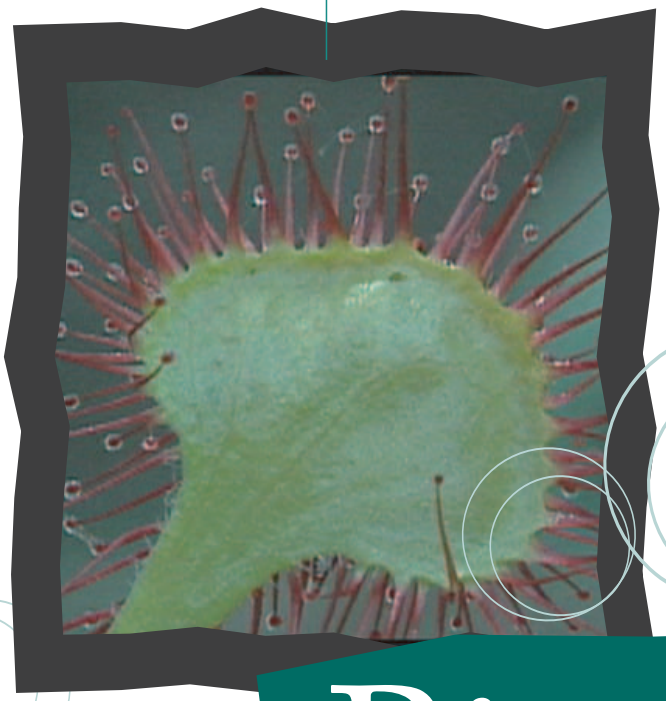
GEOLOGY

HISTORY

WATER

BIODIVERSITY

HUMAN IMPACTS & CONSERVATION



THE PINE BARRENS:

Close UP & Natural

INQUIRY BASED CURRICULUM

Biodiversity

INTRODUCTION

Biodiversity

The wild communities of the New Jersey Pine Barrens have often been described as a mosaic. As the observant explorer moves across the land and over the water bodies, he or she will surely notice that the appearance of the landscape is constantly changing. This is most apparent on cross-country treks. At times, you are surrounded by thick, old gnarled Pitch Pines with bristly-looking trunk sprouts, with huckleberry bushes providing most of the understory. In other areas, the pines are scattered here and there, upstaged by stately oaks, and perhaps Bracken Fern dominates the forest floor. As the land slopes to damp and wet areas, you'll see an abrupt, dramatic change of scenery, as oaks and pines disappear to be replaced by tall, handsome Atlantic White Cedars. Suddenly, Highbush Blueberry bushes surrounded you, and sedges and rushes are springing from the lush, green sphagnum moss.

Highbush Blueberry

The same is true when you visit the water bodies of the Pine Barrens. A canoe trip on the Oswego River takes you winding along a narrow corridor with tall cedars on each side. On a similar trip in the upper reaches of the Mullica River, you'll paddle past numerous beaver lodges in a wide vegetated pond. Batsto Lake provides a stunning display of Spatterdock and White Water-lilies, while the numerous intermittent ponds scattered throughout the Pinelands host globally rare wildflowers and provide breeding sites for Pine Barrens Treefrogs.

We call it the "Pine Barrens." Most experts have attributed the name to early settlers who couldn't grow the crops they wanted. Others have pointed out that the Pine Barrens isn't rich in species diversity - that is, the total number of distinct species - compared to some of our other forests. This is undoubtedly true, yet within the Pinelands region, one may encounter well over a dozen different broad categories of natural communities, over 800 different vascular plant species, about thirty-four mammals, 144 birds, thirty reptiles, twenty-four amphibians, thirty-six fishes and about 10,000 insects. Add to this the abundant and diverse species of mosses, liverworts, lichens, fungi, and algae, and the inestimable number of arthropods other than insects, and one can only conclude that the Pine Barrens really isn't barren at all.

Acidic soil and water are hard on most plants and animals. The reasons this is so are not yet clear to scientists. Nor is it clear how certain plants and animals have adapted to these conditions. Why can Pine Barrens Treefrogs prosper in an acidic environment, while Bull Frog eggs seem to wither and die in these conditions? Why are the heath family of shrubs so happy in acid soils, while most others simply cannot live or cannot compete successfully in Pine Barrens conditions?

The Pine Barrens' droughty, acidic and nutrient-poor soil and water also create a natural barrier against invasive species that cannot tolerate this environment. As a result, the Pine Barrens is one of the few places in North America that has not suffered significant ecological disruption from non-native, invasive species. At least, that's true where the ecosystem has not suffered chemical changes to soil and water from fertilizer runoff, liming of soils and other contaminants from suburban lawns and farm fields.

