LONG-TERM PINELANDS MONITORING PROGRAM
TASK 1: STUDY AREA SELECTION

NEW JERSEY PINELANDS COMMISSION
APRIL 1992

LONG-TERM PINELANDS MONITORING PROGRAM

TASK 1: Study Area Selection

by Robert A. Zampella

New Jersey Pinelands Commission
P.O. Box 7
New Lisbon, New Jersey

April 1992

ACKNOWLEDGMENTS

I gratefully acknowledge Richard Lathrop and John Bogner, Rutgers University, for contributing their time and expertise to digitize Pinelands Commission mapped information and prepare the land use/forest type, public lands, and land management reports used to develop the basin profiles presented here. I thank Teuvlo Airola and B. Budd Chavoosian for arranging to have Rick and John assist on this project. I also thank Thomas Breden, NJDEPE Office of Natural Lands Management, for providing information on Natural Heritage Priority Sites in the Pinelands, and Martha Windisch, John Bunnell and David Schock for their assistance in preparing this report. Keith Robinson and Robert Schopp, USGS, provided comments on the draft report.

Table of Contents

INTRODUCTION

The primary goal of the Pinelands Comprehensive Management Plan (CMP) is to preserve, protect, and enhance the natural and cultural resources of the Pinelands. These resources include the quality and quantity of surface and ground water, characteristic landscape features, biological diversity, historic and archaeological sites, and compatible agricultural uses. Recognizing the need to assess whether this goal is being successfully accomplished, the Pinelands Commission has initiated plans to implement a long-term environmental monitoring program.

The objective of the proposed environmental monitoring program is to: (1) describe the pre-CMP and current status of selected natural and cultural resources; (2) evaluate long term trends in the condition of these resources; and (3) relate any observed trends in the status of these resources to land use and land management practices. The monitoring program will be designed so the results can be directly transferred to planning and regulatory policies and programs affecting the ecological and cultural integrity of the Pinelands.

In 1990 the Commission prepared an outline describing seven tasks (Table 1) to be completed when preparing a work plan for the proposed environmental monitoring program.

Table 1. Monitoring program work plan tasks.

1. Identify study areas which adequately represent pre-CMP and post-CMP conditions using stream basins as the basic study unit.
2. Design a program to monitor the loss of upland and wetland habitat and measure the degree of resulting landscape fragmentation.
3. Design a program to monitor changes in surface water and ground water quality.
4. Design a program to monitor changes in stream flows and ground water levels.
5. Design a program to monitor the status of wetland and aquatic communities.
6. Design a program to monitor the status of wildlife species and important wildlife habitats.
7. Design a program to monitor the status of special natural and cultural resources.

The first task, study area selection, has been completed by Pinelands Commission staff. The purpose of this report is to describe the areas recommended for study and the rationale for selecting them.

STUDY AREA SELECTION

Selection Criteria

Several study area selection strategies, ranging from the random selection of study sites (U.S. Environmental Protection Agency, 1990) and stream segments (U.S. Environmental Protection Agency, 1988) to the use of specific criteria to identify stream basins (U.S. Geological Survey, 1990; Hay and Campbell, 1990), were evaluated. The latter approach was selected, and the following criteria were used to identify the pool of recommended study basins: (1) provide regional coverage; (2) include basins with upstream drainage areas located totally within the Pinelands Area; (3) include basins greater than 10 square miles in size; (4) provide representative coverage of major pre-CMP land uses and forest types[1]; (5) provide representative coverage of pre-CMP conservation lands; (6) provide representative coverage of all land management areas excepting federal installations; (7) include previously and/or currently monitored sites, emphasizing those with long term environmental (e.g., hydrologic, botanical, wildlife) data bases; (8) include areas of endangered biological diversity; and (9) include areas supporting exceptional landscape features (e.g., Atlantic white cedar swamps, geological features).

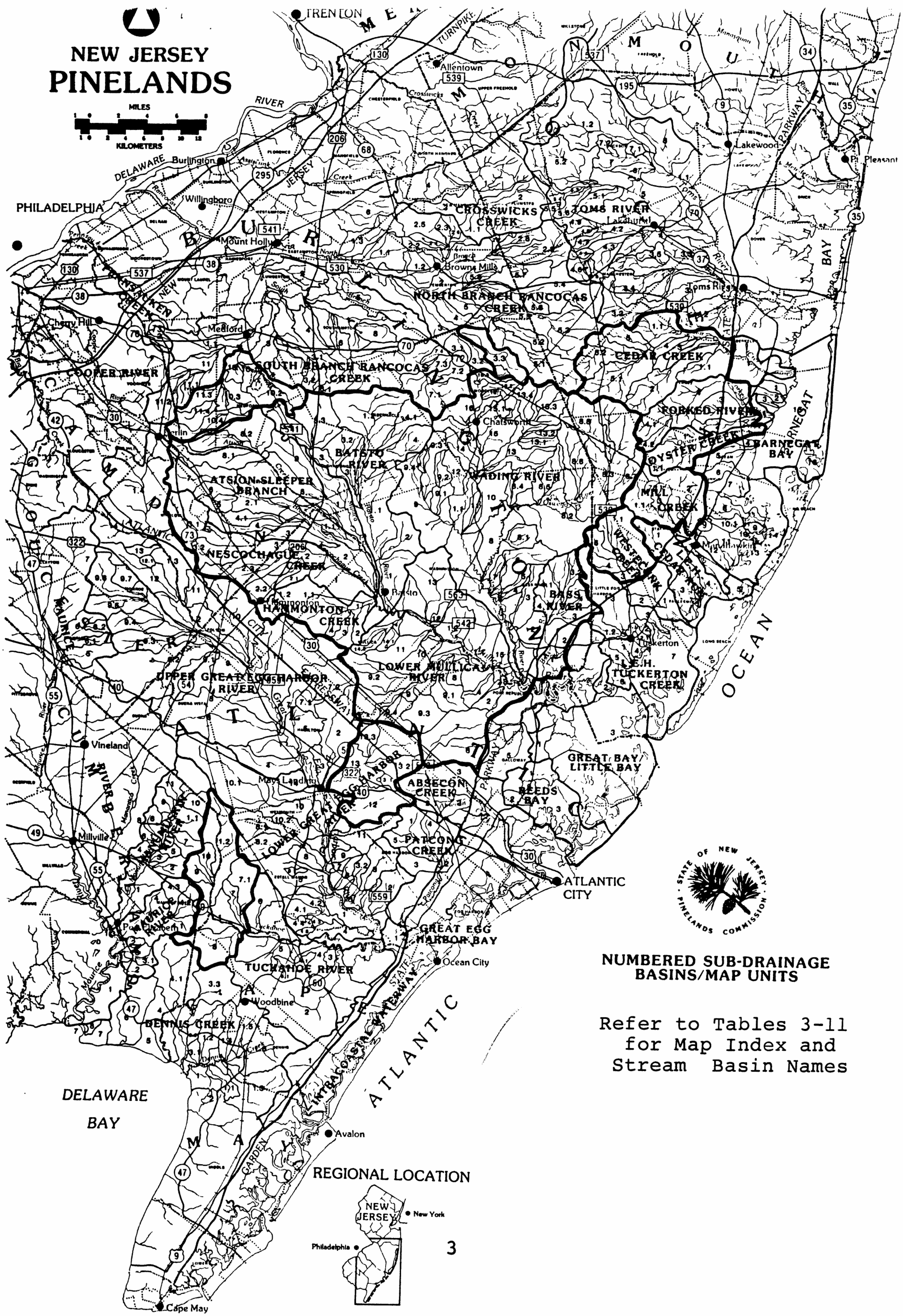
Sources of Information

Land use and forest type, public land, and Pinelands management area profiles were developed for the 394 drainage basin units described in Rogers, Golden and Halpern (1980, Figure 1) using data provided by the Rutgers Remote Sensing Lab. Basin unit boundaries were digitized from 1:125,000 scale Pinelands Commission watershed maps. Digitized data obtained by scanning 1:125,000 scale Pinelands Commission vegetation map layers and public lands maps were used for the land use/forest type and public land profiles, respectively. Data obtained by manually planimetering the Pinelands Commission bog/inland marsh map layer were added to the digitized data set. Twelve cover types (N.J. Pinelands Commission, 1980) were combined to create the six major land use and forest types used in the basin classifications: (1) upland forest (pine-oak and oak-pine forest); (2) freshwater wetlands (pitch pine lowland forest, hardwood swamps, cedar swamps, non-Pine Barrens vegetation, bogs[2], inland marsh, and water); (3) coastal marsh; (4) developed land; (5) agricultural

----

1. Land use refers to residential, commercial, industrial, and agricultural development. Forest type refers to all other cover classes.

2. Includes active cranberry bogs, shrub thickets and open bogs.



NUMBERED SUB-DRAINAGE BASINS/MAP UNITS

Refer to Tables 3-11 for Map Index and Stream Basin Names

FIGURE 1

land[3]; and (6) non-forest land.

Digitized Pinelands management area data were obtained from the New Jersey Department of Environmental Protection and Energy (DEPE) Bureau of Geographic and Statistical Analysis. Management areas (N.J.A.C. 7:50-5.12) include: (1) Preservation Area District; (2) Forest Area; (3) Agricultural Production Area; (4) Special Agricultural Production Area; (5) Rural Development Area; (6) Pinelands Village; (7) Pinelands Town; (8) Regional Growth Area; and (9) Military and Federal Installation Area. The data set also included Preservation Area District "infill area" acreages (N.J.A.C. 7:50-5.22(7)). Land use and forest type, public land, and Pinelands management area data are reported as percentages. The drainage area and percent cover values given for each stream basin are cumulative, that is, they include all upstream drainage areas. Percent cover values that are less than one percent (<1%) are reported as zero. Except when noted[4], all reported drainage areas are from Velnich (1982, 1984).

Information on past and present water resources monitoring programs were obtained from published U. S. Geological Survey (USGS) reports, U.S. Environmental Protection Agency (EPA) STORET files, and Pinelands Commission and DEPE reports. The annotated bibliographies by Buchholz and Good (1982) and Gemmell et al. (1989) were the primary sources of information on the location of sites where other environmental studies with a strong inventory or monitoring component have been conducted.

The locations of important areas for endangered biology diversity were provided by the DEPE Office of Natural Lands Management. These areas represent some of the most important sites in the Pinelands for endangered and threatened plants, animals and natural communities and have been identified by the Office of Natural Lands Management as top priorities for the preservation of biological diversity.

Recommended Study Areas

Several study areas were identified using the nine selection criteria (Table 2, Figure 1). These include: (1) the entire Mullica River basin; (2) five Barnegat Bay and Little Egg Harbor tributary basins; (3) three Rural Development Area/Regional Growth Area basins; (4) a portion of the Tuckahoe River basin;

----

3. Includes blueberry fields, pasture, croplands, and orchards.

4. Some drainage boundaries did not coincide with those used by Velnich (1982, 1984). These exceptions are noted with an asterisk in the basin profile tables.

and (5) McDonalds Branch basin (North Branch Rancocas Creek). Drainage basin characteristics and the rationale for selecting each study area are presented in the following sections.

Table 2. Recommended study areas.

Mullica River Basin
Atsion River (Upper Mullica River)
Sleeper Branch
Nescochague Creek
Hammonton Creek
Batsto River
Wading River (West Branch and Oswego River)
Tributaries to the Lower Mullica River
Bass River
Barnegat Bay and Little Egg Harbor Tributaries
Cedar Creek
Forked River
Oyster Creek
Mill Creek
Westecunk Creek
Rural Development/Regional Growth Basins
Babcock Creek (Great Egg Harbor River)
Gravelly Run (Great Egg Harbor River)
Haynes Creek (South Branch Rancocas Creek)
Tuckahoe River Southern Forest Area
Tuckahoe River above Head of River
McNeals Branch
McDonalds Branch (North Branch Rancocas Creek)

LANDSCAPE AND MANAGEMENT AREA PROFILES

Mullica River Basin

Nearly all of the 569 square mile centrally located Mullica River Basin lies within the Pinelands Area (Figure 1). It drains portions of Atlantic, Burlington, Camden, and Ocean counties. The basin is composed mostly of large drainage systems (greater than 20 square miles) including the Bass River, Oswego River (East Branch of the Wading River), West Branch of the Wading River, Batsto River, Mullica River upstream from Sleeper Branch (referred to here as the Atsion River), Sleeper Branch, Nescochague Creek, and Hammonton Creek. With the exception of Landing Creek (30.2 square miles), the lower portion of the Mullica River Basin is characterized by smaller tributary basins.

