THREATENED AND ENDANGERED VASCULAR PLANT SPECIES OF THE NEW JERSEY PINELANDS AND THEIR HABITATS

Prepared for the NEW JERSEY PINELANDS COMMISSION

by

NICHOLAS CALAZZA (Consultant)

DAVID É. FAIRBROTHERS (Project Director)

February 1980

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#### EXECUTIVE SUMMARY

Within this century, several species of plants native to the New Jersey Finelands have become jeopardized with extinction. In order to bring this issue to light, 71 rare species (including ferns, grasses, sedges and broadleaved plants) have been inventoried and assigned Endangered, Threatened or Undetermined status for the Pinelands in this report. Descriptions of specific habitats, general locations, geographic affinities, flowering times, and listings by habitat type, watershed and county are also given for each Endangered and Threatened species. A study of this information shows that more of the inventoried species are found in wetland habitats than in the drier, upland areas of the Pinelands.

Potentially destructive impacts on threatened and endangered plant populations in the Pinelands can result from direct physical destruction of habitats, pollution of habitats either directly or through the pollution of waterways draining into them, altering of water levels for long periods of time (which can eliminate established species), or mowing before or during flowering and fruiting time. Two major pollutants potentially limiting to rare Pinelands species are herbicides, which limit broadleaved plant populations, and overburdening amounts of plant nutrients from septic systems and agricultural runoff, which encourage the invasion of more competetive species. Certain small-scale physical disturbances, however, have been shown to increase the occurrence of some of the inventoried species.

#### Recommendations To The Commission

Preservation and protection is desirable for all the critical habitats described in this report. Especially significant areas are:

Atsion and vicinity, including the Batsto River; Wetlands along the West Branch of the Wading and Oswego Rivers; Land surrounding the Goose Ponds; The Plains;

Brackish marsh along the Manumuskin River; The swamp and bog area just west of Oceanville.

All development, active recreation and most other human activities should be restricted or prohibited in the above areas.

Preservation of many of these critical habitats will probably require the protection of contiguous buffer or support areas. In addition, proper land management techniques should be established to maintain and encourage endangered and threatened plant populations. These should include measures exploiting the beneficial effects of physical disturbance (such as controlled clear-cutting or burning), mowing of roadsides and bog fringes only after flowering and fruiting seasons, the elimination of practices affecting water levels over long periods of time,

reduced or prohibited use of herbicides, and perhaps even occassional irrigation of habitats by tank truck.

Continued botanical field survey of all critical habitats, as well as other, potentially productive areas is needed.

Cranberry growers should be encouraged to continue their cultivation of bogs because of their requirements for large amounts of clean, acidic water and their restricted use of fertilizers.

Further research is needed regarding the niche requirements of most of the species listed to increase our ability to protect and maintain critical habitats.

## ACKNOWLEDGMENTS

The authors wish to express sincere thanks to Vincent Abraitys, Joseph Arsenault, Ted Gordon, Louis Hand, Edmund Laport and David Snyder for several suggestions and personal insights offered during the compilation of this report.

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#### INTRODUCTION

This report is an attempt to draw attention to 71 threatened or endangered plant species and their habitats in the New Jersey Pinelands. These plants are all native to southern New Jersey, and most have been mentioned in American botanical literature as far back as 1881. Some are considered Pineland symbols, such as the curly grass fern (Schizaea pusilla) or broom crowberry (Corema conradii), while others, like the tooth cup (Rotala ramosior) are not so well known. Despite a long history of popular knowledge and concern for these plants, however, they all face ultimate extinction if present trends in habitat destruction and exploitation continue in the Pinelands.

The importance of maintaining species diversity at naturally high levels can be argued in several ways, from simple asthetic pleasure to illustrating the complex interdependence of plants, animals and the physical environment. As Fairbrothers (1979) pointed out, threatened and endangered species represent approximately 12% of the 580 native Pinelands plant species. If this 12% were to be eliminated, an important component of the Pinelands flora would be lost forever - a striking addition to the biological impoverishment of the area.

Besides a species inventory, we have included a habitat description for each plant, charts containing the habitat associations (from McCormick and Jones, 1973), watersheds and counties in which these species are found, their geographical affinity and the time range in which they flower or produce spores. Relative importance of habitats and management techniques are discussed, and our recommendations to the Commission are included at the end.

#### METHODS

The basic source for our inventory of threatened and endangered plant species is the list presented by Fairbrothers in the book Pine Barrens: Ecosystems and Landscape (1979). Two species were deleted from the original list (Asclevias variegata and Panicum cryptanthum), while Aeschenomene virginica and Habenaria cristata were added. Occasional changes were made in the status of some species as more information was available.

The individual plants in our inventory are classified as either endangered, threatened or undetermined for the Pinelands, and our definitions for these terms are modified from Fairbrothers (1979), and are as follows:

ENDANGERED. A species of plant whose survival in the Pinelands is in jeopardy. Its peril may result from the destruction of habitat, change in habitat, over-exploitation by people, predation, adverse inter-specific competition, disease, or because the Pinelands are at the edge of its geographical range. An endangered species must receive protection, or extinction probably will ensue.

THREATENED. A species of plant that, while currently not considered near extinction, is one which occurs in such small numbers in the Pinelands that it may become endangered if its environment deteriorates or other limiting factors are altered. Continued observation of its status is essential.

UNDETERMINED. This status covers two cases - a species known to be either threatened or endangered in the Finelands, or known to be either endangered or extinct. Regardless of which category an undetermined species falls into, currently available information is inadequate to determine its

status accurately, and additional information is required to reclassify it more specifically.

We have also included nine species in our inventory that have been proposed for the national list of threatened and endangered species as of October, 1979, and whose range includes the Pinelands (Federal Register, U.S. Dept. of Interior, 1975, 1976).

There are three sources of old literature that are mentioned throughout the Species Comments section of this report - Britton (1889), Stone (1911) and Taylor (1915). Some recent literature sources were used in establishing current species locations, including Fables (1954), Wherry (1959), Schuyler (1961), Swallen (1961), Fairbrothers and Hough (1973, 1975) and Ferren (1975). The prime sources of population locations and descriptions were the files and specimens of the Chrysler Herbarium, Nelson Laboratories, Rutgers University, New Brunswick. We also relied on the personal observations of D.E. Fairbrothers, and the comments and suggestions of several local amateur botanists.

#### SPECIES INVENTORY

This chapter consists of the species list including status ( Table 1 ), individual species comments including habitat description, distribution and, for many species, notes on impacts, and finally, habitat and distribution charts (Tables 2 and 3).

