Inquiry Based Curriculum

Contents

Preface and Acknowledgements

The Pinelands Preservation Alliance is pleased to present this body of lesson plans and resources to educators interested in teaching about the Pinelands of New Jersey, and in using the Pinelands as a vehicle to teach broader themes of ecology, biology, geology, history and social science. The "Pinelands" is an area of 1.1 million acres in New Jersey which was designated by an Act of Congress in 1979 for special protections from development and other human activities. The Pinelands National Reserve includes most of the surviving Pine Barrens ecosystem of New Jersey and a significant portion of New Jersey's coastal estuaries.

These lesson plans were developed for Pinelands Preservation Alliance by a wonderful team of educators:

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These lesson plans are a work in progress. The Alliance and its team of educators will continue to test, refine and improve these plans. Please send us your critiques and ideas for improvement!

These lesson plans are an element of the Alliance's ***Barrens To Beaches*** education initiative. This initiative aims to help and encourage educators at the middle and high school level to teach about the New Jersey Pinelands. The goals of this project are to communicate to educators and students a deeper understanding of:

- The Pine Barrens and coastal estuary ecosystems, their flora and fauna, and the unique interactions of natural and human history that have produced the landscape we find today.
- The way soil and water shape the Pine Barrens and coastal ecosystems, and provide a critical link between the two systems.
- How human beings are changing these ecosystems through the construction of houses, roads, shopping centers, docks and other forms of development – that is, how the built environment is affecting the natural environment.
- How our society can think about managing its activities to preserve the natural landscapes, plants and animals of these extraordinary places.

The New Jersey Pine Barrens is a globally unique and ecologically important ecosystem. Its sandy, acidic soils and water shape its plant and animal communities, providing a haven for an increasing number of species that are adapted to its rigorous conditions and are losing ground to development elsewhere. The Pine Barrens is also located in an intensively developed part of the world. More than 20 million people live within 60 miles of the Pinelands boundary, and New Jersey is the nation's densest, most highly developed state. So the survival of the Pine Barrens may be seen as a test case for our society's willingness and ability to save a natural place, with its own unique biodiversity, in a rapidly urbanizing landscape.

While the Pine Barrens is a distinctive ecosystem, it should not be viewed in isolation from the coastal bays and estuaries of the Atlantic Coast. The Pine Barrens stretches to the bay shores along much of New Jersey's Atlantic coast, and the estuaries are sustained – or contaminated – by the streams and aquifers which flow across the Pine Barrens to the bays formed by New Jersey's long line of barrier islands. For this reason, we have included material on the coastal systems, as represented by Barnegat Bay, in our introductions to each section of lesson plans. We plan over time to incorporate more lesson plans relating specifically to the estuary ecosystems.

Thank you for considering these lesson plans for use in your work!