Less than five percent of the Mullica River Basin was developed in 1980. Most development and non-berry agriculture (orchards, row and field crops) within the basin were found in the headwater areas of the Atsion River, Sleeper Branch, Nescochague Creek, Hammonton Creek, and Landing Creek basins. These areas generally coincide with lands designated as Regional Growth Area, Pinelands Town, or Rural Development Area. Non-berry agricultural lands were also a dominant landscape feature in several Batsto River headwater basins. Less than one percent of the 188 square mile Wading River Basin and the headwaters of the Bass River were developed in 1980. Most of the cranberry acreage found within the Mullica River Basin was located within the West Branch of the Wading River and Oswego River basins.

Atsion River (Upper Mullica River)[5]

The Atsion River (Upper Mullica River) drains portions of Atlantic, Burlington and Camden Counties. In 1980, most of the basin was forest land (Table 3). A majority of the basin lies within Wharton State Forest and is designated as Preservation Area District. Pre-CMP development was concentrated in the headwater areas of the Atsion River above its confluence with the Alquatka Branch. Regional Growth Area and Rural Development Area dominate this portion of the drainage basin. The principal management areas found within the Alquatka Branch basin (Preservation Area District, Forest Area, Special Agricultural Production Area) reflect the pre-CMP landscape which was comprised primarily of wetland forest and cranberry bogs. A significant portion of the Wesickaman Creek basin, where a majority of the private lands were non-berry agricultural lands, is designated Agricultural Production Area.

----

5. Above its confluence with the Sleeper Branch.

Table 3. Atsion River (Mullica River) and Sleeper Branch basins.

Map Index	Stream Basin Name	Basin Area (sq mi)	Percent Land Cover (Pre-CMP) Up-land	Wet-land	Coast Marsh	Devel-oped	Agr Land	Non-Forest	Percent Pub-lic	Management Area Percent Distribution Pres Area	For Area	Agr Prod	Rural Dev	Reg Growth	Town	Vil-lage	Spec Agr	In-fil
Atsion River (Mullica River) basin																		
ATS 8.2	Alquatka Branch at mouth	9.1	23	67	0	0	7	3	38	43	32	4	3	2	0	0	17	0
ATS 8.1	Mullica River at Jackson Rd.	16.8	24	49	0	10	15	2	27	32	21	7	15	15	0	0	10	0
ATS 8	Mullica River at outlet Atsion Lake	26.7	42	41	0	7	9	1	53	56	13	5	11	10	0	0	6	0
ATS 9	Wesickaman Creek at mouth	6.4	41	37	0	0	22	0	64	66	0	27	2	0	0	2	0	3
ATS 1.1	Mullica River trib. at mouth	4.2	13	86	0	1	0	0	90	100	0	0	0	0	0	0	0	0
ATS 1	Mullica River above the Batsto River	50.9 *	37	50	0	4	9	1	62	67	8	7	6	5	0	3	4	0
Sleeper Branch basin																		
ATS 7	Hays Mill Creek at mouth	7.4	31	20	0	30	18	2	12	10	0	0	32	56	0	3	0	0
ATS 6	Cooper Branch at mouth	2.0	31	17	0	44	9	0	26	26	0	0	4	70	0	0	0	0
ATS 5	Wildcat Branch at mouth	2.3	23	9	0	27	40	0	18	14	6	5	14	45	0	15	0	0
ATS 2.1	Sleeper Branch above JCRR bridge	16.1 *	33	26	0	23	17	1	35	34	1	3	19	40	0	3	0	0
ATS 4.1	Price Branch at mouth	2.9	32	17	0	2	48	0	50	52	0	36	2	0	0	9	0	0
ATS 4	Clark Branch at mouth	7.1	28	32	0	2	38	0	52	56	0	31	5	2	0	6	0	0
ATS 3	Gun Branch at mouth	4.4	20	65	0	0	15	0	77	97	0	3	0	0	0	0	0	0
ATS 2	Sleeper Branch at Batsto	36.2	24	49	0	10	17	0	58	61	0	7	10	19	0	3	0	0

Table 4. Nescochague Creek and Hammonton Creek basins.

Map Index	Stream Basin Name	Basin Area (sq mi)	Percent Land Cover (Pre-CMP) Up-land	Wet-land	Coast Marsh	Devel-oped	Agr Land	Non-Forest	Percent Pub-lic	Management Area Percent Distribution Pres Area	For Area	Agr Prod	Rural Dev	Reg Growth	Town	Vil-lage	Spec Agr	In-fil
Nescochague Creek basin																		
NES 3.2	Blue Anchor Brook at mouth	5.7	27	3	0	7	60	3	18	1	0	36	40	1	0	22	0	0
NES 3.1	Pump Branch at mouth	11.2	30	11	0	21	37	1	6	10	0	19	8	63	0	0	0	0
NES 3	Albertson Brook at mouth	20.2	31	11	0	14	43	1	19	18	0	25	16	35	0	6	0	0
NES 2.3	Great Swamp Branch near Hammonton	8.1	8	10	0	0	77	5	3	3	0	71	15	0	5	6	0	0
NES 2.2	Cedar Brook at mouth	4.0 *	2	4	0	51	43	0	5	6	0	16	0	0	78	0	0	0
NES 2.1	Drivers Branch at mouth	1.5	15	5	0	1	78	0	12	21	0	68	0	0	11	0	0	0
NES 2	Great Swamp Branch at mouth	16.7	9	16	0	13	60	2	16	18	0	48	7	0	23	3	0	0
NES 1	Nescochague Creek at mouth	43.8	22	17	0	11	49	1	16	18	4	37	10	16	9	6	0	0
Hammonton Creek basin																		
HAM 4	Petties Branch at mouth	1.4	57	33	0	4	6	0	0	0	100	0	0	0	0	0	0	0
HAM 3	Nortons Branch near Sweetwater	2.1	66	27	0	3	4	0	0	0	87	0	0	0	0	13	0	0
HAM 2	Brocakaways Branch at mouth	1.6	56	41	0	3	0	0	0	0	99	0	0	0	0	1	0	0
HAM 1.2	Hammonton Creek at Rt 30, Hammonton	2.5	14	10	0	51	18	6	6	0	0	0	0	0	100	0	0	0
HAM 1.1	Hammonton Creek at Nesco	15.0	35	21	0	11	31	2	1	0	38	32	0	0	26	3	0	0
HAM 1	Hammonton Creek at mouth	20.6	38	26	0	9	26	1	1	1	48	27	0	0	19	5	0	0

Sleeper Branch

The Sleeper Branch system, which originates within developed areas of lower Camden County but also drains portions of Atlantic County, lies mostly within Wharton State Forest and the Preservation Area District (Table 3). Pre-CMP development was concentrated within portions of the Hays Mill, Wildcat Branch and Cooper Branch basins. These areas have been designated primarily as Regional Growth Area and Rural Development Area. Non-berry agriculture, which was an important land use in all the headwater basins, was most extensive in the Wildcat Branch and Clark Branch basins. Agricultural Production is the dominant management area designation within the Clark Branch and Prices Branch (a tributary of Clark Branch) basins. Except for minor private inholdings, Gun Branch and the main stem of Sleeper Branch lie within Wharton State Forest and are undeveloped. Berry agriculture was the dominant pre-CMP land use in Gun Branch.

The Waterford Township sewage treatment plant and spray field is located in the lower reaches of Hays Mill Branch. A portion of the spray field is also within the Cooper Branch basin. The average wastewater flow was 0.36 mgd in 1980.

Nescochague Creek

The Nescochague Creek basin lies within the boundaries of Camden and Atlantic Counties. Half of the 43.8 square mile basin was farmland in 1980 (Table 4). The main stem of the Albertson Brook, a major tributary of Nescochague Creek, lay mostly within Wharton State Forest while nearly all of its two headwater basins (Pump Branch and Blue Anchor Brook) were privately owned. Non-berry agriculture was the dominant land use within the Albertson Brook basin. Developed lands were concentrated within the Pump Branch basin, and most of this drainage area is classified as Regional Growth Area. Blue Anchor Brook basin is primarily Agricultural Production Area and Rural Development Area. About one-quarter of the basin is designated Village. The Ancora Psychiatric Hospital wastewater spray field is located within the Blue Anchor Brook basin. The average wastewater flow was 0.23 mgd in 1980.

The Great Swamp basin was one of the most intensely farmed areas in the Pinelands. Nearly two thirds of this watershed was covered by row crops, field crops and orchards. Land use in the Cedar Brook tributary basin was divided evenly between urban land and agriculture. Agricultural Production Area is the dominant management area in the Great Swamp basin. Most of the remaining portion of the basin is classified as Pinelands Town (Hammonton) and Preservation Area District (Wharton State Forest).

Hammonton Creek

The Hammonton Creek basin is located totally within Atlantic County. In 1980, a majority of the 20.6 square mile basin was forest land (Table 4), and nearly all of the land within the basin was privately owned. Agricultural land represented the dominant pre-CMP land use. Most development was concentrated in the urban area upstream from Route 30 in Hammonton. The drainage system's three small tributary basins (Petties Branch, Nortons Branch and Brockaways Branch) were relatively undisturbed. Most of the Hammonton Creek basin is classified as Forest Area. The other management areas are, in order of relative importance: (1) Agricultural Production Area; (2) Pinelands Town; and (3) Pinelands Village. The Hammonton sewage treatment plant discharges directly to Hammonton Creek. The average wastewater flow was 1.2 mgd in 1980.

Batsto River

The 71.1 square mile Batsto River basin is located within Burlington County. Although a majority of the basin is within Wharton State Forest, its headwaters originate outside the state reserve. The three major headwater basins, Springer Brook, Batsto River above Skit Branch, and Skit Branch, displayed three distinct pre-CMP landscape profiles (Table 5). One-third of the Springer Brook basin was agricultural land comprised mainly of row and field crops. Agricultural and developed lands were most extensive within the Indian Mills Brook and Muskingum Brook tributary systems. These two basins are assigned a mix of land management areas including Agricultural Production Area, Regional Growth Area, and Rural Development Area.

In 1980, the Batsto River basin above its confluence with Skit Branch supported both berry (blueberry and cranberry) and non-berry agriculture. These land uses are reflected by the Agricultural Production Area and Special Agricultural Production Area designations assigned to portions of this headwater region. The Skit Branch basin was forest land. With the exception of a small area which is classified as Special Agricultural Production Area, this basin is designated Preservation Area District.

Lower Mullica River Tributaries

Landing Creek and several small streams which discharge directly to the lower Mullica River between Batsto and the Garden State Parkway have been included in the Lower Mullica River study area (Table 6). These basins are located within Atlantic and Burlington counties.

In 1980, the 30.2 square mile Landing Creek watershed included a mix of undeveloped, agricultural and urban basins. This diversity is reflected in the management area classifications found

Table 5. Batsto River basin.

Map Index	Stream Basin Name	Basin Area (sq mi)	Percent Land Cover (Pre-CMP) Upland	Wetland	Coast Marsh	Developed	Agr Land	Non-Forest	Percent Public	Pres Area	Management Area Percent Distribution For Area	Agr Prod	Rural Dev	Reg Growth	Town	Village	Spec Agr	Infil
BAT 1.2	Batsto River above Skit Branch	14.5 *	23	59	0	0	18	0	25	55	0	16	2	0	0	0	24	3
BAT 4.1	Roberts Branch at mouth	4.4	45	54	0	0	1	0	73	86	0	0	0	0	0	0	14	0
BAT 4	Skit Branch at mouth	10.9	49	50	0	0	1	0	87	94	0	0	0	0	0	0	6	0
BAT 3.4	Indian Mills Brook at mouth	4.4	33	14	0	7	43	3	1	2	1	30	36	28	0	4	0	0
BAT 3.3	Muskingum Brook at mouth	7.7	27	16	0	6	51	0	3	0	0	55	21	23	0	1	0	0
BAT 3.2	Bard Branch at mouth	3.7	17	69	0	2	12	0	42	79	0	6	4	0	0	0	0	11
BAT 3.1	Deep Run at mouth	2.5	4	92	0	4	0	0	101	100	0	0	0	0	0	0	0	0
BAT 3	Springers Brook at mouth	21.5	22	42	0	4	31	1	26	37	0	29	16	14	0	1	1	2
BAT 2	Penn Swamp Branch at mouth	4.98	62	38	0	0	0	0	103	100	0	0	0	0	0	0	0	0
BAT 1.1	Batsto River above Penn Swamp Branch	59.6 *	38	44	0	2	15	0	53	65	0	14	6	5	0	1	7	1
BAT 1	Batsto River at mouth	71.1	43	42	0	1	13	0	61	71	0	12	5	4	0	0	6	1

Table 6. Lower Mullica River basins.