TABLE 1. Endangered, Threatened and Undetermined Native Pinelands Plants. (E, endangered; T, threatened; U, undetermined; En, Th, endangered and threatened on proposed national list.)

Aeschynomene virginica (L.) BSP. sensitive-joint-vetch T

Asclepias rubra L. red milkweed T

Asclepias verticillata L. whorled milkweed U

Aster concolor L. silvery aster T

Breweria pickeringii (M.A. Curtis) Gray T

Bonamia pickeringii (Torr.) Gray Pickering's morning glory

Calamovilfa brevipilis (Torr.) Scribn.
Pine Barrens reedgrass Th, T

Carex barrattii Schwein. & Torr. Barratt's sedge T

Chrysopsis falcata (Pursh) Ell. sickle-leaved golden aster T

Cleistes divaricata (L.) Ames spreading pogonia E

Clitoria mariana L. butterfly pea U

TABLE 1 cont.

Corema conradii Torr. broom crowberry E Coreopsis roses Nutt. rose-colored tickseed T Crotonopsis elliptics Willd. rushfoil E Cuscuta cephalanthii Engelm. buttonbush dodder U Desmodium strictum (Pursh) DC. stiff tick trefoil T Eleocharis equisetoides (Ell.) Torr. knotted spike rush E Eupatorium resinosum Torr. resinous boneset T Eriophorum tenellum Nutt. few-nerved cotton grass U Gentiana autumnalis L. Pine Barrens gentian E Gymnopogon ambiguus (Michx.) BSP. broad-leaved beardgrass U Habenaria ciliaris (L.) R.Br. yellow-fringed orchid E Habenaria cristata (Michx.) R.Br. crested yellow orchid E Habenaria integra (Nutt.) Spreng. southern yellow orchid EN, E Juncus caesariensis Coville New Jersey rush Th, T Liparis lilifolia (L.) Richard lily-leaved twayblade Th, E Liparis loeselii (L.) Richard Loesel's twayblade E Listera australis Lindl. southern twayblade T Lobelia boykinii Torr. & Gray Boykin's lobelia E Lobelia canbyi Gray Canby's lobelia T Ludwigia hirtella Raf. hairy ludwigia T Ludwigia linearis Walt. linear-leaved ludwigia E Lygodium palmatum (Bernh.) Sw. climbing fern E Muhlenbergia torreyana (Schult.) Hitchc. Torrey's muhly Th, T Narthecium americanum Ker. yellow asphodel T Nymphoides cordata (Ell.) Fern. floating heart T Panicum hemitomon Schultes narrow panic grass T

## TABLE 1 cont.

Panicum hirstii Swallen Hirst's panic grass En, E Panicum oligosanthes Schultes few-fruited panic grass U Panicum scabriusculum Ell. sheathed panic grass U Phoradendron flavescens (Pursh) Nutt. American mistletoe T Polygala mariana Miller Maryland milkwort T Potamogeton confervoides Reichenb. alga-like pondweed U Potamogeton oakesianus Robbins Oake's pondweed U Prenanthes autumnalis Walt. slender rattlesnake root E Rhexia aristosa Britt. awned meadow beauty E Rhynchospora cephalantha Gray capitat beakrush T Rhynchospora filifolia Gray thread-leaved beaked rush U Rhynchospora inundata (Cakes) Fern. slender beaked rush T Rhynchospora knieskernii Carey Knieskern's beaked rush En, T Rhynchospora microcephala Britt. small-headed beaked rush U Rhynchospora oligantha Gray few-flowered beaked rush U Rotala ramosior (L.) Kochne tooth cup U Schizaea pusilla Pursh curly grass fern Th Schwalbea americana L. chaffseed Th, E Scirpus longii Fern. Long's bulrush Th Scleria minor (Britt.) Stone slender nut rush T Scleria reticularis Michx. reticulated nut rush T Sclerolepis uniflora (Walt.) BSP. sclerolepis T Solidago elliottii T. & G. Elliott's goldenrod U Solidago stricta Ait. wand-like goldenrod E Spiranthes tuberosa Raf. little ladies tresses T Tipularia discolor (Pursh) Nutt. crane-fly orchid U

TABLE 1 cont.

Tofieldia racemosa (Walt.) BSP. false asphodel E

Utricularia gibba L. humped bladderwort T

Utricularia clivacea Wright ex. Griseb. white-flowered bldwt. E

Utricularia purpurea Walt. purple bladderwort T

Utricularia resupinata B.D. Greene reclined bladderwort E

Uvularia pudica (Walt.) Fern. Pine Barren bellwort U

Kyris fimbriata Ell. fringed yellow-eyed grass U

Kyris flexuosa Muhl. yellow-eyed grass T

Zigadenus leimanthoides Gray coastal zygadine U

# Species Comments

Comments are provided for threatened and endangered species only.

Aeschynomene virginica. Found in New Jersey at the northern limit of its geographical range, on mud banks of brack-ish rivers and marshes. It grows in only two places in the Pinelands, on the Wading River near the village of Wading River, and on the Maurice and Manumuskin Rivers from Port Elizabeth to Manumuskin.

Asclepias rubra. Found in New Jersey at the northern edge of its geographical range. Grows in moist soil in permanently wet herbaceous marshes and along the edges of sphagnum bogs. Apparently decreasing in the Pinelands through habitat destruction. Many of the stations listed in the old literature are now destroyed. This species has recently been seen growing along the Wading and Oswego Rivers, and west of Oceanville.

Aster concolor. Grows in dry, sandy soil in open pine-oak woods with little shrubby undergrowth. Described as frequent in the Pine Barrens in the old literature, and is reputed to be decreasing each year. Recent sites include Lebanon State Forest, Wheatland and Atsion. Occurance of this species may be increased by low intensity fires in the shrub layer that do not damage the pines.

Breweria pickeringii. Found in the Finelands at the northern limit of its geographical range. Reported as uncommon in the Finelands from the old literature. Grows in open,

dry sandy fields that are in an intermediate stage of succession, originally cleared from an oak-pine or pine-oak forest area. Grasses and taller vegetation out-compete it, and its occurrence is intermittent. The only recently verified site for this species is at a railroad crossing near the Carranza memorial, although others have been reported.

Calamovilfa brevipilis. Confined in the U.S. almost entirely to the New Jersey Pinelands. Considered to be a commonly occurring species in the old literature. This species grows in herbaceous (grass-sedge) marshes, along the fringes of active cranberry bogs, and in old cranberry bogs during their early stages of abandonment. It cannot survive, however, after woody plants begin to dominate a bog or marsh, and so is decreasing in the Finelands as cranberry bogs are permanently abandoned. Recently seen near Quaker Bridge, Atsion, Batsto, and south of Chatsworth along the Wading River.