The unique geological history of the Pine Barrens has left here a unique plant community - or rather collection of communities - where northern and southern species survive together as they do nowhere else in the world. The distinctive communities of plants and animals inhabiting intact Pine

Barrens habitats tell us about the special geology and history of this ecosystem. They also provide a test or a standard for judging how well the Pine Barrens ecosystem is faring amidst human alteration of the landscape. For more than 10 years, scientists have been studying whether suburban, urban and agricultural development are altering the Pine Barrens ecosystem. As we will discuss in the section on **Human Impacts and Conservation**, scientists have found that the chemical features of stream water (such as pH and dissolved nutrients), the plants in and along the streams, and the fishes and frogs inhabiting the streams and wetlands are very accurate indicators of human impacts on the ecosystem.

Plants of the Pine Barrens

Broom Crowberry is a quintessential northern plant found as a disjunct population in the New Jersey Pine Barrens. Thought to have arrived here in front of the glaciers of the last ice age, Broom Crowberry is quite common in the New Jersey Pine Plains, but is entirely absent, with few exceptions, outside the Pine Barrens until one reaches its "normal" habitats in Labrador. The exceptions are several other, smaller disjunct populations in the Shawangunk Mountains of New York and along the coasts of Massachusetts and Maine. Broom Crowberry's northern origins are displayed in the very early blooming period – around the middle of March – of the Pine Barrens population, and in its tough, woody stems and needle-like leaves. In its unusual origins, unassuming appearance and adaptations to difficult conditions, Broom Crowberry exemplifies the fascination which the plants of the Pine Barrens hold in store for us.

The Pine Barrens is home to many species that are considered threatened or endangered because of their rarity in the State, the nation or the world. First, some numbers. The Pine Barrens is home to 8 species of gymnosperms (plants like the pine trees that do not produce true flowers), 800 species of flowering plants (angiosperms), 25 species of ferns, 274 mosses, and at least 100 (but probably 300-400) species of fungi. Of these 180 species are currently deemed threatened or endangered.

King among the gymnosperms of the Pine Barrens is the Pitch Pine, the single most characteristic plant species of this ecosystem. The Pitch Pine has evolved to prosper in the Pine Barrens' droughty, acidic and highly fire-prone conditions. Pitch Pine occupies about 283,300 hectares (700,000 acres) in New Jersey. Pitch Pines have thick, resinous bark, which helps to protect them from being killed by fire and insects. They also grow deep root systems, allowing them to reach down to the water table in many upland areas. Pitch Pine are a key food source for deer, which browse sprouts and seedlings; rabbits, mice and birds, which eat pine seeds; and many insects, which feed on various parts of the tree and needles.

Each Pitch Pine tree has both male "flowers" and female "flowers," although these organs are really cone-like structures, not true flowers in the scientific use of the term. This species relies on wind to blow the pollen from male "flowers" onto the ovulate cones of female "flowers" on the same or different trees in the area. The ovule produces the seeds and the pine cone, which protects the seeds while they develop.

On any given tree, some of these cones may open and release their seed upon maturity, but others are "serotinous" and will only open after being heated by a hot fire. The dwarf pines of the Pine Plains are almost entirely serotinous. Why would Pitch Pine evolve to have serotinous cones? What is the evolutionary advantage? The answer appears to be that Pitch Pine seeds can out-compete oak seeds only when wildfire has cleared the ground of dense beds of fallen leaves and needles. When there is a thick cover of needles and leaves, Pitch Pine seeds do not germinate as readily as the acorns of oak trees. Where oak seedlings germinate more readily, the saplings and trees into which they grow block sunlight and take up moisture and minerals, making it even more difficult for pine seedlings to grow. In contrast, where ground conditions favor pine seed germinate, pines beat oaks to the punch by grabbing the sunlight, moisture and minerals.

Pitch Pines have another extraordinary adaptation: they can easily grow new branches from their trunks and even from their roots. This unusual feat is possible because Pitch Pines develop dormant buds beneath the trees' thick bark. The thick bark protects the cambium layer and dormant buds from all but the hottest fires. The dormant buds begin to grow when stimulated by fire damage (or other similar harms.) Some of these buds lie at the base of the tree, where Pitch Pines typically produce a "basal crook" or bend that keeps the base of the trunk beneath the soil. Again, this is an adaptation that takes advantage of the fire-prone conditions in the Pine Barrens. After a wildfire, you will often see Pitch Pine trees that are completely blackened by the fire and appear to be dead, except for the bright green shoot coming out of the trunk of the tree. The shaggy look of so many pines in our region results from repeated cycles of fire and new growth from the trunk.

Within a season after a fire in the Pine Plains,

one may see broad stretches of trees burned to black above ground, but growing new shoots from their roots – a process that frequently creates trees with multiple trunks. This ability to sprout from its trunk and roots is unique to just a few species of pines.

In the dry soils of Pine Barrens uplands, wildfires are common, or were common before modern human cultures began suppressing wildfire. Pitch Pines have taken advantage of frequent fire by developing their own strategies for survival in the constant competition with oaks and other species for space, light, water and nutrition. It has even been suggested that one evolutionary purpose of the high resin content of Pitch Pine needles is to create a highly flammable bed of fuel that encourages hot wildfires. The ability to regrow from roots also suggests that some Pitch Pines in the Pine Plains may be very, very old, having regenerated themselves through hundreds, perhaps thousands of cycles of fire and regrowth.

