	-	-	-	-	-	-
BBATLAKE	F	JFB/DMG	03/24/99	09:35 PM	2	11.5	100	-	-	-	-	-	-	-	-	-	-	-	-
BBATLAKE	F	JFB	04/14/99	10:27 PM	0	8.0	59	-	-	-	-	-	-	-	-	-	-	-	-
BBATLAKE	F	JFB	06/01/99	08:59 PM	2	24.5	69	-	-	-	-	-	-	-	-	-	-	1	4
BBATLAKE	F	JFB/RAZ	06/25/99	09:09 PM	0	22.0	83	-	1	-	-	-	-	-	-	-	-	-	2
BBATN532	F	JFB/RAZ	03/27/97	07:21 PM	0	11.0	14	-	-	-	-	-	-	-	-	-	-	1	-
BBATN532	F	JFB/RAZ	04/21/97	11:03 PM	1	9.0	86	-	-	-	-	4	-	-	-	-	-	2	2
BBATN532	F	JFB/DMG	05/15/97	09:44 PM	1,4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BBATRCAR	F	JFB/RAZ	03/31/93	09:00 PM	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-
BBATRCAR	F	RAZ	05/08/93	08:15 PM	0	17.5	-	-	-	-	-	-	-	-	-	-	-	-	-
BBATRCAR	F	JFB/RAZ	06/03/93	11:17 PM	1	15.0	89	-	-	-	-	-	-	-	-	-	-	-	-
BBATRHIX	F	JFB	03/21/97	07:05 PM	1	9.5	85	-	-	-	-	4	-	-	-	-	-	-	-
BBATRHIX	F	JFB/DMG	04/03/97	08:57 PM	0	16.0	64	-	-	-	-	4	-	-	-	-	-	1	-
BBATRHIX	F	JFB/RAZ	05/12/97	09:26 PM	0	18.0	72	-	2	-	-	-	-	-	-	-	-	-	-
BBATRHIX	F	JFB	06/09/97	09:55 PM	0	12.5	88	-	-	-	-	-	-	-	-	-	-	-	-
BBATRMAH	F	JFB	03/21/97	07:14 PM	0	10.0	74	-	-	-	-	-	-	-	-	-	-	-	-
BBATRMAH	F	JFB/DMG	04/03/97	09:25 PM	1	15.0	57	-	-	-	-	1	-	-	-	-	-	2	-
BBATRMAH	F	JFB/RAZ	05/12/97	09:38 PM	0	16.5	72	-	2	2	-	1	-	-	1	-	-	2	-
BBATRMAH	F	JFB	06/09/97	10:00 PM	0	11.5	68	-	-	2	-	-	-	-	2	-	-	2	-
BBATRMAI	F	JFB	03/21/97	06:53 PM	1,4	9.5	74	-	-	-	-	-	-	-	-	-	1	-	-
BBATRMAI	F	JFB/DMG	04/03/97	09:07 PM	1	16.0	65	-	-	-	-	4	-	-	-	-	-	2	-
BBATRMAI	F	JFB/RAZ	05/12/97	09:54 PM	0	17.5	64	-	2	2	-	2	-	-	1	-	-	-	-
BBATRMAI	F	JFB	06/09/97	09:46 PM	0	12.5	88	-	-	-	-	-	-	-	1	-	-	-	1
BBATS532	F	JFB/RAZ	03/31/93	09:39 PM	2	9.0	-	-	-	-	-	2	-	-	-	-	-	-	-
BBATS532	F	JFB/RAZ	04/20/93	07:44 PM	1,4	17.0	80	-	-	-	-	-	-	-	-	-	-	-	4
BBATS532	F	JFB/RAZ	05/11/93	11:28 PM	0	24.0	80	-	-	+	-	-	-	-	-	-	-	-	4
BBATS532	F	JFB/RAZ	06/29/93	08:13 PM	2	26.0	77	-	-	-	-	-	-	-	-	-	-	-	-
BBATS532	F	JFB/RAZ	03/22/97	06:27 PM	0,4	7.0	38	-	-	-	-	-	-	-	-	-	-	-	-
BBATS532	F	JFB/RAZ	04/21/97	10:49 PM	1	9.5	86	-	-	-	-	-	-	-	-	-	-	2	-
BBATS532	F	JFB/DMG	05/15/97	09:31 PM	1,4	18.0	36	-	-	-	-	-	-	-	1	-	-	2	2
BBATS532	F	JFB/RAZ	06/17/97	09:50 PM	0	18.0	86	-	-	-	-	-	-	-	2	-	-	-	2
BDEEPRUN	F	JFB/RAZ	03/31/93	07:47 PM	2	9.5	-	-	-	-	-	-	-	-	-	-	-	3	-
BDEEPRUN	F	RAZ	05/03/93	07:50 PM	2	16.0	76	-	-	-	-	-	-	-	-	-	-	-	2
BDEEPRUN	F	JFB/RAZ	05/24/93	08:32 PM	1	21.0	72	-	2	-	-	-	-	2	3	-	-	-	2
BDEEPRUN	F	JFB/RAZ	06/16/93	11:06 PM	0	16.0	90	-	-	-	-	-	-	-	4	-	-	-	4
BDEEPRUN	F	JFB	03/21/97	09:04 PM	0	9.0	73	-	-	-	-	-	-	-	-	-	-	-	-
BDEEPRUN	F	JFB/DMG	04/03/97	07:14 PM	1	16.0	49	-	-	-	-	-	-	-	-	-	-	-	-
BDEEPRUN	F	JFB/RAZ	05/20/97	08:39 PM	0	14.5	53	-	-	-	-	-	-	-	-	-	-	-	2
BDEEPRUN	F	JFB/DMG	06/12/97	09:52 PM	0	19.5	82	-	2	-	-	-	-	-	1	-	-	-	3
BDEHAMPD	F	JFB/RAZ	03/31/93	07:53 PM	2	8.0	-	-	-	-	-	4	-	-	-	-	-	2	-
BDEHAMPD	F	RAZ	05/03/93	08:07 PM	2	15.0	85	-	-	4	-	4	-	-	-	-	-	-	2
BDEHAMPD	F	JFB/RAZ	05/24/93	08:25 PM	1	21.0	75	-	-	4	-	-	-	-	-	-	-	-	-
BDEHAMPD	F	JFB/RAZ	06/16/93	11:10 PM	0	16.0	90	-	-	1	-	-	-	-	1	-	-	-	1
BDEHAMPD	F	JFB	03/18/96	07:51 PM	0	15.0	84	-	-	-	-	-	-	-	-	-	-	2	-
BDEHAMPD	F	JFB/RAZ	03/25/96	09:25 PM	0	15.0	62	-	-	-	-	2	-	-	-	-	-	2	-
BDEHAMPD	F	JFB	04/03/96	08:13 PM	0	12.0	78	-	-	-	-	4	-	-	-	-	-	3	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