Carex Barrattii. Considered uncommon in the Pinelands in the old literature. Grows in wet soil along streams, marshes and the edges of bogs. It has been seen recently near Atsion, north of Warren Grove and south of Chatsworth along the Wading River.

Chrysopsis falcata. Found in the Pinelands at the southern edge of its limited range, where it was described in the old literature as not common. Grows in dry, sandy soil in open, non-forested areas. Has recently been found growing near Harrisville, Atsion and lower Forge. This species does well in disturbed sites, and in some areas is affected positively by mowing.

Cleistes divaricata. At the northern limit of its geographical range in the Pinelands. Grows along the edges of open bogs and herbaceous marshes which contain little woody vegetation, and is often hidden by grasses and sedges. Most known sites have been destroyed. The plant was last seen growing along the Wading River south of Chatsworth during the 1950's, and it may now be extinct in the Pinelands. Further field study is required to verify its status.

Corema conradii. Occurs in the Pinelands at the southern limit of its geographical range, and is extensively discussed in the old literature. It grows in dry, sandy soil in pine-oak forests, and is almost exclusively confined to the East, West and Spring Hill Plains areas. This species has a history of erratic appearance, and seedlings apparently establish themselves in areas of open sunlight where they grow and persist until overstory shade limits or kills them off. (For a more complete description of Corema's habitat requirements, see Vivian, 1978.) Because of the apparent

high light requirement for seedlings, disturbances which open canopy spaces in the plains would tend to favor the occurrence of this species. Indeed, it is usually found on the edges of paths or roads in disturbed sites.

Coreopsis roses. Grows in wet soil in open, grassy areas in the higher parts of hardwood swamps and bogs. Also found in grassy drainage areas devoid of trees near roadsides. This species has been recently reported to be in the Pinelands near Dorothy, Indian Mills, the Goose Ponds and a bog near Egg Harbor City.

Crotonopsis elliptica. Grows in dry, sandy soil in open, non-forest areas. It is frequently found along railroad tracks, most recently between Atsion and Parkdale. Occurrence is often favored by disturbance.

Desmodium strictum. Present in the Pinelands at the northern limit of its geographical range, where it was reported to occur frequently in the old literature. Grows in dry, open areas in pine-oak or oak-pine forests, and along road-sides. Few reports of recent sitings are available for this species, although it has been seen near Quaker Bridge. More information and search is needed.

Eleocharis equisetiodes. Grows in shallow water around ponds and in bogs and herbaceous marshes. The only record of this species in the Pinelands from the old literature is from a swamp at Repaupo, but it has not been seen there since the early 1900's. The only known current site is the Goose Ponds area.

Eupatorium resinosum. Found in the Pinelands at the northern limit of its geographical range, although perhaps no longer found outside of New Jersey. Grows in wet soil in bogs and young hardwood swamps. It has recently been located in Quaker Bridge, Folsom, Forked River, Waterford Township (Camden Co.) and south of Cassville.

Gentiana autumnalis. Found in the Pinelands at the northern limit of its range. Grows in damp, open, sandy areas often bordering pine-oak forests. Several small populations are currently located in Atsion and the surrounding area, and near Chatsworth, Hammonton, in the Lebanon State Forest, and along the Wading River. The species is rapidly disappearing, however, due to habitat destruction, collection for rock gardens and other exploitation. This is another Pinelands species that has been shown to be quite successful in disturbed areas such as roadside ditches, moved fields and burned over places.

<u>Habenaria ciliaris</u>. Grows in bogs, herbaceous marshes, or open hardwood and cedar swamps, particularly in patch-disturbed spots. There are only a few currently known

stations with small populations known in the Pinelands, including Wheatland and two sites along the Batsto River.

Habenaria cristata. Found in the Pinelands at the northern limit of its geographical range. Grows in herbaceous marshes, along open bogs and occasionally in abandoned cranberry bogs. It has most recently been sited at Quaker Bridge, Oceanville and Elwood. This species is fast disappearing due to plant succession, habitat destruction and collectors, and nearly all the stations reported in the old literature are destroyed.

Habenaria integra. Also at the northern limit of its range here. Grows in open herbaceous marshes or meadows, or perhaps along open bogs. There are only one or two sites known in New Jersey, and the species is threatened by changes in drainage and collectors. It currently grows in a wet meadow along the Oswego River and probably along the Batsto River. The occurrence of this species in certain areas may possibly be increased by mowing at certain times of the season, or where woody vegetation is cleared away.

Juncus Caesariensis. Found only in the New Jersey Pinelands and in Virginia. Grows along the edges of hardwood and cedar swamps, bogs and rivers flowing through swamps. This species has recently been found along the Tulpehocken Branch of the Wading River, along the Batsto River, south of Chatsworth. at Bamber Lake and near Atsion.

Livaris lilifolia. Grows in moist, rich sandy or loamy woods and clearings. The old literature reported this species to be frequent in northern New Jersey but rare in the south, and it has not been reported found in the Pinelands since the 1940's at Martha. It may be extinct in the Pinelands, and more searching is required.

Liparis loeselii: Grows in wet soil in depressed areas where organic matter accumulates. Not restricted to specific forest types although most likely in pine-oak or oakpine forests. One recent station from the Pinelands is available for this species, along the Oswego River. It, too, requires further survey work in the field.

Listera australis. Grows in hardwood and cedar swamps, and bogs with woody vegetation. It is usually found in these habitats among shrubs on hummocks. Only two recent sites are available for this species - Forked River and near Scullville. It was considered rare in the old literature, and most of the old stations are destroyed.

Lobelia boykinii. Found in the Pinelands at the extreme northern limit of its geographical range. Grows in wet soil around the edges of ponds and bogs, not in constant standing

water. This species was first discovered in the Pinelands in 1958 and has been seen only at the Goose Ponds and a bog near Egg Harbor City, where it could be eliminated by pollution or drainage.

Lobelia canbyi. Also at the northern limit of its range here. Grows in bogs and herbaceous marshes. Described as frequent in the Pinelands in the old literature, but its occurrence has decreased during this century. Recent sitings include Atsion, Atco, Parkdale, Bamber Lake and along the Oswego, Wading and Batsto Rivers.

Ludwigia hirtella. Found at the northern limit of its geographical range in the Pinelands, where the old literature lists it as rare. Grows in wet, peaty soil around lakes and ponds. The only recently reported location for this species is near Atsion.