Map Index	Stream Basin Name	Basin Area (sq mi)	Percent Land Cover (Pre-CMP) Up-land	Wet-land	Coast Marsh	Devel-oped	Agr Land	Non-Forest	Percent Pub-lic	Management Area Percent Distribution Pres Area	For Area	Agr Prod	Rural Dev	Reg Growth	Town	Vil-lage	Spec Agr	In-fil
Lower Mullica River tributaries																		
LMU 14	Lucas Branch at mouth	4.0	63	35	0	3	0	0	0	0	94	0	0	0	0	6	0	0
LMU 14.2	Second Branch at mouth	1.2	74	22	0	5	0	0	0	0	98	0	0	0	0	2	0	0
LMU 14.1	First Branch at mouth	1.2	59	41	0	0	0	0	0	0	100	0	0	0	0	0	0	0
LMU 13	Bull Creek at mouth	9.7	66	33	0	0	0	1	89	95	0	0	0	0	0	1	5	0
LMU 12	Little Bull Creek at mouth	1.1	38	51	0	12	0	0	50	73	0	0	0	0	0	27	0	0
LMU 11	Negro Creek at mouth	4.8	33	58	2	2	5	0	1	14	80	0	0	0	0	6	0	0
LMU 10	Pine Creek at mouth	4.0	32	64	0	0	3	1	0	23	70	0	0	0	0	8	0	0
Landing Creek basin																		
LMU 9.4	Union Creek at mouth	3.7	13	18	0	57	8	5	0	0	0	10	0	0	87	3	0	0
LMU 9.3	Elliots Creek at mouth	4.8	12	32	0	4	43	8	0	0	3	77	6	0	10	4	0	0
LMU 9.2	Indian Cabin Creek at mouth	7.9	64	16	0	17	3	0	0	0	58	3	29	0	6	3	0	0
LMU 9.1	Rubins Run at mouth	4.98	51	29	0	3	16	2	0	4	35	17	45	0	0	0	0	0
LMU 9.0	Landing Creek at mouth	30.2	35	29	2	19	12	3	0	4	36	18	20	0	20	2	0	0
Lower Mullica River tributaries																		
LMU 8	Teal Creek at mouth	1.7	33	61	4	0	2	0	0	28	72	0	0	0	0	0	0	0
LMU 7	Clarks Mill Stream at GS Parkway	8.1 *	42	25	0	5	27	1	0	0	0	22	65	8	0	5	0	0
LMU 6	Morses Mill Stream at GS Parkway	6.1 *	38	26	0	10	20	5	36	0	0	0	68	28	0	4	0	0
LMU 4	Tarkiln Branch at mouth	2.0	49	37	9	0	2	2	0	49	33	0	18	0	0	0	0	0
LMU 3	Fence Creek	0.4	14	40	45	0	1	0	0	96	4	0	0	0	0	0	0	0
LMU 2	Big Creek at mouth	1.7	53	34	9	0	4	0	0	55	27	0	19	0	0	0	0	0
LMU 15	Turtle Creek	2.0	0	30	70	0	0	0	48	100	0	0	0	0	0	0	0	0
Lower Mullica River																		
LMU 1.1	Lower Mullica river	11.9	10	62	24	3	1	0	33	87	7	0	0	0	0	3	3	0

Table 7. Bass River basin.

Map Index	Stream Basin Name	Basin Area (sq mi)	Percent Land Cover (Pre-CMP) Up-land	Wet-land	Coast Marsh	Devel-oped	Agr Land	Non-Forest	Percent Pub-lic	Management Area Percent Distribution Pres Area	For Area	Agr Prod	Rural Dev	Reg Growth	Town	Vil-lage	Spec Agr	In-fil
BAS 3.2	Dans Bridge Branch at mouth	2.4	79	21	0	0	0	0	41	100	0	0	0	0	0	0	0	0
BAS 3.1	Tommys Branch at mouth	1.3	85	15	0	0	0	0	100	100	0	0	0	0	0	0	0	0
BAS 3	East Branch Bass River at mouth	8.2	80	19	0	1	0	0	71	100	0	0	0	0	0	0	0	0
BAS 4.1	Bartletts Branch at mouth	2.6	77	23	0	0	0	0	4	100	0	0	0	0	0	0	0	0
BAS 4	West Branch of Bass River at mouth	6.7	75	25	0	0	0	0	16	99	0	0	1	0	0	0	0	0
BAS 2	Jobs Creek at mouth	2.7	27	49	19	2	0	3	15	21	69	0	0	0	0	10	0	0
BAS 1	Bass River at mouth	23.0	57	21	19	3	0	0	34	69	23	0	0	0	0	8	0	0

within the drainage area. The most important management areas in the upper portion of Landing Creek are Forest Area, Pinelands Town, and Rural Development Area. The Union Creek basin is classified primarily as a Pinelands Town (Egg Harbor City), while most of Elliots Creek is designated Agricultural Production Area. Forest Area is the dominant management area in the Indian Cabin Creek basin, and Rural Development is the second most important designation. These are also the two most important management areas within the Rubins Run basin. There were no state lands within the drainage area in 1980. Until recently the Egg Harbor City sewage treatment plant discharged wastewater directly to Union Branch, a tributary of Landing Creek. The average wastewater flow was 0.52 mgd in 1980.

Most of the smaller basins in the Lower Mullica River study area were undeveloped in 1980, and are classified mainly as Preservation Area District and/or Forest Area. The major exceptions are the Clarks Mill Stream and Morses Mill Stream basins where developed and agricultural lands were most extensive. A majority of the land in these two basins is classified as Rural Development with a smaller percentage designated as Regional Growth Area.

Wading River

In 1980, the 188 square mile Wading River watershed was the largest undeveloped drainage area in the Pinelands (Table 8). The combined acreage of developed and agricultural lands represented less than two percent of the basin (areas mapped as agriculture within this watershed consisted mostly of blueberry fields). One third of the watershed was publicly owned recreational land. The watershed includes two major drainage basins, the Oswego River (East Branch of the Wading River) and the West Branch of the Wading River.

Oswego River (East Branch of the Wading River). The Oswego River drains portions of Ocean County and Burlington County. Nearly all of the 72.6 square mile watershed was forest land in 1980. Developed lands were generally limited to the portion of Warren Grove located within the Dry Branch drainage area. Active cranberry bogs were located along the Oswego River at Sim Place and below Lake Oswego, and at the mouth of the Plains Branch. Nonforest areas, comprised primarily of sand and gravel mines, covered two percent of the Oswego River basin. Three-quarters of the basin is classified as Preservation Area District. Most of the remaining areas is designated as Forest Area and Special Agricultural Production Area. Pinelands Village comprises only one percent of the basin area.

West Branch of the Wading River. The 87 square mile West Branch of the Wading River is located within Burlington County. Like the Oswego River basin, nearly all of the drainage area was

Table 8. Wading River basin.

Map Index	Stream Basin Name	Basin Area (sq mi)	Up-land	Wet-land	Coast Marsh	Devel-oped	Agr Land	Non-Forest	Percent Pub-lic	Pres Area	For Area	Agr Prod	Rural Dev	Reg Growth	Town	Vil-lage	Spec Agr	In-fil
			Percent Land Cover (Pre-CMP)							Management Area Percent Distribution								
West Branch Wading River basin																		
WAD 16.3	Tibbs Branch at mouth	1.3	63	37	0	0	0	0	79	88	0	0	0	0	0	0	12	0
WAD 16.2	Gates Branch at mouth	1.6	56	44	0	0	0	1	62	93	0	0	0	0	0	0	7	0
WAD 16.1	Reeds Branch at mouth	0.8	40	60	0	0	0	0	19	90	0	0	0	0	0	0	10	0
WAD 16	W. Br. Wading R. at Chatsworth	9.2	51	43	0	1	4	1	25	57	0	0	0	0	0	4	36	3
WAD 15.1	Goodwater Run at mouth	1.3 *	91	8	0	0	0	2	0	44	0	0	0	0	0	0	56	0
WAD 15	Risley Branch at mouth	8.2	35	56	0	1	8	0	0	12	0	0	0	0	0	8	76	3
WAD 14	Pole Branch at mouth	3.2	51	49	0	0	0	0	0	0	0	0	0	0	0	0	100	0
WAD 13.4	Biddle Branch at mouth	2.7	79	20	0	0	0	2	0	65	0	0	0	0	0	0	35	0
WAD 13.3	Long Branch at mouth	5.6	73	24	0	0	1	2	2	85	0	0	0	0	0	0	15	0
WAD 13.2	Sykes Branch at mouth	1.6	69	22	0	0	0	9	11	100	0	0	0	0	0	0	0	0
WAD 13.1	Shreve Branch at mouth	1.7	85	14	0	0	0	0	0	100	0	0	0	0	0	0	0	0
WAD 13	Shoal Branch at mouth	19.1	70	28	0	0	1	2	1	69	0	0	0	0	0	0	31	0
WAD 1.2	W. Br. Wading R. near Chatsworth	44.8	56	39	0	1	3	1	6	44	0	0	0	0	0	3	52	1
WAD 12	Mile Run at mouth	2.7	87	8	0	0	5	0	27	29	0	0	0	0	0	0	71	0
WAD 9.4	Ore Spung Branch at mouth	0.6	47	53	0	0	0	0	104	100	0	0	0	0	0	0	0	0
WAD 9.3	Featherbed Branch at mouth	4.6	44	56	0	0	0	0	66	83	0	0	0	0	0	0	17	0
WAD 9.2	Shane Branch at mouth	1.9	41	59	0	0	0	0	12	90	0	0	0	0	0	0	10	0
WAD 9.1	Bulls Branch at mouth	3.7	36	63	0	1	0	0	24	95	0	0	0	0	0	0	5	0
WAD 9	Tulpehocken Creek at mouth	21.9	48	52	0	0	0	0	80	96	0	0	0	0	0	0	4	0
WAD 11	Hospitality Brook at mouth	1.7 *	26	71	0	2	0	0	35	36	0	0	0	0	0	0	64	0
WAD 10	Little Hauken Run at mouth	8.3 *	37	61	0	1	0	1	14	17	0	0	0	0	0	0	83	0
Oswego River (East Branch Wading River) basin																		
WAD 8.8	Yellow Dam Branch at mouth	7.4	83	15	0	0	0	2	48	100	0	0	0	0	0	0	0	0
WAD 8.7	Dry Branch at mouth	3.6	93	2	0	4	0	2	0	0	93	0	0	0	0	6	0	0
WAD 8.6	Plains Branch at mouth	6.9	66	28	0	0	0	7	11	93	0	0	0	0	0	0	7	0
WAD 8.3	Oswego River at Sim Place reservoir	38.0	76	20	0	1	0	3	24	68	29	0	0	0	0	1	1	0
WAD 8.5	Papoose Branch at mouth	5.2	69	31	0	0	0	0	40	69	0	0	0	0	0	0	31	0
WAD 8.4	Breeches Branch at mouth	3.2	71	29	0	0	0	0	71	62	0	0	0	0	0	0	38	0
WAD 8.2	Oswego River at Oswego Lake	61.4	73	24	0	0	0	3	41	75	18	0	0	0	0	1	6	0
WAD 8.1	Buck Run at mouth	3.0	81	19	0	0	0	0	79	100	0	0	0	0	0	0	0	0
WAD 8	Osewgo River at mouth	72.6	70	27	0	0	0	2	43	77	15	0	0	0	0	1	7	0
WAD 1.1	W. Br. Wading R. at mouth	87.0	53	44	0	0	2	1	34	58	0	0	0	0	0	1	40	1
Wading River tributaries																		
WAD 7	Beaver Run at mouth	1.3	38	62	0	0	0	0	13	99	0	0	0	0	0	0	1	0
WAD 6	Beaver Branch at mouth	5.9	63	37	0	0	0	0	18	100	0	0	0	0	0	0	0	0
WAD 5	Arnold Branch at mouth	1.2	80	20	0	0	0	0	15	100	0	0	0	0	0	0	0	0
WAD 4	Tub Mill Branch at mouth	0.7	61	39	0	0	0	0	26	100	0	0	0	0	0	0	0	0
WAD 3	Ives Branch at mouth	4.2	48	49	1	1	0	1	11	100	0	0	0	0	0	0	0	0
WAD 2	Merrygold Branch at mouth	2.9	26	66	0	6	0	2	10	71	0	0	13	0	0	15	0	0
WAD 1	Wading River at mouth	188.0	58	38	2	1	1	1	36	70	6	0	0	0	0	2	22	0

forest land in 1980, and Preservation Area District is the most important management area. The watershed was a major center for the Pinelands cranberry and blueberry industries. This is reflected in the high percentage of lands classified as Special Agricultural Production Area.