BDEHAMPD	F	JFB/RAZ	04/18/96	10:26 PM	0	7.0	70	-	-	-	-	2	-	-	-	-	-	1	-
BDEHAMPD	F	JFB	05/10/96	10:15 PM	1	20.0	81	-	-	3	-	-	-	-	1	-	-	2	-
BDEHAMPD	F	JFB/RAZ	06/05/96	10:18 PM	0	15.0	90	-	-	2	-	-	-	-	1	-	-	1	-
BDEHAMPD	F	JFB	06/21/96	10:25 PM	1	21.0	53	-	-	2	-	-	-	-	1	-	-	1	1
BDEHAMPD	F	JFB/DMG	07/01/96	10:30 PM	2	22.0	90	-	1	3	-	-	-	-	1	-	-	1	1
BDEHAMPD	F	JFB	03/21/97	08:58 PM	0	9.0	85	-	-	-	-	-	-	-	-	-	-	-	-
BDEHAMPD	F	JFB/DMG	04/03/97	07:28 PM	0	14.0	56	-	-	-	-	4	-	-	-	-	-	-	-
BDEHAMPD	F	JFB/RAZ	05/20/97	08:23 PM	0	14.0	53	-	-	2	-	2	-	-	2	-	-	2	-
BDEHAMPD	F	JFB/DMG	06/12/97	10:59 PM	0	18.0	86	-	-	2	-	-	-	-	2	-	-	-	1
BDEHAMPD	S	JFB	02/26/98	03:16 PM	0,4	18.0	30	-	-	-	-	-	-	-	-	-	-	-	-
BDEHAMPD	F	JFB/RAZ	03/26/98	08:54 PM	0	14.5	66	-	-	-	-	4	-	-	-	-	1	-	-
BDEHAMPD	F	JFB	04/17/98	09:39 PM	2	18.0	95	-	-	4	-	4	-	-	2	-	-	2	1
BDEHAMPD	F	JFB	05/28/98	08:38 PM	0	20.5	73	-	-	3	-	-	-	-	2	-	-	1	1
BDEHAMPD	F	JFB	06/16/98	09:25 PM	2	25.5	84	-	-	3	-	-	-	-	2	-	-	-	-
BDEHAMPD	S	JFB	03/11/99	04:11 PM	0,4	7.5	46	-	-	-	-	-	-	-	-	-	-	-	-
BDEHAMPD	F	JFB	03/18/99	05:22 PM	0,4	13.0	61	-	-	-	-	-	-	-	-	-	-	-	-
BDEHAMPD	F	JFB	04/01/99	07:51 PM	2,3,5	17.0	93	-	-	-	-	4	-	-	-	-	-	-	-
BDEHAMPD	F	JFB	05/10/99	09:21 PM	0	13.0	66	-	-	-	-	-	-	-	-	-	-	-	-
BDEHAMPD	F	JFB	06/13/99	10:14 PM	2	21.0	96	-	-	2	-	-	-	-	-	-	-	1	1
BDETRHAM	F	JFB/RAZ	03/31/93	07:53 PM	2	8.0	-	-	-	-	-	-	-	-	-	-	-	-	-
BDETRHAM	F	RAZ	05/03/93	08:00 PM	2	15.0	85	-	-	-	-	-	-	-	-	-	-	-	-
BDETRHAM	F	JFB/RAZ	05/24/93	08:25 PM	1	21.0	75	-	-	-	-	-	-	-	-	-	-	-	-
BDETRHAM	F	JFB/RAZ	06/16/93	11:10 PM	0	16.0	90	-	-	-	-	-	-	-	-	-	-	-	-
BDETRHAM	F	JFB/DMG	04/03/97	07:22 PM	0	14.0	56	-	-	-	-	3	-	-	-	-	-	1	-
BDETRHAM	F	JFB/RAZ	05/20/97	08:32 PM	0	14.0	62	-	-	-	-	-	-	-	2	-	-	1	2
BDETRHAM	F	JFB/DMG	06/12/97	10:18 PM	0	18.5	91	-	-	-	-	-	-	-	1	-	-	-	2
BHOBUTTR	F	JFB/RAZ	03/31/93	09:25 PM	2	9.0	-	-	-	-	-	4	-	-	-	-	-	-	-
BHOBUTTR	F	JFB/RAZ	05/08/93	09:00 PM	0	16.5	-	-	-	-	-	-	-	4	2	-	-	-	-
BHOBUTTR	F	JFB/RAZ	06/16/93	11:48 PM	0	20.0	90	-	-	-	-	-	-	2	-	-	-	-	-
BHOBUTTR	F	JFB/RAZ	03/27/97	07:35 PM	0	14.0	49	-	-	-	-	4	-	-	-	-	-	-	-
BHOBUTTR	F	JFB/RAZ	04/21/97	09:37 PM	1	9.5	92	-	-	-	-	4	-	-	-	-	-	-	-
BHOBUTTR	F	JFB/DMG	05/15/97	10:00 PM	1,4	18.5	36	-	2	-	-	1	-	1	2	-	-	-	-
BHOBUTTR	F	JFB/RAZ	06/17/97	10:07 PM	0,4	19.0	86	-	-	-	-	-	-	-	2	-	-	-	-
BHOCRBOG	F	JFB/RAZ	03/27/97	07:44 PM	0	12.5	58	-	-	-	-	4	1	-	-	-	-	-	-
BHOCRBOG	F	JFB/RAZ	04/21/97	09:31 PM	1	9.5	92	-	-	-	-	4	-	-	-	-	-	-	-
BHODITCH	F	JFB/DMG	05/15/97	10:12 PM	1,4	17.5	73	-	2	-	-	-	-	2	-	-	-	-	-
BHODITCH	F	JFB/RAZ	06/17/97	10:15 PM	0	18.5	86	-	-	-	-	-	-	v	-	-	-	-	-
BINOAKBG	F	JFB/RAZ	03/31/93	06:32 PM	2,4	13.0	59	-	-	-	-	4	-	-	-	-	-	-	-
BINOAKBG	S	JFB/RAZ	04/08/93	12:17 AM	0	11.5	-	-	-	-	-	-	-	-	-	-	-	-	-
BINOAKBG	S	JFB/RAZ	04/14/93	07:25 PM	1,5	-	-	-	-	-	-	+	-	-	-	-	-	-	-
BINOAKBG	F	JFB/RAZ	04/20/93	11:37 PM	0,4	-	-	-	-	-	-	4	-	-	-	-	-	-	-
BINOAKBG	S	JFB/RAZ	04/27/93	10:49 PM	0	-	-	-	-	-	-	+	-	-	-	-	-	-	-
BINOAKBG	S	JFB	05/04/93	11:36 PM	2,3,5	-	-	-	-	-	-	+	-	+	+	-	-	+	-
BINOAKBG	F	JFB/RAZ	05/11/93	12:05 AM	0	23.0	-	-	-	-	-	3	-	4	4	-	-	4	-
BINOAKBG	S	JFB/RAZ	05/25/93	11:16 PM	1	-	-	-	-	-	-	-	-	+	+	-	-	+	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