Ludwigia linearis. Found in the Pinelands at the northern limit of its range, where it was considered rare in the old literature. Grows in shallow water in hardwood swamps, bogs and along the edges of ponds. This species has been seen recently at only one place in southern New Jersey, in a bog east of Egg Harbor City.

Lygodium palmatum. Grows along streams running through. hardwood swamps, climbing up trees and shrubs up to three feet. Recently sited in New Lisbon, Pemberton, Hampton Furnace, Atsion and in the Wharton State Forest.

Muhlenbergia torreyana. Found in the Pinelands at the northern limit of its geographical range. Grows in peaty or damp, sandy soil in hardwood swamps, herbaceous marshes and bogs. Also found in forest depressions and roadside ditches that are constantly wet and have accumulated a layer of organic matter. It has recently been reported present near Hampton Furnace and in a few locations around Atsion.

Narthecium americanum. Also at the northern limit of its range here. Grows in natural bogs, herbaceous marshes and cranberry bogs that have been abandoned for 20 or more years. The presence of woody vegetation, even at a young stage, tends to shade out this species. Also, the development of new cranberry bogs can destroy its natural habitat. It has recently been sited along the branches of the Wading River south and west of Chatsworth, near Atsion, Forked River, the Carranza Memorial and Sim Place.

Nymphoides cordata. Found along the edges of slow flowing streams and ponds, particularly in coves. Although not considered common in the old literature, this species appears to be decreasing due to habitat destruction (draining of ponds, human development, etc.). Recent sitings include

the Goose Ponds, a bog east of Egg Harbor City, Batsto, Hammonton and a pond near Hampton Furnace.

Panicum hemitomon. Found in the Pinelands at the northern limit of its geographical range. Grows in bogs, herbaceous marshes, cedar and hardwood swamps and wet ditches. The only recent siting available is at the Goose Ponds near Egg Harbor, where this species can consistently be seen growing in standing water. It is also known from the Cape May peninsula.

Panicum hirstii. Found here at the northern edge of its limited range. It grows in an environment quite similar to that of Panicum hemitomon. Although there are several seemingly appropriate habitats for this species in the Pinelands, it has only been found in one place - a bog east of Egg Harbor City.

Phoradendron flavescens. Found in the Pinelands at the northern limit of its geographical range as a parasite on various decidous trees, especially red maple and black gum. Has declined in the last century primarily due to human harvesting, along with forest fires and perhaps pollution. While once considered frequent in the Pinelands, the only recent sites available are Belleplain State Forest, Albion and Indian Mills.

Polygala mariana. Found in the Pinelands at the northern limit of its range, where it was considered rare in the old literature. Grows in wet soil in herbaceous marshes, along the edges of cranberry bogs and in open readside areas. Two recently reported stations for this species are at Hampton Furnace and Bulltown.

Prenanthes autumnalis. Found in the Pinelands at the northern limit of its geographical range. Grows in sandy or peaty moist soil in roadside ditches (where organic matter and moisture accumalates), bog edges, abandoned cranberry bogs and in wet, open edges of pine-oak forests. Becoming more rare each year due to habitat distruction and other human disturbances. This species has been recently sited south of Whiting and southwest of Atsion.

Rhexia aristosa. Also found here at the northern limit of its range. It grows in sandy acid bogs of the Pinelands and southern shore area. This species has always been considered rare, and has been seen recently only at the Goose Ponds.

Rhynchospora cephalantha. Found in the Pinelands at the northern limit of its range, where it was considered rare in the old literature. Grows in sphagnous soil on the edges

of bogs and hardwood swamps, usually in standing water for part of the growing season. Recently reported stations for this species are near Lake Oswego, High Crossing, Atsion, Weekstown, Parkdale and south of Chatsworth.

Rhynchospora inundata. Grows in wet, sphagnous margins of bogs and hardwood swamps, usually in pure sedge stands. It has recently been sited at the Goose Ponds and a bog near Egg Harbor City, in the Middle Branch Watershed in Lebanon State Forest, and west of Clermont in Cape May County.

Rhynchospora knieskernii. Found only in the New Jersey Pinelands and in Delaware. Growth is restricted to bogs containing bog iron, especially where iron ore has been removed in the past. It is not found in cranberry bogs. Recently reported sites include Speedwell, along the Batsto River, Tulpehocken Creek, north of Weekstown and Reega.

Schizaea pusilla. Found in the Pinelands at the southern limit of its range. Grows in open patches in cedar swamps on hummocks or wet, rotting cedar stumps. Vivian (1978) more specifically defines its habitat as "in a distinctive zone on hummocks just above high water levels and below the grass and shrub zone." Both Vivian and Little (1974) have stated that occurrence of Schizaea is usually associated with past disturbance in a cedar swamp, including fire, lumbering, borrow pits and formation of trails, all of which open up the canopy and admit more light. Plant succession will eventually cause the elimination of this species in many of these areas, however. It has been recently sited along McDonalds Branch (Lebanon State Forest), in the Fort Dix Reservation, in several places along the Batsto and Oswego Rivers and at Webbs Mill.

Schwalbea americana. Grows in sandy soil in open, non-forest areas. It is frequently found along railroad tracks, most recently between Atsion and Parkdale. Its occurrence is often favored by disturbance.

Scirpus longii. Grows in wet soil in herbaceous marshes and along pond margins both in and out of standing water. It has recently been sited near Atsion (in several spots), Parkdale, Richland and at McDonalds Branch in Lebanon State Forest. Schuyler (1961) has suggested that temporary dry spells may be necessary for culm formation and flowering in this species, and that fires may be related to such dry conditions. He pointed out that many of the plants he studied in the wild had charred basal leaves, while many were also found along railroad tracks.

Scleria minor. Found in the Pinelands at the northern edge of its geographical range. Grows on hummocks in open areas of hardwood swamps and in sphagnous, wet, open,

non-forest areas, usually with other sedges, orchids and ericaceous plants. Recent sitings have been reported near Atsion. Speedwell and Parkdale.

Scleria reticularis. Considered quite rare in New Jersey in the old literature. Grows in wet, sphagnous soils in open bogs and hardwood swamps. This species has recently been sited at the Goose Ponds, and near Milmay, Dorothy, Speedwell and Chatsworth.

Sclerolepis uniflora. Found growing in shallow standing water in ponds, hardwood swamps and wet bogs. The only recent stations are the Goose Fonds and Quaker Bridge.