Wading River. In 1980, the main branch of the Wading River located below the confluence with its major tributaries was an undeveloped area dominated by wetlands. One-quarter of this land area consisted of tidal wetlands. Preservation Area District is the major management area in this portion of the watershed. Pinelands Village and Special Agricultural Production Area are also represented.

Bass River

Most of the 23 square mile Bass River basin is located within the Pinelands Area. The basin was primarily forest land (Table 7), and most development was concentrated in New Gretna. The area drained by the system's two major tributaries, the East Branch of the Bass River and the West Branch of the Bass River, is designated Preservation Area District. In 1980, the lower portions of both tributary basins were within Bass River State Forest.

Tributaries to Barnegat Bay and Little Egg Harbor

Five Pinelands stream systems which drain to Barnegat Bay and Little Egg Harbor are recommended for long-term monitoring. These are Cedar Creek, Forked River, Oyster Creek, Mill Creek, and Westecunk Creek. All five basins are located entirely within Ocean County in the northeastern portion of the Pinelands, and all tributaries originate within the Pinelands Area (west of the Garden State Parkway). Lands east of the Parkway are located within the Pinelands National Reserve. Land cover values for some basins include both Pinelands Area and PNR but management area profiles are given only for the Pinelands Area portions of each watershed (Table 9).

Cedar Creek

In 1980, nearly all of the 47.2 square mile Cedar Creek basin within the Pinelands Area was forest land, and the landscape profiles of the main stem and major tributary basins were similar. Resource extraction, the major land use in the basin, covered only four percent of the area. A small amount of residential development was concentrated in the village of Bamber Lake. The entire Pinelands Area portion of the Cedar Creek basin was designated as Preservation Area by the New Jersey legislature. One quarter of this area was state land in 1980.

Table 9. Barnegat Bay and Little Egg Harbor tributary basins.

Map Index	Stream Basin Name	Basin Area (sq mi)	Percent Land Cover (Pre-CMP) Up-land	Wet-land	Coast Marsh	Devel-oped	Agr Land	Non-Forest	Percent Pub-lic	Management Area Percent Distribution Pres Area	For Area	Agr Prod	Rural Dev	Reg Growth	Town	Vil-lage	Spec Agr	In-fil
Cedar Creek basin																		
CED 5.2	Webbs Mill Branch at mouth	7.2	82	16	0	0	1	1	57	98	2	0	0	0	0	0	0	0
CED 5.1	Chamberlain Branch at Bamber Lake	16.7	73	21	0	0	2	3	48	99	1	0	0	0	0	0	0	0
CED 5	Cedar Creek outlet Bamber Lake	20.0	75	20	0	0	2	3	40	99	1	0	0	0	0	0	0	0
CED 4	Daniels Branch at mouth	1.6	44	34	0	4	1	16	0	100	0	0	0	0	0	0	0	0
CED 3	Newbolds Branch at mouth	1.8	60	17	0	1	0	23	5	100	0	0	0	0	0	0	0	0
CED 2	Factory Branch at mouth	9.2	74	25	0	0	0	0	8	94	6	0	0	0	0	0	0	0
CED 1.1	Cedar Creek at Double Trouble	47.2 *	70	23	0	1	1	4	26	97	3	0	0	0	0	0	0	0
CED 1	Cedar Creek at mouth	55.3	65	25	0	5	1	4	22	--	--	--	--	--	--	--	--	--
Forked River basin																		
FOR 4.2	Long Branch	1.8	77	21	0	0	0	3	0	0	93	0	7	0	0	0	0	0
FOR 4.1	Cave Cabin Branch	3.3	73	27	0	0	0	0	0	0	100	0	0	0	0	0	0	0
FOR 4	North Branch Forked River	15.9	69	16	0	14	0	1	0	0	98	0	2	0	0	0	0	0
FOR 3	Middle Branch Forked River	5.1	55	27	0	14	0	4	0	0	100	0	0	0	0	0	0	0
FOR 2	South Branch Forked River	3.3	24	18	0	21	0	36	0	0	90	0	10	0	0	0	0	0
Mill Creek basin																		
MIL 3	Eightmile Branch at mouth	2.0	65	7	0	27	0	1	0	0	43	0	4	53	0	0	0	0
MIL 1.1	Mill Creek, Rt 72	10.4	66	8	0	22	0	4	0	0	69	0	1	30	0	0	0	0
MIL 2	Fourmile Branch at mouth	8.3	59	7	0	27	2	6	0	0	1	0	1	98	0	0	0	0
MIL 1	Mill Creek at mouth	22.9	54	10	1	30	1	4	2	0	45	0	1	53	0	0	0	0
Oyster Creek basin																		
OYS 1.1	Oyster Creek at Wells Mill	4.2	67	27	0	2	0	4	0	0	80	0	7	0	0	12	0	0
OYS 1	Oyster Creek at mouth	12.9	62	25	2	5	0	6	0	0	31	0	57	8	0	4	0	0
Westecunck Branch basin																		
WES 5	Governors Branch at mouth	2.4	82	17	0	0	0	1	54	99	1	0	0	0	0	0	0	0
WES 4	Log Swamp Branch at mouth	2.5	88	12	0	0	0	0	38	100	0	0	0	0	0	0	0	0
WES 3	Rail Branch at mouth	1.2	98	2	0	0	0	0	36	100	0	0	0	0	0	0	0	0
WES 1.1	Westecunk Creek above GS Parkway	16.0	80	17	0	0	1	2	33	61	39	0	0	0	0	0	0	0
WES 2	Uriah Branch at mouth	1.5	73	11	0	16	0	0	0	--	--	--	--	--	--	--	--	--
WES 1	Westecunk Creek at mouth	25.0	69	17	7	4	1	2	24	--	--	--	--	--	--	--	--	--

Forked River

The three tributaries of the Forked River (North Branch, Middle Branch, and South Branch) originate within the Pinelands Area. The Pinelands Area portion of these basins, which encompasses approximately 17 square miles, was undeveloped in 1980. There were no state or federal conservation lands within the area. Developed land area was relatively high east of the Parkway in the Pinelands National Reserve. A large area of non-forest land in the South Branch was associated with the Oyster Creek nuclear power plant located east of the Parkway. Most of the watershed is classified as Forest Area. Small areas of the Long Branch (a tributary of the North Branch) and South Branch basins are designated as Rural Development Area, the only other management area found within the Forked River basin.

Oyster Creek

Forest land dominated the pre-CMP landscape in the Oyster Creek basin. There were no state or federal conservation lands within the basin. Most development was found east of the Parkway in the Pinelands National Reserve. The most significant land disturbance in the Pinelands Area was associated with the 282 acre Southern Ocean Landfill located in the headwaters of the basin. Forest Area and Rural Development Area are the major land management areas.

Mill Creek

One-quarter of the Pinelands Area portion of the Mill Creek basin was developed in 1980, and the landscape profiles of the main stem and tributary basins were similar. There were no public recreational lands in the area west of the Parkway. The watershed is almost equally divided between Forest Area and Regional Growth Area. Most of the Regional Growth Area is located within the Four Mile Branch basin.

Westecunk Creek

The 16 square miles of the Westecunk Creek basin located within the Pinelands Area were undeveloped in 1980. The 2,788 acre (4.4 square miles) Stafford Forge Wildlife Management Area occupied a significant portion of the drainage area. The basin is classified as Preservation Area District and Forest Area.

Regional Growth/Rural Development Basins

Two areas which had a relatively high proportion of their area designated as Regional Growth Area and Rural Development Area are also recommended for study. These are the Haynes Creek basin, which drains portions of Evesham Township, Medford Township and

Medford Lakes in Burlington County, and the Babcock Creek and Gravelly Run basins located within Hamilton Township and portions of Galloway Township in Atlantic County (Table 10).

Haynes Creek

The 26.2 square mile Haynes Creek basin[6] is in the South Branch Rancocas Creek system. The basin was moderately developed in 1980. Developed lands covered more than one-quarter of the Haynes Creek tributary 3 at Medford Lakes basin (SBR 10.1) and the drainage area of an unnamed tributary below Van Dal Lake (SBR 11.4). Public conservation lands were limited to the extreme headwater area of Kettle Run which originates in Wharton State Forest.

The eastern and western portions of the basin display contrasting management area profiles. The western drainage area, Haynes Creek at the outlet of Pine Lake, is primarily Rural Development Area. Haynes Creek tributary 3 at Oakwood Lakes, which includes most of Medford Lakes, is mostly Regional Growth Area.

Babcock Creek and Gravelly Run

The 20 square mile Babcock Creek basin and adjacent 8.8 square mile Gravelly Run basin were relatively undeveloped in 1980. There were no public conservation lands within either drainage area. Two-thirds of the Babcock Creek basin is Rural Development Area. Most of the remaining area, located in the lower reaches of the basin, is designated Regional Growth Area. By contrast, a majority of the Gravelly Run basin is Regional Growth Area. One-third of this basin is classified Rural Development Area.

Tuckahoe River Southern Forest Area

The section of the Tuckahoe River basin proposed for monitoring includes the 30.8 square mile drainage area above Head of River and the 7.0 square mile McNeals Branch basin (Table 11). McNeals Branch was undeveloped in 1980, and development and agricultural land comprised less than ten percent of the Tuckahoe River drainage area above Head of River. Portions of Peaslee Wildlife Management Area and Belleplain State Forest are located within the area. Most of this proposed study area is designated as Forest Area.

----

6. A small portion of the basin (0.5 square miles within the Kettle Creek tributary sub-basin) lies outside the Pinelands Area.

Table 10. Rural Development\Regional Growth basins.

Map Index	Stream Basin Name	Basin Area (sq mi)	Percent Land Cover (Pre-CMP) Up-land	Wet-land	Coast Marsh	Devel-oped	Agr Land	Non-Forest	Percent Pub-lic	Management Area Percent Distribution Pres Area	For Area	Agr Prod	Rural Dev	Reg Growth	Town	Vil-lage	Spec Agr	In-fil
Lower Great Egg Harbor River tributary basins																		
Babcock Creek basin																		
LGE 13.3	Man Killer Branch at mouth	2.5	50	32	0	12	6	0	0	0	5	0	95	0	0	0	0	0
LGE 13.2	Jack Pudding Branch at mouth	3.6	50	20	0	12	13	5	0	0	0	0	91	9	0	0	0	0
LGE 13.1	Adams Branch at Cologne Ave.	0.8	28	4	0	68	0	0	0	0	0	0	5	95	0	0	0	0
LGE 13	Babcock Creek at Mays Landing	20.0	43	34	0	13	8	1	0	0	1	0	67	28	4	1	0	0
Gravelly Run basin																		
LGE 12	Gravelly Run	8.83	48	40	0	6	1	5	0	0	0	0	35	65	0	0	0	0
Haynes Creek (South Branch Rancocas Creek basin)																		
SBR 11.4	Haynes Creek tributary at mouth	2.9 *	51	16	0	29	0	4	0	0	0	0	100	0	0	0	0	0
SBR 11.3	Haynes Creek tributary 2 at mouth	2.3	47	39	0	14	0	0	0	0	0	0	100	0	0	0	0	0
SBR 10.4	Kettle Run at mouth (Centennial Lk)	5.6	44	42	0	8	5	0	4	7	11	1	80	0	0	0	1	0
SBR 10.3	Haynes Creek at outlet of Lake Pine	15.2	49	36	0	12	2	1	1	2	4	0	88	5	0	0	0	0
SBR 10.2	Haynes Creek tributary 3 at Medford	6.7	51	12	0	29	7	2	0	0	0	0	21	79	0	0	0	0
SBR 10.1	Haynes Creek tributary 3 at Oakwood	8.3	50	16	0	27	6	1	0	0	0	0	18	82	0	0	0	0
SBR 10	Haynes Creek at mouth	26.2	47	30	0	16	6	1	1	1	2	0	57	39	0	0	0	0

Table 11. Tuckahoe River Southern Forest Area and McDonalds Branch basin.