BINOAKBG	S	JFB/RAZ	06/03/93	11:45 PM	1	-	86	-	-	-	-	-	-	+	+	-	-	+	-
BINOAKBG	S	JFB/RAZ	06/09/93	11:19 PM	0	-	-	-	+	-	-	-	-	+	+	-	-	-	-
BINOAKBG	F	JFB/RAZ	06/29/93	12:22 AM	2	21.0	87	-	-	-	-	-	-	4	1	-	-	-	-
BINOAKBG	F	JFB/RAZ	03/27/97	09:46 PM	0	13.0	55	-	-	-	-	3	-	-	-	-	-	-	-
BINOAKBG	F	RAZ	04/27/97	07:51 PM	5	23.0	-	-	-	-	-	4	-	-	-	-	-	-	-
BINOAKBG	F	JFB/RAZ	05/20/97	10:57 PM	0	13.0	67	-	-	-	-	1	-	2	-	-	-	2	-
BINOAKBG	F	JFB/RAZ	06/17/97	10:58 PM	0,4	19.0	86	-	-	-	-	-	-	2	1	-	-	1	-
BINSCHOO	F	JFB/RAZ	03/31/93	06:44 PM	2	13.0	59	-	-	-	-	3	-	-	3	-	-	-	-
BINSCHOO	S	JFB/RAZ	04/08/93	12:10 AM	0	12.0	-	-	-	-	-	-	-	-	-	+	-	-	-
BINSCHOO	S	JFB/RAZ	04/14/93	11:37 PM	1,5	-	-	-	-	-	-	+	-	-	-	+	-	-	-
BINSCHOO	F	JFB/RAZ	04/20/93	11:25 PM	0,4	-	-	-	-	-	-	-	-	-	-	4	-	-	-
BINSCHOO	S	JFB/RAZ	04/27/93	10:40 PM	0	-	-	-	-	-	-	-	-	-	-	+	-	-	-
BINSCHOO	S	JFB	05/04/93	11:31 PM	2,3,5	-	-	-	-	-	-	+	-	+	+	+	-	-	-
BINSCHOO	S	JFB/RAZ	05/05/93	12:01 AM	2	-	-	-	-	-	-	-	-	+	+	+	-	-	-
BINSCHOO	F	JFB/RAZ	05/11/93	12:00 AM	0	25.0	-	-	-	-	-	-	-	2	2	-	-	-	-
BINSCHOO	S	JFB/RAZ	05/25/93	11:12 PM	1	-	-	-	-	-	-	-	-	+	+	-	-	-	-
BINSCHOO	S	RAZ	05/31/93	09:11 PM	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
BINSCHOO	S	JFB/RAZ	06/03/93	11:41 PM	1	-	-	-	-	-	-	-	-	+	+	-	-	-	-
BINSCHOO	S	JFB/RAZ	06/09/93	11:22 PM	0	-	-	-	-	-	-	-	-	+	+	-	-	-	-
BINSCHOO	F	JFB/RAZ	06/29/93	12:15 AM	2	22.0	96	-	-	-	-	-	-	2	2	-	-	-	-
BINSCHOO	S	JFB	03/13/96	06:31 PM	0	9.0	73	-	-	-	-	-	-	-	-	-	-	-	-
BINSCHOO	S	JFB	03/14/96	06:48 PM	0	16.0	51	-	-	-	-	-	-	-	-	-	-	-	-
BINSCHOO	S	JFB	03/15/96	06:18 PM	2,5	16.0	92	-	-	-	-	-	-	-	-	-	-	-	-
BINSCHOO	F	JFB/RAZ	03/25/96	06:27 PM	2	14.0	71	-	-	-	-	1	-	-	-	-	-	-	-
BINSCHOO	S	JFB	04/11/96	11:19 PM	1	15.0	57	-	-	-	-	2	-	-	-	4	-	-	-
BINSCHOO	S	JFB	04/15/96	07:36 PM	2,4,5	9.0	85	-	-	-	-	-	-	-	-	2	-	-	-
BINSCHOO	S	JFB	04/15/96	10:26 PM	2,4,5	11.0	86	-	-	-	-	-	-	-	-	2	-	-	-
BINSCHOO	S	JFB/RAZ	04/18/96	10:44 PM	0	10.0	80	-	-	-	-	-	-	-	-	4	-	-	-
BINSCHOO	S	JFB	04/28/96	08:19 PM	1	17.0	38	-	-	-	-	-	-	-	-	3	-	-	-
BINSCHOO	S	JFB	04/28/96	11:45 PM	1	17.0	52	-	-	-	-	-	-	-	-	2	-	-	-
BINSCHOO	S	JFB	05/10/96	12:09 AM	1	18.0	90	-	2	-	-	-	-	2	2	2	-	-	-
BINSCHOO	S	JFB	05/18/96	11:08 PM	2,3	22.0	95	-	1	-	-	-	-	4	2	-	-	-	-
BINSCHOO	S	JFB	03/05/97	07:32 PM	6	8.5	85	-	-	-	-	-	-	-	-	-	-	-	-
BINSCHOO	F	JFB/RAZ	03/22/97	08:00 PM	0,4	7.0	46	-	-	-	-	-	-	-	-	-	-	-	-
BINSCHOO	F	JFB/DMG	04/03/97	09:50 PM	1	16.0	59	-	-	-	-	-	-	-	-	3	-	-	-
BINSCHOO	S	JFB/RAZ	04/21/97	11:26 PM	1	9.0	86	-	-	-	-	-	-	-	-	+	-	-	-
BINSCHOO	S	RAZ	04/27/97	08:25 PM	5	21.0	-	-	-	-	-	-	-	-	-	+	-	-	-
BINSCHOO	F	JFB/RAZ	05/20/97	10:17 PM	0	14.0	53	-	1	-	-	-	-	2	3	1	-	-	-
BINSCHOO	F	JFB/RAZ	06/17/97	10:40 PM	0,4	18.5	82	-	-	-	-	-	-	1	2	-	-	-	-
BINSCHOO	S	JFB/DMG	04/14/98	07:10 PM	5	-	-	-	-	-	-	-	-	+	-	+	-	-	-
BINSCHOO	S	JFB/DMG	04/14/98	11:10 PM	2	15.0	89	-	-	-	-	-	-	-	-	2	-	-	-
BINSCHOO	S	JFB/RAZ	04/15/98	11:35 PM	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
BINSCHOO	S	JFB	04/17/98	07:38 PM	5,9	21.5	91	-	+	-	-	-	-	-	+	+	-	-	-
BINSCHOO	S	JFB	04/01/99	10:46 PM	2,3,5	16.0	100	-	-	-	-	-	-	-	-	2	-	-	-
BINSCHOO	S	JFB	04/03/99	09:45 PM	0,4	13.5	88	-	-	-	-	-	-	-	-	2	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
