

**Atlantic white-cedar:**  
**Ecology and Best Management Practices Manual**

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# Atlantic white-cedar Ecology and Best Management Practices Manual

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Under the editorial guidance of the NJ Atlantic white-cedar Initiative Steering Committee

**2000**

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## New Jersey Atlantic white-cedar Initiative Steering Committee

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**New Jersey Forestry Association**

**New Jersey Pinelands Commission**

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# I. Purpose of this Manual

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Atlantic white-cedar (*Chamaecyparis thyoides* (L.)BSP) is found along the Atlantic and Gulf coasts of the United States, from Maine to Florida and west to Mississippi. Historically, this species has been a very valuable timber species, and remains so today. It is also very important ecologically and aesthetically. Over the last two centuries, the area occupied by Atlantic white-cedar has declined drastically. With knowledge, conservation, and the use of Best Management Practices, the long-term sustainability of this forest type may be ensured.

This manual was prepared under the editorial guidance of the New Jersey Atlantic white-cedar Initiative Committee, and focuses on issues concerning white-cedar in New Jersey, although much of the information is applicable throughout the entire range of Atlantic white-cedar. Specifically, this manual is intended to:

1. Provide general information to the landowner and resource manager about Atlantic white-cedar.
2. Increase public awareness about the importance of white-cedar, both ecologically and economically, and the necessity for active management of this species.
3. Provide Best Management Practices to be followed during all phases of Atlantic white-cedar management, including the regeneration, restoration, and management of this valuable resource.



*Figure 1. Aerial view of an Atlantic white-cedar stand. Photo by George Zimmermann.*



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# II. Introduction

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## Current and historic distribution

### Rangewide distribution



- ❖ Atlantic white-cedar is found along the Atlantic and Gulf coasts, from southern Maine to central Florida, and westward to Mississippi, generally within a narrow coastal belt 50 to 100 miles wide (Harlow and Harrar 1937). Within this belt the distribution is very patchy, depending on the occurrence of suitable sites (Little 1950). The rangewide acreage of Atlantic white-cedar has declined significantly over the last two centuries.
  - At the time of European settlement, there may have been as many as 500,000 acres of Atlantic white-cedar throughout its range (Kuser and Zimmermann 1995).
  - According to one estimate, from foresters and conservationists surveyed in Spring 1995, the total rangewide acreage of Atlantic white-cedar forest (containing 5% or more of cedar) was estimated to be only 115,000 acres (Kuser and Zimmermann 1995).

*Figure 2. Rangewide distribution of Atlantic white-cedar, adapted from Little (1971).*

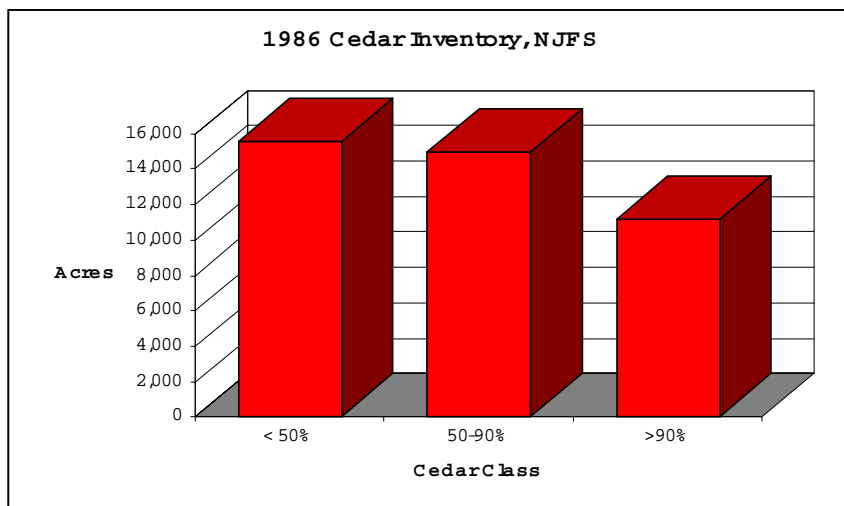
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### Distribution in New Jersey