Solidago stricta. Found in the Pinelands at the northern limit of its geographical range. It grows in damp, open sandy areas bordering pine-oak forests or along roads running through them. Recent sitings of this species have been reported near Atsion, south of Buena, near Bennetts Mill and on Oak Island near Great Bay. As with Gentiana autumnalis, whose habitat is quite similar to this species, it appears to flourish in some types of disturbed areas. It has been decreasing, however, in recent years and some old stations have been destroyed.

Spiranthes tuberosa. The habitat for this species is also quite similar to that of Gentiana autumnalis - damp open areas in or around pine-oak and oak-pine forests. Considered frequent in the old literature, yet the only recently reported sites are Quaker Bridge, Atsion and near Whiting.

Tofieldia racemosa. Found in the Pinelands at the southern limit of its range, where it was considered rare in the old literature. It grows in wet, open, grass-sedge areas within hardwood swamps where there are no trees. Recent sitings include Martha, Tulpehocken Creek, Sim Place, Speedwell and around Chatsworth. Disturbances that create open patches in hardwood canopies may tend to increase the occurrence of this species.

Utricularia gibba. Found growing in shallow water, intermittent water or mud flats in hardwood swamps, bogs and ponds. Two stations have been reported recently - Colliers Mills and an abandoned cranberry bog near the Atco Dragway.

Utricularia olivacea. This species is found in the Pinelands far beyond its usual northern limit (the Carolinas), and its habitat is quite similar to that of <u>U. gibba</u> except for its affinity for slightly deeper water. It was first found in New Jersey in 1959 at the Goose Ponds and has been seen nowhere else to date.

Utricularia purpurea. This species is a submerged aquatic

forming large mats in lakes and ponds. Sited recently in the Goose Ponds, a pond near Oceanville, the Batsto and Oswego Rivers, Colliers Mills, Webbs Mill and a pond in Forked River. Although considered frequent in the old literature, it is now decreasing as many of the old stations have been destroyed.

Utricularia resupinata. Considered rare in New Jersey in the old literature. Grows along pond edges, where sphagnum accumulates. Only two recently reported stations are available (the Goose Ponds and Martha Pond) and more searching is required.

<u>Xyris flexuosa</u>. Also found in the Pinelands at the northern limit of its range. Grows in wet soil in open bogs, herbaceous marshes and hardwood swamps, where there is little woody vegetation. Recent sitings have been reported from Success Lake, Hampton Furnace, Quaker Bridge and near High Crossing.

TABLE 2. Threatened and Endangered Plant Species of the New Jersey Pinelands, Their Geographical Affinity (North or South), Flowering Time, and Habitats in Which They Are Found. (An explanation of habitat codes can be found in Appendix 1, and the method of assigning importance ratings for species is given at the end of the table.)

	-			HA	HABITAT					FLOWERING
SPECIES/RATING	APPINITY	PO	0P	PPLL	C HDW	WATER	R BOG	MARSH	NF	RANGE
							<u> </u>	7		
Aeschynomene					-					Aug. to Oct.
virginica	8							(Brackish)	_	
Asclepias							`	`		late June to
rubra	8						>	۷		late July
Astor		`				_				mid Aug. to
concolor	ß	>								early Oct.
Breveria									<u> </u>	mid July to
pickeringii	8						_		۷	late Sept.
Calamovilfa			-					•		
brevipilia	, co						>	7		early July to
					`				·	late Sept.
Carex					_	_	•	\		April to
barrattli	•						>	>		early July
Chrysopsis									\	early July
falcata	z								>	to Sept.
Cleistes							`	\		late June to
divaricata	8						>	>		early July
Согева		<u> </u>	_							mid March to
conradii	H	>								
Coreopsis			-		\ 		\		/	early July to
rosea	z				>		۷		>	late Sept.
Crotonopsis					-				/	late July to
elliptica	N/S								>	early Sept.
Desmodium		``	\							late July to
strictum	8	>	>							early Sept.
Eleocharis			_		<u>-</u>	`	`	\		late July to
equisetoides	8/N					>	>	>		Sept.
Eupatorium		_	<del>  -</del>	-	\		`			early July to
resinosum	62			-	>		>			Oct,
-	_	_	_		_	_				

early Sept: to Oct. early July to early July to late July to mid July to early June early July early July early July early Sept early Aug. Sept. -Oct. early May late Sept. late July late July late June FLOWERING late Aug. late June late July late Aug. late July late Aug. mid July mid Aug. mid Aug. July to Spores: May to May to RANGE Aug. F. 7 MARBH BOG WATER MOH HABITAT \ Ö PPLL > **9** PO AFFINITY **8/**8 8/N S/N 02 Ø 8 CΩ C2 03 ú 02 ŝ Ø TABLE 2. (cont.) SPECIES /RATING caesariensis autumnalia americanum Muhlenbergia lilifolia australis torreyana Narthecium Nymphoides ciliaris cristata hirtella pelmetum linearis loeselii boykinii Habenaria Habenaria Habenaria integra cordata Lygodium Ludwigia Gentlana Ludvigia canbyi Lobelia Liparis Liparis Listera Lobelia Juncus

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TABLE 2. (cont.)

SPECIES /RATING	AFFINITY	ЪО	OP	H. PPLL	HABITAT C HD	PAT HDW	VATER	BOG	MARSH	<b>3</b> 3	FLOWERING RANGE
Panicum hemitomon	22				7	7	7	>	7		June to
Panicum hirstii	83						>	7	7		July
Phoradendron flavescens	83					>	!			,	mid Sept to late Oct.
Polygala mariana	9								>	>	late June to early Oct.
Prenanthes autumnalis	53	7						>		>	early Sept to late Oct.
Rhexia aristosa	8							>			July to Sept.
Rhynochospora cephalantha	တ		٠.	>		7		7		.=	early July to mid Sept.
Rhynochospora inundata	ro.					>		7			early July to late Sept.
Rhynchospora knieskernii	g					-		7			late July to Sept.
Schizaea pusilla				-	7						Spores: July-Sept.
Schwalbea americana										7	early June to
Scirpus	N						7		7		
Scleria	89					2				7	late June to late Aug.
Scleria reticularia	8/K		1			7		>			mid Aug. to late Oct.
Sclerolepis uniflora	8/N					7	7	7			early July to late Sept.
Solidago stricta	æ					7				7	mid Aug. to early Oct.
Spiranthes tuberosa	S/N	>	7					_	_	7	early July to late Sept.
											1

TABLE 2. (cont.)

