A Natural Resource Management Guide for the County of Morris

2000

Acknowledgments

True to the spirit of partnership, the production of the *Natural Resource Management Guide for the County of Morris* relied on the contribution and guidance of County Planning Board staff and interns, scientists from the New Jersey Department of Environmental Protection and New Jersey Geological Survey, United States Geological Survey and experts from local non profit agencies and municipalities. While not wishing to exclude anyone, the following individuals merit notice for their participation: Anne Bowman , Robert Canace, Gene Cass, Raymond Chang, Jeffrey Hoffman, Linda Howe, Meredith Lavery, Gigi Mallepalle, Koren Melfi, Andy Mikula, Dudley Woodbridge and Raymond Zabihach.

Special thanks is offered to Carol Simmons of the Planning Board for her artistic and graphic support.
Sabine von Aulock, Project Manager

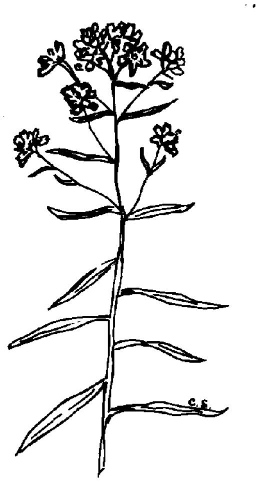
A Natural Resource Management Guide for the County of Morris

Prepared by the
Morris County Planning Board

Contents

* Torrey's Mountain Mint

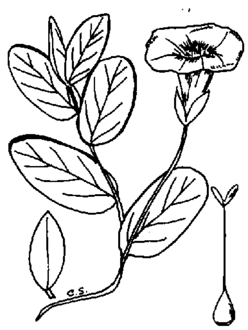
Plates Page



* Sweet Everlasting

Tables Page

* Stiff Clubmoss



* Erect Bindweed

Figures — Page

* Virginia Bunchflower

* Shining Willow

Introduction

Humankind has the ability to exert significant influence on its environment. Our historic activities of creating homes, villages, industry, sustenance, warmth, clothing, and travel have cumulatively impacted our surroundings as we became more "civilized" and sophisticated in our lifestyles. The realization that our capability bears with it a responsibility has been gradually evolving into an ecosystem sensitivity whereby humans are members of equal standing, entitled to no more or less of the resource pool.

The County of Morris is rich in its natural resource heritage. In the 1988 Open Space Element, the Morris County Planning Board acknowledged development pressures on available lands, which are more often than not environmentally sensitive. A worsening of flooding, erosion and sedimentation, among other natural hazards was anticipated resulting from existing development compounded by impacts from future development's disturbances. Therefore a county-wide Natural Resources Inventory was recommended to document resources as well as environmental constraints.

The inventory process resulted in the emergence of recurring themes namely the interrelationships among all natural resources, the far-reaching implications of human impact, and the diverse opportunities for stewardship. This document therefore consists of an inventory of natural resources and corresponding management recommendations. An assortment of maps and illustrations serve to represent historical or existing environmental conditions. Sketches of flora and fauna found in the lower corner of pages, represent species likely to occur in the various communities within the county. Those marked with an asterisk signify species designated as threatened, endangered or rare.

> "The tree in the garden and the tree in the wilderness are both wild; both require our care. We need to reconcile them, to see a natural landscape that is also cultural, in which city, suburb, countryside and wilderness each has its own place."[1]

Note: This document has been formatted so that glossaries and appendices have been located in the back of each chapter. An annotated listing of environmental legislation, referred to in the following chapters, is located on the following page.

---

[1]William Cronon, "The Trouble With Wilderness," The New York Times Magazine, Aug. 13, 1995, 43.

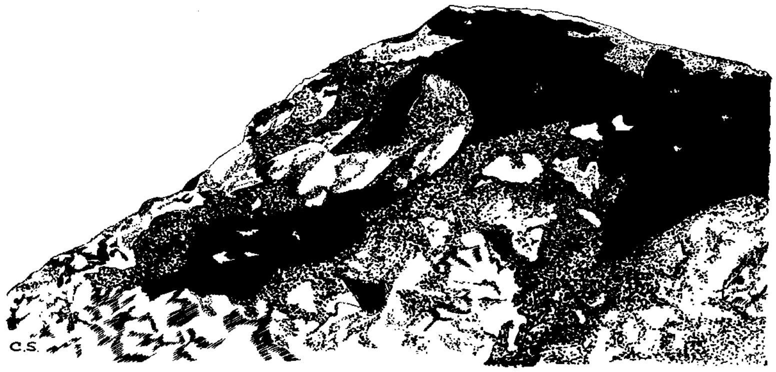
Environmental Protection Regulations

FEDERAL

- Clear Air Act - provided authority for abating air pollution which threatened human health or welfare.
- Clean Water Act - authorizes US EPA to provide grants to states for the development of ground water protection strategies and authorizes various water pollution prevention programs.
- Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) - authorizes government to clean up contamination caused by chemical spills or hazardous waste; enables citizens to sue violators of the law and establishes community right-to-know" programs (Title III) which provides a database on producers of toxic or hazardous materials called the Toxic Chemical Release Inventory.
- Endangered Species Act - determined that endangered and threatened species of fish, wildlife, and plants "are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people." It affirms that in order for these species to survive and prosper, conservation efforts would need to be directed toward "critical habitat."
- Federal Insecticide, Fungicide, and Rodenticide Act - allows US EPA's control of pesticides.
- Resource Conservation and Recovery Act - regulates the storage, transportation, treatment, and disposal of solid and hazardous wastes.
- Safe Drinking Water Act - authorizes US EPA to set standards for maximum levels of contaminants in drinking water, regulates the underground disposal of wastes in deep wells, designates areas that rely on a single aquifer for their water supply, and encourages states to develop programs to protect public water supply wells (e.g., wellhead protection programs).
- Sole Source Aquifer Program - designates critical aquifer areas serving as sole or principal drinking water source for the area. US EPA is required to review federal financially assisted projects planned for an area to determine their potential for contaminating the local aquifer.
- Toxic Substance Control Act: authorizes US EPA to control the manufacture, use, storage, distribution, or disposal of toxic chemicals.

STATE

- County Planning Act (N.J.S.A. 40:27-1 et seq.) - provides jurisdiction over road construction and maintenance and allows input on design of roads and drainage systems
- Endangered and Nongame Species Conservation Act (L.1973, c. 309, § 1) - concerns the conservation, management, enhancement and protection of endangered species and nongame species of wildlife.
- Flood Hazard Area Control Act Rules (N.J.A.C. 7:13-1.1 et seq.) - protects property, water quality, and habitat within floodplain areas and associated watercourses.
- Freshwater Wetlands Protection Act (N.J.S.A. 13:9B-1 et seq.) - preserves freshwater wetlands from disturbance.
- <u>Ground Water Quality Standards</u> (N.J.A.C. 7:9-6 et seq.) - seeks to restore, enhance and maintain the chemical, physical, and biological integrity of waters, to protect public health, to safeguard fish and aquatic life and scenic and ecological values, and to enhance the domestic, municipal, recreational, industrial and other uses of water.
- NJ Safe Drinking Water Act (N.J.S.A. 58:12A-4c et. Seq.) - controls the quality of public drinking water supplies by identifying risk levels (MCLs: maximum contaminant levels).
- NJ Solid Waste Management Act (N.J.S.A. 13:1E-1 et seq.) - mandates counties to develop comprehensive plans of waste management.
- NJ Water Pollution Control Act (N.J.S.A. 58:10A-1 et seq.) - protects uses of water through discharge controls.
- Soil Erosion and Sediment Control Act (N.J.S.A. 4:24-42) - allows jurisdiction over soil erosion and stormwater management aspects of construction activity.
- Standards for Individual Subsurface Sewage Disposal Systems (N.J.A.C. 7:9A) - provides standards for location, design, construction, installation, maintenance of individual subsurface sewage disposal systems.
- Stormwater Management Regulations (N.J.A.C. 7:8-1.1 et seq.) - addresses different stormwater responses resulting from variations in watershed conditions ranging from undeveloped to developed.
- Water Supply Management Act (N.J.S.A. 58:1A-1 et.seq.) - provides the authority for planning and controlling the allocation and provision of water, including emergency restrictions during times of drought. Water supply critical areas may be designated and regulated if severe water supply problems exist.



Geologic History of Morris County

Introduction

This inventory of Morris County's environmental features begins with geology because, indeed, it describes the substrate upon which subsequent layers of soil, water, vegetation, wildlife habitat and microclimates have evolved. An understanding of geologic history contributes to an understanding of human settlement patterns, transportation routes, and the location of certain economic activities. Current application of this understanding can be made in rectifying and preventing the problems associated with these assorted land uses, e.g., depleted aquifers, mine shaft-related cave-ins, sinkholes, and radon hot spots.

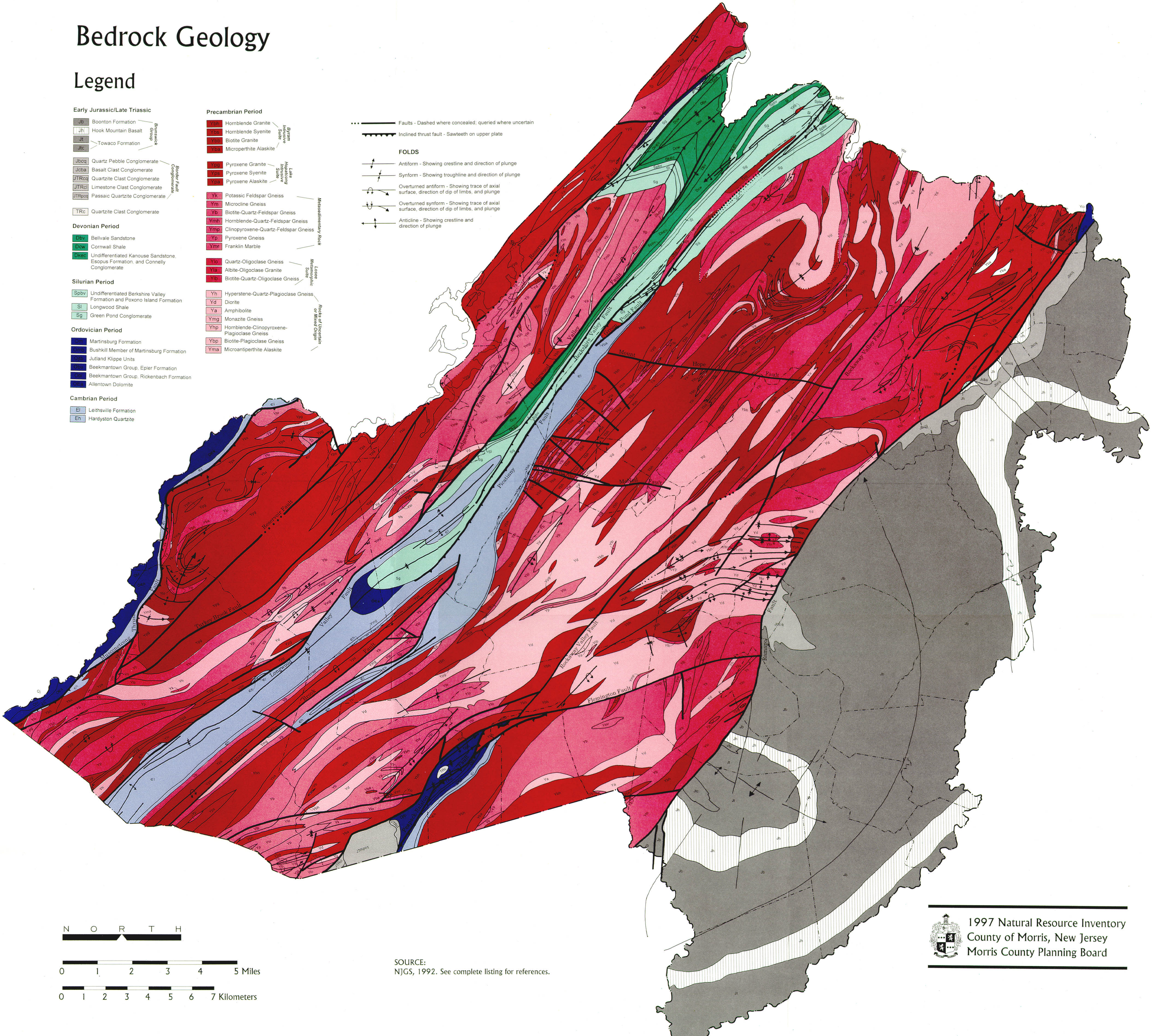
Ancient History

The processes that produced the geologic structures underlying Morris County have been operating for over one billion years. The landscape that we see is the result of cyclical mountain building, erosion, rock relocation into valleys, metamorphosis, and recycled rock being thrust up into mountains again.

Primitive rivers carved channels in the rock, forming deep valleys, only to have their direction reversed in response to the changing tilt of the land mass or the blockage of old drainage ways by erosional deposition. Seas have advanced across the land surface, and then retreated. The climate has changed from tropical to arctic and back to temperate as the landmass itself has drifted nearer then farther from the equator. Glaciers have descended from the north, covered more than half the county, and then melted back; their passage radically reshaping the landscape and trapping the groundwater that serves us today.

Geologic history is traditionally divided according to the duration of time needed to form recognizable rock units. The longest such division is commonly known as an **Era.** Eras are then subdivided into **Periods**. Periods may be further subdivided into **Epochs**. Table 1, on the following page, provides an overview of this chronology. As you continue to read, refer to the corresponding formations depicted on the bedrock geology map **Plate 1**. The variations within this geologic base have contributed to the environmental diversity specific to the county.

Bedrock Geology



SOURCE:
NJGS, 1992. See complete listing for references.

1997 Natural Resource Inventory
County of Morris, New Jersey
Morris County Planning Board

PLATE 1: Bedrock Geology

Table One - Geologic Time Scale

ERA	PERIOD		EPOCH	Millions of Years Ago	Associated Events
Cenozoic	Quaternary		Holocene Pleistocene	present - 0.01 0.01 - 1.6	Glaciers recede; Climate becomes temperate Glaciation Primitive humans; forests flourish
	Tertiary		Pliocene Miocene Oligocene	1.6 -5.3 5.3 - 23.7 23.7 - 36.6	Continents & seas assume present forms Seas recede European & Asian land masses join
Mesozoic	Cretaceous		Late Early	66.4 - 97.5 97.5 - 144	Extinction of dinosaurs Widespread swamps
	Jurassic		Late Middle Early	144 - 163 163 - 187 187 - 208	Dinosaurs thrive; first birds Sedimentation of Newark basin Lava flows from Watchung Mtn. Ridges Formation of Newark basin (Piedmont)
	Triassic		Late Middle Early	208 - 230 230 - 240 240 - 245	Continental drift resulting in rift basins First mammals Desert conditions dominate; then abate
Paleozoic	Permian		Late Early	245 - 258 258 - 286	Closure of Proto-Atlantic; formation of Pangea uplifting of Green Pond & Copperas Mountains. Alleghanian orogeny
	Carboniferous	Pennsylvanian Mississippian	Late Early	286 - 320 320 - 360	Evergreen forests flourish First reptiles
	Devonian		Late Middle Early	360 - 374 374 - 387 387 - 408	Seas advance First amphibians & insects Fish abound
	Silurian		Late Early	408 - 421 421 - 438	First leafless land plants
	Ordovician		Late Middle Early	438 - 458 458 - 478 478 - 505	First vertebrates Taconic orogeny
	Cambrian		Late Middle Early	505 - 523 523 - 540 540 - 570	Shallow seas advance & retreat Grenville Orogeny
Precambrian	Proterozoic Age		Late Middle Early	570 - 900 900 - 1600 1600 - 2500	Erosional sedimentation; volcanic activity Sea floor spreading forming "Proto-Atlantic"
	Archean Age		Late Middle Early	2500 - 3000 3000 - 3400 3400 - 3800?	

Sources: Cotterill, Rodney, Editor, The Cambridge Guide to the Material World, 1985
New Jersey Geological Survey, Information Circular 1, 1990
The Geological Society of America, The Geologic Time Scale, 1983
Wolfe, Peter E., and Crane, The Geology and Landscapes of New Jersey, 1977

The Precambrian Era

The Formation of the Highlands Province

The Precambrian Era extends from the beginning of the earth, more than four billion years ago, to the beginning of the Paleozoic Era 570 million years ago. The rocks of the mountains in western Morris County, formed during the middle Proterozoic period (latter part of the Precambrian), are among the most ancient rocks in North America. They are part of a formation resulting from chemical precipitation of calcareous sediments, running northeast to Newfoundland and west across the Hudson Bay.

These sediments, and other non-calcareous sediments, compacted into layers of sandstone, shale, and limestone. As these layers deepened over millions of years, heat and pressure metamorphosed them into banded gneiss and marble. Meanwhile volcanic activity produced lava flows, creating additional intruding layers of igneous rock--granites and feldspars. These layered formations are the bedrock of the N.J. Highlands and have created a landscape characterized by hilly uplands adjacent to steep river cuts.

The Highlands formations transformed dramatically while being deformed, folded, faulted, and thrust up into mountains. Intense heat and shearing compression further metamorphosed the rock, creating a rich complex of mineral deposits, some unique to New Jersey. From the Revolutionary War period to the twentieth century, mineral prospecting and mining, particularly of magnetite iron ore, were basic economic activities in much of western Morris County and the impetus for settling patterns. **Plate 2** depicts abandoned Iron Mines, as well as active and abandoned sand and gravel operations. Compare their locations with the Bedrock Geology map in this chapter, and the Landforms map in Chapter 2.

Over time, the Proterozoic bedrock of the Highlands has been fractured, faulted, and jointed as a result of both crustal movement and the compression, slippage, and crushing of grains that comes from bearing the weight of thousands of feet of rock. Most fractures and faults trend in a generally northeasterly direction. The nature of these cracks and faults affect the presence of ground water, its movement, and the potential for contamination.

The Paleozoic Era

Erosion and More Mountain Building

Near the beginning of the Paleozoic Era, 570 million years ago, the center of the continental land mass, from the Highlands to Utah, was covered with the shallow warm waters of a vast sea. During Proterozoic, Cambrian, and much of Ordovician time, rivers in the Highlands flowed southeasterly, washing mountain sediments onto the continental shelf of the spreading proto-Atlantic Ocean. Metamorphosed, these sediments would form the "basement" for the Mesozoic Newark Basin (Piedmont province).

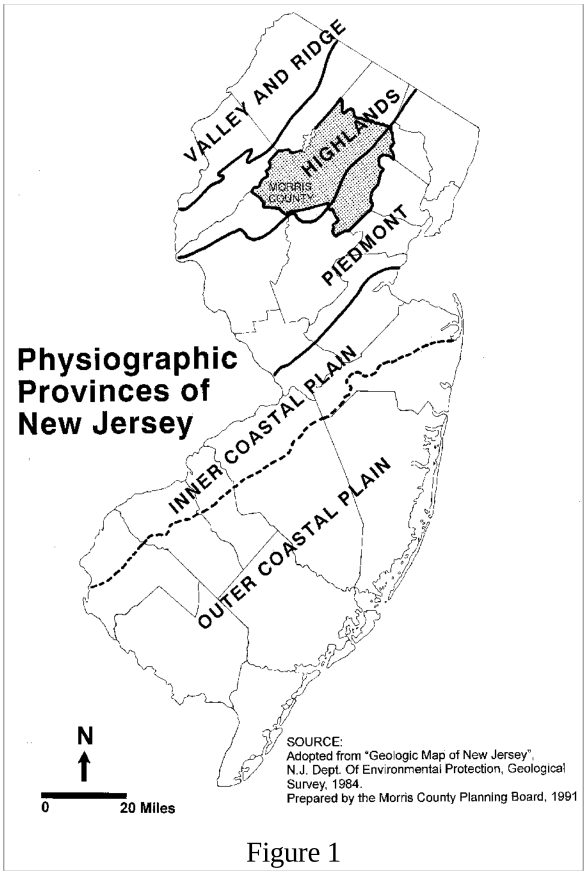


Figure 1

During the Silurian, with tilting of the continental landmass, the Highlands ridges uplifted further, and the rivers shifted their direction north and westward. Erosional debris, also washing westward, gathered in the valleys and compacted into new shales, sandstones, siltstones, and conglomerates. In Morris County, the eroding Highlands ridges formed the sedimentary rock belts of the Musconetcong valley and of the wide valley that runs northeast from Long Valley in Washington Township to the Oak Ridge Reservoir in Jefferson Township, as well as Picatinny Valley in Rockaway Township. Parallel to these valleys are ridges also derived from sedimentary rock, folded up out of the valley floor, e.g., Green Pond, Brown, and Copperas Mountains, and part of Bowling Green Mountain (refer to the Landform map in Chapter 2).

The Mesozoic Era

Newark Basin and Basalt Ridges of the Piedmont

During the Late Triassic, the rift in the Atlantic Ocean floor began to spread again, pushing North America westward. This process continues today. Parallel to this spreading rift, along the edge of the North American land mass, a series of inland basins formed as the Highlands was raised once more. The eastern part of Morris County lies within one of these northeast trending rift basins. Known as the Newark Basin, the western edge is formed by the Highlands escarpment, along which runs the Border or Ramapo Fault, extending from Mahwah through Boonton and Morristown to Gladstone. These features separate the Highlands from the Piedmont province.

ERA	EPOCH	TIME
Cenozoic	Holocene	present-0.016
	Pleistocene	0.016 - 1.0
	Pliocene	1.0 - 5.3
	Miocene	5.3 - 23.7
	Oligocene	23.7 - 36.6
	Eocene	36.6 - 57.8
	Paleocene	57.8 - 66.4
Mesozoic	Cretaceous	66.4 - 144
	Jurassic	144 - 208
	Triassic	208 - 245
Paleozoic	Permian	245 -286
	Pennsylvanian	286 - 320
	Mississippian	320 - 360
	Devonian	360 - 408
	Silurian	408 - 438
	Ordovician	438 - 505
	Cambrian	505 - 570
Precambrian	Late Proterozoic	570 - 900
	Middle Proterozoic	900 - 1600

Continuing into the early Jurassic period, sediments washed from both the Highlands slopes and the eastern upland area of the Manhattan Prong, and were deposited along rivers and in lakes within the Newark Basin, atop the Proterozoic rock. Mud, clays, silts, and gravel were deposited in broad alluvial fans on the basin floor. There they settled, compacted, hardened, and became the characteristic sedimentary reddish-brown sandstones, conglomerates, siltstones, and shales of the Brunswick Group.

"Three major (volcanic) eruptions spread lava across the Newark Basin. The lava solidified into the igneous basalt units of the Brunswick Group. Each basalt layer was covered by additional sediment coming off the Highlands. The continual rifting and tectonic activity resulted in the tilting of the basin to the northwest. The softer sedimentary units . . . eroded away, leaving behind the more resistant igneous rocks. These now underlie the ridges called the Watchung Mountains."[1]

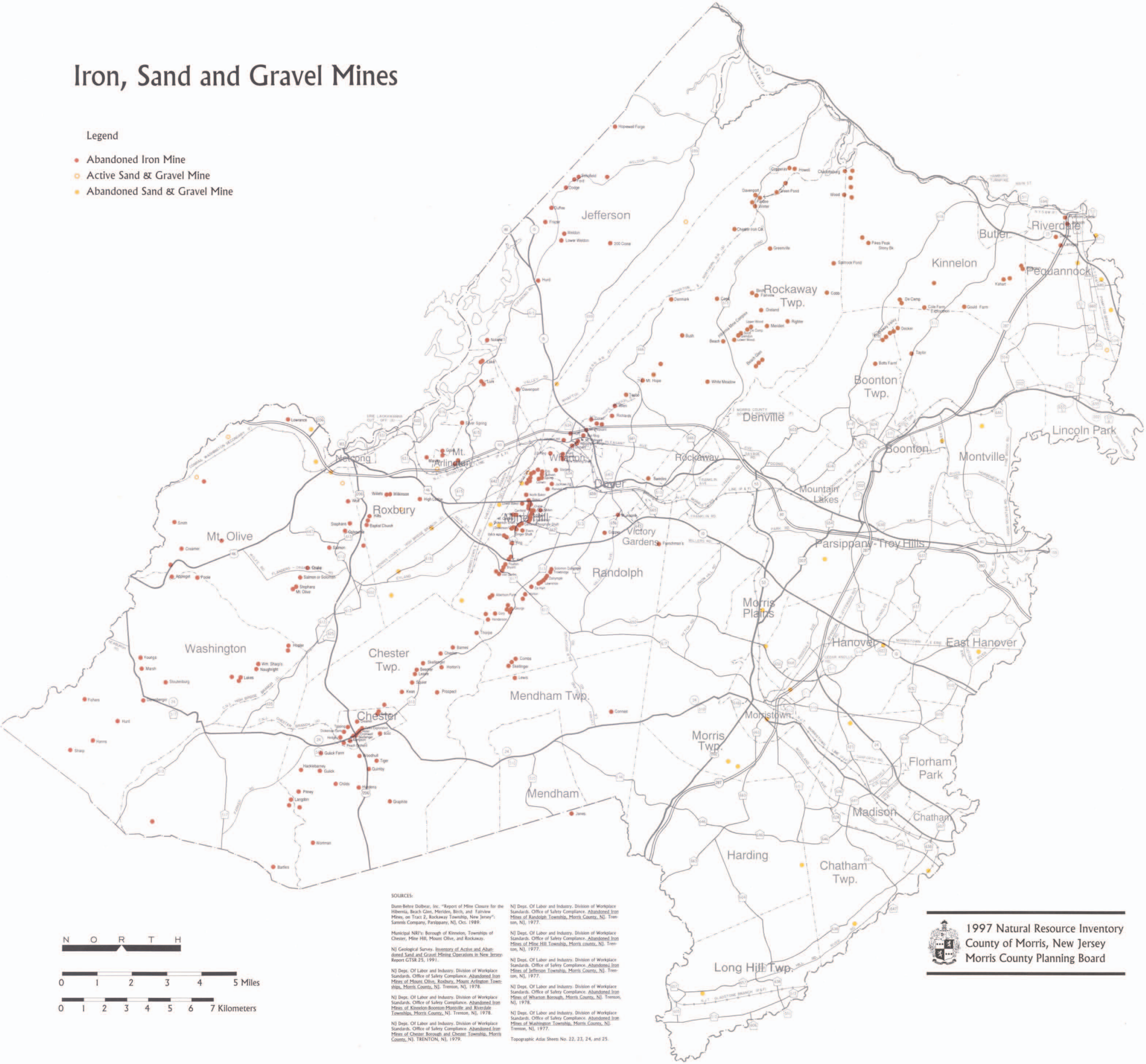
---

[1]Jeffrey L. Hoffman, Supervising Hydrogeologist, New Jersey Department of Environmental Protection. Personal correspondence, March 27, 1997.

Iron, Sand and Gravel Mines

Legend

- Abandoned Iron Mine
- Active Sand & Gravel Mine
- Abandoned Sand & Gravel Mine



N O R T H

0 1 2 3 4 5 Miles

0 1 2 3 4 5 6 7 Kilometers

SOURCES:

Dunn-Behre Dolbear, Inc. "Report of Mine Closure for the Hibernia, Beach Glen, Meriden, Birch, and Fairview Mines, on Tract 2, Rockaway Township, New Jersey": Sammis Company, Parsippany, NJ, Oct. 1989.

Municipal NRI's: Borough of Kinnelon, Townships of Chester, Mine Hill, Mount Olive, and Rockaway.

NJ Geological Survey. Inventory of Active and Abandoned Sand and Gravel Mining Operations in New Jersey: Report GTSR 25, 1991.

NJ Dept. Of Labor and Industry. Division of Workplace Standards. Office of Safety Compliance. Abandoned Iron Mines of Mount Olive, Roxbury, Mount Arlington Townships, Morris County, NJ. Trenton, NJ, 1978.

NJ Dept. Of Labor and Industry. Division of Workplace Standards. Office of Safety Compliance. Abandoned Iron Mines of Kinnelon-Boonton-Montville and Riverdale Townships, Morris County, NJ. Trenton, NJ, 1978.

NJ Dept. Of Labor and Industry. Division of Workplace Standards. Office of Safety Compliance. Abandoned Iron Mines of Chester Borough and Chester Township, Morris County, NJ. TRENTON, NJ, 1979.

NJ Dept. Of Labor and Industry. Division of Workplace Standards. Office of Safety Compliance. Abandoned Iron Mines of Randolph Township, Morris County, NJ. Trenton, NJ, 1977.

NJ Dept. Of Labor and Industry. Division of Workplace Standards. Office of Safety Compliance. Abandoned Iron Mines of Mine Hill Township, Morris county, NJ. Trenton, NJ, 1977.

NJ Dept. Of Labor and Industry. Division of Workplace Standards. Office of Safety Compliance. Abandoned Iron Mines of Jefferson Township, Morris County, NJ. Trenton, NJ, 1977.

NJ Dept. Of Labor and Industry. Division of Workplace Standards. Office of Safety Compliance. Abandoned Iron Mines of Wharton Borough, Morris County, NJ. Trenton, NJ, 1978.

NJ Dept. Of Labor and Industry. Division of Workplace Standards. Office of Safety Compliance. Abandoned Iron Mines of Washington Township, Morris County, NJ. Trenton, NJ, 1977.

Topographic Atlas Sheets No. 22, 23, 24, and 25.

1997 Natural Resource Inventory
County of Morris, New Jersey
Morris County Planning Board

PLATE 2: Iron, Sand and Gravel Mines

The Cenozoic Era

Erosion and Glaciation Sculpt the Landscape

Between the end of the Mesozoic Era (about 65 million years ago) and the beginning of the Quaternary Ice Ages (1.75 million years ago), erosion was the primary process shaping the land. Mountain building had temporarily ceased, and vegetation and forests covered the land, decelerating the erosion. The slight uplift of the Highlands during the Mesozoic caused streams to run fast and southeastward. They carved out valleys in softer shales and sandstones and helped form the gently rolling table-top, or **peneplain**, of Schooleys Mountain in Washington Township.

Three glacial advances reached New Jersey during the Pleistocene period: the Kansan (first), the Illinoisan (second), and the Wisconsinan (third). The last ice sheets of the Wisconsinan glaciation retreated northward about 17,000 years ago.[2] Remnant scars and gouges on rock outcroppings suggest that two lobes of ice from the north (one west and one east) descended across northern New Jersey. These lobes met and stopped in Morris County somewhere along the ridge of Stony Brook Mountain in Kinnelon.

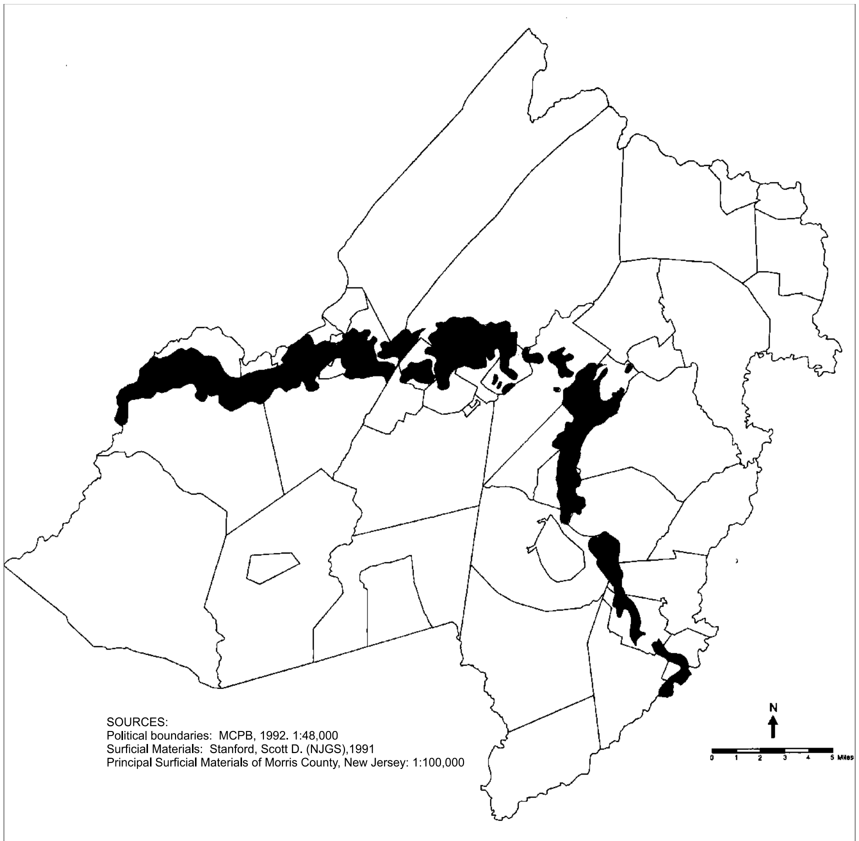


Figure 2 - Terminal Moraine

"As the glacier advanced, some material was deposited beneath it in hard till beds. Other material came out at the front of the glacier whenever melting overpowered the advance. The glacier remained at its maximum extent long enough to leave a thick deposit of sand, silt, clay, gravel, pebbles, cobbles and boulders called the **terminal moraine**."[3] (Figure 2).

---

[2] Scott D. Stanford, New Jersey Geological Survey. "The Glacial Geology of New Jersey," Hydrogeology of the Glacial Deposits of New Jersey: An Applied Field Course Cook College and Rutgers University, 1992), 20.

[3] Jeffrey Hoffman. Correspondence, March 27, 1997.

"The glacier did not erode all of the unconsolidated material in its path as it advanced southwards. Glacial melt-water streams deposited sand gravel in preglacial river valleys. Where not eroded away, the sand and gravel was covered by till, forming a **buried valley aquifer** system (Figure 3) which provides drinking water for much of northern and eastern Morris County."[4]

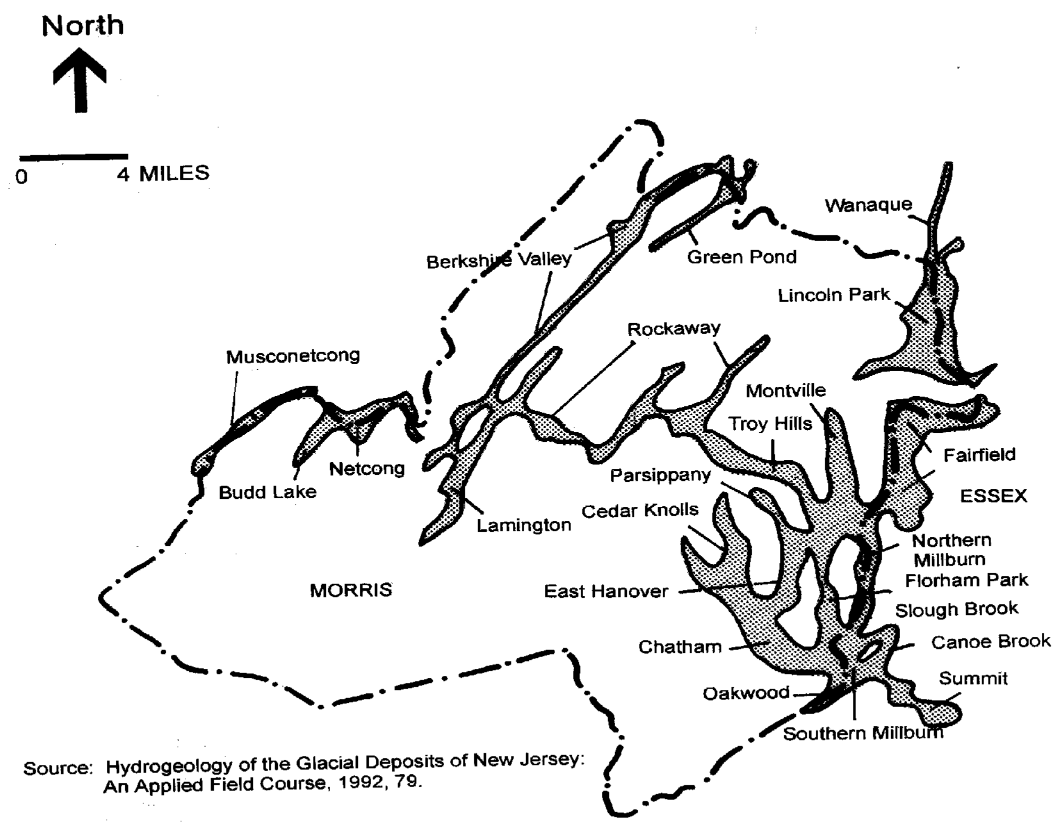


Figure 3 - Buried Valley Aquifer

Much of the evidence of the first two glaciations has been erased from Morris County by the action of the Wisconsinan glacier. However isolated patches of glacial drift from the Kansan glacier have been found in Mendham and along the North Branch of the Raritan; and of the Illinoisan just south of the Wisconsinan terminal moraine, in Dover, Denville, and Flanders.

Management Considerations

Because natural hazards are often exaggerated by human activity, there is a need to develop legislation, regulations, and management practices to protect human welfare as well as that of our natural resources.

---

[4]Jeffrey Hoffman. Correspondence, March 27, 1997.

Impacts From Natural Hazards

In Morris County, threats from geologic natural hazards are varied in intensity. Though the county is still shaken occasionally by a minor earthquake, risk to human health and property is relatively small. **Plate 3** provides an historical perspective of seismic activity in the county. Other hazards, however, such as cave-ins, erosion, and radon present significant issues justifying management intervention.

Sinkholes: Limestone formations are often prolific ground water suppliers. The very hydraulic characteristics that enable excellent aquifer recharge and ground water availability, also allow vulnerability to ground water contamination. When overlying land is disturbed, subsequent stormwater runoff may enlarge fractures, forming cavities and ultimately sinkholes.

Cave-ins: Remnants of a previously active mining industry have produced serious cave-in threats, if not actual incidences (e.g. Mine Hill) posing serious safety concerns for overlying structures and inhabitants.

Radon: An odorless, tasteless, and invisible radioactive gas, radon is produced during the decay of Uranium. Sources can be found in soils and rocks containing uranium, granite, shale, phosphate, and pitchblende, typical in the Highlands. A natural component in the atmosphere, radon does not pose a threat when outdoors. It can, however, pose a danger when concentrated in a confined environment. Generally, the greater the exposure to radon, the greater the risk for developing lung cancer.

Typical human exposure to Radon occurs in the home, particularly the basement or ground level. Access points normally are dirt floors, cracks in concrete floors and walls, floor drains, sumps, tiny cracks or pores in hollow-block walls, and water supply pipes. Indoor Radon concentrations can vary from day to day, season to season, and within different parts of a home. A person's total accumulated radon exposure from a particular home depends on several factors including:

- average concentration of radon in the home
- number of years a person has lived in the home
- amount of time spent at home each day[1]

Radon is practically ubiquitous in New Jersey, although concentration reflects the underlying geology. New Jersey Department of Environmental Protection's 1987 <u>Overview of Initial Results Statewide Scientific Study of Radon</u> reported on the testing of approximately 5300 homes for naturally occurring radon. Average indoor Radon concentrations fluctuated widely based on geographic distribution:

- Average concentration of 8.1 pCi/l was found in the Highlands region (Reading Prong).
- Average concentration in the Piedmont region was 4.2 pCi/L.

Whether remediation measures need to be taken or not, steps to safeguard your environment include:

- increase ventilation in your home
- limit the amount of time spent in the areas of highest concentration
- stop smoking and discourage smoking in your home[2]

---

[1]N.J. Department of Health, Division of Occupational and Environmental Health, <u>Facts and Recommendations on Exposure to Radon</u>, 2.

[2]N.J. Department of Health.

Because health concerns regarding radon exposure were translated to equity issues, quantifying its indoor presence has become standard real estate transactional procedure. Different sampling techniques produce results expressed in either "working levels" (WL) measuring radon decay products or "picocuries per liter (pCi/l)" measuring concentrations of Radon gas. A generalized prescription for remedial action follows:

>1.0 WL or >200 pCi/l	= perform follow-up measurements as soon as possible.
>0.1 WL-10.0 WL or 20 pCi/-200 pCi/l	= perform follow-up measurements.
0.02 WL-0.1 WL or 4 pCi/1-20 pCi/l	= perform follow-up measurements.
<0.02 WL or <4 pCi/l	= follow-up measurements are probably not required.

Earthquakes: While faultlines run throughout the quantity, likelihood of significant earthquakes is remote. Nonetheless there are rumblings as depicted on **Plate 3**. The primary relevance to today's land use activities is in terms of occurrence of ground water supplies within the underlying geology and vulnerability to contamination through the these lines.

Human Derived Impacts

Development Over Limestone formations: "The solution of the bedrock causes surface depressions, open drainage passages, and the development of irregular, sub-surface rock topography known as karsts. These conditions make such areas unstable and susceptible to subsidence and surface collapse. As a result, the alteration of drainage patterns in these areas by the placement of impervious coverage, grade changes, or increased loads from site improvements can lead to land subsidence and sinkholes."[3]

These enlarged fractures and fissures also contribute to increased vulnerability of ground water contamination. Sources of contamination can include discharges to groundwater, septic system effluent, or contaminated surface water.

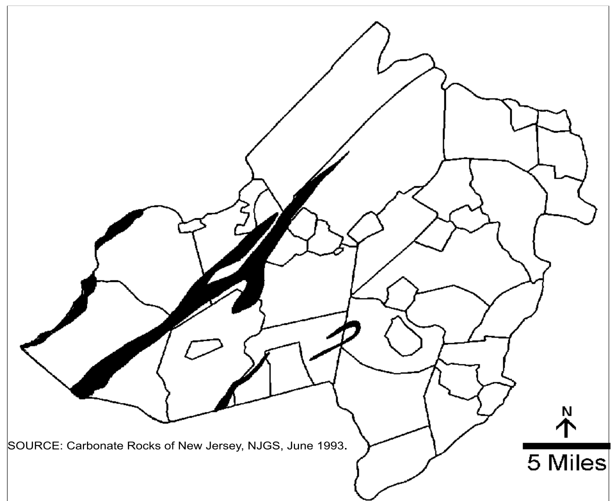
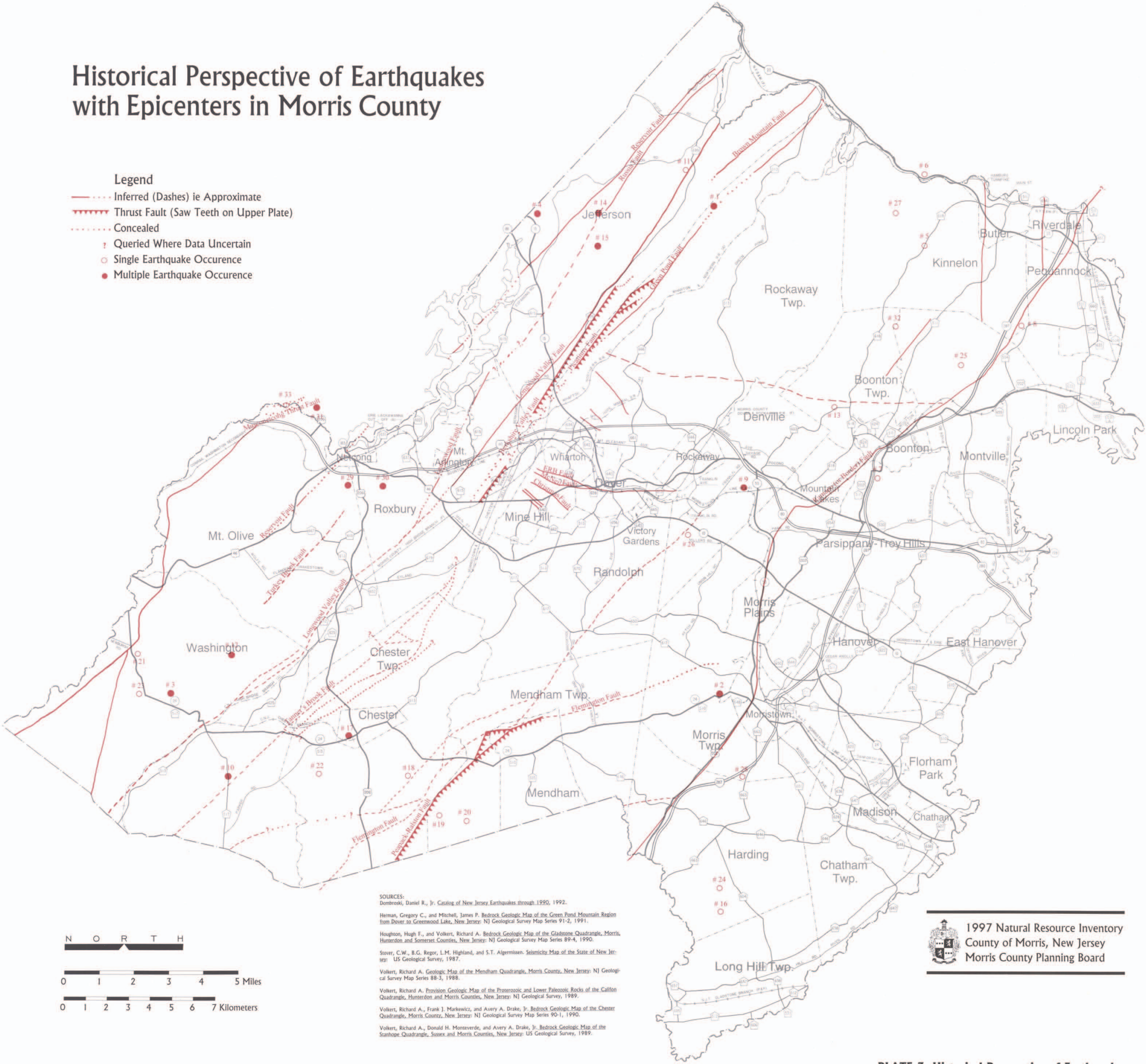


Figure 4 - Limestone Formation

Ground Water Contamination: The availability and vulnerability to contamination of ground water correlates directly to geology. Likewise, the geologically influenced connection between ground water and surface water bears implications for pollutant migration. These interactions will be described further in the ground water chapter.

[3]North Jersey Resource Conservation and Development Council. "Model Limestone Ordinance," August, 1993.

Historical Perspective of Earthquakes with Epicenters in Morris County



SOURCES:

Dombroski, Daniel R., Jr. Catalog of New Jersey Earthquakes through 1990, 1992.

Herman, Gregory C., and Mitchell, James P. Bedrock Geologic Map of the Green Pond Mountain Region from Dover to Greenwood Lake, New Jersey: NJ Geological Survey Map Series 91-2, 1991.

Houghton, Hugh F., and Volkert, Richard A. Bedrock Geologic Map of the Gladstone Quadrangle, Morris, Hunterdon and Somerset Counties, New Jersey: NJ Geological Survey Map Series 89-4, 1990.

Stover, C.W., B.G. Regor, L.M. Highland, and S.T. Algermissen. Seismicity Map of the State of New Jersey: US Geological Survey, 1987.

Volkert, Richard A. Geologic Map of the Mendham Quadrangle, Morris County, New Jersey: NJ Geological Survey Map Series 88-3, 1988.

Volkert, Richard A. Provision Geologic Map of the Proterozoic and Lower Paleozoic Rocks of the Califon Quadrangle, Hunterdon and Morris Counties, New Jersey: NJ Geological Survey, 1989.

Volkert, Richard A., Frank J. Markewicz, and Avery A. Drake, Jr. Bedrock Geologic Map of the Chester Quadrangle, Morris County, New Jersey: NJ Geological Survey Map Series 90-1, 1990.

Volkert, Richard A., Donald H. Monteverde, and Avery A. Drake, Jr. Bedrock Geologic Map of the Stanhope Quadrangle, Sussex and Morris Counties, New Jersey: US Geological Survey, 1989.

1997 Natural Resource Inventory
County of Morris, New Jersey
Morris County Planning Board

PLATE 3: Historical Perspective of Earthquakes with Epicenters in Morris County

An Historical Perspective Of Earthquakes With Epicenters In Or Near Morris County

ID	DATE	LOCATION	INTENSITY	ID	DATE	LOCATION	INTENSITY
1	11/24/1783	Near Petersburg	IV	12	12/26/1977	Schooley's Mt.	1.7 Felt
1	11/29/1783	Near Petersburg	VI	13	02/15/1978	Boonton	1.6
1	11/30/1783	Near Petersburg	IV	14	05/18/1978	Milton	1.5 Felt
1	11/30/1783	Near Petersburg	VI	15	06/12/1978	Woodstock	no data
1	11/30/1783	Near Petersburg	IV	15	06/15/1978	Woodstock	no data
2	08/10/1880	Near Morristown	III	14	06/30/1978	Milton	IV
2	09/01/1880	Near Morristown	III	14	06/30/1978	Milton	III
3	03/23/1957	Schooley's Mt.	VI	16	01/30/1979	Harding	V
4	08/14/1969	Lake Hopatcong	1.0	17	02/01/1979	Chester	1.9
4	09/14/1969	Lake Hopatcong	1.0	18	02/01/1979	Chester	III 1.9
4	10/06/1969	Lake Hopatcong	IV 1.3	19	02/01/1979	Mendham Twp.	1.8
4	10/10/1969	Lake Hopatcong	1.0	17	02/01/1979	Chester	1.5
4	11/03/1969	Lake Hopatcong	1.0	20	02/02/1979	Mendham Twp.	III
5	01/17/1976	Riverdale	1.8	21	02/23/1979	Washington	no data
6	03/11/1976	Riverdale	V 2.8	22	02/23/1979	Chester	IV
7	03/11/1976	Near Boonton	VI	23	02/23/1979	Washington	1.8
8	03/12/1976	Riverdale	2.2 Felt	24	03/09/1979	Harding	V 3.1
9	10/27/1976	Denville	Foreshock 1.0	4	03/22/1979	Lake Hopatcong	no data
9	10/27/1976	Denville	1.0	25	03/19/1981	Boonton	2.0
9	10/28/1976	Denville	Aftershock 1.0	26	06/01/1983	Dover	1.5
3	12/05/1976	Schooley's Mt.	III	27	06/03/1984	Kinnelon	1.3
10	12/05/1976	Schooley's Mt.	1.8 Felt	28	06/06/1984	Near Morristown	1.7
10	12/06/1976	Schooley's Mt.	1.7 Felt	29	08/01/1984	Mt. Olive	1.7
11	01/06/1977	Near Green Pd.	no data	30	10/25/1984	Near Mt. Olive	2.0
12	12/04/1977	Schooley's Mt.	1.8 Felt	31	12/02/1984	Byram, Sussex Co.	1.5
12	12/04/1977	Schooley's Mt.	2.1 Felt	31	12/13/1984	Byram, Sussex Co.	1.7
12	12/06/1977	Schooley's Mt.	1.6 Felt	29	12/15/1984	Byram, Sussex Co.	1.8
12	12/07/1977	Schooley's Mt.	2.3 Felt	31	12/17/1984	Byram, Sussex Co.	1.6
12	12/23/1977	Schooley's Mt.	1.4 Felt	30	02/08/1986	Flanders	1.7
12	12/24/1977	Schooley's Mt.	1.6 Felt	32	06/29/1986	Kinnelon	1.5
12	12/25/1977	Schooley's Mt.	1.5 Felt	33	04/24/1987	S. of Mohawk Lake, Sussex Co.	1.9

INTENSITY*	EQUIV.MAGNITUDE**	EFFECTS
I	1.9	Usually imperceptible to people
II	2.5	Felt indoors by few; some gentle swaying of suspended objects and liquids
III	3.1	Felt indoors by several; sensation of passing light truck traffic
IV	3.7	Felt indoors by many; causes creaks, rattle, and swinging of hanging objects
V	4.3	Felt indoors by most; buildings tremble; swinging or moving most objects
VI	4.9	Felt indoors by all; cracking and falling of plaster; falling of small-sized objects

*modified Mercalli intensity-The Mercalli scale ranks earthquakes from I through XII, although in this table only I through VI are shown because the most intense earthquake in Morris County ranked VI.
**Although earthquakes of the same maximum intensity do not always have the same magnitudes. [4]
Most earthquake activity in the county has been related to movement along the Ramapo and Green Pond Faults, as well as the Long Valley Fault centered in Hunterdon County.

---

[4]Daniel Dombroski Jr., "Catalog of New Jersey Earthquakes Through 1990." (Trenton: New Jersey Geological Survey, 1992)

Regulatory Support

- **Standards for Individual Subsurface Sewage Disposal Systems** preventing hydraulic restrictiveness due to characteristics of rock substratum

Planning Strategies

- Inventory geologically sensitive areas and associated constraints (e.g., location of limestone formation and buried valley aquifers, and sources of potential contaminants)
- Identify potential threats to life and property (e.g., historic mining activities and associated potential for cave-ins)
- Provide a stormwater management plan that would match land uses to underlying geology, respective of particular environmental sensitivities such as limestone formations
- Include notable geologic formations in Open Space Plan, providing protective measures including acquisition

Design Strategies

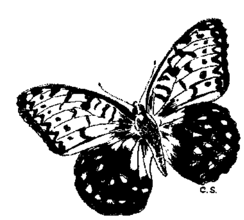
- Implement stormwater management plan (e.g., providing water quality protection in geological areas vulnerable to infiltrating contaminants; strategic location of stormwater detention basin within limestone formations; maximizing ground water recharge)
- Septic management plan appropriate to existing geologic conditions such as limestone formations
- Arrange cooperative agreements with public and private agencies to cap mine shafts
- Minimize impervious surface to maintain hydrologic regime in geologically sensitive areas such as sand and gravel, and limestone areas

Zoning and Site Plan Ordinance

- Modifying development regulations to require identification and location of geologic hazards on all subdivision and site plan submissions
- Limestone Formation Protection Ordinance (North Jersey Resource Conservation and Development Council) addressing geologically appropriate site investigation and design, construction and soil disturbance requirements, response to sinkhole formations, and stormwater runoff management
- Well Head Protection Area Ordinance

Practices

- Township of Washington's Ordinance regulating activities in the carbonate area district overlay zone. Underground storage tanks for petroleum products are not permitted in residential developments. Commercial businesses, too, excepting service stations, are not permitted underground storage tanks, unless required for public safety.
- Radon testing and mitigation education provided by the New Jersey Radon Section and NJ DEP (1-800-648-0394).



Regal Fritillary

References For Morris County Bedrock Geology Map

Baker, D.R., and A.F. Buddington. Geology and Magnetite Deposits of the Franklin Quadrangle and Parts of the Hamburg Quadrangle, NJ: US Geological Survey Professional Paper 638, 1970.

Bayley, W.S., R.D. Salisbury and H.B. Kummel. Raritan Folio, NJ: USGS Geologic Atlas, Folio 191, 1914.

Drake, A.A., Jr., et al. Bedrock Geologic Map of the Tranquility Quadrangle, Sussex, Warren, and Morris Counties, NJ: USGS Geologic Quadrangle Map GQ-1717, in press.

Drake, A.A., Jr., et. Geologic Map of NJ, Northern Bedrock Sheet: USGS, in press.

Herman, G.C. and J.P. Mitchell. Bedrock Geology of the Green Pond Mountain Region From Dover to Greenwood Lake, NJ: NJGS Geological Map Series 91-2, 1991.

Herman, G.C., and R.A. Volkert. Geological Map of the Newfoundland Quadrangle, Passaic, Morris and Sussex Counties, NJ: NJGS Geologic Map Series, in press.

Houghton, H.F. Unpublished data.

Houghton, H.F. and R.A. Volkert. Bedrock Geologic Map of the Gladstone Quadrangle, Morris, Hunterdon and Somerset Countries, NJ: NJGS, Geologic Map Series 89-4, 1989.

Minard, J.P. The Geology of Peapack-Ralston Valley in North-Central NJ: Unpublished M.S. Thesis, Rutgers University, New Brunswick, 1959.

Parker, R.A. Stratigraphic Relations of the Sedimentary Rocks Below the Orange Mountain Basalt (Lower Jurassic) Northern Newark Basin, New Jersey and New York: USGS Miscellaneous Field Studies Map MF-2208, 1992.

Parker, R.A., H.F. Houghton, and R.C. McDowell. Stratigraphic Framework and Distribution of Early Mesozoic Rocks of the Northern Newark Basin, New Jersey and New York, in, Froehlich, A.J., and Robinson, G.R., Studies of the Early Mesozoic Basins of the Eastern United States: USGS Bulletin 1776,.1988.

Sims, P.K. Geology and Magnetite Deposits of the Dover District, Morris County, NJ: USGS Prof. Paper 287, 1958.

Volkert, R.A. Geologic Map of the Mendham Quadrangle, Morris County, NJ: NJGS Geol. Map Series 88-3, 1988a.

Volkert, R.A. Provisional Geologic Map of the Proterozoic and Lower Paleozoic Rocks of the Califon Quadrangle, Hunterdon and Morris Counties, NJ: NJGS Geologic Map Series 89-3, 1989.

Volkert, R.A. Provisional Geologic Map of the Proterozoic Rocks of the Morristown Quadrangle, NJ: NJGS Geologic Map Series 88-4, 1988b.

Volkert, R.A., D.H. Monteverde, and A.A. Drake, Jr. Bedrock Geology Map of the Hackettstown Quadrangle, Morris, Warren and Hunterdon Counties, NJ: NJGS Geologic Map Series, in press.

Volkert, R.A., D.H. Monteverde, and A.A. Drake, Jr. Geologic Map of the Stanhope Quadrangle, Morris and Sussex Counties, NJ: US Geological Survey Geologic Quadrangle Mag GQ-1671, 1989.

Volkert, R.A., F.J. Markewicz, and A.A. Drake, Jr. Bedrock Geologic Map of the Chester Quadrangle, Morris County, NJ: NJ Geological Survey Geologic Map Series 90-1, 1990.

Volkert, R.A. Unpublished data.

Young, D.A. Petrology and Structure of the West-Central NJ Highlands: Unpublished Phd. Dissertation, Brown University, Providence, Rhode Island, 1969.

Glossary

BASALT Fine grained, dark colored, volcanic rock; dominant rock of Hook Mountain and Long Hill.

BEDROCK Solid rock below soil and rock fragments, sometimes exposed at surface.

CONGLOMERATE Pebbles or cobbles embedded in a fine-grained matrix of sand or silt. Reddish Greenpond conglomerate was a frequent choice for foundations for the county's historic homes.

CONSOLIDATED SEDIMENTS Sediments compressed and/or cemented together into a rock.

DOLOMITE Crystalline calcium magnesium carbonate; a metamorphosed limestone. Common in the Highlands.

GNEISS A coarse grained, metamorphic rock commonly composed of bands of mineral components, which may include quartz, feldspar, mica, and hornblende. A dominant rock type of the Highlands.

GRANITE A coarse grained, igneous rock composed primarily of quartz and feldspar. Common in the Highlands.

IGNEOUS ROCK One of three basic rock types formed by the cooling and solidification of lava.

MARBLE A recrystallized and metamorphosed limestone or dolomite.

METAMORPHIC ROCK One of three basic types of rock formed as the result of temperature, pressure, shearing stress, or chemical activity, drastically changing the integrity of pre-existing rock.

QUARTZ A very common crystalline mineral, an oxide of silicon. Common in the Highlands.

SEDIMENTARY ROCK One of three basic types of rock formed by the consolidation and cementing of loose sediments, such as sand, silt, or gravel.

SHALE A fine-grained sedimentary rock consisting of tightly packed sediments less than 1/16mm in diameter. Most shales were formed from mud deposited on lake bottoms, along rivers, or in oceans.

SLATE A very fine grained rock, derived by the metamorphosis of rocks such as shale or volcanic ash.

TILL Rocky material (clay, sand, gravel, stones, boulders) picked up by glacial ice and deposited elsewhere. Specific characteristics depend upon parent material. Most glacial till in Morris County derives from Highlands rocks. Till may be stratified (sorted into layers according to the size of rock particles) or mixed (unsorted and poorly stratified).

UNCONSOLIDATED SEDIMENTS Loose clay, sand, and gravel sediments.

Topography and Landforms

Introduction

In Chapter One we had a glimpse at the ancient geologic processes responsible for creating our global foundation. Chapter Two will explore the subsequent events shaping that foundation into the landscape we inhabit today.

The basic topographical configurations, or landforms, of Morris County correlate well with the underlying geology (**Plate 4**). Two separate regions, referred to as the Highlands and the Piedmont, are the physiographic provinces containing these configuration of similar geologic origin, type, and age (Figure 1). Landforms within the Highlands include generally northeast trending ridges and valleys gradually dropping in elevation from west to east. A 200-400 foot border escarpment on the eastern edge, traversing the county from Kinnelon through Morristown, separates the Highlands from the adjacent Piedmont.

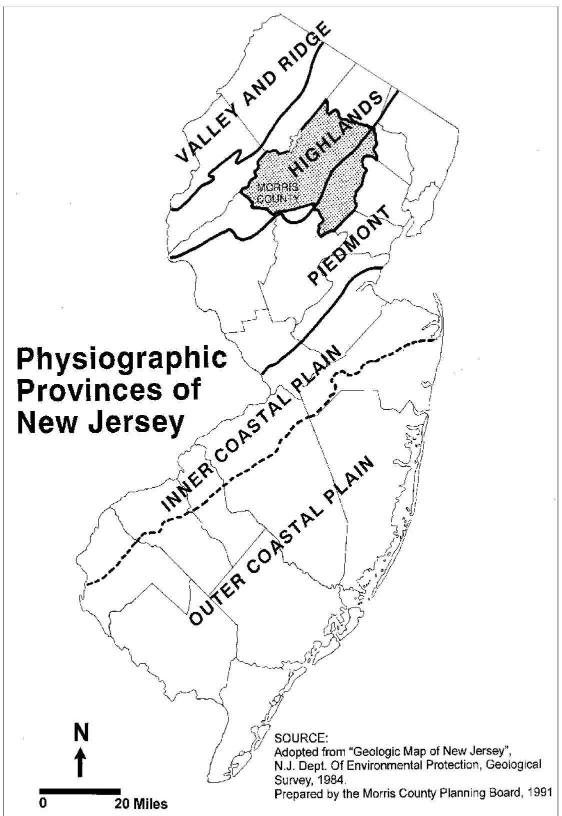


Figure 1

The Landscape

The Highlands form three identifiable ridges of mountains. Collectively referred to as the Reading Prong, these ridges begin in Reading, Pennsylvania, and run through northern New Jersey, the New York Hudson Highlands and into western Connecticut. Schooleys Mountain, Mase Mountain, Bowling Green Mountain, and Mount Paul are part of the second ridge of the Highlands. The peaks and plains east of the mountain ranges including Fox Hill and Copperas Mountain, over to the border escarpment, comprise the third ridge. The rolling hills of the Piedmont consist of sandstones and shales punctuated by the erosion-resistant volcanic igneous rocks of the Watchungs. These basalt ridges are known locally as Hook Mountain (Montville) and Long Hill (Long Hill and Harding Townships). Refer to the Landforms map (Plate 4) for location of these features.

Rivers and streams within the county flow generally southwestward, following the trends of the Highlands. Notable exceptions are the east-flowing Pequannock River, the Rockaway River, which flows south out of Berkshire Valley and then east through a gap in the eastern Highlands, and the Passaic River, which rises in southern Mendham Township, flows north through the Watchung valley, and turns eastward at Montville towards the Great Notch, Little Falls, and Paterson.

Erosion, glaciation, and human activities have sculpted our geologic foundation into the familiar shapes of today's landscape. Erosion's effect on the landscape, is related to a number of factors: erodibility of materials, e.g., shale, sandstone, and limestone wear away much more readily than granite and gneiss. Caves and solution cavities in limestone formations represent consequences of erosion. Steepness of slope and the presence or absence of vegetative cover also affect the rate and nature of the erosion process. The broad, rounded hills and flat-topped ridges of the Highlands reflect hundreds of thousands of years of erosion by wind and rain. The wide, gently rolling, eroded plateau known as the Schooleys Mountain peneplain (Washington Township) is another example of erosional manifestations.

These sloped reliefs provide a visual amenity to those traveling in the region but also contribute to the diverse ecosystems within the county. Uplands and outcrop areas, characterized by extremely dry conditions, provide excellent examples of succession where rock becomes inhabited, sequentially, by moss, lichens, herbs, shrubs, and trees. Habitat in the higher elevations host specific communities of flora and fauna, including rare species, and give rise to the headwaters of our rivers. A non-renewable resource, once blasted, ridges cannot be restored, although restoration of wetlands and disturbed areas in former quarried land is occurring.

Icy Visitors

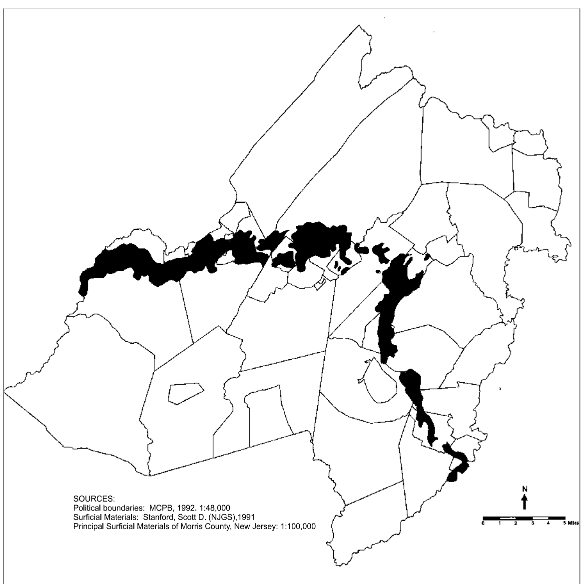
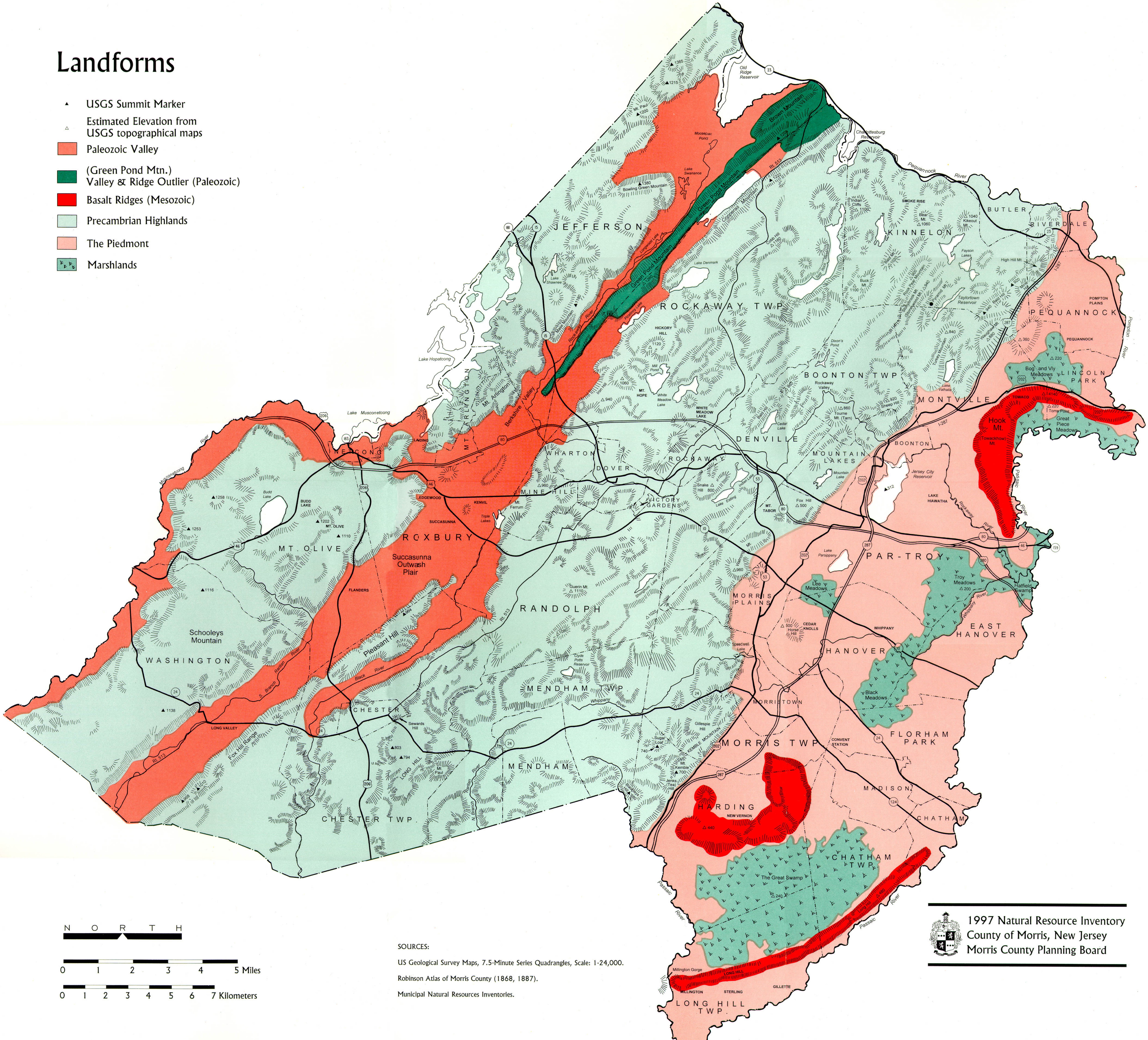


Figure 2 - Terminal Moraine

A profound impact on the landscape was the arrival, stay, and departure of the glaciers. As the lobes of ice moved across the landscape they scraped up soft shales and loose rubble and sheered off ridges exposing sharp cliffs of polished Precambrian bedrock. The southeast travels of the glacier resulted in gentler slopes and fewer rock outcrops on the northwest side of ridges, and steep escarpments and many rock outcrops on southeast slopes. Green Pond and Copperas Mountains reflect this general pattern.

Most of the tills dropped by the glacier are relatively local in origin. Generally, till deposits are thickest in valleys and at the base of slopes. Thus the overall effect of the glacier was to smooth down high places and elevate lower ones. The Newark Basin, within the Piedmont, was raised an average of 100 feet above sea level by glacial deposits.

Landforms



SOURCES:

US Geological Survey Maps, 7.5-Minute Series Quadrangles, Scale: 1-24,000.

Robinson Atlas of Morris County (1868, 1887).

Municipal Natural Resources Inventories.

1997 Natural Resource Inventory
County of Morris, New Jersey
Morris County Planning Board

PLATE 4: Landforms

This depositional till (mixture of sand, silt, clay, and boulders), created a hummocky topography with stony low-relief ridges. The terminal moraine, a prominent feature in Morris County travels in an almost continuous curved band, about one mile wide, from west of Dover to the Jersey City Reservoir and south to Madison (Figure 2). It bears tremendous water supply significance to the County by its close association with the adjacent Buried Valley Aquifer.

Glacial deposition also had a dramatic effect on surface water bodies and drainage patterns. Temporary glacial lakes such as, Succasunna, Denville, Dover, Wharton and Passaic, the largest, were formed when

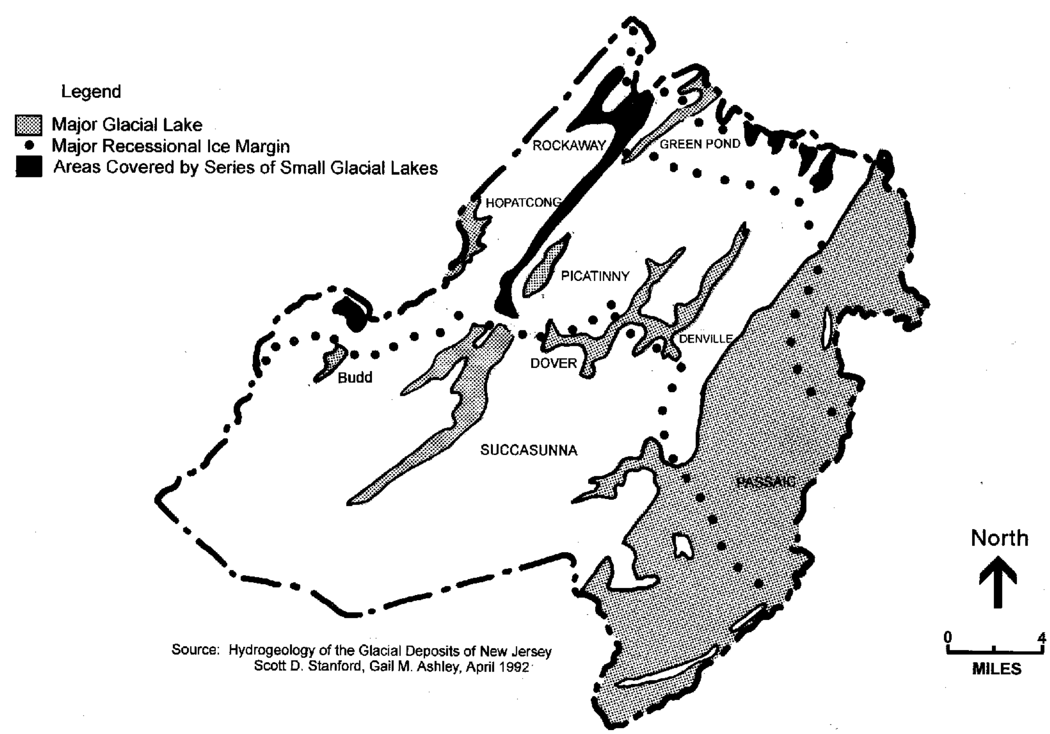


Figure 3 - Glacial Lakes in Morris County

drainage gaps were blocked by ice (Figure 3). As fine clay and silt sediments collected on the bottoms of these draining glacial lakes, creating nearly impervious layers, the stage was set for future swamp, bog, and wetlands development. Today's Great Swamp, Bog and Vly Meadow, Troy Meadows, and Great Piece Meadows are all remnants of glacial Lake Passaic. The lake bottom sediments underlying the Great Swamp are more than 50 feet deep.

The distribution of lakes in the county also show the influence of glaciation. Most naturally occurring lakes are found north of the terminal moraine, formed in kettle holes and bogs created by the retreat of the glacier, and by deposits of till that blocked pre-glacial drainage, or lakes scoured into bedrock. Glacially derived lakes and ponds remaining in existence today are Picatinny Lake, Green Pond, Budd Lake, Split Rock Pond, and Lake Hopatcong. While wetlands evolved from glacially derived kettle holes, they also developed along the valleys of the Rockaway River, Green Pond and Stony Brooks, and occasionally in gouged out Precambrian bedrock.

When the Rockaway's path through Mountain Lakes was blocked by till, it rerouted itself north through the valley west of the Tourne county park and east through a gap at Montville. The Valley at Kenvil, once accommodating the northward flowing Lamington River, became obstructed by sediment deposition in glacial Lake Succasunna. Thus the former tributary to the Rockaway changed route, flowing to the Raritan, as it does today.

Other glacial landforms are evident throughout northern Morris County. Deltas can be found in Kenvil and Victory Gardens. Kames and kame terraces are found in the valley of the Pequannock River between Oak Ridge and Newfoundland, the Rockaway Valley from the moraine to Moosepack Pond, and the Beaver Brook Valley from Beach Glen to the junction with the Rockaway River. Terraces can also be found along the Musconetcong and Raritan rivers. Kettles can be found in Convent Station. Bear Rock, the largest glacial erratic in New Jersey is located in Pyramid Mountain in Kinnelon.

South of the terminal moraine evidence of the glacier exists in flat outwash plains formed by meltwaters coursing southward. Such deposition occurred along Beaver and Weldon Brooks, and the Musconetcong and Pequannock River valleys. Other plains formations include the Succasunna Outwash Plain, drained by Drake's Brook, a tributary of the North Branch of the Raritan, and the plains of Morris Plains.

Management Considerations

The evolving landforms of ridges, slopes, valleys, floodplains and surface water bodies represent foundations of ecosystems. These topographic features, though unquestionably valuable, suffer gaps within the network of environmental protection. Wetlands and floodplains receive legislative and regulatory support. Steep slopes legislation has been and continues to be debated on a State basis. Scenic vistas may be protected on the local level.

Protection of these resources serve functional, habitat as well as aesthetic values. Erosion, flooding, cave-ins are discussed throughout this document. Their interrelationships within ecosystems are carried over in their symbiotic roles as agents of human derived hazards.

Impacts from Natural Hazards

Flooding, although a necessary and natural dynamic in riverine ecosystems, presents a hazard to inhabited areas, flushing out both animal and human residents, and causing significant property damage. The Towns of Boonton, Dover, and Morristown, the Borough of Lincoln Park and Denville, Long Hill, Parsippany-Troy Hills, and Pequannock Townships have long suffered the consequences of flooding.

Human Derived Hazards

Steep slopes figure into erosion, sedimentation and associated stormwater issues. For the purposes of this document steep slopes are those 15% or greater (Figure 4). Soils serve as the mobilized agent of disturbance. As such, stormwater management issues regarding water quality will be further explored in the soils chapter.

Floodplains normally serve as storage areas for rivers' overflow. However, our filling in activities and transitioning of land cover to impervious surfaces has detracted from their storage abilities, resulting in flooding problems throughout the county, particularly Denville, Dover, Lincoln Park, Long Hill and Pequannock. Historic storm incidence and resultant discharge records for gaging stations within rivers in the county are tabulated in the Surface Water Chapter.

Regulatory Support

- **Flood Hazard Area Control Act Rules** protect property, water quality and habitat within floodplains
- **New Jersey Stormwater Management Regulations** address stormwater responses resulting in variations of conditions within developed and undeveloped watersheds
- **The Soil Erosion and Sediment Control Act** regulates conveyance of stormwater runoff down slopes, minimizing erosion

Planning Strategies

- Identify environmentally sensitive features such as floodplains, steep slopes, wetlands, viewsheds
- Prioritize and acquire environmentally sensitive features
- Create a riparian area management plan (encompassing lands adjacent to streams and rivers, including floodplains with high water tables)

Design Strategies

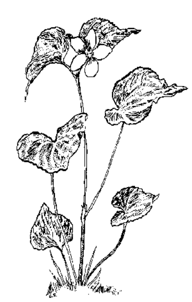
- Design according to contours of the land
- Minimize disturbance of steep slopes, maintaining maximum extent of forest cover
- Maintain hydrologic regime within floodplains, limiting impervious cover, maximizing vegetative cover

Zoning and Site Plan Ordinances

- Steep slope ordinance
- Stormwater ordinance, limiting impervious coverage in environmentally sensitive areas
- Site Plan Landscaping ordinance requiring replacement of indigenous trees and other vegetation after construction

Practices

- Re-forestation of disturbed slopes, stream buffers, etc. (e.g., Friends of the Rockaway and N.J. Trout Unlimited's river restoration project in McCarter Memorial Park, Township of Denville).
- Participate in State Blue Acres Program (acquisition program for property in the Central Passaic River Basin floodway), if appropriate, or develop similar buy-back program locally.
- Township of Washington's ordinance protecting steep slopes and ridgelines by regulating height and location of development so as not to alter views of same.
- Conversion of asphalt parking lot to vegetated buffer along the Whippany River on Center Street in Morristown (Urban Conservation Action Partnership, Inc.).



* Canada Violet

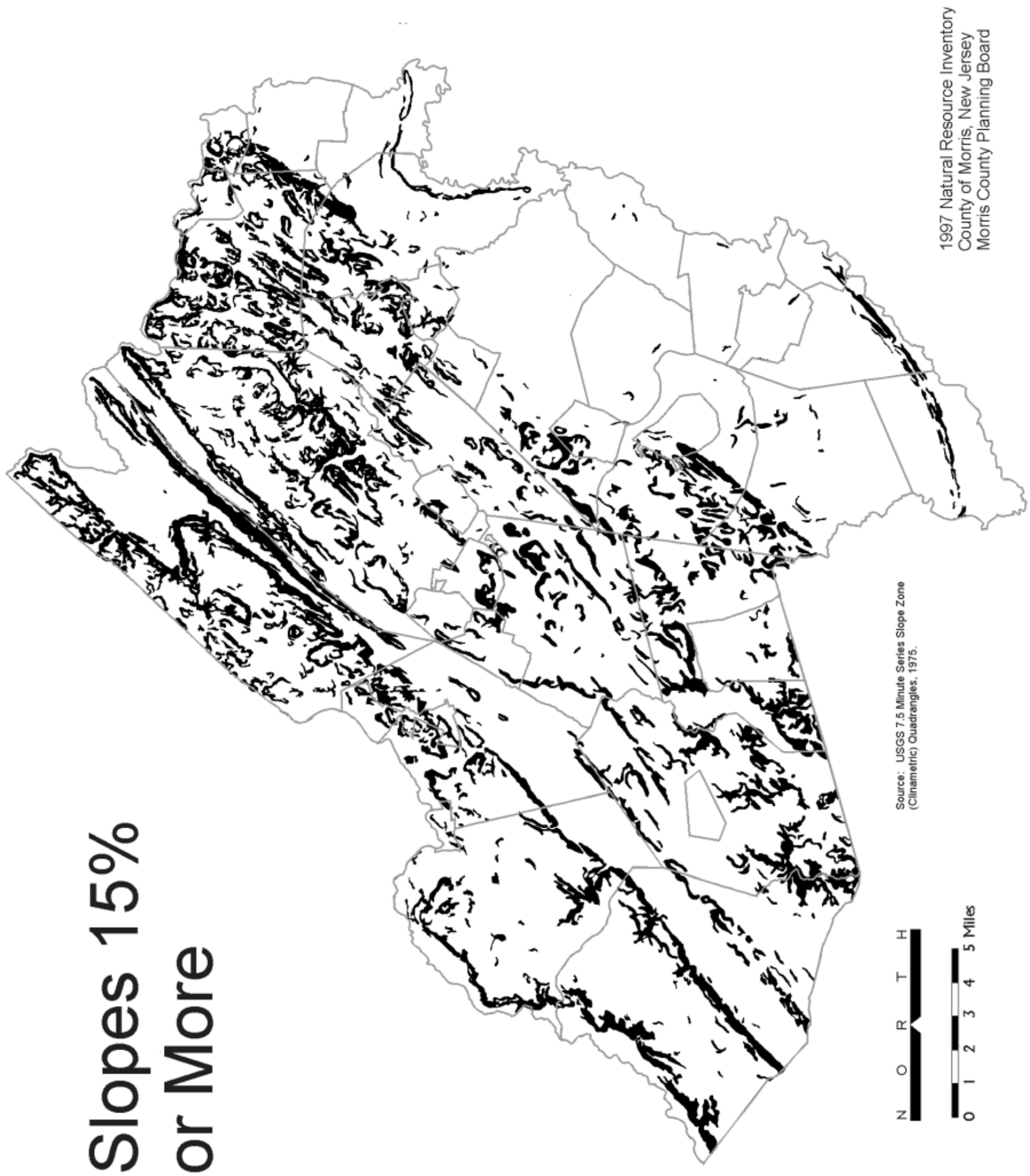

Slopes 15%
or More
1997 Natural Resource Inventory
County of Morris, New Jersey
Morris County Planning Board
Source: USGS 7.5 Minute Series Slope Zone
(Clinametric) Quadrangles, 1975.
NORTH
0 1 2 3 4 5 Miles

Figure 4

Glossary

DELTAS triangular-shaped glacial deposits at rivermouths

GLACIAL ERRATICS large, isolated boulders

HUMMOCK A low mound or ridge of earth

KAMES low conical hills of glacial drift

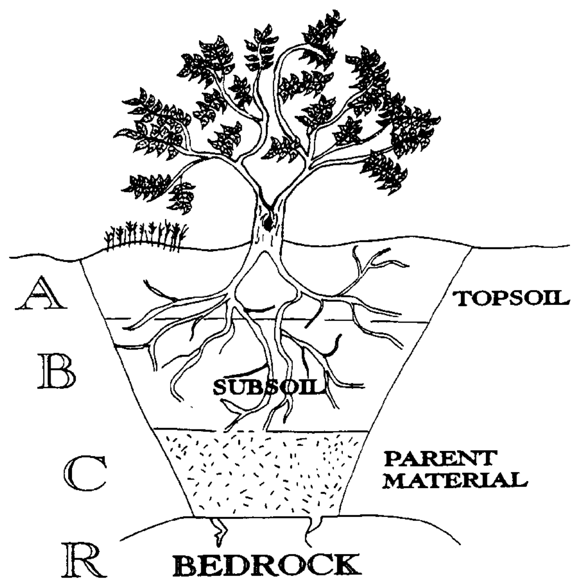
KAME TERRACES deposited between a glacier and valley

KETTLES bowl-shaped depressions caused by a slow melting piece of ice

RIPARIAN AREA is the land adjacent to creeks, streams, and rivers, including floodplains with higher water tables. These areas affect annual and seasonal quantity and quality of water as well as provide habitat to wildlife, especially migratory species.[1]

* Narrow-Leaved Vervain

[1] U.S. Department of Agriculture. Natural Resources Conservation Service. Riparian Areas, Regional Distinctions and Disturbances, NRCS/RCA Issue Brief 12, Jan. 1997.