Swamp Pink

Among the flowering plants, we will focus on the oaks, the heath family, three wildflowers that have their worldwide stronghold in the Pine Barrens, the orchids, and the carnivorous plants found here.

Oaks are the second-most dominant tree in Pine Barren. Several species of oak thrive in this environment. Like the pines, oaks in the Pine Plains remain short in height, more like shrubs than trees. Unlike pine needles, the leaves of oaks are broad and flat, enabling them to capture sunlight for photosynthesis more efficiently than can needles. Oaks reproduce by dropping acorns, which contain the oaks' seeds. Acorns have evolved to be nutritious food for squirrels and other forest mammals, which store acorns for consumption but forget to dig up and eat a certain percentage of the acorns they have gathered. Acorns also germinate and sprout more easily in thick ground cover than do pine seeds.

On the other hand, oaks are more vulnerable to being damaged or killed by fire than are pines, and oaks have no ability to grow new branches from dormant buds after wildfires. Because of the different survival strategies of oaks and Pitch Pines, it is likely that oaks will eventually come to dominate if human beings continue to suppress wildfires and do not impose prescribed or controlled burns capable of mimicking the effects of wildfire on Pitch Pines.

The understory of Pine Barrens forests and stream-side vegetation are dominated by members of the Heath family of plants. Heaths of the Pine Barrens include Sheep and Mountain Laurels, Blueberries and Cranberries, Swamp Azalea, Bear Berry and Wintergreen. Heaths are adapted to acidic soils and prosper in the Pine Barrens understory, but exactly how they handle these conditions is not well understood at this point.

Three extraordinarily beautiful wildflowers, Pine Barrens Gentian, Bog Asphodel and Swamp Pink, provide a lesson in the importance of New Jersey's Pine Barrens to preserving global biodiversity. These wetlands flowers have been virtually exterminated elsewhere, but are locally abundant in the Pine Barrens. Pine Barrens Gentian is protected as threatened or endangered by the Pinelands Comprehensive Management Plan; Swamp Pink is listed under the national Endangered Species Act as threatened; and, for now, Bog Asphodel is considered endangered in New Jersey and, based on its rarity, certainly merits a national designation. In fact, the Bog Asphodel is now thought to survive only in the New Jersey Pine Barrens. Even in the Pine Barrens, these plants have suffered from illegal collection, alteration of habitat, trampling by off-road vehicles and other careless recreational activities.

These plants are adapted to specific wetlands conditions, so any serious alteration of their wetlands habitats, whether through construction of cranberry bogs or alteration of stream flows, threatens these flowers. Other impacts are natural. These include the natural succession of wet meadows as shrubs and trees colonize savanna areas, predation by deer, geese and insects, and even the flooding of their habitat because of beaver dams. It remains an open question whether there are enough of these extraordinary plants and enough intact habitat for their long-term survival.

Similar concerns with habitat degradation and collecting arise with many of the orchids found in the Pine Barrens. The Pine Barrens is home to a delightful array of wild orchids. About 30 species occur within the Pinelands National Reserve, of which about 15 species are characteristic of true

Pine Barrens habitats. Several, such as Rose Pogonia and Grass-pink, are very abundant and easily found along Pine Barrens streams and in wet meadows and open swamps. The elegant Pink Lady's-slipper may be common in sandy woods. Other orchids range from the rare to the imperiled, the most critically imperiled being Spready Pogonia, Yellow Fringeless Orchid, and Lace-lip Ladies'-tresses.

The carnivorous species of the Pine Barrens, Pitcher Plant, Sundews and Bladderworts, have evolved different ways to capture and consume insects and other tiny animals. Pitcher Plants develop large, water-tight basins from specialized leaves, which trap rainwater and contain digestive enzymes. Pitcher Plants exude enticing aromas that attract insects to investigate, and when the insects move or fall into the "pitcher," downward facing hairs stop them from escaping. In contrast, sundews trap insects on sticky leaf surfaces, which then release enzymes to digest the animals. Bladderworts have tiny sacs attached to their modified leaves, which into water or are embedded in boggy soil, depending on the species. Very small animals are sucked into the sacs when they approach the sacs' openings, where they are subsequently digested. Scientists believe these carnivorous abilities evolved to supplement the plants' diets in conditions where it is difficult for plants to obtain enough nutrients from the soil and water alone.

As in other ecosystems of the world, fungi play a critical role in the Pine Barrens. Indeed, life as we know it on earth would not be possible without the fungi. Decomposition in acidic soils is primarily carried out by fungi, because bacteria prefer less acidic soils. The plant litter of Pine Barrens vegetation is slower to decompose than leaf litters of plants growing on richer soils. Our litters contain high levels of polyphenols and tannins, chemicals that can be toxic to most other organisms and therefore require special enzymes for their breakdown. Many basidiomycete (mushroom forming) fungi possess those enzymes.