BINSCHOO	S	JFB	04/14/99	10:51 PM	0	9.0	85	-	-	-	-	-	-	-	-	2	-	-	-
BINSCHOO	S	JFB	05/08/99	08:10 PM	2	20.0	82	-	2	-	-	-	-	-	1	-	-	-	-
BINSHADW	F	JFB/RAZ	05/20/97	10:30 PM	0	14.5	62	-	-	-	-	-	-	2	2	1	-	2	-
BINSHADW	F	JFB/RAZ	06/17/97	10:49 PM	0,4	18.0	82	-	-	-	-	-	-	2	2	-	-	-	-
BINSTOKE	F	JFB/RAZ	03/25/98	06:33 PM	0	8.5	46	-	-	-	-	-	-	-	-	-	-	-	-
BINSTOKE	F	JFB	04/29/98	10:28 PM	0,4	13.5	66	-	-	-	-	-	-	-	-	-	-	-	-
BINSTOKE	F	JFB	05/19/98	10:22 PM	2	24.0	69	-	-	-	-	-	-	1	2	-	-	-	-
BINSTOKE	F	JFB/DMG	06/15/98	08:47 PM	2	24.0	87	-	-	-	-	-	-	-	1	-	-	-	-
BMUCONCD	S	RAZ	04/07/93	10:09 PM	0	8.0	-	-	-	-	-	-	-	-	-	-	-	-	-
BMUCONCD	F	JFB/RAZ	03/27/97	10:10 PM	0	11.0	64	-	-	-	-	-	-	-	-	-	-	-	-
BMUCONCD	F	RAZ	04/27/97	08:37 PM	5	22.0	-	-	-	-	-	-	-	-	-	-	-	-	-
BMUCONCD	F	JFB/RAZ	05/20/97	11:05 PM	0	13.5	57	-	-	-	-	-	-	2	-	-	-	-	-
BMUCONCD	F	JFB/RAZ	06/17/97	11:09 PM	0	19.0	90	-	-	-	-	-	-	2	-	-	-	-	-
BMULAKED	F	RAZ	04/07/93	09:55 PM	0	8.0	-	-	-	-	-	2	-	-	-	-	-	-	-
BMULAKED	F	JFB/RAZ	05/25/93	11:00 PM	1	22.0	69	-	1	-	-	-	-	4	-	-	-	-	-
BMULAKED	F	JFB/RAZ	06/29/93	12:06 AM	2	22.0	91	-	1	-	-	-	-	1	-	-	-	-	-
BMULAKED	S	JFB	03/05/97	07:20 PM	6	8.0	85	-	-	-	-	-	-	-	-	-	-	-	-
BMULAKED	F	JFB/RAZ	03/22/97	07:51 PM	0,4	7.0	49	-	-	-	-	-	-	-	-	-	-	-	-
BMULAKED	F	JFB/RAZ	04/21/97	11:18 PM	1	9.0	86	-	-	-	-	-	-	-	-	2	-	-	-
BMULAKED	F	JFB/RAZ	05/20/97	10:08 PM	0	15.0	46	-	-	-	-	-	-	3	1	-	-	-	-
BMULAKED	F	JFB/RAZ	06/17/97	10:31 PM	1	18.5	82	-	-	-	-	-	-	3	2	-	-	-	-
BMUPRIVA	F	RAZ	04/27/97	08:00 PM	5,0	23.0	-	-	-	-	-	-	-	-	-	-	-	-	-
BMUPRIVA	F	JFB/DMG	05/15/97	10:28 PM	1,4,5	18.0	47	-	-	-	-	-	-	2	-	-	-	-	-
BMUPRIVA	F	JFB/RAZ	06/17/97	11:05 PM	0,4	18.5	86	-	-	-	-	-	-	2	-	-	-	-	-
BSKBEAVD	F	JFB	03/21/97	08:15 PM	0	9.0	62	-	-	-	-	-	-	-	-	-	-	-	-
BSKBEAVD	F	JFB/DMG	04/03/97	08:25 PM	0	16.0	65	-	-	-	-	-	-	-	-	-	-	-	-
BSKBEAVD	F	JFB/RAZ	05/12/97	10:35 PM	0	17.0	76	-	-	-	-	-	-	-	2	-	-	-	3
BSKBEAVD	F	JFB/DMG	06/12/97	10:53 PM	0	19.5	83	-	-	-	-	-	-	-	2	-	-	-	3
BSKBEAVU	F	JFB/RAZ	04/21/97	08:21 PM	1,5	10.0	100	-	-	-	-	-	-	-	-	-	-	2	2
BSKBEAVU	F	JFB/RAZ	05/12/97	10:21 PM	0	17.0	72	-	1	-	-	-	-	-	-	-	-	-	4
BSKBEAVU	F	JFB	06/09/97	09:21 PM	0	13.5	78	-	-	-	-	-	-	-	2	-	-	-	4
BSKIHEAD	F	JFB	03/18/96	08:52 PM	0	14.0	64	-	-	-	-	-	-	-	-	-	-	-	-
BSKIHEAD	F	JFB	03/26/96	07:51 PM	2	14.0	59	-	-	-	-	-	-	-	-	-	-	-	-
BSKIHEAD	F	JFB	04/03/96	07:09 PM	0	12.0	72	-	-	-	-	4	-	-	-	-	-	-	-
BSKIHEAD	F	JFB	04/19/96	10:41 PM	0	12.0	77	-	-	-	-	3	-	-	-	-	-	1	-
BSKIHEAD	F	JFB	05/10/96	08:55 PM	1	19.0	81	-	2	4	-	-	-	-	-	-	-	1	-
BSKIHEAD	F	JFB/RAZ	06/05/96	09:10 PM	0	14.5	84	-	1	4	-	-	-	-	-	-	-	2	-
BSKIHEAD	F	JFB	06/21/96	11:32 PM	1	19.5	56	-	-	2	-	-	-	-	-	-	-	-	-
BSKIHEAD	F	JFB/DMG	07/01/96	10:35 PM	2	22.0	90	-	-	4	-	-	-	-	-	-	-	-	1
BSKIHEAD	F	JFB/RAZ	03/27/97	07:00 PM	0	13.0	54	-	-	-	-	-	-	-	-	-	-	-	-
BSKIHEAD	F	JFB/RAZ	04/21/97	10:09 PM	1	9.5	86	-	-	-	-	4	-	-	-	-	-	2	-
BSKIHEAD	F	JFB/DMG	05/15/97	08:44 PM	1	17.0	79	-	-	2	-	-	-	-	-	-	-	2	1
BSKIHEAD	F	JFB	06/09/97	08:53 PM	0	13.5	78	-	-	2	-	-	-	-	-	-	-	-	-
BSKIHEAD	S	JFB	02/26/98	04:40 PM	0,4	17.0	33	-	-	-	-	-	-	-	-	-	-	-	-
BSKIHEAD	F	JFB/RAZ	03/26/98	10:09 PM	0	13.5	78	-	-	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