Soils

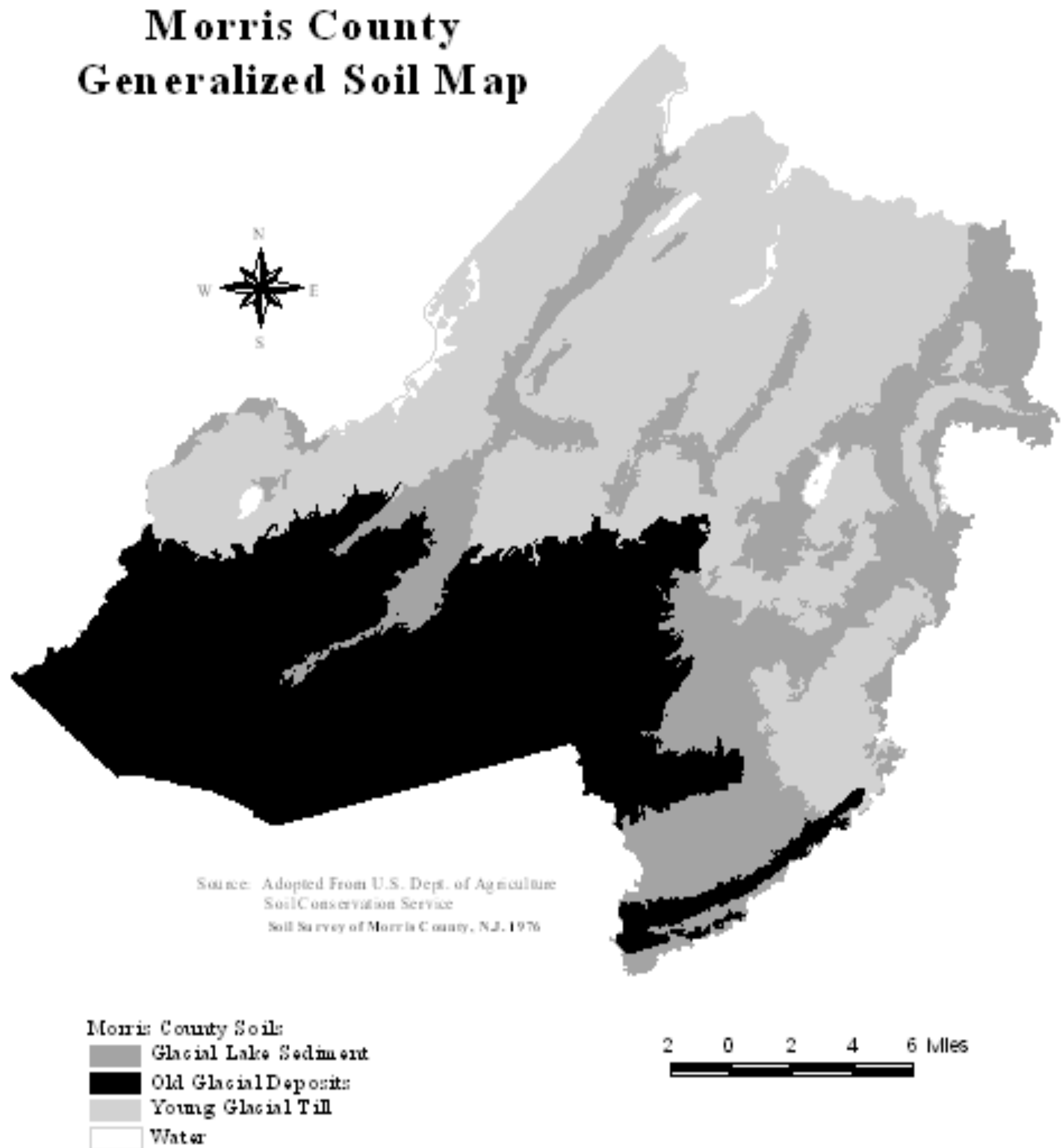
Introduction

For thousands of years, soil has provided us with a growth medium to produce life-sustaining food, support for our shelters, and a haven for our spent mortal forms. As civilization advanced both in numbers and standard of living, soil was, and continues to be, relied on to detoxify our by-products, feed a burgeoning world population, and house buildings, bridges, highways, etc.

The Geologic Connection

Soil's lineage spans the millennia. The very processes that worked to create Morris County's unique geologic and physiographic framework continued in the formation of soil. The combined factors of climate, topography, type of bedrock, vegetation, and indigenous organisms, created a substrate determining future land appearance, habitat, and human activity.

Using our geologic map as a foundation, we are able to make a connection with the soil types of today and the underlying parent material. The hard quartz grains of the Highlands' gneissic bedrock evolved into coarse sand-grained loam. The Piedmont's layered sandstone, soft red shale, and siltstone weathered into shale consisting mostly of silt or fine sand. The basalt of the Watchungs yielded a soil with silt loam or sand loam texture. Glacial Lake Passaic's floor consisted of deposits of fine-textured silt and clay. **A Generalized Soil Map of Morris County** can be found on page 3-2. **Appendix A** lists all individual soil names and abbreviations found within the county.



As described in the <u>Soil Survey of Morris County, New Jersey</u>, soil associations formed within **Glacial Lake Sediment** occur throughout the county in low lying areas. They consist of wet organic soils, wet clayey soils, and wet or dry gravelly sandy loams. Soil associations formed within **Old Glacial Deposits** are located on uplands and in valleys, in the southern and southwestern parts of the county. These soils are mostly loamy and deeply weathered, having more clay in the subsoil than in the surface layer. Soil associations formed within **Young Glacial Till** are found on ridges and in valleys. They are gravelly and extremely stony sandy loams underlain by glacial till that ranges from gravelly loamy sand to silt loam**.**

The Ecosystem

Soil is an integral component in the local and regional ecosystems. Linked to water, flora, fauna, and humans, it is the medium in which a host of plants and animals engage in symbiotic relationships. While appearing stagnant, soil and its precursors are actually dynamic. Lichens, plant roots, and freezing water break parent material apart into increasingly smaller units. Fungi and bacteria decompose organic matter, releasing nutrients, and developing soil structure. Animals such as mice, moles, millipedes, wood lice, ants, earthworms, termites, and centipedes migrate through soil, mixing up and aerating the various layers. Plant roots enable soil aeration as well as provide nutrition via decomposition.

Soil Composition

Chemical, physical, and biological processes have resulted in vertical aggregations known as soil profiles. The soil profile, as depicted on page 3-1, has been broken down into the following horizons:

❦ topsoil or A horizon:	layer of intense weathering; rich in organic matter
❦ subsoil or B horizon:	reaching a depth of 25 - 36 "; experiences some weathering; receives partially chemically altered materials from A horizon
❦ parent material or C horizon:	does not undergo much change
❦ R layer:	bedrock

Soil Components

The reasons soil does what it does are explained by its components, their properties, and the way that these parts work together. The three major components of soil are sand, clay, and silt. They form multiple combinations, e.g., gravelly loam, sandy loam, silty clay, etc. Combined in varying proportions, these ingredients are responsible for soils' specific characteristics and properties, e.g., texture and erodibility. "Water moves detached clay particles more readily than particles of silt or sand, but clay particle bonds are generally stronger than those of silt and sand, so soils with a high content of clay may be quite resistant to erosion." [1]

Soil Properties and Characteristics

There are many properties and characteristics pertinent to the construction and longevity of roads, transportation facilities, infrastructure, foundations for buildings, irrigation systems, and septic systems. It is clear from the listing how interrelated so many of the functions are. Examples of properties include: grain size, color, steepness of slope, depth to bedrock, stoniness, organic matter content, erodibility, likelihood of compaction, structure (influencing movement of water), texture (affecting soil porosity and permeability to air and water), degree of wetness, permeability, susceptibility to flooding, seasonal high water table, clay content (affecting water and ion absorption capacity, soil structure and permeability to air and water) and shrink-swell potential. **Appendix B** provides a generalized representation of soil suitability for specific land uses.

---

[1] U.S. Department of Agriculture. Soil Conservation Service. Soil Erosion By Water, Agriculture Information Bulletin 513, Aug. 1987.

Management Considerations

Soil is subject to migration via ice, wind, and water. Human activities have exacerbated the effect of these natural forces. We have flattened and created new slopes, cut and fill, removed stones and boulders, mixed horizons by plowing the land, added fertilizers, landscaped, and imported and exported soils. Many of these activities have resulted in environmental and economic impacts including degraded water quality, reduced infiltration, increased flooding potential, and habitat destruction. Conversely our efforts in soil conservation have benefitted agricultural lands, vegetated lands, animal habitat, which in turn enhances species diversity, surface water quality, aquifer recharge capability, and flood attenuation.

Impacts From Natural Hazards

The primary impacts associated with soil are erosion and sedimentation. Soil properties determining soils' erodibility include: texture, slope, soil structure, and organic matter content. A rather simple process, erosion can have devastating affects. Its evolution consists of 3 phases:

- raindrops or flowing water break natural physical and chemical bonds between soil particles
- surface flow carries particles downslope
- as erosive energy of water diminishes, soil particles are deposited as sediment

The rate of erosion depends on:

- the type and amount of rainfall
- the length and steepness of slope
- the erodibility of soil
- landcover - bare soil is most vulnerable to erosion

Human Derived Impacts

Erosion is believed to be the largest source of pollution in our waterways. While a natural dynamic, human intervention by way of clearing land, farming activities, and many development-related activities, has accelerated the pace. Impacts, secondary to erosion and sedimentation, include:

- loss of flood water storage
- degradation of wildlife habitat
- degraded ground water quality (increased nutrients, toxics)
- degraded surface water quality (increased nutrients, toxics, turbidity)
- changes in stream morphology
- silting of water bodies and reservoirs
- clogging of storm drains and detention basins
- loss of agricultural productivity
- undermining of roads and bridges

Sedimentation degrades the receiving water column, and clogs sewer lines, storm drainage systems, waterways, reservoirs, floodplains and associated habitats. Sediment serves as a vehicle for contaminants, reduces oxygen content, alters normal drainage flow, and reduces recreation and scenic value. Nutrients attached to sediment can stimulate algae growth which blocks sunlight. These alterations imperil aquatic plants and wildlife, and consequently the cleansing mechanisms vital to maintaining the integrity of the stream.

Infiltration, a function of soil permeability, has critical implications for ground water recharge, septic suitability, and stormwater management. Because ninety-five percent of Morris County's potable water is supplied by ground water, **recharge** protection is a priority. Due to the roles that soils play in the hydrologic regime, it is possible to assess areas in terms of potential for, and volume of, ground water recharge utilizing soils, climate, and land use/land cover data.[2] This methodology was tested by the County Planning Board on the Black River watershed (tributary to the Raritan). The resulting map depicts areas of poor, moderate, and excellent recharge potential (Figure 1).

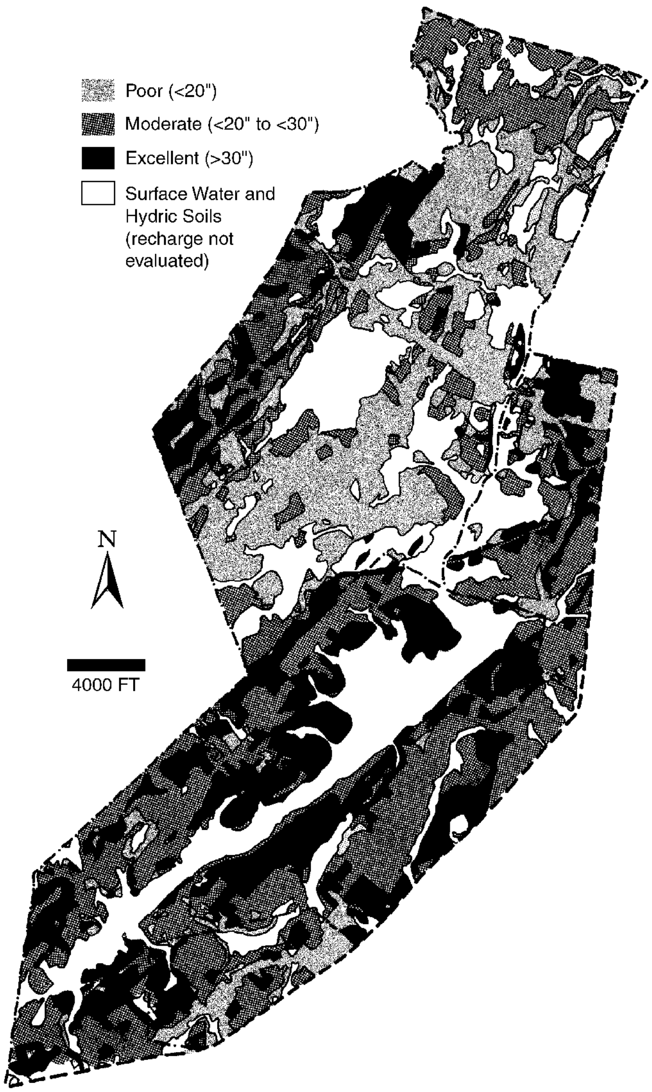


Figure 1 - Ground Water Recharge Potential - Black River Watershed

---

[2]Emmanuel G. Charles and others, A Method for Evaluating Ground-Water-Recharge Areas in New Jersey, N.J. Geological Survey Report GSR-32, 1993.

Stormwater runoff is a significant planning issue because of its role in erosion, flooding, and nonpoint source pollution. Once again, soil's structure and texture determine the fate of infiltrating water as well as the volume of air space between particles (allowing for greater infiltration rates). The less the infiltration capacity, the more runoff carrying sediment, fertilizers, and pesticides, culminating in greater likelihood for erosion, flooding and water quality degradation. Sediment can deliver nutrients to water bodies contributing to algae growth, blocking sunlight, and endangering aquatic plants and wildlife.

Wastewater treatment achieved by septics, again relies on the infiltration capacity of soils. Utilizing the same ground water as that which provides potable water, it is essential that these systems are located where soil structures allow moderate vertical water movement. Adequate flow of effluent enables the needed filtration, and biological and chemical treatment before reaching the water table.

Ideally soils should be unsaturated, have pores that are fine, yet large enough for oxidation. When soils are either too coarse or saturated, mechanical and biological filtering are impeded, jeopardizing the interfacing water table. The ensuing potential for health hazards is very real if the soils are not able to treat pathogens, Nitrogen, Phosphorous, as well as other contaminants.

Plate 5 depicts areas which currently are, or are intended to be, sewered, with the balance of the area representing septic reliance. Table 1 lists soils unsuitable for septic systems. Conversely, soils suitable for septics in Morris County are illustrated on page 3-7 (Figure 2). All highlighted areas reflect both soils that are suitable for septic systems as well as areas that are not currently, or planned to be, sewered.

Table One - Soils With Severe Limitations For Septic Tank Absorption Fields[3]

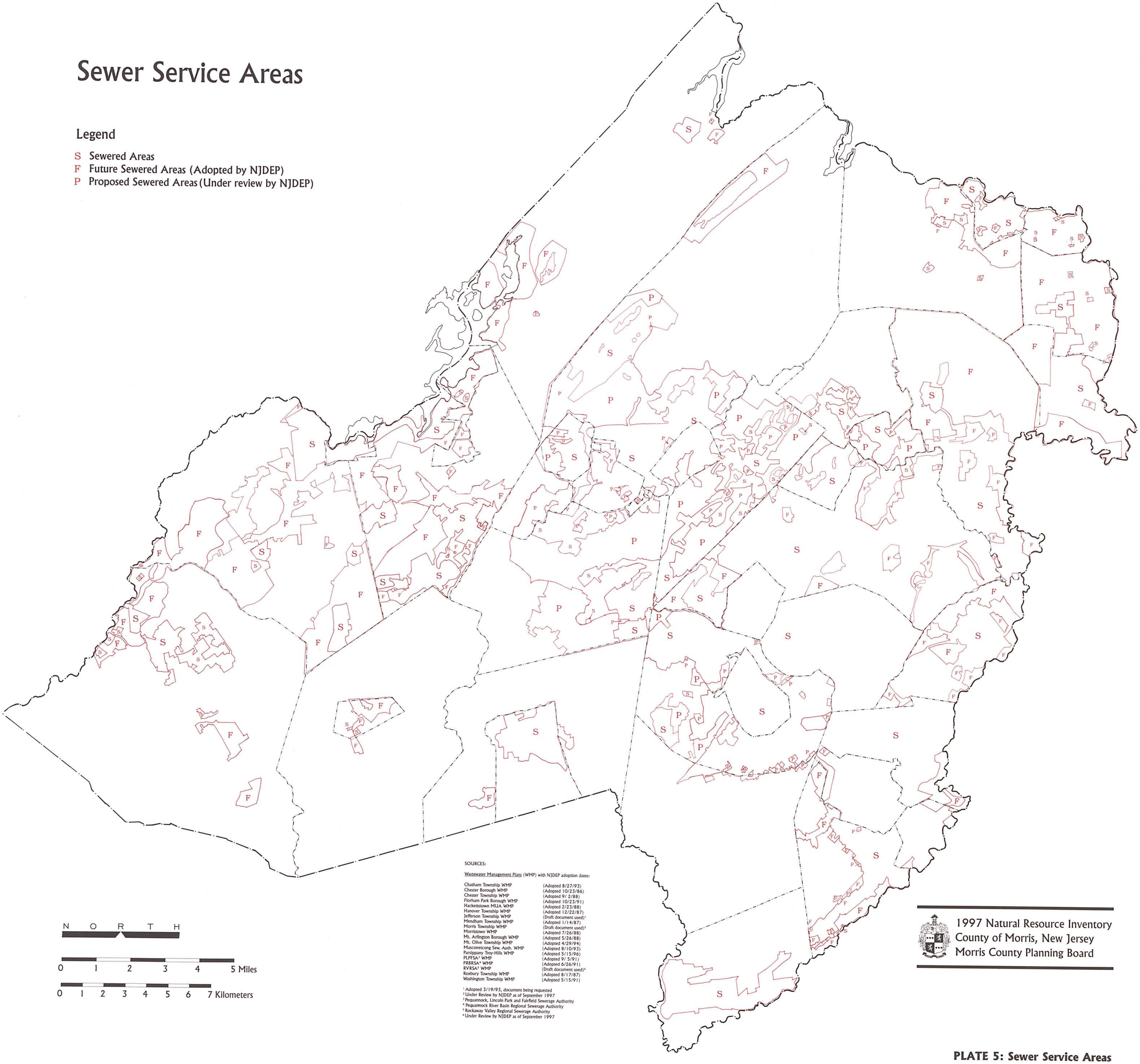
Adrian: Ad	Muck: Ms, Mu
Alluvial land: Ae, Am	Neshaminy: NfD
Barley: BaA, BaB	Otisville: OtD
Biddeford: Bd	Parker: PbD, PeD, PfE
Boonton: BpC	Parsippany: Ph, Pk
Califon: CaA, CaB, CaC, CbB, CcB, CcC	Penn: PnB, PnC, PoD
Carlisle: Cm	Pompton: PtA, PtB
Cokesbury: CoA, CoB, CsB	Preakness: Pva
Edneyville: EdD	Preakness variant: Pw
Ellington variant: ElB, ElC, ElD	Reaville variant: ReB
Haledon: HaB, HaC	Ridgebury: RgA, RlB
Hibernia: HbC, HlD	Rockaway: RrD, RsC, RsD, RsE
Holyoke: HoC, HrE	Rock outcrop: Rt, RvF
Klinesville: KlE	Turbotville: TuA, TuB
Made land: Ma	Urban land: Uh, Um, Un, UrD, Uw
Minoa: MlA, MlB	Whippany: WhA, WhB, WlA, WlB
	Whitman: Wm

[3]U.S. Department of Agriculture. Soil Conservation Service. Soil Survey of Morris County, New Jersey, Aug. 1976.

Sewer Service Areas

Legend

- S Sewered Areas
- F Future Sewered Areas (Adopted by NJDEP)
- P Proposed Sewered Areas (Under review by NJDEP)



SOURCES:

Wastewater Management Plans (WMP) with NJDEP adoption dates:

Chatham Township WMP	(Adopted 8/27/93)
Chester Borough WMP	(Adopted 10/23/86)
Chester Township WMP	(Adopted 9/ 2/88)
Florham Park Borough WMP	(Adopted 10/23/91)
Hackettstown MUA WMP	(Adopted 2/23/88)
Hanover Township WMP	(Adopted 12/22/87)
Jefferson Township WMP	(Draft document used)[1]
Mendham Township WMP	(Adopted 1/14/87)
Morris Township WMP	(Draft document used)[2]
Morristown WMP	(Adopted 7/26/88)
Mt. Arlington Borough WMP	(Adopted 5/26/88)
Mt. Olive Township WMP	(Adopted 4/29/94)
Musconetcong Sew. Auth. WMP	(Adopted 8/10/93)
Parsippany Troy-Hills WMP	(Adopted 5/15/96)
PLPFSA[3] WMP	(Adopted 9/ 5/91)
PRBRSA[4] WMP	(Adopted 6/26/91)
RVRSA[5] WMP	(Draft document used)[6]
Roxbury Township WMP	(Adopted 8/17/87)
Washington Township WMP	(Adopted 5/15/91)

[1] Adopted 3/19/93, document being requested
[2] Under Review by NJDEP as of September 1997
[3] Pequannock, Lincoln Park and Fairfield Sewerage Authority
[4] Pequannock River Basin Regional Sewerage Authority
[5] Rockaway Valley Regional Sewerage Authority
[6] Under Review by NJDEP as of September 1997

1997 Natural Resource Inventory
County of Morris, New Jersey
Morris County Planning Board

PLATE 5: Sewer Service Areas

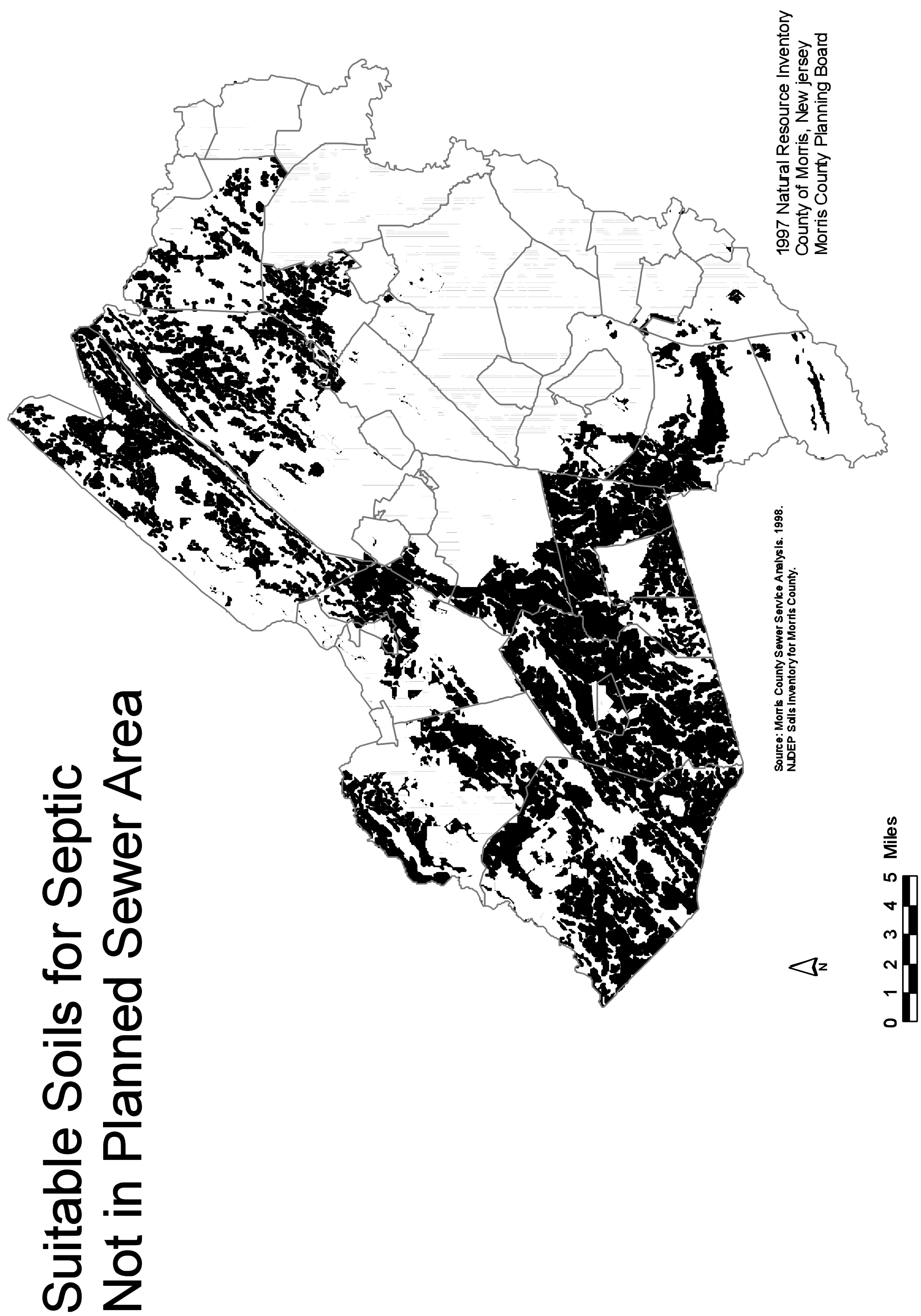

Suitable Soils for Septic
Not in Planned Sewer Area
1997 Natural Resource Inventory
County of Morris, New jersey
Morris County Planning Board
Source: Morris County Sewer Service Analysis. 1998.
NJDEP Soils Inventory for Morris County.
N
0 1 2 3 4 5 Miles

Figure 2

Regulatory Support

- **The Soil Erosion and Sediment Control Act** regulates conveyance of stormwater runoff down slopes, minimizing erosion

Planning Strategies

- Erosion and sedimentation plans including mapping areas prone to erosion
- Stormwater management plan addressing water quality and quantity, enhancing water infiltration
- Ground water recharge analyses and management plan including location of recharge areas, permeability of soils, ground and surface water interchange, and potential sources of contamination
- Land cover analyses indicating areas suitable for ground water recharge
- Hydric soils identification as part of overall habitat evaluation
- Stream corridor protection and restoration plan including suitability determination for vegetative buffers based on resident soils. Stabilizing stream banks will deter erosion and sedimentation.
- Species diversity management plan identifying potential for habitat enhancement
- Open space and recreation plan locating active and passive recreation according to soil's sensitivity to compaction and erosion
- Tree protection and re-forestation plan
- Septic system management plan

Design Strategies

Development performance standards suitable for specific environmental constraints including:

- highly erodible soils
- prime infiltration areas
- prime agricultural land
- freshwater wetlands
- potential rapid runoff areas
- prime aquifer recharge areas
- floodways
- flood fringe areas

Zoning and Site Plan Ordinances

- Soil Erosion and Sediment Control ordinance in areas outside of Natural Resources Conservation District jurisdiction
- Septic Management District ordinance establishing maintenance measures, including pumping

Practices

- Township of Chatham's ordinance establishing a management program for individual subsurface sewage disposal systems. Stipulations include restrictions on use, substances disallowed for disposal, and maintenance of disposal fields.
- Rockaway River restoration project at McCarter Park in Denville where erosion and excess geese feces were degrading the river corridor; streambanks were revegetated with shrub and tree plantings. (Urban Conservation Action Partnership, Inc.)
- Rockaway River greenway development in Dover. Through the facilitation of the Urban Conservation Action Partnership, the Dover Rockaway Railway was realigned. Fill, pavement and ballast were removed while native trees and shrubs were planted. The result was recovery of some of the channel's flood storage and the installation of a greenway trail.

- **Conservation Landscaping** to reduce erosion, water consumption, and enhance wildlife habitat

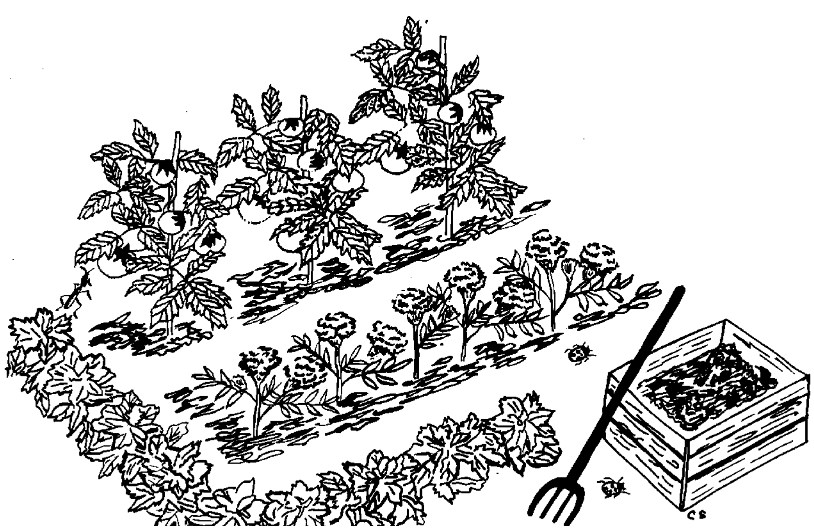
❦ Retain native species in undisturbed areas
❦ Use flat stones, interlocking or lattice pavers (flagstone, bluestone, or granite) to enable infiltration
❦ Revegetate disturbed areas with indigenous species (requires minimal or no maintenance)
❦ Use drought resistant vegetation
❦ Retain moisture e.g. using mulch
❦ Minimize lawn areas (less fertilization needed)
❦ Utilize alternative ground covers
  - pachysandra, ivy, periwinkle, and other ground covers are low maintenance and drought resistant
  - tall and fine fescues (drought tolerant)
  - perennial or self-sowing wildflowers
  - low growing deciduous or evergreen shrubs; trees
  - crown vetch on steep sunny slopes
  - meadows

❦ Fortify soil with compost, and organic matter
❦ Measure and time frequency of fertilizer applications based on soil testing
❦ Control pests by encouraging beneficial insects e.g.: ladybugs, praying mantises
❦ Control pests by practicing companion planting e.g.: marigolds and tomatoes
❦ Employ Integrated Pest Management (achieve pre-determined pest and damage levels)
❦ Test soil as basis for fertilization practices

Examples include:

- Soil conservation measures at Alstede Farms in Chester Township. A grassed waterway adjacent to Route 206 was installed to prevent continued gully erosion in the field. Stormwater along the roadway is conveyed into a catch basin, exits from a culvert into the field, and runs through the waterway. Additional conservation measures include: strip cropping, residue management, cover crops, crop rotation, grass waterways, vegetative filter strips, irrigation pond.

- Soil conservation measures at Robert Jenkinson Nursery, Inc., in Washington Township include: grassed terraces; grass waterways; drainage tiles; irrigation mainlines; grass buffer strips.



Glossary

PERMEABILITY is the soil's ability to transmit air or water.

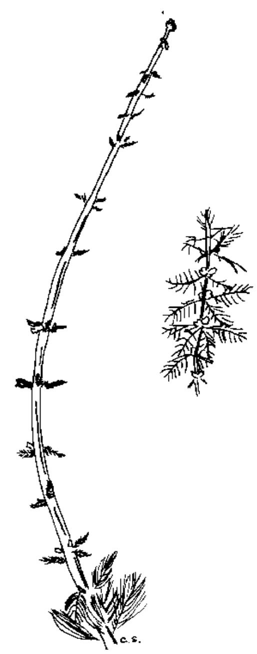
SEASONAL HIGH WATER TABLE is the upper limit of the shallowest zone of saturation which occurs in the soil (N.J.A.C. 7:9A-5.8).

SOIL CONSISTENCY is the feel of soil, as dry, moist, or wet.

SOIL STRUCTURE is the arrangement of soil particles, resulting from the ongoing processes of moistening, drying, and aeration provided by plants and animals. Soil structure influences water movement: horizontal and vertical. Implications are manifest in drainage, infiltration, and septic suitability.

TEXTURE reflects percentages of sand, silt, and clay; determine soil porosity and permeability to air and water.

WATER TABLE is the upper surface of a zone of saturation (Chapter 9A Standards for Individual Subsurface Sewage Disposal Systems, cite 21 N.J.R. 2597).



* Whorled Water-Milfoil

Appendix A

Soils Found In Morris County[10]

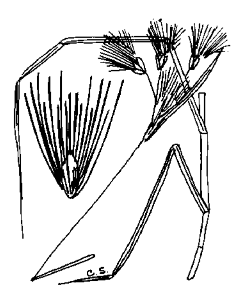
Ad Adrian muck
Ae Alluvial land
Am Alluvial land, wet
AnB Annandale gravelly loam, 3 to 8 percent slopes
AnC Annandale gravelly loam, 8 to 15 percent slopes
BaA Bartley loam, 0 to 3 percent slopes
BaB Bartley loam, 3 to 8 percent slopes
BbC Bartley gravelly loam, 8 to 15 percent slopes
Bd Biddeford silt loam
BoB Boonton gravelly loam, 3 to 8 percent slopes
BoC Boonton gravelly loam, 8 to 15 percent slopes
BpC Boonton and Haledon extremely stony soils, 8 to 15 percent slopes
CaA Califon loam, 0 to 3 percent slopes
CaB Califon loam, 3 to 8 percent slopes
CaC Califon loam, 8 to 15 percent lopes
CbB Califon gravelly loam, 3 to 8 percent slopes
CcB Califon very stony loam, 2 to 8 percent slopes
CcC Califon very stony loam, 8 to 15 percent slopes
CdB Califon loam, friable subsoil variant, 3 to 8 percent slopes
Cm Carlisle muck
CoA Cokesbury gravelly loam, 0 to 3 percent slopes
CoB Cokesbury gravelly loam, 3 to 8 percent slopes
CsB Cokesbury extremely stony loam, 0 to 8 percent slopes
EdB Edneyville gravelly loam, 3 to 8 percent slopes
EdC Edneyville gravelly loam, 8 to 15 percent slopes
EdD Edneyville gravelly loam, 15 to 25 percent slopes
ElB Ellington fine sandy loam, loamy subsoil variant, 3 to 8 percent slopes
ElC Ellington fine sandy loam, loamy subsoil variant, 8 to 15 percent slopes
ElD Ellington fine sandy loam, loamy subsoil variant, 15 to 25 percent slopes
HaB Haledon silt loam, 3 to 8 percent slopes
HaC Haledon silt loam, 8 to 15 percent slopes
HbC Hibernia stony loam, 3 to 15 percent slopes
HlD Hibernia very stony loam, 15 to 25 percent slopes
HoC Holyoke rocky silt loam, 5 to 15 percent slopes
HrE Holyoke-Rock outcrop complex, 15 to 35 percent slopes
KlE Klinesville shaly silt loam, 25 to 35 percent slopes
Ma Made land, sanitary land fill
MlA Minoa silt loam, 0 to 3 percent slopes
MlB Minoa silt loam, 3 to 8 percent slopes
Ms Muck, shallow over clay
Mu Muck, shallow over loam
NeB Neshaminy gravelly silt loam, 3 to 8 percent slopes
NeC Neshaminy gravelly silt loam, 8 to 15 percent slopes
NfD Neshaminy very stony silt loam, 15 to 25 percent slopes
NtB Netcong gravelly sandy loam, 3 to 8 percent slopes
NtC Netcong gravelly sandy loam, 8 to 15 percent slopes
OtC Otisville gravelly loamy sand, 3 to 15 percent slopes
OtD Otisville gravelly loamy sand, 15 to 25 percent slopes
PaC Parker gravelly sandy loam, 3 to 15 percent slopes
PbD Parker very gravelly sandy loam, 15 to 25 percent slopes

Narrow-Leaved Gentian

---

[10] U.S. Department of Agriculture. Soil Conservation Service. Soil Survey of Morris County, New Jersey, Aug. 1976.

PeC	Parker-Edneyville extremely stony sandy loams, 3 to 15 percent slopes
PeD	Parker-Edneyville extremely stony sandy loams, 15 to 25 percent slopes
PfE	Parker-Rock outcrop complex, 20 to 35 percent slopes
Ph	Parsippany silt loam
Pk	Parsippany silt loam, sandy loam substratum
PlB	Pattenburg gravelly loam, 3 to 8 percent slopes
PlC	Pattenburg gravelly loam, 8 to 15 percent slopes
PnB	Penn shaly silt loam, 3 to 8 percent slopes
PnC	Penn shaly silt loam, 8 to 15 percent slopes
PoD	Penn-Klinesville shaly silt loams, 15 to 25 percent slopes
Ps	Pits, sand and gravel
PtA	Pompton sandy loam, 0 to 3 percent slopes
PtB	Pompton sandy loam, 3 to 8 percent slopes
PvA	Preakness sandy loam, 0 to 4 percent slopes
Pw	Preakness sandy loam, dark surface variant
ReB	Reaville shaly silt loam, deep variant, 0 to 5 percent slopes
RgA	Ridgebury very stony loam, 0 to 3 percent slopes
RlB	Ridgebury extremely stony loam, 3 to 10 percent slopes
RmA	Riverhead gravelly sandy loam, 0 to 3 percent slopes
RmB	Riverhead gravelly sandy loam, 3 to 8 percent slopes
RmC	Riverhead gravelly sandy loam, 8 to 15 percent slopes
RnB	Riverhead gravelly sandy loam, neutral variant, 2 to 8 percent slopes
RoB	Rockaway gravelly sandy loam, 3 to 8 percent slopes
RoC	Rockaway gravelly sandy loam, 8 to 15 percent slopes
RpC	Rockaway very stony sandy loam, 3 to 15 percent slopes
RrD	Rockaway extremely stony sandy loam, 15 to 25 percent slopes
RsC	Rockaway-Rock outcrop complex, 3 to 15 percent slopes
RsD	Rockaway-Rock outcrop complex, 15 to 25 percent slopes
RsE	Rockaway-Rock outcrop complex, 25 to 45 percent slopes
Rt	Rock outcrop
RvF	Rock outcrop-Rockaway complex, steep
TuA	Turbotville loam, 0 to 3 percent slopes
TuB	Turbotville loam, 3 to 8 percent slopes
Ua	Urban land
Ub	Urban land, wet
Ue	Urban land-Edneyville complex
Uh	Urban land-Haledon complex
Uk	Urban land-Neshaminy complex
Um	Urban land-Penn complex
Un	Urban land-Preakness complex
Up	Urban land-Riverhead complex
UrC	Urban land-Rockaway complex, gently sloping and sloping
UrD	Urban land-Rockaway complex, moderately steep
Uw	Urban land-Whippany complex
WaB	Washington loam, 0 to 8 percent slopes
WhA	Whippany silt loam, 0 to 3 percent slopes
WlA	Whippany silt loam, sandy loam substratum, 0 to 3 percent slopes
WlB	Whippany silt loam, sandy loam substratum, 3 to 8 percent slopes
Wm	Whitman very stony loam



* Slender Cotton Grass

Appendix B

Soil Suitabilities[11]

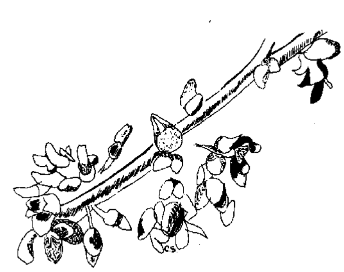
Soil Series	Foundations for dwellings	Lawns, gardens, and golf fairways	Septic tank absorption fields	Roads and parking lots	Athletic fields
Adrian: Ad	Poor	Poor	Poor	Poor	Poor
Alluvial: Ae	Poor	Poor	Poor	Poor	Poor
Am	Poor	Poor	Poor	Poor	Poor
Annandale:AnB	Good	Good	Fair	Fair	Poor
AnC	Fair	Fair	Fair	Fair	Poor
Bartley:	Fair (Good if no	Good	Poor	Poor	Fair
BbC	Fair	Fair	Fair	Poor	Poor
Biddeford: Bd	Poor	Poor	Poor	Poor	Poor
Boonton: BoB	Fair (Good if no	Fair	Fair	Poor	Fair
BoC	Fair (Good if no	Fair	Fair	Poor	Poor
BpC	Poor (Fair if no	Poor	Poor	Poor	Poor
Califon: CoA,	Poor (Fair if no	Fair	Poor	Poor	Poor
CoC	Fair	Fair	Poor	Poor	Poor
CcB, CcC	Fair	Poor	Poor	Poor	Poor
Califon variant:	Poor (Fair if no	Fair	Fair	Poor	Poor
Carlisle: Cm	Poor	Poor	Poor	Poor	Poor
Cokesbury:	Poor	Poor	Poor	Poor	Poor
CsB	Poor	Poor	Poor	Poor	Poor
Edneyville: EdB	Good	Fair	Good	Fair	Poor

[11]Ibid.

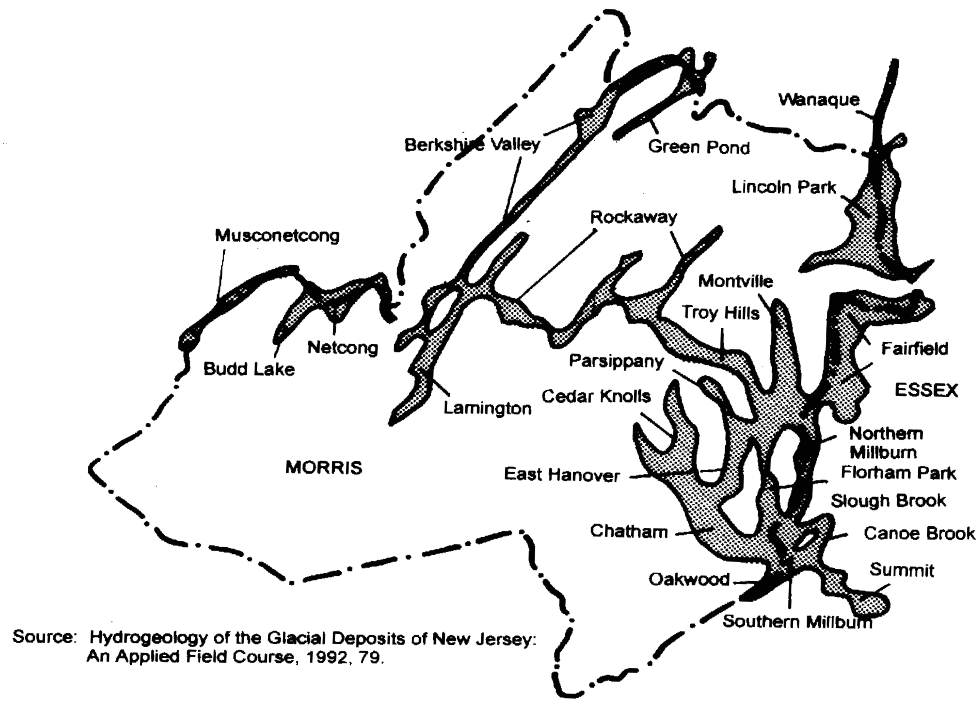
Soil Series	Foundations for dwellings	Lawns, gardens, and golf fairways	Septic tank absorption fields	Roads and parking lots	Athletic fields
EdC	Fair	Fair	Fair	Fair	Poor
EdD	Poor	Poor	Poor	Poor	Poor
Ellington variant: ElB	Fair	Fair	Poor	Poor	Poor
ElC	Fair	Fair	Poor	Poor	Poor
ElD	Poor	Poor	Poor	Poor	Poor
Haledon: HaB	Poor (Fair if no basement)	Fair	Poor	Poor	Poor
HaC	Poor (Fair if no basement)	Fair	Poor	Poor	Poor
Hibernia: HbC	Poor (Fair if no basement)	Fair	Poor	Poor	Poor
HlD	Poor	Poor	Poor	Poor	Poor
Holyoke: HoC	Poor	Poor	Poor	Poor	Poor
HrE	Poor	Poor	Poor	Poor	Poor
Klinesville: KlE	Poor	Poor	Poor	Poor	Poor
Made land: Ma	Poor (Fair if no basement)	Fair	Poor	Fair	Good
Minoa: MlA, MlB	Poor (Fair if no basement)	Fair	Poor	Poor	Poor
Muck: Ms, Mu	Poor	Poor	Poor	Poor	Poor
Neshaminy:NeB	Good	Fair	Good	Fair	Poor
NeC	Fair	Fair	Fair	Fair	Poor
NfD	Poor	Poor	Poor	Poor	Poor
Netcong: NtB	Good	Fair	Good	Good	Poor
NtC	Fair	Fair	Fair	Fair	Poor
Otisville: OtC	Fair	Poor	Good	Good	Poor
OtD	Poor	Poor	Poor	Poor	Poor
Parker: PaC	Fair	Fair	Fair	Fair	Poor

Soil Series	Foundations for dwellings	Lawns, gardens, and golf fairways	Septic tank absorption fields	Roads and parking lots	Athletic fields
PbD	Poor	Poor	Poor	Poor	Poor
PeC	Fair	Poor	Fair	Fair	Poor
PeD	Poor	Poor	Poor	Poor	Poor
PfE	Poor	Poor	Poor	Poor	Poor
Parsippany:Ph, Pk	Poor	Poor	Poor	Poor	Poor
Pattenburg: PlB	Good	Fair	Good	Fair	Fair
PlC	Fair	Fair	Fair	Fair	Poor
Penn: PnB	Fair (Good if no basement)	Fair	Poor	Fair	Fair
PnC	Fair	Fair	Poor	Fair	Poor
PoD	Poor	Poor	Poor	Poor	Poor
Pompton: PtA, PtB	Poor (Fair if no basement)	Fair	Poor	Poor	Poor
Preakness: PvA	Poor	Poor	Poor	Poor	Poor
Reaville variant: ReB	Poor (Fair if no basement)	Fair	Poor	Poor	Poor
Ridgebury: RgA	Poor	Poor	Poor	Poor	Poor
RlB	Poor	Poor	Poor	Poor	Poor
Riverhead: RmA, RmB	Good	Good	Good	Good	Poor
RmC	Fair	Fair	Fair	Fair	Poor
Riverhead variant: RnB	Good	Fair	Good	Good	Poor
Rockaway: RoB	Good	Fair	Fair	Fair	Poor
RoC	Fair	Fair	Fair	Fair	Poor
RpC	Fair	Poor	Fair	Fair	Poor
RrD	Poor	Poor	Poor	Poor	Poor
RsC	Poor	Poor	Poor	Poor	Poor
RsD	Poor	Poor	Poor	Poor	Poor

Soil Series	Foundations for dwellings	Lawns, gardens, and golf fairways	Septic tank absorption fields	Roads and parking lots	Athletic fields
RsE	Poor	Poor	Poor	Poor	Poor
Rock outcrop: Rt, RvF	Poor	Poor	Poor	Poor	Poor
Turbotville: TuA, TuB	Poor (Fair if no basement)	Fair	Poor	Poor	Poor
Urban land: Ue	Good	Fair	Good	Fair	Fair
Uh	Poor (Fair if no basement)	Fair	Poor	Poor	Poor
Uk	Good	Fair	Good	Fair	Poor
Um	Poor (Fair if no basement)	Poor	Poor	Fair	Poor
Un	Poor	Poor	Poor	Poor	Poor
Up	Fair	Fair	Fair	Fair	Poor
UrC	Fair	Fair	Fair	Fair	Poor
UrD	Poor	Poor	Poor	Poor	Poor
Uw	Poor (Fair if no basement)	Fair	Poor	Poor	Poor
Washington: WaB	Good	Good	Good	Fair	Fair
Whippany: WhA, WhB, WlA, WlB	Poor	Fair	Poor	Poor	Poor
Whitman: Wm	Poor	Poor	Poor	Poor	Poor



* Redbud



Ground Water

Introduction

We have seen how Morris County's geologic history has resulted in today's soils, rocks and landscape. These factors plus land cover, whether vegetative or manmade, influence water's journey through the hydrological cycle. The complex path ground water travels to reach the underlying aquifers necessitates informed managing of the variables affecting this vulnerable resource.

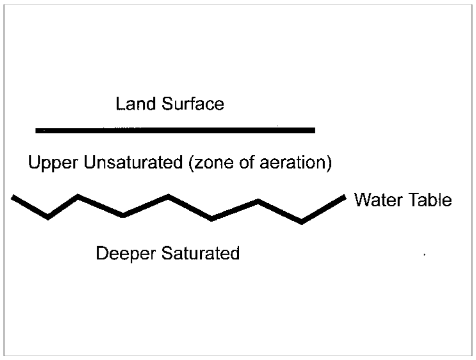
The Hydrological Cycle

The fate of precipitation holds many possibilities as it descends, hitting leaves, dirt, rivers, rooftops, parking lots, etc. It either evapotranspirates, runs across the landscape toward the nearest body of water, or begins its migration through the layers of the earth.

Although ground water can be fed from surface water bodies, it is primarily replenished through rainwater infiltration. Several factors influence infiltration: topography, soil type, climatic conditions such as antecedent rainfall and seasonal fluctuations, ground compaction of soil by man and animals as well as porosity due to tunneling animals and plant roots, and retention due to vegetative cover.

Because the county relies heavily on ground water for potable water supplies, understanding and protecting this resource has become critical. Some tools exist to achieve these goals. The NJ Geological Survey (NJGS) has devised a method for evaluating the rate and volume of rainfall likely to recharge ground water by utilizing climate, land use/land cover, and soils data. NJGS is also guiding local groups in locating wellhead areas, plus continuing their own work in refining aquifer recharge area delineations.

Traveling With Water



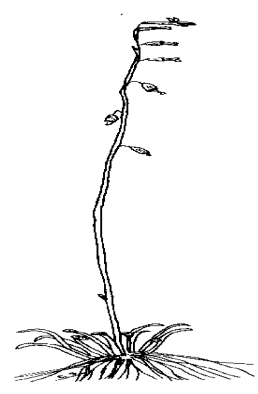
The world below the land's surface is described, hydrologically, in terms of zones, each specific in physical structure and role as a vehicle for infiltrating water. First is the unsaturated zone, or zone of aeration. Most of the pore space is filled with air, but water occurs in the smaller openings as soil moisture and in a **capillary fringe** ("zone above the water table in which water is held by surface tension"[1]) that extends upward from the water table. After a heavy rain the zone of aeration may become almost saturated; in a long, dry spell it is nearly dry. With the onset of rain, moisture taken up by plants is replaced; subsequent percolating rainfall extends beyond the zone of aeration to the water table.

The water table marks the top of the saturated zone where all the openings are saturated. Having reached this zone, rainwater's identity changes to ground water. An understanding of the water table and the thickness, permeability, and composition of the overlying unsaturated zone is instrumental in estimating ground water migration, whether in terms of recharge or movement of contaminant plumes.

All the land area transmitting water beyond the plant root zone, to the ground water, is considered to be the ground water recharge area. The water table generally follows the topography although ground water divides do not necessarily mirror surface water divides.

Ground water can recharge aquifers or provide base flow for surface waters. Where ground water meets the surface it discharges into marshes, lakes, springs, or streams where it resumes its journey through the hydrologic cycle via evaporation. Surface water bodies can either gain from or lose to ground water sources. During dry periods, ground water can provide almost sole support to stream flow. Because of ground water's interrelationship with surface water, stream flow data can enhance our understanding of regional recharge rates, aquifer characteristics, and ground water quality and quantity.

Water table, and ground water levels are dynamic, reflecting seasonal and human imposed influences impacting recharge and discharge. Normally, recharge occurs during and immediately following precipitation. During early spring, frequent rainfalls coupled with snowmelt result in rapid increases in ground water storage, and a rise in the water table. Significant recharge also occurs during late fall, and winter (unless the ground is frozen) when plants are dormant and evaporation is minimal. In late spring, summer, and early fall, much potential recharge is lost to evapotranspiration. Discharge on the other hand occurs continually, although at varied rates. In addition to normal seasonal fluctuation, long term trends of either above or below normal precipitation are manifested by a rise or fall in ground water and water table levels, respectively.



Water Lobelia

---

[1]U.S. Environmental Protection Agency, Wellhead Protection: A Guide For Small Communities, 1993.

Rock Talk

Rock, the parent of soil, contributes dramatically to the fate of rainfall. General classifications include:

- Consolidated - openings consist of fractures, e.g. sandstone, limestone, and granite;
- Unconsolidated - openings consist of pores, e.g. granular material such as sand, gravel, & clay.

In consolidated rock, ground water movement takes place primarily in intersecting fractures and fissures. These fractures and fissures, which have become enlarged by weathering, may bear considerable water. An example illustrating this dynamic is limestone dissolution. Weathering results in the creation of water soluble channels, which have the potential of developing into tunnels, sinkholes, and caves. These natural phenomena are both problematic and wondrous.

Unconsolidated deposits are underlain by consolidated rocks, which most often contribute disintegrated material to the overburden. Ground water generally moves with ease through the spaces among the grains (e.g., sand and gravel). Silt and clay, however, with very tiny spaces between tiny particles, detain water. Overall, a greater proportion of recharge and ground water movement occurs in porous unconsolidated formations (e.g., sand and gravel), than the consolidated formation (e.g., gneiss and shale).

These water-related characteristics, reflect holding capacity and mobility. **Porosity** reflects the maximum amount of water that a rock is capable of containing within its void spaces. Although fine-grained materials tend to have the largest porosities, that doesn't necessitate mobility. **Permeability,** or hydraulic conductivity, indicates degree of mobility achieved by size and interconnectedness of the voids.

Primary permeability refers to the hydrogeologic character of the original formation. Consolidated rock (e.g., shales, limestone, many sandstones and most volcanic and metamorphic rocks) have few interconnected pore spaces, and thus a very low primary permeability. Unconsolidated rock, with its generous pores, has good primary permeability.

Secondary permeability is caused by the folding, faulting, weathering, compaction, dissolution and de-cementing of the original formation. These actions accentuate the existing fractures, increasing porosity and permeability. Examples include limestone and shales which crack along bedding planes, and sandstone which is de-cemented by water flow.

When Is A Rock An Aquifer?

Although nearly all geologic formations could be considered to be aquifers, the definition has been honed specifically for human purposes. "Aquifers are geologic formations which have the capability to store and transmit water which is recoverable in sufficient quantity to be economically useable" (U.S. Army Corps of Engineers, 1972).[2]

The two types of aquifers typical to this region are **bedrock** and **surficial** aquifers. Bedrock aquifers consist primarily of sedimentary and igneous rocks; surficial aquifers consist primarily of glacial and post-glacial stratified sediments. Although the surficial aquifers are more productive they are not as abundant as the bedrock aquifers.

---

[2] The Passaic River Coalition, The Hydrogeology of the Buried Valley Aquifer System, 1983.

If an aquifer is bounded by relatively impermeable materials it is called a **confined** aquifer. Confining units include shale, clay, and silt. Confined units are recharged from their outcrop area, slow percolation of water through the confined units, and underlying and adjacent bedrock. **Unconfined** aquifers, generally closer to the surface of the land, are not hemmed in by impermeable materials and are recharged directly from precipitation. Non-confining units include sand.

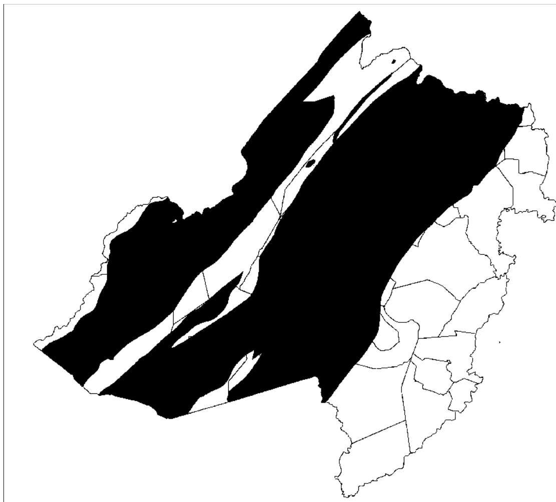
The geologic forces which molded the landscape in Morris County also resulted in an irregular layering of these varying rocks. Many of the lowland areas received unconsolidated deposits over existing consolidated rock. Where clay and silt were deposited, they form a confining layer over both the unconsolidated and consolidated rocks. These deposits, resulting in aquifers and confining layers, are pertinent when estimating ground water movement both in terms of recharge, withdrawal, and migration of contaminants.

Squeezing Water From A Rock

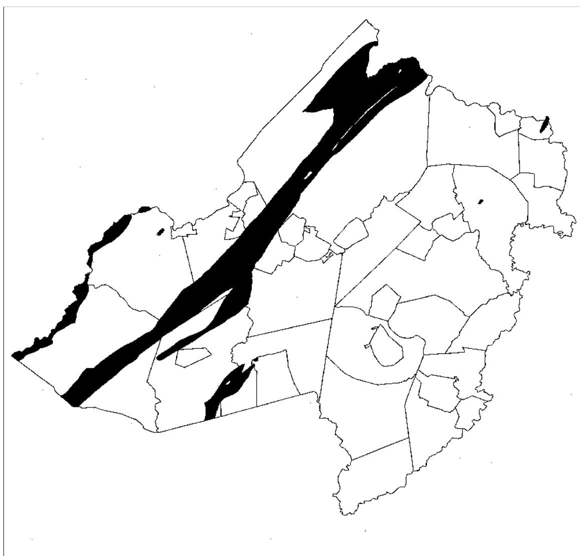
The bedrock map illustrated in Chapter One bears new significance when its units are assigned values such as water-bearing capacity as illustrated in Tables One, Two and Three on the following pages.

Precambrian rocks which are the foundation material for much of the county have variable degrees of water productivity depending on the size and number of intersecting fractures. Increased depth of this rock leads to less and narrower fractures resulting in less water bearing capacity (Table One).

Examples of areas served by Precambrian rock aquifers include the Townships of Jefferson, Morris, and the Towns of Morristown, and Morris Plains.



Precambrian Rock



Paleozoic Rock

Paleozoic rock, which run a narrow southwest-to-northeast diagonal through the county, are generally a poor source of water, as in the case of shale (Table Two). A major exception to this, however, is limestone, which in places has excellent supply potential (Table One). Sandstones contribute modestly, depending on presence or absence of cementing material. Where sandstone forms ridges it is assumed that the rock is heavily cemented and thus not water permeable.

Table One - Proterozoic and Paleozoic Rock in Morris County

Era	Period	Epoch	Stratigraphic Unit	Predominant Lithology	Hydrogeologic Characteristics
Paleozoic	Ordovician	Upper Ordovician	Martinsburg Formation	slate, siltstone, graywacke	Ground water occurs along bedding surfaces, joints, faults, solution cavities, intergranular spaces, and other openings
Paleozoic	Ordovician	Middle Ordovician	Jacksonburg Limestone	limestone, argillaceous limestone	
Paleozoic	Ordovician	Middle Ordovician – Lower Ordovician	Jutland klippe units, (not part of Kittatinny Supergroup)	shale, limestone, chert (Jutland)	
Paleozoic	Ordovician	Lower Ordovician	Kittatinny Supergroup – Beekmantown Group – Ontelaunee Formation	dolomite, limestone (Ontelaunee, Epler)	
Paleozoic	Ordovician	Lower Ordovician	Kittatinny Supergroup – Beekmantown Group – Epler Formation	dolomite, limestone (Ontelaunee, Epler)	
Paleozoic	Ordovician	Lower Ordovician	Kittatinny Supergroup – Beekmantown Group – Rickenbach Dolomite	sandy dolomite (Rickenbach)	
Paleozoic	Cambrian	Upper Cambrian	Kittatinny Supergroup – Allentown Dolomite	dolomite, calcareous sandstone	
Paleozoic	Cambrian	Middle Cambrian	Kittatinny Supergroup – Leithsville Formation	dolomite, calcareous shale	
Paleozoic	Cambrian	Lower Cambrian	Hardyston Quartzite	arkosic quartzite, conglomerate (Hardyston)	
Proterozoic	Middle Proterozoic		Byram Intrusive Suite, Lake Hopatcong Intrusive Suite, Mount Eve Granite	granite, quartz syenite, syenite, quartz monzonite, monzonite, and granodiorite	Ground water occurs in joints, faults, foliation surfaces, solution cavities, and other openings. "The Precambrian rocks are generally unproductive aquifers except where they are fractured or weathered. The more productive aquifers of the Highlands are the glacial deposits and some of the Paleozoic sedimentary rocks."*
Proterozoic	Middle Proterozoic		Metasedimentary rocks	quartzofeldspathic and calcareous metasedimentary rocks including the Franklin and Wildcat Marbles	
Proterozoic	Middle Proterozoic		Losee Metamorphic Suite	highly sodic gneissic and granitoid rocks; amphibolite	

Sources: New Jersey Geological Survey, Information Circular 1, 1990;
*NJGS, Geologic Map of NJ, 1984.

Table Two- Paleozoic Rock in Morris County

Era	Period	GREEN POND MOUNTAIN REGION: Stratigraphic Unit	GREEN POND MOUNTAIN REGION: Predominant Lithology	Hydrogeologic Characteristics
Paleozoic	Devonian	Skunnemunk Conglomerate	conglomerate	Ground water occurs along bedding surfaces, joints, faults, intergranular spaces, solution cavities, and other openings.
		Bellvale Sandstone	sandstone, siltstone, shale	
		Cornwall Shale	shale, siltstone	
		Kanouse Sandstone	conglomerate sandstone, siltstone	
		Esopus Formation	siltstone, sandstone	
		Connelly Conglomerate	conglomeratic quartzite	
	Silurian	Berkshire Valley Formation	calcareous siltstone, silty dolomite, sandstone	
		Poxono Island Formation	calcareous shale, dolomite	
		Longwood Shale	shale, siltstone	
		Green Pond Conglomerate	conglomerate quartzite, siltstone	

Table Three - Mesozoic Rock in Morris County

Era	Period	Epoch	Stratigraphic Unit			Predominant Lithology	Hydrogeologic Characteristics
Mesozoic	Jurassic	Lower Jurassic	Newark Supergroup	Brunswick Group	Boonton Formation	sandstone, siltstone, shale, conglomerate	Ground water occurs along bedding surfaces, joints, intergranular spaces, and other openings.
					Hook Mountain Basalt	basalt	
	Triassic	Upper Triassic			Towaco Formation	sandstone, siltstone, shale, conglomerate	

Source: New Jersey Geological Survey, Information Circular 1, 1990

Glacial Deposits and Their Permeability

High Permeability Material- Sands and Gravels

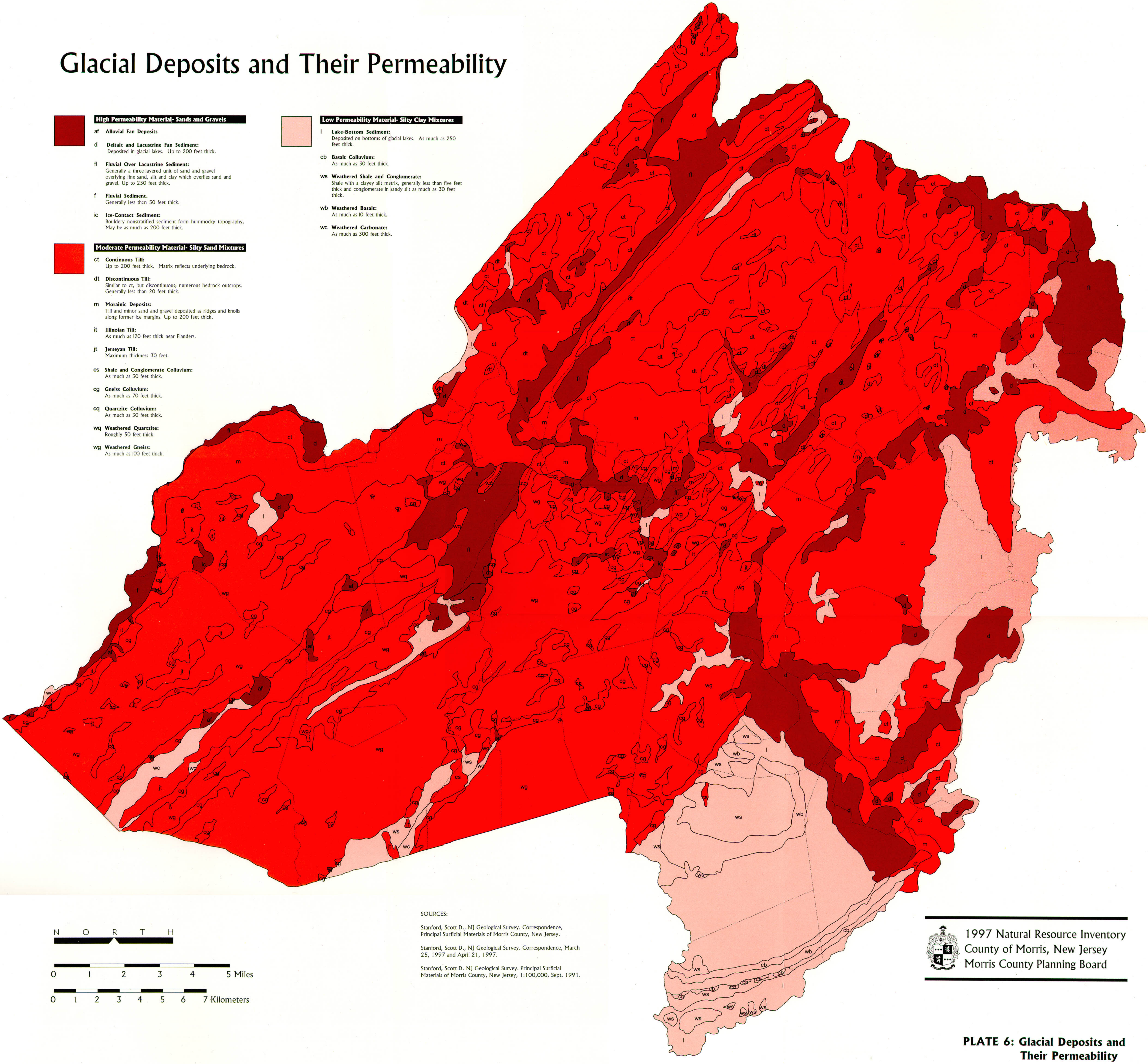
- af **Alluvial Fan Deposits**
- d **Deltaic and Lacustrine Fan Sediment:** Deposited in glacial lakes. Up to 200 feet thick.
- fl **Fluvial Over Lacustrine Sediment:** Generally a three-layered unit of sand and gravel overlying fine sand, silt and clay which overlies sand and gravel. Up to 250 feet thick.
- f **Fluvial Sediment.** Generally less than 50 feet thick.
- ic **Ice-Contact Sediment:** Bouldery nonstratified sediment form hummocky topography, May be as much as 200 feet thick.

Moderate Permeability Material- Silty Sand Mixtures

- ct **Continuous Till:** Up to 200 feet thick. Matrix reflects underlying bedrock.
- dt **Discontinuous Till:** Similar to ct, but discontinuous; numerous bedrock outcrops. Generally less than 20 feet thick.
- m **Morainic Deposits:** Till and minor sand and gravel deposited as ridges and knolls along former ice margins. Up to 200 feet thick.
- it **Illinoian Till:** As much as 120 feet thick near Flanders.
- jt **Jerseyan Till:** Maximum thickness 30 feet.
- cs **Shale and Conglomerate Colluvium:** As much as 30 feet thick.
- cg **Gneiss Colluvium:** As much as 70 feet thick.
- cq **Quartzite Colluvium:** As much as 30 feet thick.
- wq **Weathered Quartzite:** Roughly 50 feet thick.
- wg **Weathered Gneiss:** As much as 100 feet thick.

Low Permeability Material- Silty Clay Mixtures

- l **Lake-Bottom Sediment:** Deposited on bottoms of glacial lakes. As much as 250 feet thick.
- cb **Basalt Colluvium:** As much as 30 feet thick
- ws **Weathered Shale and Conglomerate:** Shale with a clayey silt matrix, generally less than five feet thick and conglomerate in sandy silt as much as 30 feet thick.
- wb **Weathered Basalt:** As much as 10 feet thick.
- wc **Weathered Carbonate:** As much as 300 feet thick.



N O R T H

0 1 2 3 4 5 Miles

0 1 2 3 4 5 6 7 Kilometers

SOURCES:

Stanford, Scott D., NJ Geological Survey. Correspondence, Principal Surficial Materials of Morris County, New Jersey.

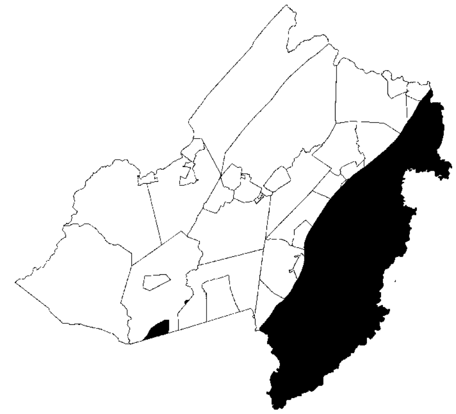
Stanford, Scott D., NJ Geological Survey. Correspondence, March 25, 1997 and April 21, 1997.

Stanford, Scott D. NJ Geological Survey. Principal Surficial Materials of Morris County, New Jersey, 1:100,000, Sept. 1991.

1997 Natural Resource Inventory
County of Morris, New Jersey
Morris County Planning Board

PLATE 6: Glacial Deposits and Their Permeability

Triassic/Jurassic rocks, in the southeastern third of the county, provide good water supply by way of well-fractured sedimentary units of shale and sandstone (when lacking cement); basalt of the Brunswick group, is a poor provider (Table Three). The sedimentary units contain aquifers supplying portions of Hanover, Harding, Long Hill, and Morris Townships, and the Town of Morristown.



Triassic/Jurassic Rock

Quaternary sediments, deposited by the glaciers, overlie much of the bedrock. The deposits can consist of any or all of the following: clay, silt, sand, gravel, and boulders. Clay and silt are normally considered confining layers; sand and gravel are generally excellent water bearers. Ground water occurs in both confined and unconfined conditions depending on presence or absence of a confining layer of clay or silt (Table Four).

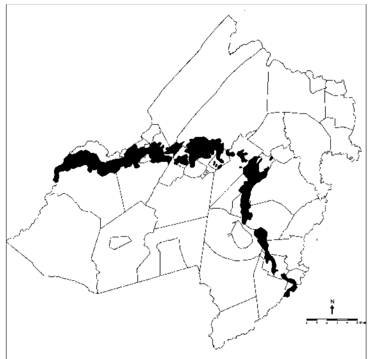
Table Four - Cenozoic Rock in Morris County

Era	Period	Epoch	Stratigraphic Unit	Predominant Lithology	Hydrogeologic Characteristics
Cenozoic	Quaternary	Holocene	alluvial, coastal, march, and wind-borne deposits	sand, gravel, silt, mud, and peat	under water-table conditions at most locations
		Pleistocene	Wisconsinan and pre-Wisconsinan alluvial, colluvial, glacial, lacustrine, and wind-borne deposits	sand, gravel, silt, clay (statewide), till and till-like deposits (northern New Jersey)	Includes glacial buried-valley aquifers.

Source: New Jersey Geological Survey, Information Circular 1, 1990

A Moraine Runs Through It

A significant piece of Morris County's heritage was its role as host to traveling glaciers. The composition, location, and layering of glacial and postglacial deposits, created varied and unique hydrogeologic conditions manifested by a broad range of aquifer productivity as summarized in Table Five. **Plate 6** depicts glacial deposits. The terminal moraine is itself not an excellent water bearing unit, as much as a point of reference for adjacent deposits constituting significant formations.



Terminal Moraine

Table Five - Hydrogeologic Characteristics of Glacial Deposits			
DEPOSITS	LOCATION	COMPOSITION	CHARACTERISTICS
STRATIFIED DRIFT			
deltaic & lacustrine fan sediments	glacial lakes	stratified sands & gravels	very productive if thick unit
fluvial sediments	deposited by meltwater in alluvial plains, or in streambed	stratified sands & gravels	very productive if thick unit
lake-bottom	glacial lakes	stratified clay, silt, and fine-grained sand	can act like semi-confining unit
till	scattered	non-stratified & non-sorted material; silt, sand, gravel & boulders	minor aquifer or semi-confining unit
morainal	along ice margins	till	minor aquifer or semi-confining unit

Source: NJ Geological Report Series 34, Ground-Water-Withdrawal and Water Level Data for the Central Passaic River Basin, New Jersey, 1898-1990, 1994.

Deltaic and lacustrine fan, fluvial, and lake-bottom sediments can be grouped together as **stratified drift.** Deposited by glacial **meltwater**, stratified drift is more uniform and better sorted than tills, which were deposited directly by the glacier. Coarse-grained, well sorted, saturated stratified drift is often associated with highly productivity aquifers.

Till is present as both terminal and ground moraine. The **terminal morainic** deposits, although moderately permeable, are of such a thickness as to yield significant amounts of water. The **ground moraine** is not nearly as productive.

Near the glacier, sediments deposited from meltwater are commonly interlayered with **till** and are highly variable both vertically and horizontally. Farther from the glacier, sediments are more uniform.

Poorly sorted sands and gravels, which have fine particles filling spaces between larger grains, may yield only small quantities of ground water.

Slow moving meltwater deposited fine-grained sand, silt, and clay in lakes and ponds. Thick deposits often act as confining layers to permeable water-bearing zones.

Postglacial materials consisting mainly of sand, gravel, silt, mud, and peat, often act as a semiconfining unit.

Buried Valleys

Preglacial and glacially deepened river valleys became filled with glacial sediments. These buried valleys have been the subject of investigation because of their excellent water-bearing capabilities, particularlywhere filled with clean sand and gravel. The buried valleys are represented in Figure 1. Deposition variation within the buried valleys affect productivity. Buried valleys filled with unconsolidated sediments, are the most productive ground water suppliers. The valley in northeast Morris Township, achieving maximum sediment thickness of over 300 feet, is very productive. However to the south of the terminal moraine (the Green Village, Long Hill and Oakwood buried valleys) and to the north of the moraine (Fairfield buried valley) are filled mostly with fine-grained material.

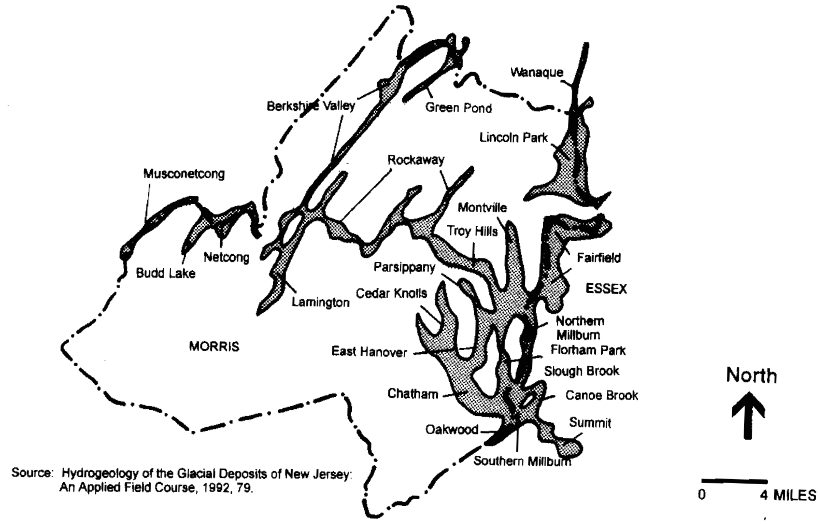


Figure 1 - Buried Valley Aquifer

Although the buried valleys could be considered to be one large system, hydraulically connected to each other as well as to the underlying bedrock aquifers, they have been segmented for investigative purposes.

The Central Passaic River Basin

The Central Passaic River Basin is demarcated by the Ramapo Fault to the west and Second Watchung Mountain to the northeast, east and south (Figure 2). A thin band of deltaic deposits (sand and gravel) to the south of the terminal moraine, extending from Long Hill to Morristown, is believed by NJGS Hydrogeologist Jeffrey Hoffman to be hydraulically connected to those to the north. The deposits on the south side are exposed, serving as recharge to the northern valley, which is confined by a layer of fine-grained sediments. Hoffman suggests that the high degree of vertical permeability of the outcrop area indicates an ability to accommodate recharge in addition to that from direct precipitation.

The outstanding value of this recharge area leads to land use questions. In addition to preservation efforts, future development and/or storm water management strategies could be designed to maintain, and even enhance, pre-development levels of runoff. Possible design would utilize the undeveloped portion of the land to accentuate recharge, by way of sewers along roads, and appurtenant detention and recharge basins with corresponding post-development maintenance agreements. Another strategy would be diverting runoff for recharge to a neighboring acre of the same geologic composition.

Areas with glacial deposits of till and lake-bottom clay are not suited to enhanced recharge because these sediments recharge at a much slower rate. It is till and clay's limited ability to promote vertical water movement that predisposes the formation of wetlands.

Figure 2 - Major Physiographic Features and Boundary of the Central Passaic River Basin

Source: N.J.G.S., Geological Survey Report GSR 34, 1994.

The wetlands within the Central Passaic River Basin exhibit varying hydrologic behaviors. Troy Meadows in East Hanover serves as a ground water **discharge** on its western edge and ground water **recharge** to the east. Both the Great Swamp and Great Piece Meadows lie atop lake-bed sediments confining the underlying aquifers. The Bog and Vly, Lee, Troy, and Black Meadows experience ground water interchange depending on water levels of the aquifer.

In the swamp areas that are underlain by clay and silt, discharge of ground water to the streams is restricted by low permeability of the materials and the slight hydraulic gradients. During the vegetative growing season, most of the ground-water discharge occurs as evapotranspiration. Thus, dry-weather stream flow is not augmented significantly, but may even be reduced.

Extensive withdrawal from the buried valleys has affected ground water flow. Significant drawdowns in the surficial aquifer system have occurred and declining water levels have been noted in all wells for which long-term records were available. As ground water divides have moved away from pumping centers more recharge is being induced into the aquifers. Typical discharge behavior (upward flow to surface followed by evaporation, transpiration or discharge to a surface water body) is diminished. As water is withdrawn from aquifers and then discharged to surface waters as waste, or pumped for export from the basin, it is unavailable for recharge.

The Eastern County

Two buried valleys (East Hanover and North
Two buried valleys (East Hanover and North
Millburn) extend through the eastern portion of the county converging in East Hanover (Figure 3). They are filled mainly with stratified drift (sand and gravel) deposits, and are interbedded with discontinuous confining clay layers.

A segment of clay layer extends beneath Sharkey's Landfill. Glacial till is also present, acting as a confining or semi-confining layer to the stratified drift. “Yields of individual wells in the thickest sections of stratified drift were as high as 1,400 gpm (or nearly 2mgd). Based on a computer model (Meisler, 1976) the highest sustainable yield for the entire East Hanover Buried Valley Aquifer is 13 mgd.”[3]

In addition to declining ground water levels due to inter-basin transfers of waste water, the aquifers in East Hanover have suffered years of contamination. The combined effects of industrial mishandling of hazardous substances, leaking underground storage tanks, suspected "midnight dumping," and the hydraulic effects of ground water pumping, have all contributed to a worsening contamination problem.