Once leaf litter has been broken down to release the nutrients in a form available for plant growth, the uptake of nutrients by roots is aided by the presence of mycorrhizae (literally 'fungus-root'), a symbiotic relationship between fungi and roots. The fungal hyphae (threads or sometimes ropes of hyphae) run further from the root surface into soil than root hairs, thus the effective surface area of the root is increased for less maintenance cost than supporting root hairs. This fungal network can explore and exploit a larger volume of soil than the root alone, thus improving nutrient uptake efficiency. Additionally, some of these mycorrhizal fungi have the ability to produce the enzymes that are required for the breakdown of the complex organic molecules contained in leaf litter. Thus they act as decomposers as well as mycorrhizae. This means that they can tap directly into the leaf litter to obtain nutrients, rather than relying on the decomposers to provide material for them. Hence the term 'direct nutrient cycling' was coined to describe this process.

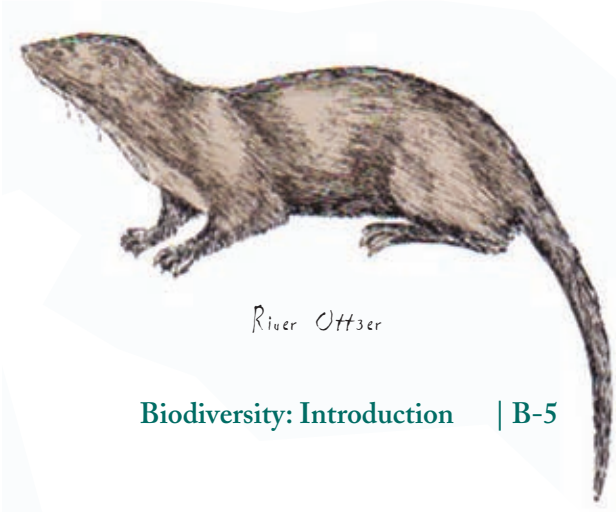
Fungi in the form of lichens are common on bare sand in our region. An association between fungi and their symbiotic algae and cyanobacteria, lichens play an important role in nitrogen fixation. Their dead remains also form the initial soil structure, which stabilizes the sand and allows other plants to colonize.

Pine Barrens Fauna

Among animals, we find 34 species of mammals, 36 species of fish, 24 amphibians, 30 reptiles, 144 birds (either year-round or migratory residents), and more than 10,000 invertebrate species (mostly insects, worms and other arthropods). Of the animals, 36 species are currently deemed threatened or endangered.

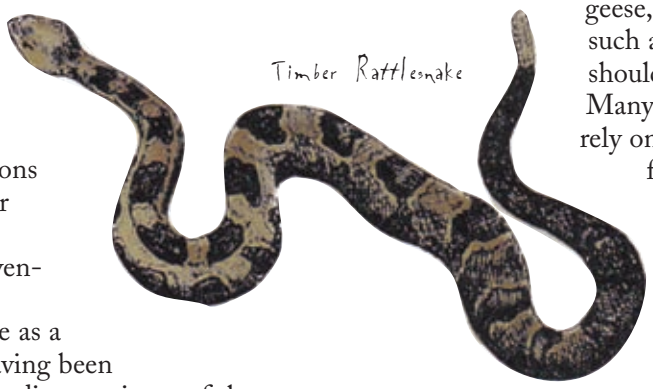
The Pine Barrens lost its top predators, Black Bears, Cougars and Wolves, long ago to hunting and trapping – although Black Bears seem to be finding their way back to the Pine Barrens. The Pine Barrens today is home to 34 species of mammals (or 35 if we include Black Bear). Large mammals include White-tailed Deer, Coyotes, the rare Bobcat, Beavers and reclusive River Otters. White-tailed Deer are plant-eaters which have proliferated in the Pine Barrens (as elsewhere in the country) due to the fragmentation of forests, which creates more edible plants of the forest edge than does a continuous, mature forest. We also find Red and Gray Fox, Mink, Long-tailed Weasel, Southern Bog Lemming, 8 species of bats, as well as raccoon, muskrat, various squirrels, chipmunks, voles and mice.

River Otters are elusive denizens of Pine Barrens streams and wetlands. Happy in fresh and brackish



waters, they most often are reported in the lower stretches of rivers flowing into the Atlantic coast estuaries. But they are also sometimes seen in cranberry bogs and reservoirs in the heart of the Pine Barrens. Otters have not been studied in the Pine Barrens. They once thrived throughout Canada and most of the United States, and while they have been extirpated in most of their historic range by humans, they are being reintroduced successfully in many places. Feeding mainly on fish, Otters will also eat shellfish, frogs and small mammals and birds. They are reported to enjoy blueberries. Given their secretive habits, one is far more likely to see otter-signs, such as the slides they wear in stream banks, than to catch sight of an otter itself.