BSKIHEAD	F	JFB	04/29/98	09:33 PM	0,4	14.0	64	-	-	-	-	2	-	-	-	-	-	1	-
BSKIHEAD	F	JFB	05/28/98	09:31 PM	0	18.5	81	-	-	3	-	-	-	-	2	-	-	1	1
BSKIHEAD	F	JFB	06/16/98	08:33 PM	2	25.5	84	-	-	4	-	-	-	-	2	-	-	1	1
BSKIHEAD	S	JFB	03/11/99	03:24 PM	0,4	6.5	50	-	-	-	-	-	-	-	-	-	-	-	-
BSKIHEAD	F	JFB	03/18/99	08:25 PM	0,4	11.0	63	-	-	-	-	-	-	-	-	-	-	-	-
BSKIHEAD	F	JFB	04/01/99	06:46 PM	2,5	14.0	100	-	-	-	-	2	-	-	-	-	-	-	-
BSKIHEAD	F	JFB	05/10/99	08:34 PM	0	12.5	65	-	-	-	-	-	-	-	-	-	-	-	-
BSKIHEAD	F	JFB	06/13/99	09:00 PM	2	21.0	92	-	-	-	-	-	-	-	-	-	-	-	-
BSKITCAR	F	JFB/RAZ	03/31/93	08:49 PM	2	10.0	-	-	-	-	-	-	-	-	-	-	-	-	-
BSKITCAR	F	RAZ	05/08/93	08:27 PM	0	17.0	-	-	-	-	-	-	-	-	1	-	-	-	2
BSKITCAR	F	JFB/RAZ	06/03/93	11:08 PM	1	17.0	90	-	-	-	-	-	-	-	-	-	-	-	2
BSKITCAR	F	JFB/RAZ	03/27/97	08:06 PM	0	9.0	64	-	-	-	-	-	-	-	-	-	-	-	-
BSKITCAR	F	JFB/RAZ	04/21/97	08:35 PM	1,5	10.0	92	-	-	-	-	-	-	-	-	-	-	-	-
BSKITCAR	F	JFB/RAZ	05/12/97	09:14 PM	0	18.0	65	-	-	-	-	-	-	-	-	-	-	-	-
BSKITCAR	F	JFB	06/09/97	10:10 PM	0	12.0	78	-	-	-	-	-	-	-	-	-	-	-	-
BSKSPHGM	F	JFB	03/18/96	08:15 PM	0	15.0	84	-	-	-	-	-	-	-	-	-	-	-	-
BSKSPHGM	F	JFB	03/26/96	07:00 PM	2	14.0	59	-	-	-	-	1	-	-	-	-	-	-	-
BSKSPHGM	F	JFB	04/03/96	07:50 PM	0	11.5	78	-	-	-	-	2	-	-	-	-	-	-	-
BSKSPHGM	F	JFB	04/19/96	09:45 PM	0	18.0	77	-	-	-	-	3	-	-	-	-	-	2	-
BSKSPHGM	F	JFB	05/10/96	09:52 PM	1	19.0	81	-	-	4	-	2	-	-	1	-	-	-	1
BSKSPHGM	F	JFB/RAZ	06/05/96	09:55 PM	0	19.0	90	-	-	2	-	-	-	-	2	-	-	2	1
BSKSPHGM	F	JFB	06/21/96	10:43 PM	1	21.0	54	-	-	2	-	-	-	-	2	-	-	-	1
BSKSPHGM	F	JFB/DMG	07/01/96	10:50 PM	2	22.0	90	-	-	3	-	-	-	-	2	-	-	1	1
BSKSPHGM	F	JFB	03/21/97	08:37 PM	0	9.0	73	-	-	-	-	-	-	-	-	-	-	-	-
BSKSPHGM	F	JFB/DMG	04/03/97	08:05 PM	0	16.0	56	-	-	-	-	4	-	-	-	-	-	-	-
BSKSPHGM	F	JFB/RAZ	05/12/97	10:57 PM	0	15.5	70	-	-	2	-	1	-	-	-	-	-	-	2
BSKSPHGM	F	JFB/DMG	06/12/97	10:39 PM	0	18.5	82	-	-	2	-	-	-	-	2	-	-	1	1
BSKSPHGM	S	JFB	02/26/98	03:36 PM	0,4	17.5	30	-	-	-	-	-	-	-	-	-	-	-	-
BSKSPHGM	F	JFB/RAZ	03/26/98	09:21 PM	0	14.5	68	-	-	-	-	3	-	-	-	-	-	-	-
BSKSPHGM	F	JFB	04/17/98	10:02 PM	2	18.0	95	-	-	2	-	2	-	-	-	-	-	2	-
BSKSPHGM	F	JFB	05/28/98	08:56 PM	0	19.5	73	-	-	2	-	-	-	-	2	-	-	2	1
BSKSPHGM	F	JFB	06/16/98	09:10 PM	2	25.0	84	-	-	3	-	-	-	-	2	-	-	-	2
BSKSPHGM	S	JFB	03/11/99	03:55 PM	0,4	7.5	56	-	-	-	-	-	-	-	-	-	-	-	-
BSKSPHGM	F	JFB	03/18/99	07:43 PM	0,4	11.0	63	-	-	-	-	-	-	-	-	-	-	-	-
BSKSPHGM	F	JFB	04/01/99	07:29 PM	2,5	17.0	100	-	-	-	-	4	-	-	-	-	-	1	-
BSKSPHGM	F	JFB	05/10/99	09:05 PM	0	14.0	66	-	-	-	-	-	-	-	-	-	-	1	-
BSKSPHGM	F	JFB	06/13/99	09:52 PM	2	21.0	96	-	-	2	-	-	-	-	2	-	-	2	1
BSKTRBRN	F	JFB	03/21/97	06:30 PM	0	10.0	64	-	-	-	-	-	-	-	-	-	-	-	-
BSKTRBRN	F	JFB/DMG	04/03/97	08:43 PM	0	17.0	65	-	-	-	-	1	-	-	-	-	-	3	-
BSKTRBRN	F	JFB/RAZ	05/12/97	09:20 PM	0	19.0	64	-	-	2	-	-	-	-	2	-	-	-	2
BSKTRBRN	F	JFB	06/09/97	09:33 PM	0	13.0	78	-	-	1	-	-	-	-	2	-	-	-	2
BSKTRHAD	F	JFB	03/21/97	08:27 PM	0	10.0	73	-	-	-	-	-	-	-	-	-	-	-	-
BSKTRHAD	F	JFB/DMG	04/03/97	07:52 PM	0	16.0	56	-	-	-	-	3	-	-	-	-	-	2	-
BSKTRHAD	F	JFB/RAZ	05/12/97	10:48 PM	0	16.0	79	-	-	-	-	-	-	-	2	-	-	-	-
BSKTRHAD	F	JFB/DMG	06/12/97	10:29 PM	0	18.0	86	-	-	-	-	-	-	-	-	-	-	-	2
BSKTRHAM	F	JFB/RAZ	03/31/93	08:20 PM	2	10.0	-	-	-	-	-	-	-	-	-	-	-	1	-