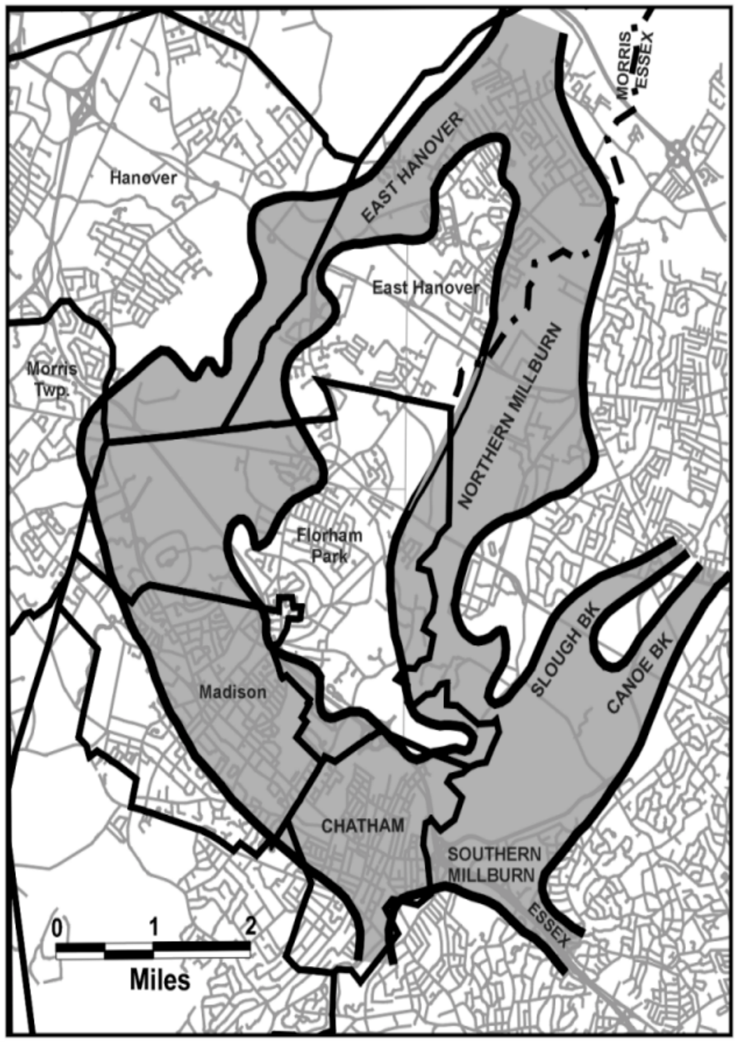
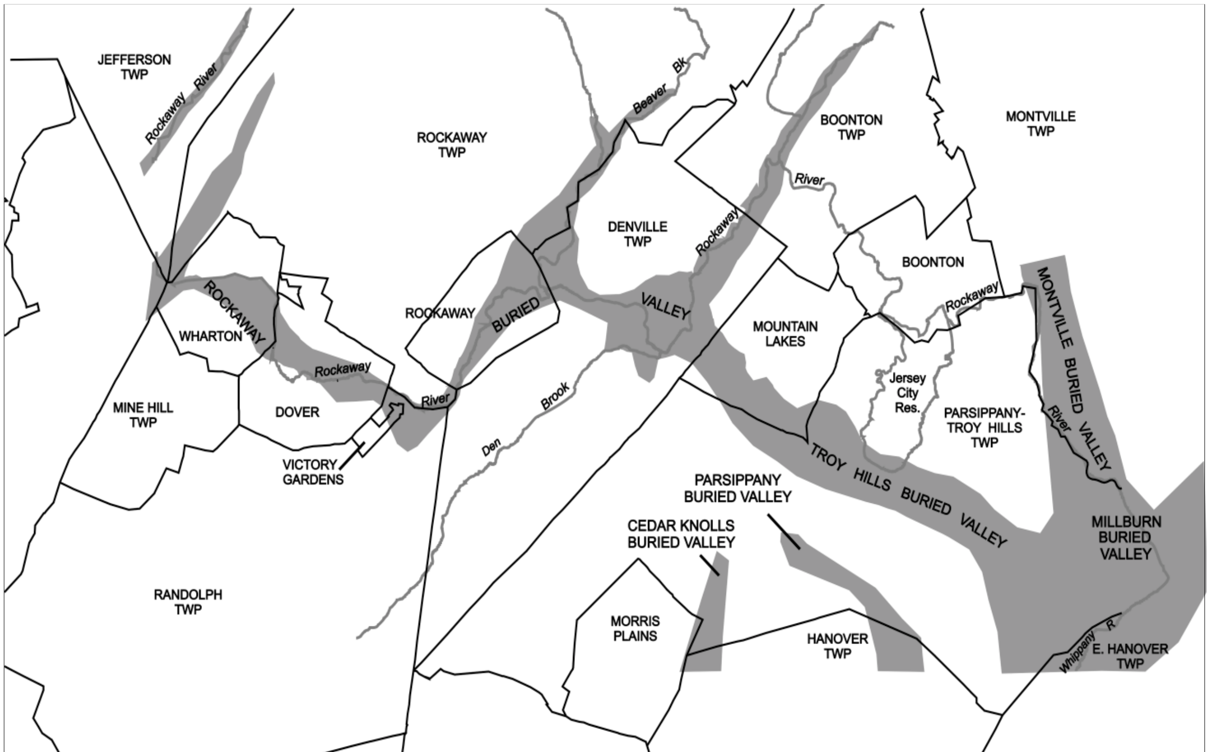


Figure 3 - East Hanover Buried Valleys

[3]Gil Oudijk, Ground-Water Contamination and the Delineation of a Well-Restriction Area in East Hanover Township, Morris County, New Jersey, NJGS Technical Memorandum 87-3, 1987.

The Rockaway River Valley

The Rockaway buried valley aquifers follow the path of the ancient Rockaway River (Figure 4). A gap between Mountain Lakes and Mount Tabor contains a semi-confined aquifer linking the Upper Rockaway Valley system with the Central Passaic River Basin. Unconsolidated deposits of till and stratified drift provide a rich source of water supply. The most prolific aquifers are the sand and gravel filled valleys in the Upper Rockaway River Basin, above the Boonton Reservoir.



Source: N.J.G.S., Geological Survey Report GSR 33, 1993.

Figure 4 - Rockaway Buried Valley Aquifers

The Rockaway River demonstrates surface and ground water exchange. Normally ground water discharges to the Rockaway particularly during late summer and fall. Pumping, however, has been suspected of reversing the flow, resulting in the river's recharging the stratified drift. A USGS study examining infiltration and movement of river water to production wells in Dover estimated that water supply consisted of 30% river water and 70% from glacial drift. Chemical changes were attributable to the infiltrating river water[4] and the substrate it passed through on its way to discharge.

[4]Joel E. Dysart, Estimates of Stream Leakage and Hydraulic Properties of a Glacial Aquifer Near Dover, New Jersey, Based on the Chemical Character of Water, Including Stable Isotopes of Hydrogen and Oxygen, U.S.G.S., Open-file Report 91-225, 1991.

The Northwest Territory

During the early eighties, having experienced drought conditions and wanting to plan for future dry spells, the NJGS studied portions of the Pequannock and Upper Rockaway River Valley (upstream from Denville) watersheds.[5] This area contains major water supplies serving Newark and Jersey City. Drainage from the Pequannock River flows to the Charlotteburg Reservoir, from which water is conveyed to the Newark Water Department. Downstream from Denville the Rockaway River flows to the Jersey City Reservoir at Boonton. The local Precambrian gneisses and Paleozoic sedimentary rocks had been considered to be generally poor water suppliers. Therefore, attention was focussed on the unconsolidated sands and gravel aquifers of the buried valleys. Recognized as likely productive ground water sources, these aquifers were examined for suitability as augmentation to surface water supply.

Buried valleys occurring in the Pequannock and Rockaway River Valleys are filled with glacial deposits including tills, stratified sands and gravels, silts, and clays. Till, without silt or clay present, allows adequate water supply for domestic use. However when fine sands, silts, clays, muck soils, and nonstratified till are present, their lack of permeability takes them out of production well contention. Their porosity, on the other hand, suits them well for slow and steady aquifer recharge.

Highly productive water-bearing zones were usually found in the deepest portion of filled valleys. These were normally close to or directly beneath streams, lakes, wetlands or flood plains. As with the Central Passaic River Basin, there were variations within the valleys resulting in differences in water production.

Within the study area, the floor of the Rockaway and its tributary valleys, are relatively flat in relief, and are covered by very permeable granular soils. These conditions were conducive to excellent aquifer recharge directly by rainfall. Additionally, runoff from the surrounding watershed area was found to contribute considerable recharge both from surface flow and movement through fractures in the bedrock.
Although valuable in their water bearing capabilities, these valley fill aquifers also have their limitations: size and depth, with bedrock walls restricting long-term yields; areas overlain by impermeable fine sand, silt, and clay; medium-to-coarse grained sands and gravels with a fine-grained matrix impeding the flow of water; unconfined or semi-confined conditions suggesting a greater vulnerability to contamination; and confined conditions conducive to inter-valley impacts from pumping, due to connectivity.

Finally, the study concluded that ground water diversion for flow augmentation is a consumptive use of groundwater and thus only suitable as a temporary solution. The heavy reliance on the surface water supplies necessitates careful assessment and consideration of historic, current, and future land use and their respective impacts on ground water quality and quantity in municipal long range planning.

* Spreading Globe Flower

---

[5]Robert Canace et al, Results of the 1980-81 Drought Emergency Ground Water Investigation in Morris and Passaic Counties, New Jersey, 1983.

The Western County

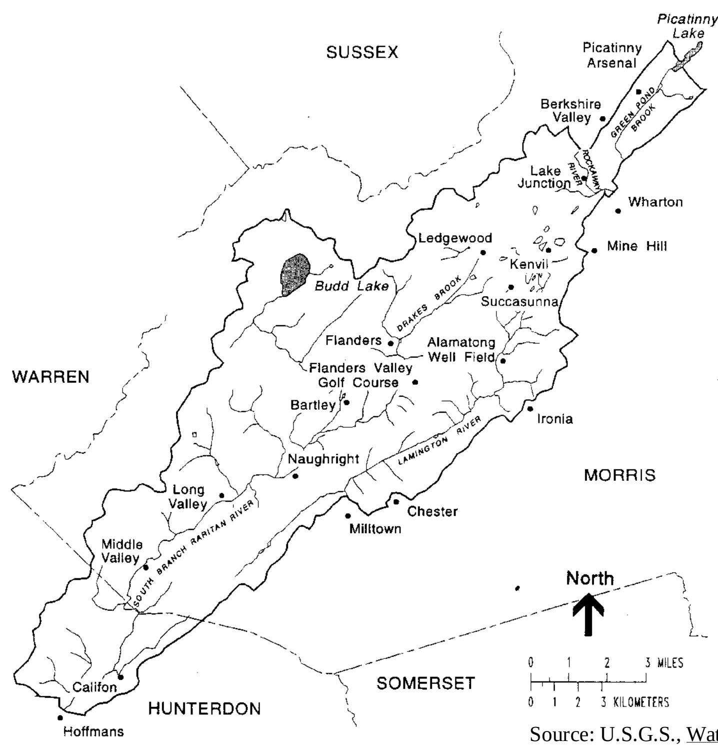
Toward the western part of the county is the band of glacial deposits lying within the Long Valley region. This aquifer system is an important source of ground water in a region which is steadily increasing its demand. A recently published study[6] investigated these valley-fill aquifers and the underlying carbonate-rock spanning the valleys of the Lamington River, Rockaway River, Green Pond Brook, Drakes Brook, and South Branch of the Raritan River.

The Lamington River Valley (Figure 5) stretching from Picatinny Arsenal southwardly to Califon (Hunterdon County) contains confining clay layers remnant from glacial Lake Succasunna. These impermeable deposits separate the confined aquifer from the unconfined aquifer present in the valleys.

The underlying carbonate-rock aquifer is of the Leithsville Formation. Its varied water supply capability is linked to enhanced secondary porosity caused by weathering and resultant solution opening of primary fractures, joints, or bedding planes. Productive wells have been located in the valleys of Drakes Brook, the South Branch Raritan River and the Lamington River. Where Hardyston Quartzite underlies the carbonate-rock aquifer, supply is mainly appropriate for domestic use.

In the northern parts of the study area the **Green Pond Conglomerate aquifer** overlies the carbonate-rock aquifer. Other than in low-lying areas, this aquifer does not produce significant amounts of water. The valley fill deposits, however, are more permeable and productive than those to the south.

Areas relying on water supply from Precambrian crystalline rocks benefit from intersecting fractures, especially those weathered-induced. Yields generally are small but are adequate for domestic supply.



Source: U.S.G.S., Water-Resources Investigations Report 93-4157, 1996.

Figure 5 - Lamington River Valley

[6] R.S. Nicholson, et al, Hydrogeology of, and Ground-Water Flow in, A Valley-Fill and Carbonate-Rock Aquifer System Near Long Valley in the New Jersey Highlands, 1996.

Results of the investigation, based on modeled projections for increased pumpage, indicated:

- decreased discharge to the river from the aquifer system;
- increased downward flow from and decreased upward flow to lower valley-fill aquifer;
- increased lateral flow of ground water into S. Branch Raritan River basin from Lamington River Basin;
- and slight increase in tributary-stream leakage to aquifer system.[7]

A connection between human activities and ground water quality was validated by volatile organic compounds found in each water bearing unit, in addition to concentrations of nitrates and chloride.

Ground Water Quality In Morris County

Ground water quality data for the county is piecemeal. Ground water quality in the Highlands is very good for most purposes, with some local areas requiring treatment for undesirable characteristics and constituents. Occasionally State-recommended secondary drinking water standards (those affecting aesthetics, e.g., appearance, taste, or odor) were exceeded. These parameters included corrosivity, hardness, iron, manganese, sodium and gross alpha particle activity.[8] Primary drinking water standards pertain to potential for adverse affect on human health.

During the early eighties' investigation of the Pequannock River and upper Rockaway River watersheds, chemical analyses of the ground water resulted in good to excellent quality designations. Total Iron and Manganese were the only parameters in excess of potable water standards. Specific examples of this occurred in samples from some municipal wells in Mountain Lakes and the Town of Boonton. These wells, adjacent to the Rockaway River and tapping the stratified drift aquifer, were receiving Iron and Manganese loads from infiltrating surface water. Though excessive levels of Iron and Manganese pose an aesthetic problem, as in staining of sinks and fabrics, they are not considered a health problem.

The Passaic River Coalition's investigation of the Buried Valley aquifer system[9] revealed limited incidences of high sulfate levels. These were associated with sulfate minerals occurring in basalt and red shale. The sand and gravel aquifers also exhibited increased incidences of hard water.

Management Considerations

Variables including human health, status of ecological resources, cost of water treatment and provision of alternative supplies justify comprehensive groundwater management. Since activities on the land impact the quality and quantity of ground water and its recharge areas, emphasis is on land use management. With drawdown occurring in the southeast, regular water shortages in the northwest, contamination to the east and elsewhere, there is an obvious need for greater geotechnical research on the extent and capability of bedrock as well as surficial aquifers.

---

[7]R.S. Nicholson, et al, Hydrogeology of, and Ground-Water Flow in, a Valley-Fill and Carbonate-Rock Aquifer System Near Long Valley in the New Jersey Highlands, 1996.

[8]Michael Serfes, Natural Ground-Water Quality in the Lower Paleozoic and Middle Proterozoic Bedrock Aquifers of the Highlands and Valley Physiographic Provinces of New Jersey, NJGS Report GSR Draft, 1997.

[9]Passaic River Coalition, The Hydrogeology of the Buried Valley Aquifer System, 1983.

Impacts From Natural Hazards

Roughly 95% of water supply within the county is provided by ground water and for the most part satisfies State and Federal quality standards. However this situation is tentative. Naturally occurring contaminants include iron, dissolved solids, sulfate and calcium. Less common, yet significant contaminants include radium, lead, and barium. Normally, as water infiltrates, mineral content is low. The quality changes, however, along the flow path. Dissolved solids as well as other constituents increase with distance and time. Thus time, distance traveled and rock solubility impact water quality.

Human Derived Impacts

The most common manmade contaminants include volatile organic compounds (VOCs), heavy metals, base neutrals, acid extractables, and pesticides. Other contaminants include petroleum products, salt, bacteria, and viruses.

Sources and modes of transmission reflect our lifestyles. The land uses supporting these lifestyles: urbanization, transportation, industrialization, and agriculture involve specific infrastructure with associated activities that either intentionally or accidentally contribute contaminants to the subsurface. Leaking underground storage tanks, pipelines, landfills, surface impoundments, underground injection wells, industrial spills, illegal discharges, septic tanks, agricultural activities, abandoned or improperly constructed wells, inactive mines, stormwater runoff, overpumping and artificial recharge are some of the many avenues for ground water contamination.

Mode of transmission of ground water contamination is influenced by substance released, location of release, and hydraulic characteristics of the geology. Four common ways of ground water contamination include:

- **Infiltration -** water percolates, dissolving contaminants into leachate, which continues traveling to the saturated zone where it follows ground water flow.

- **Direct migration -** contaminants' direct travel to ground water, e.g. from storage tanks and pipelines.

- **Interaquifer exchange -** results from the hydraulic connection between aquifers. A common vehicle of this type of contamination is a well that has penetrated more than one water-bearing formation.

- **Recharge from surface water -** results from a reversal in the hydraulic gradient so that surface water is drawn toward, and recharges the ground water, as in the overpumping of an aquifer.

Although traveling through the substrata affords some attenuation via filtration, dilution, oxidation, and biological decay, distance to the ground water may not be adequate for proper treatment and some contaminants remain unchanged. Treatment is much more difficult once the contaminant reaches ground water which normally moves extremely slowly and with very little turbulence. Instead the plume of contamination, now concentrated, simply follows the ground water flow.

Known (and unknown) sites of contamination have plumes migrating underground, which are extremely difficult to pinpoint. There are historic and current land uses threatening ground water and aquifers.

Appreciation for ground water protection is spreading as local officials have instituted land use and development ordinances, participated in the NJ Well Head Protection Program, and joined regional coalitions working to manage this commonly shared resource within the construct of the larger watershed.

In order to create a comprehensive picture of ground water quality status in the state, NJ DEP compiled a database documenting contaminated wells, associated pollutants and known pollution sources. Of the 3086 ground water pollution cases documented in 1989, 1200 were assessed, representing seven counties (one of which was Morris County). The seven counties were Hunterdon, Morris, Passaic, Somerset, Camden, Monmouth, and Ocean. These seven were diverse in terms of geographic distribution, hydrogeologic setting, population density, and land use/land cover.

Table Six excludes Ocean, Camden and Monmouth counties which lie south of the "fall line" and where infiltration rates, aquifer characteristics, and ground water flow patterns differ significantly from counties in the north. Thus the chart reflects the numbers of pollution cases for major sources of human-derived pollution for Camden, Hunterdon, Monmouth and Morris Counties. As of 1990, Morris County had the highest number of ground water pollution cases (282). Within two years, the number had risen to 400.[10]

Table Six - Major Sources of Human-Derived Pollution Listed by County

Numbers indicate frequency of pollution cases (both as absolute and as percentage of total cases within county).

MAJOR SOURCES OF POLLUTION	COUNTY							
	CAMDEN		HUNTERDON		MONMOUTH		MORRIS	
	#	%	#	%	#	%	#	%
AGRICULTURE							1	0.4
ABOVE GRND STORAGE TANKS			1	1.1				
COAL TAR			1	1.1				
DRUMS			1	1.1	5	2.7		
LAGOON	10	6.1	5	5.6	25	13.4	13	4.6
LAND SPRAY APPLICATION			1	1.1				
LANDFILL	24	14.7	6	6.7	38	20.3	21	7.4
NONE			1	1.1			2	0.7
OTHER			3	3.4	4	2.1	1	0.4
ROAD SALT PILE								
SEPTIC SYSTEM	2	1.2	8	9.0	4	2.1	30	10.6
SURFACE SPILL	11	6.7.	10	11.2	30	16.0	11	3.9
UNKNOWN	88	54.0	37	41.6	45	24.1	152	53.9
UNDRGRND STORAGE TANK	28	17.3	15	17.0.	36	19.3	51	18.1
TOTAL	163	100%	89	100%	187	100%	282	100%

Source: (NJ DEP, New Jersey 1994 State Water Quality Inventory Report, 1995.)

[10]New Jersey Department of Environmental Protection, New Jersey 1994 State Water Quality Inventory Report, 1995.

Plate 7 depicts locations of a portion of the 706 sites in Morris County severely impacted by human-derived contaminants. Each of these sites represent an "environmentally complex... site... where there are multiple sources of contamination; multiple environmental media affected (i.e. soil, ground water and air); multiple contaminants; and/or a multi-phased approach ... to clean up the site."[11] The source, Known Contaminated Sites in New Jersey, is an annual publication produced by the NJ DEP. It provides an inventory of sites where contamination is "present at levels greater than the applicable cleanup criteria for soil, ground water standards and/or maximum contamination levels of the Safe Drinking Water Standards."[12] The State's Bureau of Community Relations administers the Site Information Program which conducts radius searches for prospective real estate buyers, sellers, and other interested parties.

Areas With Ground Water Contamination In The County

Picatinny Arsenal: The Department of Defense installation at Picatinny Arsenal in Rockaway Township contains extensive and multiple sites of contamination. Sources of contamination include but are not limited to solvents, metals, explosives, and polychlorinated biphenyls. An effort is underway to remediate many of the sites. However the time line extending from remedial investigation/ feasibility study, through plan formulation and approval, to actual clean up, is protracted.

East Hanover: In response to a contaminated ground water situation affecting East Hanover and its environs, the New Jersey DEP conducted an investigation evaluating types, sources, distribution and movement of ground water contamination.[13] Contamination of the surficial, as well as bedrock, aquifers was detected in over 70 domestic wells, 70 monitor wells and 3 municipal-supply wells within the Township and in neighboring communities.

Contaminants allegedly emanated from industrial activities including manufacturing, storing, and handling of hazardous substances. Waste disposal practices including use of lagoons, seepage pits and dry wells appeared to be the worst culprits until public sewers became available in 1984. The hazardous wastes, generically identified as solvents and degreasers, included volatile organic, base neutral, acid extractable and petroleum hydrocarbon compounds. Many of these were considered carcinogenic. Aging, corroding underground storage tanks, exacerbated the situation as they seeped gasoline, fuel oils and industrial solvents. Burial of hazardous-waste drums, and suspected "midnight dumping" of wastes deluged the aquifer system with contaminants.

The combination of a large number of contaminant sources, the high mobility of volatile organic compounds, and the draw caused by pumping domestic and municipal wells, resulted in all of the ground water in East Hanover being either contaminated or vulnerable to contamination. Many neighboring towns overlying the buried valley system also suffered contamination. Affected water suppliers included:

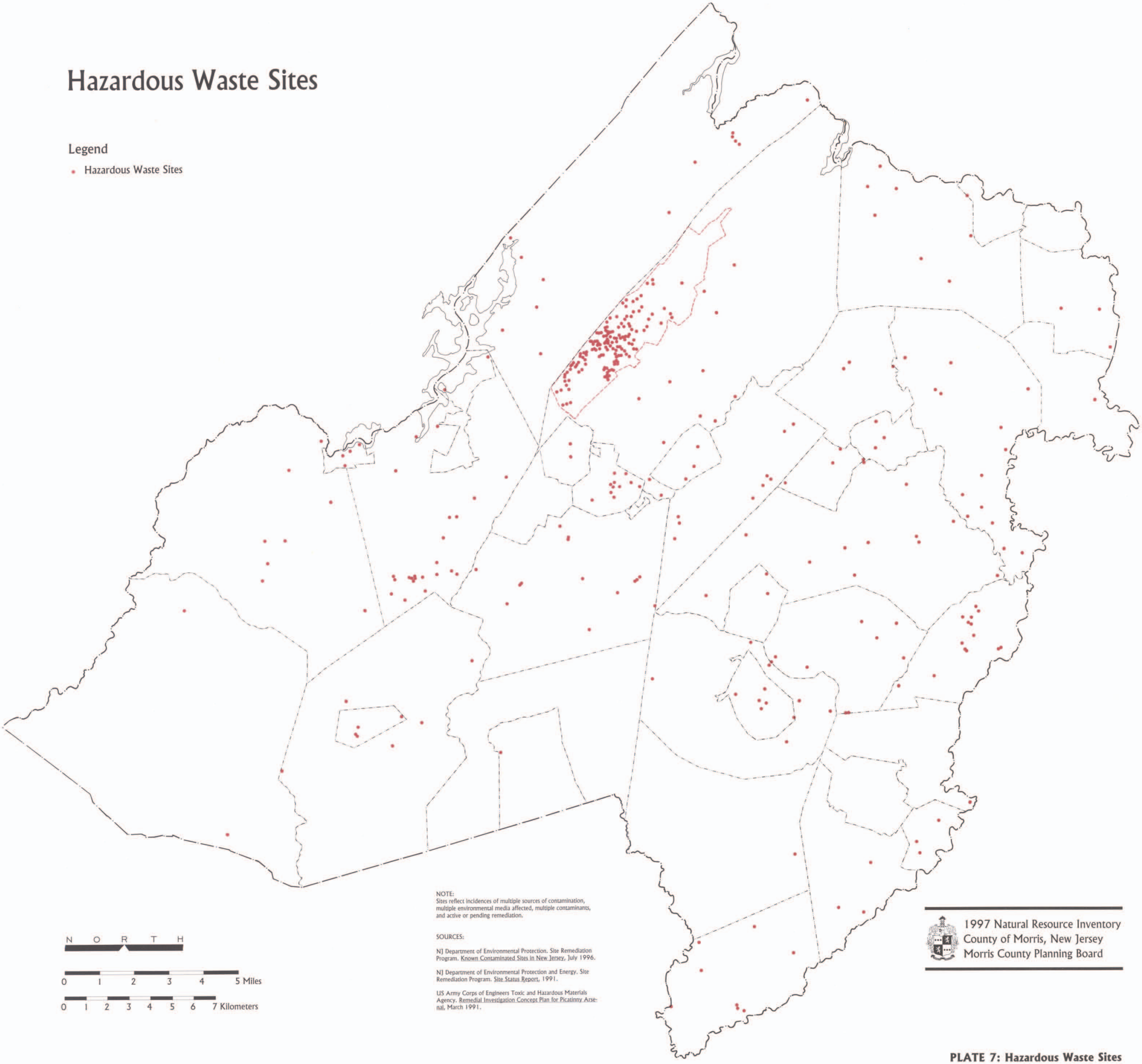
---

[11] NJ Department of Environmental Protection and Energy, Site Status Report, 1992.

[12] NJ DEP, Known Contaminated Sites in New Jersey, Sept. 1997.

[13] Gil Oudijk, New Jersey Department of Environmental Protection, Ground-Water Contamination and the Delineation of a Well-Restriction Area in East Hanover Township, Morris County, New Jersey, New Jersey Geological Survey Technical Memorandum 87-3, 1987.

Hazardous Waste Sites



NOTE:
Sites reflect incidences of multiple sources of contamination, multiple environmental media affected, multiple contaminants, and active or pending remediation.

SOURCES:

NJ Department of Environmental Protection. Site Remediation Program. Known Contaminated Sites in New Jersey, July 1996.

NJ Department of Environmental Protection and Energy. Site Remediation Program. Site Status Report, 1991.

US Army Corps of Engineers Toxic and Hazardous Materials Agency. Remedial Investigation Concept Plan for Picatinny Arsenal, March 1991.

1997 Natural Resource Inventory
County of Morris, New Jersey
Morris County Planning Board

PLATE 7: Hazardous Waste Sites

- Livingston Water Department, Essex County
- Essex Fells Water Co., Roseland, Essex County
- Fairfield Regional Contamination, Essex County
- Madison Water Dept. (as well as numerous domestic wells), Morris County
- Florham Park Water Dept., Morris County: reports were unconfirmed
- Southeast Morris Municipal Utilities Authority, Morris County: Analyses of water samples taken from the authority's distribution system in 1986 indicated contamination.

The Rockaways: During the early eighties, both Rockaway Borough and Township suffered municipal water supply contamination problems. Initially Rockaway Township discovered trichloroethylene in three wells. The source was traced back to a local industry using inadequate hazardous waste disposal methods. This episode was followed by the appearance of di-isopropyl ether and methylene chloride (additives used in unleaded gasoline) which had leaked from a storage tank at a local gas station.

The neighboring Borough of Rockaway, drawing from the same aquifer, discovered tetrachloroethylene. Both municipalities hastily made temporary provisions for potable water supply for their residents, and then invested in carbon adsorption units for long term treatment.

Regulatory Support

FEDERAL

- **Clean Water Act** provides funds for ground water protection and authorizes water pollution prevention programs.
- **Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)** authorizes government cleanup of hazardous spills, and establishes liability for contamination.
- **Federal Insecticide, Fungicide, and Rodenticide Act** authorizes EPA's control of pesticides.
- **Resource Conservation and Recovery Act** regulates storage, movement and disposal of solid and hazardous wastes.
- **Safe Drinking Water Act** protects drinking water supplies through standards for maximum levels of contaminants, regulation of underground discharge, and aquifer and wellhead recognition.
- **Sole Source Aquifer Program** designates critical aquifers serving as primary potable water supplies.
- **Toxic Substance Control Act** authorizes EPA "cradle-to-grave" control of toxic chemicals.

STATE

- **County Planning Act** provides jurisdiction over road and drainage facility's construction and maintenance.
- **NJ Safe Drinking Water Act** controls quality of public drinking water by identifying risk levels.
- **NJ Water Pollution Control Act** protects uses of water through discharge controls.
- **Soil Erosion and Sediment Control Act** regulates construction-related soil erosion and stormwater management.
- **Standards for Individual Subsurface Sewage Disposal Systems** regulates location, design, construction, installation, maintenance of individual subsurface sewage disposal systems (septics).
- **Water Supply Management Act** authorizes planning and controlling the allocation and provision of water. Water supply critical areas may be designated and regulated if need be.
- **Ground Water Quality Standards** provide rules for ground water classification and designated uses, water quality criteria and constituent standards. Further description and map are in **Appendix A**.

- The **Well Head Protection Program** is intended to control pollution sources, and regulate:
  - ❦ Public Community Water Supply Wells
  - ❦ Public Noncommunity Water Supply Wells
  - ❦ Clusters of Domestic Water Supply Wells

  Protection of wells is to be achieved through:
  - ❦ Delineation of Well Head Protection Areas (WHPA)[14]
  - ❦ Implementation of regulations to minimize pollution from point and non point discharges
  - ❦ Avoidance of siting new wells in high-risk locations.

  WHPA's rely on two basic criteria:
  - ❦ Average Time-of-Travel (TOT) for ground water to reach a well
  - ❦ Hydrologic boundaries that affect ground water flow (e.g., faults, ridges and surface water bodies)

  Each WHPA will have several tiers so that the level of control matches the pollution risk:
  - ❦ Tier 1 targets bacteria and viruses attenuation; TOT of 200 to 360 days
  - ❦ Tier 2 targets hazardous materials that do not degrade readily in ground water (such as chlorinated volatile organic chemicals); TOT between 2 and 5 years
  - ❦ Tier 3 is intended to serve monitoring and remedial efforts; TOT between 10 and 15 years.

Planning Strategies

- Analyses:
  - ❦ hydrogeological evaluation of ground water flow; ground water availability, recharge potential, rate and volume; and aquifer recharge characteristics
  - ❦ water budget - anticipated use and discharge of water
  - ❦ critical density - estimated population at full build-out
  - ❦ carrying capacity - calculated ability of an area to accommodate growth and development respective of existing and proposed infrastructure and the natural environment
  - ❦ historic land use - contaminated soils from past uses (e.g., industrial, agricultural)
  - ❦ existing land use - common sources of contamination (e.g., industrial waste disposal, underground storage tanks, farms, landfills, septic tanks)
  - ❦ inventory of sites where potential contaminants are manufactured, stored, and transported
  - ❦ monitoring - long term sampling of surface and ground water (public and private wells) quality and quantity
- Location of sensitive recharge areas or wellfields
- Acquisition of select lands (e.g., recharge areas or wellfields)
- Stormwater management plan addressing quality and quantity of infiltrating stormwater
- Individual Sanitary Sewer Disposal (Septic System) Management Plan
- Conservation Easements

---

[14]WHPA: "An aquifer volume described in plan view around a well, from which ground water flows to the well and ground water pollution, if it occurs, poses a significant threat to the water quality of the well." EPA, Wellhead Protection: A Guide for Small Communities, 1993.

Design Strategies

- Limiting impervious surfaces in ground water recharge and wellhead protection areas
- Routing clean stormwater runoff (e.g., rooftop) to infiltration basins
- Septic system density and siting away from stormwater collection areas, depressions or swales

Zoning and Site Plan Ordinance

- Overlay district over aquifer recharge as provided by the Borough of Mountain Lakes which has delineated a Prime Aquifer Area overlay zone with corresponding restricted uses
- Overlay district over wellhead protection area and corresponding regulation of hazardous substances[15]
- Impact zoning: developer's provision of positive or neutral impact on the community water supply
- Overlay district over limestone formation and corresponding restricted activities as in Washington Township[16]
- Density or clustering options based on hydrogeologic conditions such as limestone formation, aquifer recharge or wellhead protection area
- Regulate future potential sources of pollution e.g. motor vehicle-related services, laundromats, beauty salons, photographic processing, car washes, medical offices, research labs
- Individual Sanitary Sewer Disposal (Septic System) ordinance such as advocated by the Ten Town Great Swamp Watershed Committee which includes provisions for a 'design engineer required to certify installations, separate greywater and blackwater systems, approved reserve area set aside for future expansion or replacement of system, certificate required for continued use prior to transfer of title, and establishment of detailed design standards [17].

Practices

LOCAL

PUBLIC AND NONPROFIT AGENCIES

- Cooperative ventures such as the Alamatong Wellhead Protection Study supported by Chester and Randolph Townships, the County of Morris, the US Geological Survey, New Jersey DEP, and the Upper Raritan Watershed Association. Identification, delineation and investigation of the Alamatong wellhead production area provided basis for planning and zoning formulation.

  A Well Head Protection study coordinated by the Passaic Valley Ground Water Protection Committee delineated well head protection areas as well as potential pollutant sources within.[18]

---

[15]South Branch Watershed Association, Working Draft Model Planning Board Ordinance for Wellhead Protection Areas and Drinking Water Aquifer Protection, 1998.

[16]An Ordinance … of the Township of Washington, County of Morris … to Regulate Development in Limestone Areas, April 1998.

[17]Peter Messina et al, Ten Town Great Swamp Watershed Committee, Draft Model Environmental Ordinances, Jan. 1997.

[18]Passaic River Coalition and Passaic Valley Ground Water Protection Committee, Planning For Well Head Protection For Ground Water From The Whippany, Chatham and Millburn Valleys Of The Buried Valley Aquifer Systems, 1998.

HEALTH DEPARTMENT AND PUBLIC WORKS

- Enforcement of underground storage tank regulations
- Individual Sanitary Sewer Disposal (Septic System) maintenance plan as in Harding Township
- Conduct regular and thorough streetsweeping
- Implement de-icing bmp's:
  - store salt piles on impermeable surfaces, covered with waterproof covering
  - floor elevations should be raised above the 100 year storm level
  - explore de-icer alternatives:
  - Calcium Magnesium Acetate (minimal degradative effects on ground and surface water, vegetation or animals, structures; cost, however, may be prohibitive)
  - addition of abrasives, such as sand and gravel, to standard de-icers of Sodium Chloride or Calcium Chloride, or a mixture of the two
  - dispose of heavily salted snow in areas other than those around public supply wells, areas of high ground water recharge, or directly into surface water

INDIVIDUAL

- Conservation Landscaping (as outlined in the Soils Chapter): a combination of design, plants, and mulches are aesthetically pleasing, economically efficient by reducing maintenance requirements and protect the ground water resource.
- Install low water use plumbing fixtures
- Utilize hazardous waste collection services
- Exercise septic system management:
  - regular pumping
  - avoid chemical additives (these compromise the necessary microbial action)
- Monitor underground storage tanks:
  - replace old tanks (over 20 years of age) with state-of-the-art tanks
  - contain above ground tanks to prevent discharge from leakage or overfilling
  - avoid installing tanks in or below the water table
  - to assess leakage, perform a tank tightness test upon installation and periodically thereafter
- Exercise care in automobile maintenance activities:
  - store chemicals high and dry
  - dispose of waste materials properly e.g. Hazardous Waste Collection

Education and Outreach

- Build community support for regulatory programs
- Mobilize voluntary ground water protection efforts (e.g., conservation, participation in household hazardous waste cleanup days)

* Sedge Wren

Glossary

BEDROCK AQUIFER Aquifer consisting primarily of sedimentary and igneous rocks.

CONSOLIDATED Bedrock with openings consisting of fractures such as sandstone, limestone, granite.

CONFINED AQUIFER Aquifer bounded by relatively impermeable materials.

CONTAMINANT "any physical, chemical, biological or radiological substance or matter in water."[19]

GROUND MORAINE Glacial deposits formed by the downwasting of an ice sheet over a large area, leaving a landscape of low, gently rolling hills and undrained depressions.

MORAINE A mound, ridge, or other distinct accumulation normally of unsorted, unstratified glacial drift, predominantly till, deposited chiefly by direct action of glacial ice.

PERMEABILITY The degree of mobility achieved by soil grain size and interconnectedness of voids.

POROSITY The maximum amount of water that a rock is capable of containing within its void spaces.

RECESSIONAL MORAINE A ridge of glacial till deposited by an ice sheet during a temporary stillstand in its general recession.

SURFICIAL AQUIFER Aquifer consisting primarily of glacial and post-glacial stratified sediments.

SUSTAINABLE YIELD The amount of water available for pumpage indefinitely with water levels 30 above the base of the aquifer[20]

TERMINAL MORAINE The end moraine that marks the farthest advance or maximum extent of a glacier.

TILL Rocky material (clay, sand, gravel, stones, boulders) picked up by glacial ice and deposited elsewhere.

UNCONFINED AQUIFER Aquifer recharged directly from precipitation.

UNCONSOLIDATED Bedrock with openings consisting of pores such as sand, grave, clay.

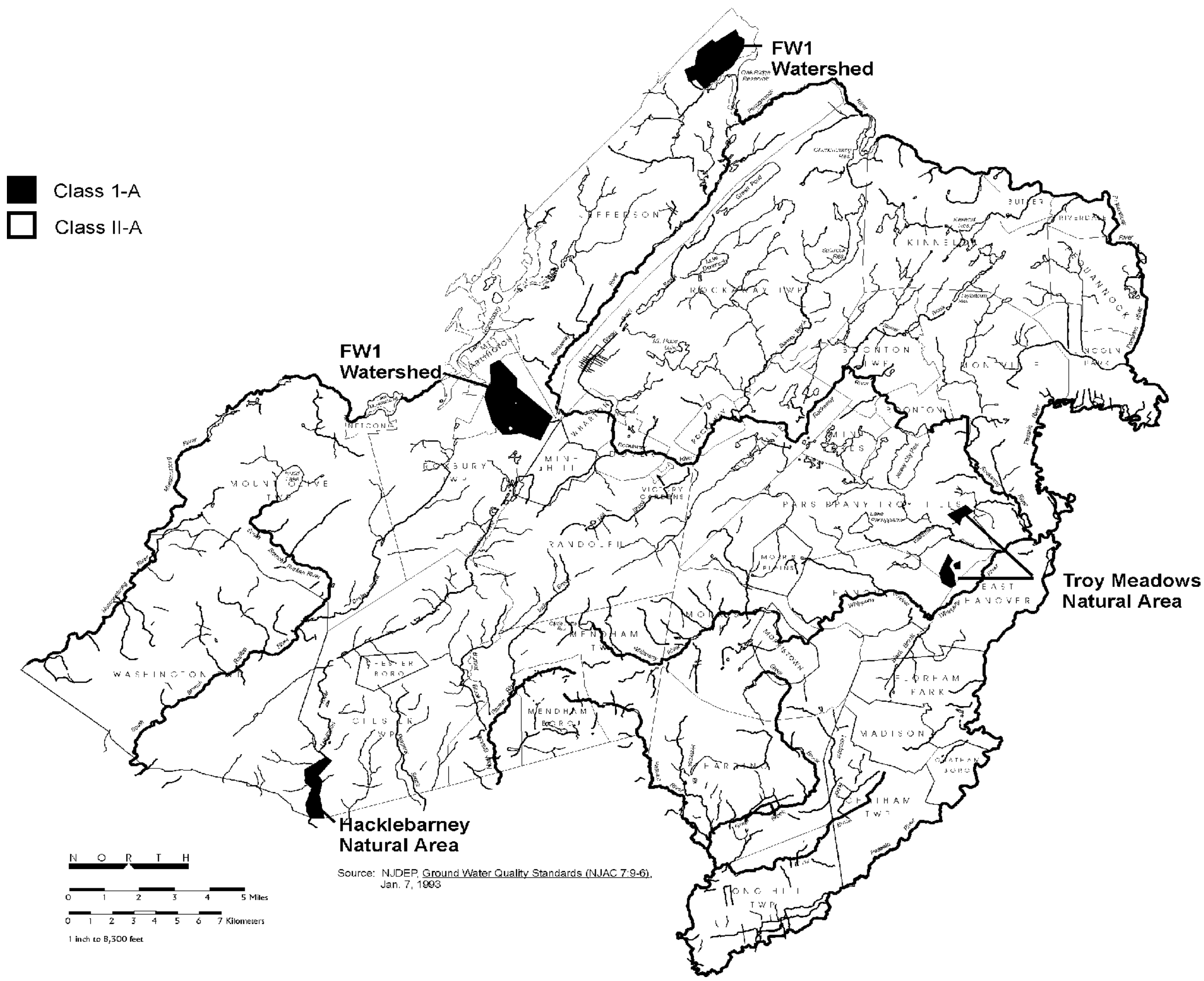
---

[19] New Jersey Safe Drinking Water Act (N.J.A.C. 7:10).

[20] Jeffrey Hoffman, NJGS Open-File Report OF-89-1, Simulated Drawdowns, 1972-1995, in The Pleistocene Buried-Valley Aquifers in Southwestern Essex and Southeastern Morris Counties, New Jersey, 1989.

Appendix A

Ground Water Quality Standards (N.J.A.C. 7:9-6 et seq.) The ground water quality standards strive to "restore, enhance and maintain the chemical, physical, and biological integrity of its waters, to protect public health, to safeguard fish and aquatic life and scenic and ecological values, and to enhance the domestic, municipal, recreational, industrial and other uses of water.



Ground Water Classifications in Morris County

Generalized provisions of the standards include:

- ground water classification
- numerical criteria for pollutants
- antidegradation controls
- effluent limits for intentional discharges
- cleanup standards and compliance levels for areas beyond the boundaries of permitted discharge sites as well as remediation sites
- loading rates and targets for pollution mitigation activities

The classification of ground water relies on hydrogeologic characteristics of the specific resource and the designated uses which are to be maintained, restored or enhanced. The following is a summation of the classifications and associated designated uses.

Class I - Ground Water of Special Ecological Significance
Primary designated use: maintenance of special ecological resources which are supported by the contributing ground water.
Secondary designated uses: potable, agricultural and industrial waters, such as not to compromise the primary use.
Class I-A - Exceptional Ecological Areas: Hacklebarney Natural Area, and Troy Meadows Natural Area. This classification stipulates nondegradation, disallowing human activities resulting in the degradation of natural quality.

[redacted]

Class II - Primary designated use: provision of potable ground water, allowing conventional water supply treatment.
Class II-A - All ground waters of the State, except for ground water designated in Classes I, II-B or III.
Primary designated use: potable water and conversion (through conventional water supply treatment, mixing or other similar technique) to potable water.
Secondary designated uses: agricultural and industrial water.

[redacted]

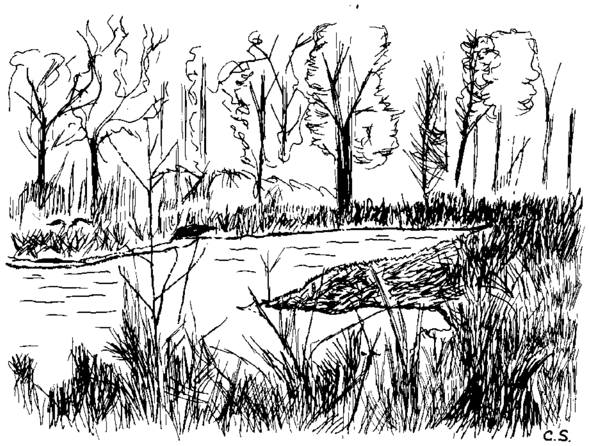
Class III - unsuitable for potable water due to natural hydrogeologic characteristics (e.g. aquitards) or natural water quality (e.g. salinity). Not applicable to Morris County
Class III-A - specific portions of the saturated zones of the glacial moraine and glacial lake deposits, and other geologic units having the characteristics of an Aquitard, excepting Class I areas.
Primary designated use: the release of ground water to adjacent classification areas and surface water.
Secondary designated uses: any reasonable uses.

The Standards, as they apply to discharge control and remediation, are implemented by:

- the Water Pollution Control Act
- the Spill Compensation and Control Act
- the Solid Waste Management Act
- the Environmental Cleanup Responsibility Act/Industrial Site Recovery Act
- the Pesticide Control Act of 1971
- the Storage of Hazardous Substances Act
- the Realty Improvement Act (Chapter 199)

. . . as well as the following programs:

- NJ Pollutant Discharge Elimination System (NJPDES)
- Underground Storage Tank (UST)
- Case Management System: coordinates case assignments, priorities, and technical standards for pollution cases involving hazardous substances
- Aquifer Recharge Area Program
- Nonpoint Source Pollution Program



Black River

Surface Water

Introduction

Water resources have inspired us to think of our natural resources as a system. Surface waters, compartmentalized into watersheds, have provided the basis for regional thinking, forcing a cultural shift from political boundary mentality to coalition around a central vital and dynamic natural resource.

Water bodies (**Plate 8**) serve as a kind of circulatory system, providing nutrients, and metabolizing waste materials. Wildlife relies on waterways for these functions, as well as shelter and a place to rest and breed. Humans enjoy the added benefits of recreation, transportation and economic opportunities.

Surface waters' surrounding microhabitat extends to vegetation, wildlife, and soils. Variation of these elements are reflected in the many "faces" of surface water: rivers, streams, ponds, lakes, swamps, marshes, and bogs. Each has a contributing watershed with specific characteristics. In watershed management these specific characteristics need to be recognized. This ecosystem or watershed approach is necessary to achieving and maintaining the health of the organism.

Water Quality Overview

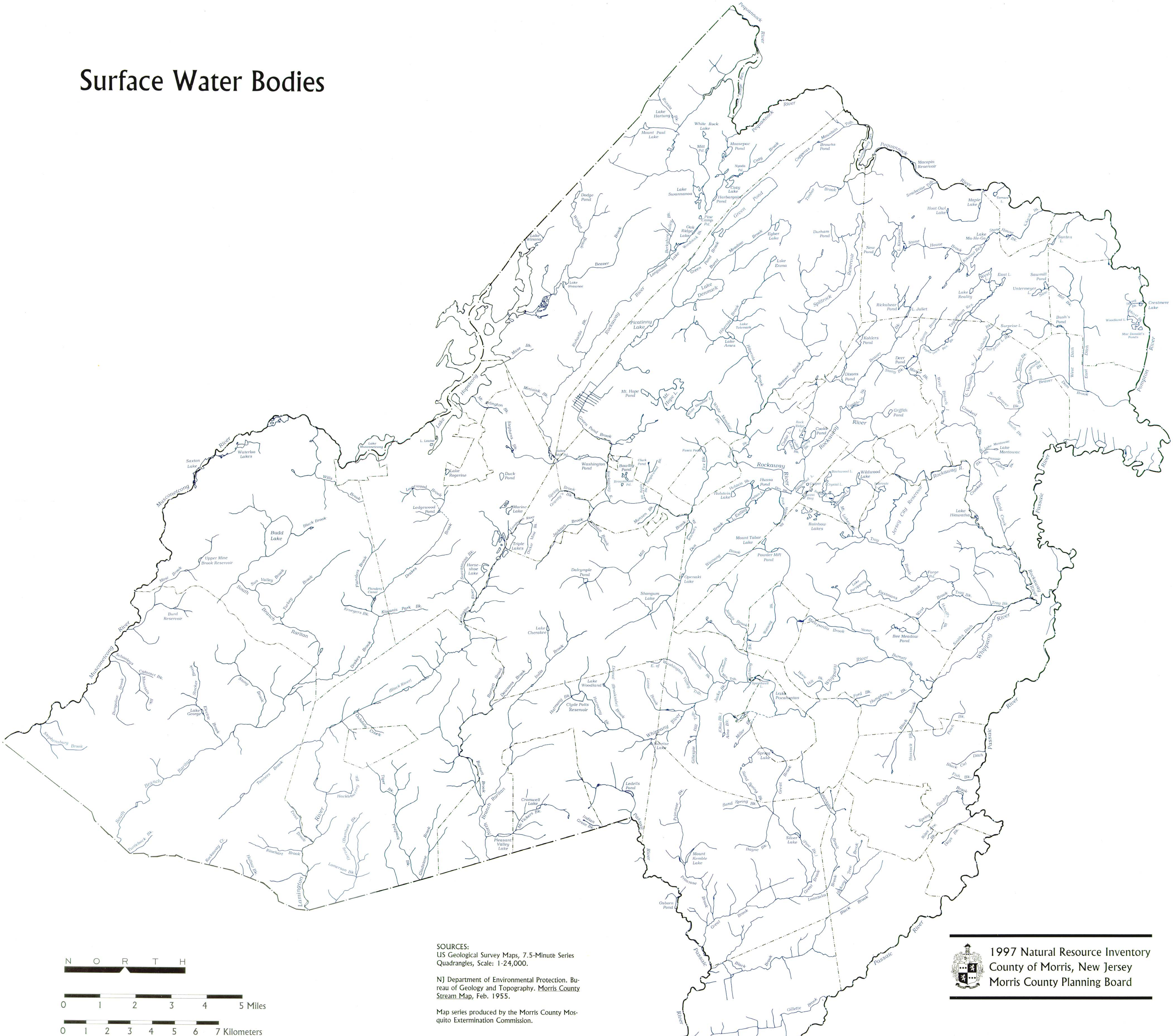
Common threats to water quality include total and fecal coliform bacteria, nutrients, depressed dissolved oxygen levels, pH fluctuations, siltation, road salts, oil and grease, and elevated stream temperatures. NJ Department of Environmental Protection (DEP) found all assessed freshwater lakes to be either "threatened or in a state of active deterioration (eutrophication)."[1] It is suspected that nonpoint sources including "construction activity, agricultural and suburban runoff, and failing septic systems are contributing the degrading pathogens, nutrients and siltation."[2]

---

[1] NJ DEP, New Jersey 1996 State Water Quality Inventory Report, 1996, I-4.

[2] NJ DEP, 1996 Inventory.

Surface Water Bodies



SOURCES:
US Geological Survey Maps, 7.5-Minute Series Quadrangles, Scale: 1-24,000.

NJ Department of Environmental Protection. Bureau of Geology and Topography. Morris County Stream Map, Feb. 1955.

Map series produced by the Morris County Mosquito Extermination Commission.

1997 Natural Resource Inventory
County of Morris, New Jersey
Morris County Planning Board

PLATE 8: Surface Water Bodies

One yardstick for measuring water quality is State-defined **designated uses** that waters should be able to support throughout the year. These are defined in the State's Surface Water Quality Standards (NJAC 7:9 et seq.). The overriding goal, as stipulated by the Federal Clean Water Act, is two-fold: surface waters are to be of "sufficient quality to allow for primary contact recreation" (swimmable). This is based primarily on the presence of fecal coliform bacteria. The fishable goal stipulates that "all possible waters should support healthy and reproducing aquatic biota and have all fish and shellfish harvested from these waters safe for human consumption."[3] Biological assessments determine success in achieving the aquatic life support designated use. Physical/chemical data supplement these assessments in order to determine a threatened status. The associated rating is as follows:

No impairment:	fully supporting aquatic life use
Moderately impaired:	partially supporting aquatic life use
Severe impairment:	no support of aquatic life us

The State's Surface Water Quality Standards also provide **classifications** corresponding to these uses and pertinent to the permitting programs; they include:

Category One (C-1) - activates antidegradation policies to protect waters from measurable changes in water quality characteristics because of their clarity, color, scenic setting, aesthetic value, and exceptional resources (ecological, recreational, water supply, or fishery).
Trout Production Waters (TP)- for trout spawning or nursery purposes during their first summer.
Trout Maintenance Waters (TM)- designated for the support of trout throughout the year.

Throughout the text you will see these surface water classifications preceded by FW1 or FW2 indicating fresh waters. Added on to this designation is either TM (Trout Maintenance), TP (Trout Production), or NT. Trout is used as a parameter because of their indication of high quality waters.

Wetlands associated with high water quality streams have separate classifications. NJ DEP, as part of its freshwater wetlands permitting program, uses the terms "exceptional" to indicate environmental sensitive wetlands. In addition, United States Environmental Protection Agency (EPA) has designated "Priority" wetlands as those systems that meet the following criteria:

- Unique habitat for fauna or flora;
- Unusual or regionally rare wetland types;
- Ecologically important and under threat of development;
- Important to surface water systems;
- Critical to protect water supplies; and
- Valuable for flood storage capacity.[4]

An overview of Morris County's surface water quality, based on the State's Surface Water Quality Standards, is provided in **Plate 9**.

---

[3] NJ DEP, Inventory, II-9.

[4] US EPA, Priority Wetlands for the State of New Jersey, March 1994, 129.

Surface Water Quality

Current Classifications

- Trout Production
- Trout Maintenance
- Category 1
- Non-Trout
- FW1
- Proposed Category 1
- Proposed Trout Production

NOTES:

All waters are designated as FW2 unless otherwise signified.

Trout production waters are used by trout for spawning or nursery purposes during their first summer.

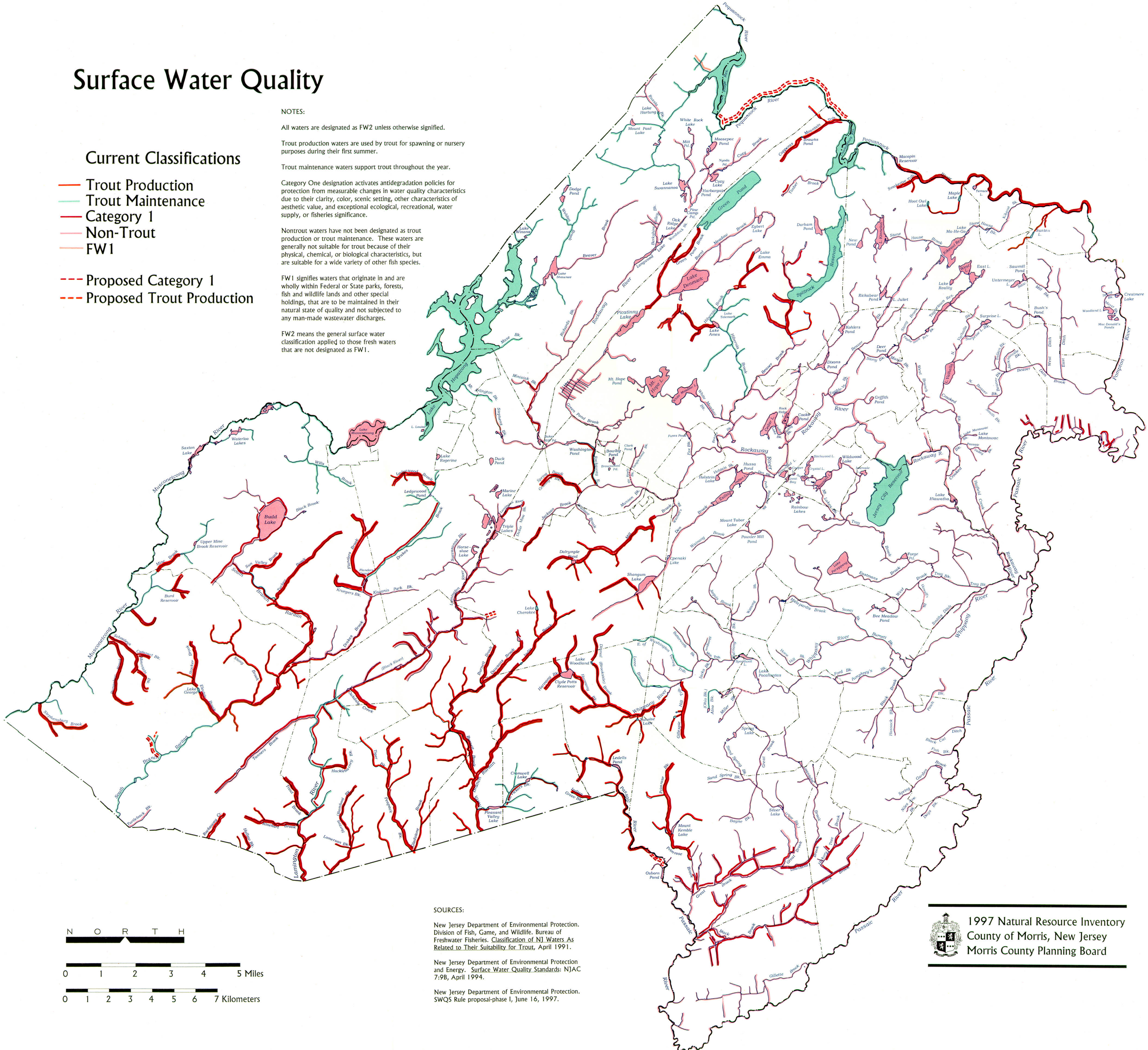
Trout maintenance waters support trout throughout the year.

Category One designation activates antidegradation policies for protection from measurable changes in water quality characteristics due to their clarity, color, scenic setting, other characteristics of aesthetic value, and exceptional ecological, recreational, water supply, or fisheries significance.

Nontrout waters have not been designated as trout production or trout maintenance. These waters are generally not suitable for trout because of their physical, chemical, or biological characteristics, but are suitable for a wide variety of other fish species.

FW1 signifies waters that originate in and are wholly within Federal or State parks, forests, fish and wildlife lands and other special holdings, that are to be maintained in their natural state of quality and not subjected to any man-made wastewater discharges.

FW2 means the general surface water classification applied to those fresh waters that are not designated as FW1.



N O R T H

0 1 2 3 4 5 Miles

0 1 2 3 4 5 6 7 Kilometers

SOURCES:

New Jersey Department of Environmental Protection. Division of Fish, Game, and Wildlife. Bureau of Freshwater Fisheries. Classification of NJ Waters As Related to Their Suitability for Trout, April 1991.

New Jersey Department of Environmental Protection and Energy. Surface Water Quality Standards: NJAC 7:9B, April 1994.

New Jersey Department of Environmental Protection. SWQS Rule proposal-phase I, June 16, 1997.

1997 Natural Resource Inventory
County of Morris, New Jersey
Morris County Planning Board

PLATE 9: Surface Water Quality

Watersheds

Following is a watershed- based presentation of Morris County's surface water. As depicted in Figures 1 and 2, the County comprises three major basins: the Delaware, Raritan, and Passaic. These basins are divided further into watersheds. Brief characterizations are provided accordingly.

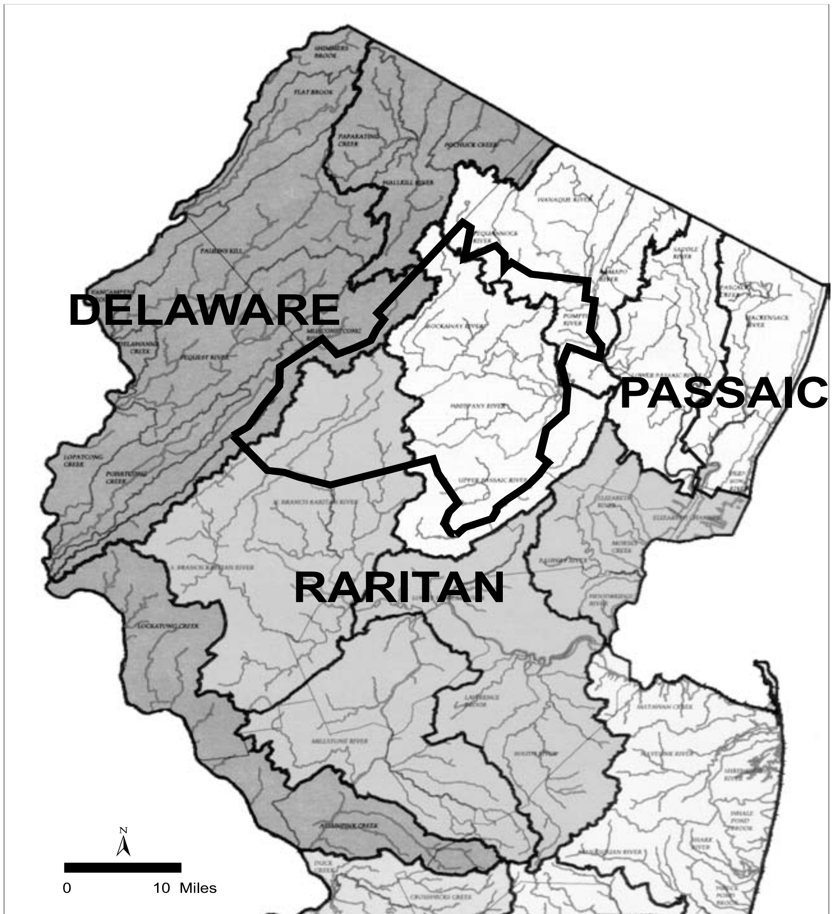


Figure 1 - Major Basins Spanning Morris County

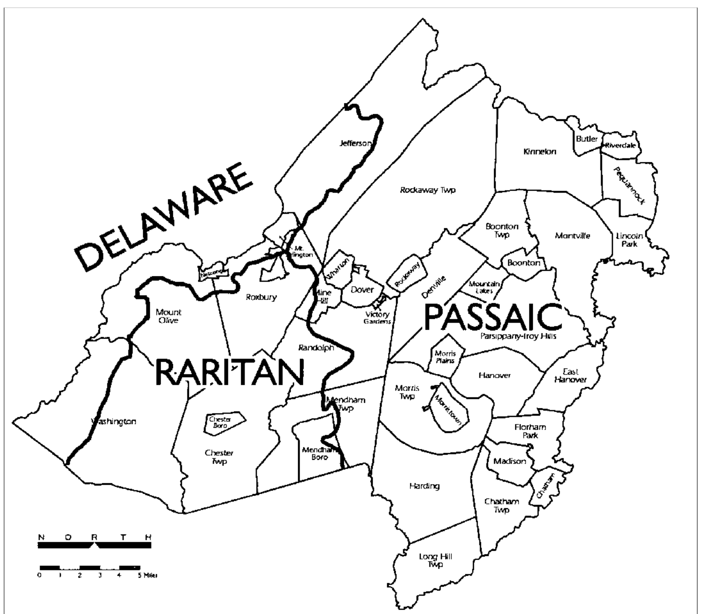
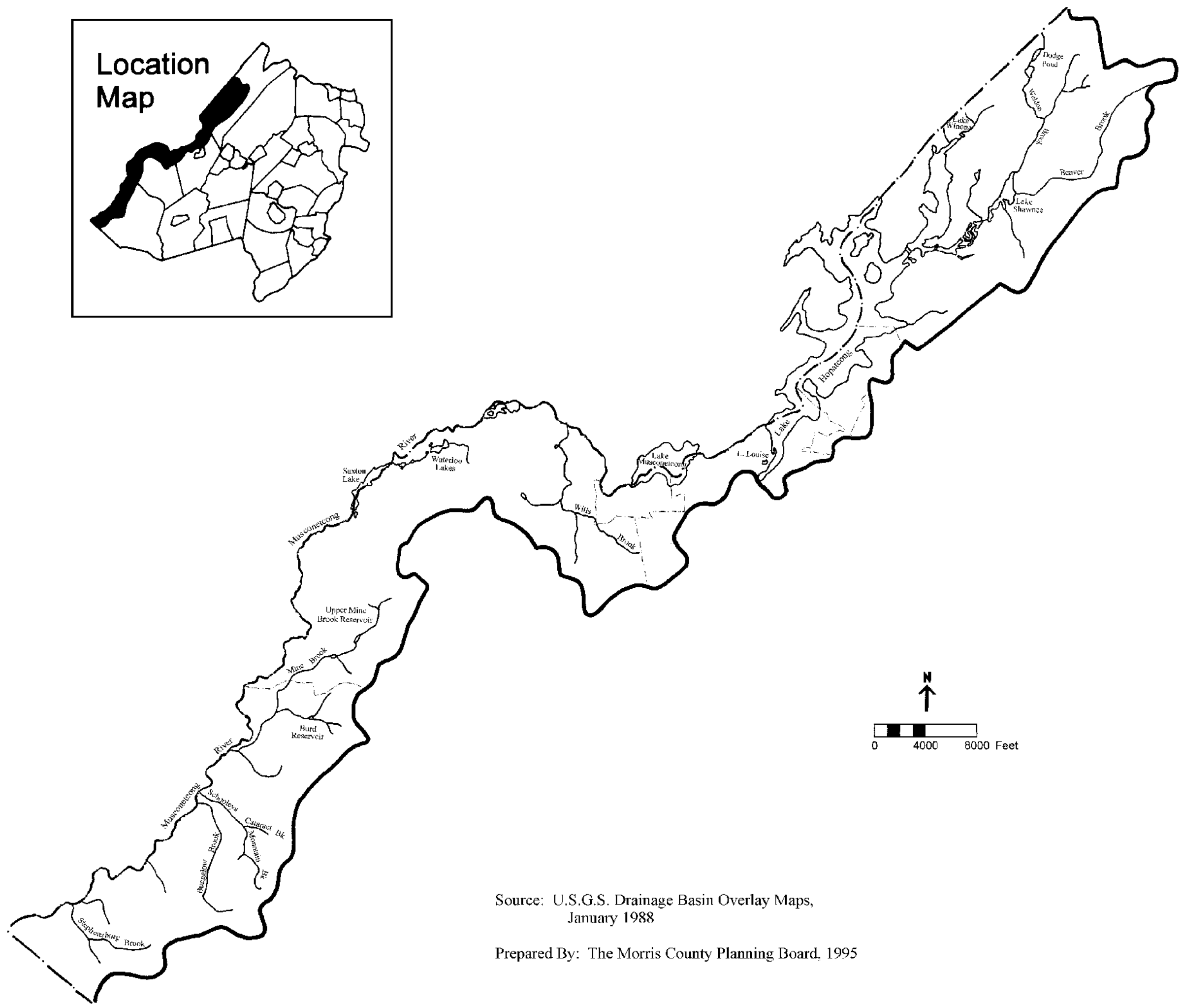


Figure 2 - Three Basins in Morris County

DELAWARE BASIN

We will begin our discussion with the Delaware basin which constitutes the smallest percentage of the County. The watershed specific to the Delaware, that exists within this county is the Musconetcong



Source: U.S.G.S. Drainage Basin Overlay Maps,
January 1988

Prepared By: The Morris County Planning Board, 1995

Musconetcong River Watershed

Musconetcong Watershed

The **Musconetcong River** forms a portion of the county's western boundary. The upper half of the river has a mix of both nonimpaired and moderately impaired stations. The river experiences elevated summertime temperatures, elevated nutrients, notably phosphorus, in the central portion of the river, and exceedances of copper and unionized ammonia at the Beattystown monitoring station (Warren County). "Portions of the upper half of the river both fully support and partially support the aquatic life designated use."[5] The river partially supports the swimmable designated use at Beattystown. The surface water quality designation is Fresh Water Trout Maintenance (FW-2 TM).

The Musconetcong is suffering impacts from areawide suburban development, urban runoff, construction activities, and heavy winter road salting. Increasing runoff from urban surfaces and from storm sewers have particularly impacted the Hackettstown area. The Musconetcong Watershed Project, a DEP initiative, is working to implement comprehensive management of nonpoint pollution sources in a cost-effective, easily implemented and measurable manner."[6]

Point sources of pollution, or dischargers, subject to the NJ Pollutant Discharge Elimination System (NJPDES), administered by the DEP, include:

Table One - Musconetcong River Watershed Dischargers		
FACILITY NAME	MUNICIPALITY	RECEIVING WATERS
Hackettstown MUA WPC	Washington	Bungalow Brook
Mt Arlington Sanitation	Mt. Arlington	Delaware Basin
Laser Crystal Corp.	Jefferson Twp.	Musconetcong River
Our Lady of Lake Reg. School	Mt. Arlington	Musconetcong River
Advanced Environ Tech. Corp.	Mt. Olive	Musconetcong River
Hackettstown MUA WPC	Washington	Musconetcong River
Elastimold Div. Amer.	Washington	Schooley's Mountain Brook
International Trade	Mt. Olive	Willis Brook
Musconetcong Water Plant	Mt. Olive	Wills Brook
Arthur Stanlick School	Wharton	Lake Shawnee
Consolidated School	Jefferson	Lake Hopatcong
Source: NJ DEP New Jersey 1992 State Water Quality Inventory Report, 1993, III		

Subsheds of the Musconetcong

Willis Brook, though supporting a cold water fishery, and classified as FW2-TM, is assessed as being moderately impaired. In addition to point sources, NPS are generated from construction, urban and road runoff, and channelization. These have also contributed to exacerbated flooding.

Mine Brook, nonimpaired; classified by the State as both FW-2 TP (C1) and FW-2 TM, is experiencing water resource degradation and flooding due to construction and highway maintenance runoff, and channelization. While agricultural runoff is a source of contamination, its impact is diminishing, as consistent with trends throughout the state.

---

[5] NJ DEP, New Jersey 1992 State Water Quality Inventory Report, 1993, 16.

[6] NJ DEP, 1996 Inventory I-15.

Bungalow Brook, classified as FW-2 TP (C1), is host to the State identified threatened Brook Trout.

Stephensburg Brook, containing a healthy cold water fishery, is classified as FW2-TP (C1).

Water Bodies

NPS of pollution continue to jeopardize the precarious good health of Lakes Hopatcong and Musconetcong. Suburban runoff, housing and road construction, and malfunctioning septic systems, have lead to advanced eutrophication in Lake Musconetcong. Lake Hopatcong is similarly threatened in addition to local fuel spills and leaks. Lake Shawnee is being negatively impacted from housing construction activities.

Wetlands Complexes

Of the wetlands within the Musconetcong watershed, the complex within Lake Hopatcong's watershed has been designated **Priority Wetlands** (Figure 3). Distinguishing characteristics of this system include waters of high quality used for water supply, and wildlife habitat "for various game and nongame species, as well as the state listed threatened barred owl."[7]

Lake Hopatcong Watershed includes:

Lees Cove watershed
Weldon Brook watershed
Liffy Island waterway
Hopatcong Canals/waterways
Beaver Brook Watershed
Great Cove watershed
Mt. Arlington Knolls watershed
Hopatcong Hills West
Lake Hopatcong tributary system

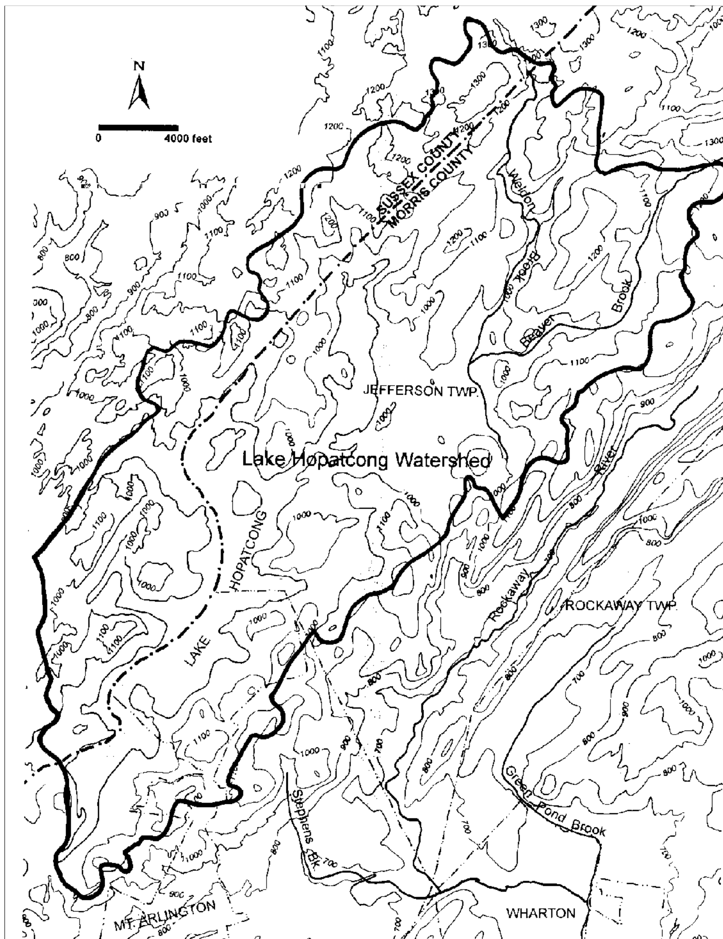
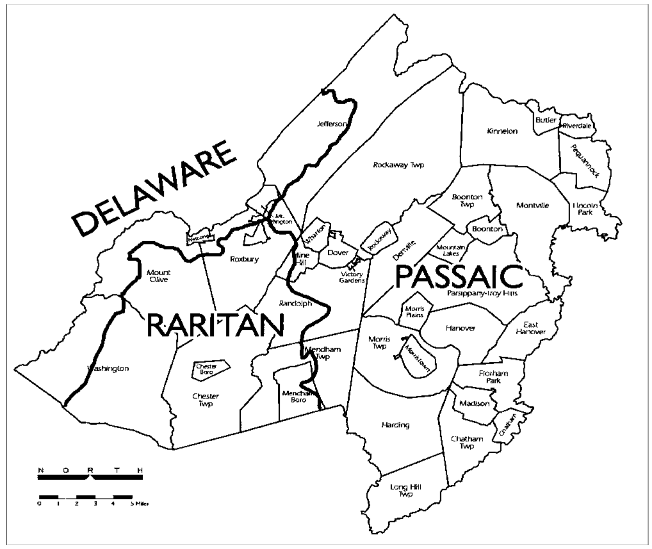


Figure 3 - Priority Wetlands Within Lake Hopatcong Watershed

---

[7]US EPA, Priority Wetlands for the State of New Jersey, 1994, 129.

PASSAIC RIVER BASIN

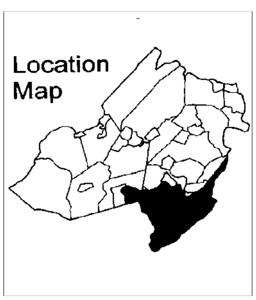


The Passaic River Basin constitutes the largest area of the county. It is made up of several watersheds including the Upper Passaic, the Whippany, the Rockaway and the Pequannock.

Upper Passaic River Watershed

The Upper Passaic River Watershed is the most extensive of the County's major river basins. Sustaining riverine, open water, and wetland habitat for wildlife, the Passaic River also provides drinking water, fishing and recreational opportunities to the region's inhabitants. These benefits are occasionally offset by the Passaic's flooding of low lying areas. Decades of urban/suburban development, filling in floodplains, altering the stream morphology, increased discharges and runoff, and decommissioning wetlands has served to exacerbate this normal phenomenon.

The **Passaic's headwaters**, emanating in Mendham Township, are considered to be generally of good-to-excellent quality. The waters are well oxygenated at all times and contain low-to-moderate nutrient concentrations.[8] The upper reaches meet the aquatic life designated use. They have received Federal Wild Trout Stream[9] designation, and NJ Surface Water Quality classification of FW-2 TP (C1).[10]



Dissolved oxygen is low at the Millington station but improves downstream near Chatham. Nutrient levels, particularly phosphorus, increase downstream. Inorganic nitrogen worsens downstream from Millington. Though lead levels are elevated at Millington and Chatham, they are within water quality criteria. The numerous municipal wastewater discharges have "severely challenged the limited assimilative capacity of the river."[11]

The 1996 Inventory describes the upper Passaic as non-impaired and its tributaries deteriorating to moderately and severely impaired downstream (Chatham and Hanover areas, Black Brook and portions of Loantaka Brook) based on macroinvertebrate communities surveys.

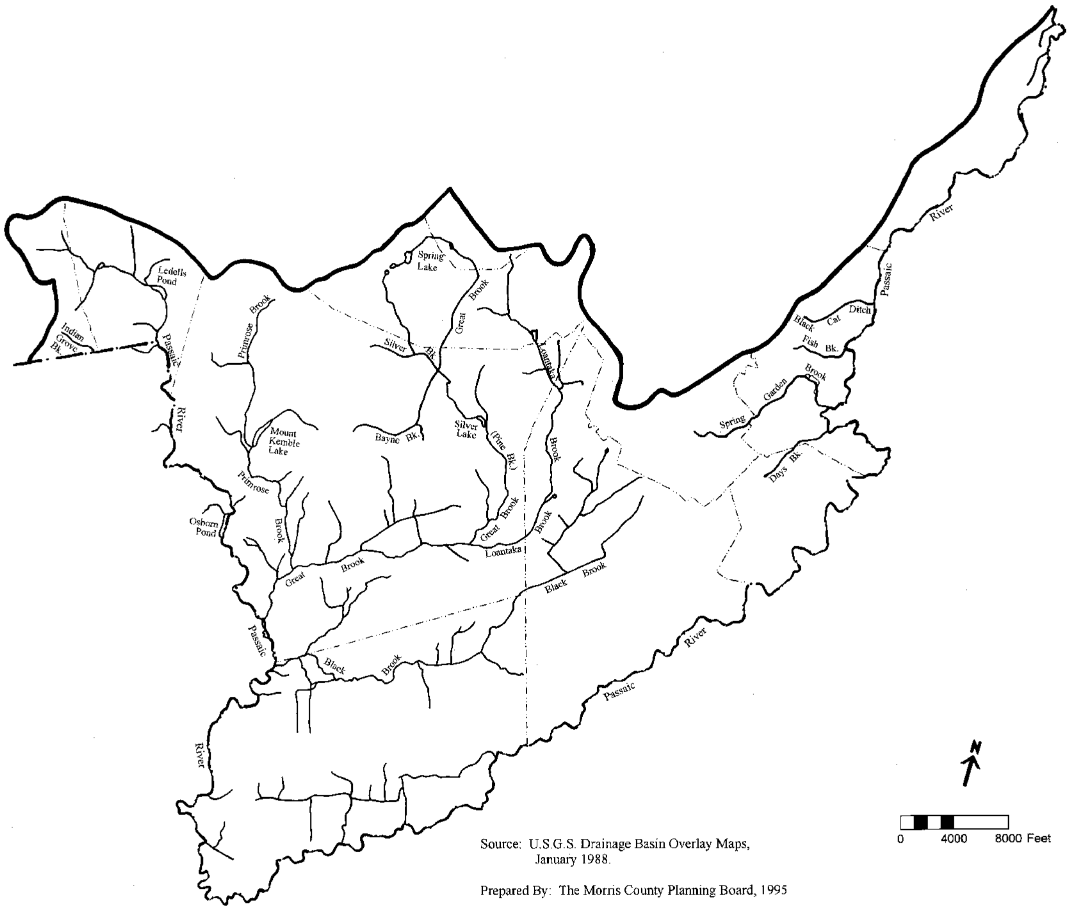
---

[8] U.S. Department of the Interior, National Park Service, Morristown National Historical Park Water Resources Scoping Report, Technical Report (NPS/NRWRD/NRTR-93/17) 7.

[9] Wild Trout Stream: stream segments supporting viable wild trout populations with a limited sport fishery; designation provides greater protection to wild trout populations by eliminating fish stocking activities and establishing more stringent fishing regulations. (National Park Service 18)

[10] NJ DEP, Surface Water Quality Standards, 1998.

[11] NJ DEP, 1996 Inventory 59.



Upper Passaic River Watershed

Primrose Brook revealed slightly elevated fecal coliform bacteria levels possibly due to septic leachate.

Jersey Brook's slightly elevated fecal coliform bacteria levels were linked to septic leachate.

Point sources of pollution in this watershed have contributed cyanide, arsenic, copper, mercury, cadmium and lead. These pollutants violate EPA's Federal Aquatic Life chronic criteria as well as EPA's Federal human health criteria for exposure to carcinogens. Accordingly DEP has labeled the stretch of the Passaic River between the confluence of the Dead River (Somerset County) and the confluence with the Whippany "impaired" as well as included it in the State's water quality limited waters list (303d list).[12] The Millington Asbestos site has been linked to the release of asbestos to the Passaic River.

Suspected generators of nonpoint sources of pollution are residential and commercial development, highway and urban surface runoff, stormwater outfalls, application of golf course, lawn and garden chemicals, septic system leachate, and leaking underground storage tanks.
Dischargers, regulated by the NJPDES, include:

---

[12] NJ DEP, 1992 Inventory III-248 and NJ DEP, 1996 Inventory 59.

Table Two - Upper Passaic River Watershed Dischargers

FACILITY NAME	MUNICIPALITY	RECEIVING WATERS
Chatham Twp.Wtr.Pol.Plant #1	Chatham Twp.	Black Brook
NJ DOT	Harding	Great Brook
Woodland STP	Morris Twp.	Loantaka Brook
Mobil SS	Chatham Borough	Passaic River
Molitor	Chatham Borough	Passaic River
Exxon Service Station	Chatham Twp.	Passaic River
National Manufacturing	Chatham Twp.	Passaic River
New Way Associates	Chatham Twp.	Passaic River
Park Central STP	Chatham Twp.	Passaic River
Givaudan Corp.	East Hanover	Passaic River
US Nike 79/80 STP	East Hanover	Passaic River
Florham Park STP	Florham Park	Passaic River
Orange Products Inc.	Florham Park	Passaic River
Long Hill Twp. STP	Long Hill Twp.	Passaic River
Forest Park STP	Montville	Passaic River
Prestige Plastics	Riverdale	Passaic River

Source: New Jersey 1992 State Water Quality Inventory Report, 1993, III

Wetland Complexes

Wetlands within the entire Passaic River Basin have been designated as EPA Priority. This classification bears witness to the multiple functions benefitting both humans and wildlife. The human sector is served by way of flood control, water supply and recreational opportunities. Habitat is provided for waterfowl, raptors, passerines, herptiles, furbearers, and fish, including various state and federally listed species.

Subsheds

The Great Swamp National Wildlife Refuge (Great Swamp) Watershed, an integral component within the upper Passaic ecosystem, has become an environmental planning prototype. Concern for this resource has resulted in the amassing of extensive data on the Swamp's features, inhabitants and overall health. Presently, the Ten Towns Great Swamp Watershed Committee is seeking to devise a comprehensive watershed management plan, with corresponding land use ordinances.

Feeder streams to Great Swamp include Great, Black, Primrose, and Loantaka Brooks. Each subwatershed is unique ranging in character from rural low density development, to urbanized high density housing, industry and infrastructure. The degree of intensity is reflected in the viability of each brook.

The USDA Great Swamp Watershed Project, a five year effort begun in 1991, was designed to "develop a strategy to ensure acceptable water quality and quantity in the Refuge."[13] Stream water quality assessment, utilizing the macroinvertebrate surveying methodology, was conducted on the Black, Great, Loantaka and Primrose Brooks as well as the upper Passaic. Results for the four years are illustrated in Table Three. Index values and their corresponding assessments are as follows:

---

[13] US Department of Agriculture, Best Management Practice Recommendations for the Great Swamp Watershed, 1994.

Table Three - Results of Macroinvertebrate Survey in Great Swamp Watershed

INDEX VALUE	WATER BODY ASSESSMENT
0	Grossly polluted
1-5	Moderately polluted
6-9	Stream clean, monotonous habitat and in-stream velocity
10 or >	Stream clean

Beck's Index Values 1992 - 1994

Sampling Point		1992	1993	1994	1995
Great Bk-1	Pleasant Plains Rd	6	2	3	1
Great Bk-2	Woodland Rd.	5	10	18	12
Great Bk-3	Below Silver Lake	15	10	16	16
Great Bk-4	Loantaka Rd.	4	9	7	4
Great Bk-5	Below Silver Lake	9	6	9	6
Black Bk -1	Southern Boulevard	3	--	3	2
Black Bk -2	Trib. north of Long Hill	2	3	3	3
Loantaka Bk-1	Green Village Rd.	2	7	9	11
Loantaka Bk-2	Above Kitchel Ave.	2	3	2	2
Loantaka Bk-3	Below Seaton Hackney	0	1	3	3
Loantaka Bk-4	Above Seaton Hackney	0	1	4	5
Passaic River -1	Below Lee's Hill Rd.	11	14	13	13
Passaic River -2	Below Interstate 287	13	12	23	24
Passaic River -3	Below Indian Grove Bk.	12	10	15	16
Primrose Bk -1	Below Lee's Hill Rd.	14	12	17	18
Primrose Bk -2	Below Bailey's Mill Rd.	9	16	12	16
Primrose Bk -3	Below Tempe Wick Rd.	15	12	19	15

Sources: 1992, 1993, 1994, 1995 Water Quality Inventory Reports, USDA.