About 20 species of snakes inhabit the Pinelands, and several of these populations are quite remarkable. For example, the Timber Rattlesnake is the only venomous species in the Pinelands and exists here as a disjunct population. Having been extirpated from the immediate environs of the Pinelands, they have managed to survive in about seven reproducing populations scattered through the region. The closest neighboring populations are in far north Jersey. The Northern Pine Snake populations of the Pinelands are also cut off from their own kind. Northern Pine Snakes are not found again until you get all the way down to Virginia and West Virginia. Similarly, the Pinelands hosts the northernmost population of the Corn Snake. The most common snake of the Pinelands may be the Northern Water Snake. Surely the most bizarre snake of the area is the Eastern Hognose, also known as the Puff Adder, since it often spreads its neck, cobra-like, when alarmed.



Two toads and twelve frogs are known to inhabit the Pinelands. All of these amphibians are dependent on high-quality aquatic habitat for breeding, but some of them are otherwise more closely associated with uplands. The Pine Barrens is the global stronghold for the Pine Barrens Treefrog, which uses mostly intermittent ponds in characteristic Pine Barrens areas for breeding. Residential development and farming in the Pinelands often result in changes to the chemistry of breeding habitats of these animals, and an influx of non-native species that can displace them. Carpenter Frogs are another characteristic Pine Barrens species, the presence of which indicates a healthy aquatic wildlife community. Some of the other more visible and well-known frog species of the Pine Barrens are the Green Frog and the Southern Leopard Frog.

While the diversity of bird species in the Pine Barrens is not particularly great, many species live within or migrate through the Pine Barrens. One may encounter about 144 species, many of which breed in the Pinelands. The Pine Barrens is important to many migrating and wintering birds. The forests and swamps of the Pine Barrens provide nesting habitat for about 100 species, including wood warblers and other songbirds. The Pine Barrens is an important area for breeding, feeding, nesting, and resting for a great variety of waterfowl, such as ducks and geese, and magnificent raptors, such as the Bald Eagle, Red-shouldered Hawk, and Osprey. Many of our bird species that rely on the estuary systems benefit directly from the quality water flowing from the Pine Barrens streams and rivers into the coastal estuaries.

Pine Barrens streams are good habitat for a very limited range of fish species, because of the streams' acidity. Most fish cannot reproduce in the Pine Barrens' naturally acid waters, because the acidity interferes with the development of their eggs. The relatively low level of algae and aquatic vegetation may also exclude some species that require their habitat to provide a greater quantity or variety of food. Native fishes include New Jersey species that are only found in the Pine Barrens and those that thrive both in the Pine Barrens and in other, non-acidic waters. Species found in the Pine Barrens are Banded Sunfish, Blackbanded Sunfish, Pirate Perch, Mud Sunfish, Swamp Darter and Yellow Bullhead. Species found in the Pine Barrens and elsewhere in New Jersey are American Eel, Bluespotted Sunfish, Eastern Mudminnow, Redfin Pickerel, Chain Pickerel, Creek Chubsucker and Tadpole Madtom.

There are several species of fish that are not found in pristine Pine Barrens waters, but are sometimes found in streams that have been altered and degraded by pollution. These species include Tesselated Darter, Bluegill, Largemouth Bass, Pumpkinseed, Brown Bullhead, Golden Shiner and Yellow Perch. We will return to these species as indicators of human alteration of the ecosystem below.

Plants and Animals of the Estuary

Barnegat Bay is home to a wonderful kaleidoscope of plants and animals which rely on the Bay to provide sustenance, shelter, and breeding and nesting grounds. The birds of Barnegat Bay are just as dependent on the Bay as the fish and shellfish that live beneath its surface. There is within the Bay and above its waters a complex web of life shaped by the Bay, and shaping the Bay in turn. The following outlines some key parts of the plant and animal communities of Barnegat Bay. While they are not discussed here, keep in mind that harbor seals, frogs, toads, snakes, turtles, song birds, rodents, and many insects, among other species, are also important and fascinating players in the ongoing drama that is the Barnegat Bay ecosystem.

Phytoplankton: Plankton are organisms that float in the water, drifting with tides and currents because they have no organs for locomotion. Phytoplankton are the very small plants that float in the water and form the base of the Bay's food chain. Phytoplankton are among the most important "primary producers" on which all other life ultimately depends. As such, phytoplankton are critical to the biology and health of the Bay. There are at least 132 species of phytoplankton found in Barnegat Bay. The most dominant species are single-celled picoplankton. Other species are larger and multicellular.

Because of their ability to multiply very rapidly, the primary limitation on phytoplankton multiplication in estuaries like Barnegat Bay is the availability of the nutrients - particularly nitrogen - which they need to live and grow. Nutrients are the "limiting factor" on plankton population growth.