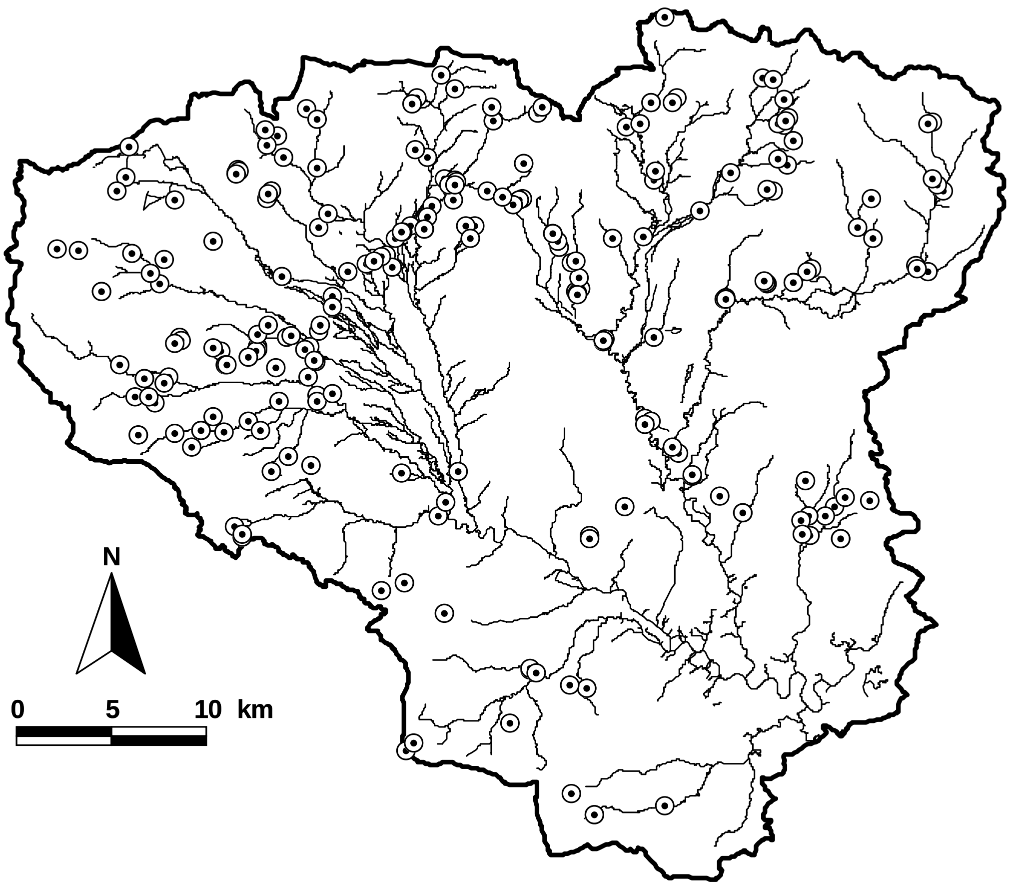
Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
BSKTRHAM	F	JFB/RAZ	05/24/93	08:05 PM	1	23.0	69	-	1	-	-	-	-	-	1	-	-	-	2
BSKTRHAM	F	JFB/RAZ	06/16/93	11:21 PM	0	16.0	90	-	-	-	-	-	-	-	2	-	-	-	-
BSKTRHAU	F	JFB	03/21/97	08:27 PM	0	10.0	73	-	-	-	-	1	-	-	-	-	-	-	-
BSKTRHAU	F	JFB/DMG	04/03/97	07:52 PM	0	16.0	56	-	-	-	-	3	-	-	-	-	-	2	-
BSKTRHAU	F	JFB/RAZ	05/12/97	10:48 PM	0	16.0	79	-	-	-	-	-	-	-	-	-	-	1	1
BSKTRHAU	F	JFB/DMG	06/12/97	10:29 PM	0	18.0	86	-	-	-	-	-	-	-	1	-	-	-	1
BSKWIDEN	F	JFB/RAZ	04/08/93	07:53 PM	0	14.0	-	-	-	-	-	2	-	-	-	-	-	3	-
BSKWIDEN	F	JFB	05/04/93	11:02 PM	2,4	16.0	100	-	-	-	-	-	-	-	3	-	-	2	4
BSKWIDEN	F	JFB/RAZ	06/03/93	11:00 PM	1	17.0	85	-	-	-	-	-	-	-	4	-	-	-	4
BSKWIDEN	F	JFB	03/21/97	07:55 PM	0	10.0	74	-	-	-	-	-	-	-	-	-	-	-	-
BSKWIDEN	F	JFB/RAZ	04/21/97	08:07 PM	1,5	10.5	100	-	-	-	-	2	-	-	-	-	-	-	2
BSKWIDEN	F	JFB/RAZ	05/12/97	10:10 PM	0	18.5	72	-	-	-	-	-	-	-	-	-	-	-	4
BSKWIDEN	F	JFB	06/09/97	09:14 PM	0	13.5	73	-	-	-	-	-	-	-	2	-	-	-	4
BSPDITCH	S	JFB/RAZ	05/20/97	09:48 PM	-	-	-	-	-	-	-	-	-	v	-	-	-	-	-
BSPHOTDG	F	JFB	03/19/98	07:02 PM	2	11.0	91	-	-	-	-	-	-	-	-	-	-	-	-
BSPHOTDG	F	JFB	04/29/98	10:49 PM	0,4	13.5	66	-	-	-	-	-	-	-	-	-	-	-	-
BSPHOTDG	F	JFB	05/19/98	09:52 PM	2	24.5	69	-	-	-	-	-	-	2	1	-	-	-	-
BSPHOTDG	F	JFB/DMG	06/15/98	08:20 PM	2	23.5	91	-	-	-	-	-	-	2	-	-	-	-	-
BSPPUDDL	F	JFB	03/21/97	09:11 PM	0	9.0	73	-	-	-	-	-	-	-	-	-	-	-	-
BSPPUDDL	F	JFB/DMG	04/29/97	11:23 PM	0	11.0	80	-	-	-	-	2	-	-	-	-	-	1	-
BSPPUDDL	F	JFB/RAZ	05/20/97	09:03 PM	0	13.5	60	-	-	-	-	-	-	-	-	-	-	1	-
BSPPUDDL	F	JFB/DMG	06/12/97	09:22 PM	0	19.5	82	-	3	2	-	-	-	-	2	-	-	2	-
BSPPUDDL	S	JFB	04/01/99	7:51 PM	2,3,5	17.0	93	-	-	-	-	-	-	-	-	-	1	-	-
BSPPUDDL	S	JFB	06/13/99	10:14 PM	2	21.0	96	-	-	-	-	-	-	v	-	-	-	-	-
BSPRRPND	F	JFB	03/18/96	07:38 PM	0	14.0	73	-	-	-	-	-	-	-	-	-	-	-	-
BSPRRPND	F	JFB/RAZ	03/25/96	09:12 PM	1	15.0	66	-	-	-	-	-	-	-	-	-	-	-	-
BSPRRPND	F	JFB	04/03/96	08:30 PM	0	11.0	72	-	-	-	-	-	-	-	-	-	-	-	-
BSPRRPND	F	JFB/RAZ	04/18/96	10:15 PM	0	7.0	72	-	-	-	-	-	-	-	-	-	-	-	-
BSPRRPND	F	JFB	05/10/96	10:32 PM	1	16.0	90	-	1	-	-	-	-	-	2	-	-	-	-
BSPRRPND	F	JFB/RAZ	03/27/97	08:47 PM	0	8.0	73	-	-	-	-	-	-	-	-	-	-	-	-
BSPRRPND	F	JFB/DMG	04/29/97	11:35 PM	0	11.0	80	-	-	-	-	-	-	-	-	-	-	-	-
BSPRRPND	F	JFB/RAZ	05/20/97	08:53 PM	0	13.0	60	-	-	-	-	-	-	-	2	-	-	-	-
BSPRRPND	F	JFB/DMG	06/12/97	09:28 PM	0	19.5	83	-	-	-	-	-	-	-	1	-	-	-	1
BSPTRAIL	F	JFB/RAZ	03/27/97	08:23 PM	0	11.0	64	-	-	-	-	-	-	-	-	-	-	-	-
BSPTRAIL	F	RAZ	04/27/97	08:13 PM	5	22.0	-	-	-	-	-	-	-	-	-	-	-	-	-
BSPTRAIL	F	JFB/RAZ	05/20/97	09:55 PM	0	15.0	53	-	-	-	-	-	-	+	+	+	-	-	-
BSPTRAIL	F	JFB/DMG	06/12/97	11:25 PM	0	22.5	83	-	1	-	-	-	-	2	2	-	-	-	-
BTOBIRCD	F	JFB/RAZ	03/22/97	07:00 PM	0,4	7.5	49	-	-	-	-	-	-	-	-	-	-	-	-
BTOBIRCD	F	JFB/RAZ	04/21/97	10:34 PM	1	11.0	80	-	-	-	-	1	-	-	-	-	-	-	2
BTOBIRCD	F	JFB/DMG	05/15/97	09:14 PM	1	19.0	64	-	2	-	-	-	-	-	1	-	-	1	2
BTOBIRCD	F	JFB/RAZ	06/17/97	09:08 PM	0	19.5	86	-	-	-	-	-	-	-	1	-	-	-	2
BTOBIRCU	F	JFB/RAZ	03/22/97	07:00 PM	0,4	7.5	49	-	-	-	-	-	-	-	-	-	-	-	-
BTOBIRCU	F	JFB/RAZ	04/21/97	10:34 PM	1	11.0	80	-	-	-	-	-	-	-	-	-	-	-	2
BTOBIRCU	F	JFB/DMG	05/15/97	09:14 PM	1	19.0	64	-	-	-	-	-	-	-	2	-	-	-	4
BTOBIRCU	F	JFB/RAZ	06/17/97	09:08 PM	0	19.5	86	-	-	-	-	-	-	-	2	-	-	-	2
BTOIM532	S	JFB	03/11/99	03:20 PM	0,4	6.5	36	-	-	-	-	-	-	-	-	-	-	-	-