Carleton Montgomery
Executive Director
Pinelands Preservation Alliance

The Pine Barrens of New Jersey

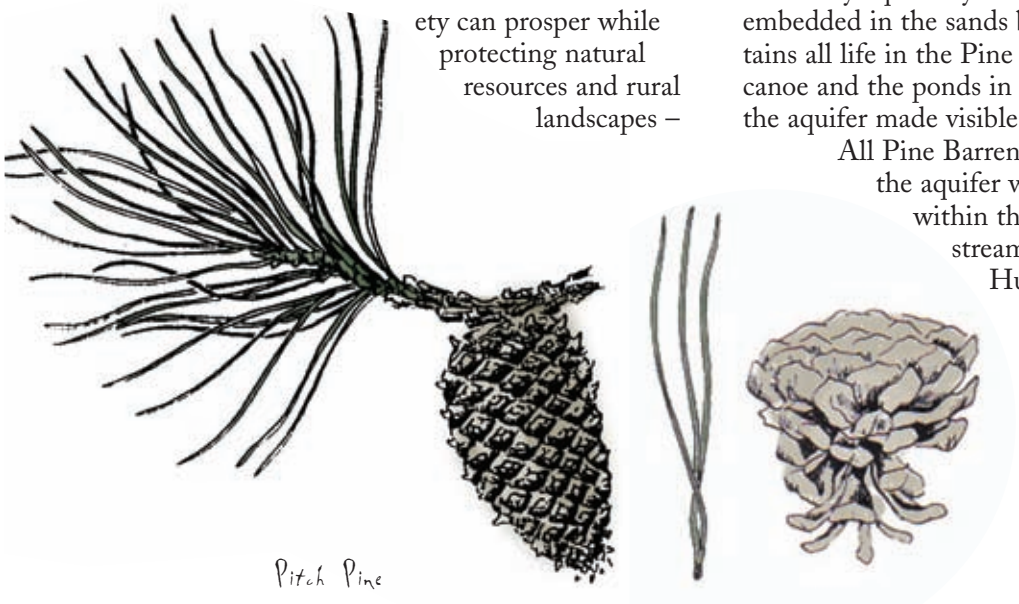
An Introduction

The Pine Barrens of New Jersey is a unique, beautiful and fascinating natural treasure. Today, as throughout our history, human beings depend on the health and vitality of the ecosystems of the New Jersey Pine Barrens. Since the United States Congress created the Pinelands National Reserve in 1979, and New Jersey passed the Pinelands Protection Act in 1980, the Pine Barrens has had the benefit of the nation's strongest development control laws. The "Pinelands" is an area of 1.1 million acres designated for special land use controls. It includes most of the surviving Pine Barrens ecosystem and much of New Jersey's Atlantic coast. It also includes preexisting cities like Hammonton, scattered settlements like Chatsworth, and new regional growth zones like parts of Medford.

The New Jersey Pinelands Commission and its Comprehensive Management Plan aim to protect forests, streams and wetlands, while also allowing development in some areas and avoiding the unconstitutional "taking" of private property. It is a difficult and complex task. The Pinelands protection laws are an experiment in "sustainable development" – the idea that our modern society can prosper while protecting natural resources and rural landscapes – but the success of this experiment is still uncertain and depends upon a knowledgeable and active citizenry.

The Pine Barrens is different from its surroundings. Its sandy soils create acidic, low-nutrient conditions. This environment is a haven for plants and animals adapted to its demanding conditions, and it excludes plants and animals, including invasive species, that are not adapted. As a result, the Pine Barrens supports plant and animal communities that are unique on earth. And while most individual species found here can also be found elsewhere, a growing number of species only survive, or now have their greatest stronghold, in the New Jersey Pine Barrens. Wildflowers like Swamp-pink and animals like the Pine Barrens Treefrog have almost disappeared from other parts of their range due to human destruction of their habitats. The Bog Asphodel, a beautiful yellow wildflower of wet meadows, can now be found only in the Pine Barrens of New Jersey, having succumbed to human impacts throughout the rest of its natural range. In the Pine Barrens, these species find a refuge.

Underlying the Pine Barrens is the Kirkwood-Cohansey aquifer system, the fresh water that is embedded in the sands beneath our feet and sustains all life in the Pine Barrens. The streams we canoe and the ponds in which we swim are simply the aquifer made visible by dips in the land surface. All Pine Barrens surface waters are fed by the aquifer waters constantly flowing within the ground and through streams and wetlands to the sea. Hundreds of thousands of residents drink the water of the Kirkwood-Cohansey aquifer, and thousands of acres of farmland and berry bogs are sustained by this water as well.



The human experience of the Pine Barrens is also fascinating, and it has shaped the landscape in which we live today. Native Americans exploited the Pine Barrens for game and berries. The remains of their settlements are common, though generally unobserved, in and around the Pine Barrens. Europeans began to arrive in numbers during the early 18th C. and quickly transformed the region, both socially and ecologically. They cleared farms around the Pine Barrens, but found the sandy soils of the barrens itself unwelcoming for farm crops – hence the name "Pine Barrens." Rather than farm, European settlers exploited the Pine Barrens for its natural resources of timber, bog iron and sand. But as virgin forests and richer sources of ore opened up to the west, our society largely abandoned the Pine Barrens, allowing the forest to recover and reclaim many of the villages scattered throughout the region for nature. Only today's sand and gravel mining operations harken back to the early, pervasive industrial exploitation of the Pine Barrens.