While phytoplankton are essential to the life of the Bay, some species can "over-produce" to the point where they create visible "blooms" that discolor the water over large areas. In a picoplankton bloom, water has been measured to contain as many as 26,000,000 plankton cells per mililiter (about 3 drops) of water. These blooms can damage the ecosystem and be unhealthy for people, shellfish and other animals. Blooms discolor the water (so-called red tides and brown tides). This discoloration is unattractive, but more importantly it reduces light penetration to benthic (bottom-dwelling) organisms, such as submerged aquatic vegetation. During blooms, for example, it has been shown that turbidity increases beyond the point at which eelgrass can normally grow in Barnegat Bay waters. In addition to reducing visibility, blooms can drastically reduce the dissolved oxygen available to other organisms. Intense phytoplankton blooms can also release poisons into the water, which can make people sick and kill or harm fish and shellfish. Phytoplankton blooms are usually attributed to human causes, particularly to excessive nutrients coming into the Bay and encouraging the uncontrolled multiplication of certain species. Other factors causing blooms may be lower rainfall coming into the Bay in times of drought, leading to higher salinity and slower flushing of the Bay's water into the sea, which is thought to favor certain phytoplankton species.

Bacteria: Bacteria play essential roles in the estuary ecosystem, as they do in all living systems on earth. In the estuary, bacteria decompose dead plant material and animal bodies. Bacteria provide food for zooplankton in the water column and tiny animals like nematode worms in the bottom sediments. As decomposers, bacteria produce and release nutrients into the soil and water of the Bay in a form that plants and other microbes can use to grow, such as nitrogen in the form of ammonium. Certain types of protozoa also consume and decompose dead plant and animal matter, providing food and nutrients for larger organisms in chemical forms those larger organisms can use for respiration and growth. Protozoa include amoebas living in sediments and foraminifera floating a plankton in the water, among many other forms and lifestyles. As with bacteria, there is a great variety of protozoa in terrestrial and marine environments, and they can be found in all parts of the Barnegat Bay ecosystem.

Zooplankton: Zooplankton are very small animals, and the term covers a wide array of creatures. Some zooplankton are tiny their entire lives; other zooplankton represent the first stage in the animal's lifecycle and may later grow into much larger animals like barnacles, clams, crabs, aquatic snails and some fish. "Zooplankton constitute the principal herbivorous component of estuarine ecosystems," because most zooplankton species feed on the phytoplankton at the base of the food chain. Some zooplankton are carnivorous and feed on other zooplankton. Not surprisingly, the abundance of zooplankton in Barnegat Bay follows that of phytoplankton: zooplankton proliferate when their food source, principally phytoplankton, are abundant.

Plants: The Barnegat Bay estuary is home to several distinctive plant communities found on its barrier islands, salt marshes, shallow bottom, and floating in its open waters. 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.

Submerged Aquatic Vegetation (SAV) 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.

Shellfish: Barnegat Bay's commercial and recreation industries are based in large part on the Bay's shellfish, whose populations have been devastated by pollution and disease. The most abundant species of shellfish today are Hard Clams, Blue and Ribbed Mussels, Blue Crab, Fiddler Crabs, Common Spider Crab, 6-spined Spider Crab, Rock Crab, and Horseshoe Crabs. Blue Crabs inhabit all parts of the Bay system, while Rock Crabs, Spider Crabs and Horseshoe Crabs favor the deeper channels. The 6-spined Spider Crab appears to prefer eelgrass beds. The Sand Fiddler and Mud Fiddler crabs are vital parts of the mud flat and salt marsh communities.

These crabs provide a good example of how consumers in the trophic structure influence the entire natural community of organisms that share their habitat. Crabs are the most abundant large animals in mud flats and salt marshes of Barnegat Bay. The Fiddler Crabs feed on bacteria, microalgae and decaying plant materials. Beyond their role as consumers, Fiddler Crabs help to create and maintain their own habitat, to the benefit of themselves and the other salt marsh residents. Fiddler Crabs dig burrows for shelter from predators and for protection from drying out at low tides. Millions of these burrows in a mud flat or marsh bring oxygen deeper into the sediments than it could otherwise penetrate. The greater availability of oxygen accelerates decomposition of organic matter within the sediments and increases the growth of organisms living in the soil, such as the marsh grasses whose roots delve into the oxygenated sediments.

Clams and, to the extent they can still be found in the estuaries, oysters also play a critical role in the life of the Bay. They suck in estuary water, filtering out bacteria, plankton and dissolved organic matter for food. Filter feeders appear to be critical players in regulating bacteria and phytoplankton populations in the estuary's waters. Where there are sufficient nutrients in the water, bacteria and phytoplanktons can sometimes overwhelm the ability of clams and other filter feeders to control their growth. They also help to recycle nitrogen and carbon when they expel excess nutrients in their wastes back into the water, where they may be picked up by other plants and animals. These creatures also help keep the estuary's waters clear by filtering out sediments suspended in the water, which they expel and deposit onto the bottom of the Bay.

Finfish: The estuary's fish population includes year-round residents, migratory residents, and anadromous species. (Anadromous species are those that breed and lay eggs in freshwater streams.

After hatching, the young swim downstream to live their lives in saltwater, then return to their place of birth to breed and lay eggs. Local anadromous species are alewife and blueback herring.) A Rutgers University study found 60 different species of fish living in the Bay over a 10-month period. Important "forage species," meaning fish that other fish and birds depend upon for food, include Herring, Menhaden, Bay Anchovy, Inland Silverside, Killifish, and Grass Shrimp. Some "cosmopolitan" fish species, such as Bay Anchovy and Atlantic Silverside, use all habitats of the Bay. Others favor particular habitats.