PLOWERING	H NF RANGE	late June to	July	early July to	late Sept.	Sept. to	Oct.	mid July to	Sept.	early July to	late Aug.	mid Aug. to	V early Sept.	-	13		20	
	BOG MARSH											`	۷		1.7		34	; —
				>	•	1	>					\	` <b>\</b>		59	<u> </u>	Α,	3
	MATER				•		>		>	\	>				13	· -		1
TAT	HDW	>		/ .	>							•	>		20		, ,	2
HABITAT	ပ		•												9			1
_	PPLL														4			<del>!</del>
	OP					٠							_	-	-#		-	^
	ЪО														7		1.	•
	AFFINITY		23		M/8		. 3		N/S		N/8		8				,	
	SPECIES /RATING	Tofieldia	racemosa	Utricularia	glbba	Utricularia	olivacea	Utricularia	purpures	Utricularia	resupinata	Xyris	flexuosa		totals of	species/habitat	totals of	agurang tagodur

Importance ratings for each species are determined by assigning points based on the pts Endangered in the Pinelands following criteria:

Threatened in the Finelands 1 pt Proposed for national list of E & T species,

or exhibiting a restricted range in the U.S. 2 pts
Near extinction in the Pinelands

(only one or two recent sitings)

The maximum rank assigned to any species is 5, the minimum is 1.

TABLE 3. Threatened and Endangered Plant Species of the New Jersey Pinelands and

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၁၀ CO Countles Š NBRCSBRCCC LMRMCDC LMRWRBRMANR FR LGEUGE TRCCADFmr AT BU CA 1 Atlantic Coastal GERR Mullica R. > > > : Delaware R.Del Bay TABLE 3. (cont.) caesariensis autumnalis Muhlenbergia americanum 1111fol1a australis torreyana ciliaria cristata loeselii palmatum Nartheclum boykinii hirtella linearis Habenaria Habenaria Habenaria integra Gentiana Ludvigia Ludwigia canbyi SPECIES Liparis Listera Liperia Lobelia Lobelia Juncus

cu oc Counties Š Y S BU 7 NBRCEBRCCC LIMRNODC LIMRNBURMANR FR LIGEUGE TRECALDER AT Atlantic Coastal GEHR Mullica R. > > Delaware R.Del Bay TABLE 3. (cont.) cephalantha reticularia knieskernii Rhynchospora Phoradendron flavescens autumnal18 Rhynchospora Rhynchospora hemitomon americana aristosa inundata Nymphoides Prenanthes Schwalbea mariana pusilla cordata hirstii Polygala Schizaea longit SPECIES Panicum Panicum Scleria Scleria Scirpus minor Rhexia

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NBRCSBRCCC LMRMCBRMANK FR LGEUGE TROMADEM AT BU CA 7 > Atlantic Constal  $\geq$ > Delaware RiDel Bay > TABLE 3. (cont.) resupinata racemosa Utricularia gibba Utricularia Sclerolepis Utricularia stricta Spiranthes olivacea purpurea flexuosa uniflora tuberosa Tofieldia Solidago SPECIES Xyris

### AREAS OF ACTUAL AND POTENTIAL CRITICAL CONCERN

# Relative Importance Of Each Habitat

(For the purposes of this report, a critical habitat is considered to be one where there is a high probability of threatened or endangered species from our inventory being found. This is based in most cases on recent - usually within the last 30 years - observations of the species mentioned.)

For a comparison of the habitat associations, one can look at the total number of threatened and endangered species. or the total of individual species ratings, from Table 2 (totals are on the bottom of the last page), and it can be seen immediately that wetland areas dominate all others with respect to species diversity. Wetlands also score higher collectively than upland sites with regards to species ratings totals (which are a reflection of both the extent of diversity and the "importance" of the species found in each habitat type). The species tally for bogs and herbaceous marshes are among the highest of all associations. Hardwood swamps also score highly, much more so than cedar swamps. Ponds, lakes and slow moving streams harbor a number of aquatic and semi-aquatic plants, while the pitch pine lowlands have the lowest number of species of the above habitats. It is within these wet areas that almost all members of the orchid and sedge families, both ferns, and many of the grasses from our list can be found.

The upland associations, pine-oak and oak-pine, combine to offer a smaller number of species than some of the lowland habitats. They are significant species however, although often exhibiting a scattered occurrence, as with Gentiana autumnalis and Corema conradii. Non-forest sites, many of which are found in the uplands, also harbor a good number of endangered species. Roadside ditches, cleared or mowed fields, and land adjacent to railroad tracks are examples of this habitat association.

# Relative Importance And Geographical Location Of Habitats Within Each Watershed

Rancocas Creek Basin - The critical habitats found in this watershed are almost entirely wetlands, including river banks, swamps and ponds running along the Rancocas River and Mount Misery Brook (Middle Branch). An oak-pine area in Lebanon State Forest, and a stretch of non-forest area along the railroad at Wheatland are also sited.

Maurice River Basin - The only critical habitat found in this watershed is brackish tidal marsh along the Manumuskin River from its mouth to the town of Manumuskin, where Aeschynomene virginica grows.

Dennis Creek Basin - A hardwood swamp near Clermont is the only noted habitat in the Dennis Creek Basin.

Lower Mullica River Basin - The southwest section of this watershed contains several important wetland areas that should be of great concern regarding aquisition and management. The two places that stand out here are the Goose Ponds and the series of bogs and swamps southeast of Egg Harbor City. Not only is the endangered species diversity quite high at these two spots, but they harbor species found nowhere else in New Jersey or the surrounding area, such as Panicum hirstii and Utricularia olivacea. In addition, there are several other ponds and bogs within Galloway Township that are very similar to these places but have not yet been the subject of extensive field search. Although no voucher specimens are presently available from them, future surveys would probably show a high diversity in many of the wetland areas of this township. Other habitats sited in this watershed are an herbaceous marsh along the Mullica River in Greenbank State Forest, a pitch pine lowlands station near the town of Wading River, and Oak Island near the mouth of the Mullica River.

Wading River Basin - There are several areas of concern in the Wading River Basin, and again the majority of them are wet. A location that has received much attention both in the old literature and in recent times is the West Branch of the Wading River from Chatsworth Lake to just south of Speedwell. This stretch of land includes stream bank, bog, herbaceous marsh, abandoned cranberry bog and active cranberry bog fringe habitats, and moderately high species diversity is exhibited. Tulpehocken Creek, which runs into the Wading River to the south of Speedwell, is a habitat for several of the same species.

Another significant expanse of river and ponds in this basin is the Oswego River system. All wetland habitat types are present here from Harrisville Pond to Martha, Oswego

Lake, Sim Place and Warren Grove. Several rare species can be found along this route, including grasses, sedges, bladderworts and orchids. The only recently verified station for Habenaria integra is found on the Oswego.