Map Index	Stream Basin Name	Basin Area (sq mi)	Percent Land Cover (Pre-CMP) Up-land	Wet-land	Coast Marsh	Devel-oped	Agr Land	Non-Forest	Percent Pub-lic	Management Area Percent Distribution Pres Area	For Area	Agr Prod	Rural Dev	Reg Growth	Town	Vil-lage	Spec Agr	In-fil
Tuckahoe River Southern Forest Area																		
TUC 10	Sharps Branch at mouth	1.8	39	13	0	0	0	48	31	0	100	0	0	0	0	0	0	0
TUC 9	Green Branch at mouth	2.5	68	8	0	0	0	24	64	0	100	0	0	0	0	0	0	0
TUC 1.2	Tuckahoe River above Hunter's Mill	17.4	61	22	0	3	2	12	34	0	92	0	0	0	0	8	0	0
TUC 8	Tarkiln Brook at mouth	7.8	44	40	0	4	11	2	48	0	95	0	0	0	0	5	0	0
TUC 1.1	Tuckahoe River at Head of River	30.8 *	56	30	1	3	4	7	44									
TUC 7.1	Pole Bridge Branch at mouth	4.8	80	18	1	0	1	0	0	0	74	0	0	0	0	26	0	0
TUC 7	McNeals Branch at mouth	7.0	76	22	1	0	1	0	5	0	100	0	0	0	0	0	0	0

McDonalds Branch Basin

The McDonalds Branch watershed is a small (5.5 square miles), undeveloped headwater basin of the North Branch Rancocas Creek. It is located almost entirely within Lebanon State Forest in Burlington and Ocean Counties. In 1980, the basin was forest land except for a relatively small sand mining area located in its extreme upper reaches (Table 11). The entire drainage area is classified as Preservation Area District.

PREVIOUS AND CURRENT MONITORING EFFORTS

The existence of prior and current monitoring efforts within an area was a study site selection criterion. Existing data bases can provide the basis for developing a long-term monitoring program provided that past and present data collection methods are comparable. Even if differences in methodology preclude the use of available data bases, they can provide insight into the development of a comprehensive long-term monitoring program.

Several existing data bases include current, site-specific information on Pinelands natural and cultural resources which can serve as the basis for monitoring changes in the status of these resources. At least portions of all the proposed study areas are covered by these regional data bases.

The Office of Natural Lands Management in the DEPE maintains the Natural Heritage Database which contains records of occurrences of endangered and threatened species and ecosystems. This comprehensive data base represents the most current record on the status of populations of threatened and endangered species in the Pinelands. The Pinelands Commission and the Office of New Jersey Heritage within the DEPE maintain inventories of known historic and prehistoric resources within the Pinelands.

The DEPE Office of Science and Research is compiling an extensive geographical information system which serves as a central department repository for environmental information. The DEPE is also currently in the process of mapping and digitizing the extent of all wetlands within the state. These maps will provide a detailed record of the abundance and distribution of Pinelands wetlands within the selected drainage basins.

Information on other Pinelands resources is available from a variety of sources. Selected basin-specific data sources and monitoring programs are described in the following sections. An inventory of hydrologic monitoring programs is presented in Table 12. Although water quality sampling constituents vary among the different programs listed in Table 12, all sites are ambient water quality stations. Sampling constituents at all these sites include nutrients, pH, conductivity, and dissolved oxygen, among others. Complete parameter lists can be found in the referenced reports.

Mullica River Basin

The water resources of the Mullica River Basin have been intensely studied. Earlier Kirkwood-Cohansey ground water studies conducted within the watershed by the U.S. Geological Survey (Lang, 1961; Lang and Rhodehamel, 1962; Lang and Rhodehamel, 1963; Rhodehamel, 1973) contributed significantly to our current knowledge of Pinelands hydrology.

Prior to 1980, the USGS established four continuous-record and 18 low-flow partial-record stream flow gaging stations within the Mullica River basin (Gillespie and Schopp, 1982). A Cohansey ground water observation well was maintained at Mount within Wharton State Forest. Harbaugh and Tilley (1984) constructed a two-dimensional steady-state model of the water table aquifer of the Mullica River basin. The model was calibrated using ground water levels measured in 47 wells and stream flow records from the USGS continual and partial record network located within the basin.

The USGS has conducted extensive water quality sampling within the Mullica River basin. In the late 1970's, water chemistry was measured on at least one occasion at forty seven stream stations. Routine monitoring is currently conducted at six of these stations located on major tributaries of the Mullica River. These include the upper Mullica River (Atsion River), Hammonton Creek, Batsto River, West Branch Wading River, Oswego River, and East Branch Bass River. The USGS has recently analyzed water quality trends at these stations for the period 1976-1986 (Hay and Campbell, 1990).

Twelve Mullica River basin stream-flow stations and eight water quality stations in lower Camden County are currently being monitored in a cooperative USGS and Commission project. During the summer of 1987, nineteen water quality stations within the same area were monitored by the DEPE in cooperation with the Commission (Kurtz, 1987). Forty additional stations are currently sampled by the Commission, the Atlantic County Utilities Authority (ACUA) and the Burlington and Ocean County health departments through the cooperative Pinelands surface water quality program (Windisch and Zampella, 1988; Windisch, 1989).

Rutgers University researchers have also developed a comprehensive, long-term water quality data base for the Mullica River and Great Bay system (Durand and Zimmer, 1982; Durand, 1988a, Morgan and Good, 1986). Crerar et al. (1981) and Yuretich et al. (1981) included Mullica River basin stations in their studies of the hydrogeochemistry of the New Jersey Coastal Plain.

Morgan et al. (1983) conducted an extensive survey of the fishes, aquatic macrophytes, periphyton and aquatic insects at stations along the Sleeper Branch, Albertson Branch, Springer Brook and Skits Branch (also see Morgan, 1987; Morgan and Philipp, 1986), and Hastings (1984) provided a detailed inventory of the fishes of the entire Mullica River basin. The physical, chemical and biological characteristics of Lake Oswego (Oswego River) and Lake Nescochague (Hammonton Creek and Nescochague Creek) have also been described (Morgan, 1983; 1985; 1986).

Table 12. Water quality and stream flow monitoring stations. Some station names have been abbreviated. Refer to Velnich (1982, 1984) and USGS Water Resources Data reports for USGS station names, and Windisch and Zampella (1989) and Windisch (1990) for Pinelands Commission and County station names. Notes: CY (current year) indicates currently active stations; LF indicates low flow stations; and an asterisk (*) indicates USGS stations with limited sampling frequency.

Basin/Stream Station	USGS Network			Pinelands Commission and County Networks	
	Station ID No	WQ Record	Flow Record	Station ID No	WQ Record
MULLICA RIVER BASIN					
Atsion River (Upper Mullica River)					
Mullica River near Atco	01409375	75-78	LF		
Mullica River at Hopewell Rd				D10,1	83-85,87-90
Mullica River at Kettle Run Rd				D10,2	83-90
Mullica River at Mill Rd				D10,3	84-90
Mullica River at Jackson-Medford Rd				D10,4	83-85,87-90
Mullica River at Jackson Rd (Rt 534)	01409383	77-78		D10,5	83,84-CY
Mullica River at Burnt House Rd near Atsion				D11,1	83-84,86-90
Mullica River at inlet of Atsion Lake				D11,2	83-84,87-90
Mullica River at outlet of Atsion Lake	01409387	76-CY		D11,3	83-84,86-CY
Wesickaman Creek at Rt 206				PCM2	89,CY
Mullica River at Atsion	01409390		LF		
Mullica River near Quaker Bridge Rd				D11,4	86-90
Mullica River tributary near Atsion	01409395		LF		
Mullica River above confluence with Sleeper Branch				PCM4	88-CY
Mullica River near Batsto	01409400		57-CY		
Sleeper Branch					
Hays Mill Creek near Chesilhurst	01409402		LF		
Wildcat Branch at Chesilhurst	01409403	77-78*	LF		
Sleeper Branch Diversion	394348074460900	77-78*			
Sleeper Branch above confluence with Mullica River				PCM6	88-CY
Sleeper Branch near Atsion at Rt 206	01409404		LF		
Clark Branch at Johnson Rd				PCSL2	CY
Clark Branch near Atsion	01409405		LF		
Sleeper Branch at Batsto	01409406		LF		
Nescochague Creek		77-78			
Pump Branch at Blue Anchor	394150074494500	77-78*			
Blue Anchor Brook near Blue Anchor	01409409		LF		
Blue Anchor Brook at Blue Anchor	394117074500400	77-78*			
Albertson Brook near Hammonton at Rt 206	01409410	77-78*	LF	PCNE1	CY
Great Swamp Branch at Elm	304018074493100	77-78*			
Great Swamp Branch near Hammonton at Rt 206	394104074454900	77-78*		PCNE2	CY
Nescochague Creek at Pleasant Mills	01409411	77-78*	LF	PCNE3	CY
Hammonton Creek					
Hammonton Creek at Rt 30, Hammonton	01409412	77-78*			
Hammonton Creek at Hammonton	01409414	77-78*			
Hammonton Creek at Wescoatville	01409416	74-CY			
Nortons Branch near Sweetwater	01409419	77-78*			

Table 12 continued.

Basin/Stream Station	USGS Network Station ID No	USGS Network WQ Record	USGS Network Flow Record	Pinelands Commission and County Networks Station ID No	Pinelands Commission and County Networks WQ Record
MULLICA RIVER BASIN					
Batsto River					
Batsto Headwater tributary west at Rt 532				D8,2	84,87-90
Batsto Headwater tributary east at Rt 532				D8,1	84,87-90
Batsto River at Hampton Gate, Carranza Rd	01409430	77-78		D8,3	84,87-CY
Unnamed tributary near Moores Meadow				D8,4	84,87-CY
Roberts Branch at Carranza Rd				D8,5	84,87-CY
Skit Branch at Carranza Rd				D8,6	84,87-CY
Deep Run at Hampton Furnace Rd				D8,8	87-90
Batsto River near Hampton Furnace	01409440	77-78			
Indian Mills Brook at Grassy Lake Rd				D1,1	83-84,86-CY
Indian Mills Brook at Stokes Rd				D1,2	83-84,86-CY
Indian Mills Brook near Indian Mills at Rt 534	01409447	77		D1,3	83,86-CY
Muskingum Brook at Red Lion-Indian Mills Rd (Rt 648)				D7,1	83-84,86-CY
Muskingum Brook at Tuckerton Rd (Rt 620)				D7,2	83-84,86-CY
Muskingum Brook at Indian Mills Lake inlet				D7,3	83-84,86-CY
Muskingum Brook at Indian Mills Lake outlet				D7,4	83-84,86-CY
Muskingum Brook at Forked Neck Rd				D7,5	86-89
Springers Brook near Indian Mills at Rt 206	01409450	76-78	LF	D1,4	83-84,86-CY
Springers Brook near Hampton Furnace at Hampton Furnace Rd	01409455	77-78		D8,7	84,87-CY
Springers Brook near Atsion	01409460		LF		
Batsto River at Quaker Bridge	01409470	76-78		PCB5	90-CY
Batsto River at Batsto, Rt 542	01409500	76-CY	27-CY	D5,2	83-85,88-CY
Batsto River at Pleasant Mills	01409510	76-78			
Lower Mullica River and Tributaries					
Mullica River at 542, Pleasant Mills				D5,1	83-85,88-CY
Lucas Branch near Sweetwater at Indian Cabin Rd.	01409515	77-78			
Lucas Branch at Sweetwater	01409525	77-78			
Mullica River at Crowley's Landing near route 542				D5,3	83-85,88-90
Bull Creek at Rt 542				D5,4	83-85,88-90
Little Bull Creek at Rt 542				D5,5	83-85,88-90
Mullica River at Green Bank, Rt 563	01409535	77-79		D5,6	83-85,88-90
Pine Creek at Weekstown, Rt 563	01409540	77-78			
Unnamed Mullica River trib. at route 542 near Lower Bank				D6,1	83-85,87-CY
Mullica River at bridge on Lower Bank Road (River Rd)				D6,2	83-84,87-CY
Unnamed Mullica River tributary at route 542				D6,3	83,87-90
Landing Creek at Philadelphia Ave, Egg Harbor City	01409575	76-78	LF		
Landing Creek near Egg Harbor City at Indian Cabin Rd	01409600	76-78		PCLM3	CY
Indian Cabin Creek at outlet of Egg Harbor City Lk (Rt 563)				PCLM2	CY
Landing Creek near Weekstown at Clarks Landing Rd	01409605	77-78			
Tarkiln Branch near Port Republic	01409620	77-78			
Mullica River at Rt 167 near Parkway				D6,4	87-90
Bass River					
East Branch of Bass River at Dans Bridge	01410130	77-78			
East Branch of the Bass River near New Gretna at Stage Road	01410150	76-CY	78-CY	D9,1	84,88-CY
West Branch of Bass R. tributary at Oswego Rd.	01410180	77-78			
West Branch of Bass River at Stage Road bridge	01410200	77-78	LF	D9,2	84,88-CY
Bass River at New Gretna, Rt 9	01410205			D9,3	84,88-90
Jobs Creek at Rt 9				D9,4	84,88-90

Table 12 continued.