Birds: Barnegat Bay provides important habitat for many bird species. Some use the Bay during migration; others breed here; some are year-round residents. Estuaries throughout the world are important to birds because they offer plentiful food and sheltered areas for nesting. Here we will focus on the waterbirds, shorebirds, waterfowl and raptors of Barnegat Bay.

Twenty species of waterbirds breed on Barnegat Bay. These include terns (Least Tern, Common Tern, Forster's Tern, Roseate Tern, Caspian Tern and Gull-billed Tern), gulls (Laughing, Herring and Great Black-backed), the Black Skimmer, egrets (Great, Snowy and Cattle), herons (Great Blue, Green-backed, Little Blue and Tri-colored Herons, Black-crowned Night-heron, and Yellow-crowned Night-heron), and the Glossy Ibis. Five of these species are designated as threatened or endangered species by the state of New Jersey. Each group favors different habitats for nesting: heron colonies choose islands that are high and dry enough to have bushes or poison ivy; gulls usually choose islands that provide good visibility of predators as they approach; and terns and skimmers favor low islands. Some species appear to stagger their arrival and nesting times in order to minimize competition for space.

The estuary provides nesting and migration grounds for many shorebirds. American Oystercatchers, Willets and Piping Plovers are shorebirds that nest in summer on the beaches and islands of Barnegat Bay. Piping Plover nest only on barrier island beaches. As these beaches have been lost to development, as humans tramp across the beaches with ever greater frequency, and as pets and other predators have invaded previously safe ground here and throughout their range, Piping Plover populations have declined precipitously. The Piping Plover is now recognized by the federal government as threatened and by the state of New Jersey as endangered.

Migratory shorebirds depend on estuaries like Barnegat Bay for places to rest and bulk up on food for their long flights south in winter or north in summer. Without stopovers like Barnegat Bay, these birds could not survive and complete their migrations. In Barnegat Bay, birds devour the shellfish, worms and other invertebrates they find in sandbars, mudflats and beaches. Species of migratory shorebirds using Barnegat Bay include Sanderlings, Semipalmated Sandpipers, Dunlin, Red Knot, Short-billed Dowitcher and Ruddy Turnstone, among many other less abundant species. Some species prefer beaches, others salt marshes or mudflats. Many waterfowl spend their winters in, or migrate through Barnegat Bay. Waterfowl include ducks, brants, geese, swans and other species that swim upon the water and dive or duck for fish or plant foods beneath the surface.

For many, Barnegat Bay's most breathtaking birds are the raptors - eagles, hawks and falcons - that soar above the Bay, diving for fish in the waters, and for mammals and crustaceans on shore. Barnegat Bay supports Bald Eagles, Ospreys, Peregrine Falcons and Northern Harriers. Ospreys are also known as Fish Hawks, as they feed on fish which they grab from the water. Osprey, Falcons and Harriers currently nest around the Bay. Ospreys and Falcons often use platforms people have built for them on public lands, while Harriers nest in marsh grasses above high tide. Peregrine Falcons prey upon other birds, while Northern Harriers hunt for rodents and small birds.

BIODIVERSITY | Lesson Plan: Species Area Curve

Length: 1 class period | Grade: 9-12

Objectives

Students will be able to…
- Define biodiversity.
- Explain how moderate levels of disturbance may enhance diversity.
- Construct a species area curve and make predictions based on the results.

Overview

Ecologists use species-area curves to plot the cumulative number of species encountered as a function of area. These curves can then be used to compare the biodiversity of different regions within an ecosystem. Students will compare the species area curves of three different intervals of disturbance (fire in the Pinelands). Conclusions will then be made relating disturbance intervals to biodiversity within the Pine Barrens. The intermediate disturbance hypothesis states that a high level of biodiversity may be found in areas with intermediate levels of disturbance.

Procedure

❍ Distribute copies of the species area curve lab and read aloud with students making sure that they understand the concepts of species area curve and the intermediate disturbance hypothesis.

❍ Distribute graph paper and have the students graph the data displayed in the table of the lab (a computer graphing program may be used instead). Make sure that they include a legend for each line plotted.

❍ When students are finished their graphs, discuss the results and answer the conclusion questions for the lab.

Materials

❏ Copies of the Species Area Curve Lab
❏ Graph Paper
❏ Pencil

Extensions

Divide students into research teams and give each group a quadrat outside. Have each group report on the number of different species found in each quadrat. Rejoin the class and have one group report on the number of species they found in their quadrat. Each successive group can report any additional species they found that the group(s) before did not find. Compile class data and graph results.

New Jersey Core Curriculum Standards

5.1, 5.3, 5.5, 5.10

Glossary

Biodiversity: The variety of life on Earth.
Intermediate Disturbance Hypothesis: High species richness is expected in regions with intermediate levels of disturbance.
Species Area Curve: A plot of the cumulative number of species encountered as a function of area.
Competitive Exclusion Principle: No two species can coexist indefinitely on the same limiting resource. (or fill the same niche). One species is driven to local as a result of interspecific competition.