Ariel View of Forest and Development

The 20th C. brought changes both benign and destructive. Starting in the late 19th C., cranberry and blueberry farmers learned to grow these native crops on a large scale, and they continue to prosper today. Most drastic, however, has been the simple influx of people who live in and around the Pine Barrens but do not make their living off the land. Today over 400,000 people live inside the Pinelands boundary. More than 20 million people live within 60 miles of the Pinelands. Residential subdivisions, shopping malls, offices and roads have eliminated and fragmented much of the original Pine Barrens ecosystem. The region's natural, cultural and historic resources have taken a beating across much of the Pine Barrens. And unlike colonial villages and industries, today's development will never give way to nature again.

Citizens and their political leaders stepped in during the late 1970s to try to save the Pine Barrens before it was lost forever. Through a tremendous effort, the national and state governments were persuaded to institute the country's most ambitious and most creative natural preservation effort. Rather than create a national park expropriating all the thousands of residents already living in the Pinelands, they decided to create a growth management plan that would use regulations and incentives to concentrate development in specified growth areas around the Pinelands' edges, while severely restricting development options in the large intact forests of the Pine Barrens' interior. The state and federal governments, with help from nonprofit land trusts, have also bought hundreds of thousands of acres of land and development rights from willing sellers for preservation.

Protecting the Pinelands, however, is still an enormous challenge, even with these laws and purchases. As land around the Pinelands, and land in the Pinelands' growth zones, is developed, the pressure only grows to make changes or exceptions to the rules against development of the conservation zones. Human activity can destroy the Pinelands not just by paving over habitats, but also by contaminating Pine Barrens waters with fertilizers and other chemicals in septic effluent and in the runoff from lawns, buildings and roads. Even when today's rules are enforced to the letter, it is not clear they are strong enough to save the Pine Barrens from the cumulative impacts of all the development taking place in and around the Pinelands. In many areas, new and better policies are needed to make the Pinelands protection ideal succeed over the long run.

The water that flows out of the Pine Barrens also sustains the estuaries that border New Jersey's Delaware and Atlantic coasts. Most of the Atlantic coast estuary of Barnegat Bay is within the Pinelands National Reserve. For this reason, the Pine Barrens and Barnegat Bay are intimately tied together.

The shore, like the interior Pine Barrens, has experienced a long history of human exploitation and landscape change. Unlike the interior forests, however, the shore has seen only accelerating development and loss of natural habitats since European settlement. Early shellfish industries have essentially given way to tourism and vacation homes as the principal human uses of the Bay. A combination of land preservation – most notably the federal Jacques Cousteau Estuary Reserve – and sporadic land use control efforts have kept Barnegat Bay a vital, if damaged, ecosystem.

Natural Communities of the Pine Barrens

We can think of the Pine Barrens as being made up, primarily, of three distinct kinds of communities: uplands, lowlands and aquatic communities. These broad categories are learning devices we invent; lots of the natural areas, especially transitional or "ecotone" areas, don't fit neatly into these three broad categories, but have characteristics of more than one.

Uplands are quite varied in the Pine Barrens, but most of them are forested. The *Pine/Oak Upland Forest* is the most common and the most characteristic natural community in the Pine Barrens. It is defined by its flora, but is also home to a diverse fauna. Many of the mammals, birds, reptiles, amphibians, and insects use the uplands for all or part of their life cycles. Many amphibians - for example, the Pine Barrens Treefrog - are really creatures of the forests, and the adults use the wetlands mainly for breeding. Here you'll notice that the majority of the canopy trees are Pitch Pines, the most characteristic tree of the Pine Barrens, with a smaller number of Shortleaf Pines, and, in some areas, a few Virginia Pines. The understory is made up of shrubs such as Scrub Oak, Mountain Laurel, Low Blueberry, Pine Barrens Heather, and Sweet-fern. Other shrubs, such as Sheep Laurel and Sand Myrtle, are more typical of damp areas often find their way to the uplands at times. And the ground cover consists of low-lying plants such as lichens, mosses, ferns, annual and perennial wildflowers, and sub-shrubs like Bearberry, Teaberry, Hudsonia and Trailing Arbutus.