Survey Information					Conditions			Species											
Site Code	Data Type	Observer(s) Initials	Date	Time	Weather Code	Air Temp. (°C)	Rel. Hum. (%)	*A. c. crepitans*	*B. w. fowleri*	*H. andersonii*	*H. versicolor*	*P. c. crucifer*	*P. t. kalmi*	*R. catesbeiana*	*R. c. melanota*	*R. palustris*	*R. sylvatica*	*R. utricularia*	*R. virgatipes*
BTOIM532	F	JFB/RAZ	03/22/97	06:45 PM	0,4	8.0	49	-	-	-	-	-	-	-	-	-	-	-	-
BTOIM532	F	JFB/RAZ	04/21/97	10:24 PM	1	10.0	86	-	-	-	-	1	-	-	-	-	-	2	2
BTOIM532	F	JFB/DMG	05/15/97	09:00 PM	1	20.5	62	-	-	+	-	-	-	-	+	-	-	+	4
BTOIM532	F	JFB/RAZ	06/17/97	09:32 PM	0,4	19.0	82	-	-	2	-	-	-	-	2	-	-	-	4
BTOIMPCA	F	JFB/RAZ	04/21/97	09:02 PM	1	9.0	100	-	-	-	-	-	-	-	-	-	-	2	2
BTOIMPCA	F	JFB/RAZ	05/12/97	08:55 PM	0	18.0	69	-	-	-	-	-	-	-	2	-	-	2	3
BTOIMPCA	F	JFB	06/09/97	10:41 PM	0	9.5	88	-	-	-	-	-	-	-	4	-	-	2	4
BTOMCARR	F	JFB/RAZ	03/31/93	08:49 PM	2	10.0	-	-	-	-	-	-	-	-	-	-	-	-	-
BTOMCARR	F	JFB/RAZ	06/03/93	11:08 PM	1	17.0	90	-	-	-	-	-	-	-	-	-	-	-	-
BTOMCARR	F	JFB/RAZ	03/27/97	08:02 PM	0	9.0	64	-	-	-	-	-	-	-	-	-	-	-	-
BTOMCARR	F	JFB/RAZ	04/21/97	08:35 PM	1,5	10.0	92	-	-	-	-	-	-	-	-	-	-	-	-
BTOMCARR	F	JFB/RAZ	05/12/97	08:38 PM	0	18.5	69	-	-	-	-	-	-	-	-	-	-	-	-
BTOMCARR	F	JFB	06/09/97	10:56 PM	0	12.0	88	-	-	-	-	-	-	-	-	-	-	-	-
BTOMCRIP	F	JFB/RAZ	03/22/97	07:30 PM	0,4	6.5	49	-	-	-	-	-	-	-	-	-	-	-	-
BTOMCRIP	F	JFB/RAZ	04/21/97	08:55 PM	1	9.5	100	-	-	-	-	2	-	-	-	-	-	-	-
BTOMCRIP	F	JFB/RAZ	05/12/97	08:47 PM	0	19.0	69	-	-	2	-	1	-	-	-	-	-	-	-
BTOMCRIP	F	JFB	06/09/97	10:27 PM	0	10.5	86	-	-	-	-	-	-	-	-	-	-	-	-
BTOMMPND	F	JFB/DMG	05/15/97	09:20 PM	1	19.0	64	-	2	2	-	-	-	-	-	-	-	2	1
BTOMMPND	F	JFB/RAZ	06/17/97	09:15 PM	0	19.0	96	-	-	-	-	-	-	-	-	-	-	-	-
BTOMR532	F	JFB/RAZ	03/31/93	09:52 PM	2,4	10.0	-	-	-	-	-	3	-	-	-	-	-	2	-
BTOMR532	F	JFB/RAZ	05/11/93	07:55 PM	0	25.5	65	-	-	-	-	-	-	-	1	-	-	-	2
BTOMR532	F	JFB/RAZ	06/29/93	08:25 PM	2	24.0	83	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	03/18/96	08:31 PM	0	14.0	77	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	03/26/96	07:28 PM	2	13.5	55	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	04/03/96	07:35 PM	0	11.0	67	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	04/19/96	10:15 PM	0	19.0	69	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	05/10/96	09:33 PM	1	19.0	81	-	-	2	-	-	-	-	1	-	-	-	-
BTOMSKIT	F	JFB/RAZ	06/05/96	09:37 PM	0	18.0	84	-	-	3	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	06/21/96	11:08 PM	1	20.0	51	-	-	1	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB/DMG	07/01/96	11:10 PM	2	22.0	90	-	-	1	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	03/21/97	08:05 PM	0	9.0	73	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB/RAZ	04/21/97	08:44 PM	1	9.5	100	-	-	-	-	2	-	-	-	-	-	-	-
BTOMSKIT	F	JFB/RAZ	05/12/97	09:07 PM	0	19.5	65	-	-	2	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	06/09/97	10:18 PM	0	11.0	86	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	S	JFB	02/26/98	03:59 PM	0,4	17.0	30	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB/RAZ	03/26/98	09:43 PM	0	15.0	66	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	04/17/98	10:21 PM	2	18.0	95	-	-	2	-	1	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	05/28/98	09:10 PM	0	19.0	72	-	-	1	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	06/16/98	08:57 PM	2	25.0	87	-	-	2	-	-	-	-	-	-	-	-	-
BTOMSKIT	S	JFB	03/11/99	03:40 PM	0,4	7.0	45	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	03/18/99	08:00 PM	0,4	11.0	63	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	04/01/99	07:13 PM	2,5	16.0	89	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	05/10/99	08:50 PM	0	14.0	71	-	-	-	-	-	-	-	-	-	-	-	-
BTOMSKIT	F	JFB	06/13/99	09:26 PM	2	20.5	96	-	-	-	-	-	-	-	-	-	-	-	-