- ❖ The majority of Atlantic white-cedar in New Jersey is found in the southern part of the state, although the species is also present in isolated areas in the northern portion.
- ❖ Prior to European settlement there may have been 115,000 acres of Atlantic white-cedar in New Jersey (New Jersey Forest Service 1997).
- ❖ In 1900, Vermeule estimated that there were 52,500 acres of Atlantic white-cedar in New Jersey, with an additional 85,100 acres of pine and hardwood swamps that contained some white-cedar (Vermeule 1900). Cottrell (1930) estimated that there were 100,000 acres of white-cedar at that time, although that estimate may be high (Little 1950).

*Figure 3. Approximate distribution of Atlantic white-cedar in New Jersey. Data interpreted by the NJ Forest Service from 1986 aerial photos.*



*Figure 4. Inventory of Atlantic white-cedar in New Jersey. Data were interpreted by the NJ Forest Service based on 1986 aerial photo interpretation and subsequent ground truthing.*

- ❖ By 1974, there were fewer than 50,000 acres of white-cedar in New Jersey (Kantor and Pierson 1985). According to a NJ Forest Service estimate from 1986 aerial photographs, there are approximately 41,690 acres of Atlantic white-cedar in New Jersey today, with 26,136 acres containing greater than 50% cedar (NJ Forest Service unpublished data - see Figure 4).

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### Southern New Jersey



- ❖ Roman and Good (1983) estimated that there were 21,450 acres (8680 ha) of Atlantic white-cedar (2% of the total land area) in the 1.1 million acre (445,000 ha) Pinelands National Reserve. This estimate, from New Jersey Pinelands Commission vegetation maps, does not include cedar that may be found in swamps dominated by hardwoods or pitch pine (*Pinus rigida*).
- ❖ In the Pinelands, cedar swamps occur mostly as narrow bands along streams. These bands are usually not more than 1,000 feet wide, some extending from the source of the stream to tide water (Cottrell 1929). Some cedar swamps are also found in broad lowlands. Pinelands Commission maps delineate a total of 626 discrete cedar swamp patches. 92% of the individual swamps are less than or equal to 100 acres (41 ha) and 84% are less than or equal to 50 acres (20 ha.) (Zampella 1987).

*Figure 5. The dark band in this aerial photo delineates a typical Atlantic white-cedar stand along a stream in the NJ Pinelands. Photo by George Zimmermann.*

### Northern New Jersey

- ❖ Cedar stands in the northern portion of the state are few and isolated. Few sites in northern New Jersey contain more than a few individuals of Atlantic white-cedar. These sites include Wawayanda State Park and the Kuser Natural Area in High Point State Park, in Sussex County. The cedar swamp at High Point is found at an altitude of 457 m (1500 ft), the highest altitude recorded for this species rangewide (Laderman 1989).
  - ❖ A number of additional sites in glaciated New Jersey previously contained cedar (Britton 1889, Vermeule 1896, Waksman et al. 1943, Heusser 1949a, 1949b, 1963). Historically, extensive cedar stands covered the Hackensack Meadowlands area and the Sandy Hook peninsula. The cedar stands of the Hackensack Meadowlands were described in detail by Torrey and others (1819). Peat deposits record increasing abundance of white-cedar from about the 14<sup>th</sup> century onward. By the time of European settlement in the 17<sup>th</sup> century, Atlantic white-cedar was the principal tree of the Hackensack swamp forests. The Hackensack forests contained trees of such size that are unknown today along the coast of New Jersey (Heusser 1949a). Today, white-cedar has been extirpated from the area (Schmid 1987).
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*Figure 6. Atlantic white-cedar stumps at the Mill Creek mitigation site in the Hackensack Meadowlands. This ancient cedar forest was uncovered in 1998 while excavating for this wetland mitigation project. These cedar trees may have been harvested in the 1860's. In the past, extensive cedar stands covered the Hackensack Meadowlands area, but today the species has been totally extirpated from the area. Photo by Robert R. Williams.*