Oak/Pine uplands are simply areas where the oaks predominate. Ecologists believe that oaks are likely to predominate in areas where wildfire has been suppressed over long periods. In some areas, the oaks may out-compete the pines so thoroughly as to become virtually exclusive.

The *Dwarf Forests or Pine Plains* of the Pine Barrens of New Jersey are upland forests that have long intrigued biologists. A botanist who visited one of the sites in 1889 described it as, "a desert of sand so sterile that even the trees of Pinus rigida [Pitch Pine], which sparsely clothe it, can attain only to the height of three or four feet." Early in the 20th Century, Witmer Stone described them as "desolate stretches of white sand barrens … for the most part devoid of trees higher than one's knees." The Dwarf Forests are dominated by dwarfed Pitch Pines and Blackjack Oaks in the low canopy. Pine Barrens Heather is frequent in the understory. Ground cover includes lichens, mosses, and the sub-shrubs Bearberry and Teaberry.

All of the tree species in the Dwarf Forests are also found throughout the Pine Barrens, so why do they take on a dwarf form in the Plains? Though the mechanisms are not entirely understood, most experts believe that a combination of factors are involved. The Pine Plains soils are partic-

ularly droughty and nutrient-poor, and, as plateaus elevated above their surroundings, the plains are subject to higher winds. Most importantly, for centuries these forests have been exposed to wildfires at least twice as frequently as other Pine Barrens forests. These extremely harsh conditions have created a forest with Pitch Pine trees that are stunted and have adopted certain genetic peculiarities. The pines of the Plains almost exclusively produce "serotinous" cones - cones that open only when subjected to the heat of wildfire - and have an extraordinary ability to send up new growth from their roots, even when the rest of the tree is completely burned. We will discuss the Pitch Pine's adaptations to fire in more detail below.

Highbush Blueberry

Lowlands include swamps, lowland forests, and wet meadows. A swamp may be defined as a forest that is periodically inundated. Lowland forests may never be inundated, but they have a high water table, so only plants that can tolerate having their roots in water thrive in lowlands. Wet meadows are covered mostly with herbaceous vegetation and very few or no shrubs and trees.

Atlantic White Cedar Swamps are the characteristic swamps of the Pine Barrens, though they are now much reduced in both size and number due to over-harvesting in the past. Old, well-established cedar swamps are magnificent. It tends to be cool and shady in an old cedar swamp. The straight-trunked cedars arise from hummocks usually covered with sphagnum mosses and various other plants, the diversity and vigor of which depend on the amount of sunlight reaching the floor. The plants growing on the hummocks typically include an occasional Swamp Maple or Pitch Pine. You'll also find Highbush Blueberry, Swamp Magnolia, Gray Birch, Swamp Azalea, Pitcher Plants, sundews, several species of orchids, various wildflowers, as well as grasses, sedges, and rushes. A great many of the Pinelands animals use cedar swamps for breeding, feeding, nesting, and resting. Some of our rarest flora and fauna have safe harbors in these communities.

One of the most famous plants of New Jersey, the tiny Curly-grass Fern, is found almost exclusively in Cedar Swamps, and always in association with Atlantic White Cedar trees. Curly-grass Fern was first recognized by botanists in 1805 at Quaker Bridge, in what is now Wharton State Forest. It can still be found in that vicinity and in many other places that provide its rather precise habitat requirements. It usually grows in early-successional spots where there is a fair amount of sunlight. Smaller populations can also be found in the Pine Barrens of Long Island, NY, and in Sussex County, DE, but it doesn't appear again until you get all the way up to Nova Scotia and Newfoundland. Botanists worldwide have made pilgrimages to the Pine Barrens to see Curly-grass Fern simply because it is so small and so rare.

Hardwood Swamps are wetland forests where the canopy is made up primarily of deciduous hardwoods - mostly Swamp Maple and Black Gum, and, in some areas, Sweet Gum. Today, hardwood swamps may be more common than cedar swamps, having developed because of over-harvesting of the cedars in the past. You may find some cedars here and there in a hardwood swamp, or cedars may be in small patches or groves. Shrubs include Highbush Blueberry, Dangleberry, Sweet Pepperbush, and Leatherleaf, and there is some variety of herbaceous plants, grasses, sedges, and rushes. Hardwood swamps are also important wildlife habitat. Extensive hardwood swamps are good nesting habitat for both Barred Owls and Red-shouldered Hawks, for example, and they are populated by a great variety of mammals, birds, reptiles, and amphibians.