Generalized Observations:

Great Brook is a transitional watershed ranging from wooded to heavily urban/suburbanized. Low index values are indicative of sedimentation, organic material, nutrients and reduced dissolved oxygen, due to reduction of instream velocity, typical of a wetland watercourse.

Black Brook is primarily located within the swamp, this Brook receives effluent from Chatham Township Waste Water Treatment Plant (WWTP) #1. Drainage area is urbanized, and includes a golf course. Low index values are attributed to low flow, reduced dissolved oxygen, and urban runoff.

Loantaka Brook receives effluent from Woodland WWTP. Low index values are attributed to an urbanized watershed, as well as waterfowl population at Loantaka Reservation Pond.

The **Upper Passaic River** is lightly developed, predominantly wooded, with rolling watersheds. Index values indicate very good water quality.

The **Primrose Brook**: Lightly developed, predominantly wooded, rolling watersheds. Index values indicate very good water quality.

Conclusions of the study were consistent with current findings on NPS of pollution, namely that increased percentage of impervious areas associated with urbanized areas correlate with increased organic and inorganic substances. To provide a meaningful, implementable tool, based on these findings, the USDA developed groupings of Best Management Practices (BMP's) applicable to each specific subwatershed (**Appendix A**).

The wastewater treatment plants in the Great Swamp watershed have been a major source of contention over the years. The 1991 Final EIS on the Upper Passaic River Basin 201 Facilities Plan plus the Great Swamp Water Quality Study evaluated the impacts of the Chatham Township (#1) and Morris-Woodland WWTP on the Black and Loantaka Brooks respectively, as well as on the Great Swamp National Wildlife Refuge.

It was determined that under base flow conditions and even more so during storm flow conditions, "the discharges of treated wastewater from the Morris-Woodland and Chatham Township WWTP'S generated significantly elevated nutrient concentrations (orthophosphate, total phosphorus, and total soluble inorganic nitrogen) in their receiving waters. The principal exception to these findings occurred on Loantaka Brook, where the difference in nitrate concentrations in the brook upstream and downstream of the Morris-Woodland WWTP discharge were negligible."[14] Malfunctions of the Morris Township Woodland WWTP resulted in major fishkills in Loantaka Brook during the summers of 1988 and 1990.

Nonpoint sources were also determined to be contributing substantial nutrient loadings to Loantaka and Black Brooks particularly by way of stormwater runoff.

The Great Swamp Water Quality Study reported the positive impact this wetlands complex had on base flow water quality in the Great and Black Brooks. Nutrient measurements taken upstream and at the end of the swamp indicated equal or diminished concentration. This function was repeated during storm events. The findings confirmed the hypothesis that the Great Swamp acts as a nutrient sink.

With DEP's required upgrade to Class 4 treatment, nutrient loadings from both WWTP's are anticipated to be reduced. The improved nutrient removal is expected to prevent future surface water algal blooms; and UV disinfection technology will eliminate chlorination of the wastewater. The reduction in point source pollution suggests that emphasis be placed on control of NPS's of pollution.

Increased hydraulic loadings to tributary streams as a result of future development and associated impervious surfaces were predicted. In addition "projected increases in the development of undeveloped lands will increase the non-point source (stormwater) loadings of tributary streams, while reducing base flows. . ."[15]

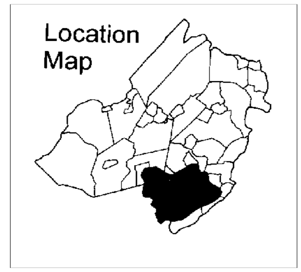
Extensive collection of water quality and quantity data, albeit disjointed, has provided a basis for discussion regarding this watershed's management. The inconclusive nature of many of the studies demand a commitment to continued and long term data collection.

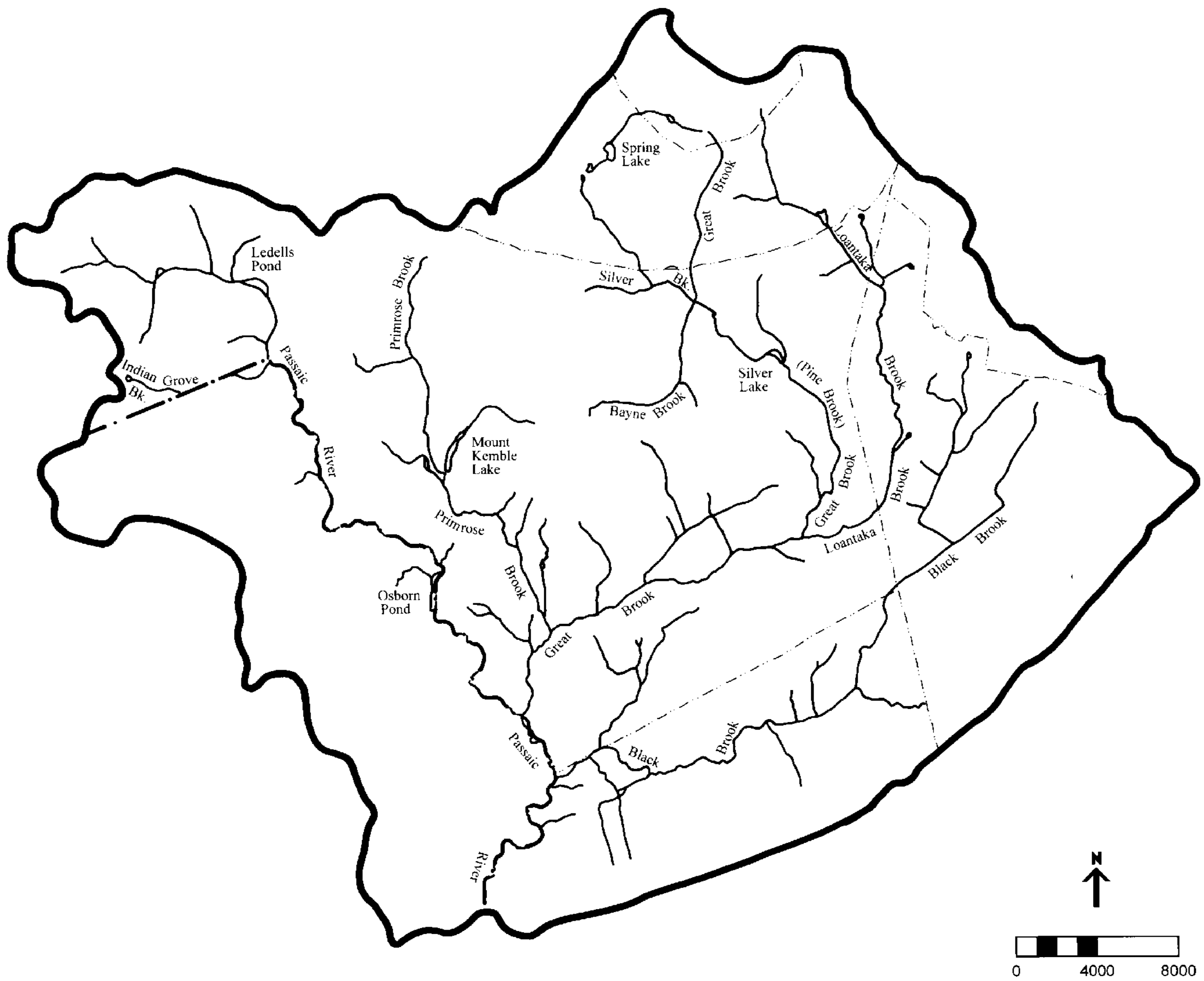
---

[14] US EPA, Final Environmental Impact Statement on the Upper Passaic River Basin 201 Facilities Plan, in Morris, Somerset and Union Counties, New Jersey, Sept. 1991, 5-38.

[15] US EPA, Final Environmental Impact Statement 5-40.

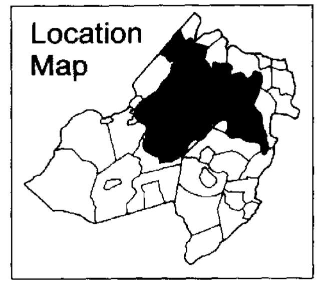
Great Swamp Watershed

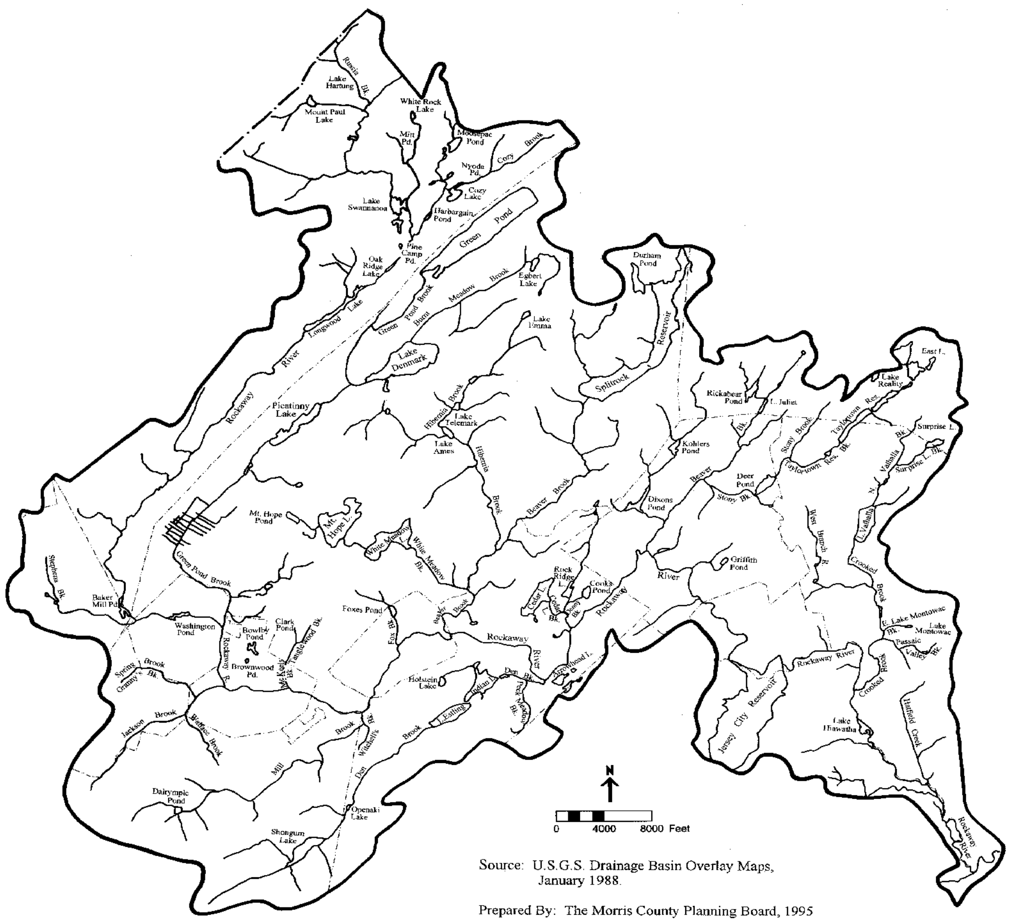




Source: U.S.G.S. Drainage Basin Overlay Maps, January 1988.

Prepared by: The Morris County Planning Board, 1995





The Rockaway River Watershed

Rockaway River Watershed

The **Rockaway River** emanates in Sussex County. As it travels through Morris County it confronts more intensive land uses, water control structures, dischargers, and ultimately a water supply reservoir. State surface water classifications reflect these diverse settings. Headwaters are classified as FW2-TM; a stretch downstream from Washington Pond is FW2-TM(C1), and much of the remaining river is FW2-NT. The river segment running through Berkshire Valley has the added protection of C1 designation.

From the headwaters to the Boonton reservoir the river is generally of good quality, deteriorating to fair below. From Randolph to Boonton (above the reservoir) the river fully supports the aquatic life support designated use (non-impaired). In Jefferson Township and below the reservoir, aquatic life support is partially met (moderately impaired). The river partially supports swimmable use attainment as determined by fecal coliform bacteria measurements.

Water quality in the upper Rockaway is generally considered good but degrades to fair below the reservoir at Pine Brook due to elevated nutrients (inorganic nitrogen and phosphorus), sodium and lead, and copper (but within standards). One sign of improvement has been a reduction of fecal coliform levels at the Pine Brook monitoring station.

In the lower Rockaway, the Rockaway Valley Regional Sewage Authority (RVRSA) "is suspected of being the prime source of nutrients, ammonia and depressed Dissolved Oxygen."[15] Volumetrically, it is estimated that RVRSA "contributes up to 50% of the Rockaway's stream flow during extreme low-flow periods."[16] Two suspected pollutant sources include Sharkey's landfill in Par-Troy, and L.E. Carpenter in Wharton Borough.[17] Picatinny Arsenal, conversely, has eliminated some of its discharges.

Consistent with water quality trends, NPS of pollution are playing a greater role in the Rockaway River. Typical nonpoint sources of pollution in the Rockaway, downstream from Dover, are impacts from urban/suburban development. Construction activities, urban runoff from storm sewers and urban surfaces, combine to cause siltation, elevated temperatures, and riparian vegetation destruction.

While the Rockaway River is heavily impacted from point and nonpoint sources as it courses through urbanized areas, it nonetheless has tremendous potential for remediation (Katz, 1987). Friends of the Rockaway River, a grassroots organization, has formulated a river corridor management plan (<u>The Rockaway River and Its Treasured Resources</u>) which strives to enhance the corridor and associated wildlife habitat, recreational access, and water quality.

The same group joined with NJ Trout Unlimited (a national conservation education organization) in restoring a one-quarter mile stretch in McCarter Memorial Park, Denville Township. Utilizing bioremediation techniques, trout habitat has been restored. Strategies to stop erosion and foster trout habitat include: planting native trees, shrubs, and herbaceous plants in the riparian zone; placing mud sills along the streambank; and using boulders and stones in the stream to deflect flow.

---

[15] NJ DEP, <u>1992 Inventory</u> III-266.

[16] NJ DEP, <u>1992 Inventory</u> III-266.

[17] NJ DEP, <u>1996 Inventory</u> 63.

Table Four - Rockaway River Watershed Dischargers

FACILITY NAME	MUNICIPALITY	RECEIVING WATERS
Ivex Corp.	Rockaway Borough	Beaver Brook
Jim Salerno Pontiac	Randolph	Black River
Keuffel & Esser Co.	Rockaway Twp.	Burnt Meadow
Par-Troy Hill	Par-Troy	Eastman's Brook
Department of the Army	Rockaway Twp.	Green Pond Brook
Hewlett-Packard Co.	Rockaway Twp.	Hibernia Brook
Adron Inc.	Par-Troy	Lake Intervale
Randolph High School	Randolph	Mill Brook
White Rock STP	Jefferson	Mitt Pond Trib.
Mt. Hope Rocks Product	Wharton	Mount Hope Lake
Department of the Army	Rockaway Twp.	Picatinny Lake
St. Clares Hospital	Denville	Rockaway River
Green Hammer Metal	Dover	Rockaway River
Berkshire Sand and Stone Co.	Jefferson	Rockaway River
Jefferson Middle & High School.	Jefferson	Rockaway River
Rockaway Valley Reg.	Par-Troy	Rockaway River
Mc Williams Forge Co.	Rockaway Borough	Rockaway River
Howmet Turbine Co.	Rockaway Twp.	Rockaway River
Air Products & Chemical	Wharton	Rockaway River
Gha Lock Joint	Wharton	Rockaway River
L.E. Carpenter & Company	Wharton	Rockaway River
Boonton Water Filtration	Montville	Stony Brook
Montville Twp.	Montville	Valhalla Brook
Action Technology Co.	Rockaway Twp.	White Meadow Bk.
Rockaway Twp. WT	Rockaway Twp.	White Meadow Bk.

Source: New Jersey 1992 State Water Quality Inventory Report, 1993, III-346-373 and New Jersey 1996 State Water Quality Inventory Report, 1996, 64.

Subsheds:

Hibernia and **Mill Brooks**, classified by the State as FW2-TP(C1), contain healthy cold water fisheries. Mill Brook and **Russia Brook** partially supports the aquatic life support designated use (non-impaired).

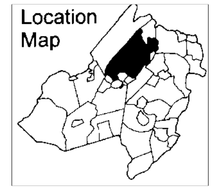
Jackson Brook, a portion of which has been classified as FW2-TP(C1), has suffered degradation and fishkills resulting from construction and urban runoff. The Jackson Brook Watershed Hydrologic Study investigated the effect that increased land development within the watershed had upon peak flows in the Brook. A 93% increase in peak flows, for a ten year storm from 1983-1988, was linked with erosion of the stream bed and banks and consequent siltation in both the Brook and the lake in Hedden Park .[18]

The mainstem of **Den Brook** has been classified as FW2-NT, with a tributary feeding Shongum Lake receiving FW2-TP(C1) designation. It does not support the aquatic life support designated use, is considered severely impaired and has suffered complete habitat destruction due to development activities.

[18] North Jersey Resource Conservation and Development Area, Jackson Brook Watershed Hydrologic Study, April 1989, 1.

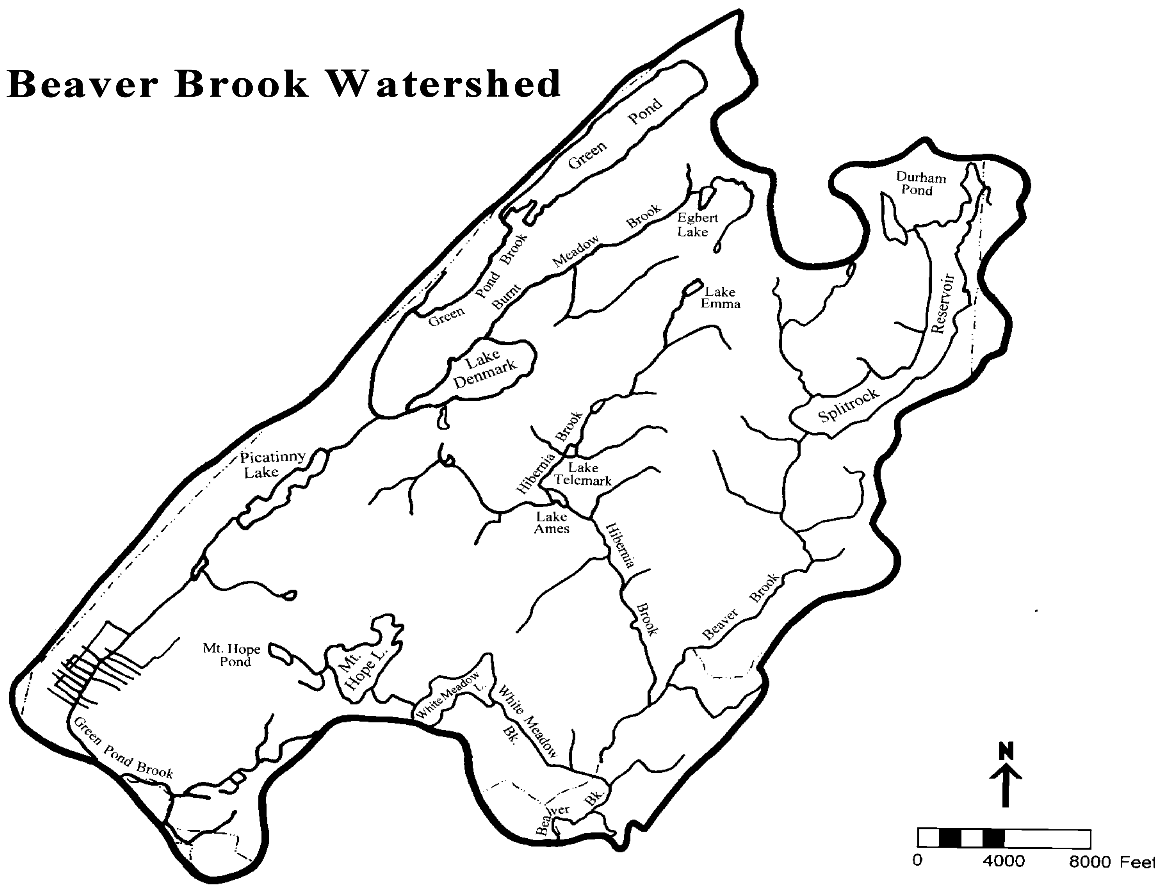
Portions of **Crooked Brook** partially support the aquatic life support designated use (non-impaired).

Portions of **Beaver Brook** have been classified as FW2-TP(C1), and partially support the aquatic life support designated use (non-impaired). In its lower reaches it is moderately impaired due to on-going road and housing construction.



An inventory[19] of natural resources within portions of the watershed revealed: uplands of various successional stages, forested and scrub-shrub wetlands, and open waters supporting a multitude of fish and wildlife, including State listed threatened and endangered species. Water resources include headwaters and springs, stream corridors, wetlands, and aquifer recharge areas.

The impacts of urbanization/suburbanization in this watershed include risk of ground water contamination from degraded surface waters, hazardous waste infiltration, and continued ecosystem fragmentation and

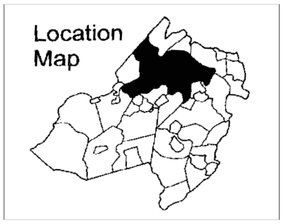


Source: U.S.G.S. Drainage Basin Overlay Maps, January 1988
Prepared By: The Morris County Planning Board, 1995

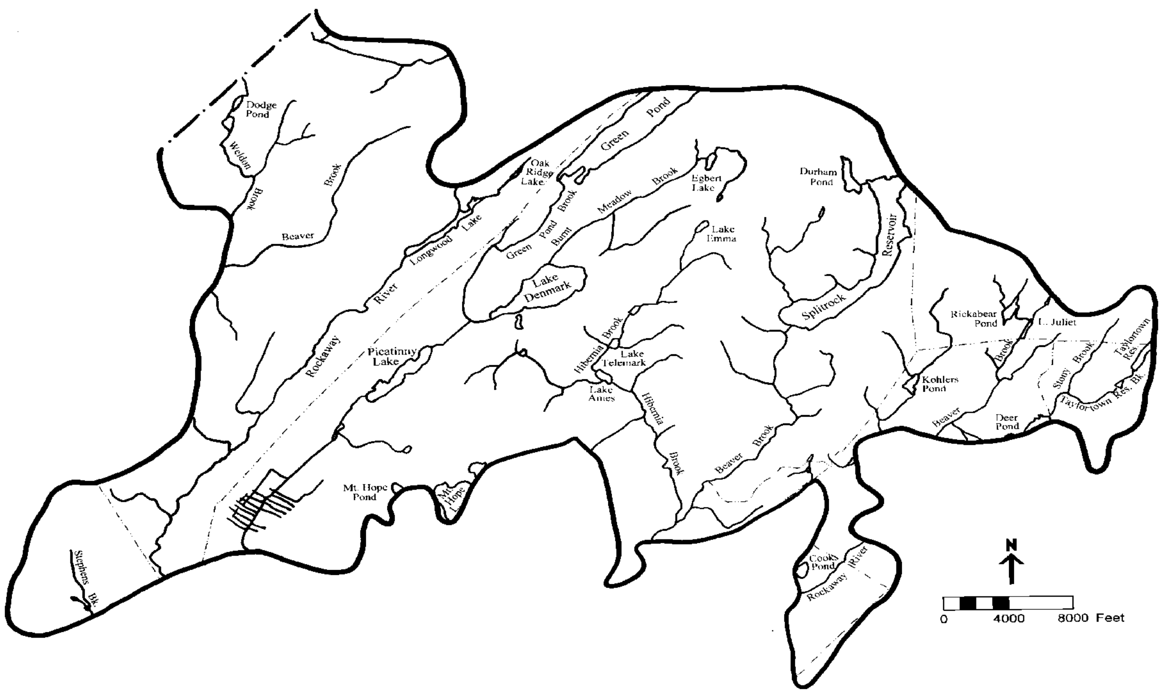
---

[19] US Fish and Wildlife Service, Pilot Study on the Feasibility of Protecting the Beaver Brook Area in the Townships of Rockaway, Denville, and Boonton and the Borough of Kinnelon, Morris County, New Jersey, April 1991.

habitat destruction. Recommendations made by the Study for protection resemble those of the Farny Highlands Coalition, found in **Appendix B**. Partners of the Beaver Brook Restoration Project utilized bioengineering techniques, (5-34) planted native vegetation and installed wood duck and bat boxes to enhance habitat along 450 feet of riparian streambank.



The Farny Highlands Watershed, spanning 30,000 acres, consists of environmentally sensitive features including surface waters supplying major reservoir systems, an underlying sole source aquifer, and habitat of threatened, endangered and rare plants and wildlife. An abridged listing of protection and preservation strategies compiled by the Farny Highlands Watershed Coalition can be found in **Appendix C**.



Farny Highlands Watershed

Waterbodies

Prior to 1700 there were four natural impoundments: Green Pond, Split Rock Reservoir, Cranberry Pond and one unnamed pond, below Oak Ridge Lake. The iron industry's need for water impoundments, water supply, recreation, and real estate development, resulted in the current number of 304 impoundments (29 lakes and 275 ponds).[20] Today the major impoundments include Mountain Lake, Upper Longwood Lake, Boonton Reservoir, Taylortown Reservoir, Splitrock Reservoir, White Meadow Lake, and Lake Denmark.

[20] Katz 9.

Wetland Complexes

The wetlands within the Rockaway basin, subset of the Passaic River Basin, are EPA Priority Wetlands. **Big Pine Swamp**, specifically identified as a Priority Wetland reaches into Jefferson Township with the bulk lying in Sussex County. Criteria satisfying this designation include: ecologically important, under threat of development, and a unique habitat for fauna or flora (e.g., Northern goshawks and Barred owls as well as a wide variety of breeding warblers and other passerines).

Goshawk

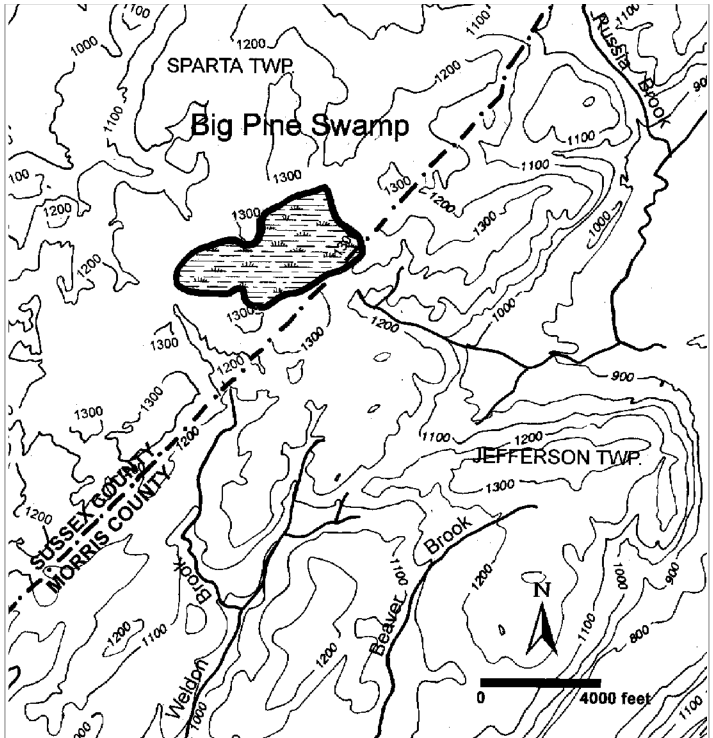


Figure 4 - Big Pine Swamp

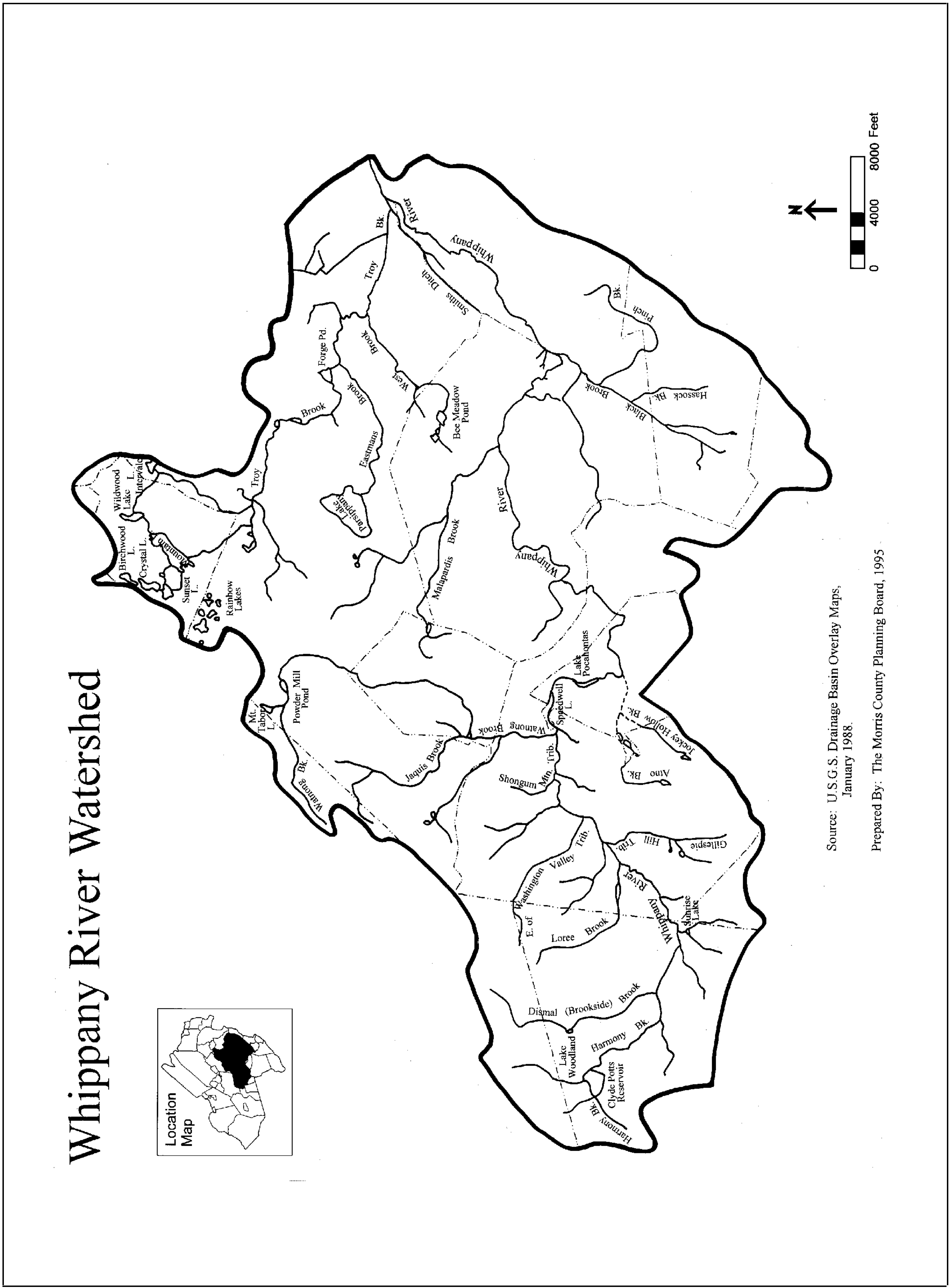
Whippany River Watershed

The Whippany River has its origins in the rural setting of Mendham Borough, traversing the county in an easterly direction, undergoing chemical and physical transformations as it continues through Morristown, Par-Troy, Hanover, and East Hanover. Though seriously degraded in areas, the overall health of the system actually has improved over the years.

Generally, the Whippany River is considered healthy in its headwaters but moderately impaired downstream from Morristown. The upper portions of the Whippany fully support the “aquatic life” designated use. Downstream waters only partially support this use. This is consistent with DEP's Surface Water Quality Classification of FW2-TP(C1) for the headwaters and feeder streams.

Monitoring stations at Morristown and Pine Brook indicate elevations in both total phosphorus and inorganic nitrogen, as well as highly elevated levels of bacteria (fecal coliform). Sodium exceeded water quality criterion at Pine Brook, threatening the river’s potability. The river falls short of attaining swimmable use. However, water quality improvement, by way of increased dissolved oxygen levels, is attributed to the upgrades of the wastewater treatment systems.

During the year 2000, the NJ DEP-initiated Whippany River Watershed Project, will be providing additional water quality data from monitoring efforts. A specially designed model will extrapolate the data, specific to the entire watershed, representing various hydrological scenarios. This technical characterization of the water resource will guide future watershed management including the developing of total maximum daily loads.


Whippany River Watershed
Location
Map
0
4000
8000 Feet
N
Source: U.S.G.S. Drainage Basin Overlay Maps, January 1988.
Prepared By: The Morris County Planning Board, 1995
Whippany River
Troy Bk.
Smiths Ditch
Pinch Bk.
Hassock Bk.
Black Brook
West Brook
Forge Pd.
Bee Meadow Pond
Eastmans Brook
Troy Brook
Parsippany Lake
Wildwood Lake
Intervale L.
Birchwood L.
Crystal L.
Mountain L.
Sunset L.
Rainbow Lakes
Malapardis Brook
Whippany River
Mt. Tabor L.
Powder Mill Pond
Watnong Bk.
Jaquis Brook
Watnong Brook
Speedwell L.
Lake Pocahontas
Jockey Hollow Bk.
Arno Bk.
Shongum Mtn. Trib.
Washington Valley Trib.
E. of Washington
Gillespie Hill Trib.
Whippany River
Sunrise Lake
Loree Brook
Dismal (Brookside) Brook
Harmony Bk.
Lake Woodland
Clyde Potts Reservoir
Harmony Bk.

Municipal and industrial point sources of pollution regulated by the NJPDES are listed below. Discharges to the river include pollutants such as arsenic, copper, mercury, cadmium, chromium, lead, zinc, and beryllium. Metals and volatile organics have been linked with Sharkey Landfill in Par-Troy.

Table Five - Whippany River Watershed Dischargers

FACILITY NAME	MUNICIPALITY	RECEIVING WATERS
Novartis Pharmaceutical	East Hanover Twp.	Black Brook
Precision Rolled Products	East Hanover Twp.	Black Brook
Exxon	Florham Park Borough	Black Brook
SMCMUA-Black Brook WTP	Hanover Twp.	Black Brook Ditch
Allied-Signal Inc.	Morristown	Black Brook
Atlas Soundolier	Par-Troy	Eastmans Brook
Consumer Health Care (Pfizer)	Par-Troy	Eastmans Brook
SMCMUA-Clyde Potts WTP	Mendham Twp.	Harmony Brook
Greystone Park Hospital	Morris Twp.	Jacqui Pond
Hanover Marriott Hotel	Hanover Twp.	Malapardis Brook
Whippany Paperboard Fac.	Hanover Twp.	Malapardis Brook
Novartis Pharmaceutical	East Hanover Twp.	Pinch Brook
Prepress Solutions	East Hanover Twp.	Pinch Brook
Adron, Inc.	Boonton	Troy Brook Trib.
Warner-Lambert Co.	Morris Plains Borough	Watnong Brook
East Hanover Twp. Well #2	East Hanover Twp.	Whippany River
Givaudin	East Hanover Twp.	Whippany River
Novartis Pharmaceutical	East Hanover Twp.	Whippany River
Sunoco S/S	East Hanover Twp.	Whippany River
Colloid Chemical Inc.	Hanover Twp.	Whippany River
Fabricated Plastics	Hanover Twp.	Whippany River
Hanover Sewerage Authority	Hanover Twp.	Whippany River
Magulian Fuel Corp.	Hanover Twp.	Whippany River
Morris Center YMCA	Hanover Twp.	Whippany River
Ray Petroleum Company, Inc.	Hanover Twp.	Whippany River
Simmonds Precision	Hanover Twp.	Whippany River
Litton Industries Inc.	Morris Plains Borough	Whippany River
Butterworth STP	Morris Twp.	Whippany River
Exxon	Morristown	Whippany River
First Morris Bank	Morristown	Whippany River
Mennen Co.	Morristown	Whippany River
Morristown High School	Morristown	Whippany River
Philips Electronics N.A.	Morristown	Whippany River Trib.
Advanced Wastewater	Par-Troy	Whippany River
Champion Intl Dairy	Morristown	Unnamed Trib
St. Mary's Abbey	Morris Twp.	Unnamed Trib.

Source: New Jersey 1992 State Water Quality Inventory Report, 1993, Pg. III - 349-373.

Nonpoint sources of pollution entering the Whippany reflect surrounding land use. Urban/suburban development is suspected of degrading the water quality in the upper reaches by way of runoff from construction activity, stormwater discharges, impervious surfaces, and loss of riparian vegetation. Siltation in the river has diminished the river's trout holding capability. Downstream of Speedwell Lake urban runoff and chemical spills have resulted in severe siltation and an overall degradation of the river's water quality, manifested by fish populations limited to pollution-tolerant forms, as well as fish kills. Though phosphorus loadings have decreased from point sources, levels continue to increase due to “nonpoint sources such as fertilizers, groundwater discharges, wildlife populations, surface runoff, the re-suspension of bottom material and ineffective stormwater management.”[21]

Subsheds

Troy Brook is assessed as moderately impaired, and partially supports the “aquatic life” designated use. **Watnong Brook** is mostly moderately impaired with one station found to be non-impaired. It partially supports the “aquatic life” designated use.

Waterbodies

Clyde Potts Reservoir, Speedwell Lake, and Pocahontas Lake are the major water bodies within the Whippany watershed. Speedwell Lake is heavily impacted from construction-related runoff, as well as local storm sewers. Clyde Potts Reservoir, a water supply source, has chronically experienced water quality degradation.

Wetland Complexes

Wetlands within the Whippany basin are EPA Priority Wetlands by virtue of their inclusion within the larger Passaic River Basin. **Washington Valley,** located in the upper reaches of the Whippany watershed, in Morris Township, was identified as a Priority wetland due to its environmentally sensitive features. This area comprises a mix of wetlands and uplands creating diverse habitat for wildlife, including threatened and endangered species (e.g., wood turtles, red-shouldered hawk). The tract remains a potential candidate for water supply (ground water) and is considered vulnerable to upland development pressure. Downstream, Black and Troy Meadows are receiving severe and increasing runoff from construction activity and from local storm sewers.

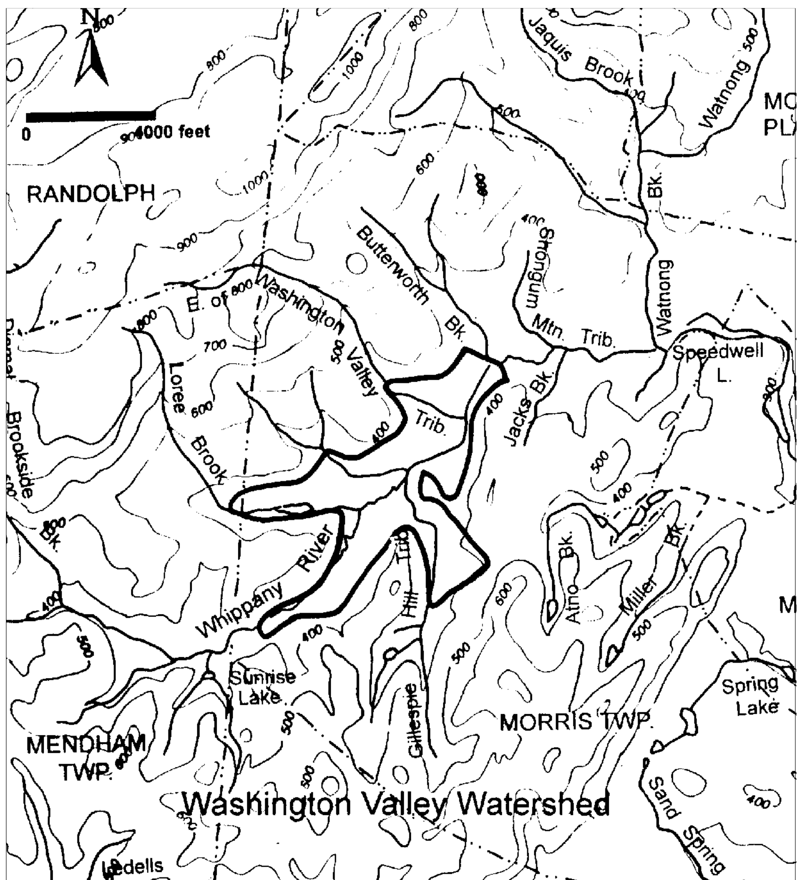
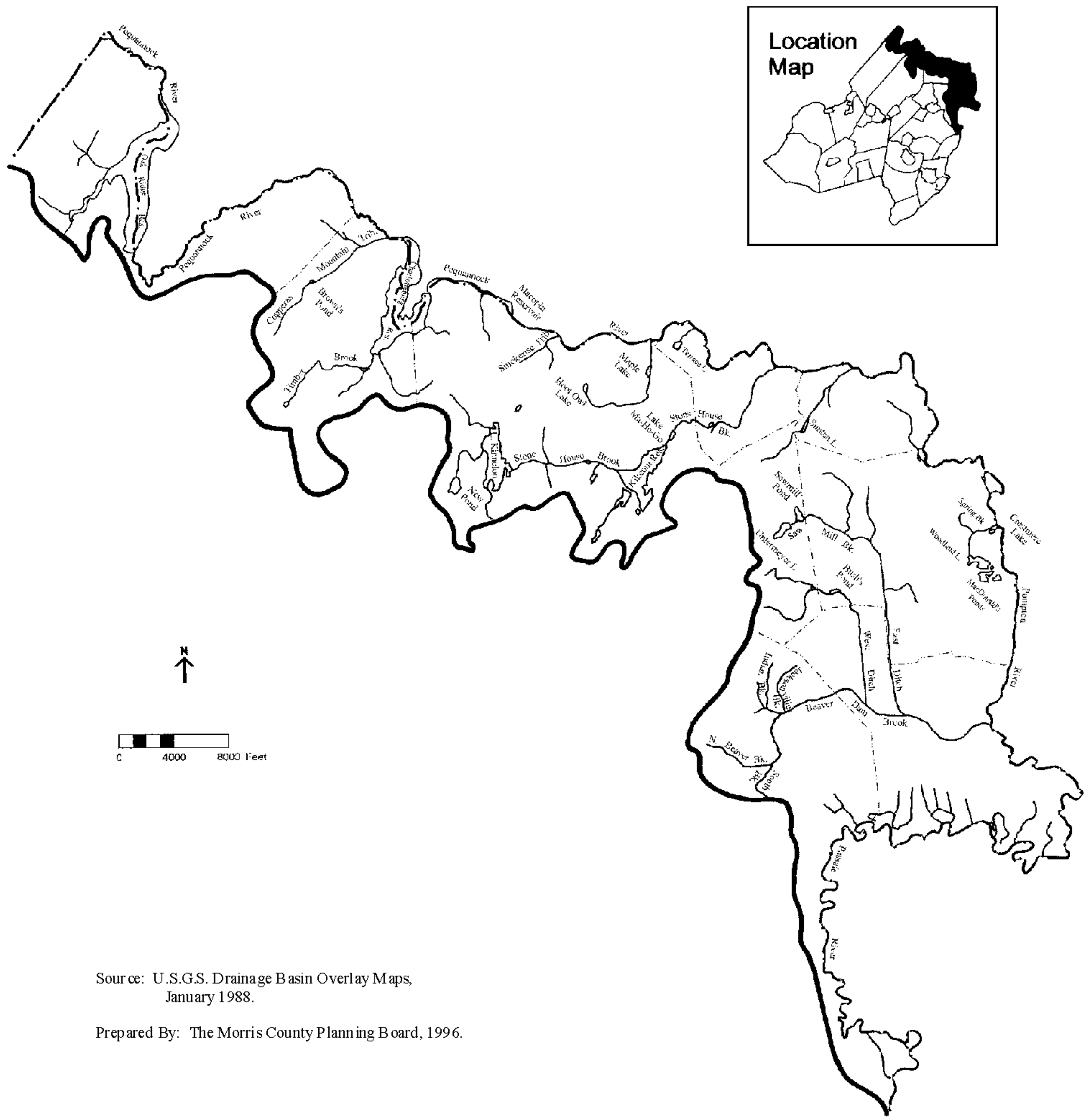


Figure 5 - Priority Wetlands Within Washington Valley

---

[21]NJ DEP, 1996 Inventory 69.



Source: U.S.G.S. Drainage Basin Overlay Maps,
January 1988.

Prepared By: The Morris County Planning Board, 1996.

Pequannock River Watershed

Pequannock River Watershed

The Pequannock River, beginning its travels in Sussex County, flows in a southeasterly direction, forming the north and northeast border of Morris County. Coursing its way through chiefly forested and protected water supply lands, the Pequannock encounters population centers in Butler and Riverdale.

Overall water quality is good becoming fair during summer months when stream temperatures are elevated. Biological monitoring (macroinvertebrate assessments) indicates non-impaired waters while upstream waters are assessed as moderately impaired. Most of the river attains the "aquatic life support" designated use with the upper most portion partially supporting this use. Phosphorous, copper and lead levels are elevated. Fecal coliform levels are adequate to fully support the swimmable use.

The NJ Surface Water Quality Standards list the Pequannock as FW2-TM for most of its course, with an isolated stretch downstream of the Macopin Reservoir as FW2-TP(C1). Feeder streams are classified as FW2-TP(C1) and waters within the Newark water supply area are classified as FW-1.

Point sources of pollution regulated by the NJPDES are listed below:

Table Six - Pequannock River Watershed Dischargers

FACILITY	MUNICIPALITY	RECEIVING WATERS
Butler Water Dept.	Butler	Kakeout Brook
Jefferson Twp.	Jefferson	Mitts Pond
Org Maintenance Shop	Riverdale	Pequannock
Pan Automotive Parts	Riverdale	Pequannock
Stonybrook School	Kinnelon	Pequannock
Raia Industries	Riverdale	Unnamed Trib.
Two Bridges Sewerage	Lincoln Park	Pompton
Laurel Homes STP	Pequannock	Pompton
Plains Plaza Shopping	Pequannock	Pompton
Our Lady of the Magn.	Kinnelon	Butler Reservoir
Kinnelon Bd. of Ed.	Kinnelon	Trib. to Pequannock

Source: New Jersey 1992 State Water Quality Inventory Report, 1993, Pg. III - 349-373.

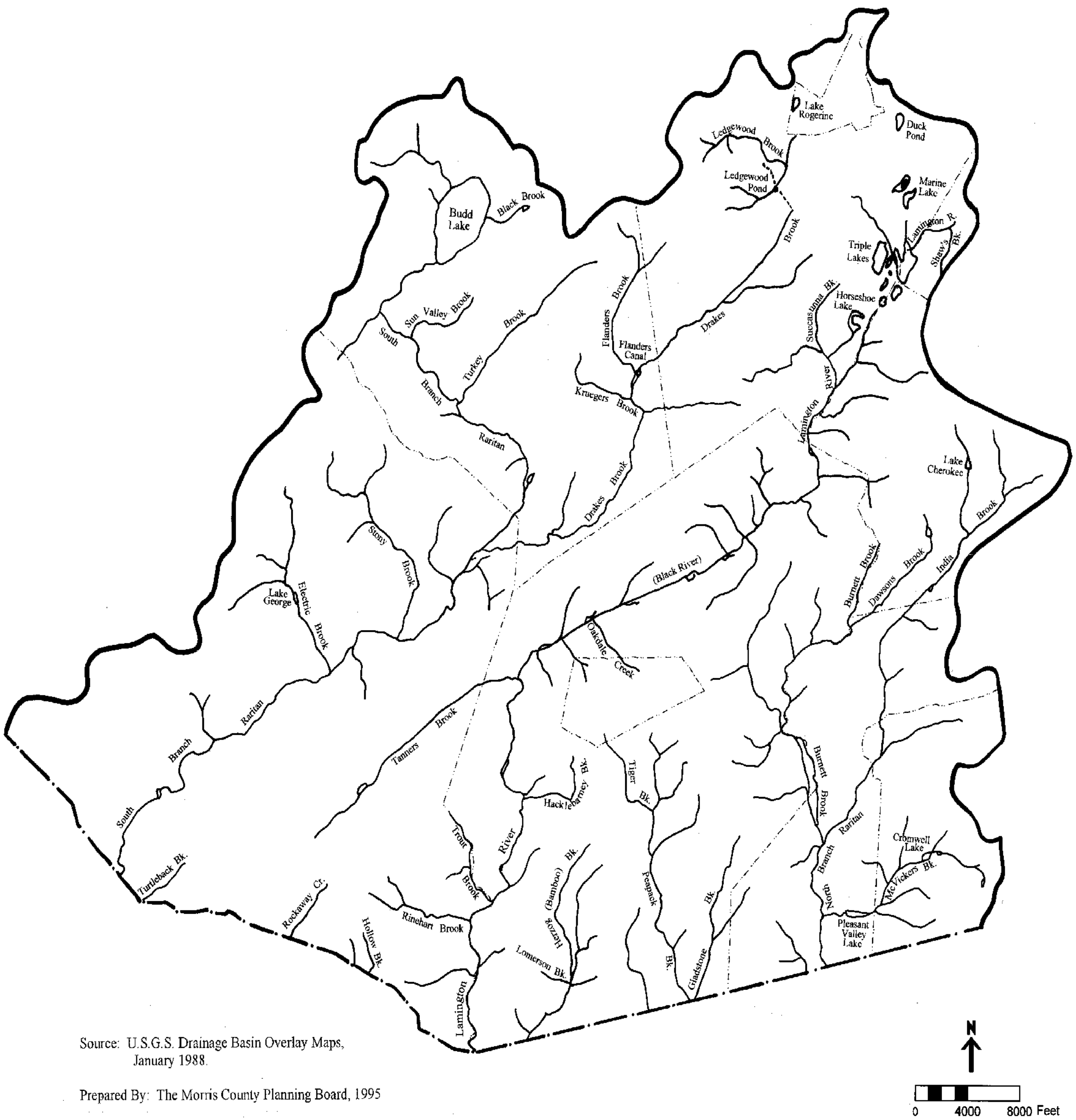
"The principal source of nonpoint source pollution in the Pequannock River watershed is urban/suburban development ... In general, water quality declines as one travels downstream, especially as one passes through the Butler-Bloomingdale area. Reported pollution sources include increased runoff from roads, building construction, urban surfaces, storm sewers and surface mines. Additional problems below Bloomingdale include channelization, streambank modification, and the removal of riparian vegetation. All this has contributed to high water temperatures, silt loads, and organic pollution."[22]

Waterbodies

Of the many lakes, ponds and reservoirs, the major impoundments are the Lake Kinnelon and Kakeout, Charlottesburg and Oak Ridge Reservoirs.

---

[22]NJ DEP, 1996 Inventory, 33.



Source: U.S.G.S. Drainage Basin Overlay Maps, January 1988.

Prepared By: The Morris County Planning Board, 1995

Raritan River Watershed

RARITAN BASIN

South Branch of the Raritan River Watershed

The South Branch of the Raritan generally exhibits good water quality, actually improving as it progresses downstream (transitioning from FW2-NT(C1), to FW2-TM(C1), to FW2-TP(C1). The upper reaches of the river exhibit a moderately impaired biota. Downstream from Long Valley nonimpaired conditions exist. Most of the upstream tributaries (Sun Valley, Turkey, Flanders, Ledgewood, and Electric Brooks) are rated FW2-TP(C1).

Problems in the river include warm summertime temperatures which pose a threat to aquatic life. Phosphorus is slightly elevated and the swimmable designated use is partially supported. Elevated lead levels are considered a threat to the "aquatic life support" designated use.

Point sources of pollution as regulated by the NJ DEP include:

Table Seven - South Branch of the Raritan River Watershed Dischargers

FACILITY	MUNICIPALITY	RECEIVING WATERS
Gold Mine Estates	Mount Olive	Budd Lake
Cloverhill Treatment	Mount Olive	Drakes Brook
Days Inn	Roxbury Township	Drakes Brook
Skyview STP	Roxbury Township	Trib. to Drakes Brook
Chester Shopping Center	Chester Borough	Tiger Brook
Equity Shopping Plaza	Mount Olive	South Branch Raritan
Schooley's Mountain STP	Washington Twp.	South Branch Raritan
Welsh Farms Inc.	Washington Twp.	Trib. to South Branch Raritan

Source: New Jersey 1992 State Water Quality Inventory Report, 1993, Pg. III - 349-373 and
New Jersey 1996 State Water Quality Inventory Report, 1996, Pg. 91.

The nature of the nonpoint source contamination reflects a declining influx from agriculture paralleled by an increase from suburban development contributions. Nonetheless the Natural Resources Conservation Services has identified "agricultural sheet and rill erosion to be severe in the watershed."[23] Septic tanks, road runoff, storm drains, and construction-related activities are also exacting significant impact by way of nutrient and sediment loadings to the river.

Portions of **Drakes Brook** have received FW2-TM(C1) designation, with a tributary designated as FW2-TP(C1). The upper reaches support the "aquatic life support" designated use, and the lower reaches fully support it. Accordingly, the upper reaches of the brook is considered moderately impaired and non-impaired downstream before joining the mainstem.

Stony Brook fully supports the "aquatic life support" designated use. It is designated as FW2-TP(C1).

---

[23] NJ DEP, 1996 Inventory 92.

Subsheds:

The North Branch of the Raritan River and its tributaries exhibit generally fair to good water quality conditions, supporting healthy macroinvertebrate and fish communities as well as recreational fishing. Headwaters are classified as FW2-TP(C1) and non-impaired. The monitoring station at Chester Borough reveals mild nutrient elevations and slightly elevated fecal coliform levels resulting in partial support of the swimmable designated use. Summertime temperature elevations pose a threat to the trout population. Improved water quality is evidenced by reductions in phosphorus and fecal coliform levels.

Point sources of pollution as regulated by the NJPDES include:

Table Eight - North Branch of the Raritan River Watershed Dischargers

FACILITY	MUNICIPALITY	RECEIVING WATERS
Mendham Borough STP	Mendham Township	India Brook

Source: New Jersey 1992 State Water Quality Inventory Report, 1993, Pg. III - 349-373.

Nonpoint sources of pollution, particularly nutrients and sediments, appear to be primarily caused by the suburbanization of the watershed. Agricultural sources include pasture lands and feedlots. Urban surface runoff has been a problem but is showing reductions as a result of better stormwater control

Though **Rockaway Creek** is considered to be of generally good water quality, it does not support the swimmable designated use. Presence of lead posed a threat to the aquatic community. It is classified as FW2-TP(C1). Horse pastures and septic systems are likely sources of NPS.

India, Dawson's, Burnetts, Peapack and Tanners Brooks exhibit healthy biota. All except Tanners Brook are classified as FW2-TP(C1). **Gladstone**, and **Tiger Brooks** are also designated FW2-TP(C1). **McVickers Brook** is classified as FW2-TM(C1).

The Lamington (Black) River contains good water quality with the exception of the headwater station near Ironia, where conditions are fair and degrade to poor during the summer months. Elevated stream temperatures pose a threat to the trout production portions of the river. The river is considered non-impaired excepting the monitoring site in Chester where it is assessed as moderately impaired. The monitoring station near Pottersville indicates full support of the swimmable use designation.

A river whose water quality improves downstream, the Lamington begins with a (C1) designation, progresses to FW2-TM(C1) beyond Oakdale Creek, and subsequently FW2-TP(C1) after Rinehart Brook. The excellent water quality, FW2-TP(C1), of feeder streams Oakdale and Rockaway Creeks, and Hacklebarney, Trout, Rinehart and Hollow Brooks provides restorative properties to the main stem.

Point sources of pollution as regulated by the NJPDES include:

Table Nine - Lamington River Watershed Dischargers

FACILITY	MUNICIPALITY	RECEIVING WATERS
County Concrete Corp.	Roxbury Twp.	Black River
Hercules Inc.	Roxbury Twp.	Black River
Roxbury-Ajax STP	Roxbury	Lamington River

Source: New Jersey 1992 State Water Quality Inventory Report, 1993, Pg. III - 349-373.

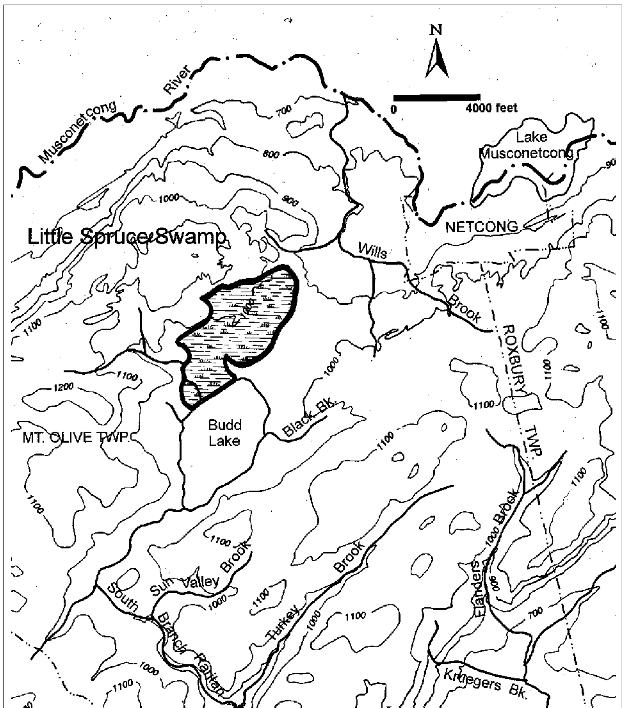


Figure 6 - Little Spruce Swamp

Nonpoint sources of pollution are linked to agriculture and suburbanization (storm sewers, septic tank leachate, and housing construction). Development along the entire length of the river is suspected of contributing significant quantities of nutrients and sediments.

Wetland Complexes

EPA Priority wetland designation has been assigned to two areas within the Raritan River Basin in Morris County. **Little Spruce Swamp**, is located in Mount Olive. It provides habitat to "Federally listed plant species; . . . State imperiled and rare flora, including at least one extant record; and a State rare natural community."[1] The major threat to this complex is impact from current and future development.

The **Lamington River Watershed**, extends from Succasunna (Roxbury Township) to Hacklebarney (Chester Township). This area provides important "habitat for waterfowl and rails . . . State listed species (e.g. Barred owl, American bittern); and rare flora. Major threats consist of groundwater and surface water impacts by way of water table drawdown by wells, and development pressure to adjacent uplands, respectively."[2]

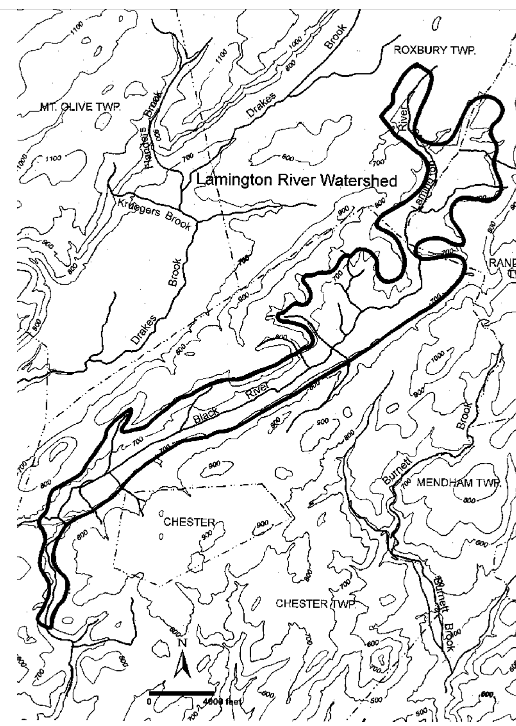


Figure 7 - Lamington River Watershed

[1] US EPA, Priority Wetlands for the State of New Jersey, 130.

[2] US EPA, Priority Wetlands for the State of New Jersey, 130.

Management Considerations

Type and intensity of land use determine quantity and quality of pollutants which are mobilized during rain events. Table One depicts pollutants, sources and impacts. Residential areas tend to contribute fertilizers, pesticides, pet droppings, vegetative matter, sediment, litter, debris, household chemicals, and petroleum hydrocarbons. Commercial and industrial facilities, with vast stretches of impervious surfaces, transmit petroleum hydrocarbons, nitrates, and heavy metals. Impervious surfaces tend to deliver deteriorating surface materials, trash debris, thermal loadings, petroleum hydrocarbons, and atmospheric deposits to receiving water bodies. Pollutants associated with agriculture include sediment, livestock wastes, plant residues, fertilizers and solid wastes. Construction sites promote sediment-laden runoff which carries many of the above-listed pollutants.

Common contaminants derived from these sources include nitrogen, phosphorous, carbon, solids, and trace metals such as lead, zinc, copper and cadmium. Oxygen-demanding substances are responsible for oxygen depletion in the waterways resulting in fish kills. Trace metals, as well as hydrocarbons, attach themselves to sediment, settling out over time, and become available for bioaccumulation in plants and aquatic life, often to their detriment. A particular public health concern is lead and its cumulative impact on children.[3] In addition some petroleum hydrocarbon constituents are carcinogenic. Bacteria, mostly derived from animal wastes, are usually indicative of other harmful constituents. Trash debris, mainly a visual detraction, is a forceful instigator in mobilizing citizen action.

Impacts From Natural Hazards

Natural hazards associated with surface water include flooding, erosion, and sedimentation. Erosion and sedimentation have been discussed in the Soils Chapter. Flooding episodes in the county have been documented by U.S.Geological Survey. Hydrological data enable us to observe trends occurring throughout the watersheds. Some discharge records for gaging stations, as well as reservoir volume records, have been extracted from the 1997 Water Resources Data report and are listed in **Appendix C**. Notice the fluctuations of discharge records, and the extreme highs and lows. October 10, 1903 experienced the highest daily mean of discharge. 1984 followed by 1952 experienced the highest and next highest annual mean discharges, respectively. 1965 experienced the lowest annual mean.

Extremes can be found from year to year as in a wet 1984 followed by a dry 1985, and within the same year as in 1996. 1998 presented normal precipitation (as measured at 3 U.S.G.S. index stations) for the first half of the year. From July through December precipitation rates were far below normal. Records taken at the Passaic River near Chatham indicated the lowest streamflow levels in seventy-one years of record. At Little Falls, the Passaic River experienced the lowest streamflow levels in one hundred and two years of record.[4]

---

[3] NJ DEPE, Stormwater and Nonpoint Source Pollution Control Best Management Practices Manual, Dec. 1994, 2.11.

[4] US Geological Survey, Water Resources Division. Summary of Monthly Hydrologic Conditions in New Jersey, Dec. 1998.

Table Ten - Impacts to Surface Water

Pollutant	Nonpoint Sources	Water Quality and Associated Impacts
Sediment	cropland forestry activities pasture streambanks construction activities roads gullies livestock operations other land disturbances	- decrease in transmission of light through water - increase in aquatic plants & phytoplankton upon which other species feed - obscures sources of food, habitat, hiding places, nesting sites - interferes with mating activities that rely on sight, delays reproductive timing - effects respiration & digestion of aquatic species - decrease in viability of aquatic life; affects species composition - increase in temperature of surface layer of water, increases stratification & reduces oxygen mixing with lower layers, decreasing oxygen supply - decrease in recreational (boating, swimming, fishing) & commercial activities: - reduced aesthetic value - increased potable water costs
Salts	agricultural activities urban runoff	- favors salt-tolerant aquatic species; affects types & pop. of fish & wildlife - fluctuations in salinity may be worse than absolute levels of salinity - reduces crop yields - destruction of habitat and food source plants for fish species - reduced suitability for recreation through higher salinity levels - affects quality of drinking water
Pesticides & Herbicides	lands where pesticides are used: (cropland, forest, pastures, urban/ suburban, golf courses, waste disposal sites) urban runoff	- hinders photosynthesis in aquatic plants - lowers organism's resistance & increases susceptibility to other stresses - can affect reproduction, respiration, growth & development in aquatic species - reduce food supply & destroy habitat for aquatic species - can kill non-target species - can bioaccumulate in tissues - can be carcinogenic, mutagenic and/or teratogenic - reduces commercial/sport fishing & other recreational values - health hazard to humans consuming contaminated fish/water
Nutrients (Phosphorus, Nitrogen)	erosion from fertilized areas urban runoff septic systems animal production operations cropland or pastures where manure is spread	- premature aging of lakes (eutrophication) - algal blooms & decay of organic materials create turbid conditions that eliminate submerged aquatic vegetation & destroy habitat & food source - blooms of toxic algae can affect health of swimmers & aesthetic quality - favors pollutant-tolerant fish - interferes with boating & fish activities - reduced water quality - reduced dissolved oxygen levels can suffocate fish species - reduction of waterfront property values - nitrates can jeopardize infant health
Metals	urban runoff	- accumulates in sediments, threatening bottom-feeders & their predators - can bioaccumulate in animal tissues - disrupts food chain , and reproduction rates & lifespans of aquatic species - can affect recreational & commercial fishing - can affect water supplies
Bacteria	animal operations cropland or pastures where manure is spread septic systems urban runoff wildlife	- introduction of pathogens to surface waters - reduced recreation usage - increase in treatment costs for drinking water - human health hazard

Source: Rutgers University, Watershed Management Strategies for New Jersey, 1989.

Human Derived Impacts

Natural hazards associated with surface water including flooding, erosion, and sedimentation are exacerbated by human activities and usually relegated to the realm of stormwater management. While impact is separated out into water quality and water quantity, the two are joined from a resource management perspective. Changes in volume, velocity, and composition of stormwater runoff have tremendous impact on ecosystems. A generalized depiction of impacts is outlined below.

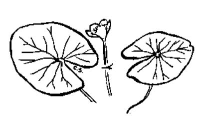
Changes to Stream Hydrology
+ increase in magnitude and frequency of severe floods
+ increased frequency of erosive bankfull floods
+ increase in annual volume of surface runoff
+ more rapid stream velocities
+ decrease in dry-weather baseflow in stream

* Lesser Bladderwort

Changes to Stream Geomorphology
+ stream channel widening and downcutting
+ increased streambank erosion
+ shifting bars of coarse grained sediments
+ elimination of pool/riffle structure
+ imbedding of stream sediments[5]
+ stream relocation/enclosure or channelization
+ stream crossings form fish barriers

Changes to Water Quality
+ massive pulse of sediment during construction stage
+ increased washoff of pollutants
+ nutrient enrichment leading to benthic algal growth
+ bacterial contamination
+ increase in organic carbon loads
+ higher levels of toxics, trace metals & hydrocarbons (Pb, Cd, Cu, & Zn)
+ water temperature enhancement
+ trash/debris jams

Changes to Aquatic Ecology
+ reduction in diversity of aquatic insects
+ reduction in diversity and abundance of fish
+ destruction of wetlands, riparian buffers, and springs



* Small Yellow Pond Lily

---

[5] Imbedding occurs when sand, silt and clay fill up the interstitial voids between larger cobbles and gravels. This sharply limits the quality and availability of fish spawning areas, particularly for trout. (Schueler, 1991)

Water Quality

Impacts have been categorized as point or nonpoint sources (NPS) of pollution. Since the implementation of State and Federal regulations, impact from point discharges has diminished prompting greater emphasis on NPS. The disperse nature of NPS makes them difficult to track, however some general observations can be made. The most common sources include runoff from construction activities and urban/suburban surfaces (paved surfaces such as roads, highways, and parking lots, and lawns), and agricultural runoff.

Water Quantity

Urbanization is characterized by an increase in the amount of impervious surfaces (roads, parking lots, rooftops, sidewalks, compacted fill, etc.) yielding reduced infiltration with resultant increased amounts and rate of stormwater run-off. "In extremely developed watersheds (impervious >50%), the post-development peak discharge rate may increase by a factor of five from the pre-development rate."[6] Land use acts as a generator and receiver of increased water volume. Flooding has long plagued areas in the county, such as Long Hill Township, the Borough of Lincoln Park and Pequannock Township on the Passaic River, the Town of Boonton, Denville Township, Town of Dover and Township of Parsippany-Troy Hills on the Rockaway River, and the Town of Morristown on the Whippany River.

Regulatory Support

FEDERAL

- **The Clean Water Act** authorizes water pollution prevention programs.
- **The Safe Drinking Water Act** authorizes US EPA to set standards for maximum levels of contaminants in drinking water.

STATE

- **Flood Hazard Area Control Act** protects property, water quality, and habitat within floodplain areas and associated watercourses.
- **NJ Freshwater Wetlands Protection Act** preserves freshwater wetlands from disturbance.
- **NJ Water Pollution Control Act** protects uses of water through discharge controls
- **NJ Water Quality Planning Act** mandates the development, adoption and modification of a statewide water quality management plan and areawide water quality management plans, and authorizes the development of county water quality management plans.
- **Water Supply Management Act** authorizes the planning and controlling of allocation and provision of water, including emergency restrictions during times of drought. Water supply critical areas may be designated and regulated if severe water supply problems exist.

- **Statewide Watershed Management Initiative** (implements goals and milestones for water resource management as articulated by the National Performance Partnership System, with the US EPA).
- **Nonpoint Source Pollution Control and Management Implementation Grants** fund watershed management initiatives addressing root causes of nonpoint source pollution, through partnerships implementation of measurable techniques.

---

[6]Thomas R. Schueler, "Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Government," Watershed Restoration SourceBook (Metropolitan Washington Council of Governments, 1991) 22.

Planning Strategies

Watershed groups have long advocated principles of watershed management. Current convention recognizes impacts spanning municipal boundaries and the consequent need for regional strategies. A directory of watershed groups can be found in **Appendix D**.

A generalized format for watershed management planning consists of creating a process that can be duplicated, implemented, measured and monitored, evaluated and modified. Though there is not one set formula for watershed management, there are some basic principles offering a framework for reference:

- ❦ prevention of further degradation of the natural resource
- ❦ enhancement of ecological functions of degraded natural resource
- ❦ restoration of ecological functions to natural resource

The U.S. Environmental Protection Agency, in its Framework for Ecological Risk Assessment promotes protection and preservation of water quality and quantity as well as aquatic and terrestrial communities.

- identifying stressor cause/effect relationships within an ecosystem
- identifying necessary data and analytical tools, verification and monitoring
- establishing reasonable natural resource standards
- including scientific as well as policy considerations
- prioritizing protection and preservation strategies
- creating scientific basis for regulatory actions

Local planning strategies can include:

- Stormwater management plan retaining pre-development hydrological conditions of peak discharge, runoff volume, infiltration capacity, base flow levels, ground water recharge, and water quality
- Land acquisition programs
- Conservation easement proposals
- Habitat restoration plan
- Identify areas suitable for stream bank restoration (e.g., Friends of the Rockaway River's Visions & Strategies for their Recovery
- Identify existing and potential sources of nonpoint sources of pollution with associated remedies

Design Strategies

- Configuring development away from drainage paths and vegetative cover
- Preserving and utilizing natural drainage systems by blending constructed landscape with natural one
- "Fingerprinting" [7] - molding development to the terrain allowing for minimum intrusion on the site and safeguarding existing habitat.
- Limiting impervious surfaces
- Shield sources of pollution from contact with stormwater
- Matching Best Management Practice (see page 5-33) to specific environmental constraints on site
- Stream corridor buffers

---

[7] Schueler, "Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Government," Watershed Restoration SourceBook. 58.

Zoning and Site Plan Ordinance

- Clustering ordinance requiring configuration of designated open area to buffer surface water resources
- Site Plan Landscaping ordinance requiring replacement of indigenous trees and vegetation
- Steep slope ordinance
- Stormwater management ordinance incorporating watershed management principles such as limitations on impervious coverage, BMP implementation etc. consistent with Stormwater Management Plan
- Sediment and erosion control (limiting area and time of disturbance, inspection, and enforcement)
- Set-backs requirement (from surface water resource)
- Critical area ordinance, including buffer zones
  - steep slope
  - tree cover
  - stream corridor
  - floodplain
  - extended wetland buffer

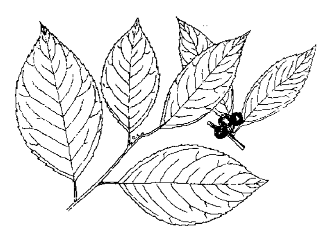
* Featherfoil

Practices

- **Best Management Practices** (BMP's) encompass the "schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State."[8] **BMP**'s can result in multiple benefits. Primary benefits may be reduced flows during storm events resulting in lessened flooding and water quality degradation. There can also be augmented ground water recharge through infiltration, and streambank erosion prevention. Secondary benefits may include enhanced aquatic and terrestrial habitat via stream, pond, and wetland protection, and a beautified landscape. Preserving the functional integrity of ecosystems is beneficial economically, by way of preventing degradation and the consequent expense of mitigation.

Successful BMP selection requires specific application to site, stream, and watershed. Suitable matches take into consideration:

- physical characteristics of the watershed (topography, soils, indigenous vegetation)
- environmentally sensitive areas:
  - wellhead protection areas
  - aquifer or ground water recharge areas
  - surface water areas
- suitability within the context of desired/or existing habitat
  - long term water quality and quantity targets
- category of pollutants to be controlled
- suitability for BMP combinations or linkages
- suitability for retrofit techniques
- land use and density
- community needs



* Mountain Holly

For example Whippany River Watershed BMP Guidance Manual.

---

[8] NJ DEP, Stormwater and Nonpoint Source Pollution Control BMP Manual 1.1.

- **Retrofit** BMP's are used for existing developments. Retrofitting can consist of behavioral changes in terms of daily operations. It can also utilize structural or nonstructural BMP's, to create a more effective mechanism for achieving desired water quality/quantity targets. Examples include:

  - ❦ open channel retrofits (e.g., an extended detention-shallow marsh pond system)
  - ❦ natural channel retrofit (e.g., pond system installed in-line or off-line)
  - ❦ off-line retrofit
    - flow-splitter installed within the storm drain system diverting first flush of runoff to a lower open area for treatment (e.g., peat-sand filters and shallow marsh systems)
  - ❦ enlarge capacity of dry stormwater detention or flood control structure, converting it to a permanent pool, extended detention storage or a shallow wetland (or a combination of all three)
  - ❦ disconnecting impervious areas (e.g., installing drywells to collect rooftop runoff)
  - ❦ reforestation/revegetation of impervious, barren or vacant areas
  - ❦ pollution abatement
    - recycling or substitution of pollutant sources
    - covering source materials
    - spill prevention by proper storage, handling, and disposal of materials

Evaluation of BMP performance, maintenance and inspection criteria is a necessary component in environmental management. Questions to consider:

- ❦ does the BMP coordinate with the proposed site plan and environmental constraint areas.
- ❦ is BMP selection compatible with desired long term water quality targets
- ❦ does the BMP mitigate development's expected impact to the stream
- ❦ status of aquatic ecosystem before and after installation
- ❦ does the BMP accommodate anticipated stormwater runoff events generated at the site
- ❦ has maintenance responsibility and financing been established and followed through

- **Bioengineering** combines basic engineering principles with biological and ecological concepts. Thus, a structure providing water quality treatment and/or flood control can also support wildlife habitat, as well as add to the aesthetic value of an area. The secret to bioengineering's success is its maximization of the inherent strengths of a site. It is versatile in both applicability (slope, soil, and water resource protection) and construction (various combinations of structural and nonstructural features). Examples of suitable sites for bioengineering include wetland buffers, reservoir drawdown areas, streambanks, and slopes. The product is a living, functioning system which is incorporated into the landscape. References in the bibliography pertaining to bioengineering are highlighted (❦).

LOCAL PUBLIC WORKS

De-icing: the application of road salt carries with it the potential for surface and ground water contamination, as well as impairment to roadside vegetation, aquatic ecosystems, and infrastructure corrosion. Areas of concern regarding sodium chloride, and mixes there of, are unprotected stockpiles and over-application. It has been estimated that 80% of the environmental damage from de-icing chemicals is caused by inadequate storage facilities. [9] Therefore recommended practices include:

---

[9] Minnesota Pollution Control Agency, Protecting Water Quality in Urban Areas. Best Management Practices for Minnesota, October 1989, 5.5-1.

- Covered stockpile areas
- Containment provisions for stockpile runoff
- Alternative de-icing compounds
  - ❦ Calcium magnesium acetate
    Pro: little threat to ground and surface water, vegetation, animals, and infrastructure
    Con: costly
  - ❦ Calcium chloride
    Pro: less corrosive; fast de-icer
    Con: similar, but lesser impacts than road salt (vegetation, ground & surface water)
- De-icing program consisting of treatment specific to targeted areas
  - ❦definition and delineation of environmentally sensitive areas. e.g.:
    - wellhead protection areas
    - water supply areas
    - groundwater recharge areas
  - ❦BMPs such as buffer zones around sensitive areas
  - ❦definition of levels of service, e.g.:
    - no salt use
    - plowing and sanding
    - de-icing compound(s) application
  - ❦factors determining level of service, e.g.:
    - environmental consideration
    - road type
    - weather conditions
    - traffic volume
- Education of road crew
  - ❦ location of environmentally sensitive areas
  - ❦ application timing
  - ❦ equipment calibration and maintenance

Sources: NJ DEPE, Stormwater and Nonpoint Source Pollution Control Best Management Practices Manual, 1994, 4.15-4.18. and "Technical Note 55 Rating Deicing Agents - Road Salt Stands Firm", Watershed Protection Techniques, 1995, 217-219.

Street sweeping is most effective for handling the following pollutants: sediment, nutrients and oxygen demanding substances.

INDIVIDUAL
- Litter, trash and pet waste control
- Judicious fertilizer and pesticide handling

Education and Outreach

Fostering environmental stewardship necessitates the development of a meaningful relationship between citizens and the resources. To this end, organized activities might include:
- macroinvertebrate surveys
- storm drain stenciling
- adopting stream segments
- habitat improvement projects such as the McCarter Park Project in Denville, facilitated by the Friends of the Rockaway.

Glossary

BEST MANAGEMENT PRACTICES “encompass the schedules of activities, prohibitions of practices, maintenance procedures, and other management practices or prevent or reduce the pollution of waters of the State.”[10]
Nonstructural BMP’s can be utilized for delivery reduction as well as source control purposes (e.g., stormwater control plans, street sweeping, and buffer zones.
Structural BMP’s temporarily store and treat stormwater runoff, and are not intended to reduce nonpoint source pollution at the source (e.g., detention basins, grassed swales and filter strips).

BIOENGINEERING combines basic engineering principles with biological and ecological concepts.

SPECIFIC CONDUCTANCE “...a measure of the ability of a water to conduct an electrical current. It is related to the type and concentration of ions in solution and can be used for approximating the dissolved-solids content of the water.”[11]

SURFACE WATER QUALITY CLASSIFICATIONS:
FW1 fresh waters that originate in and are wholly within Federal or State parks, forests, fish and wildlife lands and other special holdings, that are to be maintained in their natural state of quality and not subjected to any man-made wastewater discharges.
FW2 fresh waters that are not designated as FW1.
Nontrout waters fresh waters that are neither trout production or trout maintenance.
TM (trout maintenance) waters designated for the support of trout throughout the year.
TP (trout production) waters designated for use by trout for spawning or nursery purposes during their first summer.

WETLANDS CLASSIFICATIONS
Exceptional wetlands either discharge into FW-1 waters or FW-2 Trout Production waters, or which serve as habitats for threatened or endangered species. This designation stipulates a 150' transitional area (buffer) when such a wetland is subject to disturbance.
Intermediate wetlands are those not defined as exceptional or ordinary. A 50' transition area is required adjacent to these wetlands.
Ordinary wetlands do not have the environmental qualities that exceptional wetlands do. In addition they tend to be isolated and significantly surrounded by development. Likely examples include drainage ditches, swales and detention facilities.

---

[10]NJ DEP, Stormwater and Nonpoint Source Pollution Control BMP Manual 1.1.

[11]TJ Reed, GL Centinaro, MJ DeLuca, JT Hutchinson, and J Scudder ,US Geological Survey Water-Data Report NJ-96-1 Water Resources Data, New Jersey, Water Year 1996, 1997.

Appendix A

Best Management Practices For The Great Swamp Watershed

GROUP 1 BMP'S: REDUCE AN EXISTING POLLUTION PROBLEM
(Suitable to Black and Loantaka Brooks)

- Filter Strips
- Riparian Forest Buffer
- Individual Homeowner Practices
  - ❦ maintenance of septic systems
  - ❦ recycling and composting of organic yard waste
  - ❦ proper storage and disposal of all toxics
  - ❦ lawn management practices involving less fertilization, watering, and mowing
- Conversion of mowed turf to natural vegetation
- Agricultural Practices: comprehensive resource management system addressing the soil, water, air, plants, and animals within that microhabitat

GROUP 2 BMP'S: PREVENT A FUTURE POLLUTION PROBLEM
(Suitable to Primrose Brook and Passaic River)

- Watershed-based planning
- Stream corridor buffer requirement
- Steep slope ordinance
- Cluster zoning with permanent open space dedication
- Limits to impervious areas
- Water quality structures in new developments
  - ❦ riparian buffers
  - ❦ filter strips
  - ❦ enhanced grass waterways (instead of curbs, catch basins and storm sewers along streets)

GROUP 3 BMP'S: RESTORE IN-STREAM FISH HABITAT
(Suitable to Primrose, Great, and Loantaka Brooks, and Passaic River)

- Streambank stabilization using bioengineering
- Preservation and enhancement of riparian buffers

Source: U.S. Department of Agriculture, Best Management Practice Recommendations for the Great Swamp Watershed, 1994.

Red Maple

Appendix B

Farny Highlands Coalition's Recommendations:

1. **Federal:**

A. Federal wildlife refuge designation for the Beaver Brook-Hibernia Brook watershed.
B. Picatinny Arsenal's natural areas designated as permanent open space.
C. Federal Land and Water Conservation Funds dedicated to purchasing forested tracts.

2. **State:**

A. Farny State Park expanded by acquiring pre-determined sites and by obtaining conservation easements.
B. High priority for Green Acres open space applications within the Farny Highlands Watershed.
C. No sewer extensions allowed within the project area to service vacant lands.
D. No water diversion permits for large new developments in the project area. Ground water reserves should be protected against large withdrawals.
E. DEP review of septic systems proposed for 50 or more units prior to local planning board approval.
F. Classification of Farny Highlands Watershed's wetlands as "Exceptional Resource."
G. Natural Heritage Priority Site boundaries be enlarged to include the entire Farny Highlands Watershed.