*Figure 7. Jack Shuart of the New Jersey Forest Service after cutting sections from one of the larger Atlantic white-cedar stumps at the Mill Creek site. Initial dendrochronological analysis at Richard Stockton College of New Jersey indicates that this tree was at least 240 years old when it was cut. Photo by Kristin Mylecraine.*

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## Value of Atlantic white-cedar

### *Ecological value*

- ❖ Atlantic white-cedar ecosystems may provide many ecological benefits:
  - Cedar swamps may help to filter and purify water, by absorbing and filtering pollutants and sediment. These swamps also stabilize streamflows, by temporarily storing floodwaters and mitigating the effects of drought.
  - Cedar swamps provide a unique environment throughout the year and benefit a wide range of plant and animal species. In particular, they provide important winter habitat for deer and other wildlife.
  - Cedar swamps provide habitat for several threatened and endangered plant and animal species.
  - Cedar swamps frequently act as natural firebreaks (Little 1964); however this role varies considerably, depending on the wind orientation in relation to the stream, wind velocity, lowland width and lowland water table depth at the time of fire (Windisch 1987).

### Economic value

#### Wood properties

- ❖ Atlantic white-cedar has been called the most important timber tree of the pine region of southern New Jersey (Moore and Waldron 1938). Several properties of Atlantic white-cedar wood make this species valuable for timber. The wood is durable, lightweight, aromatic, and usually has an even, straight grain. The heartwood is so durable that logs buried deep in the swamps for 50 years or longer furnish excellent lumber (Korstian and Brush 1931, Little 1950).

#### Uses

- ❖ Atlantic white-cedar wood is used for a wide variety of timber products. These include: boats, tanks, siding, fencing, decking, millwork, shingles, lawn furniture, poles, posts, stakes, channel markers, clam stakes, boxes and crates (Korstian and Brush 1931, Ward 1989). In the past, fishermen utilized the tough and fibrous bark to string their fish.
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*Value of associated species*

- ❖ Although they have significant ecological value, the principal associates of cedar in New Jersey are of far less economic value. Red maple (*Acer rubrum*) has seldom been harvested, being suitable only for firewood, temporary corduroy roads, and other uses that will hardly, if at all, pay for the cost of removal. In general, blackgum (*Nyssa sylvatica*) is a species of low economic value, although it is harvested to some extent for specialized uses. This species is usually not cut in New Jersey because of the high cost of removal from swamps (Little 1950).

## Historic utilization

### 17<sup>th</sup> and 18<sup>th</sup> centuries

- ❖ Exploitation of Atlantic white-cedar began with the arrival of European settlers to the Atlantic coast. In North Carolina, there was a significant period of exploitation between 1653 and 1750, following European settlement (Phillips et al. 1998). White-cedar was heavily cut in New Jersey as early as the 18<sup>th</sup> century. As early as 1749, Peter Kalm warned that heavy cutting in New Jersey might be extirpating white-cedar entirely from the state. He wrote that white-cedar was not only used for many purposes in New Jersey, but was also cut heavily for export (Benson 1937). During this time, most houses in Philadelphia and Wilmington were built with cedar shingles from southern New Jersey cedar swamps (Benson 1937, Kantor and Pierson 1985). Shingles and other products were exported to New York and the West Indies (Benson 1937). In 1758, white-cedar products formed about 20% of the exports from Cape May County (Cook 1857).
- ❖ During this time, Atlantic white-cedar was not only valued for the wood itself, but also for the land on which it existed. During the 17<sup>th</sup> and 18<sup>th</sup> centuries, many cedar swamps in New Jersey were cut, flooded and converted into cranberry bogs (Pierson and Zimmermann 1993). Beginning in the 18<sup>th</sup> century, large areas of cedar forest in North Carolina were also drained for agriculture (Frost 1995).