Pitch Pine Lowlands may be recognized by the

abundant Pitch Pines intermingled with a great variety of moisture-loving plants, since the water table is quite close to the surface. These lowlands are hotspots for rare plants such as Yellow Fringeless Orchid, Pine Barren Gentian, Sand Yellow-eyed-grass, Rose-color Coreopsis, and Long's Woolgrass.

While Pine Barrens soils are dominated by sand, these soils are really a mosaic of sand interspersed with pockets of gravel, silt and clay. These pockets can shape and alter the landscape. Clay layers in the soil can create "clay lenses" or places where water cannot pass easily. These lenses sometimes create Pine Barrens "spongs." Spongs (pronounced like "spungs") are small isolated wetlands that hold water and provide a very distinctive habitat for plants, amphibians and other animals in the Pine Barrens.

Some of the most beautiful lowland communities in the Pinelands are the *Wet Meadows or Savannas*. They vary greatly in size and species make-up, but are recognized by the lack of trees, and abundance of herbaceous plants, grasses, sedges, and rushes. This is another hotspot for rare plants, some of them of worldwide significance. They include globally rare species such as New Jersey Rush, Bog Asphodel, and several of the Beaked-rushes.

Experts say many of the savannas are shrinking due to natural succession, the process by which open areas gradually become colonized grasses, then shrubs, and finally by forest trees. It is likely that people who were digging out bog iron long ago created at least some of the savannas we see today. The process undoubtedly severely disrupted the land surface, leaving a wide, wet, sandy/mucky surface. No one knows how long it may have taken such areas to become colonized again by plants, but we may be seeing a late stage of the long, complex process of succession in these shrinking sites. In natural cycles, some savannas would be maintained and, occasionally, created by wildfires and storms. Today, humans suppress wildfires in the Pine Barrens to protect property and lives. The effect of wildfire suppression on savannas is one of several ways in which our efforts to prevent uncontrolled fires is shaping the natural landscape of the Pine Barrens.

Aquatic habitats of the Pine Barrens are particularly important to this curriculum, because they provide a laboratory in which to investigate the effects of human development, the "built environment" on the Pine Barrens ecosystem.

Canoes on Mullica River

Looking at a map, you can see that most of the *Rivers and Streams* in the Pine Barrens flow east into the estuaries and bays along the Atlantic. One river, the Rancocas Creek, flows west to the Delaware River. These are all slow-moving streams and rivers, fed by rains and the Kirkwood-Cohansey aquifer. These rivers and streams, when undisturbed by human impacts, are highly acidic and very low in nutrients. These key water quality characteristics shape the biological cycles and communities within the rivers, streams and wetlands.

The streams and rivers of the Pine Barrens support unique plant communities and complex wildlife communities. About sixteen species of fish are considered indigenous to the Pinelands waters, and another forty-six species, including peripheral and introduced species, may be encountered.

Permanent natural Lakes are absent from the Pine Barrens. The only natural ponds or lakes in the Pine Barrens are those created by beaver, which dam up streams to create ponds and foster growth of the aquatic plants they like to eat. The larger lakes one sees today are all manmade. People have been damming up watercourses in the Pinelands since the earliest European settlers arrived. Impoundments that can be called lakes in a technical sense (with water deep enough to limit plant growth in some areas) are the result of activities

designed to use water power: people built dams and waterwheels to drive machinery such as grist mills, sawmills, and the bellows associated with the forges and furnaces.

Ponds are technically any body of fresh water that is shallow enough to permit plant growth from the bottom throughout the entire area of the pond. Small impoundments made by people for various reasons qualify as ponds. Beavers make ponds throughout the area, when they have the opportunity.

A very important kind of pond are the *Intermittent Pools or "Pingoes,"* sometimes also called vernal ponds. These pools are only filled with water part of the year. They form in shallow depressions where the water table is very near the surface for most of the year. These ponds fill with water in the fall, winter and early spring, then dry up in the late spring and summer as the water table falls. Intermittent pools support many rare plants and animals. For example, they are favored by Pine Barrens Treefrogs and salamanders for breeding because they do not harbor fish that would prey on the amphibians' eggs.