Basin/Stream Station	USGS Network Station ID No	USGS Network WQ Record	USGS Network Flow Record	Pinelands Commission and County Networks Station ID No	Pinelands Commission and County Networks WQ Record
MULLICA RIVER BASIN					
West Branch Wading River					
Gates Branch near Chatworth	01409675	77-78*			
Pole Branch at Rt 532				D4,1	83-84,87-90
W. Br. Wading R. at Chatsworth, at outlet of Chatsworth Lake	01409690	77-78*		D4,2	83-84,87-CY
W. Br. Wading R. at Dukes Bridge	01409700	77-78*			
W. Br. Wading R. at Rt 563, between Speedwell and Chatsworth				D4,3	83-85,87-90
Pole Branch (Jakes Spung Branch) at Rt 563				D4,4	83-85,87-90
Shoal Branch at Chatsworth-Tuckerton Rd				PCW2	88-CY
Shoal Branch at Rt 563				D4,6	83-85,87-90
Cranberry bogs at Rt 563 between Speedwell and Hog Wallow				D4,7	83,87-90
W. Br. Wading River at Rt 563 in Speedwell				D4,5	83-85,87-CY
W. Br. Wading River near Chatsworth	01409730		LF		
Tulpehocken Creek near Jenkins at Big Hawkin Bridge	01409780	77-78*	LF	PCW5	88-CY
Little Hauken Run at Rt 563 near Hog Wallow				D4,8	83-85,87-CY
W. Br. Wading River near Harrisville at Godfrey Bridge	01409800		LF		
W. Br. Wading River near Jenkins	01409810		74-CY		
W. Br. Wading River at Maxwell, Evans Bridge on Rt 563	01409815	76-CY		D4,9	83-85,87-CY
W. Br. Wading River, above confluence with Oswego River					
Oswego River (East Branch Wading River)					
Oswego River at Rt 72 near Brookville	01409870	77-78*			
Yellow Dam Branch at Rt 72 near Brookville	01409875	77-78*			
Oswego River at Beaver Dam Road near Warren Grove				PCW7	88-CY
Papoose Branch near Sim Place at Jenkins Road	01409960	77-78*		D2,1	83-85,87-CY
Breeches Branch at mouth, Jenkins Road at Oswego Lake inlet				D2,2	83-85,87-CY
Oswego River at Oswego Lake, Andrews Road	01409970	77-78*	LF	D2,3	83-85,87-CY
Oswego River at Harrisville, Rt 679 at Harrisville Pond outlet	01410000	76-CY	30-CY	D3,1	84,87-CY
Wading River					
Beaver Run at Harrisville, Chatsworth Rd	01410005	77-78*			
Tub Mill Branch at Rt 679				D3,2	84-85,87-90
Wading River at Wading River Rt 542 and Leektown Rd	01410070	77-78*		D3,4	84-85,87-90
Ives Branch at Rt 679				D3,3	84-85,87-90
Ives Branch at Rt 542				D3,5	84,87-90
Merrygold Branch at Rt 542				D3,6	84,87-90

Table 12 continued.

Basin/Stream Station	USGS Network			Pinelands Commission and County Networks	
	Station ID No	WQ Record	Flow Record	Station ID No	WQ Record
TRIBUTARIES TO BARNEGAT BAY AND LITTLE EGG HARBOR					
Cedar Creek					
Webbs Mill Branch near Whiting	01408800	77-78	LF		
Webbs Mill Branch tributary near Whiting	01408810		LF		
Cedar Creek at Cedar Crest, Whiting Lacey Road	01408830	77-78		OCN045	76-CY
Factory Branch at Whiting-Lacey Rd (Rt 614)				PCC2	88-CY
Cedar Creek at Double Trouble	01408870	77-78		OCN044	76-CY
Cedar Creek at Lanoka Harbor, Rt 9	01409000	76-78		OCN043	76-87
Forked River					
North Branch Forked River at abandoned RR crossing	01409040	77-78*			
North Branch Forked River at GSP (JCP&L Power Lines)	01409050		LF	OCN047/PFR4	85, 87-CY
North Branch Forked River at Deerhead Lake outlet				PFR4B	88-90
North Branch Forked River at Parker Ave				OCN046	85,87
North Branch Forked River at Forked River	01409055	77-78*			
Middle Branch Forked River at Rt 9				OCN048	85,87
South Branch Forked River near Forked River	01409080		LF		
Oyster Creek					
Oyster Creek at Brookville Boy Scout Camp				OCN052	85,87
Oyster Creek near Brookville at Rt 532	01409095	75-78	66-75	OCN051	85,87-CY
Oyster Creek near Waretown at Garden State Parkway	01409100		LF		
Mill Creek					
Mill Creek near Manahawkin, Rt 72	01409150	76-78*	LF	OCN054	76-CY
Fourmile Branch near Brookville	01409180	77-78*	LF		
Fourmile Branch at Garden State Parkway	01409200	77-78*			
Fourmile Branch at Oxycoccus-Littleville Mill Rd				OCN055	76-87
Fourmile Branch at Lighthouse Drive, upstream from Parkway				PMI6	88-CY
Mill Creek at Manahawkin Lake, Route 180	01409210	77-78*		OCN053	76-87
Westecunck Creek					
Governors Branch near Stafford Forge, Rt 539	01409270	77-78*			
Westecunk Creek at Stafford Forge, upstream from GS Parkway				OCN059	85,87-CY
Westecunk Creek above GS Parkway	01409280		73-88,LF		
Westecunk Creek at West Creek, Rt 9	01409282		76-78*	OCN058	85,87

Table 12 continued.

Basin/Stream Station	USGS Network: Station ID No	USGS Network: WQ Record	USGS Network: Flow Record	Pinelands Commission and County Networks: Station ID No	Pinelands Commission and County Networks: WQ Record
RURAL DEVELOPMENT/REGIONAL GROWTH BASINS					
Babcock Creek					
Babcock Creek at Holly Street				PCGEHAM0	88-89
Man Killer Branch at Holly Street				PCGEHAM1	89
Jack Pudding Branch at Cologne Ave				PCGEHAM1	89
Babcock Creek at Pine Street				PCGE10	88-89
Babcock Creek near Mays Landing, at Rt 322	01411196	75-78		PCGE9	88-89,CY
Babcock Creek at Old Egg Harbor Rd				PCGE5	88-89
Babcock Creek at Mays Landing	01411200		LF		
Haynes Creek					
Barton Run at Kresson Lake outlet, Braddock Mill Rd				B10,1	84,86-88
Back Run at Kenilworth Lake outlet, Kenilworth Rd				B10,2	84,86-88
Barton Run at Tomlinson Mill Rd (Rt 619)				B10,7	84,86-88
Black Run at Tomlinson Mill Rd (Rt 619)				B10,6	84,86-88
Barton Run at Tuckerton Rd (Rt 620)				B12,2	84,86-87
Southwest Branch of the Rancocas Creek at Hartford Rd				B12,3	84-87
Kettle Run at Marlton Lakes, Kettle Run Rd and Hopewell Rd				B10,4	84,86-88
Kettle Run at inlet of Centennial Lake at Braddocks Mill Rd				PCSR8	90-CY
Haynes Creek at Centennial Lake outlet				B11,4	84-90
Haynes Creek tributary at Mimosa Lks inlet, Braddocks Mill Rd				B11,7	84-85,87-88
Haynes Creek tributary at Mimosa Lakes, Scout Drive				B11,6	84-89
Haynes Creek tributary at Mimosa Lakes outlet, Pontiac Drive				B11,5	84-89
Unnamed trib of Haynes Ck above Harmony Lk, Kettle Run Rd				B10,3	84,86-88
Unnamed trib of Haynes Creek Harmony Lk outlet, Hopewell Rd				B10,5	84,86-88
Haynes Creek at Taunton Lake outlet				B11,3	84-89
Haynes Creek tributary 2 below Blue Lake (Blue Lake outlet)				B11,2	84-87,89-90
Haynes Creek at outlet of Lake Pine				B11,1	84-CY
Haynes Creek tributary above Lake Stockwell, Tuckerton Rd				B1,5	84-87,89-90
Haynes Creek tributary at Lake Stockwell inlet, Stokes Rd				B1,4	84-90
Haynes Creek trib at Upper Aetna Lake outlet, Beach Trail				B1,3	84-88,90
Haynes Creek tributary at Lower Aetna Lake outlet, Stokes Rd				B1,1	84-88,90
Haynes Creek trib at Lake Mishe-Mokwa inlet, Cheyenne Trail				B1,6	84-90
Haynes Creek trib at Lake Mishe-Mokwa inlet, Tuckerton Rd				B1,7	84-85,87-88,9
Haynes Creek tributary below Lake Mishe-Mokwa, Lenape Trail				B1,2	84-90
Haynes Creek tributary at Birchwood Lakes outlet				B1,8	84-90
Haynes Creek tributary 3 at Oakwood Lakes, Ramblewood Dr				B1,9	84-88,90
Haynes Creek at Oliphant Mills, Himmelein Rd				B12,4	84-87,90
Southwest Branch Rancocas Creek at Main Street in Medford				B12,5	84-87,90
TUCKAHOE RIVER SOUTHERN FOREST AREA					
Tuckahoe River near Estell Manor	01411290	75-78			
Tuckahoe River north of Rt 49 at Hunter's Mill Bogs				PB19a	84-86
Tuckahoe River at Hunter's Mill Bog outlet, Rt 49				PB18a and PCTU	84-86
Tuckahoe River south of Rt 49 at Hunter's Mill Bogs				PB20a	84-86
Tarkiln Brook, upstream from bogs at power line right-of-way				PB17a	84-86
Tarkiln Brook tributary at Belleplain Rd (Rt 605)				PB16	84-CY
Tarkiln Brook at bog spillway, Rt 548				PB17b	87-CY
Tuckahoe River at Head of River, Rt 49	01411300	75-82	1969-CY	PB18b	87-CY
McNeals Branch at Rt 649				PCTU2	CY
MCDONALDS BRANCH BASIN					
McDonalds Branch in Lebanon State Forest	01466500	63-CY	53-CY		

Ehrenfeld (1983) conducted a qualitative survey of the vegetation of Pinelands swamp sites within the basin to determine the impact of development on species composition, and Ehrenfeld (1986) and Ehrenfeld and Gulick (1981) measured hardwood swamp community attributes at Mullica River basin sites. Stoltzfus (1991) and Zampella (1991) measured community composition and water levels in cedar swamps and pitch pine lowlands, respectively, at several Mullica River basin sites. Windisch (1986) prepared a detailed map of the Pine Plains, and Buchholz and Zampella (1987) mapped the extent of recent fires which occurred in that area.

Brush (1985) described the bird communities of areas within Penn State Forest and the West Plains. Zappalorti and Johnson (1982) conducted a herpetological survey of Wharton State Forest.

Tributaries to Barnegat Bay and Little Egg Harbor

During the 1970's, the USGS maintained a number of low-flow stations and short-term surface water quality stations within each of the five proposed study basins. Water quality sampling was most intensive along the Oyster Creek (Fusillo et al., 1980; Johnson, 1979a, 1979b; Morgan, 1984). Continuous record stream flow data are available for Oyster Creek and Westecunk Creek stations.

In 1976, the Ocean County Health Department began monitoring surface water quality at stations located throughout the proposed study area. The Commission and Ocean County continue to maintain most of these stations through the cooperative Pinelands program. A ground water quality network, which includes several sites within the proposed study area, has also been established by the USGS and the Ocean County Planning Board (Harriman and Voronin, 1984).

Ehrenfeld and Schneider (1987) and Schneider (1988) monitored ground water chemistry at two cedar swamp sites in the Cedar Creek basin. They also described the species composition and hydrology of the two sites.