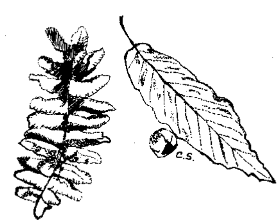
3. **County:**

A. Allocation of county funds for acquiring additional tracts in the Farny Highlands Watershed.
B. Continued support of the Farny Highlands Watershed effort.
C. Recommendations made by the Morris County Planning Board to municipal governments for revisions to master plans and land use ordinances that would protect the region's water and biological resources.

4. **Municipal:**

A. Master plans and land use ordinances revised to provide protection of the project area's forest and water resources.
B. Open space acquisitions in the project area to be dedicated as permanent conservation lands to protect the region's forests and water resources.

Source: Morris County Park Commission. Farny Highlands Watershed, A Plan to Protect Water Supplies and to Preserve Forests, July 1991.



Appendix C

Surface Water Hydrological Data

Discharge Records for Gaging Stations (**cubic feet per second**)

Note: Water Year (WY) = the 12 month period October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 1985, is called the "1985 water year."

When looking at these charts, notice maximum and minimum values compared to the mean. 1965 is listed regularly as the lowest annual mean, with 1952, 1984, and 1996 as wet years.

STREAMS IN THE PASSAIC RIVER BASIN

01379000 Passaic River Near Millington, NJ
Statistics of monthly mean data for water years 1904-1998, by water year (WY)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	49.1	86.8	107	114	130	187	145	94.2	57.9	45.4	49.2	50.3
Max	345	340	335	463	380	439	420	365	292	307	398	380
(WY)	1997	1933	1984	1905	1904	1994	1983	1989	1972	1975	1942	1971
MIN	3.56	7.47	8.18	6.78	26.1	64.2	25.9	20.3	3.95	1.25	1.37	.73
(WY)	1964	1966	1966	1981	1934	1981	1985	1965	1965	1965	1966	1964

WATER YEARS 1904-1998			
Annual Mean	91.9		
Highest Annual Mean	163.0		1984
Lowest Annual Mean	32.3		1965
Highest Daily Mean	2230.0	Oct 20	1996
Instantaneous Peak Flow	2290.0	Oct 20	1996

01379500 Passaic River Near Chatham, NJ
Statistics of monthly mean data for water years 1903-1998, by water year (WY)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	94.4	159	205	228	240	341	266	176	115	84.9	93.6	93.4
Max	576	590	655	735	493	719	711	637	533	539	664	713
(WY)	1904	1973	1984	1979	1908	1994	1983	1989	1972	1975	1942	1971
Min	8.05	13.8	32.3	21.5	63.2	94.5	54.3	7.52	13.6	7.74	7.35	4.70
(WY)	1965	1950	1940	1981	1980	1911	1985	1903	1965	1966	1957	1906

WATER YEARS 1903-1998			
Annual Mean	173.0		
Highest Annual Mean	305.0		1984
Lowest Annual Mean	67.7		1965
Highest Daily Mean	2990.0	Jan 9	1905
Instantaneous Peak Flow	3380.0	Aug 2	1973

01379700 Rockaway River at Berkshire Valley, NJ
Statistics of monthly mean data for water years 1985-1996, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	36.3	59.7	63.2	63.7	56.4	83.3	94.1	67.0	38.0	25.5	21.4	27.9
Max	95.2	120	105	173	111	125	190	170	85.2	49.9	59.7	100
(WY)	1990	1996	1991	1996	1996	1994	1993	1989	1992	1990	1990	1987
Min	12.2	27.3	25.9	28.1	26.4	46.5	35.9	28.3	16.3	6.58	3.38	9.34
(WY)	1989	1992	1989	1989	1987	1989	1995	1995	1993	1993	1993	1995

WATER YEARS 1985-1996			
Highest Annual Mean	61.2		1990
Lowest Annual Mean	35.9		1995
Highest Daily Mean	875.0	Jan 20	1996

01379773 Green Pond Bk at Picatinny Arsenal, NJ
Statistics of monthly mean data for water years 1983-1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	7.54	11.3	18.5	16.1	16.6	23.3	26.5	18.8	11.1	7.74	5.77	5.59
Max	26.1	22.4	49.5	45.5	32.0	49.5	64.1	50.6	21.8	32.6	20.9	24.7
(WY)	1990	1996	1997	1996	1996	1983	1983	1989	1992	1984	1990	1987
Min	.68	2.07	5.29	5.85	5.92	10.5	3.84	5.77	3.54	2.65	2.13	1.36
(WY)	1998	1985	1992	1992	1992	1985	1985	1995	1987	1991	1991	1998

WATER YEARS 1983-1998			
Annual Mean	14.1		
Highest Annual Mean	21.4		1984
Lowest Annual Mean	6.63		1985
Highest Daily Mean	248.0	Apr 5	1984
Instantaneous Peak Flow	333.0	Apr 5	1984

01379780 Green Pond Bk. below Picatinny Lake, at Picatinny Arsenal, NJ
Statistics of monthly mean data for water years 1985 - 1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	8.76	14.3	22.0	19.0	17.8	23.8	25.8	21.4	11.9	6.53	6.42	7.00
Max	33.3	29.5	60.7	51.2	31.8	38.8	51.1	66.7	32.4	18.4	28.6	36.7
(WY)	1990	1996	1997	1996	1998	1994	1993	1989	1998	1990	1990	1987
Min	.71	.28	5.28	6.98	7.08	10.6	2.48	5.32	2.23	1.48	.54	1.73
(WY)	1985	1985	1985	1985	1992	1985	1985	1995	1987	1993	1991	1998

WATER YEARS 1985-1998			
Annual Mean	15.4		
Highest Annual Mean	22.1		1990
Lowest Annual Mean	6.35		1985
Highest Daily Mean	206.0	May 17	1990
Instantaneous Peak Flow	243.0	Sept 13	1987

01379790 Green Pond Bk. at Wharton, NJ
Statistics of monthly mean data for water years 1983 - 1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	13.6	21.4	33.1	29.1	29.6	41.5	47.9	33.6	19.9	14.3	10.1	11.3
Max	46.7	46.3	79.4	80.2	49.7	89.2	112	87.0	40.9	61.4	36.4	54.0
(WY)	1990	1996	1997	1996	1996	1983	1983	1989	1998	1984	1990	1987
Min	3.69	4.23	11.7	11.3	13.2	17.8	8.96	10.7	6.65	3.12	3.04	2.70
(WY)	1998	1985	1985	1985	1992	1985	1985	1995	1987	1993	1993	1998

WATER YEARS 1983-1998

Annual Mean	25.4		
Highest Annual Mean	40.7		1984
Lowest Annual Mean	12.5		1985
Highest Daily Mean	512.0	Apr 6	1984
Instantaneous Peak Flow	572.0	Apr 5	1984

01380500 Rockaway River above reservoir, at Boonton, NJ
Statistics of monthly mean data for water years 1938 - 1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	126	223	278	265	278	393	395	281	183	128	115	119
Max	523	694	718	855	590	798	979	836	847	553	447	484
(WY)	1956	1973	1997	1979	1973	1977	1983	1989	1972	1975	1955	1971
Min	23.7	63.7	67.2	74.8	107	152	87.0	90.5	35.3	18.1	16.6	16.8
(WY)	1965	1962	1940	1981	1940	1985	1985	1965	1965	1966	1957	1964

WATER YEARS 1938-1998

Annual Mean	232.0		
Highest Annual Mean	396.0		1952
Lowest Annual Mean	88.3		1965
Highest Daily Mean	4220.0	Jan 25	1979
Instantaneous Peak Flow	5590.0	Apr 5	1984

01381000 Rockaway River below reservoir, at Boonton, NJ
Statistics of monthly mean data for water years 1950-1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	50.3	103.0	177	171	178	283	304	197	102.0	52.4	42.0	45.1
Max	408	483	802	692	499	739	978	873	671	445	269	346
(WY)	1956	1973	1997	1979	1973	1994	1983	1989	1972	1984	1990	1960
Min	.23	.43	.35	.39	1.49	13.9	11.4	18.6	.40	.25	.29	.28
(WY)	1964	1966	1966	1966	1966	1981	1985	1955	1957	1966	1966	1957

WATER YEARS 1950-1998

Annual Mean	142.0		
Highest Annual Mean	296.0		1952
Lowest Annual Mean	7.19		1965
Highest Daily Mean	3850.0	Apr 6	1984
Instantaneous Peak Flow	7560.0	Oct 10	1903

01381400 Whippany River near Morristown, NJ
Statistics of monthly mean data for water years 1995-1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	60.5	31.4	64.7	52.9	47.2	46.8	55.3	46.7	24.7	18.9	8.56	10.4
Max	145	40.4	154	73.8	52.3	49.9	60.6	63.4	34.0	31.3	11.0	16.7
(WY)	1997	1996	1997	1996	1996	1996	1996	1998	1998	1996	1997	1996
Min	26.4	34.3	19.2	49.0	38.8	41.9	47.7	35.4	18.5	16.7	9.23	6.53
(WY)	1996	1997	1996	1997	1997	1997	1997	1997	1997	1997	1996	1995

	WATER YEARS 1995-1998		
Annual Mean	29.7		
Highest Annual Mean	50.9		1997
Lowest Annual Mean	29.7		1998
Highest Daily Mean	2000	Oct 20	1996
Instantaneous Peak flow	2950	Oct 20	1996

01381500 Whippany River at Morristown, NJ
Statistics of monthly mean data for water years 1922 - 1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	32.9	46.0	55.2	59.4	65.5	87.5	88.2	67.4	47.5	38.7	35.3	34.2
Max	133	132	185	211	147	215	231	237	214	186	158	123
(WY)	1997	1933	1997	1979	1973	1936	1983	1989	1972	1975	1942	1971
Min	8.72	13.4	14.2	16.9	23.5	28.1	30.2	24.4	14.6	10.3	8.02	7.25
(WY)	1931	1937	1940	1922	1940	1981	1985	1941	1965	1965	1932	1932

	WATER YEARS 1922-1998		
Annual Mean	54.7		
Highest Annual Mean	98.5		1984
Lowest Annual Mean	23.3		1965
Highest Daily Mean	1510.0	Aug 28	1971
Instantaneous Peak Flow	2800.0	Aug 28	1971

01381800 Whippany River Near Pine Brook, NJ
Statistics of monthly mean data for water years 1997 - 1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	184	142	403	228	237	231	293	241	136	77.7	50.9	55.5
Max	323	161	696	260	274	234	331	274	181	104	65.1	75.8
(WY)	1997	1997	1997	1997	1997	1997	1997	1998	1998	1997	1997	1997
Min	45.5	122	109	197	200	229	256	208	90.7	51.7	36.7	35.2
(WY)	1998	1998	1998	1998	1998	1998	1998	1997	1997	1998	1998	1998

	WATER YEARS 1997-1998		
Average Mean	190		
Highest Annual Mean	236		1997
Lowest Annual Mean	144		1998
Highest Daily Mean	1820.0	Oct 20	1996
Instantaneous Peak Flow	2080	Oct 20	1996

01381900 Passaic River at Pine Bk., NJ
Statistics of monthly mean data for water years 1980-1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	409	574	801	681	798	1017	1202	826	536	367	257	251
Max	1566	1355	2286	1516	1268	2204	2842	2537	1482	1485	1024	849
(WY)	1997	1996	1984	1996	1996	1994	1983	1989	1984	1984	1990	1989
Min	133	161	107	105	211	272	161	289	188	126	117	91.0
(WY)	1995	1981	1981	1981	1980	1981	1985	1995	1981	1993	1981	1980

WATER YEARS 1980-1998

Annual Mean	642		
Highest Annual Mean	1125.0		1984
Lowest Annual Mean	276.0		1981
Highest Daily Mean	7910.0	Apr 7	1984
Instantaneous Peak Flow	8000	Apr 7	1984

01382500 Pequannock River at Macopin intake dam, NJ
Statistics of monthly mean data for water years 1923-1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	16.7	33.3	41.6	42.4	52.2	100	134	68.5	32.2	19.0	14.6	18.7
Max	288	309	357	308	270	572	506	263	360	238	228	211
(WY)	1956	1928	1997	1996	1939	1936	1983	1989	1972	1938	1955	1960
Min	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
(WWY)	1929	1929	1929	1931	1930	1965	1950	1954	1944	1923	1923	1929

WATER YEARS 1923-1998

Annual Mean	47.6		
Highest Annual Mean	109.0		1952
Lowest Annual Mean	.12		1954
Highest Daily Mean	3170.0	Apr 6	1984
Instantaneous Peak Flow	6100	Oct 10	1903

01382800 Pequannock River at Riverdale, NJ
Statistics of monthly mean data for water years 1994 -1997, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	89.7	1039	185	149	153	238	253	105	26.3	46.1	23.9	23.2
Max	272	210	574	307	271	453	393	182	41.8	128	44.0	31.4
(WY)	1997	1996	1997	1996	1996	1994	1994	1996	1996	1996	1994	1997
Min	13.8	32.5	37.5	73.1	82.0	110	55.2	37.5	13.6	12.3	16.0	10.6
(WY)	1995	1994	1996	1994	1995	1997	1995	1995	1995	1995	1995	1995

WATER YEARS 1994-1997

Highest Annual Mean	150.0		1996
Lowest Annual Mean	50.2		1995
Highest Daily Mean	2610.0	Dec 2	1996

01388500 Pompton River at Pompton Plains, NJ
Statistics of monthly mean data for water years 1903-1997, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	292	423	538	521	573	931	972	631	377	238	213	218
Max	2370	1417	2245	1777	1654	2477	2995	2778	2177	1530	1520	1057
(WY)	1904	1956	1997	1996	1973	1983	1983	1989	1972	1945	1955	1971
Min	40.2	52.3	34.8	39.2	149	118	62.7	110	62.9	34.2	34.2	46.7
(WY)	1981	1981	1981	1981	1969	1981	1985	1965	1965	1965	1966	1980

	WATER YEARS 1903-1998		
Annual Mean	492.0		
Highest Annual Mean	906.0		1952
Lowest Annual Mean	117.0		1965
Highest Daily Mean	28300.0	Oct 10	1903 ←
Instantaneous Peak Flow	28300	Oct 10	1903

STREAMS IN THE RARITAN RIVER BASIN

01399500 Lamington (Black) River near Pottersville, NJ
Statistics of monthly mean data for water years 1922-1998, by water year

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	34.6	50.2	60.6	65.4	70.7	90.3	89.0	67.4	45.9	36.9	32.7	32.4
Max	116	163	207	225	144	230	239	169	191	165	126	123
(WY)	1956	1928	1997	1979	1973	1936	1984	1989	1972	1984	1928	1971
Min	5.69	11.2	15.4	11.7	28.0	32.0	25.9	19.0	10.1	5.48	5.61	3.76
(WY)	1931	1965	1981	1981	1934	1981	1985	1965	1965	1965	1966	1964

	WATER YEARS 1922-1998		
Annual Mean	56.3		
Highest Annual Mean	104.0		1928
Lowest Annual Mean	20.5		1965
Highest Daily Mean	905.0	Jan 25	1979
Instantaneous Peak Flow	3460	Jul 7	1984

RESERVOIRS IN THE PASSAIC AND DELAWARE RIVER BASINS

Reservoir stage and content extremes for Period of Record

Reservoir	Max. Contents	Date	Elevation	Min. Contents	Date	Elevation
Boonton	8,580,000,000 gal	5-12-98	309.50 ft	1,445,000,000 gal	1-31-81	274.71 ft.
Splitrock	3,652,500,000 gal	4- 5-73	836.75 ft	1,522,800,000 gal	1-4-54	824.20 ft.
Lk Hopatcong	8,777,000,000 gal	8-19-55	(a) 10.55 ft.	1,525,000,000 gal	12-29-60	(a) .65 ft.

(a) gage height

Sources: T.J. Reed, M.J. Deluca, G.L. Centinaro, and J.H. Oden Water Resources Data, New Jersey, Water Year 1997. Volume 1. Surface-Water Data. U.S. Geological Survey Water-Data Report NJ-97-1.

T.J. Reed, G.L. Centinaro, J.F. Dudek, V. Corcino, G.C. Steckroat, and R.C. McTigue. Water Resources Data, New Jersey, Water Year 1998, Volume 1. Surface-Water Data U.S. Geological Survey Water-Data Report NJ-98-1.

Appendix D
Local Watershed Groups

Great Swamp Watershed Assoc.
c/o Presbyterian Church
19 Green Ave.
Madison, NJ 07940
973-966-1900

Hacklebarney Watershed Greenway Coalition
P.O. Box 292
Pottersville, NJ 07979

Highlands Coalition
c/o the NJ Conservation Foundation
Bamboo Brook
170 Longview Rd.
Far Hill, NJ 07931-2626
908-234-1225

Musconetcong Watershed Assoc.
PO Box 87
Washington, NJ 07882
908-537-7060

Passaic River Coalition
246 Madisonville Rd.
Basking Ridge, NJ 07920
908-766-7550

Pequannock River Coalition
PO Box 392
Newfoundland, NJ 07435

Protect Our Wetlands, Water, Woods
P.O. Box 438
Denville, NJ 07834
973-625-9649
Joan Lisi

Rockaway River Watershed Cabinet
c/o Morris 2000
2 Ridgedale Ave.
Cedar Knolls, NJ 07927
973-984-2000

South Branch Watershed Assoc.
45 Emery Ave.
Flemington, NJ 08822
908-782-0422

Ten Towns Great Swamp Watershed Committee
c/o Morris 2000
2 Ridgedale Ave.
Cedar Knolls, NJ 07927
973-984-2000

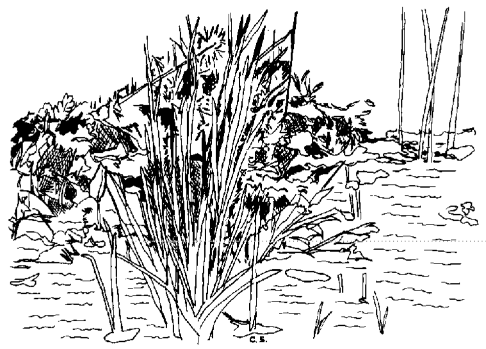
Upper Raritan Watershed Assoc.
P.O. Box 273
Gladstone, NJ 07934
908-234-1852

Upper Rockaway River Watershed Association
P.O. Box 555
Denville, NJ 07834
973-361-1359

Whippany River Watershed Action Committee
c/o Township of Par-Troy
973-263-4293
Art Vespignani

Whippany Watershed Association
Morris Plain, NJ 07950
Jennifer Archibald

The Great Swamp



Great Swamp

Vegetation

Introduction

While our natural world appears to be a constant, resilient, backdrop for our human existence, in reality it is a dynamic, ever-changing organism that responds to the participation of all its members. This mutuality is exemplified within the plant community. Vegetation reflects the interactions of geology, topography, soil type, hydrology, light, temperature, wind and atmospheric composition. Variations in these factors affect plant diversity and the rate of succession, both of which contribute ultimately to the end product of land cover.

Our Green Community

The New Jersey Natural Heritage Program, dedicated to preserving the full array of natural diversity in the state, has identified individual natural communities. A natural community is defined as a "distinct and recurring assemblage of populations of plants, animals, bacteria and fungi naturally associated with each other and their physical environment."[1] An inventory of common, as well as "special" species, and a glossary are located in the back of the chapter. Listings and rankings of endangered and threatened species monitored by the Natural Heritage Program, can be found in **Appendix A**.

* Downy Phlox

Two broad categories have been established: Palustrine and Terrestrial, with subcategories following accordingly. The **Palustrine System** includes various vegetated wetlands and associated open waters such as floodplains, marsh, swamp, bog, ponds, lakes, and river channels. **Terrestrial Systems** correspond to drier, land-based areas such as uplands and mountains.

[1] Thomas F. Breden, "A Preliminary Natural Community Classification for New Jersey, " New Jersey's Rare and Endangered Plants and Animals, Institute for Environmental Studies, 1989, 157.

Streamside/Lakeside Shrub Swamp

Shrub swamps receiving streamside or lakeside sediments; likely to occur in the Highlands and Piedmont. The Rockaway River is flanked by dense thickets of various types of shrubs including alder, willow, and several species of viburnum.

<u>Common Species</u>:
Black Willow
Buttonbush
Dogwood
Speckled Alder
Swamp Rose

* Bog Willow

River Bar Community (Palustrine - Open Canopy)

Communities formed on islands or river banks with sand, gravelly, or cobbly river deposits; likely to occur in the Piedmont and Highland.

<u>Common Species</u>:
Sand Cherry
River Birch
Willow

Northern NJ Shrub Swamp (Palustrine - Open Canopy)

An acidic shrub swamp likely to be found in the Highlands and Piedmont (e.g., Farny Highlands) dominated by woody vegetation less than 20 feet in height.

<u>Dominant Shrubs/Vines</u>:
Alder, Smooth
Alder, Speckled
Arrowwood, Northern
Arrowwood, Southern
Blackberry, Allegheny
Blueberry, Highbush
Buttonbush
Chokeberry, Black
Maple, Red (Sapling)
Meadowsweet
Silky Dogwood
Steeplebush
Swamp Azalea
Swamp Rose
Sweet Pepperbush
Willows
Winterberry

<u>Common Shrub/Vines:</u>
Maleberry
Poison Ivy
Poison Sumac
Red Osier Dogwood

<u>Common Herbs</u>:
Arrow Arum
Arrow-leaved Tearthumb
Blue Flag
Duckweed
False Nettle
Soft Rush
Sphagnum moss
St. Johnswort
Tussock Sedge
Woolgrass

* Cloud Sedge

Inland Graminoid (grasses) Marsh (Palustrine - Open Canopy)

Acting as transitional areas between uplands and waterbodies, marshes are inundated with standing water most of the year, or flooded regularly. In a natural undisturbed freshwater marsh there will be low-growing grasses, rushes, sedges, forbs, and other herbaceous or grass-like plants. Historically exploited as dumping areas for industrial and sewage treatment plant discharges, marshland vegetation betrays anthropogenic assaults. Reed grass dominates polluted areas which are unable to support much else. Troy Meadows exemplifies this community type.

Dominant Herbs:

Bluejoint	Grass, Reed (Phragmites)	Rice Cutgrass	Sweet Flag
Cattail	Millet Smartweeds	Sedge,Tussock	Water Willow
Goldenrods	Pickerelweed	Soft Rush Burreeds	Wild Rice
Grass, Reed Canary	Purple Loosestrife	Spike-rushes	Woolgrass

Common Shrubs/Vines:

Alders	Buttonbush	Poison Sumac	Steeplebush
Blackberry, Allegheny	Maple, Red (Saplings)	Silky Dogwood	Swamp Rose
Blueberry, Highbush	Meadowsweet	Southern Arrowwood	Willows
	Poison Ivy	(Viburnum)	Winterberry

Common Herbs:

Angelica	Boneset	False Nettle	Orange-flowerTouch-me-not
Arrowhead	Bugleweeds	Fern, Marsh	Skunk Cabbage
Arrow-arum	Bulrush	Fern, Sensitive	Swamp Loosestrife
Asters	Bulrush, Soft-stemmed	Jewelweed	Swamp Milkweed
Blue Flag	Bur Reed	Mock Bishopweed	Water Dock
Blue Vervain	Crowfoots	NY Ironweed	Winter Cress

Inland Noncalcareous (not associated with limestone) Pond Shore (Palustrine - Open Canopy)

Shallow edges of noncalcareous ponds or reservoirs, which experience seasonal rise and drop of water level, occurring mostly in glaciated portions of the Highlands and Piedmont.

Common Species:

Engelmann's Quillwort	Pennsylvania Smartweed
Floating Heart	Spiny Quillwort

* Small Bur-reed

Glacial Bogs (Palustrine - Open Canopy)

Glacial bogs are ranked by the New Jersey Heritage Program as critically imperiled because of their extreme rarity (five or less occurrences). They occur in the glaciated portion of the Highlands, often around kettle holes (small ponds) such as the Mount Hope bog. Bogs are wet due to very poor drainage with no outlets. The extremely low pH environment provides an inhospitable habitat for microorganisms that would normally decompose dead plants. The consequent accumulation of organic material forms layers of peat. Plant life consists of acid-tolerant sphagnum moss, sedges, shrubs, and conifers.

The bog microsystem is unique in its constitution. Succession in bogs takes form in a floating mat of vegetation across the surface of the water body. The mat increases in size and thickness in sync with the growing plant population. Sphagnum moss collects at the outer edge of the mat, creating the characteristic buoyancy. Trees congregate where sphagnum forms hummocks. At their base are the unusual carnivorous plants, e.g. pitcher plant as well as sundew, and ferns.

The richness in unique plantlife has unfortunately been exploited. Laurel, swamp azalea, inkberry, sphagnum, and other mosses have been harvested for sale, as well as seasonal clippings of branches from pine and holly trees. This has resulted in a very protective stance on the part of many naturalists regarding bog locations.

<u>Common Trees</u>:

Alder	Hemlock	Pine, White
Birch,Yellow	Larch	Spruce, Black
Blackgum	Maple, Red	Tamarack

<u>Common Shrubs/Vines</u>:

Alder, Black	Fetterbush	Laurel, Sheep	Staggerbush
Blueberry	Huckleberry	Leatherleaf	Swamp Azalea
Cranberry	Inkberry	Sweet Pepperbush	Swamp Laurel

<u>Common Herbs</u>:

Bladderworts	Fern, Climbing	Sedges	Sundews
Bog Moss	Fern, Marsh	Sphagnum bartlettianum	Swamp Loosestrife
Fern, Bracken	Liverworts	Sphagnum cuspidatum	Virginia Cotton Grass
Fern, Chain	Pink Lady's Slipper	Sphagnum fallax	Wild Orchids
Fern, Cinnamon	Pitcher plant	Sphagnum recurvum	Wintergreen

<u>Rare species</u>:

Bog rosemary
Dwarf mistletoe
Labrador teapale laurel
Rosebay rhododendron
Sheathed cotton grass

* Bog Rosemary

PALUSTRINE - CLOSED CANOPY (FORESTED)

Floodplain Forest

Floodplain Forests are considered rare by the NJ Heritage Program. They occur in the broad flood plains of the larger rivers such as the Raritan, Passaic and the Rockaway. These communities host diverse vegetation with no single dominant species.

Common Trees:

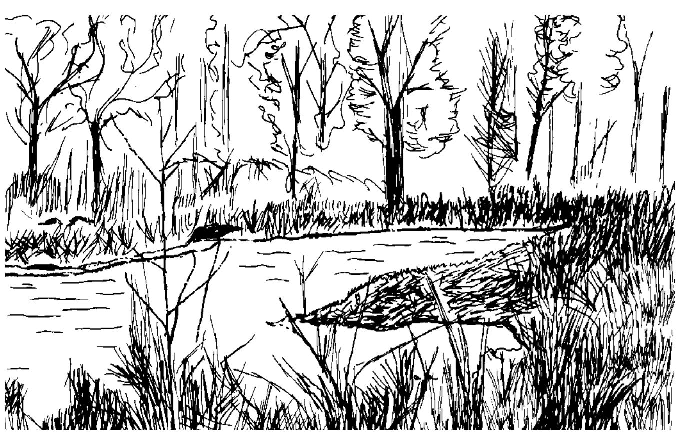
Ash, White	Elder, Box	Maple, Sugar
Basswood, American	Elm, American	Oak, Pin
Beech, American	Elm, Slippery	Oak, Swamp White
Birch, River	Hackberry	Sycamore
Blackgum	Maple, Red	Walnut, Black
	Maple, Silver	Willow

Common Shrubs/Vines:

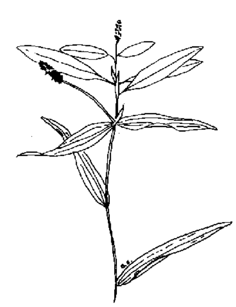
American Bladdernut	Japanese Honeysuckle	Spicebush
Bittersweet	Poison Ivy	Virginia creeper
	Poison Sumac	Wild Grape

Common Herbs:

Cardinal Flower	May Apple	Spreading Chervil
Dutchman's Breeches	Nodding Trillium	Spring Beauty
False Mermaid	Nyctelea	Troutlily
Fern, Lowland Fragile	Pale Corydalis	Violet, Creamy
Fern, Sensitive	Sedge, Gray's	Waterleaf, Broad-leaved
Green-Dragon	Sedge, Narrow-leaved	Waterleaf, Virginia
Jack-in-the-pulpit	Sedge, Nebraska	Wild Leek
Jewelweed or Touch-me-not	Sedge, Rosy	Winged Monkeyflower
Jumpseed, or Virginia Knotweed	Sedge, Stellate	Wood Nettle



Black River



* Northern Pondweed

Inland Red Maple Swamp (Palustrine - Closed Canopy)

A community typically found in the Highlands (e.g., Mahlon Dickerson Reservation and Jockey Hollow) and the Piedmont with the following vegetation:

Dominant Tree:
Maple, Red

Common Trees:

Ash, Black	Ash, White	Birch, White	Maple, Red
Ash, Green	Birch, Black	Birch, Yellow	Sour Gum

Common Shrubs/Vines:

Alder, Speckled	Buttonbush	Spicebush	Winterberry
Azalea, Swamp	Highbush blueberry	Sweet pepper bush	

Common Herbs:

Fern, Cinnamon	Marsh Marigold	Skunk Cabbage	Swamp Saxifrage
Fern, Marsh	Scarlet Cardinal Flower	Sphagnum Moss	Violet
Fern, Sensitive			

The forested swamp in the Piedmont is the most distinctive plant community differentiating this physiographic province from the Highlands. Vegetation includes the following:

Dominant Tree:
Maple, Red

Common Trees:

Ash	Elm	Oak, Pin	Sycamore
Blackgum	Maple, Silver	Oak, Swamp White	Willow

Occasional Tree:
Birch, Yellow

Common Shrubs/Vines:

Arrowwood	Shadbush	Viburnum
Mountain Laurel	Spicebush	Witch Hazel

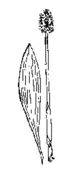
Herbs:

Fern	Orchids
Marsh Marigold	Skunk Cabbage
Mosses	Trillium

* Low Rough Aster

Black Spruce Swamp (Palustrine - Closed Canopy)

This plant community has been classified by the NJ Heritage Program as critically imperiled. It is an atypically cool swamp environment, with remnants occurring within the Farny Highlands (e.g., Budd Lake in Mount Olive Township). Often found adjacent to bogs, these swamps form a later successional stage of bogs.



* Swamp Pink

Dominant Trees:
Black Spruce

Common Species:
Goldthread
Painted Trillium
Starflower
Three-Leaved Solomon's Seal
Yellow Lintonia

Rare Species:
Creeping Snowberry
Dwarf Mistletow
Swamp Pink

* Dwarf Mistletoe

* Creeping Snowberry

Hardwood-Conifer Swamp (Palustrine - Closed Canopy)

Hardwood-Conifer Swamps have been ranked by the Heritage Program to be imperiled-to-rare, primarily due to habitat destruction. Existing communities occur in the Highlands.

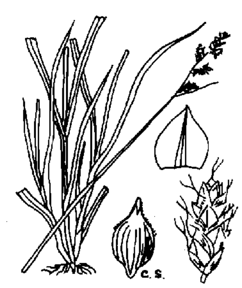
Dominant Trees:
Eastern Hemlock
Maple, Red

Common Trees:
Tupelo
Blackgum

Common Shrubs/Vines:
Alder, Speckled
Highbush Blueberry
Rhododendron, Great
Swamp Azalea
Winterberry

Common Herbs:
Sphagnum Mosses

Rare species:
Calla lily
Grass Pink
Orchids
Pitcher Plant
Sundews
3-leaved Solomon's Seal
Rose Pogonia



* Brownish Sedge

TERRESTRIAL SYSTEM

Terrestrial Systems, implying uplands, contain sub-categories reflecting degree of aridity, which ranges from moderately wet to xeric (extremely dry) conditions. There is a primary distinction between mesic uplands and outcroppings. In general, mesic sites can be flat or rolling terrain, and even contain valleys and ravines, which are not as wet as lowlands. Rock outcroppings, on the other hand, exhibit xeric conditions. The differences in soil amount and type, as well as the degree of moisture, result in the variations seen in habitat.

THE GREENING OF A MOUNTAIN

The process of succession occurring on the seemingly barren substrate can be witnessed in the hills of Morris County. **Lichens** and **mosses** are the first to invade rock surfaces.

Moss, Haircap	Moss, Pine Cushion
Moss, Pigeon Wheat	Reindeer Moss (a true lichen)

As soil becomes embedded on the lichen and moss, pioneer **herbs** take a stronghold:

Beardgrass	Grass, Hair	Sedges
Fern, Marginal Shield	Grass, Impoverished	Three-toothed Cinquefoil
Fern, Rock Polypody	Grass, Poverty	Wild Sarsaparilla

<u>On higher slopes</u>:

Columbine	Dutchman's Breeches	<u>Rare</u>:
Dittany	Mountain Mint	Trailing Arbutus
	Pale Corydalis	

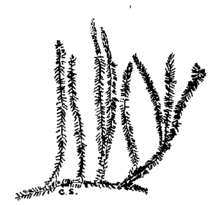
As this vegetative mat becomes established, **shrub** pioneers appear:

Black Huckleberry	Chokeberry	Oak, Scrub
Blueberry	Juneberry (shadbush)	Sheep Laurel
		Sumac

The increasing canopy creates shade, which proves detrimental to herbs that rely on full sun. As these plants die and decompose, the layer of organic material accumulates creating more fertile conditions for tree inhabitation. Eventually a ridgetop **Pitch Pine-Scrub** Oak forest or **Chestnut Oak forest** evolves.

<u>Common species</u>:

Birch, Sweet	Juneberry	Sarsaparilla
Blueberry	Laurel	Shadbush
Fern, Bracken		



* Stiff Clubmoss

Silicaceous Rock Outcrop Community (Terrestrial - Open Canopy)

This plant community has been ranked by the Heritage Program as being at risk of becoming rare. Likely locations for this community would be in the Highlands (e.g., Farny) where the bedrock weathers to very acidic soils (e.g., quartzite, sandstone, granite, schist, granitic-gneiss, and certain conglomerates).

Common species:

Rinodina (lichen)	Moss, Haircap	Moss, Thread
Umbilicaria (lichen)	Moss, Rock	Moss, White

Common Herbs:

Little Bluestem	Fern, Marginal Wood	Grass, Staved Panic
Corydalis, Pale	Fern, Rock Cap	Sedges, Carex
Corydalis, Rock	Grass, Poverty	

Rare Ferns:

Mountain Spleenwort	Rusty Woodsia

Ridgetop Pitch Pine -Scrub Oak Forest (Terrestrial - Open Canopy)

Pitch Pine-Scrub Oak forests occur on the high ridgetops of the Highlands (e.g., Green Pond Mountain). Vegetation contends with a scant soil supply, and exposure to harsh weather conditions of strong winds and frequent sleet and ice storms.

Dominated Species:

Oak, Scrub	Pine, Pitch

Common Species:

Birch, Gray	Maple, Red	Oak, White
Birch, Sweet	Oak, Chestnut	Serviceberry, Roundleaf
Black Huckleberry	Oak, Scarlet	

Shrubs:

Bayberry family	Mountain Laurel	Tree Sparkleberry
Chokeberry, Black	Sumac family	Virginia Creeper

Herbs:

Canada Mayflower	Ginseng
Fern, Bracken	

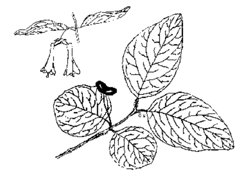
* Torrey's Mountain Mint

Talus Slope Community (Terrestrial - Open Canopy)

This woodland, ranked imperiled-to-rare by the Heritage Program, occurs in the Highlands as well as the Piedmont. It is found on steep ridge slopes, often at the base of cliffs, atop rockslide aftermath.

Dominant Trees:	Oak, Chestnut	Pine, Eastern White
Birch, Sweet	Oak, Scrub	Pine, Pitch

Rare Species:	Fly Honeysuckle	Pine, Red
Allegheny Vine	Mountain Clematis	Sedge, Dewey's
Birch, Paper	Mountain Spleenwort	Skunk Currant



* Fly Honeysuckle

Successional Field (Terrestrial - Open Canopy)

The rolling fields which blanket much of the county and contribute to its aesthetic charm are either pastures, farmlands, or vacant lands. When allowed to progress through the multi-phased process of succession, a field will transition from annuals to perennials, to shrubs, and finally to trees. Within 50-60 years' time a former field will be converted into a woodland. In this region succession can be expected to result in the following plant communities.

STAGE 1
Annual or Biennial Herbs:

Bentgrass	Foxtail, Yellow	Queen Anne's Lace	Sweetclover, White
Crabgrass, Large	Horseweed	Ragweed, Common	Wintercress
Foxtail, Nodding	Mullein, Common		

STAGE 2
Perennial Herbs:

Butter-and-Eggs	Goldenrod, Grass-leaved	King Devil Hawkweed	Ox-eye Daisy
Canada Thistle	Gldnrod, Rough-stemmed	Milkweed, Common	Sweet Vernal Grass
Common St. Johnswort	Hairyvetch	Poison Ivy	Timothy
Goldenrod, Canada	Kentucky Bluegrass	Orchard Grass	Wild Bergamot
			Virginia Creeper

STAGE 3
Shrubs:

Allegheny Blackberry	Olive, Autumn	Multiflora Rose	Sumac, Staghorn
Dogwood, Gray	Raspberry, Black	Sumac, Smooth	

STAGE 4
Trees:

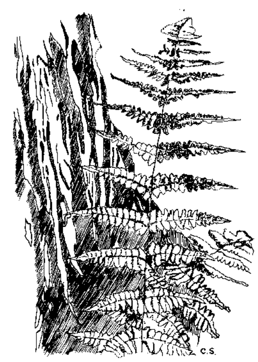
Aspen, Big-toothed	Birch, Yellow
Aspen, Trembling	Cedar, Red
Birch, Gray	Cherry, Black

* Stiff Goldenrod

Dry-Mesic Inland Mixed Oak Forest (Terrestrial - Closed Canopy)

This plant community, further categorized into two subtypes, occurs in both the Highlands and the Piedmont. The mixed oak forest provides us with an example of the devastating change in character wrought by a single source, in this case the Chestnut blight. At one time the largest deciduous tree of the northeast, the American Chestnut no longer dominates this plant community but rather exists for an abbreviated time as a young sapling.

MIXED OAK-HARDWOOD FOREST *SUBTYPE* - (COOL/MOIST) e.g., northern and eastern facing slopes and ravines.



Dominant Trees:

Oak, Black	Oak, White	
Oak, Red	Tulip tree	

Common Trees:

Ash, White	Cherry, Black	Maple, Sugar
Basswood	Linden, American	Sourgum
Beech, American	Maple, Red	Tupelo, Black
Birch, Sweet		

Common Shrubs/Vines:

Blueberry	Hornbeam, American	Spicebush
Dogwood, Flowering	Mountain Laurel	Viburnum, Maple-leaved
Greenbrier	Pinxter-Flower	Virginia Creeper
Hophornbeam	Poison Ivy	Wild Grape

MIXED OAK FOREST *SUBTYPE* - (DRY) e.g., southern and western facing slopes and on level areas overlying the shallow soils of the red-shaled Piedmont.

Dominant Trees:	Oak, Scarlet
Oak, Black	Oak, White

Common Trees:	Birch, Sweet	Hickory, Mockernut	Maple, Sugar
Ash, White	Dogwood, Flowering	Hickory, Shagbark	Chestnut Oak
Beech, American	Hickory, Bitternut	Hophornbeam	Sassafras
		Maple, Red	Tulip Tree

Common Shrubs/Vines:	Viburnum, Maple-leaved
Dogwood, Flowering	Virginia Creeper
Mountain Laurel	

Common Herbs:	Fern, Lady	Jack-in-the Pulpit
False Solomon's Seal	Fern, Marginal Wood	Mayapple
Fern, Christmas	Fern, Wood	Violets

* Allegheny-Vine

Mesic Hemlock-Hardwood Forest (Terrestrial - Closed Canopy)

These woodlands have a canopy consisting of 50% Eastern hemlocks. Characteristically the environs are cool and moist sites such as ravines and north facing slopes, e.g., Hacklebarney Natural Area. While found in the both the Piedmont and the Highlands, in the Piedmont they exist as part of the traprock formations and in the Highlands on slopes of gneiss. Hemlock leaf litter creates an acidic forest floor. This substrate and the lack of sunlight hinders understory vegetation.

<u>Dominant Tree</u>:	<u>Common Tree</u>:	Birch, Yellow	Oak, Black
Eastern Hemlock	Ash, White	Blackgum	Oak, Chestnut
	Basswood, American	Linden, American	Oak, Red
	Beech, American	Maple, Red	Oak, White
	Birch, Sweet	Maple, Sugar	Tulip Tree

<u>Common Shrub/Vine</u>:	Spicebush
Mountain Laurel	Viburnum, Maple-leaved
Rhododendron	Witch-Hazel

<u>Common Herbs</u>:	Goldthread	Pink Lady's Slipper
Fern, Christmas	Partridgeberry	Starflower
Fern, Hay-Scented		

<u>Rare</u>:
Fern, Long Beech
Fern, Oak
Painted Trillium

* Blunt-Lobed Grape Fern

Chestnut Oak Forest (Terrestrial - Closed Canopy)

This forest is dominated by Chestnut Oak, found on the high, steep slopes and ridgetops in both the Highlands (e.g., Farny , and the Piedmont). The Chestnut Oak forest differs in appearance from the Mixed Oak forest in that the trees are not as tall (mostly less than 50 feet in height) and the understory is not as abundant.

<u>Dominant Tree</u>: Chestnut	<u>Common Tree</u>:	Hickory	Oak, Scrub
Tree sprouts	Birch,Gray	Maple, Red	Oak, White
	Birch, Sweet	Oak, Black	Pine, Pitch
	Cherry, Black	Oak, Red	Pine, White
	Dogwood	Oak, Scarlet	Sassafras

<u>Common Shrubs/Vines</u>:		<u>Common Herbs</u>:	Pipsissewa
Blueberries	Mountain Laurel	Orchid, Rattlesnake	Wild Sarsaparilla
Huckleberry	Virginia Creeper	Partridgeberry	Wintergreen

Sugar Maple-Mixed Hardwood (Terrestrial - Closed Canopy)

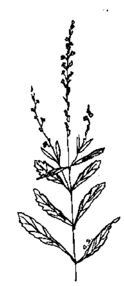
The Sugar Maple-mixed hardwood plant community occurs infrequently in Morris County. Mahlon Dickerson does however provide us with one of these infrequent sites. While sugar maple is the dominant species, the general character is similar to that of the Mixed Oak forest.

Dominant Tree:
Sugar Maple

Common Trees:
Ash, White
Basswood
Beech, American
Birch, Sweet
Birch, Yellow
Cherry
Dogwood
Hickory, Bitternut
Hickory, Shagbark
Hornbeam, Hop
Linden, American
Maple, Red
Oak, Black
Oak, Red
Oak, White
Sassafras, White
Tulip Tree

Occasional Trees:
Elm, American
Hemlock
Oak, Yellow
Pine, White
Walnut, Black

Common Shrubs:
Beaked Hazel
Dogwood, Flowering
Black Haw
Ironwood
Spicebush
Viburnum, Mapleleaf
Witch-Hazel

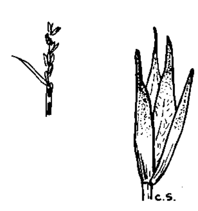


* Narrow-Leaved Vervain

Common Herbs:
Anemone, Rue
Anemone, Wood
Aniseroot
Bloodroot
Common Blue Violet
Dutchman's Breeches
Fern, Christmas
Fern, New York
Goldenrod, Blue-stemmed
Hepatica
Jack-in-the-Pulpit
Mayapple
Solomon's-Seal
Virginia Stickseed
Wild Ginger

"To waste, to destroy, our natural resources, to skin and exhaust the land instead of using it so as to increase its usefulness, will result in undermining in the days of our children the very prosperity which we ought by right to hand down to them ..."

TheodoreRoosevelt



* Puff-Sheathed Dropseed

Special Areas

* Tall Millet Grass

Several areas have received designations due to the rarity and diversity of species within the specific ecosystem. To avoid duplication, areas with multiple designations have been listed according to the program offering the most extensive description.

The Natural Areas System administered by Natural Lands Management of the NJ DEP is "designed to preserve and protect the habitats of rare or endangered plants and animals, and representative examples of ecosystems of New Jersey."[1] Of the forty-two officially designated sites, 4 are located in Morris County: Black River, Farny, Hacklebarney, and Troy Meadows Natural Areas.

HACKLEBARNEY NATURAL AREA

The Hacklebarney Natural Area spans portions of Chester and Washington Townships. Natural features include ridges, moderate to steep hillsides, and ravine walls. The desire to preserve the river ravine, northern hemlock/mixed hardwood forests, and rare species' habitats, prompted inclusion of this region in the Natural Areas System. Other communities include mixed oak/hardwood forest and the transitional forest. Flora, other than those already mentioned in these specific communities are listed below.

Mixed Oak/Hardwood Forest:

Shrubs	Ground Cover
Arrowwood	Grasses
	Sedges
	Spring-beauty

Hemlock-Mixed Hardwood Forest:

Trees	Ground Cover
Ash, Black	False Lily-of-the -Valley
Oak, Red	Mosses
	Partridge Berry

Old Fields:

Trees	Ground Cover
Maple, Red	Barberry
Sassafras	Little Bluestem Grass

Shrubs and Vines
Hawthorn
Honeysuckle,Japanese

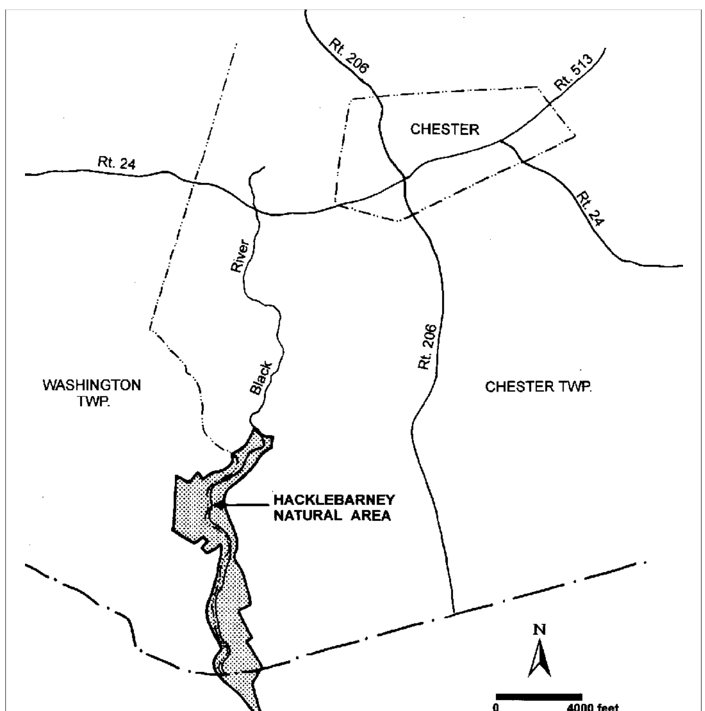


Figure 1 - Hacklebarney Natural Area

[1]NJ DEP, Natural Lands Management, Division of Parks and Forestry, information sheet.

FARNY NATURAL AREA

The Farny Natural Area is located within the Highlands. It harbors headwaters to, and reservoirs of, potable water supplies, as well as diverse plant communities including habitat of threatened and endangered species, and old growth forests. Glaciers sculpted the terrain and drainage patterns thus influencing the evolution of soils, vegetation and wildlife.

Mesic uplands contain colonies of mixed oak, sugar maple-mixed hardwoods, and hemlock/mixed hardwood. Xeric communities of Pitch Pine/Scrub Oak and Chestnut Oak forests occur in the higher elevations. Low lying wet areas include red maple swamps, floodplain forests, marshes, shrub swamps, bogs, and successional fields. Flora, other than those already mentioned in previous community descriptions, are listed.

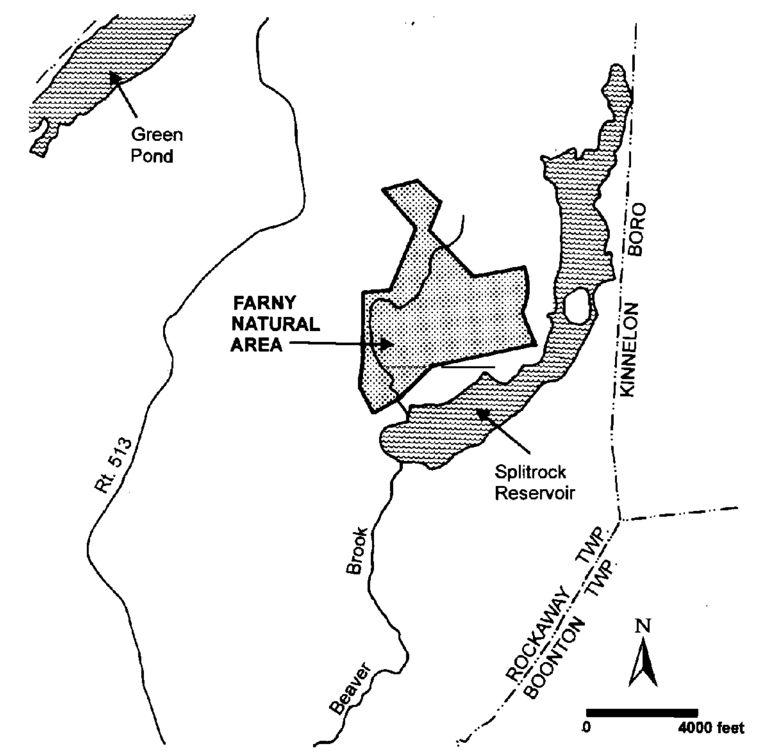


Figure 2 - Farny Natural Area

MESIC UPLANDS:
Mixed Oak Forest :

Dominant Trees:
Ash, Green
Aspen
Birch, Black
Birch, Gray
Chestnut, American
Hazelnut, American

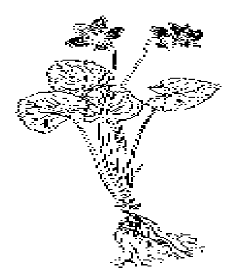
Shrubs/Vines:
Grapes, Fox
Leatherleaf
Rhododendron

Herbs:
American Liverleaf
Clubmoss, Flat Branch
Clubmoss, Ground
Clbmss, Running Gr. Pine
Clubmoss, Shining
Clubmoss, Staghound
Downy Rattlesnake Plantain
Dutchman's Breeches
False Solomon's Seal
Garlic Mustard
Indian Cucumber Root
Showy Ladyslipper
Spring Beauty
Stinking Benjamin
Sweet Cecily

Sugar Maple-Mixed Hardwoods:

Dominant Trees:
Black Cherry
Sugar Maple

Herbs:
Geranium, Wild
Pipsissewa, Striped
Violet, Common Blue

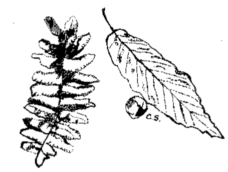


* Northern Blue Violet

Hemlock-Hardwood Forest:

Occasional Stands:
Eastern White Pine

Herbs:
Canada Mayflower
False Lily-of-the-Valley
Fern, Spinulose Wood



XERIC UPLANDS

Chestnut Oak forest:

Common Trees:
Bitternut Hickory
Black Cherry
Hickory, Shagbark
Maple, Green-barked
Maple, Striped bark

Ridgetop Pitch Pine-Scrub Oak Forest:

Common Trees:
Cedar, Eastern Red

Shrubs/Vines:
Blueberry

Herbs:
Wild Sarsaparilla

Rock Outcrop:

Trees
Aspen, Quaking
Birch, Black
Oak, Chestnut
Oak, Scrub

Herbs:
Columbine
Dittany
Fern, Common Rock Cap
Fern, Sweet
Hair Grass
Lichens
Moss, Pigeon Wheat
Moss, Pincushion
Moss, Reindeer
Sedges
Trailing Arbutus

WETLANDS

Graminoid (grass) Marsh

Shrubs/Vines:
Alder, Smooth
Willow, Black

Herbs:
Common Cattail
Fern, Royal
Goldenrod, Canadian
Loosestrife, Purple
Loosestrife, Swamp
Pickerel weed
Reed, Common
Sedge, Tussock
Spike Rush

Bog:

Herbs:
Goldthread

Shrubs/Vines:
Arrowwood
Mountain Laurel

Black Spruce Bog

Herbs:
Arrowhead
Bulrushes
Ferns
Pitcher Plant
Sedges
Sphagnum Moss
Sundew
Swamp Loosestrife
Wild Orchids

Shrubs/Vines:
Blueberry
Bog Rosemary
Cranberry
Huckleberry
Labrador Tea
Leatherleaf
Rosemary Rhododendron
Sheep Laurel
Swamp Azalea

Trees
Birch, Yellow
Hemlock
Larch
Maple, Red
Pine, White

* Marsh Cinquefoil

Northern NJ Shrub Swamp

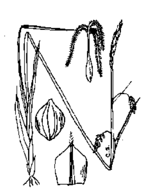
Trees:	Herbs:	Shrubs/Vines:	
Sand Cherry	Canada Mayflower	Alder, Speckled	Lily,Sweet Scented White Water
	Duckweed	Allegheny Vine	Lily, Yellow Pond
	Sedges	Black Huckleberry	Maleberry
		Clematis, Mountain	Rose, Multiflora
		Fly Honeysuckle	Rose, Swamp
			Southern Arrowwood
			Willow, Pussy
			Winterberry

Floodplain Forest

Tree:	Shrubs/Vines:	Herbs:	
Alder	Elderberry	Arrowhead	Jewelweed
Birch, Yellow	Juneberry, Roundleaf	Fern, Crested	Lily, Canada
Burwood	Shadbush	Fern, Interrupted	Lily, Wood
Ironwood		Fern, Lady	Lily, Sweet Scented White Water
Tulip Tree		Fern, Maidenhair	Mosses
Willow, Swamp		Fern, Royal	Sedges
		Fern, Sensitive	Skunk Cabbage
		Jack-in-the-Pulpit	Watercress
			Witchhazel

Red Maple Swamp

Trees:	Shrubs:	Herbs:	
Ash	Buttonbush	Anemone, Wood	Ladyslippers
Basswood	Highbush Blueberry	Cardinal Flower	Marsh Marigold
Dogwood, Flowering	Speckled Alder	Fern, Cinnamon	Skunk Cabbage
Maple, Red	Spicebush	Fern, Marsh	Sphagnum Moss
	Swamp Azalea	Fern, Sensitive	Star Flower
	Sweet Pepperbush	Indian Pike	Swamp Milkweed
	Viburnum	Gentian, Fringed	Trout Lily
	Winterberry	Ginseng, Dwarf	Turtlehead



* Mud Sedge

Threatened, Endangered, And Rare Species' Macrosites

Morris County hosts rare and endangered species, potential habitat for same, and natural communities. The Natural Heritage Program has designated these as priority sites, or macrosites. "If these areas are allowed to be degraded or destroyed, we may lose some of the unique components of our natural heritage."[2] The following section briefly describes and delineates specific communities, as well as provides a listing of species considered to be of conservation concern. A specific rating scale is applied to the priority sites, and evaluates the degree of biological diversity. A listing of threatened, endangered, and special plants and their rankings, as well as code explanations can be found in **Appendix A**.

Macrosite Basic Record Code Explanation

BIODIVERSITY SIGNIFICANCE

B1: Outstanding significance - generally of a "last of the least" type, such as only known occurrence of any element (species or natural community), the best or an excellent (A-ranked) occurrence of a G1 element, or a concentration (4+) (A or B ranked) occurrences of G1 or G2 elements. Site should be viable and defensible for elements and ecological processes contained.

B2: Very high significance - such as the most outstanding occurrence of any community element, regardless of its element rank. Also includes areas containing any other (B, C, D ranked) occurrence of a G1 element, a good (A or B ranked) occurrence of a G2 element, an excellent (A ranked) occurrence of a G3 element, or a concentration (r+) of B ranked G3 or C ranked G2 elements.

B3: High significance - such as any other(C or D ranked) occurrence of a G2 element, a B ranked occurrence of a G3 element, an A ranked occurrence of any community, or a concentration (4+) of A or B ranked occurrences of G4 or G5 S1 elements.

B4: Moderate significance - such as a C-ranked occurrence of a G3 element, a B ranked occurrence of any community, an A or B ranked or only state (but at least C ranked) occurrence of a (G 4 or G5) S1 element, an A ranked occurrence of an S2 element, or a concentration (4+) of good (B ranked) S2 or excellent (A ranked) S3 elements.

B5: Of general biodiversity or open space interest

Source: NJ DEP, Natural Lands Management, Natural Heritage Site Report, 1991.

"In our every deliberation we must consider the impact of our decisions on the next seven generation."
The Great Law of the
Six Nations Iroquois Confederacy

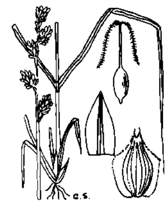
* Early Buttercup

[2] NJ DEP, Natural Heritage Priority Site Maps, 1995.

Black River - (B5) (Black River Macrosite Map, Page 6-20)

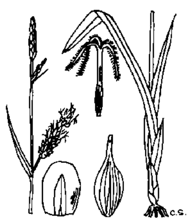
A large, forested, emergent wetland complex adjacent to the Black River, surrounded by a drainage basin that is largely forested or under agriculture, but with some residential development.

Species:
Cuckoo Flower
Dry-Spiked Sedge
Wild Lupine



* Dry-Spiked Sedge

Chester Railroad - (B3) (Black River Macrosite Map, Page 6-20)



* Variable Sedge

Abandoned railroad corridor containing both wet and upland habitats provided by a wooded slope and Lamington River.

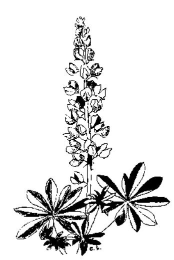
Species:
Variable Sedge

Ironia - (B3) (Black River Macrosite Map, Page 6-20)

Habitat includes forested wet and uplands, and an abandoned sand pit.

Species:
Rhodora
Low Rough Aster
New England Blackberry
Fraser's St. John's-Wort
Swamp-Pink
Three-Leaved False Solomon's-Seal
Variable Sedge

* Rhodora



* Wild Lupine

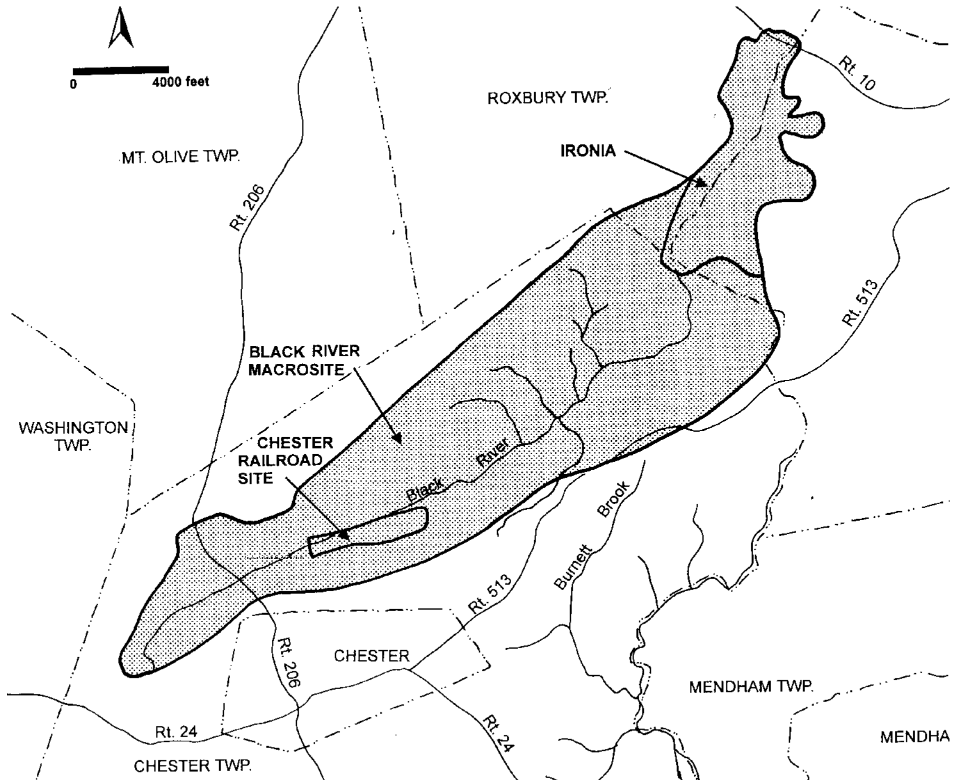


Figure 3 - Black River, Chester Railroad and Ironia

Bridge to Nowhere - (B4)

Forested wetlands and uplands, and abandoned canal along stream. One state listed endangered plant, one historical plant species, plus special concern plant species.
←

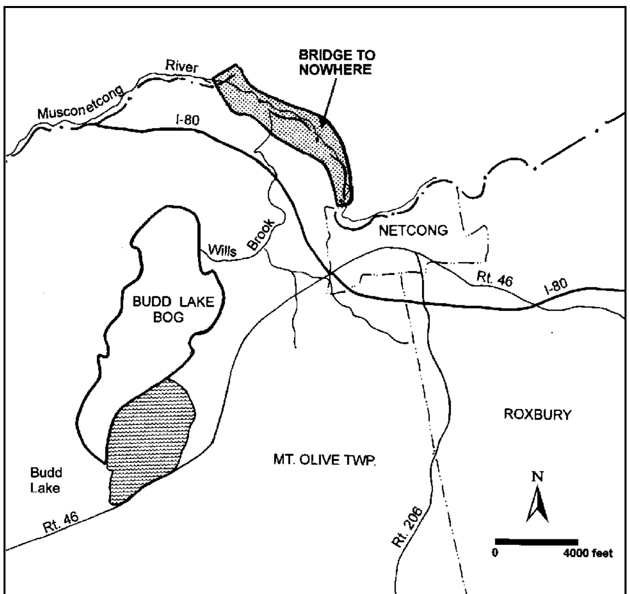
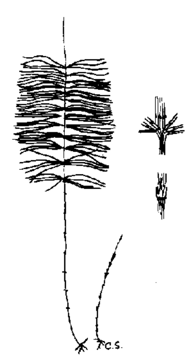


Figure 4 - Bridge to Nowhere

Species:
Cuckoo Flower
Leatherwood
Meadow Horsetail
Star Duckweed
Tall Millet Grass



* Meadow Horsetail

Budd Lake Bog - (B3)

The Natural Heritage Program has given this plant community, a rare spruce-tamarack bog, which overlies glacial till of the Wisconsin Terminal Moraine, high significance. Large hummocks support an open canopy of Maple, Spruce, Larch, a very dense shrub layer of Blueberry, Swamp Honeysuckle, and scattered other species, and sphagnum blanketing the base. Uplands are dominated by mixed oak forests.

<u>Species</u>:
Black Spruce Swamp
Blunt-Lobed Grape-Fern
Grass, Arrow
Grass, Northern Panic
Hairy Angelica
Pale Laurel
Sedge, Beaked
Sedge, Bog
Sedge, Brownish
Sedge, Mud
Shining Willow
Slender Cottongrass
Spreading Globe Flower
Swamp Pink
Virginia Bunchflower

* Arrow-Grass

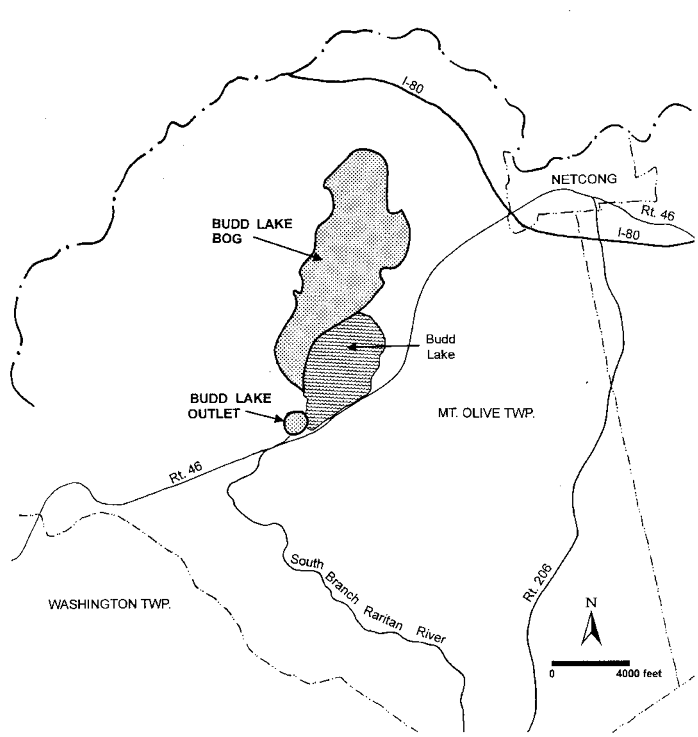


Figure 5 - Budd Lake Bog and Budd Lake Outlet

Budd Lake Outlet - (B5)

Boggy woods provide a wetland habitat.

<u>Species</u>:
Bog Rosemary
Bog Willow
Illinois Pondweed
Marsh Cinquefoil

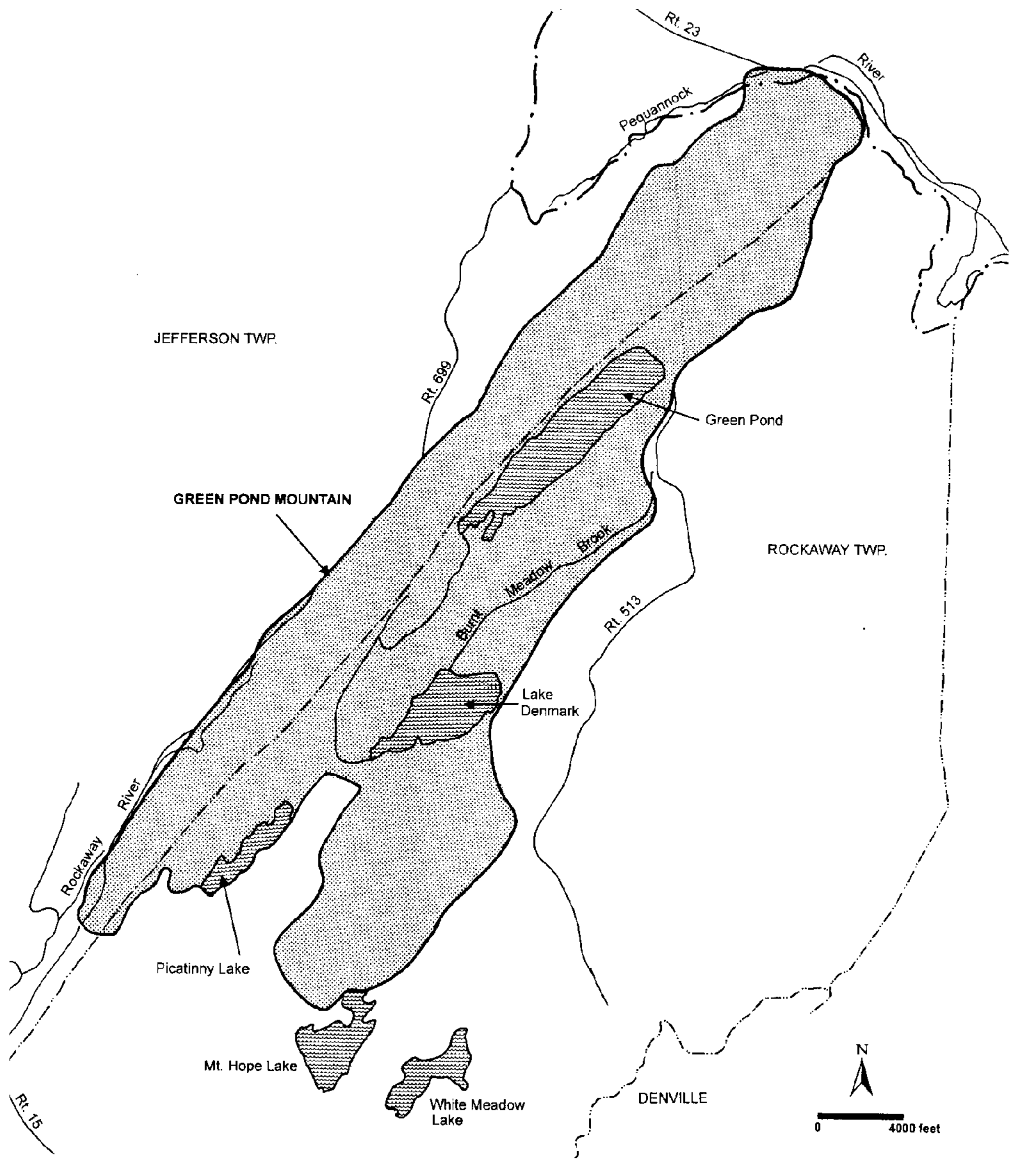
* Illinois Pondweed

Green Pond Mountain - (B4)

Large, contiguous forests and two large lakes provide habitat for rare plants, birds of prey, vertebrate and invertebrate species.

Species:

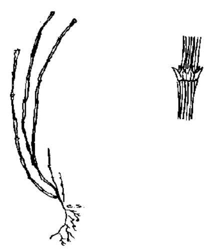
Featherfoil	Mountain Holly	Purple Cress	Soft-Leaved Sedge
Floating Heart	Mountain Spleenwort	Purple-Fringed Orchid	Tall Cinquefoil
Hooker's Orchid	Narrow-leaved Bur-reed	Robbin's Pondweed	Virginia Snakeroot
Lesser Bladderwort	Purple Bladderwort	Small Bur-reed	Water Lobelia
			White Water Buttercup



New Russia Gravel Pit Site - (B5)

An abandoned sand and gravel pit, with some ponding. ➜

Species:
Variegated Horsetail



*Variegated Horsetail

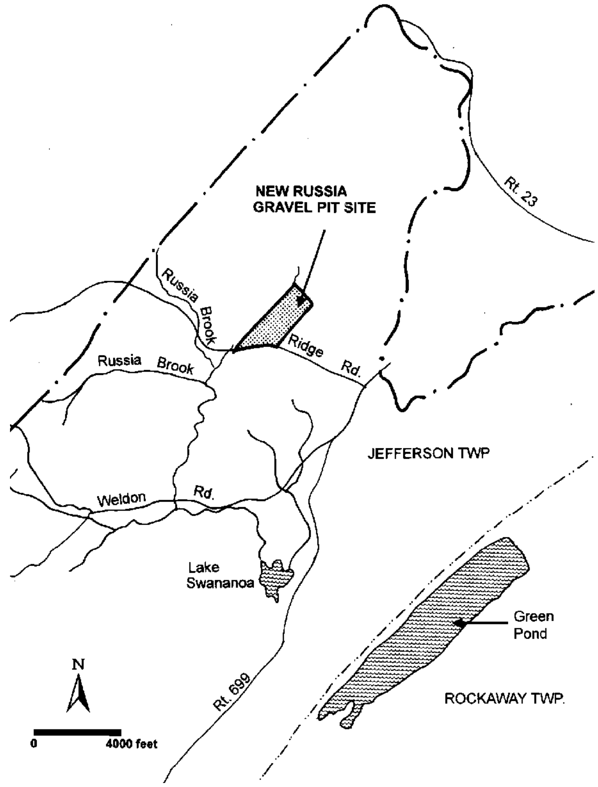


Figure 6 - New Russia Gravel Pit Site

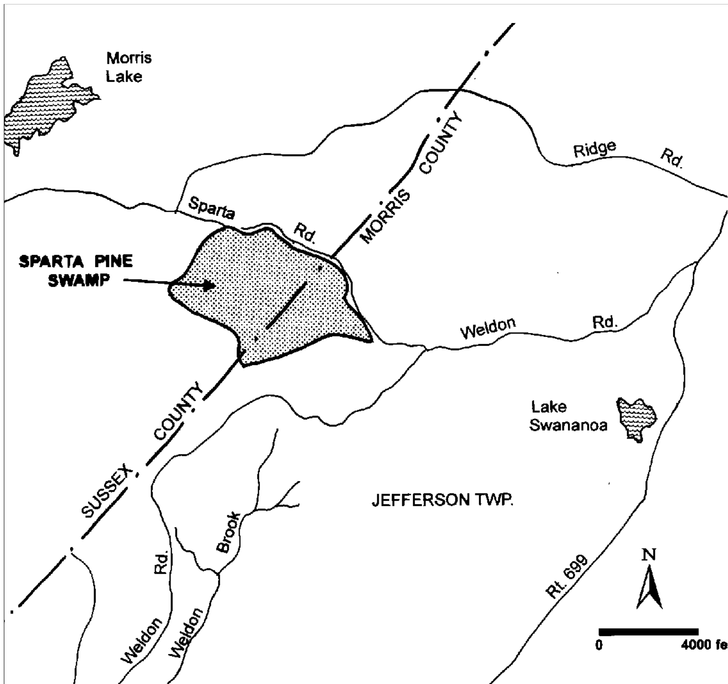


Figure 7 - Sparta Pine Swamp

Sparta Pine Swamp - (B3)

Habitat consists of a forested swamp with spruce dominant in places.
⬅

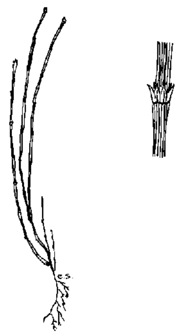
Species:
Hardwood-Conifer Swamp
Creeping Snowberry
Dwarf Mistletoe
Fernald's Meadow Grass
Rosy Twisted-Stalk

* Rosy Twisted-Stalk

Lincoln Park Gravel Pits - (B4)

Habitat consists of wetlands, and abandoned sand and gravel pits. ➜

Species:
Variegated Horsetail



* Variegated Horsetail

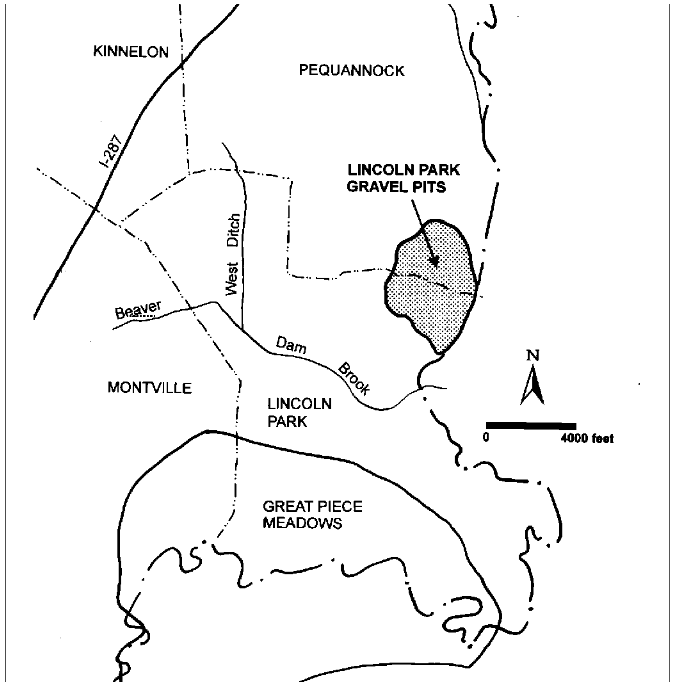


Figure 8 - Lincoln Park Gravel Pits

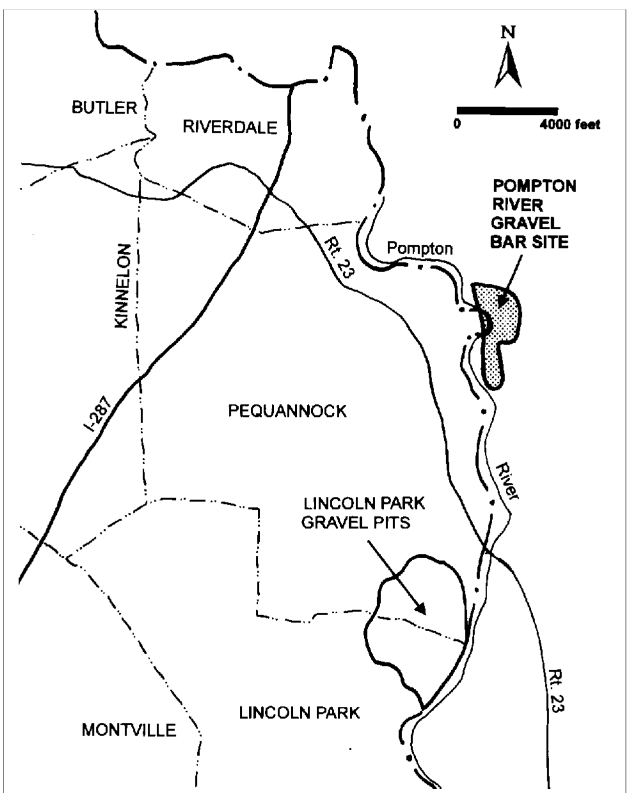


Figure 9 - Pompton River Gravel Bar

Pompton River Gravel Bar - (B5)

Habitat provided by rivershore lined by gravel bar. 🡐

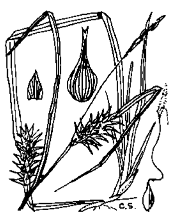
Species:
Hemicarpha

* Hemicarpha

Passaic Meadows - (B4) →

The wetlands complex, remnant of ancient glacial Lake Passaic, includes Troy Meadows and Great Piece Meadows. Vegetation consists of emergent marsh and forested swamp.

Species:
Low Spearwort



* Louisiana Sedge

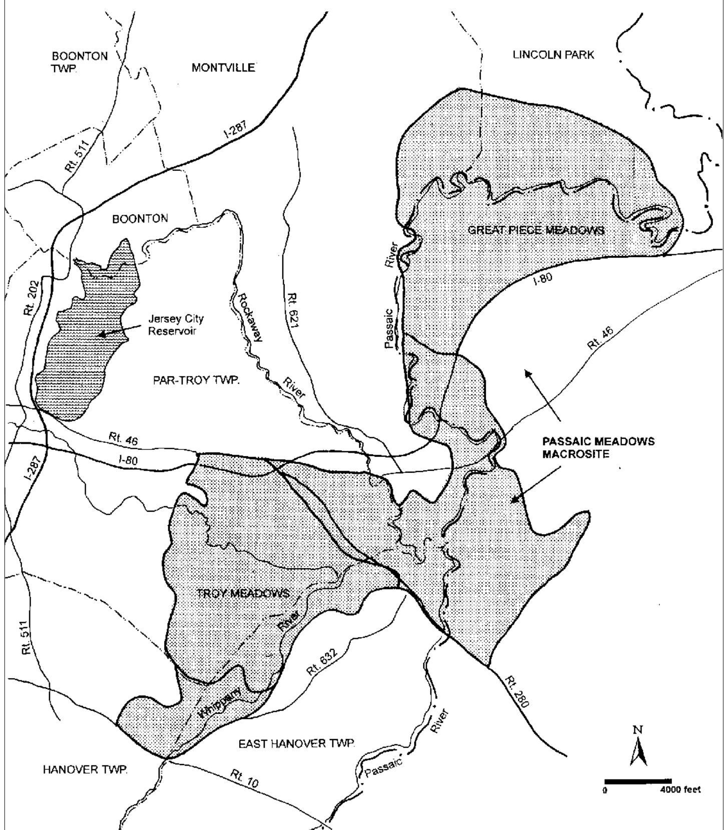


Figure 10 - Passaic Meadows

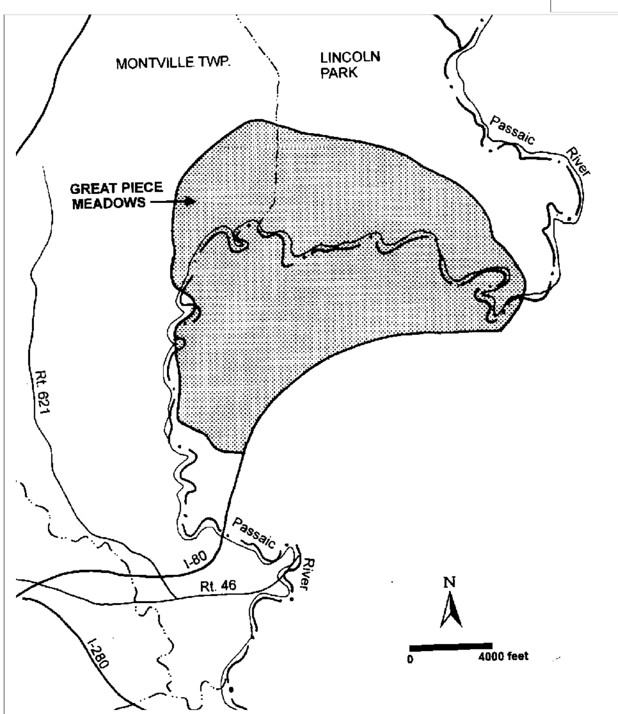


Figure 11 - Great Piece Meadows

Great Piece Meadows - (B4)

Varied wetland habitats including forested, scrub-shrub, and emergent areas.