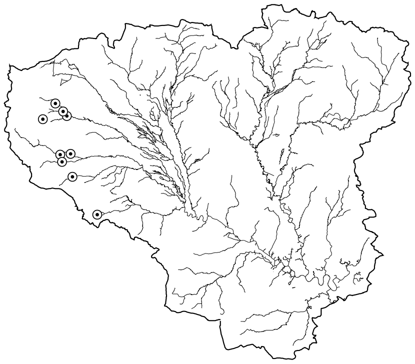
Appendix 6.7. Common and scientific names for 12 anuran species in the Mullica River Basin. Nomenclature follows Conant and Collins (1998).

Scientific Name	Common Name
Acris crepitans crepitans	northern cricket frog
Hyla andersonii	Pine Barrens treefrog
Hyla versicolor and H. chrysoscelis	gray treefrog
Bufo woodhousii fowleri	Fowler's toad
Pseudacris crucifer crucifer	northern spring peeper
Pseudacris triseriata kalmi	New Jersey chorus frog
Rana catesbeiana	bullfrog
Rana clamitans melanota	green frog
Rana palustris	pickerel frog
Rana utriculatia	southern leopard frog
Rana sylvatica	wood frog
Rana virgatipes	carpenter frog

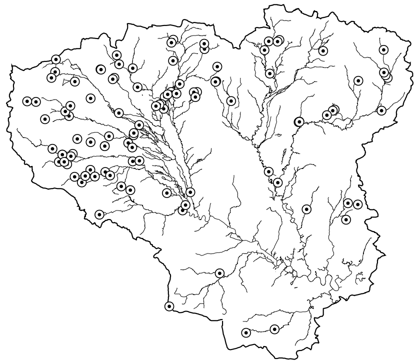
APPENDIX 6.8. ANURAN-DISTRIBUTION MAPS



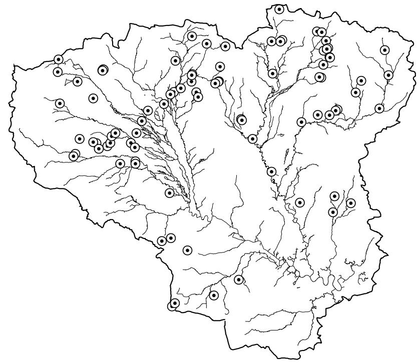
Location of 242 anuran (frog and toad) survey sites. Distribution maps on the following pages show where each anuran species was present.



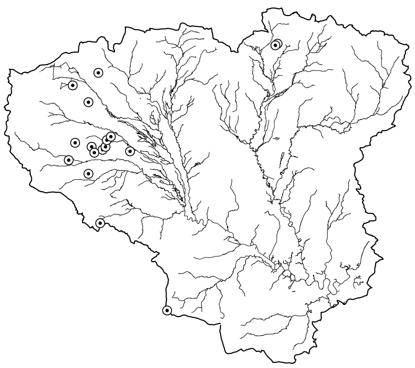
Acris crepitans crepitans
northern cricket frog



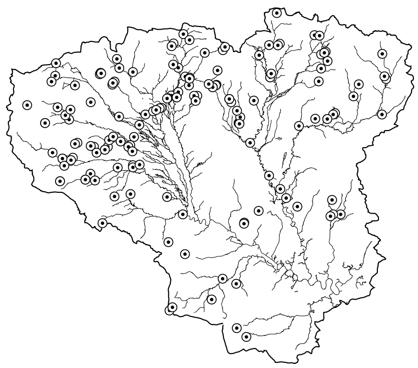
Bufo woodhousii fowleri
Fowler's toad



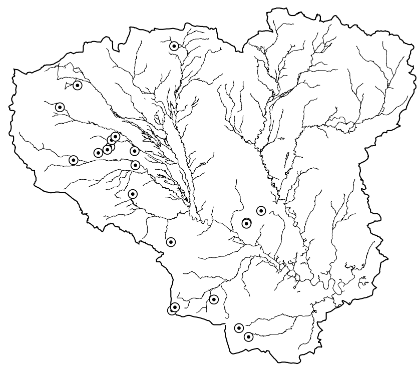
Hyla andersonii
Pine Barrens treefrog



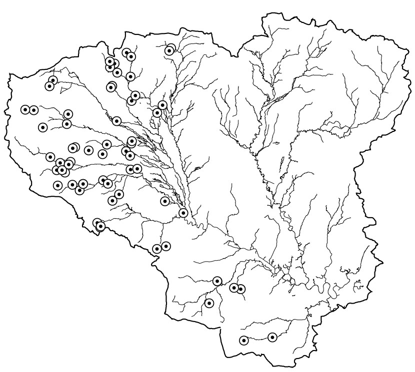
Hyla versicolor
gray treefrog



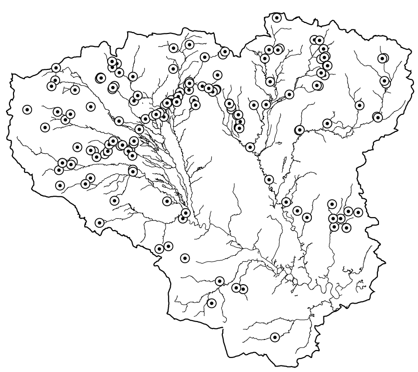
Pseudacris crucifer crucifer
northern spring peeper



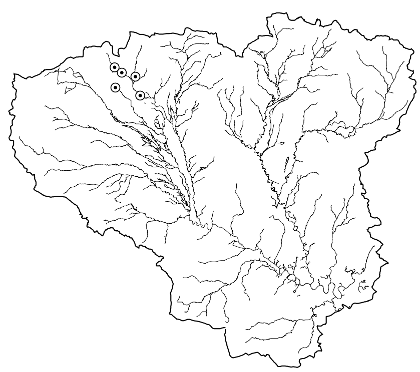
Pseudacris triseriata kalmi
New Jersey chorus frog



Rana catesbeiana
bullfrog

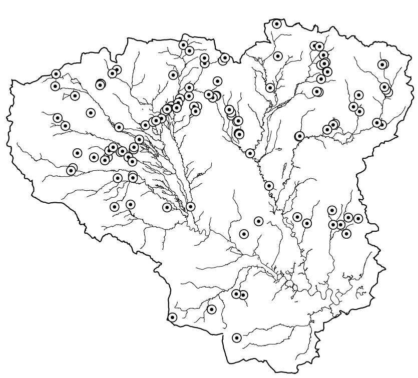


Rana clamitans melanota
green frog

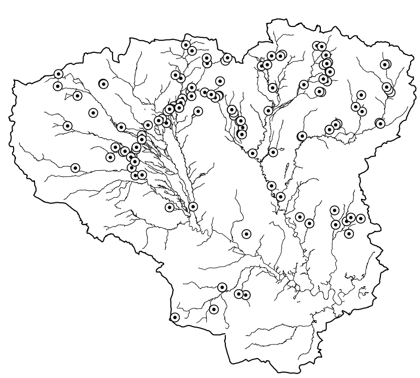


Rana palustris
pickerel frog

Rana sylvatica
wood frog



Rana utricularia
southern leopard frog



Rana virgatipes
carpenter frog