Regional Growth/Rural Development Basins

The USGS operated a short-term surface water quality station and a low flow station along the Babcock Creek. Surface water quality was sampled and stream flow was measured at several stations within the Babcock Creek and Gravelly Run basins as part of a hydrologic impact assessment conducted by the Commission (N.J. Pinelands Commission, 1990). The Commission and the ACUA continue to monitor surface water quality within this area.

Tuckahoe River Southern Forest Area

The USGS previously monitored water quality along the Tuckahoe River at Cumberland Avenue and Head of River (Route 49), and continues to maintain a long-term stream discharge station at Head of River. Water quality is currently monitored by the Commission, ACUA, and Cape May County Health Department at several stations as part of the cooperative Pinelands program.

McDonalds Branch Basin

The McDonalds Branch basin is one of the most intensely studied areas in the Pinelands. This is the major reason for recommending that it be included in the long-term monitoring program. The USGS gaging station in Lebanon State Forest is a Hydrologic Benchmark station that is part of a nationwide network of stations located in small, undeveloped watersheds. Stream discharge and water quality data have been intensely monitored here by the USGS since 1953 and 1963, respectively. This long period of record has allowed detailed water quality trend analyses to be completed (Johnson, 1979a, 1979b; Morgan, 1984; Hay and Campbell, 1990). Numerous hydrogeochemical studies have also been conducted in the basin (Swanson and Johnson, 1980; Budd et al., 1981; Turner et al., 1985a; 1985b; Lord et al., 1990).

The hydrogeochemical monitoring network established by Lord et al. (1990) within the basin included an extensive system of upland and wetland water-level and water quality monitoring wells. Using this network as a foundation, the USGS has recently initiated an investigation of the relations between ground water hydrology and vegetation. The USGS also operates two permanent Kirkwood-Cohansey ground-water level monitoring wells within the basin with periods of record extending back to at least 1979.

McCormick (1955) described and mapped the vegetation of McDonalds Branch, and several wetland community studies, including the collection of water-level data and ground water chemistry, have been conducted within the basin (Ehrenfeld and Schneider, 1987; Schneider 1988; Stoltzfus, 1990; Zampella, 1990).

BIOLOGICAL DIVERSITY AND EXCEPTIONAL LANDSCAPE FEATURES

Atlantic White Cedar Swamps

Atlantic white cedar swamps are an important ecological resource which has been declining since European settlement (Roman et al., 1987; Zampella, 1987). In 1980, there were 21,450 acres of Atlantic white cedar in the Pinelands (Roman and Good, 1985). Fifty-five percent of the total cedar acreage was found within the Mullica River basin, and 12% was found in the Barnegat Bay and Little Egg Harbor tributary systems (Table 13). Nearly one quarter of all cedar swamps were found in the Wading River basin.

Table 13. Distribution of Pinelands cedar swamps.

Stream basin	Percentage of all Pinelands Atlantic white cedar swamps
Mullica River	55%
Atsion River	3%
Sleeper Branch	4%
Batsto River	5%
Nescochague Creek	2%
Hammonton Creek	<1%
Wading River	23%
Lower Mullica River tributaries	15%
Bass River	3%
Barnegat Bay/Little Egg Harbor	12%
Cedar Creek	5%
Forked River	4%
Oyster Creek	1%
Mill Creek	<1%
Westecunk Creek	<1%
Tuckahoe River	1%
Rural Development/Regional Growth	<1%
Babcock Creek and Gravelly Run	1%
Haynes Creek	<1%
McDonalds Branch	1%

Pine Plains

The Pine Plains are a unique Pinelands forest type characterized by low growing pitch pine and scrub-form oaks and maintained by frequent and severe wildfires (Good and Good, 1979; Buchholz and Zampella, 1987). The Pine Plains are a prominent feature of the Wading River ecosystem, and contribute substantially to the watershed's ecological importance (McCormick, 1970). Although most of the Pine Plains are located within the Wading River basin, portions of the East Plains lie within the Westecunk Creek and Bass River basins.

Natural Heritage Priority Sites

The recommended study areas include many sites displaying exceptional biodiversity. Each site is listed here along with a brief description of the factor(s) responsible for its biological significance. The terms critically imperiled globally, imperiled globally, and globally rare are used to describe a species status. The Heritage Program ranks species as critically imperiled globally due to extreme rarity (e.g., 5 or fewer occurrences) and imperiled globally due to rarity (e.g., 6-20 occurrences). A species may also be imperiled due to factors which make it vulnerable to extinction. As used in this section, globally rare refers to any of several levels of rarity described by the Heritage Program.

Mullica River Basin

Atsion River

Atsion Burn. Four globally imperiled insect and globally imperiled, state endangered plant species, five globally rare plant and insect species, and numerous other state rare species.

Atsion Recreation Area Site. An excellent population of a globally imperiled insect species, other globally rare insects, and one state endangered animal species.

Sleeper Branch

Atco Lake. One state endangered plant species.

Sand Ridge Pond. An excellent population of a globally imperiled, state endangered plant species.

Batsto River

Batsto River Macrosite. Numerous exemplary globally rare communities and plant and insect species including nineteen state endangered plant species, two state endangered and three state threatened animal species.

Long Savanna. Largest Pine Barrens savanna in New Jersey with concentration of globally imperiled and rare plant species, including four state endangered species.

Nescochague Creek

Ancora Bogs. One globally imperiled plant species.

East Branch Wading River (Oswego River)

Bear Swamp Hill Lowland. Excellent or good populations of six globally imperiled and globally rare plant and insect species. Includes three state endangered species.

East Plains[7]. Exemplary stand of a globally imperiled natural community (Pine Plains) and a number of globally rare plant and animal species.

Little Plains. Pine Plains.

Oswego River Lowland Macrosite. Numerous excellent occurrences of globally rare and imperiled plants and insects, including nine state endangered plant species. An exceptionally large concentration of significant species occurs within the wetlands along the Oswego River. Two endangered and one threatened animal species are also found within this macrosite.

Spring Hill Plains. A small area of Pine Plains vegetation.

Warren Grove. A globally rare plant species.

West Plains.[8] An excellent example of a globally imperiled community (Pine Plains), a number of globally rare insects, a globally rare plant species, and a state threatened animal species.

West Branch Wading River

Carranza Memorial Macrosite. A concentration of three state endangered and threatened animals and several state endangered and rare plant species.

Chatsworth Goose Pond. Several globally rare species, including one state endangered species.

Decou Pond. One state endangered animal species.

West Branch Wading River Macrosite. High quality populations of fourteen globally imperiled, state endangered plant species and one state endangered and one state threatened animal species.

Wading River

Wading River Tidal Marsh. One globally imperiled state endangered plant species and one rare species.

Landing Creek

Atlantic Goose Ponds. A high quality example of rare natural community, several globally rare plant species, and a concentration of six state endangered plants and one state endangered animal species.

Berlin Avenue Bogs. One critically imperiled global, state endangered plant species and one globally rare plant species.

Cape May Avenue Site. Three globally rare plant species.

Clarks Landing Bog. One state endangered plant species.

---

7. Portions of the East Plains are also found within the Bass River and Westecunk Creek watersheds.

8. A portion of the West Plains is also located within the West Branch of the Wading River.

Frankfurt Avenue Bog. A good population of a globally imperiled, state endangered plant species as well as a globally rare plant species.

Mackenzie Swales. One critically imperiled global species, one imperiled global species, and four globally rare species. Includes four state endangered species.

Reading at Darmstadt. A good populations of one globally imperiled, state endangered plant species and four globally rare plant species.

Other Lower Mullica River tributary basins

NE of Weekstown Site. One globally rare plant species.

Hirst Ponds. High quality natural community (vernal pond), a state endangered animal species, and several globally imperiled and rare plant species, including three state endangered species.

Pomona Woods. Populations of two threatened bird species.

Turtle Creek. One state imperiled plant species.

Bass River

Bass River Macrosite. Several globally rare plant species and contiguous habitat for two state endangered and one state threatened animal species.

Ballanger Creek (PNR). One globally imperiled and one rare plant species.

Dans Island (PNR). Two globally rare plants, including one state endangered species.

Rural Development/Regional Growth

Babcock Creek

Archers Meadow. One globally rare and one state endangered plant species.

Cape May Pond. A globally rare wetland natural community (vernal pond) and an excellent population of a globally rare plant species.

Cologne Road RR West Site. One critically imperiled global, state endangered species and several globally rare species.

Drosera. One critically imperiled global, state endangered plant species and three globally rare plant species.

Laurel Street Pond. Two globally rare plant species.

Gravelly Run

Reega. Three state endangered plant species, including critically imperiled and imperiled global plants.

Tributaries to Barnegat Bay and Little Egg Harbor

Cedar Creek

Bamber Macrosite. Three state endangered and one state threatened animal species, two state endangered plant species, one federal listed, state endangered plant species, and several other rare plant species.

Forked River

Forked River Pond (PNR). One globally imperiled, state endangered plant species and two rare plants.

Forked River Woods. One critically imperiled state plant species.

Middle Branch. Four state endangered plant species and three globally rare species.

Pits and Pond. One critically imperiled global plant, one imperiled global plant, and two globally rare plant species. Includes two state endangered plant species.

Tuckahoe RR Bed. Two state endangered and one state threatened animal species.

Mill Creek

Manahawkin Lake (PNR)[9]. One federally listed plant species and one state endangered animal species.

Westecunk Creek

Pond 74. A population of a critically imperiled, state endangered plant species.

Tuckahoe River Southern Forest Area

Five Acre Pond. High quality globally rare natural community and several plant species of global or state significance, including one state endangered plant.

Hunters Mill Site. One globally imperiled, state endangered plant species.

----

9. The Manahawkin Lake area supports a large population of swamp pink (Helonias bullata) which is federally listed and state endangered. This species is also found upstream within the Pinelands Area.

McDonalds Branch

Mt. Misery. Populations of three state endangered animal species, one state threatened animal species, and one federally listed plant species.

Topographic and Geologic Features

Two distinctive topographic features are found within the proposed study basins. Apple Pie Hill, the highest point in the Pinelands (208 ft), is located on the divide between the Batsto River and the West Branch of the Wading River. The Forked River Mountains, a group of hills that are of local cultural interest, are located along the divide between the Cedar Creek and Forked River basins (Barnegat Bay tributaries). The Wading River basin and the Barnegat Bay tributary basins also contain the most extensive deposits of Beacon Hill Gravel found in the Pinelands. The Beacon Hill Gravel, which may represent the last major geologic deposit derived from sources outside the Pinelands, is now limited to small, scattered remnants (Rhodehamel, 1979).

SUMMARY AND RECOMMENDATIONS

Each of the five study areas recommended for long-term monitoring possesses a distinct set of characteristics which makes it suitable as a study area. The different management area profiles of the Barnegat Bay and Little Egg Harbor tributary basins, which reflect varying landscape profiles, include Preservation Area District (Cedar Creek), Forest Area (Forked River), Forest Area and Rural Development Area (Oyster Creek), Forest Area and Regional Growth Area (Mill Creek), and Preservation Area and Forest Area (Westecunk Creek). A relatively continuous long-term surface water quality data set, extending from the mid-1970's through the present time, exists for each of the five basins comprising this study area.

The geographically distant Haynes Creek and Babcock Creek/Gravelly Run basins represent two of the largest and most actively developing Rural Development and Regional Growth Areas in the Pinelands. A hydrologic record exists for both areas, and water quality is currently monitored in all three stream basins. The Babcock Creek basin also exhibits relatively high biological diversity as indicated by the number of Natural Heritage Priority Sites located within its boundaries.

The Tuckahoe River study area is a large, undeveloped watershed that characterizes the southern part of the Pinelands Area. Past and present surface water quality and stream flow monitoring programs have created a sound hydrologic data base for the basin. The long history of hydrologic and ecological research in the McDonalds Branch qualifies it as a Pinelands "benchmark" basin.

Of all the study areas, the Mullica River basin offers the greatest opportunities for monitoring the long-term environmental effects of the Comprehensive Monitoring Plan. The basin is centrally located and consists of several large drainage units, each possessing its own characteristic set of landscapes and management areas. It includes a core reserve surrounded on many sides by areas which support more intense land uses. Biological diversity is exceptionally high, and the drainage area's ecology has been well studied. A number of surface water monitoring programs are currently in progress, and the USGS maintains several long-term surface water quality monitoring and discharge stations within the watershed.