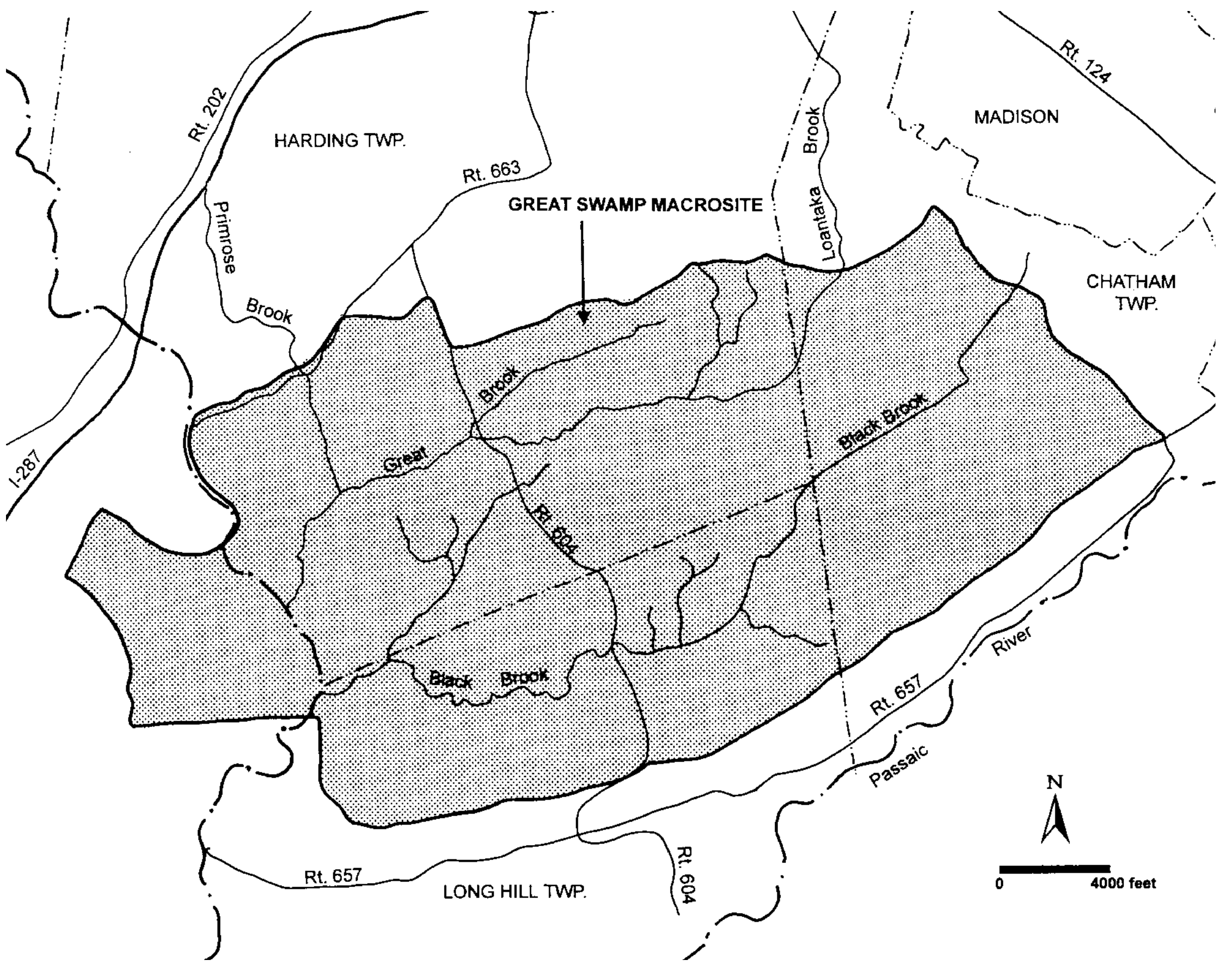
←

Species:
Button-Bush Dodder
Cat-Tail Sedge
Louisiana Sedge

Great Swamp - (B4)

The Great Swamp site, which resides where ancient glacial Lake Passaic once was, is ringed by hardwood covered ridges (mesic mixed oak forests) which transition into wooded and then emergent meadows, marsh, shrub and forested swamp. Changing land uses have correlated with regional "progress." Draining, clearing, farming, deforestation, expanding impervious surfaces, runoff, siltation, and nutrient loadings have all impacted water quality as well as hydrology. The result has been a mesic environment in some areas and inundated conditions in others. Home to hundreds of species (Appendix B), the Great Swamp also serves as habitat to threatened and endangered species of which the flora is listed below.

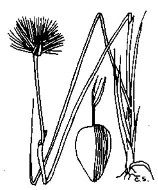
<u>Species</u>:
Downy Phlox
Featherfoil
Virginia Bunchflower



Mount Hope Bog - (B5)

This site is a glacial kettlehole bog, surrounded by a mixed hardwood /conifer swamp. It contains an example of a state imperiled wetland natural community and a state endangered plant species. ➜

Glacial Bog
Species:
Pale Laurel
Sheathed Cottongrass



* Sheathed Cottongrass

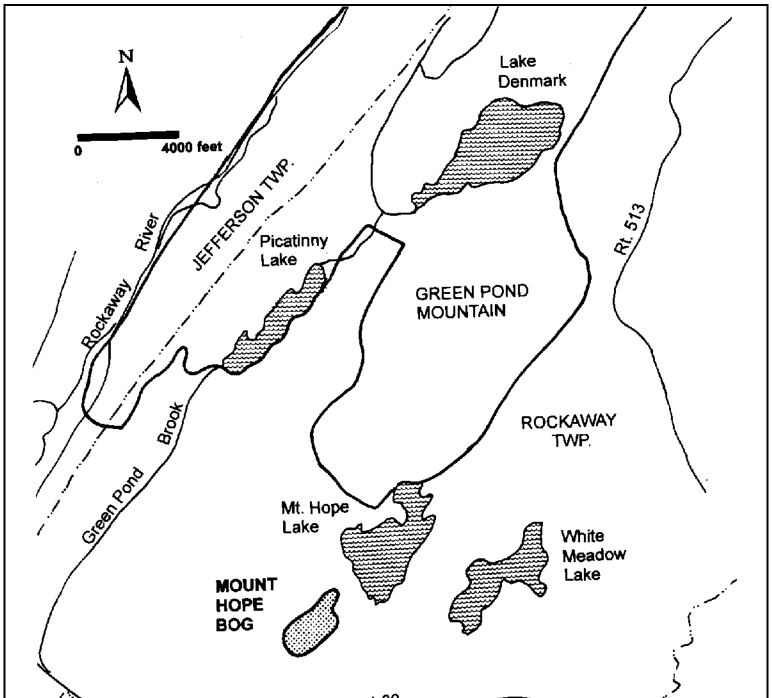


Figure 12 - Mount Hope Bog

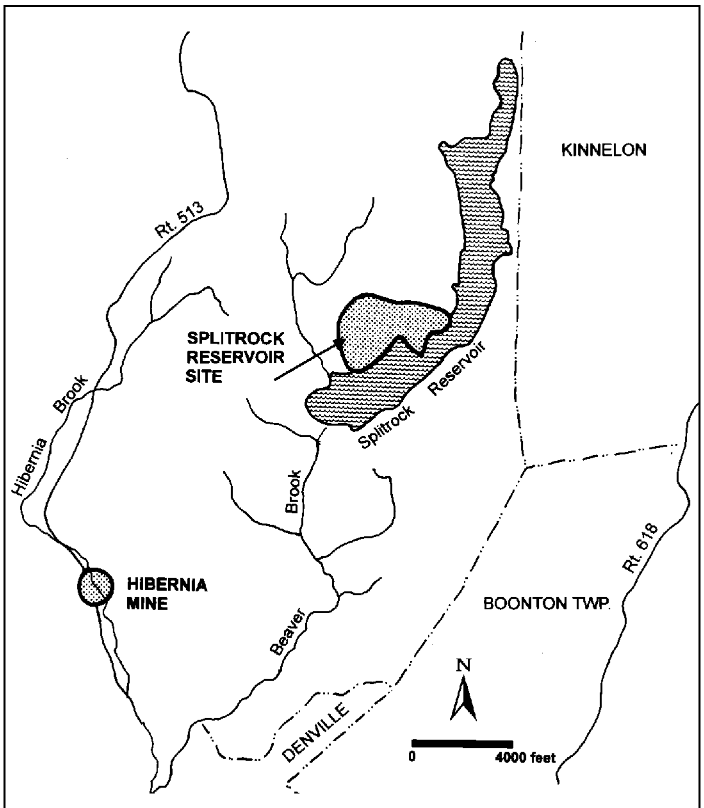


Figure 13 - Splitrock Reservoir

Splitrock Reservoir - (B5)

Habitat offers deciduous forests, steep, rocky slopes, and intermittent streams. 🡐

Species:
Three Birds Orchid

* Three Birds Orchid

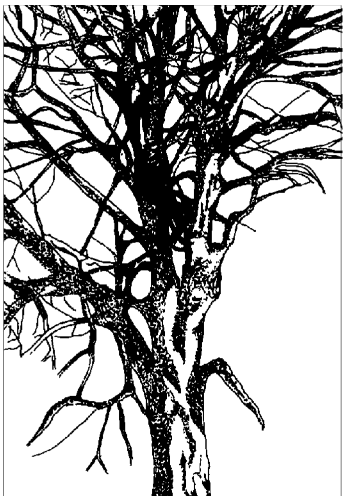
Noteworthy Trees

Morris County hosts several specimen trees which have been documented in various sources including local and regional natural resource inventories and NJDEP's New Jersey's Biggest Trees. These trees have been recognized for their size, age, and historical significance. Although most of our forested areas are second and third growth, scattered examples of old growth, and individual specimens remain.

STANDS:

Hemlock and Red Oak Forest (Proposed route of the Mount Hope Pumped Storage Power Facility transmission line) estimated to be at least 250 years old.

INDIVIDUALS:



American Beech (Madison) estimated to be 350 years old.

American Sycamore (Drew University, Madison)

Ash, Black (Hacklebarney State Park, Washington Twp.)

Birch, Yellow (Jefferson Twp.)

The Butternut Tree (Kinnelon)

Hercules-Club (Chester Twp.)

Hickory, Shagbark (Jefferson)

Hophornbeam, Eastern (Jefferson Twp.)

Maple, Norway (Jefferson Twp.)

White Oak (a.k.a. Walter Kinney Oak, Harding)

Oak, Shingle (Morris Twp.)

White Walnut (Washington Twp.)

Management Considerations

Vegetation management necessitates consideration of the entire habitat. For species to survive and thrive, specific components constituting a habitat need to be present in adequate quantity and quality (e.g., climate, hydrology, appropriate soils and species diversity). **Appendix C** provides a representation of floral species diversity within the County.

Impacts From Natural Hazards

- **Biological** impacts have been profound. The chestnut blight fungus resulted in the near annihilation of the chestnut tree population, except for the short-lived saplings. Equally devastating was the obliteration of Elm trees by the transmission of Dutch Elm disease fungus from the Elm bark beetle. The gypsy moth, canker worm, leaf roller, locust, Hemlock Wooly Adelgid and cicada have all engaged in foliage binges, often devastating entire stands. The most recent assault (September 1996) has been from the Asian long-horned beetle. This large bug has a voracious appetite for maples, chestnuts and poplars, making half of NJ's two million street trees particularly vulnerable.[3]

- Larger **animals** such as beaver and deer have altered plant communities. Beavers' den and dam building activities have impacted drainage, and consequently hydrology, resulting in swamp and pond creation. Hydrophobic vegetation died out and were replaced by water-tolerant species. Conversely, lodges served as foundations for hummock formation enabling mesic vegetation to gain a stronghold.

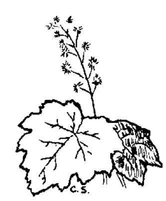
- The current **deer** dilemma demonstrates the impact of human encroachment on habitat. We frequently experience deer displacement by way of consumption of ornamental vegetation. Equally dramatic is the damage exacted by deer on forest understory, resulting in destruction of entire populations of new growth. Consequences in terms of future woodlands soundness, measured by degree of species and age diversity, are dire.

- **Environmental stresses** tend to have a cumulative effect rendering trees more susceptible to insect and pathogen infestations. It is believed that the dogwood decline was caused by a combination of acid rain, drought, and extreme winter weather.

Human Derived Impacts

The advent and progress of man brought sweeping changes to the landscape, many of which contributed to the diversity in vegetation we see today.

- **Farming** practices effected mechanical and chemical alterations. Land was clearcut, treated with fertilizers and pesticides, planted with monocultures, and inhabited by herds of hooved creatures.



* Foam Flower

[3] Kit R. Roane, "Knocking on the Door: A Tree-Eating Beetle That Will Stay for Dinner," The New York Times, Nov. 1996. Pg. 9.

- **Timbering** practices impacted plant communities by favoring shade-tolerant species such as the sugar maple. Fire, on the other hand, destroyed understory plants and groundcovers, supporting the growth of sun-loving plants. Both cutting and burning created openings enabling sunlight to reach the forest floor. This new profusion of light encouraged the production of oak, hickory and tulip seedlings. An undisturbed mature forest would tend to support shade tolerant sugar maple, hemlock, yellow birch, sweet birch, beech, hophornbeam, and dogwood.

- **Landscaping** practices have involved the introduction of exotic species, often leading to the crowding out of native species. Examples of species which have become invasive in character include:

Amur Honeysuckle	Black Swallowwort	Fly Honeysuckle	Norway Maple
Autumn Olive	Common Buckthorn	Garlic Mustard	Porcelain Berry
Bachelor Buttons	Common Reed Grass	Japanese Barberry	Purple Loosestrife
Bell's Honeysuckle	Crown Vetch	Japanese Honeysuckle	Russian Olive
Black Locust	Curly Pondweed	Japanese Knotweed	Tree of Heaven
	Eurasian Water Milfoil	Multiflora Rose	Water Chestnut

- **Hydrological fluctuations**, resulting from natural as well as human sources, can cause profound changes in resident vegetation. Flooding, for example, fills soil pore spaces, hindering the necessary soil-air exchange, and making plants vulnerable to insects and disease. A good illustration of the effects of hydrological fluctuations is evident in the Great Swamp where the invasive phragmites and arrow arum have crowded out sensitive natives such as wild millet, sedges, and smartweed.
- **Urbanization** effects changes on the soil, which is compacted by construction. The necessary soil-air-exchange is prevented, stifling good root growth and threatening viability and longevity.

Regulatory Support

FEDERAL

- **The Endangered Species Act** affirms conservation of "critical habitats" to protect threatened and endangered species**.**
- **Executive Order 13112** serves to control invasive species and their impact on economic, ecological, and human health.

STATE

- **Natural Areas System** protects ecologically significant areas. "Lands ... may not be sold, leased, exchanged or altered in any way without the approval of the DEPE. Although boundary revisions are possible, only legislation may remove an area from the System."[4]
- **NJ Freshwater Wetlands Protection Act** preserves freshwater wetlands from disturbance.

[4]New Jersey Natural Areas, NJ DEPE, Office of Natural Lands Management, brochure.

- The **NJ Landscape Project**, instituted by the NJ DEP's Division of Fish, Game and Wildlife, strives to provide protection to rare species and their habitat, via data gathering and dissemination. The Project focuses on specific land units or Landscape Protection Areas, which are defined by "existing public lands, physiographic boundaries and regions of high biodiversity."[5] Regional in design, the program strives to provide defensible information to regulators, land managers and planners.
- **Forest Stewardship Program** promotes management of private woodlands to benefit wildlife, recreation, aesthetics, water quality, and also timber and wood production. The program offers long-term, comprehensive management for landowners of 5-1000 acres of non-industrial private forest.

Planning Strategies

Plant habitat protection strategies often parallel those for wildlife; they include:

- Maintaining large patches of native vegetation to prevent fragmentation (breaking up of contiguous parcels)
- Rank and prioritize species identified for protection; provide habitat requirements accordingly
- Guiding development activities away from wetlands, riparian zones, ledges, or mature forests
- Maintain and manage significant ecological processes (e.g., floods, fire) in protected areas
- Map habitat of sensitive species; provide protection through local conservation plan

Design Strategies

Some key components constituting a habitat:

- Climate suitability
- Diversity
- Risks from pest, disease, or urbanization
- Tendency to invade
- Sustainability
- Exotic vs. Native (exotics may be invasive & have no support value for native wildlife)
- Regional & Microclimate Conditions:
  - ❦ vegetation
  - ❦ topography
  - ❦ intended use
  - ❦ grouping of plants by water needs
  - ❦ soil analysis
  - ❦ wind direction
  - ❦ sun exposure

* Virginia Snakeroot

Zoning and Site Plan Ordinances

- Special Overlay District that protects habitat by providing
  - ❦ protection of vegetative cover, including trees
  - ❦ setbacks from sensitive areas such as wetlands and streams
  - ❦ avoidance of critical habitat
- Habitat Protection Zone: prevent traffic-intensive or people-intensive activities
- River Corridor Performance Standards
- Vegetation Management: regulate cutting of trees or vegetation known to be sensitive habitat; control types of vegetation removed or planted
- Tree Removal and Protection Ordinance (Ten Town Great Swamp Watershed Committee "Draft Model Environmental Ordinances," 1997.

---

[5] Jeanette Bowers-Altman, "New Jersey's Landscape Project," Nongame News (NJ DEP, 1994) 7.

- Construction Activity Controls
  - ❦ prevention of accidental cutting of trees or vegetation
  - ❦ restriction on excavation near roots or root masses
  - ❦ limitations on severe grade changes near sensitive habitat

Practices

- **Exotic Vegetation Management Volunteer Program** (Morris County Park Commission) is designed to train volunteers in both exotic and native plant identification, and forest restoration.

- **Landscaping Ordinance -** Sustainability in Landscaping Ordinance (Irvine, California), developed in 1991. This ordinance targets new development design and retrofits existing ones. Landscape strategies incorporate more shrubbery, less turf, and carefully selected and placed trees, resulting in a diverse urban forest. Policy goals and recommendations include water and energy conservation, improvement of the soil, and reduction of green waste.

- **Conservation Landscaping** (described in the Soils Chapter) can take on many forms and provides multiple benefits as described below.

  ❦ **Vegetative filter strips** (grass, trees or shrubs) filter stormwater runoff, enhance groundwater recharge, support wildlife habitat by providing food, cover and corridors for movement, and contribute aesthetically (e.g., McCarter Park, Denville Streamside Restoration Project).
  ❦ **Riparian forest buffer** (trees and other vegetation) located adjacent to surface water bodies, intercept and remove or reduce nutrients from surface runoff, wastewater, subsurface flows. Aesthetics, air purification, climate modification and habitat enhancement are additional benefits. Examples of appropriate vegetation include Silky and Red Stem Dogwood, Purpleosier, Pussy Willow and Bankers Dwarf (e.g., Beaver Brook Restoration Project).
  ❦ **Urban forestry** (trees and vegetation within an urban area such as street trees, parks, and private lands) help to reduce the velocity of stormwater runoff remove sediments, nutrients, and chemicals from surface runoff, provide habitat for wildlife, corridors for wildlife movement, air purification, climate modification, noise reduction and aesthetics (e.g., Center Street, Morristown Streamside Restoration Project).
  ❦ **Xeriscaping** utilizes drought tolerant plant material for the purpose of water conservation. Wildlife are also served through increased habitat. Examples of suitable species include:

Annuals:	**Perennials:**	**Shrubs**
Aster	Artemisia	Adams Needle
Bearberry	Candytuft	American Holly
Blanket Flower	Chrysanthemum	Anthony Water Spirea
Celosia	Clematis	Chaste Tree
Cleome	Columbine	Dense Yew
Geranium	Coneflower	Glossy Abelia
Immortelle	Coreopsis	Japanese Holly
Marigold	Crocus	Mugo Pine
Nasturtium	Daffodils	Wintergreen Barberry
Portulaca	Daisies	
	Daylilies	


* Robbin's Pondweed

Evergreen	**Small Trees**	**Shade Trees**
Amur Maple	Atlas Cedar	Amur Cork Tree
Blackhaw Viburnum	Douglas Fir	Common Hackberry
Common Witchhazel	Japanese Black Pine	Ginkgo
Crabapples	Pfitzer Juniper	Green Ash
Goldenraintree	Red Cedar	Japanese Pagodatree
Gray Birch	Scotch Pine	Japanese Zelkova
Japanese Tree Lilac	Spruces	Pin Oak
Mimosa	White Fir	Red Maple
Shadlow Serviceberry	White Pine	Red Oak
		Scarlet Oak
		White Ash
		White Oak

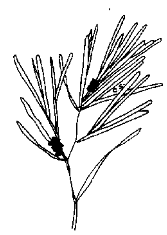
❦ **Wildlife habitat landscaping** utilizes plant material beneficial to wildlife for food, nesting or cover. Examples of suitable species include:

Evergreens:	Deciduous Shrubs:	Evergreen Shrubs:
Arborvitae	Flowering Almond	Azalea
Columnar Juniper	Neigela	Barberry
Hinoki False Cypress	Spirea	Chinese Holly
Spruce		Cotoneaster
White Pine		

Education and Outreach

- BayScapes is an example of an environmental education initiative developed by the Alliance for the Chesapeake Bay, Inc., for the purpose of promoting pollution prevention. Emphasis is on utilizing landscaping to achieve the following 5 principles:
  - ❦ Conservation landscaping
  - ❦ Conserve water
  - ❦ Create diversity
  - ❦ Use beneficial plants
  - ❦ Long term planning

- Educating private landowners on existence of threatened and endangered species and associated voluntary conservation measures



* Obtuse-Leaved Pondweed

Glossary

COMMUNITY all the plant and animal populations occupying a given area.

ECOSYSTEM includes all components, living and not, of an environment**.**

ENDANGERED SPECIES one "whose prospects for survival in New Jersey are in immediate danger because of a loss or change of habitat, over-exploitation, predation, competition or disease. Immediate assistance is needed to prevent extinction." [6]

FRAGMENTATION "breaking up of continuous areas of habitat into smaller parcels."[7]

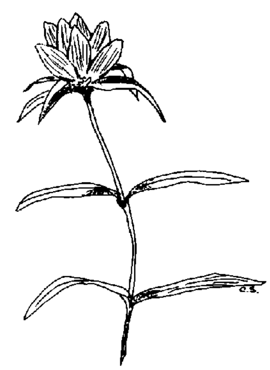
HABITAT all the "physical features and biological characteristics needed to provide food and shelter for wildlife."[8]

LANDSCAPE "a large land area that contains habitat for wildlife."[9]

SPECIES DIVERSITY richness and abundance of a species in a given area.

TAXA plural of taxon, a group of organisms sharing common characteristics in varying degrees of distinction that constitute one of the categories in taxonomic classification, such as a phylum, order family, genus, or species.[10]

THREATENED SPECIES one which "may become endangered if conditions surrounding the species begin or continue to deteriorate." [11]



Narrow-Leaved Gentian

---

[6] NJ DEP. Division of Fish, Game and Wildlife. New Jersey is for Wildlife.

[7] Habitat Protection Planning.

[8] Christopher J. Duerksen and others, American Planning Association, Habitat Protection Planning, Where the Wild things Are, PAS 470/471, May 1997.

[9] Habitat Protection Planning.

[10] Webster's II New Riverside University Dictionary, The Riverside Publishing Company, 1984.

[11] New Jersey is for Wildlife.

Appendix A

Morris County Area Rare Species and Natural Communities

Codes Used In Natural Heritage Reports

FEDERAL STATUS CODES

The following categories and definitions of endangered and threatened plants and animals have been modified from the U.S. Fish and Wildlife Service (F.R. Vol. 50 No. 188; Vol. 61, No. 40; F.R. 50 CFR 17).

LT: Taxa formally listed as threatened.

STATE STATUS CODES:

E: Indicates taxa listed as endangered on New Jersey's official Endangered Plant Species List N.J.A.C. 7:5C-1.1.).

GLOBAL ELEMENT RANKS:

G1: Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

G2: Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3: Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range; with the number of occurrences in the range of 21 to 100.

G4: Apparently secure globally; although may be quite rare in parts of its range, especially at the periphery.

G5: Demonstrably secure globally; although it may be quite rare in parts of its range, especially at the periphery.

G?: Species has not yet been ranked.

Q: Taxon is of questionable, or uncertain taxonomical standing.

T: Infraspecific taxon is ranked differently than the full species.

STATE ELEMENT RANKS (Specific to New Jersey):

S1: Critically imperiled in New Jersey because of extreme rarity (5 or fewer occurrences or very few remaining individuals or access). Species so ranked are often restricted to an extremely small (3%) geographical area of the state. Also included are species which were formerly more abundant, but because of habitat destruct or some other critical factor of its biology, they have been demonstrably reduced in abundance. In essence, these are species for which, even with intensive searching, sizable addition occurrences are unlikely to be discovered.

S2: Imperiled because of rarity (6 to 20 occurrences), due primarily to habitat destruction.

S3: Rare with 21 to 100 occurrences (plant species in this category have only 21 to 50 occurrences). Includes elements which are widely distributed in the state but often occurring in small populations, and also in habitats which may be common or widespread. Species have moderately restricted distribution, but locally abundant. Not yet imperiled in state but may soon be if additional populations are destroyed.

SH: Species of historical occurrence. Despite some searching of historical occurrences and/or potential habitat, no extant occurrences are known. Since not all of the historical occurrences have been field surveyed, and unsearched potential habitat remains, historically ranked taxa are considered possibly extant, and remain a conservation priority for continued field work.

SU: Species believed to be in peril but the degree of rarity is uncertain. Also included are rare taxa of uncertain taxonomical standing. More information is needed to resolve rank.

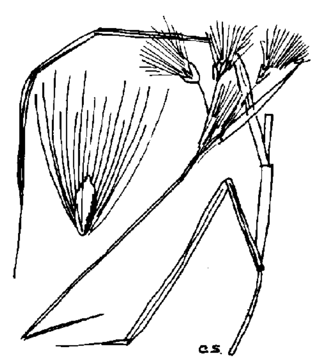
SX: Species that have been determined or are presumed to be extirpated from New Jersey. All historical occurrences have been searched (or are conclusively known to have been destroyed), and a reasonable search of potential habitat has been completed. Extirpated taxa are not a current conservation priority.

.1: Species documented from a single location.

Note: To express uncertainty, the most likely rank is assigned and a question mark added (e.g., G2?). A range is indicated by combining two ranks (e.g., G1G2, S1S3).

"Treat the earth well, it was not given to you by your parents, it was loaned to you by your children."

Kenyan Proverb



* Rough Cottongrass

Morris County Area Rare Species and Natural Communities Presently Recorded in the New Jersey Natural Heritage Database

NAME	COMMON NAME	FEDERAL STATUS	STATE STATUS	GRANK	SRANK
Adlumia Fungosa	Allegheny-Vine	-	-	G4	S2
Andromeda Glaucophylla	Bog Rosemary -	E	G5	S1	
Angelica Venenosa	Hairy Angelica -	-	G5	S2	
Aristolochia Serpentaria	Virginia Snakeroot -	-	G5	S3	
Asplenium Bradleyi	Bradley's Spleenwort	-	E	G4	S1
Asplenium Montanum	Mountain Spleenwort	-	-	G5	S2
Aster Radula	Low Rough Aster	-	E	G5	S1
Botrychium Multifidum	Leathery Grape-Fern	-	E	G5	S1
Botrychium Oneidense	Blunt-Lobed Grape-Fern	-	-	G4	S2
Calystegia Spithamaea	Erect Bindweed	-	E	G4G5	S1
Cardamine Douglassii	Purple Cress	-	-	G5	S2
C. Pratensis Var. Palustris	Cuckoo Flower -	-	G5T5	S3	
Carex Brunnescens	Brownish Sedge	-	E	G5	S1
Carex Disperma	Soft-Leaved Sedge -	-	G5	S2	
Carex Foenea	Dry-spiked sedge	-	E	G5	S1
Carex Haydenii	Cloud Sedge	-	E	G5	S1
Carex Leptonervia	Finely-Nerved Sedge	-	E	G4	S1
Carex Limosa	Mud Sedge	-	E	G5	S1
Carex Louisianica	Louisiana Sedge	-	E	G5	S1.1
Carex Polymorpha	Variable Sedge -	E	G2G3	S1	
Carex Rostrata	Beaked Sedge	-	-	G5	S2
Carex Typhina	Cat-Tail Sedge -	-	G5	S3	
Castilleja Coccinea	Scarlet Indian Paintbrush	-	-	G5	S2
Cercis Canadensis	Redbud	-	E	G5	S1
Clematis Occidentalis	Purple Clematis	-	-	G5	S2
Cuscuta Cephalanthi	Button-Bush Dodder	-	E	G5	S1
Dirca Palustris	Leatherwood	-	-	G4	S2
Equisetum Pratense	Meadow Horsetail -	E	G5	S1	
Equisetum Variegatum	Variegated Horsetail	-	E	G5	S1
Eriophorum Gracile	Slender Cottongrass -	E	G5	SH	
Eriophorum Tenellum	Rough Cottongrass -	E	G5	S1	
E. Vaginatum Var Spissum	Sheathed Cottongrass	-	E	G5T5	SH.1
Glyceria Grandis	American Mannagrass	-	E	G5	S1
Gnaphalium Macounii	Clammy Everlasting	-	E	G5	SH
Gymnocarpium Dryopteris	Oak Fern	-	-	G5	S2
Helonias Bullata	Swamp-Pink	-	E	G3	S3
Hemicarpha Micrantha	Hemicarpha	-	E	G4	S1
Hieracium Kalmii	Canada Hawkweed -	E	G5	SH	
Hottonia Inflata	Featherfoil	-	E	G4	S1
Ilex Montana	Mountain Holly	-	E	G5	S1
Kalmia Polifolia	Pale Laurel	-	E	G5	S1
Ledum Groenlandicum	Labrador Tea	-	-	G5	SX.1
Lemna Trisulca	Star Duckweed -	-	G5	S2	
Lilium Philadelphicum	Wood Lily	-	-	G5	S3
Lobelia Dortmanna	Water Lobelia -	E	G4	SH	
Lupinus Perennis	Wild Lupine	-	-	G5	S3

NAME	COMMON NAME	FEDERAL STATUS	STATE STATUS	GRANK	SRANK
Lycopodium Annotinum	Stiff Clubmoss -	E	G5	S1	
Lycopodium Inundatum	Northern Bog Clubmoss	-	-	G5	S2
Lysimachia Thyrsiflora	Tufted Loosestrife	-	-	G5	S3
Melanthium Virginicum	Virginia Bunchflower	-	E	G5	S1
Milium Effusum	Tall Millet Grass	-	E	G5	SH
Myriophyllum Verticillatum	Whorled Water-Milfoil	-	E	G5	SH
Nuphar Microphyllum	Small Yellow Pond Lily	-	E	G5	SH
Nymphoides Cordata	Floating Heart -	-	G5	S3	
Obolaria Virginica	Virginia Pennywort -	-	G5	S2	
Panicum Boreale	Northern Panic Grass	-	E	G5	S1
Phlox Pilosa	Downy Phlox	-	E	G5	SH
Platanthera Hookeri	Hooker's Orchid	-	E	G5	S1
Platanthera Psycodes	Purple-Fringed Orchid	-	-	G5	S3
Potamogeton Alpinus	Northern Pondweed -	E	G5	S1	
Potamogeton Illinoensis	Illinois Pondweed	-	E	G5	S1
Potamogeton Obtusifolius	Obtuse-Leaved Pondweed	-	E	G5	S1
Potamogeton Robbinsii	Robbin's Pondweed -	E	G5	S2	
Potamogeton Zosteriformis	Flat-stemmed Pondweed	-	E	G5	S1
Potentilla Arguta	Tall Cinquefoil -	-	G5	S3	
Potentilla Palustris	Marsh Cinquefoil	-	E	G5	S1
Prenanthes Racemosa	Smooth Rattlesnake Root	-	E	G5	SH
Prunus Alleghaniensis	Alleghany	-	E	G4	S1
Prunus Pumila Var Depressa	Low Sand Cherry	-	-	G5T5	S2
Pycnanthemum Torrei	Torrey's Mountain Mint	-	E	G2	S1
Ranunculus Fascicularis	Early Buttercup	-	E	G5	S1
Ranunculus Pusillus	Low Spearwort -	-	G5	S2	
Rhododendron Canadense	Rhodora	-	E	G5	S1
Salix Lucida	Shining Willow	-	-	G5	S2
Salix Pedicellaris	Bog Willow	-	E	G5	S1
Scheuchzeria Palustris	Arrow-Grass	-	E	G5	SH
Smilacina Trifolia	3-Leaved Solomon's-Seal	-	E	G5	S1
Solidago Rigida	Stiff Goldenrod -	E	G5	S1	
Sparganium Angustifolium	Narrow-leaved Bur-reed	-	E	G5	SH
Sparganium Minimum	Small Bur-reed -	E	G5	S1	
Sporobolus Neglectus	Puff-Sheathed Dropseed	-	E	G5	S1
Streptopus Roseus	Rosy Twisted-Stalk -	E	G5	S1	
Tiarella Cordifolia	Foamflower	-	E	G5	S1
Triadenum Fraseri	Fraser's St. John's-Wort	-	-	G4G5	S3
Triphora Trianthophora	Three Birds Orchid -	E	G4	S1	
Trollius Laxus SSP Laxus	Spreading Globe Flower	-	E	G4T3Q	S1
Utricularia Intermedia	Flat-Leaved Bladderwort	-	-	G5	S3
Utricularia Purpurea	Purple Bladderwort -	-	G5	S1	
Verbena Simplex	Narrow-Leaved Vervain	-	E	G5	SH
Viola Canadensis	Canada Violet -	E	G5	S1	
Viola Incognita	Large-leaved White Violet	-	-	G5	S3
Black Spruce Swamp	Black Spruce Swamp	-	-	G4	S1
Glacial Bog	Glacial Bog	-	-	G4?	S1
Hardwood-Conifer Swamp	Hardwood-Conifer Swamp	-	-	G4?	S2S3

Appendix B

Vegetation In The Great Swamp

Palustrine Forested Trees/Shrubs:

Alder	Cedar, Red	Maple, Red	Poplar, Tulip
Ash, White	Gum, Black	Oak, pin	Rose, Swamp
Azalea	Gum, Sweet	Oak, Swamp White	Willow
High-bush blueberry			

Terrestrial Forested Trees/Shrubs:

Beech	Gum, Black	Mountain Laurel	Oaks
Birch, Gray	Hickory, Shagbark	Maple, Sugar	Rhododendron

Herbs

Agrimony	Bur-reed	Indian Hemp	Mountain-mint
Anemone, Rue	Butter-and-eggs	Indian Tobacco	Mullien
Anemone, Wood	Buttercup	Iris	Mullien, Moth
Arrowhead	Buttercup, Swamp	Iris, Blue Flag	Multiflora Rose
Aster,Small-flowered	Buttercup,Creeping	Iris, Slender	Orchid, Fringed
Aster,White Wood	Butterfly Weed	Ironweed	Partridgeberry
Aster, Calico	Buttonbush	Jack-in-the-pulpit	Pepperbush
Aster, Heath	Campion, White	Jerusalem Artichoke	Periwinkle
Aster, New England	Canada Lily	Jewelweed	Phlox
Aster, Purple-stemmed	Cardinal Flower	Joe-Pye Weed	Pickerelweed
Aster, Smooth	Celandine	King Devil	Pinxter Flower
Aster, Tradescant's	Chicory	Knapweed	Plantain, English
Azalea, Flame	Gerardia, White	Ladies'Tresses,Grsslvd	Plantain, Rattlesnake
Bartonia	Ginger	Lady's Slipper	Plantain, Water
Beardtongue	Ginseng	Laurel	Pokeweed
Bedstraw	Goatsbeard	Lily-of-the-valley	Purple Dead Nettle
Beggar Ticks	Golden Alexander	Lizard's Tail	Pussytoes
Bellwort	Golden Ragwort	Lobelia, Spiked	Queen Anne's Lace
Bergamot	Goldenrod, Canada	Loosestrife	Rattlesnake Root
Bindweed	Goldenrod, Early	Loosestrife, Fringed	St. Johnswort
Birdsfoot Trefoil	Goldenrod,Grassleaved	Loosestrife,Whorled	Sarsaparilla
Bittersweet	Gldnrd,Roughstemmed	Mallow	Saxifrage
Blackberry	Goldenrod, Tall	Mallow, Musk	Scarlet Pimpernel
Black-eyed Susan	Goldenrod, Broadleavd	Marsh Marigold	Seedbox
Bladderwort	Ground Ivy	Mayapple	Selfheal
Blazing Star	Hawkweed	Meadow Rue	Shadbush
Bloodroot	Hellebore, False	Meadowsweet	Silver-rod
Bluebell	Hempweed	Milkweed	Skullcap, Mad-dog
Blueberry	Hepatica	Milkweed	Skullcap, Marsh
Blue-eyed, Grass	Honeysuckle, Swamp	Milkweed, Swamp	Skunk Cabbage
Boneset	Honeysuckle, Japanese	Milkwort	Smartweed
Bouncing Bet	Hop Clover	Mint	Sneezeweed
Bugleweed	HopClover,Smaller	Moneywort	Solomon's Seal
Burdock	Indian Pipe	Monkey flower	Solomon's Seal,False

Sow Thistle
Spatterdock
Spiderwort
Spotted Joe-PyeWeed
Spring Beauty
Starflower
Stargrass
Star-of-Bethlehem
Steeplebush
Strwbrry Sundrops, Sm
Sundrops, Small
Sunflower, Giant
Swamp Candles
Swamp Rose
Sweet Cicely
Sweet Clover
Tansy
Teasel
Thistle, Bull
Thistle, Field
Thistle, Canada
Thistle, Pasture
Tick Trefoil
Tick Trefoil, Panicled
Trailing Arbutus
Trillium
Trout Lily
Turk's-cap Lily
Turtlehead
Venus' Looking-glass
Vetch
Vervain
Viburnum
Violet
Violet, Arrow-leaved
Violet, Lance-leaved
Violet,Marsh Blue
Violet, Northern White
Viper's Bugloss
Water Arum
Water Hemlock
Water-horehound
White Snakeroot
Wild Indigo
Winter Cress
Wintergreen
Witch Hazel
Wood Betony
Wood Sorrel
Woundwort
Yarrow

Bog Laurel

Appendix C
Floral Species In Morris County

Scientific Name	Common Name
Acer negundo	Box Elder
Acer platanoides	Norway Maple
Acer pseudoplatanus	Sycamore Maple
Acer rubrum	Red Maple (Scarlet Maple, Swamp Maple)
Acer saccharinum	Silver Maple
Acer saccharum	Sugar Maple (Hard Maple, Rock Maple
Achillea millefolium	Yarrow
Actaea alba	White Baneberry
Actaea pachypoda	White Baneberry
Acorus calamus	Sweet Flag
Adiantum pedatum	Maidenhair Fern
Adlumia fungosa	Allegheny Vine
Aeshna clepsydra	Mottled Darner
Aeshna mutata	Spatterdock Darner
Aeshna tuberculifera	Black-Tipped Darner
Agrimonia parviflora	Agrimony
Aiisma subcordatum	Water Plantain
Ailanthus altissima	Ailanthus
Alium tricoccum	Wild Leek
Allium canadense	Wild onion grass
Allium vineale	Field Garlic
Alliaria officinalis	Garlic Mustard
Alliaria petiolata	Garlic Mustard
Alnus rugosa	Speckled Alder
Alnus serrulata	Smooth Alder
Amaranthus retroflexus	Green Amarath
Ambrosia artemisiifolia	Common Ragweed
Amelanchier sp.	Roundleaf Serviceberry (Shore Shadbush)
Amelanchier arborea	Downy juneberry
Amelanchier canadensis	Shadbush (Serviceberry, Juneberry)
Amelanchier laevis	Smooth Juneberry
Amelanchier sanguinea	Roundleaf Juneberry
Anagallis arvensis	Scarlet Pimpernel
Analia nudicaulis	Wild Sarsaparilla
Anaphalis margaritacea	Pearly Everlasting
Andromeda glaucophylla	Bog Rosemary
Anemone quinquefolia	Wood Anemone
Anemone virginiana	Thimbleweed
Anemonella thalictroides	Rue Anemone
Angelica venenosa	Hairy Angelica
Antemisia vulgaris	Mugwort
Antennaria neglecta	Pussytoes
Antennaria neodioica	Pussytoes
Anthemia cotula	Mayweed
Anthoxanthum odoratum	Sweet Vernal Grass
Apios americana	Groundnut
Apocynum androsaemifolium	Spreading Dogbane
Apocynum cannabium	Indian Hemp
Aquilegia canadensis	Columbine
Aralia hispida	Bristly Sarsaparilla
Aralia nudicaulis	Wild Sarsaparilla
Aralia racemosa	Spikenard
Aralia spinosa	Hercules-club
Arceuthobium pusillum	Dwarf Mistletoe
Arctium lappa	Great Burdock
Arctium minus	Burdock

Scientific Name	Common Name
Arigomphus furcifer	Lilypad Clubtail
Arisaema dracontium	Green-Dragon or Dragon-Root
Arisaema triphyllum	Jack-in-the-pulpit
Aristolochia serpentaria	Virginia Snakeroot
Arobis hirsuta	Hairy Rock cress
Aronia melanocarpa	Black Chokeberry
Asarum canadense	Wild Ginger
Asclepias exaltata	Poke Milkweed
Asclepias incarnata	Swamp Milkweed
Asclepias quadrifolia	Four-leaved Milkweed
Asclepias purpurascens	Milkweed
Asclepias syriaca	Common Milkweed
Asclepias tuberosa	Butterfly Weed
Asclepia syriaca	Common Milkweed
Asclepias tuberosa	Butterfly Weed
Asplenium bradleyi	Bradley's Spleenwort
Asplenium montanum	Mountain spleenwort
Asplenium platyneuron	Ebony Spleenwort
Aster divaricatus	White Wood Aster
Aster laevis	Smooth Aster
Aster lateriflorus	Calico Aster
Aster novae-angliae	New England Aster
Aster pilosus	Heath Aster
Aster puniceus	Purple-stemmed Aster
Aster radula	Low Rough Aster
Aster tradescanti	Tradescant's Aster
Aster vimineus	Small-flowered Aster
Athyrium felix femina	Lady Fern (Upland and Rubrum)
Athyrium thelypteroides	Slvery Athyrium, (Silvery Spleenwort)
Baptisia tinctoria	Wild Indigo
Barbarea vulgaris	Wintercress
Bartonia virginica	Bartonia
Berberis thunbergii	Japanese Barberry
Beteroa incana	Hoary Alussum
Betula alleghaniensis	Yellow Birch
Betula lenta	Sweet Birch (Black birch, Cherry birch)
Betula lutea	Yellow Birch
Betula nigra	River birch (or Red or Black)
Betula papyrifera	Paper birch
Betula populifolia	Gray Birch (Wire birch, White birch)
Bidens spp.	Tickseed-sunflower
Bidens aristosa	Beggar Ticks
Bidens frondosa	Beggar Ticks
Botrychium dissectum, var. obliquum	Grape Fern (Common Cut-leaved)
Botrychium dissectum,	Grape Fern, Cut-leaved var. typicum
Botrychium lanceolatum	Triangle Grape Fern
Botrychium multifidum	Leathery Grape Fern
Botrychium oneidense	Blunt-Lobed Gr.Fern
Botrychium simplex	Dwarf Grape Fern
Botrychium verginianum	Rattlesnake Gr.Fern
Brassica nigra, hirta, rapa etc.	Mustards
Byrum spp.	Thread mosses
Calamagrostis canadensis	Bluejoint
Calla palustris	Water Arum
Caltha palustris	Marsh Marigold (Cowslip)

Scientific Name	Common Name
Calystegia spithamaea	Erect Bindweed
Campanula divaricata	North Carolina Harebell
Campanula rapunculoides	Creeping Bellflower
Capsella bursa-pastoris	Shepherd's Purse
Cardamine douglassii	Purple Cress
Cardamine pratensis	Cuckoo Flower var palustris
Carex amphibola	Narrow-leaved Sedge
Carex brunnescens	Brownish Sedge
Carex deweyana	Dewey's sedge
Carex disperma	Soft-Leaved Sedge
Carex foenea	Dry-spiked sedge
Carex grayii	Gray's Sedge
Carex haydenii	Cloud Sedge
Carex jamesii	Nebraska sedge
Carex limosa	Mud Sedge
Carex louisianica	Louisiana Sedge
Carex paupercula	Bog Sedge
Carex pensylvanica	Pennsylvania Sedge
Carex polymorpha	Variable Sedge
Carex rosea	Stellate Sedge
Carex rostrata	Beaked Sedge
Carex stricta	Tussock Sedge
Carex typhina	Cat-Tail Sedge
Carpinus caroliniana	American Hornbeam (Blue Beech; Ironwood)
Carya spp	Hickory family
Carya cordiformis	Bitternut Hickory
Carya glabra	Pignut Hickory
Carya ovata	Shagbark Hickory
Cassia fasciculata	Partridge - Pea
Cassia nictitans	Wild Sensitive Plant
Castanea dentata	American Chestnut
Castilleja coccinea	Scarlet Indian Paintbrush
Caulophyllum thalictroides	Blue Cohosh
Celastrus scandens	Bittersweet
Celtis occidentalis	Hackberry (Sugarberry or Nettle tree)
Centaurea maculosa	Knapweed
Centaurea nigra	Black Knapweed
Cephalanthus occidentalis	Buttonbush
Cercis canadensis	Redbud
Chaerophyllum procumbens	Spreading Chervil
Chamaedaphne calyculata	Leatherleaf
Chelidonium majus	Celandine
Chenopodium album	Pigweed Lamb's Qrters
Chimaphila maculata	Spotted Wintergreen
Chimaphila umbellata	Pipsissewa
Chrysanthemum leucanthemum	Ox-eye Daisy
Chelone glabra	Turtlehead
Chimaphila maculata	Spotted Wintergreen (Pipsissewa Striped)
Cichorium intybus	Chicory
Cicuta maculata	Water Hemlock
Cirsium arvense	Canada Thistle
Cirsium discolor	Field Thistle
Cirsium pumilum	Pasture Thistle
Cirsium vulgare	Bull Thistle
Claytonia virginica	Spring Beauty
Clematis occidentalis	Purple Clematis
Clematis verticillairs	Mountain Clematis
Clematis sp.	Clematis
Clethra alniflora	Pepperbush

Scientific Name	Common Name
Climacium americanum	Tree Moss
Collinsonia canadensis	Horsebalm
Comandra umbellata	Bastard Toadflax
Commelina communis	Asiatic Dayflower
Commelina virginica	Dayflower (Spiderwort)
Comptonia peregrina	Sweet Fern
Conopholis americana	Squawroot
Convolvulus sepium	Bindweed
Conyza canadensis	Horseweed
Coptis groenlandica	Goldthread
Cordulegaster obliqua	Arrowhead Spiketail
Cornus alternifolia	Alternate-leaved Dogwood
Cornus amomum	Swamp (Silky) Dogwood
Cornus canadensis	Bunchberry
Cornus florida	Flowering Dogwood
Cornus racemosa	Gray Dogwood
Cornus stolonifera	Red-Osier Dogwood
Corydalis flavula	Corydalis
Corydalis sempervirens	Pale corydalis
Corylus americana	American Hazelnut
Crystopteris fragilis	Brittle Fern (Fragile Fern)
Cunila origanoides	Dittany
Cuscuta cephalanthi	Button-Bush Dodder
Cypripedium acaule	Stemless Lady's Slipper (Pink Ladyslipper, Moccasin Flower)
Cypridedidum orchid	Ladyslipper
Cypripedium reginae	Showy Ladyslipper
Cystopteris protrusa	Lowland Fragile Fern
Dactylis glomerata	Orchard Grass
Danthonia spicata	PovertyOatgrass
Daucus carota	Queen Anne's Lace (Wild Carrot)
Decodon verticillatus	Swamp Loosestrife
Dennstaedtia punctilobula	Hay-scented Fern
Dentaria diphylla	Toothwort
Deschampsia flexuosa	Hairgrass
Desmodium canadense	Tick Trefoil
Desmodium paniculatum	Tick Trefoil, Panicled
Dianthus armeria	Deptford Pink
Dicentra cucullaria	Dutchman's Breeches
Dicranum spp.	Rock mosses
Dicranum scoparium	Broom moss
Diervilla lonicera	Bush Honeysuckle
Digitaria sanguinalis	Large Crabgrass
Dimelaena oreina	Dimelaena
Dipsacus sylvestris	Teasel
Dirca palustris	Leatherwood
Dryopteris cristata	Crested Fern
Dryopteris marginalis	Marginal Wood Fern
Dryopteris noveboracensis	New York Fern
Dryopteris spinulosa	American Shield Fern (Spinulose Wood)
Echium vulgare	Viper's Bugloss
Elaeagnus umbellata	Autumn Olive
Eleocharis spp.	Spike-rush
Ellisia nyctelea	Nyctelea
Enallagma laterale	New England Bluet
Epigaea repens	Trailing Arbutus
Epifagus virginiana	Beechdrops
Equisetum pratense	Meadow Horsetail
Equisetum variegatum	Variegated Horsetail
Erigeron annuus	Fleabane
Erigeron canadensis	Horsewood
Erigeron philadephicus	Fleabane

Scientific Name	Common Name
Erigeron pulchellua	Robin Plantain
Eriophorum gracile	Slender Cottongrass
Eriophorum tenellum	Rough Cottongrass
Eriophorum vaginatum	Sheathed Cottongrass var spissum
Erythronium americanum	Trout Lily (Adder's Tongue)
Eupatorium aubium	Joe-Pye-Weed
Eupatorium dubium	Joe-Pye Weed
Eupatorium maculatum	Spotted Joe-PyeWeed
Eupatorium perfoliatum	Boneset
Eupatorium rugosum	White Snakeroot
Eupatorium sessilifolium	White Snakeroot
Euthamia graminifolia	Grass-leaved Goldenrod
Fagus grandifolia	American Beech
Floerkea proserpinacoides	False Mermaid
Fragaria vesca	Wood Strawberry
Fragaria virginiana	Common Strawberry
Fraxinus americana	White Ash
Fraxinus nigra	Black Ash
Galium boreale	Bedstraw
Galium circaezans	Wild White Licorice
Galium palustre	Bedstraw
Gaultheria hispidula	Creeping Snowberry
Gaultheria procumbens	Wintergreen (Checkerberry)
Gaylussacia baccata	Black Huckleberry
Geanothus americanus	New Jersey Tea
Gentiana andrewsii	Closed Gentian
Gentiana crinita	Fringed Gentian
Gentiana linearis	Narrow-Leaved Gentian
Geranium maculatum	Wild Geranium
Gerardia albiflora	White Gerardia
Gerardia laevigata	False Foxglove
Gerardia purpurea	Purple Gerardia
Geum canadense	White avens
Geum peckii	Rough Avens
Glechonia hederacea	Ground Ivy
Gleditsia triacanthos	Honey Locust
Glyceria grandis	American Mannagrass
Glyceria striata	Manna-grass
Gnaphalium macounii	Clammy Everlasting
Gnaphalium obtusifolium	Sweet Everlasting
Gomphus rogersi	Sable Clubtail
Goodyera pubescens	Rattlesnake Plantain
Gymnocarpium dryopteris	Oak Fern
Habenaria lacera	Fringed Orchid
Hackelia virginiana	Virginia Stickseed
Hamamelis virginiana	Witch Hazel
Hedeoma pulegioides	Pennyroyal
Helenium autumnale	Sneezeweed
Helianthus annuus	Sunflower
Helianthus giganteus	Giant Sunflower
Helianthus tuberosus	Jerusalem Artichoke
Helonias bullata	Swamp Pink
Hemerocallis fulva	Day Lily
Hemicarpha micrantha	Hemicarpha
Hepatica acutiloba	Round Leaf Hepatica
Hepatica americana	Hepatica
Hemerocallis fulva	Day Lily
Hemicarpha micrantha	Hemicarpha
Hesperis matronalis	Dame's rocket
Heuchera americana	Alumroot
Hibiscus palustris	Mallow
Hieracium aurantiacum	Orange Hawkweed
Hieracium caespitosum	King Devil Hawkweed
Hieracium cronovii	Hawkweed

Scientific Name	Common Name
Hieracium kalmii	Canada Hawkweed
Hieracium praetense	King Devil
Hieracium venosum	Rattlesnake
Hottonia inflata	Featherfoil
Hydrophyllum canadense	Broad-leaved Waterleaf
Hydrophyllum virginianum	Waterleaf Family
Hylocomium splendens	Hylocomium
Hypericum canadense	Canadian Saint Johnswort
Hypericum perforatum	Common Saint Johnswort
Hypoxis hirsuta	Stargrass
Ilex montana	Mountain Holly
Ilex verticillata	Winterberry
Impatiens capensis	Jewelweed (Touch-Me-Not)
Ipomoea sp.	Bindweed
Iris cristata	Crested Iris
Iris pseudocorus	Iris
Iris prismatica	Slender Iris
Iris pseudacorus	Yellow Marsh Iris
Iris versicolor	Blue Flag Iris
Isutria verticillata	Whorled Pogonia
Juglans cinerea	White Walnut (Butternut)
Juglans nigra	Black Walnut
Juncus effusus	Common Rush
Juniperus virginiana	Red Cedar
Kalmia angustifolia	Sheep Laurel
Kalmia latifolia	Mountain Laurel
Kalmia polifolia	Pale Laurel
Krigia biflora	Two-Flowered Cynthia
Lactucca canadense	Wild Lettuce
Lactuga scariola	Prickly Lettuce
Lamium purpurem	Purple Dead Nettle
Laportea canadensis	Wood Nettle
Larix laricina	Larch
Ledum trisulca	Star Duckweed
Leersia oryzoides	Rice Cutgrass
Lemna trisulca	Star Duckweed
Lepedeza capitata	Round-head'd Bush Clover
Lepidium ruderate	Roadside Peppergrass
Lepidium virginicum	Peppergrass (Poor-Man's Pepper)
Leucobryum glaucum	White Moss
Liatris spicata	Blazing Star
Ligustrum sp.	Privet
Lillium spp.	Lilies (Wood, Canada and Turk's-Cap)
Lilium canadense	Canada Lily
Lillium philadelphicum	Wood Lily
Lilium superbum	Turk's-cap Lily
Linaria vulgaris	Butter-and-eggs
Lindera benzoin	Spicebush
Liriodendron tulipifera	Yellow-poplar (Tuliptree, Tulip-Poplar)
Lobelia cardinalis	Cardinal Flower
Lobelia inflata	Spiked Lobelia (Indian Tobacco)
Lobelia dortmanna	Water Lobelia
Lobelia siphilitica	Blue Lobelia
Lobelia spicata	Indian Tobacco
Lonicera canadensis	Fly Honeysuckle
Lonicera japonica	Japanese Honeysuckle
Lonicera tatarica	Tartarian Honeysuckle
Lotus corniculatus	Birdsfoot Trefoil
Ludwigia alternifolia	Seedbox
Lupinus perennis	Wild Lupine
Lychnis alba	White Campion
Lychnis flos-cuculi	Ragged Robin
Lycopodium annotinum	Stiff Clubmoss
Lycopodium clayvatum	Staghound Clubmoss

Scientific Name	Common Name
Lycopodium complanatum	Christmas Green, Running Ground Pine Clubmoss
Lycopodium lucidulum	Shining Clubmoss
Lycopodium obscurum	Tree Clbmss Flat Branch Ground Pine
Lycopodium treslachyum	Ground Cedar (GroundPine) Clubmoss
Lycopus americanus	Cut-leaved Water-horehound
Lycopus virginicus	Bugleweed
Lysimachia ciliata	Fringed Loosestrife
Lysimachia nummularia	Moneywort
Lysimachia quadrifolia	Whorled Loosestrife
Lysimachia salicaria	Purple Loosestrife
Lysimachia terrestris	SwampCandles(YellowSwamp)Loosestrife
Lysimachia thrysiflora	Tufted Loosestrife
Lythrum salicaria	Purple Loosestrife
Maianthemum canadense	Canada Mayflower (Wild Lily of the Valley)
Malitotus alba	White Sweet Clover
Malus var.	Crabapple
Malva moschata	Musk Mallow
Medeola virginiana	Cucumber Root (Indian Cucumber Root)
Melampyrum lineare	Cow-wheat
Melanthium virginicum	Virginia Bunchflower
Melilotus alba	White Sweet Clover
Melilotus officnialis	Sweet Clover
Mentha arvensis	Mint
Mertensa virginica	Bluebell
Mianthemum canadense	Lily-of-the-valley
Mikania scandens	Hempweed
Milium effusum	Tall Millet Grass
Mimulus alatus	Winged Monkey Flower
Mimulus ringens	Monkey flower
Mitchella repens	Partridgeberry
Mitella diphylla	Bishop's Cap (Miterwort)
Monarda fistulosa	Wild Bergamot
Monotropa uniflora	Indian Pipe
Morus alba	White Mulberry
Mulva neglecta	Common Mallow Cheese
Myosotis scirpoides	Forget-me-not
Myrica asplenifolia	Bayberry family
Myrica pennsylvanica	Bayberry
Myriophyllum verticillatum	Whorled Water-Milfoil
Nuphar advena	Spatterdock
Nuphar microphyllum	Small Yellow Pond Lily
Nymphaea odorata	Water Lily
Nymphoides cordata	Floating Heart
Nyssa sylvatica	Black Tupelo (Blackgum, Pepperidge)
Obolaria virginica	Virginia Pennywort
Oenothera biennis	Evening Primrose
Oenothera fruticosa	Small Sundrops
Oenothera perennis	Small Sundrops
Onoclea sensibilis	Sensitive Fern
Orchis spectabilis	Showy Orchis
Ornithogalum umbellatum	Star-of-Bethlehem
Osmorhiza claytoni	Sweet Cicely
Osmorhiza longistylis	Aniseroot
Osmunda cinnamonea	Cinnamon Fern
Osmunda claytoniana	Interrupted Fern
Osmunda regalis	Royal Fern
Ostrya virginiana	Eastern Hophornbeam
Oxalis montana	Common Wood Sorrel
Oxalis stricta	Wood Sorrel

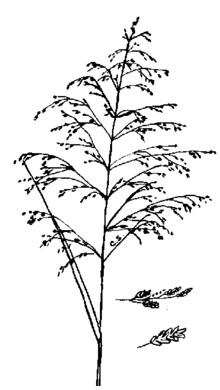
Scientific s Name	Common Name
Panax trifolim	Dwarf Ginseng
Panicum boreale	Northern Panic Grass
Panicum depauperatum	Starved Panic-grass
Parthenocissus quinquefolia	VirginiaCreeper
Pastinaca sativa	Wild Parsnip
Pedicularis canadensis	Wood Betony (Lousewort)
Peltandra virginica	Arrow Arum
Penstemon digitalis	Beardtongue
Phalaris arundinacea	Reed Canary Grass
Phleum pratense	Timothy
Phlox paniculata	Phlox
Phlox pilosa	Downy Phlox
Phragmites australis	Phragmites
Phytolacca americana	Pokeweed
Phytolocca decandra	Pokeweed
Picea abies	Norway Spruce
Picea mariana	Black spruce
Pinus resinosum	Red pine
Pinus rigida	Pitch pine
Pinus strobus	Eastern White or Northern White pine
Plantago lanceolata	English Plantain
Plantago major	Plaintain
Platanthera hookeri	Hooker's Orchid
Platanthera psycodes	Purple-Fringed Orchid
Platanus acerifolia	London Plane
Platanus occidentalis	Sycamore (American Planetree)
Poa pratensis	Kentucky Bluegrass
Podophyllum peltatum	Mayapple
Polemonium reptans	Valerian
Polygala paucifolia	Fringed Polygala
Polygala sanguinea	Milkwort
Polygala verticittata	Milkwort
Polygonatum biflorum	Solomon's Seal
Polygonatum pubescens	Hairy Solomon's-seal
Polygonum	Knotweeds
Polygonum hydropiper	Water Pepper
Polygonum orientale	Prince's feather
Polygonum pensylvanicum	Smartweed
Polygonum punctatum	Dotted Smartweed
Polygonum sagittatum	Arrow-leaved Tearthumb
Polygonum scandens	Climbing False Buckwheat
Polypodium virginianum	Common polypody
Polypody vulgare	Polypody (Cmmn Rock Cap Fern)
Polystichum achrostichoides	Christmas Fern
Polytrichum spp.	Haircap Mosses
Polytrichum juniperinum	Juniper Haircap Moss
Polytrichum piliferum	Awned Haircap Moss
Pondeteria cordata	Pickerelweed
Populus deltoides	Common Cottonwood
Populus grandidentata	Big-toothed Aspen
Populus tremuloides	Trembling Aspen
Portulaca oleracea	Purslane
Potamogeton alpinus	Northern Pondweed
Potamogeton illinoensis	Illinois Pondweed
Potamogeton obtusifolius	Obtuse-Leaved Pondweed
Potamogeton robbinsii	Robbin's Pondweed
Potamogeton zosteriformis	Flat-Stemmed Pondweed
Potentilla arguta	Tall Cinquefoil
Potentilla fruiticasa	Cinquefoil
Potentilla palustris	Marsh Cinquefoil
Potentilla recta	Rough-fruited Cinquefoil
Prenanthes alba	Rattlesnake Root (White & tall Lettuce)

Scientific Name	Common Name
Prenanthes racemosa	Smooth Rattlesnake Root
Prenanthes serpentaria	Gall-of-the-Earth
Prunella vulgaris	Selfheal (Heal All)
Prunus avium	Sweet Cherry
Prunus depressa	Sand Cherry
Prunus pensylvanica	Fire Cherry
Prunus pumila var depressa	Low Sand Cherry
Prunus serotina	Black Cherry
Prunus virginiana	Choke Cherry
Pteridium aquilinum	Bracken Fern
Puccinellia fernaldii	Fernald's Meadow Grass
Pycnanthemum torrei	Torrey's Mountain Mint
Pycanthemum virginianum	Mountain-mint
Pyrola elliptica	Shinleaf Pyrola
Pyrola rotunderfolia	Round leaved Pyrola
Pyrus callaryana	Bradford Pear
Quercus alba	White Oak (Stave Oak)
Quercus bicolor	Swamp White Oak
Quercus borealis	Red Oak
Quercus coccinea	Scarlet, Red or Black Oak
Quercus ilicifolia	Scrub Oak (Bear Oak)
Quercus imbricaria	Shingle Oak
Quercus montana	Chestnut Oak
Quercus palustris	Pink Oak
Quercus prinus	Chestnut Oak
Quercus rubra	Northern Red Oak (Red Oak, Gray Oak)
Quercus velutina	Black Oak
Ranunculus acris	Buttercup
Ranunculus pusillus	Low Spearwort
Ranunculus repens	Creeping Buttercup
Ranunculus septentrionalis	Swamp Buttercup
Ranunculus trichophyllus	White Water Buttercup
Rhododendron calendulaceum	Flame Azalea
Rhododendron canadense	Rhodora
Rhododendron maximum	Rhododendron
Rhododendron nudiflorum	Pink Azalea
Rhodo. periclymenoides	Pinxter Flower
Rhododendron viscosum	Swamp Honeysuckle
Rhus copallina	Winged Sumac
Rhus glabra	Smooth Sumac
Rhus radicans	Poison Ivy
Rhuas typhina	Staghorn Sumac
Rhus spp.	Sumac family
Ribes glandulosum	Skunk Currant
Robinia pseudoacacia	Black Locust
Rosa multiflora	Multiflora Rose
Rosa palustris	Swamp Rose
Rubus allegheniensis	Blackberry
Rubus idaeus strigosus	Amer. Red Raspberry
Rubus occidentalis	Black Raspberry
Rubus odoratus	Purple flwrd Raspberry
Rubus phoenicolasius	Wineberry
Rubus semisetosus	New England Blckbrry
Rudbeckia hirta	Black-eyed Susan
Rumex crispus	Curled Dock
Rumey acetocella	Sheep Sorrel
Salicornia	Glasswort
Sagittaria latifolia	Broad-leaved Arrowhead
Salix alba	White willow
Salix interior	Willow
Salix lucida	Shining Willow
Salix nigra	Black Willow
Salix pedicellaris	Bog Willow
Sambucus canadensis	Common Elder (Elderberry)

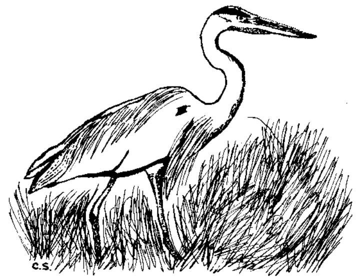
Scientific Name	Common Name
Sanguinaria canadensis	Bloodroot
Saniculo marilandica	Black Snakeroot
Saponaria officinalis	Bouncing Bet (Soapwort)
Sarracenia purpurea	Pitcher Plant
Sassafras albidum	Sassafras
Saururus cernuus	Lizard's Tail
Saxifraga pensylvanica	Saxifrage
Saxifraga virginiensis	Early Saxifrage
Scheuchzeria palustris	Arrow-Grass
Schizachyrium scoparium	Little Bluestem
Scirpus cyperinus	Woolgrass
Scirpus validus	Great bulrush
Scutellaria epilobiifolia	Marsh Skullcap
Scutellaria integrifolia	Skullcap Hyssop
Scutellaria laterifolia	Mad-dog Skullcap
Sedum telephium	Orpine (Live Forever)
Senecio aureus	Golden Ragwort
Setaria faberi	Nodding Foxtail
Setaria glauca	Yellow Foxtail
Silene cucubalus	Bladder Campion
Silene stellata	Starry Campion
Silene virginica	Firepink
Sisyrinchium angustifolium	Blue-eyedGrass
Sisykinghium graminoides	Blue-eyed Grass
Smilacina racemosa	False Solomon's Seal
Smilacina trifolia	3-Lvd Solomon's-Seal
Smilax sp.	Greenbrier
Solanum dulcamara	Bittersweet Nightshade
Solanum nigrum	Common Nightshade
Solidago altissima	Tall Goldenrod
Solidago bicolor	Silver-rod
Solidago caesia	Blue-Stmmd Goldenrod
Solidago canadensis	Canada Goldenrod
Solidago flexicaulis	Broad-leaved Goldenrod
Solidago graminifolia	Grass-leaved Goldenrod
Solidago juncea	Early Goldenrod
Solidago odora	Sweet Goldenrod
Solidago rigida	Stiff Goldenrod
Solidago rugosa	Rough-stem'd Goldenrod
Sonchus oleraceus	Sow Thistle
Sphagnum bartlettianum	
Sphagnum cuspidatum	
Sphagnum fallax	
Sphagnum recurvum	
Sparganium spp.	Bur-reed
Sparganium americanum	Bur-reed
Sparganium angustifolium	Narrow-lved Bur-reed
Sparganium minimum	Small Bur-reed
Specularia perfoliata	Venus' Looking-glass
Spiranthes vernalis	Grass-leaved Ladies' Tresses
Spirea latifolia	Meadowsweet
Spirea tomentosa	Steeplebush (Meadowsweet)
Sporobolus neglectus	Puff-Sheathed Dropseed
Stachys palustris	Woundwort
Staphylea trifolia	American Bladdernut
Stellaria media	Chickweed
Streptopus amplexifolius	Twisted Stalk
Streptopus roseus	Rosy Twisted-Stalk
Symplocarpus foetidus	Skunk Cabbage
Tanacetum vulgare	Tansy
Taraxacum officionale	Dandelion
Thalicrum dioicum	Early Meadow Rue
Thalicrum polygamum`	Tall Meadow Rue
Thelypteris noveboracensis	New York Fern

Scientific Name	Common Name
Thelypteris palustris	Marsh Fern
Thlaspi arvense	Field Pennycress
Thuidium delicatulum	Fern Moss
Tiarella cordifolia	Foamflower
Tilia americana	American Linden
Tilia cordata	Small-leafed Linden
Tovaria virginiana	Jumpseed or Virginia Knotweed
Toxicodendron radicans	Poison Ivy
Tradescantia virginiana	Spiderwort
Tragopogon pratensis	Goatsbeard
Triadenum fraseri	Fraser's St. Johnswort
Trientalis borealis	Starflower
Trifolium agrarium	Hop Clover
Trifolium pratense	Clover
Trifolium procumbens	Smaller Hop Clover
Trifolium repens	Clover
Trifolium hybridum	Alsike Clover
Trillium cernuum	Nodding Trillium
Trillium grandiflorum	Trillium
Triphora trianthophora	Three Birds Orchid
Trollius laxus ssp laxus	Spreading Globe Flower
Tsuga canadensis	Eastern Hemlock (Canada Hemlock, Hemlock Spruce)
Tussilago farfara	Coltsfoot
Typha angustifolia	Narrow-leaved Cattail
Typha latifolia	Broad-leaved Cattail
Ulmus americana	American Elm
Ulmus rubra	Slippery Elm
Umbilicaria mammulata	Smooth Rock Tripe
Urtica dioica	Stinging Nettle
Utricularia minor	Lesser Bladderwort
Utricularia purpurea	Purple Bladderwort
Utricularia vulgaris	Bladderwort
Uvularia grandiflora	Large Flowered Bellwort
Uvularia perfoliatum	Bellwort
Uvularia sessilifolia	Wild Oats
Vaccinium spp.	Tree sparkleberry (Farkleberry,Huckleberry)
Vaccinium angustifolium	Late Lowbush Blueberry
Vaccinium corymbosum	Blueberry
Vaccinium pallidum	Early Lowbsh Blueberry

Scientific Name	Common Name
Vaccinium stamineum	Deerberry
Veratrum viride	False Hellebore (Indian Poke)
Verbascum blattaria	Moth Mullien
Verbascum thapsus	Common Mullien
Verbena hastata	Vervain
Verbena simplex	Narrow-leaved Vervain
Veronica officinalis	Speedwell
Veronica noveboracensis	Ironweed
Viburnum acerifolium	Maple-leaved Viburnum
Viburnum dentatum	Arrowwood Viburnum
Viburnum edule	Squashberry
Viburnum lentago	Nannyberry Viburnum
Viburnum prunifolium	Blackhaw
Vicia americana	Purple Vetch
Vicia cracca	Vetch, cow or tufted
Vinca minor	Periwinkle
Viola affnis	Violet
Viola blanca	Sweet White Violet
Viola canadensis	Canada Tall Whte Violet
Viola comspersa	Dog Violet
Viola cucullata	Marsh Blue Violet
Viola fimbriatula	Northern Downy Violet
Viola incognita	Large-leaved White Violet
Viola ianceolata	Lance-leaved Violet
Viola spp. Violets	(Blue, Yellow and White)
Viola pallens	Northern White Violet
Viola papilionacea	Common Blue Violet
Viola pedata	Birdsfoot Violet
Viola pennsylvania	Smooth Yellow Violet
Viola pubescens	Downy Yellow Violet
Viola rotundifolia	Round-leaved Violet
Viola sagittata	Arrow-leaved Violet
Viola septentrionalis	Northern Blue Violet
Viola sororia	Common Blue Violet (Wooly Blue)
Viola striata	Creamy Violet
Vioila triloba	Three-lobed Violet
Vitis sp.	Grape
Vitis labrusca	Fox Grapes
Xanthoparmelia conspersa	Rock Lichen
Zizia aurea	Golden Alexander



* American Mannagrass



* Great Blue Heron

Wildlife

Introduction

The preceding chapters have depicted the evolution of the infrastructure constituting our environment. We have seen how multiple environmental variables resulted in specific geologic, geographic, and plant-cover conditions. These individualized ecosystems are further distinguished by the fauna feeding, breeding, resting, or nesting there.

Today's wildlife population roaming the county's lands is minus some species which succumbed to environmental intrusions. Gone are the gray wolf, mountain lion, elk, marten, fisher, snowshoe hare, and passenger pigeon. Near extinguishment was suffered by the beaver, porcupine, white-tailed deer, wild turkey, timber rattlesnake and northern copperhead. Fortunately these populations survived, even rebounded in some cases. Nevertheless their future existence is in jeopardy as continued intrusions on habitat occur.

Throughout the ages wildlife has provided humankind companionship, sustenance, income potential, sporting opportunities, and aesthetic pleasure. It is only relatively recently that we have come to realize that animals also have valuable lessons to teach us. Because their needs mirror ours (e.g., housing, food, water) we can measure their vitality as an indicator for gaging our own welfare. Byproducts of civilization's progress, including acid rain, pesticides, oil spills, disease, nonpoint pollution, radioactivity, and ground water drawdown, have been paralleled by the modulation of wildlife's abundance, diversity and distribution. Therefore, managing our environmental resources in terms of restoration, preservation and protection, benefits wildlife, their habitat, and consequently, humankind.

Corridors

Many species, particularly the larger mammals, but also migratory birds, have extensive ranges. Corridors connecting habitats prevent isolation of populations, or island effects. These linkages are also effective in boosting biodiversity within (sub)urban areas, "maintaining a broad gene pool, allowing foraging, and dispersing the species outside confined areas."[1] Open lands, including farmlands, as well as forests, rivers, and streams that lie between publicly owned parks, forests, swamplands, and other biologically productive natural habitats are potential candidates for corridors.

---

[1] Schwab, Planning for Wildlife Migration Corridors.

Morris County acts as a transportation corridor for wildlife. The Highlands serve as a connecting link for migrating birds in the Atlantic Flyway. Farny Natural Area is part of a major travel corridor between Wawayanda and Picatinny Arsenal.[2]

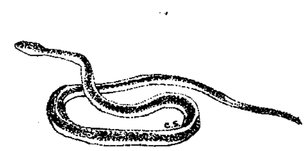
Communities

Plant communities described in the "Vegetation" Chapter will be revisited from a faunal perspective. The animals listed within each category represent species likely to be found in that particular habitat. Species that have been classified as "Rare" by NJ DEP are identified by **"Rr"**. Of the two general types of communities, palustrine and terrestrial, palustrine is particularly rich in wildlife diversity. These systems include wetlands, and associated open waters such as floodplains, marshes, swamps, bogs, ponds, lakes, and river channels. Freshwater fish rely on wetlands for food, spawning and nursery grounds. Migratory as well as resident birds feed, breed, rest, and overwinter. Furbearers such as the muskrat and beaver, as well as reptiles and amphibians, depend on wetlands. Terrestrial systems, or uplands, can range in character from moderately wet to xeric. Rock outcroppings are sparsely populated by wildlife, reflecting scarcity of moisture.

PALUSTRINE - OPEN CANOPY

Streamside/Lakeside Shrub Swamp

These communities are likely to occur in both the Highlands and the Piedmont. A typical location would be along the Rockaway River, in Jefferson Township. These communities are host to snakes (e.g., Eastern Garter and Eastern Ribbon Snake) frogs, salamanders, and small fish.

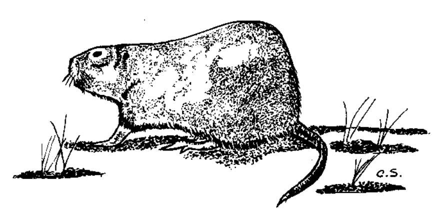


Eastern Garter Snake

Inland Graminoid (grasses) Marsh (Palustrine - Open Canopy)

Marshlands are versatile ecosystems providing refuge, resting, nesting, breeding and feeding areas to resident and migratory animals. Troy Meadows contains marsh as well as shrub and forested swamp, with numerous ephemeral ponds on the edge of extensive emergent wetlands. It is representative of a successional process that has been influenced by human, animal and hydric contributions.

Reptiles and Amphibians	Birds	Mammals
Bullfrog	American bittern **(Rr)**	Mink
Green frog	Black duck	Muskrat
Pickerel frogs	Great blue heron **(Rr)**	
Northern brown snake	Green-backed heron	
Northern water snake	Mallard	
Painted turtle	Marsh wren	
Snapping turtle	Red-winged blackbirds	
Spotted turtle	Sora	
	Swamp sparrows	
	Virginia rail	
	Wood duck	



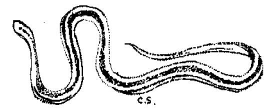
Muskrat

[2] NJ DEPE, Division of Parks and Forestry, Farny Natural Area Management Plan, June 6, 1994, 9.

Glacial Bogs (Palustrine - Open Canopy)

These extremely rare communities exist in the glaciated portions of the Highlands (e.g., the Long Valley Bog). The infamous bog turtle, well known because of its association with pristine environments, resides in boggy meadows fed by clean, unpolluted, spring-fed streams.

Eastern Ribbon Snake
Bog turtle **(Rr)**



Eastern Ribbon Snake

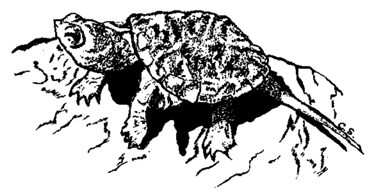
Northern NJ Shrub Swamp (Palustrine - Open Canopy)

These swamps are characterized by acidic conditions and are likely to be found in the Highlands (e.g., Farny) as well as the Piedmont.

Mammals
Mink
Muskrat

Reptiles and Amphibians
Bullfrog
Green frog
Pickerel frogs
Northern brown snake
Northern water snake
Painted turtle
Snapping turtle
Spotted turtle

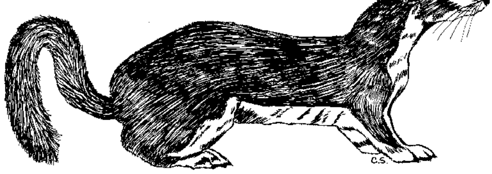
Birds
American bittern **(Rr)**
Black duck
Great blue heron **(Rr)**
Green-backed heron
Mallard
Marsh wren
Red-winged blackbirds
Sora
Swamp sparrows
Virginia rail
Wood duck



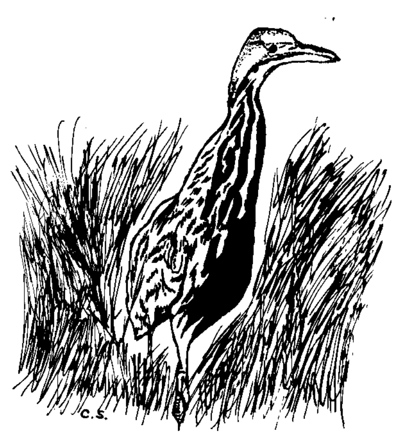
Snapping Turtle

Inland Noncalcareous Pond Shore (Palustrine - Open Canopy)

This community is most likely to occur in the glaciated portions of the Highlands and the Piedmont. Habitat hosts resident raccoon and long-tailed weasel, as well as migrating Shorebirds and herons.



Long-Tailed Weasel



* American Bittern

PALUSTRINE - CLOSED CANOPY (FORESTED)

Black Spruce Swamp

Extremely rare; representative communities are likely to be found in Farny and Pine Swamp in Jefferson Township.

* Barred Owl

Birds
Barred owl **(Rr)**
Golden-crowned kinglet
Nashville warbler
Northern waterthrush
Red-breasted nuthatch

Amphibian
Four-toed salamander

Floodplain Forest (Palustrine - Closed Canopy)

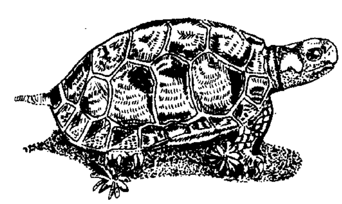
Rare, broad floodplains of the larger rivers such as the Raritan, Passaic and Rockaway.

River Otter

Reptiles
Northern water snake
Northern brown snake

Mammals
Mink
Raccoon
River otter

Birds
Belted kingfisher
Green-back heron
Spotted sandpiper
Wood duck
Yellow-throated vireo



* Bog Turtle

Inland Red Maple Swamp (Palustrine - Closed Canopy)

Found in the Highlands and Piedmont (e.g., Mahlon Dickerson, Jockey Hollow and Great Piece Meadows), this forested habitat contains multi-aged living and dead trees, providing habitat, shelter, and food to a variety of animals including:

Birds
Alder flycatcher
Barred owl **(Rr)**
Blue-gray gnatcatcher
Eastern bluebird
Green-back heron
Hooded merganser
Red-headed woodpecker **(Rr)**
Red-shouldered hawk (**Rr)**
Wood duck

Amphibians
Northern cricket frog
Northern spring peeper
Northern gray tree frog
New Jersey chorus frog
Woodfrog
Wood turtle (**Rr)**

Mammals
Beaver
Black bear
Long-tailed weasel
Raccoon

Northern Gray Tree Frog

Hardwood Conifer Swamp (Palustrine - Closed Canopy)

A very rare community, occurring in the Highlands (e.g., Mahlon Dickerson Reservation), hosting some rare species including the sharp-shinned hawk, and the four-toed salamander.

Birds
Alder flycatcher
Barred owl **(Rr**)
Blue-gray gnatcatcher
Eastern bluebird
Green-back heron
Hooded merganser
Nashville warbler
Northern waterthrush
Red-headed woodpecker **(Rr)**
Red-shouldered hawk **(Rr)**
Sharp-shinned hawk
Wood duck

Amphibians
Four-toed salamander
Northern cricket frog
Northern spring peeper
Northern gray tree frog
New Jersey chorus frog
Woodfrog
Wood turtle **(Rr)**

Mammals
Beaver
Black bear
Long-tailed weasel
Raccoon

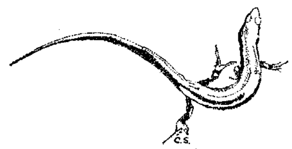
* Red-Headed Woodpecker

Ridgetop Pitch Pine - Scrub Oak Forest (Terrestrial - Open Canopy)

This community can be found in the higher elevations of the Highlands (e.g., Farny) where conditions are severe due to constant wind, and low temperatures with subsequent shorter growing season, in addition to thin, poor soils. Paucity of vegetation is reflected in low vertebrate diversity.

Birds
Black-capped chickadee
Bluebird
Chestnut-sided warbler
Downy woodpecker
Indigo bunting
Northern flicker
Tufted titmouse

Amphibians/Reptiles
Black racer
Copperhead
Timber rattlesnake (**Rr**)
Five-lined skink (lizard)



Five-Lined Skink

Talus Slope Community (Terrestrial - Open Canopy)

This community is rare, although can be found in both the Highlands (e.g., Green Pond Mountain) and the Piedmont.

Mammals
Eastern wood rat
Short-tailed shrew

Amphibians/Reptiles
Timber rattlesnake **(Rr)**

Short-Tailed Shrew

Dry-Mesic Inland Mixed Oak Forest & Mixed Oak - Hardwood Forest (Cool/Moist) (Terrestrial - Closed Canopy)

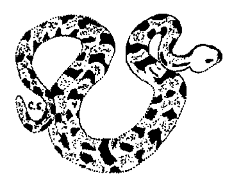
Community found readily in both the Highlands and the Piedmont; virtually in every State and County park.

Mammals
Black bear
Gray fox
Gray squirrel
Eastern chipmunk
Long-tailed weasel
Mice
Opossum
Porcupine
Red fox
Red squirrel
Shrew
Southern flying squirrel
White-tailed deer

Reptiles
Box turtle
Wood turtle
Eastern worm snake
Northern copperhead
Northern ringnecked snake
Red-Bellied snake

Amphibians
Red-backed salamander
Spotted salamander
Woodfrog

Birds
Bat
Bluejay
Downy woodpecker
Great horned owl
Ovenbird
Red-eyed vireo
Ruffed grouse
Scarlet tanager
White-breasted nuthatch
Wild turkey
Woodthrush



* Timber Rattlesnake

Mesic Hemlock-Hardwood Forest (Terrestrial - Closed Canopy)

Typified by a cool, moist environment, this community can be found in the Highlands (e.g., Hacklebarney Natural Area) as well as the Piedmont.

Mammals
Eastern chipmunk
Gray squirrels
Porcupine
Red squirrels
River otter
Southern flying squirrel
White-tailed deer

Amphibian
American toad
Green frog
Northern dusky salamander
Northern two-lined salamander
Pickerel frog
Red eft
Slimy salamander
Wood frog

Fish
American eel
White sucker
Longnose dace
Pumpkinseed
Rock bass
Brook trout
Longnose dace
Blacknosed dace
Largemouth bass
Fallfish

Reptiles
Northern water snake
Snapping turtle

Birds
Belted kingfisher
Black-throated blue warbler
Black-throated green warbler
Blackburnian warbler
Blue jay
Brown creeper
Hermit thrush
Pine grosbeak
Red crossbill
Solitary vireo
Tufted titmouse
White-winged

Eastern Gray Squirrel

Chestnut Oak Forest (Terrestrial - Closed Canopy)

Chestnut Oak forests are represented by the high, steep slopes and ridgetops of both the Piedmont and Highlands (e.g., Farny).