Habitats of Barnegat Bay

Estuaries are very productive because rivers deposit nutrients into estuaries. These nutrients are not immediately lost in the vast waters of the sea, but are temporarily trapped in the cycles of the estuary. In addition, estuaries typically encompass a great variety of habitats, since the meeting of fresh and salt water within a partially enclosed space creates variations in salinity, depth, sediments types, temperature, tidal forces, even local weather, across the estuary. This variety of habitats creates a diverse, if closely connected, set of plant and animal communities, providing opportunities for many different species to thrive within the overall estuary ecosystem.

Everywhere you look there are ecosystems within ecosystems. Pick any part of the estuary and you will find a distinctive ecosystem within - and intimately connected with - the other niches that make up the broader estuary ecosystem.

Take for example the tubes that burrowing animals like hard clams dig into the sediment at the bottom of the Bay. These tubes become minute but complex ecosystems in their own right, with their own microclimate, food webs, and energy and nutrient cycles that feed into the overall food web and cycles of the estuary. Within these tubes, bacteria that are otherwise inaccessible within the sediment are exposed and consumed by the filter-feeding hard clam that lives in the tube it built, as well as by zooplankton and other organisms that find their way into the tube. These predatory microorganisms are also on the clam's menu. In this way, the clam creates for itself not only a shelter from predators, but a restaurant with a selection of the foods the clam has evolved to prefer.

Some of the other important habitats that make up the Barnegat Bay system are:

- Barrier islands
- Open water
- Sandbars and mudflats
- Bay bottom, or the "benthic zone"
- Bay islands
- Salt marshes
- Submerged aquatic vegetation (SAVs)

Barrier islands: The barrier islands create and protect the estuary, but are also complex habitats in their own right. On most of New Jersey's barrier islands, the dunes that maintain the islands are being destroyed by beachfront development, but there are still some pristine areas left to explore. If one walks from the waves breaking on the ocean shore to the Bay across the nature preserve at the southern end of Long Beach Island, you will find a typical progression of habitats formed by the work of waves, tides and wind on the sands that make up the island: the surf or intertidal zone, primary dune, secondary dune, bayshore and tidal marsh zones. Within these zones may be found numerous different plant communities distinguished by the variety of plants adapted to the conditions in each zone and by the animals adapted to living in each plant community. One plant community that has been almost completely eliminated by human development is the maritime forest, a tough community of short Pitch Pine trees, American Holly, Atlantic White Cedar and White Oaks. One of the surviving examples of this surprising forest type can be explored at Barnegat Light on the north end of Long Beach Island.

Open water: The Bay's open waters provide the principal habitat for its finfish and the birds that feed on these fish. In Barnegat Bay's open water are also found jellyfish, squid and octopi. Open waters provide the main habitat for phytoplankton and zooplankton, primary producers of energy and nutrients for the entire estuary system. These open waters also serve complex and vital functions in regulating the physical and chemical conditions

throughout the estuary by diluting pollutants discharged into the Bay, absorbing and dispersing the heat of solar energy, and moderating salinity and other chemical qualities of the Bay's waters.

Sandbars and mudflats: These habitats are submerged for at least part of every tide. Sandbars and mudflats are teaming with life, though they may appear barren from the surface. One signal of the life beneath the surface is the flocks of gulls that collect when these areas are exposed at lower tides.

Bay bottom, or the "benthic zone": The sediments at the bottom of the Bay are also a habitat, home to a wide range of organisms such as shellfish, various worms, protozoans, microalgae and bacteria. A complete list of the animals living on the bottom (epifauna) or within the sediments (infauna) would include dozens of species of shells and whelks, crinoids, bivalves, amphipods, shrimp, urchins, starfish and worms. The type of sediment (silt, sand and clay) making up the bottom, depth, wave action, and water chemistry factors all affect the types and abundance of many benthic animals suited to live there. Microalgae and other microbes of the benthic zone play the dominant role in regulating the movement of nutrients (nitrogen and phosphorous) out of sediments into the water above, where the level of nutrients influences the growth of other organisms, especially phytoplankton.