The Plains, a well known uplands habitat characteristic of the Pinelands, is found entirely in the Wading River Basin. The East, West and Spring Hill Plains denote almost the entire range of Corema conradii in New Jersey.

Batsto River Basin - From Batsto to Indian Mills Lake, the bogs, marshes, swamps and open water along the length of this river are relatively densely populated with a large number of threatened and endangered plant species. The Batsto has been well surveyed by botanists, and its high productivity of wetland habitats almost completely dominates the whole watershed, with the exception of intermittent nonforest sites along the tracks of the Central Railroad of New Jersey.

Mechesactauxin-Atsion River Basin - Threatened and endangered species are found in this watershed in a variety of habitat types. The greatest diversity is shown in an area of swamps, bogs and pitch pine lowlands around Atsion and south of Atsion Lake. Several species are also found in non-forest habitats along the tracks of the Central Railroad of New Jersey and Route 206. Gentiana autumnalis can be found in pine-oak, oak-pine and pitchpine lowland areas throughout the central portion of the basin. A cedar swamp and an abandoned cranberry bog in Medford Township are also critical sites in this watershed.

Nescochaque River Basin - There are two small critical areas in this watershed - a non-forest habitat along the tracks of the Central Railroad of New Jersey and a pond northwest of Hammonton.

Forked River Basin - Scattered hardwood and cedar swamps are the major critical habitats in this watershed, along with one oak-pine site for an outlying Corema conradii population.

## Great Egg Harbor River Basin

Upper GEHR - The old literature reports the occurrence of many of the plants in our inventory along the branches of Great Egg Harbor River near Folsom. However, due to the development of the area and the construction of the Black Horse Pike and the Atlantic City Expressway, most old stations have been destroyed. Apparently only a section of Penny Pot Stream near Folsom remains in the area as a critical wetland habitat, and further field survey is necessary to ascertain what species survive there.

Lower GEHR - Scattered areas of hardwood swamp are the only critical habitats found in this basin, and their locations include south of Richland, just southwest of Estellville, outside of Reega and just northwest of Scullville.

Tuckahoe River Basin - The two critical areas in this watershed also consist solely of hardwood forests. One area is along the Tuckahoe River at Estell Manor, and the other is just east of the Woodbine Municipal Airport.

Atlantic Drainage Basin - There are only two endangered species sites reported in this watershed as well, Patcong Lake and a bog west of Oceanville, both surrounded by hardwood swamp. The Oceanville site lies just outside of the Pinelands National Reserve, however.

Toms River Basin - Upland sites play a more prominent role in this watershed. An oak-pine station in Jackson Township is reported for <u>Eupatorium resinosum</u>, and there are a number of scattered places around Whiting in oak-pine and pine-oak forests where <u>Gentiana autumnalis</u> grows. The two significant wetland habitats found here are at Colliers Mills and Success Lake.

Cedar Creek Basin - Wetlands dominate the critical areas of this basin, including hardwood and cedar swamps along the shore of Bamber Lake, and cedar swamps and pitch pine low-lands along Webbs Mill Branch.

## IMPACTS, ISSUES AND LAND MANAGEMENT TECHNIQUES

# Potential Impacts Of Development On Critical Habitats

The most obvious effect of development on habitats is direct physical destruction. A less direct impact, but of potentially equivalent consequence, is the pollution of habitats and the waterways draining into them. One should be especially concerned with the impact of pollution in the Pinelands because of the abundance of wetland species in our inventory and the great extent to which the Pinelands soil is permeable. Different kinds of materials which limit plant populations and may flow into Pineland habitats include herbicides and overburdening amounts of nutrients (especially Nitrogen compounds). Herbicides are, after all, poisons directed specifically at broadleaved plants, making many of our inventoried species vulnerable, especially due to reduced flowering and fruiting. Excess nutrients, either from septic systems or agricultural and lawn runoff (fertilizer), can affect rare plant populations in several ways. Too much nitrogen in the soil may upset the nitrogen-phosphorus balance required for normal flowering in many species. Changes in species composition may also be expected; many of the threatened and endangered plant species of the Pinelands are adapted to the nutrient-deficient soil conditions found there, and an increase in nutrients may favor more competetive, "nuisance" species. In aquatic systems, algal blooms, which can be caused by increased inputs of nutrients, have been seen to crowd out Utricularia species (personal observation).

Another negative effect on critical habitats can come from altering the water level in wetlands, ostensibly by mosquito ditching (lowers the level) or by roadside ditching (raises the level). It is known, for instance, that mosquito ditches can have profound effect on the species composition of wetlands during unusually dry seasons, and that roadside ditches can cause repeated flooding of nearby areas. Another development-related practice, mowing of roadside areas and wet meadows, can abruptly interrupt the life cycle of many important plant species if done during flowering time.

The occurrence of cranberry bogs presents a special situation regarding impacts on Pineland habitats. The building of cranberry bogs can destroy the habitats of several species, such as Narthecium americanum, which can only survive in natural bogs. However, due to their minimal need for fertilizer and their demand for relatively pure water, cranberry bogs may be considered a "clean" disturbance. They create modified habitats for several species growing along their edges, and when abandoned provide suitable habitats for several rare species until woody vegetation moves

in and becomes dominant.

# Issues Requiring Land Use Controls And Standards

The primary goal of land use controls for critical habitats should be to minimize the destructive and polluting effects of development on them. This should also include the pollution of areas upstream from or that drain into critical habitats, and alterations of water levels and drainage. Unfortunately, not enough is known about the physiological requirements and limiting factors of the species in our inventory to identify specific standards regarding pollutant concentrations or "buffer zone" size. As Withner (1977) has pointed out, "orchid ecology is in its infancy". However, the rapid decline in population numbers and size for several of these species in New Jersey during this century, and their present rare state indicate how fragile these plants and/or their habitats are. It can be implied that they are relatively intolerant to disturbance caused by development and pollution.

Certain small-scale physical disturbances, though, may actually increase the occurrence of several plant species in the Pinelands. It has long been argued that fire plays an important role in maintaining much of the characteristic Pinelands flora (McCormick, 1970; Little, 1946). Several of the species contained in our inventory have niche requirements that prohibit their survival under closed canopies or in competition with many common trees and shrubs. Vivian (1978) reported that Schizaea pusilla "is maintained in a habitat that has an open canopy and continual disturbance" in the cedar swamps where it grows. Little (1974) spoke of other herbacious plants that are favored by minor and major disturbances which open up patches in hardwood and cedar forests, and this would include many of the species on our list, particularly some orchids and sedges. It appears that controlled timber cutting, if confined to designated areas, can serve to increase species diversity in the lowland forests. Upland sites experiencing disturbance, such as cleared roadsides and along railroad tracks, may also harbor threatened or endangered species, such as Gentiana autumnalis, Scleria minor and Crotonopsis elliptica. Obviously, future management practices in the Pinelands would benefit from the inclusion of particular kinds of controlled disturbances.