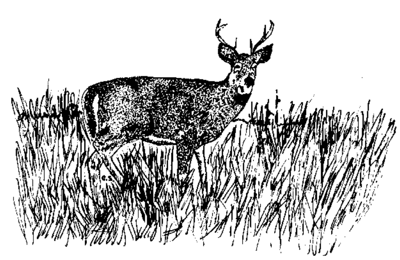
Mammals
Black bear
Gray squirrel
Eastern chipmunk
Long-tailed weasel
Southern flying squirrel
White-tailed deer

Birds
Bluejay
Ovenbird
Red-eyed vireo
Scarlet tanager
Wild turkey
Woodthrush

Reptiles
Box turtle
Wood turtle
Eastern worm snake
Northern copperhead
N.ringnecked snake **
Red-Bellied snake

Amphibians
Red-backed salamander
Spotted salamander
Woodfrog

** Primarily in the Piedmont



White-Tailed Deer

Sugar Maple-Mixed Hardwood (Terrestrial - Closed Canopy)

Not common in Morris County, although character is similar to Mixed Oak forest; can be found in Mahlon Dickerson.

Mammals
Black bear
Gray squirrel
Eastern chipmunk
Long-tailed weasel
Southern flying squirrel
White-tailed deer

Birds
Bluejay
Ovenbird
Red-eyed vireo
Scarlet tanager
Wild turkey
Woodthrush

Reptiles
Box turtle
Wood turtle
Eastern worm snake
Northern copperhead
Northern ringnecked snake
Red-Bellied Snake

Amphibians
Red-backed salamander
Spotted salamander
Woodfrog

Black Bear

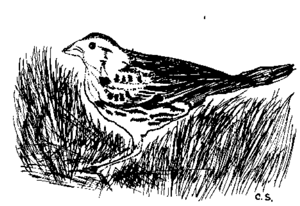
Farmland and Successional Field (Terrestrial - Open Canopy)

Successional fields, as well as farmlands, provide a variety of habitats: hay fields, fallow fields and abandoned fields - hosting such species as grassland birds, almost all of which are listed by the State as threatened or endangered, or are in decline (NJ Natural Heritage Program 1991a).[3] The Rockaway Valley provides an example for this community.

Birds
American woodcock
Barred owl **(Rr)**
Blue-winged warbler
Bobolink **(Rr)**
Brown thrasher
Common yellowthroat
Eastern kingbird
Eastern meadowlark
Field sparrow
Golden-winged warbler
Grasshopper sparrow (**Rr)**
Horned lark
Indigo bunting
Prairie warbler
Rufous-sided towhee
Savannah sparrow
Song sparrow
Vesper sparrow

Reptiles
Black rat snake
Eastern box turtle
Eastern garter snake
Eastern milk snake
Northern brown snake
Northern copperhead
Red-bellied snake

Mammals
Eastern cottontail rabbit
Mice
Mole
Shrew
Striped skunk
Whitetail deer
Woodchuck



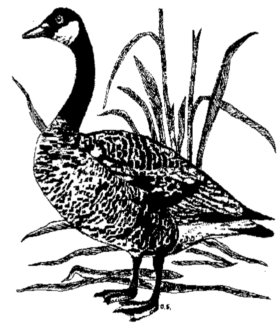
* Bobolink

[3]Alison E. Mitchell, The New Jersey Highlands: Treasures at Risk, New Jersey Conservation Foundation, 1992, 80.

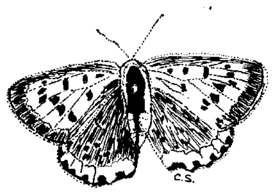
URBAN/SUBURBAN

Residential, commercial, industrial, and open space reflect the impacts of human intrusion on habitat.

Mammals	Birds	Reptiles
Chipmunks	Blue Jay	Eastern Garter snake
Cottontail	Canada goose	Northern Brown snake
Norway rat	Crow	Northern Water snake
Opossum	Gull	Snapping turtle
Raccoon	Killdeer	
Skunk	Mallard duck	
Squirrel	Nighthawk	
White-tailed deer	Prairie warbler	



Canada Goose



Bronze Copper

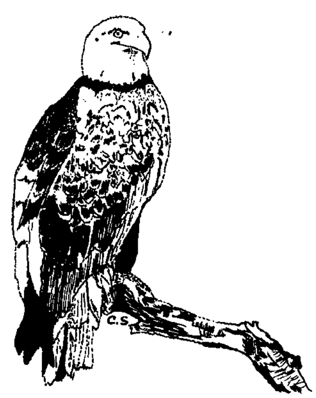
Special Areas

WETLANDS

Many areas within the county provide habitats hosting rare and diverse species. Several of the wetland systems remnant from ancient glacial Lake Passaic (e.g., the Great Swamp, Troy Meadows, Lee Meadows, Hatfield Swamp, and the Great Piece Meadows) are rich in diverse species. The Great Swamp, a widely studied ecosystem, has abundant wildlife as listed in **Appendix A**. It, along with Great Piece, Passaic, and Troy Meadows, are all identified as communities of conservation concern, or macrosites.

HIGHLANDS

The Highlands physiographic province, traversing roughly 2/3 of the county, contains specific features extremely desirable to a wide array of wildlife. Ridges, large unbroken tracts of forests, a mix of vegetation, and a variety of water resources including streams, wetlands, floodplains, and ponds provide habitat and migration corridors to traveling and resident species. Many of the animals, particularly the larger mammals such as black bear, bobcat, mink, and river otter require extensive contiguous habitat. The woodland tracts provide multiple accommodations by way of habitat for nesting, resting, feeding, and breeding to reptiles, amphibians, mammals, resident and migrating birds. **Appendix B** illustrates the breadth of wildlife species representative to the Highlands.



* Bald Eagle

HACKLEBARNEY NATURAL AREA,[4]

The Hacklebarney Natural Area (refer to Vegetation Chapter), located within the Highlands, has been designated as a Conservation Preserve. This distinction enables habitat management designed to preserve a plant or animal species, community type or ecosystem. Because of the richly diverse habitat, it is likely that the following threatened and endangered species would be resident.

Cooper's hawk	Red-headed woodpecker
Great blue heron	Red-shoulder hawk
Long-tailed salamander	

PEQUANNOCK WATERSHED

This vast forested area within the Highlands provides abundant habitat in which to rest, nest, feed, and breed. Interior nesting migrant birds use the watershed as an important breeding area. Threatened and endangered species such as cooper's hawk, barred owl, red-shouldered hawk, bog turtle and timber rattlesnake have found relative safety in these environs. The U.S. Fish and Wildlife Service has cited the Pequannock Watershed as some of the best hawk, owl, and warbler nesting habitat found along the entire eastern seaboard.[5]

Threatened, Endangered, And Rare Species' Macrosites

The following macrosites were introduced in the vegetation chapter as areas housing specific communities of conservation concern. Associated wildlife, generically classified as rare, are listed accordingly. These "wildlife preserves" protect our vulnerable species as their numbers decline in unprotected areas. One example is the barred owl which has been declining in number since the fifties in areas such as the Hatfield Swamp and Great Piece Meadows, but sustains healthy populations in the Great Swamp and the Pequannock Watershed. There are 47 species categorized as rare by the New Jersey Natural Heritage Database. A listing of rare animals and their rankings can be found in **Appendix C**. The list includes native animal species that are listed or candidate species on the Federal Endangered and Threatened Wildlife List, species listed as endangered or threatened on the State Endangered and Nongame Wildlife List, and additional species considered to be rare in New Jersey.

Northern Harrier

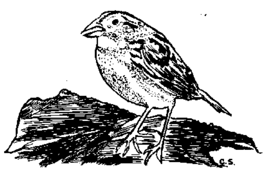
---

[4] Natural Area - ". . . an area of land or water, owned in fee simple or held as a conservation easement by the NJ DEP, which has retained its natural character, although not necessarily completely undisturbed, or having rare or vanishing species of plant and animal life, or having similar features of interest, which are worthy of preservation for present and future residents of the State." NJ DEP. Division of Parks and Forestry. Natural Areas Systems Rules, Dec. 21, 1987.

[5] US Dept. of the Interior. Fish and Wildlife Service. Partners in Flight. US EPA. Migratory Songbird Conservation.

Black River

American Bittern
Grasshopper Sparrow
Barred Owl
Wood Turtle
Bobolink



* Grasshopper Sparrow

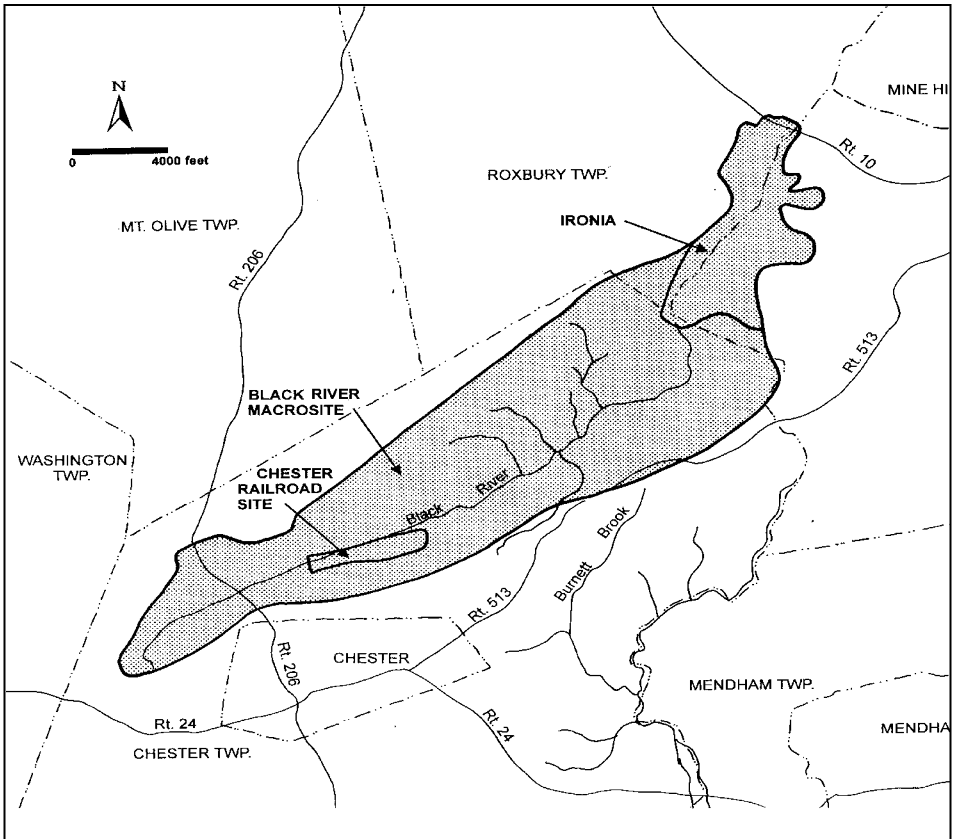


Figure 1 - Black River

Great Piece Meadows

Barred Owl
Blue-Spotted Salamander
Sedge Wren
Wood Turtle

Passaic Meadows

Barred Owl
Red-Shouldered Hawk
Savannah Sparrow
Wood Turtle

* Red-Shouldered Hawk

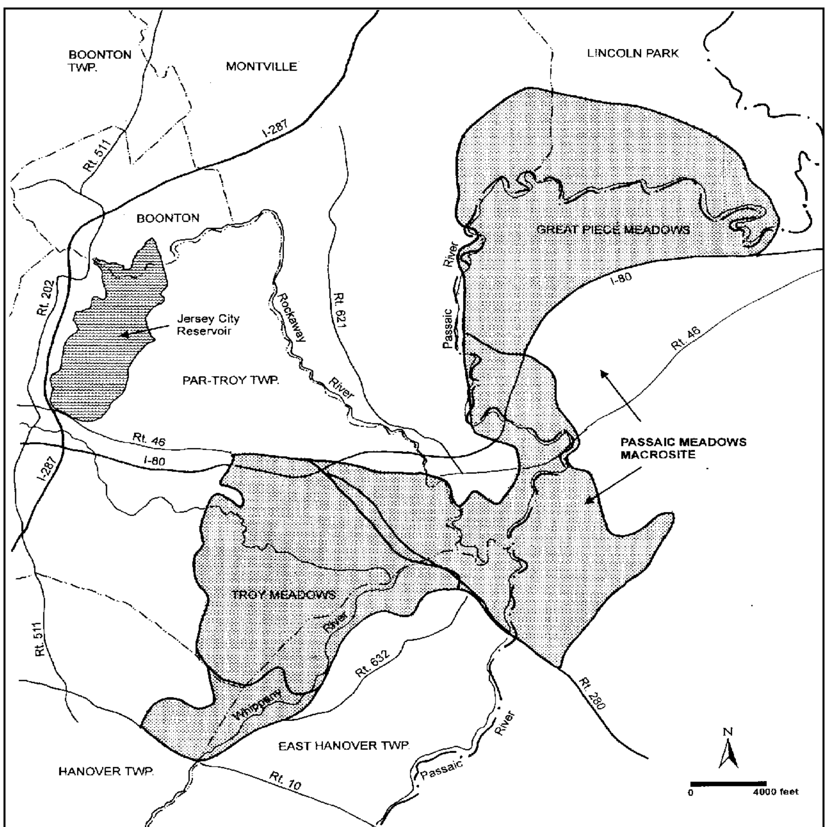
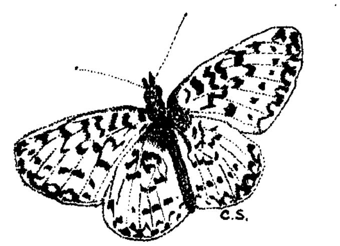


Figure 2 - Great Piece and Passaic Meadows

Great Swamp

American Bittern
Barred Owl
Blue-Spotted Salamander
Bobolink
Bog Turtle
Grasshopper Sparrow
Great Blue Heron
Harris' Checkerspot
Henslow's Sparrow
Red-Headed Woodpecker
Red-Shouldered Hawk
Regal Fritillary
Sedge Wren
Silver-Bordered Fritillary
Wood Turtle



* Silver-Bordered Fritillary

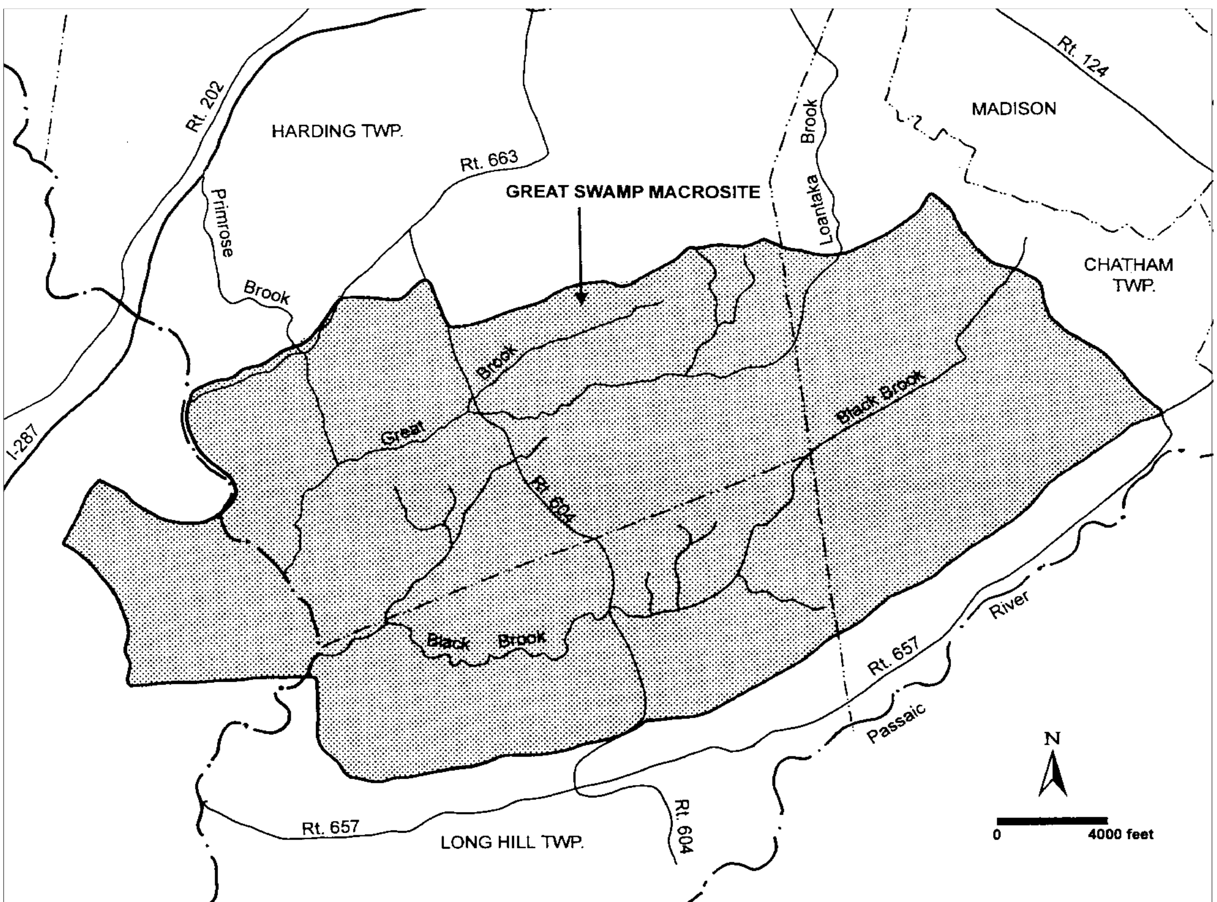
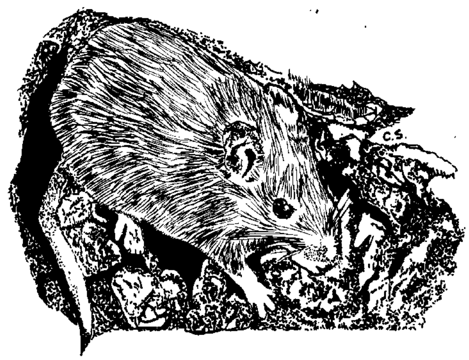


Figure 3 - Great Swamp

Green Pond Mountain

Barred Owl	Northern Goshawk
Cooper's Hawk	Red-Shouldered Hawk
Eastern Woodrat	Wood Turtle

The shy Eastern Woodrat represents the precariousness of many species' existence. Fortunately it is at home in the boulder piles of the Green Pond Mountain range, while neighboring New York and eastern Pennsylvania have classified it as extinct.



* Eastern Woodrat

Figure 4 - Green Pond Mountain

Hibernia Mine

This old abandoned iron mine located in Rockaway Township, ranked as having high significance,[6] currently serves as a bat cave. It is one of the largest bat hibernacula in the eastern U.S. hosting an estimated ". . .26,000+ bats, mostly little brown bats, for hibernation between October and April." [7]

Often maligned, if not intentionally killed, bats are beneficial to humans particularly for their insect-consuming behavior. Mike Valent, biologist for the State Division of Fish, Game and Wildlife, has estimated that a single little brown bat can eat 500 to 600 flying insects per hour, including mosquitoes and agricultural pests. In order to protect the bats from human intrusion, which causes undue stress on the animals' well-being, a specialized gate has been installed at the entrance of the cave.

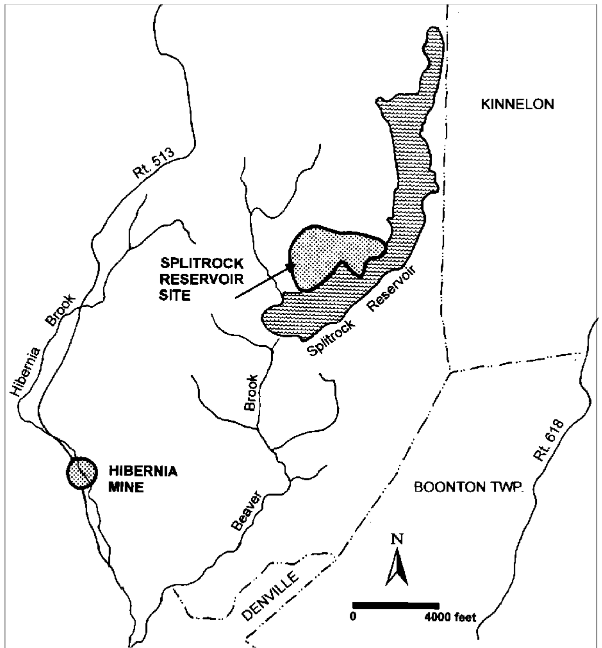


Fig. 5 - Splitrock Reservoir & Hibernia Mine

* Indiana Bat

GloballyRare	Unclassified
Eastern Small-Footed Myotis	Big Brown Bat
Indiana Bat	Little Brown Bat
	Northern Long-eared Bat (Keen's myotis)

Two other Indiana bat hibernacula sites have been found in Rockaway Township. U. S. Fish and Wildlife Service has identified issues of vandalism and destruction to habitat, as well as animal vulnerability to pesticides and other chemical toxicants. Based on Indiana bats daily and lifelong behavior, a 5-mile radius around the hibernacula sites has been delineated with accompanying habitat protection recommendations. Ideally, land use accommodations could be provided while providing for continued residential and commercial growth.

Splitrock Reservoir

Red-Shouldered Hawk
Osprey[2]

* Osprey

[6] NJ DEP, Natural Lands Management, Natural Heritage Site Report, 1991.

[7] Mike Tschappat, "Campaign Takes Wing to Protect Rockaway Township Bats," The Daily Record, Oct. 13, 1995.

[8] NJ DEPE, Division of Parks and Forestry, Farny Natural Area Management Plan, June 6, 1994

Sparta Pine Swamp

Barred Owl
Cooper's Hawk
Northern Goshawk
Red-Shouldered Hawk
Wood Turtle

* Cooper's Hawk

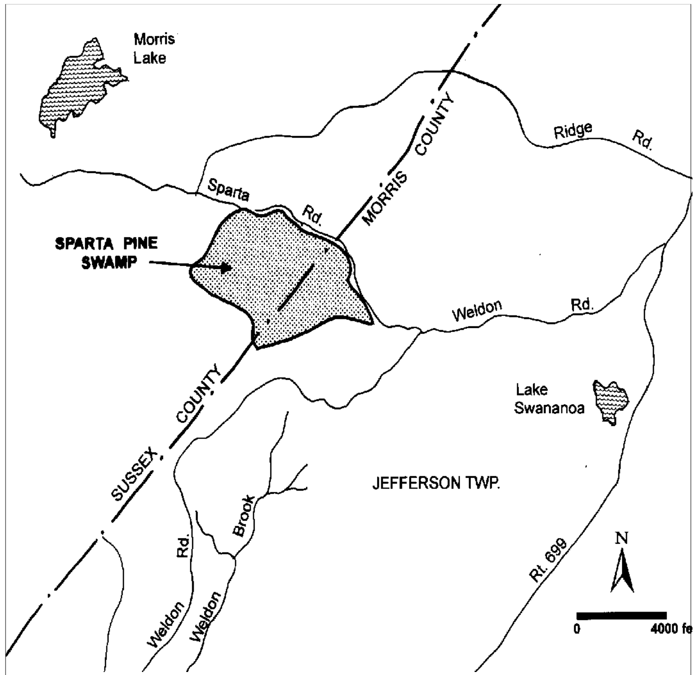


Figure 6 - Sparta Pine Swamp

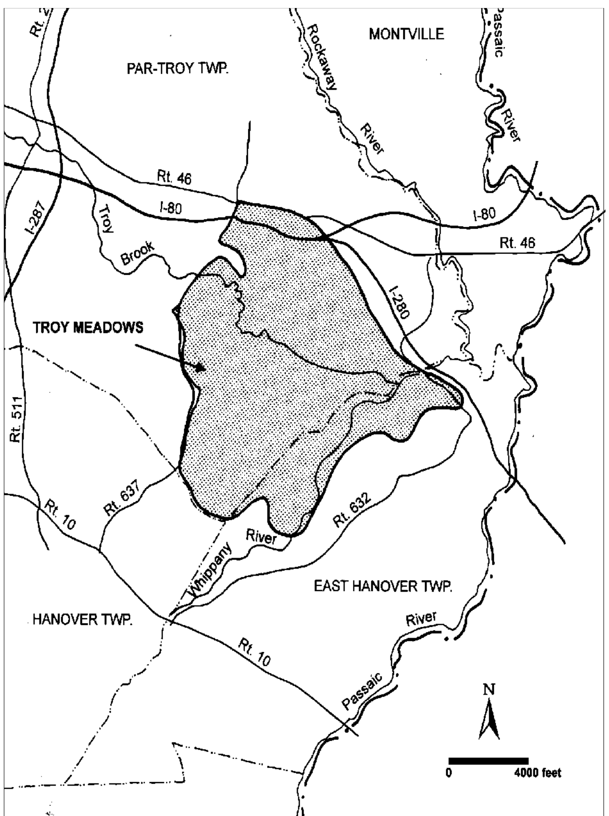
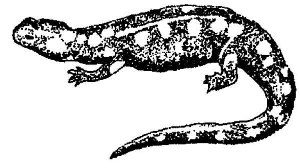


Figure 7 - Troy Meadows

Troy Meadows

The successional process occurring in Troy Meadows since the receding of Ancient Glacial Lake Passaic's waters has been significantly influenced by wildlife. Waterfowl have been the principle agents of seed dispersal. A healthy muskrat population has cleared areas of cattail for house construction. The open waters, interspersed by these residential islands, have resulted in hydrophytic and mesophytic vegetation, attracting habitat-specific fauna.

Blue-Spotted Salamander	Northern Harrier
Great Blue Heron	Sedge Wren
Long-Eared Owl	Wood Turtle



* Blue-Spotted Salamander

Management Considerations

Wildlife management entails providing food, shelter and water in sufficient quantity, quality, and in the proper location. These ingredients dictate the carrying capacity (numerical value) of animals supportable by a particular habitat.[1] Just as carrying capacity changes in response to ecological succession, or cataclysmic events (e.g., fire, disease, infestation) it also can be influenced by human intervention.

Species at risk warrant a greater effort on our part since we cannot afford losing their genetic heritage through extinction. While pockets of populations exist in "safe havens" throughout the county, there is cause for concern. Observations have been made on a regional level indicating a decline in numbers of neotropical birds, as well as shorter distance migrants such as common flickers, meadowlarks, field sparrows and belted kingfishers, grosbeak, blackpoll warblers, and residents such as the Barred owl.

Impacts From Natural Hazards

Wildlife has long been regarded as the barometer as well as forecaster of our environmental and personal well-being. The canary in the cave metaphor has been broadly applied to questions of environmental management. Our role in determining the prognosis of the canary and its brethren is based on an awareness, understanding, and respect of the interconnected web housing all species, including humans. Every time there is a change in the topography, vegetation, climate etc., there is an impact to the animal community. Following are categories of impacts to habitat, and thus wildlife.

- **Biological** opponents have taken the form of pets, livestock, and even stowaway imports. Both intentional and unintentional imports were carriers of disease, preyed on resident species, and competed for food sources. Example of species introduced by humans include:

Black rat	House mouse	Ring-necked pheasant
English sparrow	Norway rat	Starling

Some species migrated to, and stayed, in areas newly made hospitable. These newcomers altered the distribution and frequency of resident species. Some animals which had been rare, even non-existent, thrived in their new homes to the detriment of natives; examples include:

Carolina wren	Mockingbird	Mockingbird
Cattle egret	Opossum	Tufted titmouse

Competition has served as a checks and balances among prey and predator. Conversely, Gypsy moths, with few predators, have had recurring surges in populations, exacting severe damage on agricultural crops as well as forests.

Domestic predators, particularly cats, exact a tremendous toll in the suburban ecosystem. Fledglings, birds roosting at night, and nesting birds as well as reptiles, amphibians, and small mammals are vulnerable. An artificially reduced lifespan results in accelerated reproductivity. This is evidenced by species such as robins, chickadees, mourning doves, and cardinals who raise multiple broods each year.

Bonelli's Warbler

---

[1] Delwin E. Benson, Helping Wildlife: Working With Nature, Wildlife Management Institute, 1977.

New arrivals or "Alien species"[6] infiltrating habitats threaten native species' viability, if not existence. Newcomer birds such as house sparrows and starlings not only usurp native cavity dwellers of their nests, but kill resident young and adults. Native bluebirds and the red-headed woodpecker have suffered devastating population losses due to the domineering starling.

Biological impacts in the form of blight or pest removes food sources while decimating stands of vegetation (e.g., American Chestnut). As animals struggle to adjust, alternate food sources are exploited.

- **Environmental stresses** such as acid rain and drought impact wildlife. The impact of drought, such as we are experiencing in the summer of 1999, has cumulative effects on the animal kingdom, where some species are favored and others are stressed. Insects adaptable to drought conditions, such as grasshoppers and crickets, are available to sustain predators such as grouse and turkey. Conversely insects that are more sensitive to drought such as aphids and caterpillars are removed from the diet of their predators. Therefore, songbirds, such as robins, sparrows, catbirds, and warblers, as well as their young are deprived of this food source. Fish are imperilled as droughts diminish water quantity and thus quality. Lack of moisture drives animals such as black bear outside of their range in search of hydration and supplemental food sources.

Human Derived Impacts

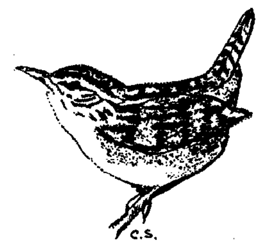
The Raptor Center, a nonprofit rehabilitation center located in Millington, provides us with a reflection of the impact of human activities. Injuries sustained by the birds are the result of chain saw accidents, hunting accidents, building or vehicle collisions, and poisonings from insects feeding on treated lawns. Additional examples of human derived impacts include:

- **Farming** operations supporting monoculture crops promote impoverished habitat in terms of opportunities for nesting/resting/feeding/breeding. Alternatively, where farmfields have been abandoned and converted to forest or residential and industrial development, grassland-dependent species have suffered significant declines, such as the Upland sandpiper.
- **Timbering** practices involving the clear-cutting of large parcels, or even of swaths throughout woodlands, decimate food sources, dens and snags. The resulting shortfall in nesting places displaces cavity-dwelling species like woodpeckers.
- Traditional **landscaping** practices replacing indigenous vegetation with turf, ornamentals and exotic plantings seriously compromise wildlife habitat. Removing trees and understory strips an area of nesting sites, cover, and food sources. Subsequent maintenance in the form of mowing and chemical application continues the obliteration of insects necessary to many bird species such as flycatchers and swallows. Accentuating this imbalance is our garden-tending. Many vegetable and flower crops provide "free lunches" to omnivores, such as raccoon, crow, and gulls, giving them an advantage.
- **Hydrological** impacts (e.g., stream channelization, and draining and filling of wetlands) have taken a drastic toll on habitats. The Great Swamp National Wildlife Refuge provides an excellent illustration of this. Higher water levels, favored by the aggressively invasive phragmites and arrow arum, result in the overrunning of native wild millet, sedges, and smartweed. Not only is vegetative diversity compromised, but so are important sources of food and cover for wildlife.

---

[6]Alan Burdick, It's Not the Only Alien Invader, The New York Times Magazine, Nov. 13, 1994, 49-88.

- **Urbanization**'s intrusion on habitat results in direct and indirect repercussions. Animals who adapt well to disturbed environments thrive (e.g., the Norway rat). These "adaptables" act as opportunists nesting in (sub)urbanized dwelling places such as ledges, crevices, holes, storm sewers, bushes, and chimneys. Examples are the crow, blue jay, mallard duck, Canada goose, squirrel, cottontail and skunk. The white-tailed deer, has taken on the stigma of pest due to its consumption and destruction of gardens as well as wild areas. Rare and endangered plants are at risk as is the entire understory, preventing the maturation of plant communities.



* Sedge Wren

  Our garbage has become a staple for omnivores, like raccoons, crows, gulls, blue jays, and chipmunks. In addition, their diet is supplemented by preying on the nests of migratory songbirds, indulging in both eggs and chicks. Thus, songbirds, as well as neotropical populations are compromised.

  While birdfeeding nourishes our souls as well as animals' guts, it also sustains many adaptables (e.g., crows, blue jays and squirrels). Select species are given an advantage. This is evident in the no longer migrating water fowl, Canada geese, who are at home on our vast supply of turf.

  Chemicals can be delivered directly through consumption or contact, or indirectly through bioaccumulation. Immediate death or prolonged demise by way of altered behavior, reduced reproductive success and offspring viability are possible outcomes.

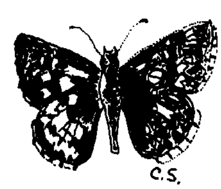
Due to wildlife and human habitat overlap, there are more direct and frequent interactions. This bears physical safety repercussions, including threat of diseases like rabies and Lyme disease. Consequently it becomes clear that managing alien and adaptable species will become increasingly important.

- **Fragmentation of habitat,** or the breaking of continuous areas, impact species relaying on the interior of woodlands such as:

Acadian flycatcher	Broad-winged hawk	Hermit thrush
American redstart	Canada warbler	Hooded warbler
Barred owl **(Rr)**	Cerulean warbler	Louisiana waterthrush
Black-and-white warbler	Eastern wood-pewee	Red-eyed vireo
Black-throated green warbler		

When habitat is fragmented by development-related activities, isolated small parcels result. Even seemingly benign land uses such as bike trails, often result in the creation of these dividing lines between habitat types. This resulting specialized edge habitat promotes the proliferation of certain species, again compromising the delicate balance sustaining biodiversity.

These fragmented deep woods habitats not only lose plant and animal species but also convert into different habitats, much like ecological succession. Many edge dwellers such as raccoons and cowbirds prey upon eggs and nesting young of forest-dwelling songbirds. Other adaptables (e.g, ruffed grouse, hairy woodpecker, pileated woodpecker, red-breasted nuthatch, white-breasted nuthatch, brown creeper, veery, ovenbird and scarlet tanager) prefer interior woodlands but are able to subsist on the edge. Large mammals, particularly predators, suffer profoundly when their ranges, constituted by habitat and the connecting corridors are separated. Bear have become unexpected visitors in places such as Montville and Boonton Townships.



* Grizzled Skipper

Regulatory Support

FEDERAL

- **The Endangered Species Act** affirms conservation of "critical habitats" to protect threatened and endangered species.
  - **Candidate Conservation Agreements with Assurances** encourages landowners to provide habitat protection, through management, or restoration actions for species considered to be in decline. Landowners are free from restrictions if species are listed in the future.
  - **Safe Harbor** provides incentives to private and other non-Federal property owners to restore, enhance, or maintain habitats of species listed as threatened or endangered.
- **National Invasive Species Act** controls the unintentional introduction and spread of invasive species.
- **Executive Order 13112** seeks to curb the introduction and spread of invasive species

STATE

- **NJ Freshwater Wetlands Protection Act** preserves freshwater wetlands from disturbance, with special allowances for areas associated with endangered species.
- **The Endangered and Nongame Species Conservation Act** provides regulatory oversight for the conservation, management, enhancement and protection of wildlife endangered and nongame species.

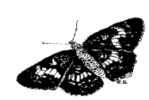
Planning Strategies

Habitat destruction is wildlife's primary death knell. Residential, commercial or industrial expansion, including roads, infrastructure, etc. often enhance our quality of life, but severely impacts wildlife.

Wildlife management weaves together private and public lands, urban areas, and wilderness. It has been recognized that in conserving ecosystems, biodiversity is supported. In this way targeted species as well as the animals, plants, and materials with which they interact, are protected. Provisions within the Federal Endangered Species Act enable the development of Habitat Conservation Plans such as that created for San Bruno Mountain. This tool "permitted limited residential and commercial development within the critical habitat of the endangered mission blue butterfly."[7]

Locally, integration of planning tools can serve to achieve multiple benefits. Incorporating consistent resource protection objectives throughout plans (stormwater, open space and conservation, river corridor protection, scenic vistas management) will achieve multiple benefits, in a unified fashion.

- Habitat protection and restoration
  - Rank and prioritize species identified for protection; provide habitat requirements accordingly
  - Identify and protect corridors utilized by wildlife
  - Maintain and manage significant ecological processes (e.g., floods) in protected areas
  - Map habitat of sensitive species; provide protection through local conservation plan
  - Balance needs for public recreation with habitat needs of wildlife
- Tools for preserving and augmenting natural habitat
  - Acquisition
  - Easements
  - Bequests



* Harris Checkerspot

[7] James F. Berry, Endangered Legislation for Endangered Species, Environment and Development, Nov./Dec. 1995.

Design Strategies

Having determined extent and type of habitat, and associated carrying capacity, design strategies need to assure adequate amounts of quality food, cover, water, and nesting habitat. These are necessary in order for animals to be able to withstand diseases, parasites, extreme weather conditions and predators.

- Maintaining large patches of native vegetation by preventing fragmentation
- Protect habitats within a landscape by guiding development activities away from wetlands, riparian zones, ledges, or mature forests

Zoning and Site Plan Ordinance

Habitat protection mechanisms include establishment of greenways, open space, and managed forest districts. In 1990 Tuscon adopted an "environmental resource zone ordinance, which used overlay zones to establish protective measures for areas deemed essential to wildlife, including migration corridors."[8] Within the overlay zone "100% restoration or preservation of habitat"[9] needed to be demonstrated by developers before approval.

- Habitat Protection Zone
- Overlay Zone for sensitive areas providing vegetative cover protection, setbacks, percentage requirements for open space preservation, and avoidance of critical areas such as nesting areas
- Zoning provisions preventing "traffic-intensive or people-intensive activities from occurring close to prime habitat areas, migration corridors," [10] or other sensitive habitat
- Minimum lot size requirements or maximum residential densities providing minimal "number of people on sensitive lands and the frequency of human-animal interaction"[11]
- Vegetation protection controlling type of vegetation planted as a means for attracting species
- River corridor protection standards
- Garbage management standards preventing wildlife scavenging
- Phased development standards enabling wildlife adaptation to intrusion

Practices

Creative uses of resources in providing habitat requirements can often accentuate existing conditions that might, by themselves, be inadequate. As stated in the Vegetation Chapter, management strategies often bear multiple benefits. Interventive wildlife management programs have reversed the decline and/or demise of some populations (e.g., bobcat, black bear, river otter, beaver, egrets, herons, trumpeter swans, and peregrine falcon). Examples of conservation programs include:

* Loggerhead Shrike

---

[8] Jim Schwab, Planning for Wildlife Migration Corridors, Environment and Development, April 1994, 2.

[9] Schwab, 3.

[10] Christopher J. Duerksen et al, Habitat Protection Planning, Where the Wild Things Are (American Planning Association, Planning Advisory Service Report Number 470/471, 1997) 32.

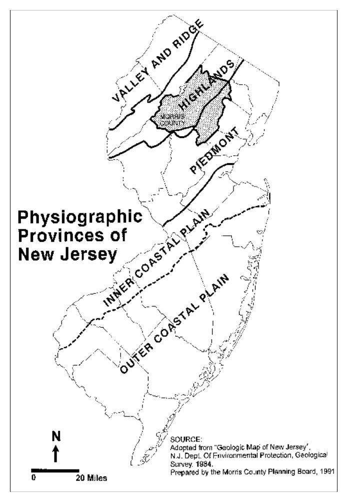
[11]Duerksen, Habitat Protection Planning.

❦ **Bring Back the Natives** (US Fish and Wildlife Service, National Fish and Wildlife Foundation, Bureau of Land Management, USDA Forest Service, Bureau of Reclamation, and Trout Unlimited) is a cooperative effort working "to restore native aquatic species and their habitats through local and regional partnerships."[12] Sites in Morris County include Beaver Brook, Rockaway Township and Primrose Brook in Harding Township. Both sites feature streambank and habitat restoration.

❦ **Habitat Restoration Program[13]** (US Fish and Wildlife Service**)** is a cooperative venture reaching out to governmental agencies, public and private organizations, and private landowners. Without infringing on private ownership, this program strives to improve and protect fish and wildlife habitat by restoring the ecosystem in which they are located. Restoration efforts target cleared, drained or otherwise degraded freshwater and saltwater wetlands, riparian habitats, and habitats of neotropical migratory birds, endangered and threatened species, and fish.

❦ **Partners for Fish and Wildlife Program** (US Fish and Wildlife Service**)** promotes cooperative efforts between itself and other federal, state, tribal agencies, and private land owners to utilize bioengineering techniques to restore habitat.

❦ **Gap Analysis Project[14]** (New Jersey) is designed to identify and prioritize habitat relative to richness of biodiversity. Vertebrate distribution maps created via geographic information systems, are based on vegetation community maps (derived from Landsat Thematic Mapper imagery) and records of known animal locations. Ownership and management maps will be created characterizing land by management status for biodiversity ranging from one (highly managed for biodiversity, e.g., a national park) to four (no management, e.g., an urbanized area). In using this prioritization method, in terms of optimal habitat, it is hoped that cooperative planning will incorporate these ecoregions into conservation management.



❦ **Landscape Project** (New Jersey) was designed to preserve wildlife biodiversity by focusing on specific Landscape Protection Areas (LPA). "Landscape Protection Areas are defined by existing public lands, physiographic boundaries and regions of high biodiversity."[15] The project includes creation of an inventory of State Endangered and Threatened species, as well as those having special habitat needs. Major wildlife groups surveyed are migratory birds, herptiles and invertebrates. The data are translated into Geographic Information System generated maps of rare populations and critical areas.

---

[12] US Fish and Wildlife Service, Bring Back the Natives Fact Sheet, Oct. 1998.

[13] You Want to do WHAT on my Land? Frequently Asked Questions and Answers About the US Fish and Wildlife Service's Habitat Restoration Program, Partners for Wildlife, 6.

[14] Patrick J. Crist, Filling the GAP with Planning, Environment and Development, Dec. 1994, 1.

[15] Jeanette Bowers-Altman, New Jersey's Landscape Project, Nongame News, Newsletter of the New Jersey Endangered and Nongame Species Program, NJ DEPE, Division of Fish Game and Wildlife, Winter 1994. 7.

Protection guidelines are made available to land-use regulatory agencies and planning groups within the LPA. The primary message conveyed is that rare species protection and economic development are not mutually exclusive. Neither additional legislation nor large land acquisitions are the vehicles for protection. Instead, success is contingent on the cooperative efforts of government and private land use organizations, and regulatory protection agencies in local, county, state and federal governments.

The Highlands was chosen for investigation in 1995. Endangered and Nongame Species Program (ENSP) biologists are surveying bog turtles, bobcats, timber rattlesnakes, neotropical migrant songbirds, and freshwater mussels. This will be supplemented by field investigation conducted for the Herptile Atlas.

❦ **Wildlife Diversity Tours - A Watchable Wildlife Program for New Jersey**[16] promotes the benefits of wildlife and habitat protection and open space conservation, while supporting local economy (ecotourism). Destination sites are chosen based on representative dominant ecosystems, and the inherent relationships of wildlife and man (e.g., Great Swamp Outdoor Education Center - Chatham Township, Pyramid Mountain - Borough of Kinnelon, Wildcat Ridge Hawk Watch - Rockaway Township.

❦ **The Conservation Reserve Program,**[17] an offshoot of the 1985 Congressional Farm legislation, promotes the conversion of highly erodible production acreage into soil-conserving meadows and woodlands. In this way habitat diversity is restored, inviting the return of wildlife.

❦ **MAPS** (Monitoring Avian Productivity and Survivorship), developed by the Institute for Bird Populations of Point Reyes Station, Ca., specializes in tracking specific bird populations.

❦ **Multiple Habitat Conservation Program** (San Diego County) has mapped habitat types and their resident species. The habitats consist of biological core areas which provide biologically important interior areas (relative to edge), vegetative diversity, and linkages (e.g., floodplains and steep slopes).

❦ **The Partners in Flight/Aves de las Americas Program** utilizes habitat protection, management, professional training, and public education to protect neotropical migratory birds throughout the Americas. Relying on broad-based involvement, the program has recruited Federal and State governmental entities, nongovernmental organizations, academia and industry.

INDIVIDUAL

- **Landscaping**: Niches often host specific populations: low-growing ground cover hosts tortoises and quail; shrubs are home to rabbits, grouse, and pheasant; young forests provide food and shelter for deer, mouse, grouse, catbirds, raccoons, doves, and woodpeckers; and squirrels, hawks, and owls use the high forest canopy. Expanding plant communities can enhance biodiversity.

Landscaping can also stretch habitat reaches. Lands adjacent to protected habitat can be landscaped to maintain or re-establish native vegetation (flowers, shrubs, trees, grasses and vines). Choosing natives over exotics is favorable in that the latter often have no support value for native wildlife. In this way, habitat provisions of food, cover, and nesting sites are maximized.

---

[16] Jim Sciascia, Wildlife Diversity Tours - A Watchable Wildlife Program for New Jersey, Conserve Wildlife, NJ DEP, Endangered and Nongame Species Program, 6.

[17] Schwab, Conservation Reserve Program, 1.

Basic Guidelines for Backyard Wildlife Management

- Provide basic ingredients: food, water, rest area, nest area, plus connections by way of:

❦green fences	❦brush piles	❦uncultivated plots	❦vegetative filter strips
❦streamside forest	❦snags/dying trees	❦food plots	❦wetlands & water areas

Native plant options:

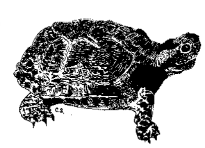
Evergreen Trees	Deciduous Trees	Deciduous Shrubs	Evergreen Shrubs
American Holly	Autumn Olive	American Cranberry	Azalea
Arborvitae	Cherry	Firethorn	Barberry
Columnar Juniper	Crabapple	Flowering almond	Chinese holly
Hinoki False Cypress	Flowering Dogwood	Gray-stemmed Dogwood	Cotoneaster
Pitch Pine	Hawthorn	Highbush Blueberry	Inkberry
Red Cedar	Hickory	Multiflora Rose	Northern Bayberry
Scrub Pine	Mountain Ash	Neigela	
Shortleaf Pine	Oak	Raspberry	Vines
Spruce	Osage Orange	Silky Dogwood	Amur Honeysuckle
White Pine	Red Maple	Spirea	Bittersweet
	Red Osier Dogwood	Sumac	Japanese Honeysuckle
	Russian Olive		Tatarian Honeysuckle
	Sassafras		Virginia Creeper

- **Pest control**: Traditional methods of dealing with "pest" species included trapping, poisoning, and shooting. Less drastic measures such as "scare" devices and reproductive inhibitors have also been experimented with. Our dilemma in dealing with the white-tailed deer population is an example of the conflict in management philosophies. One approach, the deer hunt, has been extremely contentious with little evidence of success in areas where utilized.[18] Reproductive inhibitors have been tried with some success, but are cost prohibitive on a large scale.

Pesticides have been the first line of defense in pest control. However, through the eradication process, entire populations and/or food supplies and water resources were also eliminated or degraded. To keep the ecosystem intact, less devastating methods have been implemented such as mechanical and biological techniques, **integrated pest management**, and planting of pest-resistant species.

Introduced alien species have jarred ecosystems. Therefore, importing any new species intentionally is a weighty decision. An example is the State Mosquito Control Officials' deployment of the Gambusia affinis, or "mosquito fish." This guppy-sized fish is a ravenous mosquito eater. It has been estimated that one pair of Gambusia are capable of eating 1,000 larvate in an hour.[19] However, use of the Gambusia is one of many strategies to be used. Though a benign biological alternative to insecticides, safeguards are in place whereby areas with natural fish populations or delicate environments will not be stocked.

- **Lifestyles:** Though many of us are animal enthusiasts, the wild kingdom is in danger of being loved to death. Therefore it is necessary to minimize human-related influences, e.g., browsing and hunting pets, human intrusions into habitat, contaminants such as run off, garbage, and pollutants of all kinds.



* Wood Turtle

[18] Paul Bonassera, Park Puts Deer Hunt on Hold, The Daily Record, Oct. 4, 1994.

[19] Art Charlton, "Fish With a Mission," The Star-Ledger, 10 July 1991:19.

Glossary

CARRYING CAPACITY The number of inhabitants that an ecosystem can support at a given time.

COMMUNITY All the plant and animal populations occupying a given area.

CRITICAL HABITAT Habitat, essential to some wildlife species, threatened by one or more factors.

ECOSYSTEM includes all components, living and not, of an environment.

ENDANGERED A species "whose prospects for survival in New Jersey are in immediate danger because of a loss or change of habitat, over-exploitation, predation, competition or disease. Immediate assistance is needed to prevent extinction."[20]

HABITAT The sum of conditions constituting an area where plants and animals live.

HIBERNACULA A mine or cave used for hibernation.

INTEGRATED PEST MANAGEMENT "A systematic approach to minimizing undesirable pest damage by maintaining a landscape planting that is part of a functioning ecosystem, determining acceptable pest population and damage levels, and by considering all possible pest control options before action to control is taken."[21]

NEOTROPICAL MIGRANTS Birds that breed in the temperate zone forests of Canada and the U.S., and spend the remainder of the year in tropical and subtropical areas to the south of the U.S. (e.g., ruddy turnstone, yellow-billed cuckoo, common nighthawk, yellow-bellied flycatcher, scarlet tanager, bobolink, red-eyed vireo and Cape May warbler).

POPULATION The total number of animals of a single kind (species) that live in a common geographical area at a given time.

SUCCESSION A sequence of plant and animal communities which replace one another in a given area determined by climate.

THREATENED A species which "may become endangered if conditions surrounding the species begin or continue to deteriorate."[22]

"All things are connected like the blood that unites us all. Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself." Chief Seattle

---

[20] NJ DEP. Division of Fish, Game and Wildlife. New Jersey is for Wildlife.

[21] ND DEP. Planning for Clean Water, the Municipal Guide, March 1999, 58.

[22] New Jersey is for Wildlife.

Appendix A
Wildlife Of The Great Swamp

* UNCOMMON OR OCCASIONAL ABUNDANCE

Birds

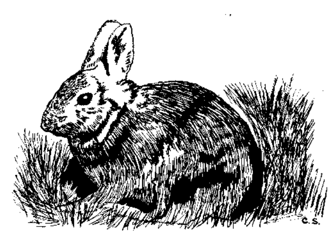
Common Loon *
Horned Grebe *
Pied-billed Grebe *
American Bittern **(Rr)**
Least Bittern
Cattle Egret *
Great Egret *
Snowy Egret *
Black-crowned Night-Heron *
Great Blue Heron **(Rr)**
Green -backed Heron
Little Blue Heron *
Yellow-crowned Night-Heron *
Glossy Ibis *
Mute Swam *
Canada Goose
Snow Goose *
Blue-winged Teal
Green-winged Teal
American Black Duck
Ring-necked Duck *
Ruddy Duck *
Wood Duck
Mallard
Northern Pintail *
Northern Shoveler *
Gadwall*
American Wigeon *
Canvasback*
Common Goldeneye *
Bufflehead*
Common Merganser *
Hooded Merganse r*
Red-breasted Merganser *
Black Vulture *
Turkey Vulture
Osprey **(Rr)**
Bald Eagle **(Rr)**
Golden Eagle *
Northern Harrier **(Rr)**
Broad-winged Hawk *
Cooper's Hawk Rr
Red-shouldered Hawk * **(Rr)**
Red-tailed Hawk
Rough-legged Hawk *
Sharp-shinned Hawk *
Northern Goshawk **(Rr)**
American Kestrel
Merlin *
Peregrine Falcon *
Ring-necked Pheasant
Ruffed Grouse *
Northern Bobwhite *
King Rail*
Virginia Rail
Sora
Common Moorhen
American Coot*
Killdeer
Greater Yellowlegs *
Lesser Yellowlegs *
Pectoral Sandpipe r*
Semipalmated Sandpiper *
Solitary Sandpiper *
Spotted Sandpiper *
Upland Sandpiper *** (Rr)**
Least Sandopper *
Dunlin*
Short-Billed Dowitcher *
Common Snipe
American Woodcock
Bonaparte's Gull *
Great Black-Backed Gull *
Herring Gull*
Ring-Billed Gull*
Black Tern *
Mourning Dove
Rock Dove *
Black-Billed Cuckoo *
Yellow-Billed Cuckoo *
Barred Owl **(Rr)**
Common Barn-Owl *
Eastern Screech-Owl *
Great Horned Owl
Long-Eared Owl **(Rr)**
Northern Saw-Whet Owl *
Common Nighthawk
Chimney Swift
Ruby-Throated Hummingbird *
Belted Kingfisher
Downy Woodpecker
Hairy Woodpecker *
Pileated Woodpecker *
Red-Bellied Woodpecker
Red-Hooded Woodpecker
Yellow-Bellied Sapsucker *
Northern Flicker
Olive-Sided Flycatcher *
Eastern Wood-Pewee
Acadian Flycatcher *
Alder Flycatcher *
Great Crested Flycatcher
Least Flycatcher *
Willow Flycatcher
Yellow-bellied Flycatcher *
Eastern Phoebe
Eastern Kingbird
Horned Lark *
Purple Martin *
Bank Swallow *
Barn Swallow
Cliff Swallow *
Northern Rough-Winged S.
Tree Swallow
Blue Jay
American Crow
Fish Crow*
Black-Capped Chickadee
Tufted Titmouse
Red-Breasted Nuthatch *
White-Breasted Nuthatch
Brown Creeper
Carolina Wren *
House Wren
Marsh Wren
Sedge Wren **(Rr)**
Winter Wren *
Golden-Crowned Kinglet *
Ruby-Crowned Kinglet
Blue-Gray Gnatcatcher
Eastern Bluebird
Veery
Gray-Cheeked Thrush *
Swainson's Thrush
Wood Thrush
American Robin
Gray Catbird
Northern Mockingbird
Brown Thrasher
Water Pipit *
Cedar Waxwing *
Northern Shrike *
Loggerhead Shrike **(Rr)**
European Starling
Philadelphia Vireo*
Red-Eyed Vireo
Solitary Vireo *
Warbling Vireo *
White-Eyed Vireo
Yellow-Throated Vireo
Bay-Breasted Warbler *
Black-and-White Warbler
Black-Throated Blue Warbler
Black-Throated Green Warbler
Blackburnian Warble r *
Blackpoll Warbler
Blue-Winged Warbler
Cape May Warbler *
Cerulean Warbler *
Chestnut-sided Warbler
Connecticut Warbler *
Golden-Winged Warbler *
Hooded Warbler*
Kentucky Warbler *
Magnolia Warbler *
Mourning Warbler *
Nashville Warble r*
Palm Warbler
Pine Warbler *
Prairie Warbler *
Prothonotary Warbler*
Tennessee Warbler
Wilson's Warble r*
Yellow Warbler
Yellow-Rumped Warbler
Yellow-Throated Warbler *

Northern Parula
American Redstart
Ovenbird
Louisiana Waterthrush *
Northern Waterthrush*
Common Yellowthroat
Yellow-Breasted Chat*
Scarlet Tanager
Summer Tanager*
Northern Cardinal
Evening Grosbeak*
Rose-Breasted Grosbeak
Indigo Bunting*
Rufous-Sided Towhee
American Tree Sparrow
Chipping Sparrow
Field Sparrow
Fox Sparrow*
Grasshopper Sparrow *
Henslow's Sparrow
House Sparrow
Lincoln's Sparrow*
Savannah Sparrow*
Song Sparrow
Swamp Sparrow
Vesper Sparrow*
White-Throated Sparrow *
Dark-Eyed Junco
Snow Bunting *
Bobolink **(Rr)**
Eastern Meadowlark *
Red-Winged Blackbird
Rusty Blackbird
Yellow-Headed Blackbird *
Common Grackle
Brown-Headed Cowbird
Northern Oriole
Orchard Oriole *
House Finch
Purple Finch *
Red Crossbill *
White-Winged Crossbill *
Common Redpoll *
Pine Siskin *
American Goldfinch

Reptiles & Amphibians
Snapping Turtle
Stinkpot (Musk Turtle)
Eastern Mud Turtle *
Spotted Turtle
Bog Turtle **(Rr)**
Wood Turtle **(Rr)**
Eastern Box Turtle
Eastern Painted Turtle
Five-Lined Skink *
Northern Water Snake
Northern Brown Snake
Eastern Ribbon Snake
Eastern Garter Snake
Earth Snake *
Eastern Hognose Snake *
Northern Ringneck Snake *
Eastern Worm Snake *
Northern Black Racer *
Eastern Smooth Green Snake *
Black Rat Snake *
Eastern Milk Snake *
Blue-Spotted Salamander **(Rr)**
Red-Spotted Newt
Northern Dusky Salamander
Red-Backed Salamander
Slimy Salamander
Four-Toed Salamander *
American Toad
Fowler's Toad
Northern Cricket Frog
Northern Spring Peeper
Gray Tree Frog
N J Chorus Frog
Upland Chorus Frog *
Bullfrog
Green Frog
Northern Leopard Frog
Pickerel Frog *
Wood Frog

Fish
White Sucker
Creek Chubsucker
Carp
Meadows
Golden Shiner
Brown Bullhead
Chain Pickerel
Eastern Mudminnow
Redfin Pickerel
American Eel
Smallmouth Bass
Largemouth Bass
Banded Sunfish
Pumpkinseed
Bluegill
Black Crappie
Tessalated Darter
Redbreast Sunfish
Fallfish
Common Shiner
Spottail Shiner
Yellow Bullhead
Bluespotted Sunfish
Satinfin Shiner
Mud Sunfish
Spotfin Shiner
Green Sunfish
Blacknose Dace
Creek Chub
Brook Trout

Insects
Silver-bordered Fritillary **(Rr)**
Harris' Checkerspot **(Rr)**
Bronze Copper **(Rr)**
Regal Fritillary **(Rr)**



Eastern Cottontail Rabbit

Sources:
US Dept. Of The Interior. Fish and Wildlife Service, Birds of Great Swamp, National Wildlife Refuge, Sept. 1985.
US Dept. Of The Interior. Fish and Wildlife Service, Reptiles, Amphibians and Fishes, Great Swamp National Wildlife Refuge, Aug. 1988.

Appendix B

Wildlife Of The Highlands

Birds
Acadian flycatcher
Alder flycatcher
American bittern (Rr)
American goldfinch
American redstart
Bald eagle (Rr)
Bank swallow
Barn swallow
Barred owl (Rr)
Belted kingfisher
Black and white warbler
Black capped chickadee
Bl. throated green warbler
Blue gray gnatcatcher
Blue grosbeak
Blue jay
Blue winged warbler
Bobolink (Rr)
Broad winged hawk
Brown headed cowbird
Brown thrasher
Canada warbler
Canada goose
Carolina wren
Cattle egret
Chestnut sided warbler
Chipping sparrow
Common crow
Common flicker
Common grackle
Common yellowthroat
Cooper's hawk (Rr)
Downy woodpecker
Eastern bluebird
Eastern wood pewee
Eastern phoebe
English sparrow
Field sparrow
Golden winged warbler
Grasshopper sparrow (Rr)
Gray catbird
Great blue heron (Rr)
Great crested flycatcher
Great horned owl
Green backed heron
Hairy woodpecker
Hermit thrush
Hooded warbler
House wren
Indigo bunting
Killdeer
Kingbird
Louisiana waterthrush
Mallard
Mockingbird
Mourning dove
Mute swan
Northern cardinal
Northern goshawk (Rr)
Northern oriole
Northern parula
Northern waterthrush
Osprey (Rr)
Ovenbird
Pileated woodpecker
Prairie warbler
Red-bellied woodpecker
Red-headdwoodpecker(Rr)
Red-shouldered hawk (Rr)
Red eyed vireo
Red tailed hawk
Ring-necked pheasant
Robin
Rose breasted grosbeak
Wood duck
Rough winged swallow
Ruby throated hummingbird
Ruffed grouse
Rufous sided towhee
Scarlet tanager
Song sparrow
Spotted sandpiper
Starling
Tree swallow
Tufted titmouse
Turkey vulture
Veery
White breasted nuthatch
Wild turkey
Wood thrush
Worm eating warbler
Yellow billed cuckoo
Yellow throated vireo
Yellow warbler

Mammals
Beaver
Big brown bat
Black bear
Black rat
Bobcat
Coyote
Eastern cottontail
Eastern pipistrelle bat
Estrn. small-footed bat (Rr)
Eastern wood rat (Rr)
Gray fox
Gray squirrel
House mouse
Indiana bat (Rr)
Keen's bat
Little brown bat
Longtailed weasel
Meadow vole
Mink
Mole
Muskrat
Norway rat
Opossum
Porcupine
Raccoon
Red bat
Red fox
River otter
Shorttail shrew
Squirrel
Striped skunk
Vole
Woodchuck
Woodland mouse

Amphibians
American toad
Bullfrog
Eastern newt
Fowler's toad
Green frog
Jefferson salamander
Leopard frog
Mole salamander
Northern chorus frog
Northern cricket frog
Northern dusky salamander
Northern red salamander
Pickerel frog
Redback salamander
Slimy salamander
Spotted salamander
Spring peeper
Striped newt
Wood frog

Reptiles
Black racer
Black rat snake
Bog turtle (Rr)
Copperhead
DeKay's brown snake
Eastern box turtle
Eastern garter snake
Eastern hog-nosed snake
Eastern mud turtle
Eastern painted turtle
Eastern snapping turtle
Five lined skink
Milk snake
Musk turtle
Northern water snake
Northern ring-necked snake
Spotted turtle
Timber rattlesnake (Rr)
Wood turtle (Rr)

Sources: The Highlands Study Team, New York-New Jersey Highlands Regional Study.
US Fish and Wildlife Service, Pilot Study on the Feasibility of Protecting The Beaver Brook Area in the Townships of Rockaway, Denville, and Boonton and the Borough of Kinnelon, Morris County, New Jersey, Technical Assistance Report (Special Project NJFO-91-2), Summary of Breeding Bird Survey; ARDEC Land Management, Spot Count Method - 100 Stations, April 1991.
NJ DEPE, Division of Parks and Forestry, Farny Natural Area Management Plan, June 6, 1994.
NJ DEP, Division of Parks and Forestry, Natural Lands Management, Natural Heritage Priority Site Maps, Aug. 3, 1995.
Alison E. Mitchell, The New Jersey Highlands: Treasures at Risk, NJ Conservation Foundation, 1992.

Appendix C

Morris County Rare Species and Natural Communities Presently Recorded in the New Jersey Natural Heritage Database

NAME	COMMON NAME	FEDERAL STATUS	STATE STATUS	GRANK	SRANK
Vertebrates					
Accipiter Cooperii	Cooper's Hawk	-	E	G5	S2
Accipiter Gentilis	Northern Goshawk	-	E/E	G5	S1
Ambystoma Laterale	Blue-Spotted Salamander	-	E	G5	S1
Ammodramus Savannarum	Grasshopper Sparrow	-	T/T	G5	S2
Ardea Herodias	Great Blue Heron	-	S/S	G5	S2
Asio Otus	Long-Eared Owl	-	T/T	G5	S3
Bartramia Longicauda	Upland Sandpiper	-	E	G5	S1
Botaurus Lentiginosus	American Bittern	-	E/S	G4	S2
Buteo Lineatus	Red-Shouldered Hawk	-	E/T	G5	S2
Circus Cyaneus	Northern Harrier	-	E/U	G5	S2
Cistothorus Platensis	Sedge Wren	-	E	G5	S1
Clemmys Insculpta	Wood Turtle	-	T	G4	S3
Clemmys Muhlenbergii	Bog Turtle	LT	E	G3	S2
Crotalus Horridus Horridus	Timber Rattlesnake	-	E	G5T5	S2
Dolichonyx Oryzivorus	Bobolink	-	T/T	G5	S2
Eurycea Longicauda	Longtail Salamander	-	T	G5T5	S2
Haliaceetus Leocephalus	Bald Eagle	LTNL	E	G4	S1
Lanius Ludovicianus Migrans	Loggerhead Shrike	-	E	G5T3Q	S1
Lynx Rufus	Bobcat	-	E	G5	S3
Melanerpes Erythrocephalus	Red-Headed Woodpecker	-	T/T	G5	S3
Myotis Leibii	Small-Footed Myotis	-	U	G3	S1
Myotis Sodalis	Indiana Bat	LE	E	G2	S1
Neotoma Magister	Eastern Woodrat	-	E	G3G4	S1
Pandion Haliaetus	Osprey	-	T/T	G5	S3
Passerculus Sandwichensis	Savannah Sparrow	-	T/T	G5	S2
Strix Varia	Barred Owl	-	T/T	G5	S3
Invertebrates					
Aeshna Clepsydra	Mottled Darner	-	-	G4	S?
Aeshna Mutata	Spatterdock Darner	-	-	G3G4	S1?
Aeshna Tuberculifera	Black-Tipped Darner	-	-	G4	S1?
Alasmidonta Heterodon	Dwarf Wedgemussel	LE	E	G1	S1
Alasmidonta Undulata	Triangle Floater	-	-	G4	S3
Alasmidonta Varicosa	Brook Floater	-	-	G3	S1
Amblyscirtes Hegon	Pepper and Salt Skipper	-	-	G5	S2S3
Arigomphus Furcifer	Lilypad Clubtail	-	-	G5	S1?
Boloria Selene Myrina	A Silver-Bordered Fritillary	-	-	G5T5	S2
Chlosyne Harrisii	Harris' Checkerspot	-	-	G4	S3?
Cordulegaster Obliqua	Arrowhead Spiketail	-	-	G4	S1?
Enallagma Basidens	Double-Striped Bluet	-	-	G5	S2?
Enallagma Laterale	New England Bluet	-	-	G3	S1

NAME	COMMON NAME	FEDERAL STATUS	STATE STATUS	GRANK	SRANK
Gomphus Rogersi	Sable Clubtail	-	-	G4	S1?
Lampsilis Radiata	Eastern Lampmussel	-	-	G5	S3
Lanthus Vernalis	Single-Striped Clubtail	-	-	G4	S1?
Lycaena Hyllus	Bronze Copper	-	-	G5	S1?
Manduca Jasminearum	Ash Sphinx	-	-	G4	SU
Neonympha Mitchellii Mitchellii	Mitchell's Satyr	LE	E	G2T2	SH
Ophiogomphus Aspersus	Brook Snaketail	-	-	G3G4	S1?
Ophiogomphus Mainensis	Twin-Horned Snaketail	-	-	G4	S1?
Papaipema Necopina	Sunflower Borer Moth	-	-	G4?	SH
Papilio Cresphontes	Giant Swallowtail	-	-	G5	S1S2
Polites Mystic	Long Dash	-	-	G5	S3?
Pyrgus Wyandot	Grizzled Skipper	-	-	G2	SH
Satyrium Acadicum	Acadian Hairstreak	-	-	G5	S2S3
Somatochlora Washii	Walsh's Emerald	-	-	G5	S1?
Somatochlora Williamsoni	Williamson's Emerald	-	-	G5	S1?
Speyeria Idalia	Regal Fritillary	-	-	G3	SX
Other Types					
Bat Hibernaculum	Bat Hibernaculum	-	-	G?	S?

CODES USED IN NATURAL HERITAGE REPORTS

The following status codes were derived pursuant to the Endangered and Nongame Species Conservation Act of 1973 (NSSA 23:2A-13 et seq.). They were compiled from the list of endangered species (N.J.A.C. 7:25-4.13) and the list defining status of indigenous, nongame wildlife species of New Jersey (N.J.A.C. 7:25-4.17[a])

FEDERAL STATUS CODES

The following categories and definitions of endangered and threatened animals have been modified from the U.S. Fish and Wildlife Service (F.R. Vol. 50 No. 188; Vol. 61, No. 40; F.R. 50 CFR 17).

LE: Taxa formally listed as endangered.

LT: Taxa formally listed as threatened.

STATE STATUS CODES:

E: Endangered species - one whose prospects for survival within the state are in immediate danger due to one or many factors - a loss of habitat, over exploitation, predation, competition, disease. An endangered species requires immediate assistance or extinction will probably follow.

S: Stable species - a species whose population is not undergoing any long-term increase/decrease within its natural cycle.

T: Threatened species - a species that may become endangered if conditions surrounding the species begin to or continue to deteriorate.

U: Undetermined species - a species about which there is not enough information available to determine the status.

Status for animals separated by a slash(/) indicate a dual status. First status refers to the state breeding population, and the second status refers to the migratory or winter population.

GLOBAL ELEMENT RANKS:

G1: Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

G2: Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3: Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range; with the number of occurrences in the range of 21 to 100.

G4: Secure globally although may be quite rare in parts of its range, especially at the periphery.

G5: Secure globally; although it may be quite rare in parts of its range, especially at the periphery.

G?: Species has not yet been ranked.

Q: Taxon is of questionable, or uncertain taxonomical standing.

T: Indicates that the infraspecific taxon is being ranked differently than the full species.

STATE ELEMENT RANKS (Specific to New Jersey):

S1: Critically imperiled in New Jersey because of extreme rarity (5 or fewer occurrences or very few remaining individuals or access). Species are often restricted to an extremely small (3%) geographical area of the state. Also included are species which were formerly more abundant, but because of habitat destruction or some other critical factor of its biology, they have been demonstrably reduced in abundance. These are species for which, even with intensive searching, sizable additional occurrences are unlikely to be discovered.

S2: Imperiled because of rarity (6 to 20 occurrences), due primarily to habitat destruction. Also includes species which occur in habitats restricted to 10% of the total state area.

S3: Rare with 21 to 100 occurrences**.** Includes species which are widely distributed but with small populations, and also in habitats which may be common or widespread. Species having a moderately restricted distribution (but greater than 10%) in New Jersey, but are locally abundant. Not yet imperiled in state but may soon be if additional populations are destroyed.

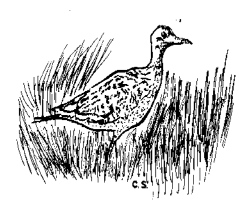
SH: Species of historical occurrence. Despite some searching of historical occurrences and/or potential habitat, no extant occurrences have been confirmed. Since not all of the historical occurrences have been field surveyed, and unsearched potential habitat remains, historically ranked taxa are considered possibly extant, and remain a conservation priority for continued field work.

SU: Species believed to be in peril but the degree of rarity is uncertain. Also included are rare taxa of uncertain taxonomical standing. More information is needed to resolve rank.

SX: Species that have been determined or are presumed to be extirpated from New Jersey. All historical occurrences have been searched (or are conclusively known to have been destroyed), and a reasonable search of potential habitat has been completed. Extirpated taxa are not a current conservation priority.

Note: To express uncertainty, the most likely rank is assigned and a question mark added. A range is indicated by combining two ranks (e.g., G1G2, S1S3).

Sources: The Natural Heritage Network. Standardized data on endangered species and communities, www.heritage.tnc.org, March 16, 1999 and phone conversation with Thomas Breden, Natural Heritage Program, NJ DEP, Nov. 19, 1999.



* Upland Sandpiper

Appendix D
Wildlife In Morris County

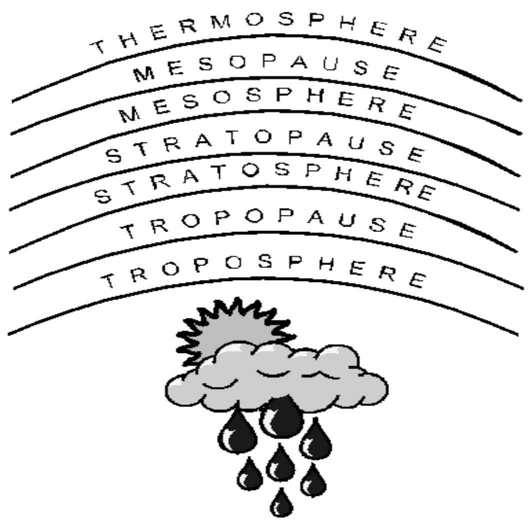
Scientific Name	Common Name
Acantharchus pomotis	Mud Sunfish
Accipiter cooperii	Cooper's Hawk
Accipiter gentilis	Northern Goshawk
Accipiter striatus	Sharp-shinned Hawk
Acris crepitans	Northern Cricket Frog
Agelaius phoeniceus	Red-winged Blackbird
Agkistrodon contortrix mokasen	Northern Copperhead
Aix sponsa	Wood Duck
Ambloplites rupestris	Rock bass
Ambystoma Jeffersonianum	Jefferson Salamander
Ambystoma laterale	Blue-spotted Salamander
Ambystoma maculatum	Spotted Salamander
Ambystoma opacum	Marbled Salamander
Ambystoma tidae	Mole Salamander
Ammodramus Henslowii	Henslow's sparrow
Ammodramus Savannarum	Grasshopper Sparrow
Anas platyrhynchos	Mallard
Anas rubripes	American Black Duck
Anguilla rostrata	American Eel
Archilochus colubris	Ruby-throatHummingbrd
Ardea herodias	Great Blue Heron
Asio Otus	Long-Eared Owl
Boloria Selene Myrina	Silver-Bordered Fritillary
Bombycilla cedrorum	Cedar Waxwing
Bonasa umbellus	Ruffed Grouse
Botaurus Lentiginosus	American Bittern
Branta canadensis	Canada Goose
Bubo virginianus	Great Horned Owl
Bubulcus ibis	Cattle Egret
Bufo americanus	American Toad
Bufo woodhousei fowleri	Fowler's Toad
Buteo jamaicensis	Red-tailed hawk
Buteo lineatus	Red-shoulder hawk
Buteo platypterus	Broad-winted Hawk
Butorides striatus	Green-backed Heron
Cardinalis cardinalis	Northern Cardinal
Carduelis flammea	Common Redpoll
Carduelis tristis	American Goldfinch
Carphophis amoenus	Eastern Worm Snake
Carpodacus mexicanus	House Finch
Carpodacus purpureus	Purple Finch
Catostomus commersoni	White sucker
Cathartes aura	Turkey Vulture
Catharus fuscescens	Veery
Catharus guttatus	Hermit Thrush
Catharus ustulatus	Swainson's Thrush
Catostomus commersoni	White Sucker
Centurus carolinus	Red-bellied woodpecker
Certhia americana	Brown Creeper
Ceryle alcyon	Belter Kingfisher
Chaetura pelagica	Chimney Swift
Charadrius vociferus	Killdeer
Chelydra serpentina	Snapping turtle
Chlosyne Harrisii	Harris' Checkerspot
Chordeiles minor	Common Nighthawk
Chrysemys picta	Painted Turtle
Circus synaeus	Northern Harrier
Cistothorus Platensis	Sedge Wren
Clemmys muhlenbergi	Bog Turtle
Clemmys insculpta	Wood Turtle

Scientific Name	Common Name
Clemmys guttata	Spotted Turtle
Coccothraustes vespertinus	Evening Grosbeak
Coccyzus americanus	Yellow-billed Cuckoo
Coccyzus erythropthalmus	Black-billed Cuckoo
Colaptes auratus	Northern Flicker
Coluber constrictor	Northern Black Racer
Columba livia	Rock Dove
Contopus virens	Eastern Wood-Pewee
Corvus brachyrhynchos	American Crow
Crotalus horridus	Timber Rattlesnake
Cyanocitta cristata	Blue Jay
Cyprinus carpio	Carp
Dendroica caerulescens	Black-throated BlueWarbler
Dendroica castanea	Bay-breasted Warbler
Dendroica coronata	Myrtle Warbler
Dendroica discolor	Prairie Warbler
Dendroica fusca	Blackburnian Warbler
Dendroica magnolia	Magnolia Warbler
Dendroica palmarum	Palm Warbler
Dendroica pensylvanica	Chestnut-sided Warbler
Dendroica petechia	Yellow Warbler
Dendroica striata	Blackpoll Warbler
Dendroica tigrina	Cape May Warbler
Dendroica virens	Black-throated Green Warbler
Desmognathus fuscus	Northern Dusky Salamander
Diadophis punctatus edwardsi	Northern Ringneck Snake
Didelphus virginiana	Oppossum
Dolichonyx oryzivorus	Bobolink
Dryocopus pileatus	Pileated Woodpecker
Dumetella carolinensis	Gray Catbird
Elaphe obsoleta	Black Rat Snake
Enneacanthus gloriosus	Bluespotted Sunfish
Enneacanthus obesus	Banded Sunfish
Erimyzon oblongus	Creek Chubsucker
Erethizon dorsatum	Porcupine
Esox americanus	Redfin Pickerel
Esox niger	Chain Pickerel
Etheostoma olmstedi	Tessalated Darter
Eumeces fasciatus	Five-lined Skink
Eurycea bislinenata bislineata	Nrthrn 2-lined Salamander
Eurycea longicauda	Long-tailed Salamander
Falco sparverius	American Kestrel
Gallinago gallinago	Common Snipe
Geothlypis trichas	Common Yellowthroat
Glaucomys volans	Southern Flying squirrel
Hemidactylium scutatum	Four-Toed Salamander
Heterodon platyrhinos	Eastern Hognose Snake
Hirundo pyrrhonota	Cliff Swallow
Hirundo rustica	Barn Swallow
Hyla crucifer	Northern Spring Peeper
Hyla versicolor	Gray Tree Frog
Hylocichla mustelina	Wood Thrush
Ictalurus natalis	Yellow Bullhead
Ictalurus nebulosus	Brown Bullhead
Icterus galbula galbula	Northern Oriole
Junco hyemalis	Dark-Eyed Junco
Kinosternon subrubrum	Eastern Mud Turtle
Lampropeltis triangulum	Eastern Milk Snake
Lanius excubitor	Northern Shrike
Lepomis auritus	Redbreast Sunfish

Scientific Name	Common Name
Lepomis cyanellus	Green Sunfish
Lepomis gibbosus	Pumpkinseed
Lepomis macrochirus	Bluegill
Loxia curvirostra	Red Crossbill
Loxia leucoptera	White Winged Crossbill
Lutra canadensis	River Otter
Lynx rufus	Bobcat
Marmota monax	Woodchuck
Melanerpes carolinus	Red-Bellied Woodpecker
Melanerpes erythrocephalus	Red-Headed Woodpecker
Melospiza georgiana	Swamp Sparrow
Melospiza melodia	Song Sparrow
Mephitis mephitis	Striped skunk
Micropterus dolomieui	Smallmouth Bass
Micropterus salmoides	Largemouth Bass
Mimus polyglottos	Northern Mockingbird
Mniotilta varia	Black-and-white Warbler
Molothrus ater	Brown-headed Cowbird
Mus musculus	House mouse
Mustela frenata	Longtailed weasels
Mustela vison	Mink
Myiarchus crinitus	Great Crested Flycatcher
Myotis Leibii	Eastern Small-Footed Myot
Myotis lucifugus	Little Brown Myotis
Myotis Sodalis	Indiana Bat
Natrix sipedon	Northern Water Snake
Neotoma floridana	Eastern Woodrat
Neotoma Magister	Eastern Woodrat
Notemigonus crysoleucas	Golden Shiner
Notophthalmus viridescens	Red-spotted Newt
Notropis analostanus	Satinfin Shiner
Notropis cornutus	Common Shiner
Notropis hudsonius	Spottail Shiner
Notropis spilopterus	Spotfin Shiner
Odocoileus virginianus	Whitetail deer
Ondatra zibethica	Muskrat
Opheodrys vernalis	Eastern Smooth Green Snake
Oporornis formosus	Kentucky Warbler
Otus asio	Screech Owl
Pandion haliaetus	Osprey
Parula americana	Northern Parula
Parus atricapillus	Black-capped Chickadee
Parus bicolor	Tufted Titmouse
Passer domesticus	House Sparrow
Passerculus Sandwichensis	Savannah Sparrow
Passerella iliaca	Fox Sparrow
Passerina cyanea	Indigo Bunting
Phasianus colchicus	Ring-necked Pheasant
Pheucticus ludovicianus	Rose-breasted Grosbeak
Picoides pubescens	Downy Woodpecker
Picoides villosus	Hairy Woodpecker
Pinicola enucleator	Pine Grosbeak
Pipilo erythrophthalmus	Rufous-sided Towhee
Pipistrellus subflavus	Eastern pipistrelle
Piranga olivacea	Scarlet Tanager
Plethodon cinereus	Red-backed Salamander
Plethodon glutinosus	Slimy Salamander
Polioptila caerulea	Blue-grayGnatcatcher
Pomoxis nigromaculatus	Black Crappie
Procyon lotor	Raccoon
Progne subis	Purpose Martin
Pseudacris triseriata kalmi	New Jersey Chorus Frog
Pseudacris triseriata feriarum	Upland Chorus Frog
Quiscalus quiscula	Common Grackle
Rana catesbeiana	Bullfrog

Scientific Name	Common Name
Rana clamitans melanota	Green Frog
Rana palustris	Pickerel Fro
Rattus norvegicus	Norway Rat
Rana pipiens	Northern Leopard Frog
Rana sylvatica	Wood Frog
Rattus rattus	Black Rat
Regulus calendula	Ruby-Crowned Kinglet
Regulus satrapa	Golden-Crowned Kinglet
Rhinichthys atratulus	Blacknose Dace
Rhinichthys cataractae	Longnose Dace
Salmo gairdneri	Rainbow Trout
Salmo trutta	Brown Trout
Salvelinus fontinalis	Brook Trout
Sayornis phoebe	Eastern Phoebe
Sciurus carolinensis	Eastern Gray Squirrel
Scolopax minor	American Woodcock
Seiurus aurocapillus	Ovenbird
Semotilus atromaculatus	Creek Chub
Semotilus corporalis	Fallfish
Setophaga ruticilla	American Redstart
Sialia sialis	Eastern Bluebird
Sitta cadensis	Red-Breasted Nuthatch
Sitta carolinenesis	White-Breasted Nuthatch
Speyeria Idalia	Regal Fritillary
Sphyrapicus varius	Yellow-Bellied Sapsucker
Spizella arborea	American Tree Sparrow
Spizella Passerina	Chipping Sparrow
Spizella pusilla	Field Sparrow
Sternotherus odoratus	Stinkpot (Musk Turtle)
Storeria dekayi	Northern Brown Snake
Strix varia	Barred Owl
Sturmus vulgaris	European Starling
Sturnella magna	Eastern Meadowlark
Sylvilagus floridanus	Eastern Cottontails
Tachycineta bicolor	Tree Swallow
Tamias striatus	Easter Chipmunk
Tamiasciurus hudonicus	Red Squirrel
Terrapene carolina	Eastern Box Turtle
Thamnophis sauritus	Eastern Ribbon Snake
Thamnophis sirtalis	Eastern Garter Snake
Thryothorus ludovicianus	Carolina Wren
Troglodytes aedon	House Wren
Troglodytes trotlodytes	Winter Wren
Turdus migratorius	American Robin
Tyrannus tyrannus	Eastern Kingbird
Umbra pygmaea	Eastern Mudminnow
Urocyon cinereoargenteus	Gray Fox
Ursus americanus	Black Bear
Vermivora peregrina	Tennessee Warbler
Vermivora pinus	Blue-Winged Warbler
Vermivora ruficapilla	Nashville Warbler
Vireo flavifrons	Yellow-Throated Vireo
Vireo griseus	White-Eyed Vireo
Vireo olivaceus	Red-Eyed Vireo
Vireo solitarius	Solitary Vireo
Virginia valeriae	Earth Snake
Vulpes vulpes	Red Fox
Wilsonia canadensis	Canada Warbler
Zenaida macroura	Mourning Dove
Zonotrichia albicollis	White-Throated Sparrow

Savannah Sparrow



Air and Climatology

Introduction

Climatology reflects a component of our ecosystem whose operating mechanisms are complex and impacts are profound. Weather's expressions includes precipitation of all forms, temperature, and wind. Geography, terrain, vegetation, natural and human-derived chemical constituents are some of the principal participants. These, in turn, affect air and water quality, flooding, droughts, flora and fauna and even human vitality.