Bay islands: There are about 165 islands. Islands are dynamic as they are created, destroyed and changed by erosion from ocean tides and boat wakes, and by rising sea levels. There are two kinds of islands in Barnegat Bay: natural sedge islands and human-made dredge spoil islands. Sedge islands consist of marsh grasses and a mat of peat made up of plant materials from dead grasses and soil bound together. Dredge spoil islands were created and are maintained by humans as dumps for sand and mud dredged out of the bay. Both kinds of bay islands are important habitat for breeding birds, because they provide relative sanctuary from predators and ready access to the food supplies of fish in the Bay and shellfish buried in surrounding sand bars and mud flats.

Salt marshes: Salt marshes are one of the most important habitats of the Bay. Found along undeveloped shorelines of the Bay, these are tidal wetlands, generally containing many tidal creeks. Salt marshes are most common on the western, inland side of the Bay south of Barnegat Inlet. The marshes are principally composed of Spartina grasses which grow in the mud and organic material held in place by the plants' roots. The Spartinas are Salt Marsh Cord Grass, and Salt-meadow Grass or Salt Hay. Salt marshes also can be made up of Black Grass, Wood Glasswort and Phragmites. A typical salt marsh can be separated into zones: the lowest area closest to open water is usually dominated by Salt Marsh Cord Grass; higher ground that is flooded only at higher tides is occupied by Salt Hay; and yet higher ground that is rarely if ever flooded is home to Salt Hay, Black Grass and other grasses and rushes, as well as Sea Lavender, asters and other wildflowers.

Another habitat within the salt marsh occurs in shallow depressions, call pannes, which flood only rarely. Because they are isolated from the tides, these pannes become very saline when the sea water in them evaporates over time, depositing its salt on the bottom of the panne. This process makes the pannes a very inhospitable environment for most plants; only specialists like certain species of glasswort, can thrive in these conditions.

If left to their own devices, salt marshes will change and spread through natural succession. Plants at the edge of the marsh will move gradually out into open water, holding sediments and their own leaves and roots together to form stable, higher ground. The former edge of the marsh captures more soil, becomes higher and less frequently flooded, allowing species from the interior to move outward behind the advancing marsh edge. Salt marshes can also retreat due to natural erosion, when storms or strong tides batter their edges, or inland storms cause streams flowing into the marsh to deposit extraordinary amounts of sediment. Salt marshes will also advance and retreat due to rising or falling sea levels over longer periods of geologic time. These are examples of "succession," much like the natural transformation of meadows to mature forests that we discussed in the Pine Barrens section.

Submerged Aquatic Vegetation (SAVs): These are the beds of plants that grow entirely underwater. Most are Eelgrass growing on a sand or silt bottom that is 1 m deep or shallower. Large algae such as Sea Lettuce also constitute SAV. One researcher reported finding 116 species of benthic algae in Barnegat Bay. The abundance and location of SAVs depends on several factors, including clarity of water, temperature, salinity and the type of bottom sediment.

SAVs are one of the primary producers of the estuary system. Many species feed on the submerged plants and their detritus of dead leaves, stems and roots. Fish, ducks, snails, muskrats and other species eat SAV leaves, while bacteria and other microbes decompose dead plant material and so recycle the nutrients bound up in their leaves, stems and roots. SAVs, moreover, create one of the key habitats of Barnegat Bay. The beds provide shelter and protection for many aquatic species, such as juvenile fish. They provide a substrate for certain species of algae on which other species feed, and they provide food for animals like ducks that graze on their leaves. SAVs also hold soil together and create a stable substrate for organisms living in the soils around their roots.

Salt Marsh

It appears that eelgrass beds have diminished in recent times. This may be due to several human factors, including nutrient-induced phytoplankton production that lowers the clarity of water, allowing less sunlight to penetrate to the plants that need light for photosynthesis. As we will discuss in the section on **Human Impacts and Conservation**, disease has played a role in the decline of eelgrass in Barnegat Bay, and human-induced stresses may make the plants more vulnerable to disease."