### 19<sup>th</sup> century

- ❖ Immense quantities of white-cedar were removed during the 19<sup>th</sup> century, much of which was second growth. Thousands of rails and sawed timber were being exported annually (Cook 1857). During this time, mining of cedar logs buried in swamp peat was a profitable industry in New Jersey (Cook 1868, Hall and Maxwell 1911, Korstian and Brush 1931). By 1857 many of the swamps of Cape May County had been cut over twice and some three times, and not a single acre of original growth was left (Little 1950).
  - ❖ During this period, heavy cedar cutting also occurred in other regions. In North Carolina, cedar cutting during this period was facilitated by the advent of steam-powered trains and dredging equipment, to drain previously inaccessible cedar swamps (Earley 1987, Frost 1987). Frost (1987) speculates that 50% of all the existing white-cedar acreage in the state was cut between 1870 and 1890.
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## 20<sup>th</sup> century

- ❖ Utilization of white-cedar has continued into the 20<sup>th</sup> century. At the turn of the century, New Jersey was the predominant source of Atlantic white-cedar lumber (Ward 1989). Vermeule (1900) estimated that cedar wood was valued at \$90 per acre at that time. In 1911, over 669,000 board feet of cedar were cut in New Jersey. In addition, over 20 million cedar shingles were made (Bones 1973). By 1930, Cottrell observed that white-cedar had become less important in the state's annual cut than it had been 25 or 50 years earlier, largely because merchantable stands had been so heavily cut. In 1982, the annual cedar harvest was 250,000 board feet (Pierson and Zimmermann 1993). Today, many swamps in the Pine Barrens have been clearcut at least five times (Little 1979a). The amount of timber cut annually has now been reduced to a small amount, due to extensive cutting, conversion of cedar lands to other uses, and wetland protection (Ward 1989).
- ❖ In North Carolina, a decline in logging began in the 1920s to 1930s and continued into the 1970s to 1980s. This lull was followed by a third wave of exploitation. By this time, stands that had regenerated following earlier logging were 70 to 90 years old. New technology also became available during this period, including hydraulic equipment and wide, 6-foot tracks (Phillips et al. 1998). During this period, Atlantic Forest Products, a timber company, produced about 13 million board feet of white-cedar every year (Earley 1987).
- ❖ Atlantic white-cedar wood remains very valuable today. In 1989, North Carolina was the most important production area, with New Jersey and the Florida panhandle – southern Alabama region as secondary centers. In 1991, the retail price for finished lumber was at least \$750 to \$1000 per thousand board feet. In comparison, loblolly pine (*Pinus taeda*) retailed at \$450 (Phillips et al. 1998).



*Figure 8. Historic photo of Atlantic white-cedar harvest. Photo courtesy of George Pierson.*

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## General site and stand characteristics

- ❖ In New Jersey, Atlantic white-cedar typically forms dense stands of trees all the same age (even-aged), or sometimes with mixed age classes (uneven-aged) (Harshberger 1916). According to Sheffield and others (1998) only 1/5 of the rangewide area of this species contains 50% or more Atlantic white-cedar. Nearly 2/3 of the total area contains proportions of less than 25% cedar. On more hydric sites, cedar commonly constitutes a greater proportion of the total stand.
- ❖ Because of their dense nature, cedar swamps are protective. The dense trees suppress movements of air, creating a calm, nearly windless environment within the swamp. Cedar swamps are cooler than the surrounding forest in the spring and summer, and warmer in the winter (Harshberger 1916).
- ❖ Atlantic white-cedar swamps are typically characterized by hummock-hollow topography. The bases of the cedar trees are typically surrounded by raised cushions of bog mosses (hummocks). Between the hummocks are depressions (hollows), which may contain standing water at certain times of year (Harshberger 1916).
- ❖ L.H. Reineke and C.F. Korstian (in Korstian and Brush 1931) developed several stand tables for Atlantic white-cedar based on field data collected in North Carolina, Virginia, and New Jersey, one of which is presented here (see Table 1.)