It is recommended that plans for the development of a comprehensive, long-term environmental monitoring program focus on the Mullica River basin, and that initial plans for the other proposed study areas be limited to maintaining surface water quality sampling networks. The Mullica River basin will provide the best possible case study of the successes and/or failures of the state's efforts to protect the full range of Pinelands natural and cultural resources. However, since water quality is among the most important measures of land use related impacts, surface water monitoring in the other basins may provide additional insight on the regional effectiveness of the Pinelands program. The specific study units and study sites to be monitored within the Mullica River basin and the other study areas will be determined as the remaining monitoring program work plan tasks are completed.

REFERENCES CITED

Brush, T. 1987. Birds of the Central Pine Barrens: abundance and habitat use. Bulletin of the New Jersey Academy of Science 32:5-17.

Buchholz, K. and R.E. Good. 1982. Compendium of New Jersey Pine Barrens literature. Center for Coastal and Environmental Studies, Rutgers, the State University of New Jersey. New Brunswick, NJ. 324 pp.

Buchholz, K. and R.A. Zampella. 1987. A 30-year fire history of the New Jersey Pine Plains. Bulletin of the New Jersey Academy of Science 32:61-69.

Budd, W.W., A.H. Johnson, J.B. Huss, and R.S. Turner. 1981. Aluminum in precipitation, streams, and shallow groundwater in the New Jersey Pine Barrens. Water Resources Research 17: 1179-1183.

Crerar, D.A., J.L. Means, R.F. Yuretich, M.P. Borcsik, J.L. Amster, D.W. Hastings, G.W. Knox, K.E. Lyon, and R.F. Quiett. 1981. Hydrogeochemistry of the New Jersey Coastal Plain: 2. Transport and decomposition of iron, aluminum, dissolved organic matter and selected trace elements in stream, ground- and estuary water. Chemical Geology 33:23-44.

Durand, J.B. and B.J. Zimmer. 1982. Pinelands surface water quality, Part I. Center for Coastal and Environmental Studies, Rutgers, the State University of New Jersey, New Brunswick, NJ. 262 pp.

Durand, J.B. 1988a. Field studies in the Mullica River-Great Bay estuarine system. Volume 1. Center for Coastal and Environmental Studies, Rutgers, the State University of New Jersey, New Brunswick, NJ.

Durand, J.B. 1988b. Field studies in the Mullica River-Great Bay estuarine system. Volume 2. Center for Coastal and Environmental Studies, Rutgers, the State University of New Jersey, New Brunswick, NJ.

Ehrenfeld, J.G. 1983. The effects of changes in land-use on swamps of the New Jersey Pine Barrens. Biological Conservation 25:353-375.

Ehrenfeld, J. G. and M. Gulick. 1981. Structure and dynamics of hardwood swamps in the New Jersey Pine Barrens: contrasting patterns in trees and shrubs. American Journal of Botany 68:471-481.

Ehrenfeld, J.G. 1986. Wetlands of the New Jersey Pine Barrens: the role of species composition in community function. The American Midland Naturalist 115:301-313.

Ehrenfeld, J.G. and J.P. Schneider. 1987. The effects of suburban development on water quality and vegetation of cedar swamps in the New Jersey Pinelands. Center for Coastal and Environmental Studies, Rutgers University, the State University of New Jersey, New Brunswick, NJ.

Fusillo, T.V., J.C. Schornick, Jr., H.E. Koester, and D.A. Harriman. 1980. Investigation of acidity and other water-quality characteristics of upper Oyster Creek, Ocean County, New Jersey. USGS Water Resources Investigation 80-10. USGS, Trenton, NJ.

Gemmell, D.J., N.F. Good, and R.E. Good. 1989. Compendium II New Jersey Pine Barrens Literature. Center for Coastal and Environmental Studies, Rutgers, the State University of New Jersey, New Brunswick, NJ. 221 pp.

Good, R.E. and N.F. Good. 1979. The Pine Barren Plains. In Pine Barrens: ecosystem and landscape, R.T.T. Forman (ed.), Academic Press, New York, NY. pp. 283-295.

Gillespie, B.D. and R.D. Schopp. 1982. Low-flow characteristics and flow duration of New Jersey streams. U.S. Geological Survey Open-File Report 81-1110, Trenton, NJ. 164 pp.

Harbaugh and Tilley. 1984. Steady-state computer model of the water-table aquifer in the Mullica River basin, the Pine Barrens, New Jersey. U.S. Geological Survey Water-Resources Investigation Report 84-4295, Trenton, NJ. 38 pp.

Harriman, D.A. and L.M. Voronin. 1984. Water-quality in east-central New Jersey, 1981-82. U.S. Geological Survey Open-File Report 84-821, Trenton, NJ. 39 pp.

Hastings, R.W. 1984. The fishes of the Mullica River, a naturally acid water system of the New Jersey Pine Barrens. Bulletin of the New Jersey Academy of Sciences 29:9-23.

Hay, L.E. and J.P. Campbell. 1990. Water-quality trends in New Jersey streams. U.S. Geological Survey Water-Resources Investigation Report 90-4046, West Trenton, NJ. 297 pp.

Johnson, A.H. 1979a. Evidence of acidification of headwater streams in the New Jersey Pinelands. Science 206:834-836.

Johnson, A.H. 1979b. Acidification of headwater streams in the New Jersey Pine Barrens: Journal of Environmental Quality 8: 383-386.

Kurtz, B.A. 1987. Mullica River Basin Surface Water Quality Monitoring Project. Bureau of Monitoring Management, NJ. Department of Environmental Protection, Trenton, NJ. 35 pp.

Lang, S.M. 1961. Natural movement of ground water at a site on the Mullica River in the Wharton Tract, southern New Jersey. U.S. Geological Survey Professional Paper 424-D:D52-D54, Washington, D.C.

Lord, D.G., J.L. Barringer, P.A. Johnsson, P.F. Schuster, R.L. Walker, J.E. Fairchild, B.N. Stroka, and E. Jacobsen. 1990. Hydrogeochemical data from an acidic deposition study at McDonalds Branch basin in the New Jersey Pinelands, 1983-1986. U.S. Geological Survey Open-File Report 88-500. West Trenton, NJ.

McCormick, J. 1955. A vegetation inventory of two watersheds in the New Jersey Pine Barrens. Ph.D. Thesis, Rutgers University, New Brunswick, NJ.

McCormick, J. 1970. The Pine Barrens: a preliminary ecological inventory. N.J. State Museum Research Report No.2, Trenton, NJ.

Morgan, M.D., R.W. Hastings, G.W. Wolfe, and K.R. Philipp. 1983. A comparison of aquatic species composition and diversity in disturbed and undisturbed Pinelands waters. Center for Coastal and Environmental Studies, Rutgers, the State University of New Jersey, New Brunswick, NJ.

Morgan, M.D. 1983. Impact of changing acidity on the trophic dynamics of Pine Barrens plankton communities. Center for Coastal and Environmental Studies, Rutgers, the State University of New Jersey, New Brunswick, NJ.

Morgan, M.D. 1984. Acidification of headwater streams in the New Jersey Pinelands: a revaluation. Limnology and Oceanography 29:1259-1266.

Morgan, M.D. 1985. Photosynthetically elevated pH in acid waters with high nutrient content and its significance for the zooplankton community. Hydrobiologia 128:239-247.

Morgan, M.D. 1986. The effect of altered pH on zooplankton community structure in a disturbed New Jersey Pine Barrens pond. Journal of Freshwater Ecology 3:467-476.

Morgan, M.D. and R.E. Good. 1986. Impact of acid precipitation on stream chemistry in the New Jersey Pinelands. Center for Coastal and Environmental Studies, Rutgers, the State University of New Jersey, New Brunswick, NJ.

Morgan, M.D. 1987. Impact of nutrient enrichment and alkalinization on periphyton communities in the New Jersey Pine Barrens. Hydrobiologia 144:233-241.

Morgan, M.D. and K.R. Philipp. 1986. The effect of agricultural and residential development on aquatic macrophytes in the New Jersey Pine Barrens. Biological Conservation 35:143-158.

Morgan, M.D. and R.E. Good. 1988. Stream chemistry in the New Jersey Pinelands: the influence of precipitation and watershed disturbance. Water Resources Research 24:1091-1100.

NJ Pinelands Commission. 1990. An assessment of the hydrologic impact resulting from development in Regional Growth Areas in Hamilton Township, Atlantic County. NJ Pinelands Commission, New Lisbon, NJ.

Rhodehamel, E.C. 1979. Geology of the Pine Barrens of New Jersey. In Pine Barrens: ecosystem and landscape, R.T.T. Forman (ed.), Academic Press, New York, NY. pp. 39-60.

Roman, C.T. and R.E. Good. 1985. Wetlands of the New Jersey Pinelands: values, functions, and impacts. Division of Pinelands Research, Center for Coastal and Environmental Studies, Rutgers, the State University of New Jersey, New Brunswick, NJ.

Roman, C.T., R.E. Good, and S.B. Little. 1987. Atlantic white cedar swamps of the New Jersey Pinelands. In Atlantic white cedar wetlands, A.D. Laderman (ed.), Westview Press, Boulder, CO. pp. 35-39.

Schneider, J.P. 1988. The effects of suburban development on the hydrology, water quality and community structure of <u>Chamaecyparis thyoides</u> (L.). B.S.P. wetlands in the New Jersey Pinelands. Ph.D. Dissertation, Rutgers, the State University of New Jersey, New Brunswick, NJ.

Stoltzfus, D.L. 1991. Development of community structure in relation to disturbance and ecosystem fragmentation in Atlantic white cedar swamps in the Pinelands National Reserve, New Jersey. Ph.D. Dissertation, Rutgers, the State University of New Jersey, New Brunswick, NJ.

Swanson, K.A. and A.H. Johnson. 1980. Trace metal budgets for a forested watershed in the New Jersey Pine Barrens. Water Resources Research 16:373-376.

Turner, R.S., A.H. Johnson, and D. Wang. 1985a. Biogeochemistry of lead in McDonalds Branch watershed, New Jersey Pine Barrens. Journal of Environmental Quality 14:305-314.

Turner, R.S., A.H. Johnson, and D. Wang. 1985b. Biogeochemistry of aluminum in McDonalds Branch watershed, New Jersey Pine Barrens. Journal of Environmental Quality 14:314-323.

U.S. Environmental Protection Agency. 1988. Chemical characteristics of streams in the Mid-Atlantic and Southeastern United States (National Stream Survey-Phase 1), Volume I: Population descriptions and physico-chemical relationships. EPA/600/3-88/021a. Environmental Protection Agency, Washington D.C.

U.S. Environmental Protection Agency. 1990. Environmental Monitoring and Assessment Program, Overview. EPA/600/9-90-001. U.S. Environmental Protection Agency, Washington, D.C.

U.S. Geological Survey. 1990. Implementation Plan for the National Water-Quality Assessment Program. U.S. Geological Survey Open-File Report 90-174.

Velnich, 1982. Drainage areas in New Jersey: Delaware River basins and streams tributary to Delaware Bay. U.S. Geological Survey Open-File Report 82-572. U.S. Geological Survey, Trenton, NJ. 48 pp.

Velnich, 1984. Drainage areas in New Jersey: Atlantic Coastal Basins, South Amboy to Cape May. U.S. Geological Survey Open-File Report 84-150. U.S. Geological Survey, Trenton, NJ. 33 pp.

Yuretich, R.F., D.A. Crerar, D.J. Kinsman, J.L. Means and M.P. Borcsik. 1981. Hydrogeochemistry of the New Jersey Coastal Plain: 1. Major-element cycles in precipitation and river water. Chemical Geology 33:1-21.

Windisch, A.G. 1986. Delineation of the New Jersey Pine Plains and associated communities. Skenectada 3:1-16.

Windisch, M.A. and R.A. Zampella. 1989. New Jersey Pinelands surface water quality data, 1983-1988. NJ Pinelands Commission, New Lisbon, NJ.

Windisch, M.A. 1990. New Jersey Pinelands surface water quality data, 1988-1990. NJ Pinelands Commission, New Lisbon, NJ.

Zampella, R.A. 1987. Atlantic white cedar management in the New Jersey Pinelands. In Atlantic white cedar wetlands, A.D. Laderman (ed.), Westview Press, Boulder CO. pp. 295-311.

Zampella, R.A. 1991. Gradient analysis and classification of pitch pine (Pinus rigida Mill.). Ph.D. Dissertation, Rutgers, the State University of New Jersey, New Brunswick, NJ.

Zappalorti, R.T. and E.W. Johnson. 1982. A herpetological survey of Wharton, Lebanon and Belleplain State Forests, with special notes on management of critical habitat. Herpetological Associates, Inc., Staten Island, NY.