The Atmosphere

As we continue our exploration from the crust of the earth upward, we find an heterogeneous atmosphere. Distinct "layers" have specific characteristics. We begin with the troposphere wherein weather is formed. It serves as insulation for some of the sun's captured energy as it radiates to and rebounds from the oceans and land. With increasing elevation is a concurrent decrease in temperature. The upper extent of the troposphere, or tropopause, is so cold as to cause migrating water vapor to condense or freeze, preventing further ascension through the higher spheres. Next we proceed through the stratosphere where temperatures begin to climb due to ozone production. Passing through the stratopause, we arrive at the mesophere which reverts to an ascending cooling pattern. As we exit via the mesopause, we reach the outlying thermosphere.

Weather

Weather is driven by many factors, interacting on a global scale. In essence, our atmosphere is sectioned into convection cells. These units contain perpetually cycling currents of air. The sun's energy, serving as the primary mobilizer behind atmospheric circulation, provides intense solar radiation at the equator. The warmed air which is less dense rises, spreads out and sinks with cooler air moving in from the poles.

This model of circulation receives continual influences, both globally and locally. The earth's rotation effects an overall east-west direction of air flow. Land surfaces also impact flow. Wind direction and speed are influenced by topography as evidenced by its channeling through valleys and ascent up mountain slopes. Land cover is influential with densely vegetated areas reducing wind speeds by 30% to 40%.[1]

While our weather conditions may seem drastically variable, and global warming is a phenomenon that cannot be ignored, the system as a whole is relatively stable. New Jersey's temperature fluctuations are mitigated by the stabilizing nature offered by the Atlantic Ocean. Occasionally, however, extreme weather events do occur in the form of hurricanes, tropical storms, and "northeasters."

Most of the U.S. is in a zone of westerlies, in which winds generally blow from west/southwest to east/northeast. New Jersey experiences seasonal variations of this pattern. During the winter, prevailing winds are from the west or northwest. "Frequent surges of cold air masses move southward over the State ... Such outbreaks of cold weather are preceded by the passage of a frontal system, generally in association with a vigorous cyclonic system. These general systems often are associated with large quantities of snow or rain"[2] which can result in widespread flooding.

In summer, the main system arriving from the southwest is the Bermuda High. It transports warm, moist air from the Gulf of Mexico, arriving as "hot and muggy summer days with temperatures that occasionally reach 100 F in the interior sections of the State."[3] Instability in the north-moving flow of air and the passage of frontal systems can yield thundershowers that provide abundant moisture coupled with local flooding.

PRECIPITATION Annual precipitation in the north-central part of the state is roughly 52 inches.[4] Actual precipitation data for the county is collected at several weather stations. Table 1 lists average annual precipitation from 1978 - 1997. The average annual precipitation for the county (as calculated by averaging total weather stations' data[5]) during the time span 1978 - 1997, was 55.49 inches/year.

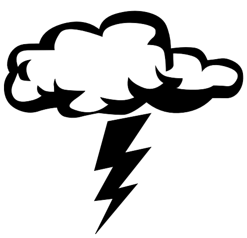


Table 1 - Average Annual Precipitation
1978 - 1997

Station	Inches/year
Wharton (1978-1990)	47.04
Boonton (1978-1997	49.01
Charlotteburg Res.	51.69
Pottersville	51.34
Oak Ridge Res.	51.21
Long Valley	51.59

[1]Montgomery, 184.

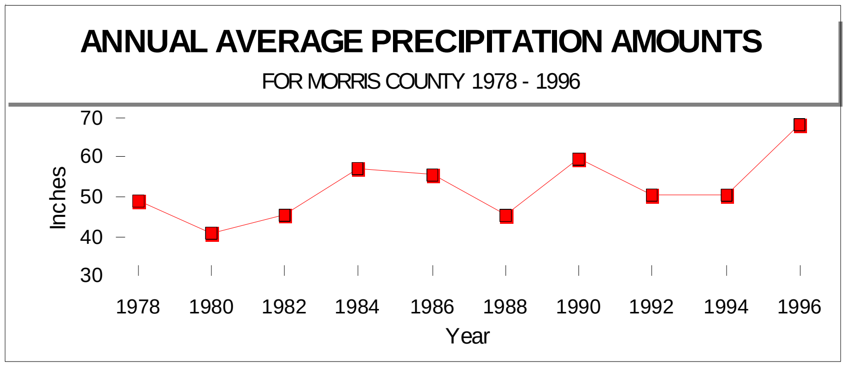
[2]Bauersfeld, W.R. and R.D. Schopp (U.S. Geological Survey) and M.D. Schulman (Rutgers University), "New Jersey Floods and Droughts." National Water Summary 1988-89 Floods and Droughts: NJ.

[3]Ibid, 2.

[4]Ibid.

[5]National Oceanic and Atmospheric Administration, Climatological Data Annual Summary New Jersey, 1978, 1980, 1982, 1984, 1986, 1988, 1990, 1992, 1994, 1995, 1996, 1997, Newark, NJ (EWR).

Graph A illustrates the variation in annual average precipitation amounts for the county derived from combined figures from all weather stations.



Graph A

While annual **snowfall** reaches almost 50" in the northern uplands, the record mean as measured at the Newark station is 27.6 inches.[6] Extended, widespread **droughts** are infrequent in this area. However, short-term local droughts can be serious as recently experienced during the summer of 1995.[7] 1998 experienced a normal annual precipitation although it ended the year in a near drought emergency. The Passaic River, near Chatham, had the lowest streamflow in 71 years of record, and at Little Falls, the lowest in 102 years of record.[8] The drought of 1961-66 was the most severe in NJ's history with a record low total rainfall in 1965 with 26.09" falling at the Newark station.[9]

The average annual temperature[10] derived from the four stations in Morris County, for the time span 1982 - 1996 was 49.45 F. Temperature extremes and freeze data for the time period ranging from 1978 - 1996 reveal the highest recorded temperature occurring in July of 1988.[11] Temperatures of 100 degrees were reported at Boonton and Morris Plains. The lowest recorded temperature of -24 degrees occurred January 22, 1984 at Charlotteburg Reservoir.[12]

Average Annual Temperature
1982 - 1996

Charlotteburg	48.70
Long Valley	48.73
Morris Plains (‘84-’88)	49.66
Boonton	50.69

[6]Bauersfeld.

[7]Ibid.

[8]US Geologic Survey, Summary of Monthly Hydrologic Conditions in New Jersey, West Trenton, NJ, Dec. 1998.

[9]National Oceanic and Atmospheric Administration, Local Climatological Data Annual Summary with Comparative Data, Newark, NJ (EWR) 1994.

[10]NOAA, Climatological Data Annual Summary NJ 1978, 1980, 1982, 1984, 1986, 1988, 1990, 1992; & Local Climatological Data Annual Summary with Comparative Data, Newark, NJ (EWR)1994, 1996.

[11]NOAA, Climatological Data Annual Summary New Jersey 1988, 93:13.

[12]NOAA, Climatological Data Annual Summary New Jersey 1984, 89:13.

More Than Hot Air

Our atmosphere is a cauldron of ingredients, providing transportation to particles, a medium for chemical reactions, and a recycling depot for inherent or human-derived components. Components include oxygen, nitrogen, carbon, sulfur, water, aerosols, particulates, metals such as arsenic, barium, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, vanadium, and zinc and the chemically inert gases including argon, helium, and neon. When these constituents are either disproportionately increased, or compounded (e.g., oxides of carbon, nitrogen, and sulfur) their participation in the airshed is significantly modified.

OXYGEN About 1/5 of all molecules in the atmosphere are oxygen (O_2).[13] It is an active participant in biological and chemical processes. Oxygen is added to the atmosphere during photosynthesis by plants. It is removed by oxygen breathing organisms, by solution in the oceans, by reaction with rocks during weathering, and by combustion.

OZONE A natural and valuable constituent in the upper atmosphere, ozone presents a significant environmental problem when near the ground, contributing to smog creation. In the upper atmosphere (stratosphere) it absorbs potentially harmful ultraviolet radiation, protecting biological activities on earth. Health risks associated with ultraviolet radiation exposure include an increase in skin cancer frequency.

Ground level ozone is formed when sunlight reacts with hydrocarbons and nitrogen oxides. These are emitted primarily from motor vehicles, but also power plants, chemical plants, dry cleaners, and paint shops. Ozone reaches its highest concentration during hot summer months when heat and sunlight are most intense. Thus from morning to mid-to-late afternoon, April through September, ozone presents a serious concern for New Jerseyans.

Weather and pollution emission patterns determine which parts of New Jersey will have high ozone concentrations. Northeastern New Jersey generally has the highest levels in the state. Ozone serves well to demonstrate regional impacts. Precursor pollutants are emitted to the south and west of us and follow wind currents. This transportation corridor extends from Washington, D.C. to Maine. Emissions generated in New Jersey are in turn converted to ozone in the north.

NITROGEN Over 3/4 of the molecules in the atmosphere are nitrogen.[14] While biological action accounts for 90% of nitrogen dioxide (NO_2)contribution to the atmosphere, human additions are significant by way of sheer concentration, primarily in urban and industrialized areas. Autos, trucks and airplanes consuming fossil fuels, are responsible for 55% of NO_2 production. Forty percent of nitrogen oxides (NOX) emissions come from stationary sources including industrial boilers, electric generating facilities, asphalt plants and drying ovens used in manufacturing processes. The remaining 5% of NOX emissions comes from mobile sources such as construction, landscaping equipment and diesel trains.

Nitrogen oxide, working with strong sunlight, contributes to form both ozone and smog. Nitrogen oxides also react with water vapor forming acid rain and nitric acid which are both irritants and corrosives.

---

[13]Carla W. Montgomery, Environmental Geology (Iowa: Wm. C. Brown Publishers, 1986), 329.

[14]Samuel J. Williamson, Fundamentals of Air Pollution (Massachusetts: Addison-Wesley Publishing Company, 1973), 55.

CARBON The impact of carbon is felt by way of its compounds. Carbon monoxide (CO) is derived mainly from fossil-fuel burning. The single largest source of CO in the atmosphere is the automobile. Motor vehicles contribute roughly 90% of CO with stationary sources supplying the balance.[15] This is particularly pronounced in heavily trafficked areas. In urban areas congestion coupled with tall buildings trap the polluted air. Temperature inversion layers, likely to occur during winter, prevent dispersal of CO, causing exceedances of standards.

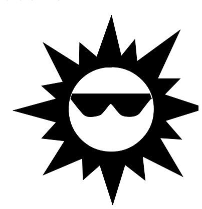
Carbon dioxide (CO_2) is produced through natural processes including volcanic eruptions, respiration by oxygen-breathing organisms, and combustion. Removal occurs during photosynthesis and solution in the oceans. CO_2 shows seasonal variations in response to the growth cycle of vegetation in each hemisphere.

SULFUR Sulfur is emitted primarily from coal combustion in factories, power generating plants, in some home heating units, and from the refining and burning of petroleum. Within a few days of release into the atmosphere, sulfur dioxide reacts with water vapor and O_2 in the atmosphere to form sulfuric acid (H_2SO_4). The resulting precipitation referred to as acid rain, threatens entire ecosystems. Acid precipitation has been linked to the destruction of vegetation and aquatic life, the contamination of potable water supplies due to leaching of heavy metals, the accelerated weathering of materials, the aggravation of respiratory ailments, and the reduction of visibility.

AEROSOLS AND PARTICULATES The predominant natural sources include volcanic eruptions, forest and grass fires, dust storms, and sea spray. Human-derived sources include rock-crushing operations, trash incineration, smelters, power plants, and heating furnaces which emit sulfur oxides, particularly Sulfur Dioxide (SO_2). Pollens and spores taunt allergy sufferers. Particulates usually have short residence times in the atmosphere, being removed by precipitation within days or weeks. Thus particulate pollution is normally a local problem, most severe close to its source and for a short duration.

WATER AND WATER VAPOR Water and water vapor are influential through their absorptive capabilities. Pollutants are retained rather than dispersed, accentuating their characteristics. Absorbing thermal radiation and sending it back to the earth, rather than to the atmosphere, contributes to a net increase in surface temperature, commonly referred to as the "greenhouse effect." [16]

RADON Radon, mentioned in the geology chapter, is nearly ubiquitous in New Jersey with concentrations reflecting the underlying geology. A Statewide study conducted in 1986 tested approximately 5300 homes for naturally occurring radon. Average indoor Radon concentrations fluctuated widely based on geography.



- Average concentration of 8.1 pCi/l was in the Highlands region (Reading Prong).
- Average concentration in the Piedmont region was 4.2 pCi/L.
- Statewide, the average Radon concentration was found to be 5.4 pCi/l.
- The lowest was 0.1 pCi/L.
- The highest was 246 pCi/L.[17]

---

[15]Regional Plan Association - New Jersey, "Public Opinions About Air Pollution and its Remedies: Results of the Eagleton Survey for Project:CLEAN AIR," Improving New Jersey's Air Quality, August 1991, No.9:2.

[16]Williamson, 93.

[17]NJ DEP, Overview of Initial Results Statewide Scientific Study of Radon, Sept. 10, 1987.

VOLATILE ORGANIC COMPOUNDS These compounds come from both human derived and naturally derived sources. They include petroleum, petrochemicals, solvents, and other organic compounds that vaporize easily at normal atmospheric temperature and pressures. Present in the air primarily in gaseous form, volatile organics may react with other chemicals to form new compounds, such as ozone. Many compounds, like benzene and formaldehyde, are toxic to humans and/or suspected of causing cancer.

Hydrocarbons (carbon and hydrogen compounds) are derived chiefly from gasoline and other petroleum products. Mobile sources constitute about 35% of the total.[18] Another 1/3 comes from emissions at refineries, tanks, gasoline stations and other parts of the gasoline delivery network.[19] The remainder is from solvents, paints, coatings and fuels used by industry, dry cleaners and in the home.

Air Quality in Morris County

As has occurred statewide since the passage of the Clean Air Act in 1970, air quality in Morris County has improved. Tabular representations of parameters and corresponding levels can be found in **Appendix A**.

The New Jersey Pollutant Standards Index is used to summarize air quality by region. Chester and Morristown fall within the "Suburban" reporting region. Table Two represents historic ratings since 1987.

Table Two - Pollutant Standards Index Descriptor Ratings
Suburban Reporting Region
Compilation of Annual Summaries: 1987-1997[20]
Number of Days

YEAR	GOOD	MODERATE	UNHEALTHFUL	VERY UNHEALTHFUL	NOT AVAILABLE
1987	160	186	16	1	2
1988	165	176	23	2	0
1989	196	167	2	0	0
1990	187	166	10	0	2
1991	180	178	7	0	0
1992	188	174	4	0	0
1993	167	198	0	0	0
1994	201	158	5	0	1
1995	213	145	7	0	0
1996	202	158	4	2	0
1997	243	106	12	4	0

---

[18]Public Service Electric and Gas Company, Public Service Electric and Gas Company Environmental Progress Report, 1995, 3.

[19]Public Service Electric and Gas Company, 3.

[20]NJ DEP, Air Quality Report, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998.

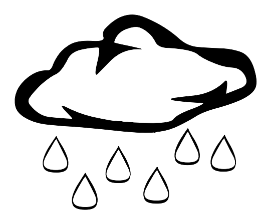
Various meteorological parameters including temperature, wind direction and speed, relative humidity, and solar radiation are measured at specific stations. These data are indicators of formation and movement of pollutants. Migration, or the lack of, can present a major risk to the public's health, welfare, and safety. When meteorological conditions develop which may inhibit the dispersion of airborne pollutants for extended periods of time, there is a potential public health risk. Thus when an air stagnation advisory is issued, pollutant levels are monitored continuously to ascertain if air quality has deteriorated sufficiently to warrant emergency action.

In Morris County there are two air quality monitoring stations measuring specific criteria pollutants as per the National Ambient Air Quality Standards. One site is on Washington St. in Morristown where Carbon Monoxide and Smoke Shade (linked to haze) are monitored. The other site is located on Route 513 in Chester, where Sulfur Dioxide, Nitrogen Oxides, Ozone and solar radiation are monitored. These stations provide data from which to generate a daily morning and afternoon air quality report and forecast. During emergency situations, this Pollutant Standards Index (PSI) plus additional information are issued to the media. If high levels are anticipated, an hourly watch is initiated. If primary standards are exceeded, a health advisory press release is issued.

Regions not meeting US EPA allowable levels are classified as "non-attainment" areas.[21] Most of New Jersey, including Morris County is classified as a Severe 2 ozone non-attainment region with ozone levels exceeding standards by 58 to 133 percent. (A Severe 2 classification indicates 1 hour concentrations of oxides of nitrogen (Nox) of 0.190 up to 0.280 parts per million (ppm).[22] Significant improvement has been observed during recent years, insofar as the number of violations have reduced. The surge in 1988 was blamed on an unusually hot summer.

The levels of carbon monoxide have also been gradually dropping, as reflected in the decreasing number of violations shown in Table 3. No violations of the US EPA standard have been recorded at the Morristown station since 1986. However the region has been classified as "moderate 2" non-attainment, exceeding standards by more than 40%. The Moderate CO classification indicates an 8 hour concentration of CO at 9.1 to 16.4 ppm.[23]

Of the pollutants monitored in the County, ozone and carbon monoxide are the two chemical culprits responsible for the area's poor air quality rating. Table 3 provides an historical perspective of incidence of violations for these two parameters since 1975. Ozone’s production is influenced by degree of sunshine, temperature, and wind speed and direction. Though Chester’s station has not reported primary (health effect) violations in recent years, secondary (welfare effects) violations have occurred as represented in **Appendix A**. Future data may show a worsening of conditions since more stringent standards for ozone were promulgated in 1997.



---

[21]Morris County Department of Planning and Development, Division of Transportation Management, <u>1993 Morris County Air Quality Plan for Mobile Source Emissions: An Analysis of Transportation Control Measures</u>, Feb. 1993, 96.

[22]Ibid, 1.

[23]Ibid.

Table Three - Summary of Air Quality in Morris County (1975 - 1998)[24]

YEAR	CARBON MONOXIDE	# VIOLATIONS (not in compliance with 8-hour standard)	OZONE	# VIOLATIONS (not in compliance with 1-hour standard)
1975	Morristown	267		
1976	Morristown	136		
1977	Morristown	102	Chester	6
1978	Morristown	81	Chester	5
1979	Morristown	81	Chester	3
1980	Morristown	40	Chester	11
1981	Morristown	25	Chester	2
1982	Morristown	9	Chester	8
1983	Morristown	10	Chester	11
1984	Morristown	5	Chester	0
1985	Morristown	2	Chester	0
1986	Morristown	5	Chester	6
1987	Morristown	0	Chester	4
1988	Morristown	0	Chester	18
1989	Morristown	0	Chester	2
1990	Morristown	0	Chester	3
1991	Morristown	0	Chester	5
1992	Morristown	0	Chester	1
1993	Morristown	0	Chester	0
1994	Morristown	0	Chester	0
1995	Morristown	0	Chester	2
1996	Morristown	0	Chester	0
1997	Morristown	0	Chester	0
1998	Morristown	0	Chester	0

* Northern Panic Grass

[24] NJ DEP, 1997 Air Quality Report, 1998 and draft Summary of 1998 Air Quality in New Jersey, Sept. 7, 1999.

Management Considerations

The relationship between climatology and air quality is influenced by geographical variations, human activities, and natural occurrences such as volcanic eruptions and forest fires. The resulting smog, acid rain, and climate in turn impact entire ecosystems. Human health impacts are manifested not only by medical expenses, but also by absenteeism, and loss of production.

Natural and Human Derived Impacts

GLOBAL TEMPERATURE Increased levels of carbon dioxide are associated with the greenhouse-effect heating of the atmosphere, and its related potentially harmful impacts on global climate and civilization. Ozone, which is strongly affected by weather patterns such as wind, temperature, and sunlight, has become a regional environmental issue with a long term remediation time frame.

LOCAL TEMPERATURE Urbanized areas affect local weather in multiple ways. Heat is generated from automobiles, factory ovens, power generating stations, and underground steam lines often creating heat islands. Urban land compared to soil coverage in rural areas exhibits significant temperature differences. Air circulation is enhanced as warm air reflects from the thermally conducting surfaces, rises over the city, and is replaced by cooler air blowing in from the surrounding areas. Ventilation is reduced, however, if building patterns impede circulation.

HUMAN HEALTH Carbon Monoxide is considered a significant health threat in New Jersey. Its effect in the body is to reduce the amount of oxygen carried to body tissues. Possible physical reactions include nausea, dizziness, headache, vision impairment, slowed reaction time and, in high concentrations, death. A diminished supply of oxygen to the heart makes cardiac patients especially vulnerable.

Metals, particularly arsenic, chromium, cadmium, mercury, nickel, and lead are associated with damage to the respiratory and nervous systems; some are known to be carcinogens. Particulates coated with organic compounds can have serious health affects such as Benzo(a)pyrene, found in exhaust from diesel-fueled vehicles, wood burning and in cigarette smoke, and is believed to be a carcinogen.

Airborne sulfuric acid is a severe irritant to lungs and eyes.

Ozone is associated with respiratory disease, particularly afflicting the young, elderly and outdoor exercise enthusiasts. Small amounts of ozone inhalation are enough to cause cell death, temporarily reducing lung capacity. Coughing, shortness of breath or rapid shallow breathing, chest soreness, reduced infection-fighting ability, and irritated eyes, nose and throat are some of the physical manifestations.

Thermal inversions demonstrate a natural occurrence influenced by human activities. Normally air temperatures decrease with rising elevation. In an inversion a warm layer of air lies over low lying colder air. Causes are varied: a warm front moving across a hilly terrain, trapping pockets of cold air in the valleys, rapid cooling of near-surface air on a clear, calm night, or warm emissions from cars and smokestacks rising and laying over denser cold air. Sometimes the cold/warm air boundary appears as a distinct layer above the polluted zone. This scenario becomes unhealthy, if not deadly, when the cooler zone remains stagnant, carrying its load of trapped pollutants.

WILDLIFE Acidic precipitation can have profound effects on freshwater and forest ecosystems as exhibited in the northeast. Aquatic systems are effected throughout the entire foodchain including phytoplankton, zooplankton, benthos, invertebrates, amphibians, fish, birds and mammals. Acidification has a diminishing effect on aquatic invertebrates particularly mayflies, caddisflies, molluscs, crustaceans, and some insects. Associated predators including waterfowl, shorebirds and many passerines e.g. flycatchers, swallows, blackbirds and warblers, hooded merganser and common goldeneye, are vulnerable to compromised egg production, and growth and survival of offspring.

When fish populations decline, predators such as common loons, common mergansers, herons, bitterns, terns, gulls, eagles, kingfishers, and ospreys suffer. Even omnivores, such as the American black duck and ring-necked duck, as well as migratory birds, may suffer a diminished breeding season.

The effect of metals such as mercury, cadmium, and lead is exaggerated in acidified aquatic ecosystems. Though the exact science is unclear, it is believed that metals present in acidified waters bioaccumulate and subsequently biomagnify in the aquatic foodchain supporting fish and their predatory birds and mammals.

VEGETATION Air pollution has been associated with compromised tree growth throughout the world. Various pollutants have been implicated (e.g., sulfur dioxide, nitrogen oxides, fluorides, and heavy metals). Ozone causes damage to plants by inhibiting photosynthesis. Agricultural productivity has been impacted, as exhibited by varieties of potatoes, lettuce, tomatoes, grapes and onions suffering stunted growth and browned leaves.[25] The soil itself responds to acidification by way of decrease in fertility and, thus yield.

ARCHITECTURE Air pollutants such as acid precipitation can also exact aesthetic as well as structural damage to building materials such as stone and metal. This has become an expensive maintenance concern.

Regulatory Support

FEDERAL

- The Clean Air Act - First instituted in 1970, the Clean Air Act (CAA) focussed on the nation's air quality. Its 1990 Amendment required the EPA to set national ambient air quality standards (NAAQS) for air pollutants by setting allowable concentration and exposure limits for various pollutants. It also identified actions and time frames for meeting NAAQS in nonattainment areas to insure that these standards were met. Ramifications for Morris County are that ozone and carbon monoxide reduction is required with deadlines of November 2007 for ozone and December 1996 for carbon monoxide.

While stricter standards and regulations have netted air quality improvements, there have been increases in motor vehicles and their use. In addition there have been challenges to the Clean Air Act (CAA), e.g., the 1995 dismantling of the Employer Trip Reduction provision of the Clean Air Act Amendment (CAAA).

Planning Strategies

Planning strategies for protecting and restoring air quality, or the air shed, are directed at reducing exhaust emissions throughout various elements of the Master Plan.

- Circulation plan incorporating:
  - ❦ convenient and protective bicycle routes
  - ❦ continuous sidewalks radiating from town center outwards
  - ❦ provision of jitney services at commercial centers and train stations

*Bradley's Spleenwort

---

[25] Bauersfeld, 3

- Station Area Plan identifying and establishing area around transit station accommodating mixed uses specific to riders' needs (e.g., banks, day care, eating establishments) as well as an intensification of uses
  - Plan for station environment providing adequate parking, direct access for rider drop-off and pick-up, opportunities for alternative vehicle modes of access and parking
- Open Space plan including linear park development
- Land Use Plan promoting:
  - clustering of buildings and creation of transit-friendly internal circulation system
  - mix of land uses accommodating pedestrians
- Land Acquisition for linear park development

Design Strategies

- Parking facilities serving multiple occupancy vehicle programs and/or transit service
- Dedicating portions of road surfaces to the use of non-motorized vehicles and/or pedestrian use

Zoning and Site Plan Ordinances

- Station Area Overlay Zone
- Site Plan standards for sidewalks, landscaping, bicycle rack inclusions
- Provision of vegetation requirements (oxygenation and filtering of air resources)
- Special Improvement District enhancing downtown area, pedestrian use and transit ridership

Practices

INDIVIDUAL

- Consolidate trips
- Reduce daily driving; walk, use mass transit, and car pool or van pool
- Avoid idling vehicle
- Limit vehicle's warm-up time
- Keep car engine well tuned so that it burns gas efficiently; a vehicle's fuel efficiency can be improved by as much as 15% by keeping it well tuned
- Do not tamper with emission control equipment. This could reduce your car's performance and fuel efficiency as well as emissions control benefits.
- Perform regular tune-ups: replace air filter, hoses, belts, spark plugs, oil filter, oil and other fluids; also check and/or replace tires, fuel injection system, brakes, transmission and emissions control system, ignition timing, crankcase, choke, etc.

Sources: Clean Air, Improving NJ's Air Quality, 1991; Let's Clear the Air, 1996.

Citizens, planning officials, and legislators face a tremendous challenge in protecting our airshed. The requisite transportation network reflected in land use decisions, traffic management, and improved pollution control technology need consistent support, funding, and follow through.

* Flat-Stemmed Pondweed

Glossary

AEROSOL particles that due to their small size, reside for a relatively long time (several days) in the atmosphere. Primary example: ash from coal-burning electrical power generating stations.
secondary example: formed by reactions between primary pollutants and components of the atmosphere, e.g., development of droplets of sulfuric acid in sulfurous smog.[26]

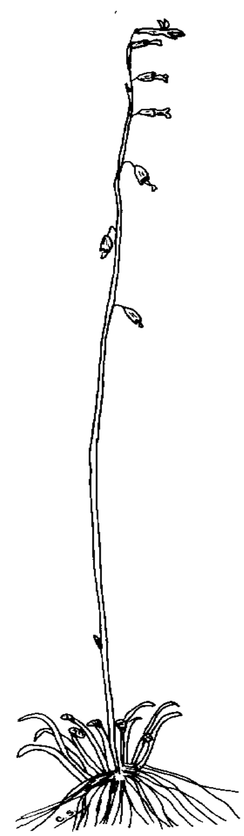
PASSERINE perching birds and songbirds e.g. jays, blackbirds, finches, warblers, and sparrows.

picoCurie The curie is a measure of radioactivity; pico means one-trillionth (0.00000000001).[27]

pCi/1 - picoCurie per liter a measurement of the concentration of radioactivity by volume of air in this case

SMOG the hazy mixture of microscopic droplets, solid particles and gases produced by motor vehicles and other sources of emissions.[28]

THERMALS rising warm currents of air.[29]



Water Lobelia

---

[26]Williamson 21.

[27]US EPA, Office of Research and Development, Air and Energy Engineering Research Laboratory, Radon Reduction Techniques for Detached Houses Technical Guidance EPA/625/5-86/019.

[28]Bauersfeld, W.R. and R.D. Schopp. U.S. Geological Survey, and M.D. Schulman, Rutgers University. "New Jersey Floods and Droughts." National Water Summary 1988-89 Floods and Droughts: NEW JERSEY

[29]Williamson 139.

Appendix A

AIR QUALITY IN NJ COMPARED WITH AIR QUALITY STANDARDS

1987 - 1997

SULFUR DIOXIDE

CHESTER

3-hour and 12-month averages
Parts Per Million (ppm)

AMBIENT AIR QUALITY STANDARDS
3-Hour Average Secondary Standard: 1300 ug/m^3 (0.5 ppm) [a]
12-Month Average Primary Standard: 80 ug/m^3 (0.03 ppm) [a]
12-Month Average Secondary Standard: 60 ug/m^3 (0.02 ppm) [b]
24-Hour Primary Standard: 0.14 ppm
24-Hour Secondary Standard: 0.10 ppm

YEAR	3 Hr. Avg. MAX.	(ppm)[c] 2nd HIGHEST	# Above 0.5 ppm	VIOL. CODE	12 Month MAX.	Avg. Cal. YEAR	VIOL. CODE
1987	.092	.072	0	-	.007	.007	-
1988	.253	.118	0	-	.008	.008	-
1989	.087	.085	0	-	.008	.008	-
1990	.081	.063	0	-	.008	.007.	-
1991	.089	.053	0	-	.007	.006	-
1992	.166	.120	0	-	.006	.006	-
1993	.050	.047	0	-	.005	.005	-
1994	.054	.052	0	-	.006	.006	-
1995	.055	.047	0	-	.005	.004	-
1996	.066	.063	0	-	.005	.005	-
1997	.049	.048	0	-	.005	.005	-

a) New Jersey and National Ambient Air Quality Standard not be exceeded more than once in any 12-month period.
b) NJ Ambient Air Quality Standard
c) Based on non-overlapping 3-hour moving averages.

Sources: Air Quality Report, 1988-1998.

AIR QUALITY IN NEW JERSEY COMPARED WITH AIR QUALITY STANDARDS

1987 - 1997

SULFUR DIOXIDE

CHESTER

24-Hour and Daily Averages
Parts Per Million (ppm)

AMBIENT AIR QUALITY STANDARDS FOR SULFUR DIOXIDE:

24-Hour Average Primary Standard: 365 ug/m^3 (0.14 ppm) [a]
24-Hour Average Secondary Standard: 260 ug/m^3 (0.1 ppm) [a]
Daily Average Primary Standard: 365 ug/m^3 (0.14 ppm) [b]

			# ABOVE			DAILY AVERAGE		
YEAR	24 Hr. Ave. MAX.	(ppm)c 2nd HIGHEST	0.14	0.10	VIOL. CODE	MAX.	2nd HIGHEST	VIOL. CODE
1987	.049	.033	0	0	--	.033	.026	--
1988	.066	.056	0	0	--	.064	.056	--
1989	.050	.044	0	0	--	.050	.042	--
1990	.042	.042	0	0	--	.042	.036	--
1991	.033	.028	0	0	--	.027	.027	--
1992	.060	.045	0	0	--	.049	.045	--
1993	.028	.026	0	0	--	.028	.024	--
1994	.040	.040	0	0	--	.033	.032	--
1995	.036	.027	0	0	--	.036	.027	--
1996	.034	.029	0	0	--	.027	.023	--
1997	.031	.027	0	0	--	.029	.027	--

a) NJ Ambient Air Quality Standard not be exceeded more than once in any 12-month period.
b) National Ambient Air Quality Standard not to be exceeded more than once a year.
c) Based on non-overlapping 24-hour moving averages.
d) State and Local Air Monitoring Sites - These sites fulfill the federal monitoring requirements for the State (1994 Air Quality Report, 1995, 5).

Sources: Air Quality Report, 1988-1998.

AIR QUALITY IN NJ COMPARED WITH AIR QUALITY STANDARDS
1987 - 1997

OZONE [c]

CHESTER

1-Hour Average
Parts Per Million (ppm)

AMBIENT AIR QUALITY STANDARDS FOR OZONE
Maximum Daily 1-Hour Avg. Primary Standard: 0.12 ppm (235 ug/m^3) [a b]
1-Hour Average Secondary Standard: 0.08ppm (160 ug/m^3) [b]

VIOLATION CODES: XXX = N J & NATIONAL
XX = NEW JERSEY
X = NATIONAL

(PS) = PRIMARY STANDARD
(SS) = SECONDARY STANDARD
-- = NO VIOLATION

	DAILY MAX. 1-Hour Avg.		# DAYS With Hrs> .12	VIOL. CODE	1-Hour Avg.		# Hours > .08	VIOL. CODE
Year	MAX	2nd High			MAX	2nd High		
1987	.162	.132	4	XXX(PS)	.162	.147	212	XX(SS)
1988	.186	.181	18	XXX(PS)	.186	.181	366	XX(SS)
1989	.158	.132	2	XXX(PS)	.158	.148	178	XX(SS)
1990	.138	.128	3	XXX(PS)	.138	.128	217	XX(SS)
1991	.139	.137	5	XXX(PS)	.139	.137	273	XX(SS)
1992	.133	.107	1	X(PS)	.133	.127	76	XX(SS)
1993	.122	.121	0	X(PS)	.122	.121	161	XX(SS)
1994	.124	.119	0	---	.124	.124	123	XX(SS)
1995	.130	.125	2	XX(PS)	.130	.129	214	XX(SS)
1996	.125	.113	1	---	.125	.118	110	XX(SS)
1997	.116	.115	0	---	.116	.115	136	XX(SS)

a) National Ambient Air Quality Standard - averaged over a three year period the expected number of days above the standard must be less than or equal to one.
b) NJ Ambient Air Quality Standard not to be exceeded more than once in any 12-month period.
c) State and Local Air Monitoring Sites - These sites fulfill the federal monitoring requirements for the State.
Source: Air Quality Report, 1989-1998.

NITROGEN DIOXIDE AND NITRIC OXIDE
1987 - 1997
CHESTER (D)

12-Month Averages
Parts Per Million (ppm)

AMBIENT AIR QUALITY STANDARDS FOR NITROGEN DIOXIDE

12-month Average Primary Standards: 100 ug/m^3 (.05 ppm) [a]
Annual Average Primary Standard: 100 ug/m^3 (.05 ppm)[b] ; .053 ppm (100 ug/m^3)[b]
12-Month Average Secondary Standard: 100 ug/m^3 (.05 ppm) [a]
Annual Average Secondary Standard: 100 ug/m^3 (.05 ppm)[b]; .053 ppm (100ug/m^3) [b]
1 Hour Average Guideline: 470 ug/m^3 (.25 ppm) [c]

No Ambient Air Quality Standards Have Been Established For Nitric Oxide

	NITROGEN DIOXIDE			
YEAR	12-month average (ppm)		VIOL.	NITRIC OXIDE
	Maximum	Cal. Year	CODE	12-Month Avg. (ppm)
1987	.015	.015	--	.005
1988	.016	.016	--	.006

	NITROGEN DIOXIDE		NITROGEN DIOXIDE			
	1-Hour average (ppm)		12-Month average (ppm)		Viol.	Nitric Oxide
	Maximum	2nd Highest	Maximum	Cal.Year	Code	Annual Avg. (ppm)
1989	.075	.074	.016	.015	--	.007
1990	.094	.091	.015	.014	--	.004
1991	.082	.080	.014	.013	--	.004
1992	.068	.068	.014	.014	--	.005
1993	.085	.085	.014	.013	--	.004
1994	.098	.081	.014	.013	--	.005
1995	.061	.060	.013	.012	--	.003
1996	.095	.085	.012	.012	--	.004
1997	.060	.060	.011	.011	--	.003

a) NJ Ambient Air Quality Standard
b) National Ambient Air Quality Standard
c) California State Primary Standard used by NJ for analysis of short-term impacts in dispersion modeling studies.
d) State and Local Air Monitoring Sites - These sites fulfill the federal monitoring requirements for the State.
Source: Air Quality Report, 1989-1998.

SMOKE SHADE

1989 - 1997

MORRISTOWN [a]

Daily And Annual Averages
Coefficient Of Haze (COHs)

NO AMBIENT AIR QUALITY STANDARDS HAVE BEEN ESTABLISHED FOR SMOKE SHADE

Year	Daily Avg. Max	2nd Highest	Annual Avg.
1987	1.34	1.21	0.58
1988	1.81	1.69	0.57
1989	1.71	1.56	0.55
1990	1.53	1.39	0.57
1991	1.84	1.81	0.51
1992	1.46	1.46	0.57
1993	1.47	1.34	0.54
1994	1.58	1.42	0.50
1995	1.24	1.22	0.44
1996	1.87	1.40	0.49
1997	1.43	1.19	0.40

a) Special Purpose Monitors - These monitors fulfill a specific need or purpose and are not federally required. SPM's are used for a number of reasons:
1) to collect data for research projects;
2) to monitor around major point sources; or
3) to collect data concerning pollutants for which National Ambient Air Quality Standards not been established.

Source: Air Quality Report, 1989-1998.

* Northern Pondweed

Conclusion

This Natural Resource Management Guide is an attempt to represent the variety of environmental resources within the County. Protection of these resources requires the recognition of inherent value regardless of location. Using the time-honored art of quilt-making as a model in which fragments of plain fabrics are assembled into a vibrant masterpiece, we bear the responsibility of stewarding all of this region, with its many diverse components.

> "I know that each parcel of land is a precious, distinct, and irreplaceable portion of this distinct and irreplaceable planet. I will treat it with the respect that it deserves, recognizing that I will be judged by the integrity and permanence of my developments, which will survive my lifetime. . . I will be ever vigilant toward preserving the quality of the larger environment - the air, the water and the land. . . Recognizing that change is inevitable, I will pursue excellence with an open mind. . . "
>
> (The Urban Land Institute Code of Ethics)[1]

[1]George Burton Brewster, "The Ecology of Development, Integrating the Built and Natural Environments," Urban Land, June 1996, 22.

Bibliography

Introduction

Cronon, William. The Trouble With Wilderness. The New York Times Magazine, Aug. 13, 1995.

NJ Department of Environmental Protection. A Ground Water Strategy for New Jersey, 1989.

---. Water for the 21st Century: The Vital Resource, New Jersey Statewide Water Supply Plan, Aug. 1996.

US Environmental Protection Agency. Citizen's Guide To Ground-Water Protection, 1990.

Geology Chapter

Canace, Robert, New Jersey Geological Survey. Correspondence, March 27, 1997.

Cotterill, Rodney, Editor. The Cambridge Guide to the Material World, NY Cambridge University Press, 1985.

Dombroski, Daniel Jr. Catalog of New Jersey Earthquakes Through 1990. Trenton: NJ Geological Survey, 1992.

The Geologic Society of America. The Geologic Time Scale, Boulder, Co, 1983.

Hoffman, Jeffrey L., Supervising Hydrogeologist, New Jersey Geological Survey. Correspondence, March 27, 1997.

Houghton, Hugh F. (NJGS), John J. Flynn (Rutgers University). Geology and Hydrogeology of the Piedmont Lowlands Province: The Early Mesozoic Newark Basin in NJ. Field Short Course on the Geology and Hydrogeology of NJ, Fall 1988.

NJ Department of Health. Division of Occupational and Environmental Health. Facts and Recommendations on Exposure to Radon.

NJ Geological Survey. Geologic Map of NJ. 1984.

---. Generalized Stratigraphic Table for New Jersey. Information Circular 1. 1990.

North Jersey Resource Conservation and Development Council. Model Limestone Ordinance, Annandale, NJ, 1993.

Rutgers University Department of Geological Sciences and Cook College Office of Continuing Professional Education. A Two Day Field Short Course Examining New Jersey's Highlands, Valley and Ridge, and Lowlands Provinces, Sept. 1989.

Stanford, Scott D. and Gail M. Ashley. Hydrogeology of the Glacial Deposits of New Jersey: An Applied Field Course. Cook College Office of Continuing Professional Education in Cooperation with Rutgers University Department of Geological Sciences, April 1992.

US Department of Housing and Urban Development. US Department of the Interior. Environmental Planning and Geology. 1971.

Wolfe, Peter E., and Crane. The Geology and Landscapes of New Jersey, Russak and Co., Inc., 1977.

Topography

Gill, Harold E. and John Vecchioli. Availability of Ground Water in Morris County, New Jersey: US Geological Survey Special Report No. 25, 1965.

Stanford, Scott D. Surficial Geologic Map of the Boonton Quadrangle, Morris County, N.J.: NJ Geological Survey Map Series 89-1, 1989.

—. Surficial Geologic Map of the Dover Quadrangle, Morris and Sussex Counties, N.J.: NJ Geological Survey Map Series 89-2, 1989.

Stanford, Scott D. and Gail M. Ashley. Hydrogeology of the Glacial Deposits of New Jersey: An Applied Field Course. Cook College Office of Continuing Professional Education in Cooperation with Rutgers University Department of Geological Sciences, April 1992.

Urban Conservation Action Partnership, Inc. Streamside Restoration, Center Street.

---. Streamside Restoration, McCarter Park.

US Department of Agriculture. Natural Resources Conservation Service. Riparian Areas, Regional Distinctions and Disturbances. NRCS/RCA Issue Brief 12, Jan. 1997.

US Geological Survey. 7.5-Minute Series Slope Zone (Clinametric) Quadrangles (maps), 1975.

Wolfe, Peter E., and Crane. The Geology and Landscapes of New Jersey. Russak and Co., Inc., 1977.

Soils

An Ordinance of the Board of Health of the Township of Chatham, In the County of Morris, New Jersey, Relating to the Licensing, Operating and Maintenance of Individual Subsurface Sewage Disposal Systems Within the Township.

Charles, Emmanuel g., and others. A Method for Evaluating Ground-Water-Recharge Areas in New Jersey: NJ Geological Survey Report GSR-32, 1993.

Cook College, Rutgers, the State University of New Jersey. Soil Manual for Site Evaluation in New Jersey.

Friends of the Rockaway River, Inc. The Rockaway River and its Treasured Resources: Visions & Strategies for Their Recovery, May 1998.

Morris County Planning Board. Land and Its Use, Part 1: Physical Characteristics, 1966.

New Jersey Department of Environmental Protection and Energy. Chapter 9A Standards for Individual Subsurface Sewage Disposal Systems, Jan. 1990.

Sediment and Erosion Control in the Chesapeake Bay Drainage Basin. Solomons forum White Paper, Aug. 1989.

Urban Conservation Action Partnership. Streamside Restoration, McCarter Park.

US Department of Agriculture. Soil Conservation Service. Conservation Choices, Your Guide to Thirty Conservation and Environmental Farming Practices.

---. Important Farmlands. 1981.

---. Soil Erosion By Water. Agriculture Information Bulletin 513, Aug. 1987.

---. Urban Hydrology for Small Watersheds, Technical Release 55, June 1986.

Ground Water

An Ordinance To Amend Chapter 16, Land Subdivision, Chapter 17, Zoning, chapter 20, Land Use Procedures, And Chapter 21, Site Plan Review, Of The Revised General Ordinances Of The Township of Washington, County Of Morris And State Of New Jersey, To Regulate Development In Limestone Areas. Adopted April 1998.

Ayers, Mark A. and Edward A. Pustay. National Water Summary 1986 - Ground-Water Quality: State Summaries, US Geological Survey Water-Supply Paper 2325, 1986.

Baldwin, Helene L. and C. L. McGuinness. A Primer On Ground Water, US Geological Survey, 1963.

Canace, Robert and others. Results of the 1980-81 Drought Emergency Ground Water Investigation in Morris and Passaic Counties, New Jersey: NJ Geological Survey Report Series Report No. 83-3, 1983.

Canace, Robert, Scott D. Stanford, and David W. Hall, Hydrogeologic Framework of the Middle and Lower Rockaway River Basin, Morris County, New Jersey: NJ Geological Report Series 33, 1993.

Chapter 9A Standards For Individual Subsurface Sewage Disposal Systems. New Jersey Register, Aug. 21, 1989: Cite 21 N.J.R. 2597.

Charles, Emmanuel G., and others. A Method for Evaluating Ground-Water-Recharge Areas in New Jersey: NJ Geological Survey Report GSR-32, 1993.

Chester Township and others. Alamatong Wellhead Protection Study, Dec. 1998.

Dysart, Joel E. Estimates of Stream Leakage and Hydraulic Properties of a Glacial Aquifer Near Dover, New Jersey, Based on the Chemical Character of Water, Including Stable Isotopes of Hydrogen and Oxygen: US Geological Survey Open-file Report 91-225, 1991.

Geonics, Water Resource Study, Rockaway Valley, Morris County, New Jersey, 1979.

Geraghty & Miller, Inc. An Evaluation of Ground-Water Resources of the Rockaway River Valley Within the Communities of Denville, Boonton Township, Town of Boonton, Montville, and Mountain Lakes, NJ, 1978.

Gill, Harold and John Vecchioli. Availability of Ground Water in Morris County, N.J.: US Geological Survey Special Report No. 25, 1965.

Hoffman, Jeffrey. A letter to Dudley Woodbridge, Morris County Planning Board, July 8, 1991.

---. A letter to Ms. Ella Filippone, Passaic River Coalition, Sept. 13, 1991.

---. A letter to Mr. Richard Brown, P.E., Storch Engineers, July 9, 1991.

---. Simulated Drawdowns, 1972-1995, in The Pleistocene Buried-Valley Aquifers in Southwestern Essex and Southeastern Morris Counties, New Jersey: NJGS Open-File Report OF-89-1, 1989.

Hoffman, Jeffrey L. and John Quinland. Ground-Water-Withdrawal and Water-Level Data for the Central Passaic River Basin, New Jersey, 1898-1990: NJ Geological Report Series 34, 1994.

McAuley, Steven D., and others. Plan to Evaluate the Hydrogeology of the Valley-Fill and Carbonate-Rock Aquifers near Long Valley in the New Jersey Highlands: NJ Geological Report Series 92-3, 1992.

Messina, Peter A., and others. Ten Town Great Swamp Watershed Committee, Draft Model Environmental Ordinances, Jan. 1997.

Metzger, Philip C., Edwin H. Clark II, and Geraldine Bachman. The Developer's Stake in Groundwater Protection, Urban Land, April 1986.

Morrissey, Daniel J. Estimation of the Recharge Area Contributing Water to a Pumped Well In a Glacial-Drift, River-Valley Aquifer: U.S. Geological Survey Water-Supply Paper 2338, 1989.

New Jersey Safe Drinking Water Act (N.J.A.C. 7:10).

Nicholson, R.S., and others. Hydrogeology of, and Ground-Water Flow in, a Valley-Fill and Carbonate-Rock Aquifer System Near Long Valley in the New Jersey Highlands: US Geological Survey Water-Resources Investigations Report 93-4157 with NJ DEP, 1996.

NJ Department of Environmental Protection. A Ground Water Strategy For New Jersey, 1989.

---. Known Contaminated Sites in New Jersey, Sept. 1997.

---. New Jersey 1994 State Water Quality Inventory Report, 1995.

---. New Jersey Statewide Water Supply Plan, 1995.

NJ Department of Environmental Protection and Energy. Ground Water Protection Practices for Motor Vehicle Services, 1992.

---. Ground Water Protection Practices for Roadway Deicing, 1992.

---. Ground Water Protection Practices for Septic Systems, 1992.

---. Ground Water Protection Practices for Unregulated Underground Storage Tanks, 1992.

---. Ground Water Protection Practices for Urban/Suburban Landscaping, 1992.

---. Ground Water Quality Standards (N.J.A.C. 7:9-6), Jan. 7, 1993.

---. New Jersey 1992 State Water Quality Inventory Report, Nov. 1993.

---. New Jersey Well Head Protection Program Plan, 1991.

---. Site Status Report, 1992.

NJ Geological Survey. Geologic Map of New Jersey, 1984.

---. Information Circular 1, 1990.

Oudijk, Gil. Ground-Water Contamination and the Delineation of a Well-Restriction Area in East Hanover Township, Morris County, New Jersey. NJ Geological Survey Technical Memorandum 87-3, 1987.

Passaic River Coalition. The Hydrogeology of the Buried Valley Aquifer System, 1983.

Passaic River Coalition and Passaic Valley Ground Water Protection Committee. Planning For Well Head Protection for Ground Water From The Whippany, Chatham and Millburn Valleys Of the Buried Valley Aquifer Systems, 1998.

Reilly, Sean M., Sr. and Marie Kneser. Working Draft Model Planning Board Ordinance For Wellhead Protection Areas And Drinking Water Aquifer Protection, March 1998.

Schaefer, F.L., and others. Hydrologic Conditions in the Upper Rockaway River Basin, New Jersey: Water-Resources Investigations Report 91-4169, 1993.

Serfes, Michael E. (Draft) Natural Ground-Water Quality in the Lower Paleozoic and Middle Proterozoic Bedrock Aquifers of the Highlands and Valley Physiographic Provinces of New Jersey: NJGS GSR, 1997.

US Environmental Protection Agency. Citizen's Guide To Ground-Water Protection, 1990.

---. Guide To Ground-Water Supply Contingency Planning For Local And State Governments, Technical Assistance Document, May 1990.

---. Handbook, Ground Water, 1987.

---. Progress in Ground-Water Protection And Restoration, 1990.

---. Wellhead Protection: A Guide for Small Communities, 1993.

US Geological Survey. Basic Ground-Water Hydrology: Water-Supply Paper 2220, 1983

---. NJ Ground-Water Quality. National Water Summary - Ground-Water Quality; New Jersey: Water-Supply Paper 2325, 1986.

Waller, Roger M. Ground Water and the Rural Homeowner, USGS/Department of the Interior, 1989.

When a Water Supply Went Bad. American City and County, Dec. 1981.

Surface Water

Anacostia Restoration Team, Metropolitan Washington Council of Governments. A Commitment to Restore Our Home River, A Six-Point Action Plan to Restore the Anacostia River. Collected Papers Presented at the Conference "Restoring Our Home River: Water Quality and Habitat in the Anacostia," College Park, Md., Nov. 6 & 7, 1991.

❦ Biotechnical Slope Protection Measures for Erosion and Sediment Control. New York Guidelines for Urban Erosion and Sediment Control, Oct. 1991.

Cannon, Jonathan Z. Geographic Approaches to Environmental Management: Bioregionalism Applied. Proceedings WATERSHED '93, A National Conference on Watershed Management, Alexandria, Virginia, March 21-24, 1993.

Charles, Emmanuel G. A Method for Evaluating Ground-Water-Recharge Areas in New Jersey: NJ Geological Survey Report GSR-32, 1993.

Cook College Department of Environmental Resources/Rutgers, The State University of New Jersey, Watershed Management Strategies for New Jersey. New Brunswick, New Jersey: New Jersey Agricultural Experiment Station, 1989.

Cunniff, Shannon E. The National Environmental Policy Act Process: A Tool for Watershed Analysis and Planning. Proceedings WATERSHED '93, A National Conference on Watershed Management, Alexandria, Virginia, March 21-24, 1993.

Di Lorenzo, Joseph, Howard S. Litwack, Tavit O. Najarian, and Georgia R. Marino. Adaptation of a Hydrologic and Water Quality Model to the Great Swamp Watershed: Generation of a Management Tool. Jan. 1988.

Friends of the Rockaway River, Inc. The Rockaway River and Its Treasured Resources, Visions and Strategies for Their Recovery, May 1998.

Gerritsen, Jeroen, James Green and Ron Preston. Establishment of Regional Reference Conditions for Stream Biological Assessment and Watershed Management. Proceedings WATERSHED '93, A National Conference on Watershed Management, Alexandria, Virginia, March 21-24, 1993.

❦ Goldsmith, Wendi and Lothar Bestmann. An Overview of Bioengineering for Shore Protection. Proceedings of Conference XXIII, International Erosion Control Association, Reno, Nevada, Feb. 18-21, 1992.

Hacklebarney Chapter, Trout Unlimited & Friends of the Rockaway River. Rockaway River Restoration Project. Dec. 1994.

Katz, Harvey M., Edward Samanns, Lisa M. Gonzalez and Anne Harris Katz. An Analysis of the Ecodynamics of the Rockaway River: Investigation of its Trout Supporting Capability: Great Swamp Research Institute Research Report Series: Number 10, May 1987. (Prepared for the Upper Rockaway River Watershed Association.)

Minnesota Pollution Control Agency. Protecting Water Quality in Urban Areas, Best Management Practices for Minnesota, Oct. 1989.

Morris County Park Commission. Farny Highlands Watershed, A Plan to Protect Water Supplies and to Preserve Forests, July 1991.

Morris County Soil Conservation District. Resource Review, 85-4.

National and Fish and Wildlife Foundation and the US Fish and Wildlife Service. Fisheries Across American Program. Beaver Brook Restoration Project.

NJ Department of Environmental Protection. Ambient Biomonitoring Network; Arthur Kill, Passaic, Hackensack, and Wallkill River Drainage Basins; 1993 Benthic Macroinvertebrate Data; Executive Summary, 1994.

---. The Clean Water Book. 1988.

—. Evaluation and Recommendations Concerning Buffer Zones Around Public Water Supply Reservoirs, Report to Governor Thomas H. Kean, The New Jersey State Legislature and The Board of Public Utilities, Dec. 1989.

---. New Jersey 1994 State Water Quality Inventory Report. 1995

---. New Jersey 1996 State Water Quality Inventory Report. 1996.

---. New Jersey Freshwater Wetlands Protection Act, Amendments to the Regulations, June 1992.

---. NJPDES Permit Database. WWW.state.nj.us/dep/dwq/database.html, 1998.

---. Statewide Watershed Management Framework Document for The State of New Jersey, Jan. 1997.

---. Surface Water Quality Standards, N.J.A.C. 7:9B. April 1996.

NJ Department of Environmental Protection and Energy. New Jersey 1992 State Water Quality Inventory Report. Nov. 1993.

---. Stormwater and Nonpoint Source Pollution Control Best Management Practices Manual. Dec. 1994.

---. Whippany River Watershed Characterization Report. Nov. 1995.

NJPDES Permitting Database. Retrieved from the www.state.nj.us/dep/dwq/database.htm. Spring 1999.

North Jersey Resource Conservation & Development Area. Jackson Brook Watershed Hydrologic Study. April 1989.

Price, C.V. and F.L. Schaefer. Estimated Loads of Selected Constituents From Permitted and Nonpermitted Sources at Selected Surface-Water-Quality Stations in the Musconetcong, Rockaway, and Whippany River Basins, New Jersey, 1985-90: U.S. Geological Survey Water-Resources Investigations Report 95-4040, 1995.

Reed, T.J., and others. Water Resources Data, New Jersey, Water Year 1997, Volume 1. Surface-Water Data: US Geological Survey Water-Data Report NJ-97-1, U.S. Department of the Interior in cooperation with the NJ Department of Environmental Protection, and other agencies, 1998.

Reed, T.J., and others. Water Resources Data, New Jersey, Water Year 1998, Volume 1. Surface-Water Data: US Geological Survey Water-Data Report NJ-98-1, U.S. Department of the Interior in cooperation with the NJ Department of Environmental Protection, and other agencies, 1999.

Schueler, Thomas R. Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Government. Watershed Restoration SourceBook. Collected Papers Presented at the Conference "Restoring Our Home River: Water Quality and Habitat in the Anacostia," College Park, Md., Nov. 6 & 7, 1991.

Schueler, Thomas R. and others. Developing Effective BMP Systems for Urban Watersheds. Watershed Restoration SourceBook. Collected Papers Presented at the Conference "Restoring Our Home River: Water Quality and Habitat in the Anacostia" College Park, Md., Nov. 6 & 7, 1991.

❦ Soil Conservation Service. Chapter 18 Soil Bioengineering for Upland Slope Protection and Erosion Reduction, Oct. 1992.

Technical Note 55 Rating Deicing Agents-Road Salt Stands Firm. Watershed Protection Techniques, 1:4, Summer 1995.

US Department of Agriculture. 1992 Water Quality Inventory, Macroinvertebrate Sampling Study, Sept. 1994.

---. 1993 Water Quality Inventory, Macroinvertebrate Sampling Study, Sept. 1994.

---. 1994 Water Quality Inventory, Macroinvertebrate Sampling Study, Sept. 1994.

---. 1995 Water Quality Inventory, Macroinvertebrate Sampling Study, Sept. 1994.

---. Best Management Practice Recommendations for the Great Swamp Watershed, Sept. 1994.

US Department of Agriculture. Soil Conservation Service. Proposed Fisheries Resource Enhancement Project, Bungalow Brook, Washington Township, Morris County, April 1993.

---. Soil Survey of Morris County, New Jersey, 1976.

---. Your Guide to 30 Conservation and Environmental Farming Practices, 1994.

US Department of the Interior. National Park Service. Morristown National Historical Park Water Resources Scoping Report: Technical Report NPS/NRWRD/NRTR-93/17, Oct. 1993.

US Environmental Protection Agency. Final Environmental Impact Statement on the Upper Passaic River Basin 201 Facilities Plan, in Morris, Somerset and Union Counties, New Jersey, Sept. 1991.

US Environmental Protection Agency Region 2. Priority Wetlands for the State of New Jersey, March 1994.

US Fish and Wildlife Service. Pilot Study on the Feasibility of Protecting the Beaver Brook Area in the Townships of Rockaway, Denville, and Boonton and the Borough of Kinnelon, Morris County, New Jersey: Technical Assistance Report (Special Project NJFO-91-2), April 1991.

---. Regional Wetlands Concept Plan Emergency Wetlands Resources Act. Oct. 1990.

US Geological Survey. Drainage Basin Overlays (maps). Jan. 1988.

US Geological Survey. Water Resources. Summary of Monthly Hydrologic Conditions in New Jersey, Dec. 1998.

Wayland, Bob. A Note From Bob Wayland, Director of EPA's Office of Wetlands, Oceans and Watersheds. EPA Watersheds Events, An EPA Bulletin on Integrated Aquatic Ecosystem Protection, Spring 1994.

Whippany River Watershed Public Advisory Group. Whippany River Watershed Best Management Practices Guidance Manual, Draft, 1999.

Vegetation

Bailey, L.H. The Standard Cyclopedia of Horticulture. NY: The MacMillan Co., 1919.

BayScapes An environmental education initiative developed by the Alliance for the Chesapeake Bay, Inc.

Beat the Heat with Trees. Urban Forestry, 14(5), Oct./Nov. 1994.

Bowers-Altman, Jeanette. New Jersey's Landscape Project. Nongame News, Winter 1994.

Breden, Thomas F. A Preliminary Natural Community Classification for New Jersey. New Jersey's Rare and Endangered Plants and Animals, Institute for Environmental Studies, 1989.

Britton, Nathaniel Lord and Hon. Addison Brown. An Illustrated Flora of the Northern U.S. and Canada. Vols. 1 & 3. NY: Dover Publications, 1970.

---. An Illustrated Flora of the Northern U.S., Canada and the British Possessions. Vol. 1, NY: Charles Scribner's Sons, 1986.

Budd Lake Bog Natural Area Adds 29 Acres, Mplc@mail.gti.net (electronic bulletin board), Nov. 10, 1998.

Cartica, Robert J. Endangered Plants in New Jersey. New Jersey Audubon, 11(3), Fall 1985.

Ching, Thomas. Xeriscaping Helps When the Water Supply Is Low. The New York Times, Sunday, July 1, 1990.

Collins, Beryl Robichaud and Karl H. Anderson. Plant Communities of New Jersey; a Study in Landscape Diversity, New Brunswick, NJ: Rutgers University Press, 1994.

Dana, Mrs. William Starr. How to Know Wildflowers, Dover Publications, Inc., 1963.

Dey, Mandy. New Jersey's M.A.P.S. Project. Conserve Wildlife, Endangered and Nongame Species Program. NJ DEP. Division of Fish, Game and Wildlife, Fall 1994.

Dietz, Marjorie, J. The Concise Encyclopedia of Favorite Wild Flowers, Doubleday and Co., Inc., 1965.

Farny Highlands Watershed, sponsored by the Morris County Park Commission, July 1991.

Fowler, L., Angela Mark Satre, Theodore V. Wall, III. The Chesters - The Mendhams, Philadelphia: Department of Landscape Architecture and Regional Planning University of Pennsylvania, Spring 1976.

Gangloff, Deborah. The Sustainable City. American Forests, May/June 1995.

Great Swamp to be Sprayed with Herbicide. Daily Record, June 6, 1995.

Grimm, William. The Book of Shrubs, The Telegraph Press, 1957.

Hersey, Jean. Woman's Day Book of Wildflowers, Fawcett Publications, 1976.

The Highlands Study Team. New York-New Jersey Highlands Regional Study, coordinated by the USDA Forest Service, Northeastern Area, State and Private Forestry.

Hitchcock, A.S. Manual of the Grasses of the U.S., 2nd ed., Vol. 1, revised by Agnes Chase. NY: Dover Publications, Inc., 1971.

Hopps, Michael W. Go With the Flow: Legacy of the '93 Flood. Urban Forests, 14(3), June/July 1994.

Hotchkiss, Neil. Common Marsh, Underwater and Floating-Leaved Plants of the U.S. and Canada
Favorite Wildflowers, NY: Dover Publications, 1972.

House, Homer D. Wildflowers, The Macmillan Co., 1934.

Huxley, Anthony. Mountain Flowers in Color, Blandford Press, Ltd., 1967.

International Society of Arboriculture. Benefits of Trees, America the Beautiful and Urban and Community Forestry Programs of the USDA Forest Service, 1991.

Jervis, Robert A. The Vascular Plants and Plant Communities of Troy Meadows - A Fresh Water Marsh in Northern New Jersey, The Bulletin, New Jersey Academy of Science, 8(2), Fall 1963.

Kinnelon Environmental Commission. Natural Resource Inventory of Kinnelon, NJ, 1973-1974

Klaber, Doretta. Violets, A.S. Barnes and Co. Inc., 1976.

Lyons, Janet and Sandra Jordan. Walking the Wetlands. NY: John Wiley and Sons, Inc., 1989.

MacDonald, Lynn. Go Native or Exotic. Urban Forests, Oct./Nov. 1993.

Madison Environmental Commission. Environmental Resources Borough of Madison, Morris County, N.J. 1982.

Marshall, Nina L. Mosses and Lichens, A Popular Guide to the Identification and Study of Our Commoner Mosses and Lichens, Their Uses, and Methods of Preserving. NY: Doubleday, Page and Co., 1908.

Metropolitan New York forest Ecosystems Council, Inc. Top 20 Most Invasive Plants in New York State. Metro Forest Council News, 3(2), Spring & Summer 1999.

Miller, Larry S. Hacklebarney Natural Area Management Plan. NJ DEP/ Division of Parks and Forestry, June 1988.

Mitchell, Alison E. The New Jersey Highlands: Treasures at Risk, NJ Conservation Foundation, 1992.

Moll, Gary and Jack Petit. The Urban Ecosystem: Putting Nature Back in the Picture. Urban Forests, 14(5), Oct./Nov. 1994.

Montgomery, James D. and David E. Fairbrothers. New Jersey Ferns and Fern-Allies, Rutgers University, 1992.

Morris County Park Commission. Free-A-Tree Invasive Exotic Vegetation Volunteer Program.

NJ Audubon Society, The Audubon Owl, Franklin Lakes, NJ, June, 1975.

NJ Department of Agriculture. Protecting Our Streams With Plants, Shrubs for Streambank Conservation.

NJ Department of Environmental Protection. Division of Parks and Forestry. Protection and Care of the Urban Forest.

---. Urban Forestry: A National Trend. Urban Forestry, Fall 1994.

NJ Department of Environmental Protection. Division of Parks and Forestry. Office of Natural Lands Management. Boundary Maps for the New Jersey Natural Areas System, March 15, 1991.

---. Information sheet.

—. Morris County Rare Species and Natural Communities Presently Recorded in the New Jersey Natural Heritage Database, Dec. 19, 1997 (www.heritage.tnc.org/nhp/us/nj/county.html, Mar.11, 1999).

---. New Jersey Natural Areas, brochure, 1992.

---. Natural Heritage Priority Site Maps, Aug. 3, 1995.

---. Natural Heritage Site Report, Aug. 3, 1995.
NJ DEPE. Office of Natural Lands Management. Special Plants of New Jersey, Jan.1992.

Newcomb, Lawrence. Newcomb's Wildflower Guide. Boston: Little, Brown and Co., 1977.

North Jersey Resource Conservation & Development. Forest Stewardship Program, brochure

Partners of the Beaver Brook Restoration Project. Beaver Brook Restoration Project.

Pohl, R.W. How to Know the Grasses. Dubuque, Iowa: Wm. C. Brown Co. Publishers, 1954.

Porcella III, Santiago and George H. Pierson. New Jersey's Biggest Trees. NJDEP. Division of Parks and Forestry, Summer 1991.

Rickett, H.W. Odyssey Book of American Wildflowers, The Odyssey Press, Inc., 1964.

Rickett, H.W. ed. Wildflowers of America, From Paintings by Mary Vaux Walcott and Dorothy Falcon Platt, Crown Publishers, Inc., 1953.

Roane, Kit R. Knocking on the Door: A Tree-Eating Beetle That Will Stay for Dinner. The New York Times, Nov. 24, 1996.

Robichaud, Beryl and Murray F. Buell. Vegetation of New Jersey, A Study of Landscape Diversity, New Brunswick, NJ: Rutgers University Press, 1983.

Shelton, Theodore and Bruce Hamilton, Rutgers Cooperative Extension. Landscaping for Water Conservation, A Guide for New Jersey, New Brunswick, NJ: Rutgers, The State University of New Jersey.

Shosteck, Robert. Flowers and Plants, An International Lexicon with Biographical Notes, Quadrangle/The New York Times Book Co., 1974.

Some Plants are Ideal for Water Conservation. The New York Times, Sunday, March 5, 1989: 70.

Special Plants of New Jersey, retrieved from http.//www.heritage.tnc.org/nhp/us/nj/njplant1.htm on March 16, 1999.

Speiser, Robert and Thomas Bosakowski. Trouble in the Dogwood Patch: A Victim of Environmental Stress? NJ Audubon, Summer 1990.

Stupka, Arthur. Wildflowers in Color, NY: Harper and Row Publishers, 1965.

Ten Town Great Swamp Watershed Committee. Model Environmental Ordinances, Draft, Jan. 1997.

Tiner, Ralph W.J. Wetlands of New Jersey. US Fish and Wildlife Service, July 1985.

Urban Conservation Action Partnership. Streamside Restoration, Center Street.

---. Streamside Restoration, McCarter Park.

USDA. Soil Conservation Service. Conservation Plants for the Northeast, revised Feb.1991.

---. Our Environment Begins With Your Yard, March 1991.

US Department of the Interior. Fish and Wildlife Service. Common Wildflowers of the Great Swamp National Wildlife Refuge, New Jersey, Aug.1986.

---. Department of the Interior Final Environmental Impact Statement, Great Swamp National Wildlife Refuge Master Plan, 1987.

---. Environmental Assessment for the Proposed Natural Gas Pipeline Construction Within the Great Swamp National Wildlife Refuge, Morris County, New Jersey, June 1986.

---. Swamp Pink Identification Guide, March 1998.

---. Technical Assistance Report (Special Project NJFO-91-2) Pilot Study on the Feasibility of Protecting the Beaver Brook Area in the Townships of Rockaway, Denville, and Boonton and the Borough of Kinnelon, Morris County, New Jersey, April 1991.

US Environmental Protection Agency. Vegetative Filter Strips, July 1988.

---. Xeriscape Landscaping, Preventing Pollution and Using Resources Efficiently, April 1993.

Welsch, David J. Riparian Forest Buffers, Function and Design for Protection and Enhancement of Water Resources, Forest Resources Management, Northeastern Area, State and Private Forestry, USDA Forest Service, Radnor, Pa. NA-PR-07-91.

The White House. Office of the Press Secretary. Executive Order 13112, Invasive Species. Retrieved from www.pub.whitehouse.gov on March 2, 1999.

Wildlife

Benson, Delwin E. Helping Wildlife: Working With Nature, Wildlife Management Institute, 1977.

Berry, James F. Endangered Legislation for Endangered Species. Environment and Development, Nov/Dec 1995.

Bonasera, Paul. Park puts deer hunt on Hold. The Daily Record, Oct. 4, 1994.

Bosselman, Fred P. Planning to Prevent Species Endangerment. Land Use Law and Zoning Digest, 44(3), Mar. 1992.

Bowers-Altman, Jeanette. Landscape Ecology Sweeps Into Action: A New Dawn for Conservation in New Jersey. Conserve Wildlife, Endangered and Nongame Species Program. NJ DEP. Division of Fish, Game and Wildlife.

—. New Jersey's Landscape Project. Nongame News, Newsletter of the New Jersey Endangered and Nongame Species Program, NJ DEPE. Division of Fish, Game and Wildlife, Winter 1994.

Breden, Thomas. (NJ DEP. Natural Heritage Program). Phone conversation, Nov. 19, 1999.

Brewer, Bonnie. Black Bears Roaming Boonton-Montville Area. Daily Record, June 27, 1994.

Briscoe, David. Climate Shift Perils Bird Migrations. The Star Ledger, Sept. 20, 1996.

Burdick, Alan. It's Not the Only Alien Invader. The New York Times Magazine, Nov. 13, 1994.

Charlton, Art. Fish with a Mission. The Star-Ledger, July 10, 1991.

Crist, Patrick J. Filling the GAP with Planning. Environment and Development, Dec. 1994.

Day, Clifford G., Supervisor, U.S. Department of the Interior. Fish Game and Wildlife. Correspondence, Oct. 7, 1999.

Duerksen, Christopher J. and others. Habitat Protection Planning, Where the Wild Things Are (American Planning Association, Planning Advisory Service Report Number 470/471, 1997) 32.

Farny Highlands Watershed, A Plan to Protect Water Supplies and to Preserve Forests, Sponsored by the Morris County Park Commission, July 1991.

From Minnow to Sturgeon, North American Fish are in Peril. The New York Times, Jan. 30, 1990.

Fullam, Anne C. Injured Wild Birds Get Second Chance. The New York Times, Jan. 8, 1995.

Good Cover for Birds. Conserve Wildlife, Newsletter of the New Jersey Endangered and Nongame Species Program, NJ DEP, Division of Fish, Game and Wildlife, Summer 1999.

Hanley, Robert. Beyond Brown Grass, Nature Withers in Drought. The New York Times, Sept. 10, 1995.

The Highlands Study Team. New York-New Jersey Highlands Regional Study, Coordinated by the USDA.

Hoffman, Cindy. U.S. fish and Wildlife Service Announces Joint Policies to Encourage Landowners to Protect Species. Garden State Environet, June 18, 1999.

Johnson, Tom. Three Up, 4 Down for Jersey's Imperiled Birds. Star Ledger, Oct. 7, 1998.
Juoma, Jon R. In Wisconsin, a Debate Over Ways to Manage National Forest Growth. The New York Times, Oct. 18, 1988.

Line, Les. Birds That Nest in the Grasslands Find Their Habitats Under Siege. The New York Times, Dec.31, 1996.

MacDonald, Lynn. Making Room for Wildlife. Urban Forests, 14(4), Aug./Sept.1994.

McHugh, Margaret. Venomous Visitors. The Daily Record, July 8, 1992.

McLain, Pete. The Snakes of New Jersey, Reprinted from New Jersey Outdoors.

Mitchell, Alison, E. The New Jersey Highlands: Treasures at Risk, NJ Conservation Foundation, 1992.

Monette, Darrell. Why Restoration? Restoring the land's natural balance. Field Notes, US Fish & Wildlife Service, Sept. 1999.

NJ Department of Environmental Protection. Planning for Clean Water, The Municipal Guide, March 1999.

NJ Department of Environmental Protection. Division of Fish, Game and Wildlife. New Jersey is for Wildlife.

---. Wildlife, the Environmental Barometer, 1985.

NJ Department of Environmental Protection. Division of Parks and Forestry. Hacklebarney Natural Area Management Plan, 1988.

---. Morris County Rare Species and Natural Communities Presently Recorded in the New Jersey Natural Heritage Database, Dec. 19, 1997 (www.heritage.tnc.org/nhp/us/nj/county.html, Mar.11, 1999).

---. Natural Areas System Rules, Dec. 21, 1987.

---. Natural Heritage Priority Site Maps, Aug. 3, 1995.

---. Natural Heritage Site Report, Aug. 3, 1995.

NJ Department of Environmental Protection and Energy. Division of Parks and Forestry. Farny Natural Area Management Plan, June 6, 1994.

NJ DEPE. Division of Parks and Forestry. Office of Natural Lands Management. Special Animals of New Jersey, Jan. 1992.

1986 North Jersey Barred Owl Survey. Records of N.J. Birds, 12(4).

Schwab, Jim. The Biology of Wildlife Migration Corridors. Environment and Development, Apr. 1994.

Schwab, Jim. Conservation Reserve Program: A Walk on the Wildlife Side. Environment and Development, March 1995.

Schwab, Jim. Planning for Wildlife Migration Corridors. Environment and Development, May 1994.

Sciascia, Jim. Wildlife Diversity Tours - A Watchable Wildlife Program for New Jersey. Conserve Wildlife, Endangered and Nongame Species Program, NJ DEP.

Stevens, William K. Opportunistic Species Gain in Battle for the Backyard. The New York Times, March 1, 1994.

Stiles, Eric and Bob Raftovich. New Jersey's Herptile Atlas. Conserve Wildlife, Newsletter of the New Jersey Endangered and Nongame Species Program, NJ DEP, Division of Fish, Game and Wildlife, Spring/Summer 1995.

Tschappat, Mike. Campaign takes wing to protect Rockaway Twp. Bats. Daily Record, October 13, 1995.

US Department of Agriculture. Soil Conservation Service. Invite Birds to your Home, Conservation Plantings for the Northeast.

US Department of the Interior, Endangered Species, 1986.

US Dept. of the Interior. Fish and Wildlife Service. Birds of Great Swamp, National Wildlife Refuge, Sept. 1985.

---. Bring Back the Natives. Fact Sheet, Oct. 1998.

---. Partners in Flight. US EPA. Migratory Songbird Conservation.

---. Reptiles, Amphibians and Fishes, Great Swamp National Wildlife Refuge, Aug. 1988.

—. Technical Assistance Report (Special Project NJFO-91-2) Pilot Study on the Feasibility of Protecting The Beaver Brook Area in the Townships of Rockaway, Denville, and Boonton and the Borough of Kinnelon, Morris County, New Jersey, April 1991.

You Want to do WHAT on my Land? Frequently Asked Questions and Answers About the US Fish and Wildlife Service's Habitat Restoration Program, Partners for Wildlife, 6.

Valent, Mike. Rare Bat Find at Picatinny Arsenal. Conserve Wildlife, Endangered and Nongame Species Program, NJ DEP.

Valent, Mike and Rick Dutko. Bat Conservation Gate Protects State's Largest Hibernaculum. Conserve Wildlife, Endangered and Nongame Species Program, NJ DEP. Division of Fish, Game and Wildlife.

Venezia, Joyce A. Specialists Hoping to Save Periled Wood Rat. The Star-Ledger, May 10, 1990.

Watchable Wildlife. Conserve Wildlife, Newsletter of the New Jersey Endangered and Nongame Species Program, NJ DEP, Division of Fish, Game and Wildlife, Summer 1999.

Watchable Wildlife Program for New Jersey. Conserve Wildlife, Newsletter of the New Jersey Endangered and Nongame Species Program, NJ DEPE, Division of Fish, Game and Wildlife, Fall 1994.

The White House. Office of the Press Secretary. Executive Order 13112, Invasive Species, www.pub.whitehouse.gov, March 2, 1999.

—. Statement by the President, Oct. 26, 1996 (HR 4283 National Invasive Species Act of 1996), www.pub.whitehouse.gov, March 2, 1999.

Wildlife Management Institute. Placing Wildlife Management in Perspective, 1984.

You Want to do WHAT on my Land? Frequently Asked Questions and Answers About the U.S. Fish and Wildlife Service's Habitat Restoration Program. Partners for Wildlife.

Will We Lose Our Songbirds? Not if We can help it!, Partners in Flight, National Fish and Wildlife Foundation, Washington, DC.

Zappalorti, Robert T. Results of 1982 Research on the Bog Turtle, *Clemmys muhlenbergii* in New Jersey, Staten Island, NY: Herpetological Associates, Inc., Aug. 15, 1983.

Climatology

Bauersfeld, W.R. and R.D. Schopp (U.S. Geological Survey), and M.D. Shulman (Rutgers University). New Jersey Floods and Droughts. National Water Summary 1988-89 Floods and Droughts: NEW JERSEY

Legislative Update. The Commuter 3 (1) Winter 1996: 2.

Longcore, Jerry R., R. Kenyon Ross, and Kathleen L. Fisher. Wildlife Resources at Risk Through Acidification of Wetlands, reprinted from Transactions of the Fifty-second North American Wildlife and Natural Resources Conference, edited by Richard E. McCabe. Washington, D.C.: Wildlife Management Institute, Sept. 1987.

McNicol, Donald K., Barry E. Bendell, and Daniel G. McAuley. Avian Trophic Relationships and Wetland Acidity, reprinted from Transactions of the Fifty-second North American Wildlife and Natural Resources Conference, edited by Richard E. McCabe. Washington, D.C.: Wildlife Management Institute, Sept. 1987.

Mc Rides Celebrates Ten Years 1986-1996. The Commuter 3 (1) Winter 1996: 1.

Mikula, Andy (NJ DEP. Bureau of Air Monitoring). Phone conversation, March 27, 1996.

Montgomery, Carla W. Environmental Geology. Iowa: Wm. C. Brown Publishers, 1986.

Morris County Department of Planning and Development. Division of Transportation Management. 1993 Morris County Air Quality Plan for Mobile Source Emissions: An Analysis of Transportation Control Measures. Feb. 1993.

Morris County Department of Planning and Development. Division of Transportation Management In cooperation with Morris County Planning Board. Morris County Master Plan, Circulation Element. March 5, 1992.

National Oceanic and Atmospheric Administration. Climatological Data Annual Summary New Jersey, 1978.

---. Climatological Data Annual Summary New Jersey, Newark, NJ (EWR), 1980.

---. Climatological Data Annual Summary New Jersey, 1982.

---. Climatological Data Annual Summary New Jersey, 1984.

---. Climatological Data Annual Summary New Jersey, 1986.

---. Climatological Data Annual Summary New Jersey, 1988.

---. Climatological Data Annual Summary New Jersey, 1990.

---. Climatological Data Annual Summary New Jersey, 1992.

---. Climatological Data Annual Summary New Jersey 99:13, 1994.

---. Climatological Data Annual Summary New Jersey 100:13, 1995.

---. Climatological Data Annual Summary New Jersey 101:13, 1996.

---. Climatological Data Annual Summary New Jersey 102:13, 1997.

---. Local Climatological Data Annual Summary With Comparative Data. Newark, NJ (EWR), 1994.

---. Local Climatological Data Annual Summary With Comparative Data. Newark, NJ (EWR), 1996.

NJ Department of Environmental Protection. Overview of Initial Results Statewide Scientific Study of Radon. Sept. 1987.

---. Short Term Storage Containerized Radium-Tainted Soils. 1987.

NJ Department of Environmental Protection. Bureau of Air Monitoring. 1987 Air Quality Report. July 1988.

---. 1988 Air Quality Report. July 1989.

---. 1989 Air Quality Report. July 1990.

---. 1992 Air Quality Report. Sept. 1993.

---. 1993 Air Quality Report. July 1994.

---. 1994 Air Quality Report. Sept. 1995.

---. 1995 Air Quality Report. Aug. 1996.

---. 1996 Air Quality Report. Aug. 1997.

---. 1997 Air Quality Report. Oct. 1998.

---. Summary of 1998 Air Quality in New Jersey. Sept. 7, 1999.

NJ Department of Environmental Protection and New Jersey Department Of Transportation. Let's Clear the Air, Clean Air Facts. 1996.

NJ Department of Health. Division of Occupational and Environmental Health. Facts and Recommendations on Exposure to Radon.

NJ Transit. Planning for Transit-Friendly Land Use, A Handbook for New Jersey Communities, June 1994.

Office of Air Quality Management. Notice of Revisions to the State Implementation Plan for Ozone. New Jersey Register, Sept. 20, 1993: Cite 25 N.J.R. 4519.

Public Service Electric and Gas Company. Public Service Electric and Gas Company Environmental Progress Report. 1995.

Regional Plan Association - New Jersey. From A to Ozone. Project: CLEAN AIR, Improving New Jersey's Air Quality 2:2, March 1990.

---. Public Opinions About Air Pollution and its Remedies: Results of the Eagleton Survey for Project: CLEAN AIR. Project: CLEAN AIR, Improving New Jersey's Air Quality 9:1, Aug. 1991.

Regional Plan Association - New Jersey. The Health Effects of Ozone. Project: CLEAN AIR, Improving New Jersey's Air Quality 3:1, April 1990.

Schleicher, Judith. President's Prerogative. The Commuter 3 (1) Winter 1996: 2.

United States Environmental Protection Agency. Office of Air and Radiation. US Dept. of Health and Human Services. Centers for Disease Control. A Citizen's Guide to Radon, What it is and What to do About it, OPA-86-004, Aug. 1986.

US Environmental Protection Agency. Office of Research and Development, Air and Energy Engineering Research Laboratory. Radon Reduction Techniques for Detached Houses Technical Guidance, EPA/625/5-86/019.

US Geological Survey. Summary of Monthly Hydrologic Conditions in New Jersey, West Trenton, NJ, Dec. 1998.

Williamson, Samuel J. Fundamentals of Air Pollution. Massachusetts: Addison-Wesley Publishing Company, 1973.

Wiener, James G. Metal Contamination of Fish in Low-pH Lakes and Potential Implications for Piscivorous Wildlife, reprinted from Transactions of the Fifty-second North American Wildlife and Natural Resources Conference, edited by Richard E. McCabe. Washington, D.C.: Wildlife Management Institute, Sept. 1987.