*Table 1. Stand table from Korstian and Brush (1931). Total number of Atlantic white-cedar trees per acre, 1 inch or greater in diameter, by age and site index.*

Age (years)	Site Index					
	20	30	40	50	60	70
Number of trees per acre						
20	18,000	14,700	10,800	7,400	4,600	2,800
25	13,000	10,500	7,600	5,100	3,300	2,000
30	9,600	7,600	5,600	3,850	2,400	1,450
35	7,400	5,800	4,500	2,950	1,860	1,120
40	5,800	4,500	3,400	2,300	1,440	870
45	4,600	3,700	2,700	1,900	1,170	720
50	3,900	3,100	2,250	1,550	970	580
55	3,350	2,600	1,950	1,330	830	500
60	2,900	2,300	1,700	1,170	740	435
65	2,550	2,050	1,500	1,050	660	380
70	2,300	1,850	1,350	940	580	350
75	2,150	1,700	1,250	860	540	330
80	1,980	1,550	1,150	790	500	300
85	1,850	1,450	1,075	740	460	280
90	1,750	1,350	1,000	700	430	260
95	1,650	1,270	950	660	420	250
100	1,550	1,200	900	620	385	230

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*Figure 9.  
Typical Atlantic  
white-cedar  
stand in New  
Jersey. Note  
the dense,  
monospecific  
nature typical  
of these stands.  
Photo by  
George  
Zimmermann.*

*Figure 10.  
Forest floor of  
a typical  
Atlantic white-  
cedar stand in  
New Jersey,  
characterized  
by Sphagnum  
covered  
hummocks and  
hollows. Photo  
by Kristin  
Mylecraine.*



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## Flora associated with Atlantic white-cedar

### Tree species

- ❖ **Northern New Jersey:** In northern New Jersey, red maple is the predominant hardwood associate. Other associates include blackgum, black spruce (*Picea mariana*), tamarack (*Larix laricina*), and Eastern hemlock (*Tsuga canadensis*) (Little 1950).
- ❖ **Southern New Jersey:** Red maple is also the predominant hardwood associate in the Pinelands of southern New Jersey. Other common associates include blackgum, sweetbay magnolia (*Magnolia virginiana*), pitch pine and gray birch (*Betula populifolia*). In some areas of central New Jersey and Cape May County, white-cedar may be found with sweetgum (*Liquidambar styraciflua*), and rarely with tulip poplar (*Liriodendron tulipifera*) (Little 1950).

### Shrub species

- ❖ In some cedar swamps, the dense overstory may prevent the development of a dense understory. In swamps that are more open, or along swamp edges, several shrub species can be found. One study found 25 species of shrubs associated with Atlantic white-cedar in southern New Jersey (Little 1951). Table 2 lists some of the most common shrub associates in this portion of New Jersey. In northern New Jersey cedar swamps, great rhododendron (*Rhododendron maximum*) is also very common (Collins and Anderson 1994).

*Table 2. Some shrub species occurring with Atlantic white-cedar in southern New Jersey, compiled from Harshberger (1916), Little (1951), Collins and Anderson (1994), Roman et al. (1987), Stoltzfus and Good (1998), and Laidig and Zampella (1999).*