## Recommendations To The Commission

It is desirable that all of the critical habitats described by watershed in this report, as well as those discovered in the future, be preserved and protected to maintain the populations of threatened and endangered plant species in the Pinelands. However, there are certain areas in the Pinelands that deserve special attention, either because they contain significantly higher numbers of endangered species or because certain plants from the list presented in this report can be found only in one or two of these places.

A location that fits both of the above criteria includes the Goose Ponds west of Egg Harbor City. The large number of threatened and endangered plant species seen there (some of which have been found nowhere else in New Jersey) justifies the immediate protection of this habitat.

There are four other critical areas strongly deserving protection that are similar in that they are large tracts of land that harbor several threatened and endangered species. These include the following:

Atsion and the immediate vicinity, including land along railroad tracks and Route 206 to the southwest, and the Batsto River and its tributaries from Indian Mills and Hampton Gate to Batsto.

Wetlands along the West Branch of the Wading River from the cranberry bogs just north of Chatsworth to where it meets Tulpehocken Creek.

Wetlands along the Oswego River from Harrisville Pond to Sim Place.

Land that includes several of the bogs and ponds immediately southeast of Egg Harbor City.

Areas harboring fewer (or perhaps one) threatened or endangered plant species, but that are significant because of the restricted range of those species, are the following three:

The entire Plains area.

The brackish marsh and mud banks along the Manumuskin River from its mouth to the village of Manumuskin.

The hardwood swamp and bog area just west of Route 9 at Oceanville.

All forms of land development, roadways and active recreation must be prohibited in these critical areas and habitats establishment of footpaths and off-trail activities should be discouraged in the areas deserving special attention.

As discussed in the "Issues" section of this report, destructive impacts on critical habitats should be minimized. In attaining this goal (especially in the case of wetland habitats) it is necessary to protect additional "buffer" or support areas to provide watershed protection. Land upstream or that drains into a critical area is particularly important in this regard. We cannot, as has been mentioned, give a specific formula for determining buffer zone size, but perhaps the cranberry growers practice of acquiring four to ten acres of surrounding, uncultivated land for every acre of cranberry bog (N.J. Governor's Pinelands Review Committee, 1978) will provide a starting guideline.

Proper management techniques for critical habitats should be developed to take advantage of the beneficial effects of fire, timber clear-cutting and mowing. For example, Vivian (1978) suggests control burning, clearing of 1-5 acre areas in cedar swamps with slash removal, and even irrigation by tank truck in times of drought to provide suitable habitats for many rare and endangered species. Also, mowing of roadsides and along cranberry bogs should be confined to the fall or early winter after plants have had the opportunity to flower and fruit. Practices that affect the water level in critical habitats for long periods of time (or permanently) should be regulated. The use of herbicides to control woody vegetation should be prohibited in or near the critical habitat areas because of their negative effect on the life cycles of herbaceous plants. Land use regulations should be implemented to reduce the impact of excess nutrients introduced either from septic systems or agricultural and lawn runoff. . .

Continued botanical field survey should be applied to the above critical habitats as well as the following - the areas southeast and east of Egg Harbor City containing hardwood swamps, bogs and herbaceous marshes, the wetlands along Penny Pot Stream and Hospitality Branch near Folsom and the wetlands along Deep Run in Hamilton Township. Although there are few recent reports of endangered plant species from most of these geographical areas, they are known to contain habitats similar to many of the critical ones we have described, and deserve thorough search.

Cranberry growers should be encouraged to continue their cultivation of bogs due to their dependence on relatively pure water and the habitat diversity that recently abandoned cranberry bogs provide. Rather than digging new bogs, however, recycling older, abandoned bogs with woody growth should be investigated.

### DATA GAPS AND ISSUES REQUIRING FURTHER STUDY

There are two basic information sources regarding Pinelands threatened and endangered species that require additional research. First, as we have stated throughout this report, field search is necessary to verify old reports of plant locations and to find new ones. Secondly, there is a drastic need for field and laboratory research to discern what the niche requirements are for most of the species discussed. The data obtained from such research will enable workers to determine why particular species are located in certain sites, and this will not only allow predictions about species occurrence, but help establish land control standards and modified habitats to allow for the increased occurrence of such species.

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APPENDIX 1. Habitat Associations used in this report (from McCormick and Jones, 1973) and their abbreviations from Table 2.

Upland Forest Complex

Pine-Oak PO Oak-Pine OP

Lowland Forest Complex

Pitch Pine Lowland Forest PPLL Cedar Swamp Forest Hardwood Swamp Forest HDW

Marshes or Water

Streams, Ponds and Lakes Water Bog

Herbaceous Marshes Marsh

NF Non-Forest Area

AFPENDIX 2. Watersheds and counties within the New Jersey Pinelands and their abbreviations from Table 3.

## <u>Watersheds</u>

# Delaware River Basin

Rancocas Creek Basin (RC)
North Branch Rancocas Creek (NBRC)
South Branch Rancocas Creek (SBRC)

Crosswicks Creek Basin (CC)

## Delaware Bay Basin

## Counties

Maurice River Basin (MR)

Lower Maurice River (LMR)

Manumuskin Creek (MC)

Camden (CA)

Cape May (CM)

Dennis Creek Basin (DC)

Cumberland (CU)

Ocean (OC)

## Atlantic Coastal Basin

Gloucester (not used)

Mullica River Basin (MR)
Lower Mullica River (LMR)
Wading River (WR)
Batsto River (BR)
Mechesactauxin and Atsion River (MA)
Neschochaque River (NR)

Forked River Basin (FR)

Great Egg Harbor River Basin GEHR)
Lower Great Egg Harbor River (LGE)
Upper Great Egg Harbor River (UGE)

Tuckahoe River Basin (TR)

Cedar Creek Basin (Cd)

Atlantic Drainage Basin (AD)

Toms River Basin (TmR)

The preparation of this document was financed in part through a planning grant from the National Park Service, Department of Interior, under the provisions of the Land and Water Conservation Fund Act of 1965(Public Law 88-578, as amended).