Common Name	Scientific Name	Common Name	Scientific Name
Shadbush	<i>Amelanchier spp.</i>	Staggerbush	<i>Lyonia mariana</i>
Red chokeberry	<i>Aronia arbutifolia</i>	Bayberry	<i>Myrica pennsylvanica</i>
Leatherleaf	<i>Chamaedaphne calyculata</i>	Virginia creeper	<i>Parthenocissus quinquefolia</i>
Sweet pepperbush	<i>Clethra alnifolia</i>	Swamp azalea	<i>Rhododendron viscosum</i>
Fetterbush	<i>Eubotrys racemosa</i>	Swamp dewberry	<i>Rubus hispidus</i>
Black Huckleberry	<i>Gaylussacia baccata</i>	Sassafras	<i>Sassafras albidum</i>
Dwarf Huckleberry	<i>Gaylussacia dumosa</i>	Laurel-leaved greenbrier	<i>Smilax laurifolia</i>
Dangleberry	<i>Gaylussacia frondosa</i>	Common greenbrier	<i>Smilax rotundifolia</i>
Inkberry	<i>Ilex glabra</i>	Poison ivy	<i>Toxicodendron radicans</i>
Smooth winterberry	<i>Ilex laevigata</i>	Poison sumac	<i>Toxicodendron vernix</i>
Winterberry holly	<i>Ilex verticillata</i>	Highbush blueberry	<i>Vaccinium corymbosum</i>
Sheep laurel	<i>Kalmia angustifolia</i>	Cranberry	<i>Vaccinium macrocarpon</i>
Mountain laurel	<i>Kalmia latifolia</i>	Lowbush blueberry	<i>Vaccinium pallidum</i>
Spicebush	<i>Lindera benzoin</i>	Southern arrowwood	<i>Viburnum dentatum</i>
Maleberry	<i>Lyonia ligustrina</i>	Southern wild-raisin	<i>Viburnum nudum</i>

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### Herbaceous plants

- ❖ Herbaceous plants found in cedar swamps include insectivorous sundews (*Drosera* spp) and pitcher plants (*Sarracenia purpurea*), although these are more common in open, sunny locations (Collins and Anderson 1994). Other species include bladderworts (*Utricularia* spp), golden club (*Orontium aquaticum*), starflower (*Trientalis borealis*), and Arethusa (*Arethusa bulbosa*) (Collins and Anderson 1994). Several species of orchids are confined almost exclusively to cedar swamps (Harshberger 1916). Cedar swamps also provide habitat for the federally endangered swamp pink (*Helonias bullata*).
- ❖ Several species of ferns can be found, including the rare curly grass fern (*Schizaea pusilla*), which can be found growing at the base of the cedar trees (Harshberger 1916, Collins and Anderson 1994). Other common fern species include cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*) and chain ferns (*Woodwardia* spp) (Collins and Anderson 1994).
- ❖ Clumps of sedges may be common, including long sedge (*Carex folliculata*) and Collins' sedge (*Carex collinsii*) (Collins and Anderson 1994).
- ❖ The ground and bases of trees are typically covered with several species of sphagnum mosses and liverworts (Collins and Anderson 1994).

**Note:** The plant species listed above are only some of the more common species found in New Jersey Atlantic white-cedar swamps. For a more extensive list of plant species found throughout the entire range of cedar, see Laderman (1989) and Laderman and Ward (1987).

### Fauna associated with Atlantic white-cedar

- ❖ The information on animals associated with Atlantic white-cedar communities is limited. Laderman (1989) has collected much of the information that is available.

#### Bird species

- ❖ There have only been a few detailed studies of bird species associated with Atlantic white-cedar. Terwilliger (1987) found that cedar stands in the Great Dismal National Wildlife Refuge held nearly twice as many birds per unit area as a surrounding hardwood forest.
  - ❖ In southern New Jersey, Brady (1980) found that mature cedar swamps support the lowest breeding bird species diversity of any habitat type. However, Wander (1980-1981) found that one species, the black-throated green warbler (*Dendroica virens*), was entirely restricted to cedar swamps for breeding. Two other species, the brown creeper (*Certhia familiaris*) and sharp-shinned hawk (*Accipiter striatus*), were largely restricted to cedar swamps for breeding.
  - ❖ The ecotones between cedar swamps and surrounding habitats are also utilized by a great variety of bird species (Wander 1980-1981).
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### Mammal species

- ❖ Cedar swamps provide important winter habitat (Burke 1979) and food supply (Little et al. 1958, Little and Somes 1965) for the white-tailed deer (*Odocoileus virginianus*). The cottontail rabbit (*Sylvilagus floridanus*) and meadow mouse (*Microtus pennsylvanicus*) also feed on cedar seedlings. Ward and Clewell (1989) report trees with black bear (*Ursus americanus*) markings in Florida cedar wetlands. Nineteen species of mammals are reported to be currently associated with cedar swamps in the NJ Pinelands (NJ Pinelands Commission 1980):

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Beaver	<i>Castor canadensis</i>	Mink	<i>Mustela vison</i>
Southern red-backed vole	<i>Clethrionomys gapperi</i>	Little brown bat	<i>Myotis lucifugus</i>
Star-nosed mole	<i>Condylura cristata</i>	White-tailed deer	<i>Odocoileus virginianus</i>
Virginia opossum	<i>Didelphis virginiana</i>	Muskrat	<i>Ondatra zibethicus</i>
Big brown bat	<i>Eptesicus fuscus</i>	Eastern pipistrelle	<i>Pipistrellus subflavus</i>
River otter	<i>Lutra canadensis</i>	Pine vole	<i>Pitymys pinetorum</i>
Striped skunk	<i>Mephitis mephitis</i>	Raccoon	<i>Procyon lotor</i>
Meadow vole	<i>Microtus pennsylvanicus</i>	Eastern cottontail	<i>Sylvilagus floridanus</i>
Long-tailed weasel	<i>Mustela frenata</i>	Southern bog lemming	<i>Synaptomys cooperi</i>

### Amphibian and reptile species

- ❖ Several species of herptiles can be found in association with Atlantic white-cedar, many of which are considered threatened, endangered or rare. The following amphibian and reptile species can be found in the NJ Pinelands (NJ Pinelands Commission 1980):

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Northern Cricket Frog	<i>Acris c. crepitans</i>	Spotted turtle	<i>Clemmys guttata</i>
Four-toed salamander	<i>Hemidactylium scutatum</i>	Bog turtle	<i>Clemmys muhlenbergii</i>
Pine Barrens treefrog	<i>Hyla andersoni</i>	Nothern black racer	<i>Coluber c. constrictor</i>
Eastern mud salamander	<i>Pseudotriton m. montanus</i>	Eastern king snake	<i>Lampropeltis g. getulus</i>
Northern red salamander	<i>Pseudotriton r. ruber</i>	Northern pine snake	<i>Pituophis m. melanoleucus</i>
Carpenter frog	<i>Rana virgatipes</i>	Red-bellied turtle	<i>Pseudemys rubriventris</i>
		Northern red-bellied snake	<i>Storeria o. occipitamaculata</i>

### Fish species

- ❖ There are a number of fish species which are considered characteristic of acid Pinelands streams (NJ Pinelands Commission 1980), which may be associated with Atlantic white-cedar. Mud minnows (*Umbra pygmaea*) have been observed in small temporary ponds in Atlantic white-cedar clearcuts (Rudolf Arndt 1999, personal communication). For additional information about the fish species of the Pinelands, see Hastings (1979, 1984) and Zampella and Bunnell (1998).
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### Insect species

- ❖ Numerous insect species can be found within Atlantic white-cedar swamps, including the rare butterfly, Hessel's hairstreak (*Mitoura hesseli*), which has been found in bogs from Connecticut to North Carolina (Laderman 1989). The larva of this species feed exclusively on Atlantic white-cedar (Cryan 1985).



Figure 11. Hessel's hairstreak adult.  
Photo by George Zimmermann.



Figure 12. Pine Barrens treefrog. Photo by Rudolf Arndt.



Figure 13. Timber rattlesnake. Photo by Rudolf Arndt.



Figure 14. Mud minnow. Photo by Rudolf Arndt.

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