Species Area Curves

Student Activity

Species Area Curves

Graph the following data with the cumulative number of plant species encountered on the Y-axis vs. the size of the area sampled on the X-axis. You will have three different lines (one for each type of burn) drawn on your graph. Be sure to include a legend to differentiate between the different levels of disturbance.

Cumulative Numbers of Species Encountered vs. Disturbance Intervals

Area Sampled	2 Year Burn	15 Year Burn	50 Year Burn
1m2	1	2	2
4m2	3	4	4
9m2	5	7	6
16m2	7	11	8
25m2	9	13	12
36m2	9	19	14
49m2	9	23	15
64m2	9	24	16
81m2	9	25	17
100m2	9	25	17

Inquiry

1. What is "biodiversity"?
2. Which of the three intervals had the most biodiversity? The least? Explain.
3. What happens to the number of species as the area sampled increases in size? Why do you think this happens?
4. Why do scientists want to obtain many different quadrats (increase the size of the area sampled) instead of just one when conducting ecological investigations?
5. Why do you think an intermediate level of disturbance increases biodiversity?

Pine Barrens Gentian

BIODIVERSITY | Lesson Plan: Exploring Biodiversity in the Pines

Length: 1-5 days | Grade: 9-12

Objectives

Students will be able to…

- Recognize the distinct biodiversity of the Pine Barrens.
- Utilize technology to develop a power point or poster presentation for one a single native organism.
- Identify the characteristic adaptations of their assigned organism.
- Show how interrelationships among the Pine Barrens organisms can be illustrated as a Food Web.
- Specify the nature of the relationships in their Food Web as mutualism, commensalism, parasitism, predation, competition and saprophytism.

Overview

- Biodiversity refers to the variety of life that is found in a particular location. While there are three kinds of biodiversity – genetic diversity, species diversity, and ecosystem diversity – this activity will primarily focus on species diversity in the Pine Barrens ecosystem.
- To raise awareness in students about the significance and interrelatedness of organisms in an ecosystem, a lesson on biodiversity can provide both a cognition and appreciation of the unique adaptations of Pine Barrens biota. Students show how these organisms interrelate to each other by constructing a food web and completing a predator/ prey lab activity.
- Today, many species of the Pine Barrens are threatened, endangered, or being faced with extinction. Consideration of the ethical, legal and social implications involved in protecting or not protecting these organisms is a natural outcome of viewing the effect that humans have on this ecosystem.

Procedure

Pre-Activity

❍ Decide ahead of time whether you want students to work as individuals, small groups or large groups. To engage the students in their "search" for Pine Barrens biodiversity, begin by prompting them on native species with which they are familiar (consider a variety of producers, herbivores, second and third order carnivores, and decomposers that are typical of the Pine Barren communities). As students suggest the names of Pine Barrens species, write the names on the board and group them according to their ecological role. The copy master will provide examples of appropriate categories. These organisms will also serve as the basis for the food web construction activity.

❍ Show *The Pine Barrens*: *Up Close and Natural* video.

Activity

❍ Students are to utilize books, magazines, Internet sites and research information about their assigned organisms. Students will require both written and pictorial information to showcase the general anatomy and physiology, ecology, natural history, and specialized adaptations of their selected organism that allows each organism to survive in the Pine Barrens.

You can suggest the following information:

- Physical appearance of the organism (anatomical and physiological adaptations).
- Classification of the organism (genus, species, endangered, threatened, etc.).
- Conditions under which the organism flourishes.
- Life History of the organism (development, reproduction etc).

- Distribution within the Pine Barrens.
- Benefits to humans (food, medicine, aesthetic, etc.)
- Ecological threats to the organism (pollution, pests, habitat loss, etc.)
- Laws that impact this organism.
- Advise students that the power of a power point presentation is in their visuals.
- Encourage pictures that allow the student to speak to the content with ease.
- Discourage lengthy list of information and paragraphs.
- Let students be creative and utilize humor.
- Many students will be making presentations like this in their career so this is a perfect opportunity to work on honing their skills.
- Encourage students to put their presentation on CD's or onto a Memory Stick for ease of transporting and depositing on laptops at presentation time.

❍ When all the presentations are done, prompt the students on the Inquiry questions posed in the student activity handout.

❍ Organize the food web cards into a large Food Web in the center of the floor or on the board. Have students add arrows to the feeding relationships to show who is providing energy to who. When the food web is done have students decide how they would identify each of the relationships with the names: predation, competition, mutualism, commensalisms, saprophytism (decomposition).

❍ Distribute the student activity page for the predator/ prey simulation. Review the use of the data table.

Materials

❑ LCD projector and laptop
❑ Availability to the internet
❑ CD ROMs
❑ Masking Tape
❑ Meter Stick
❑ Owl and Vole Cards
❑ Food Web Organism Cards
❑ Students Activity Sheets
❑ Graph Paper

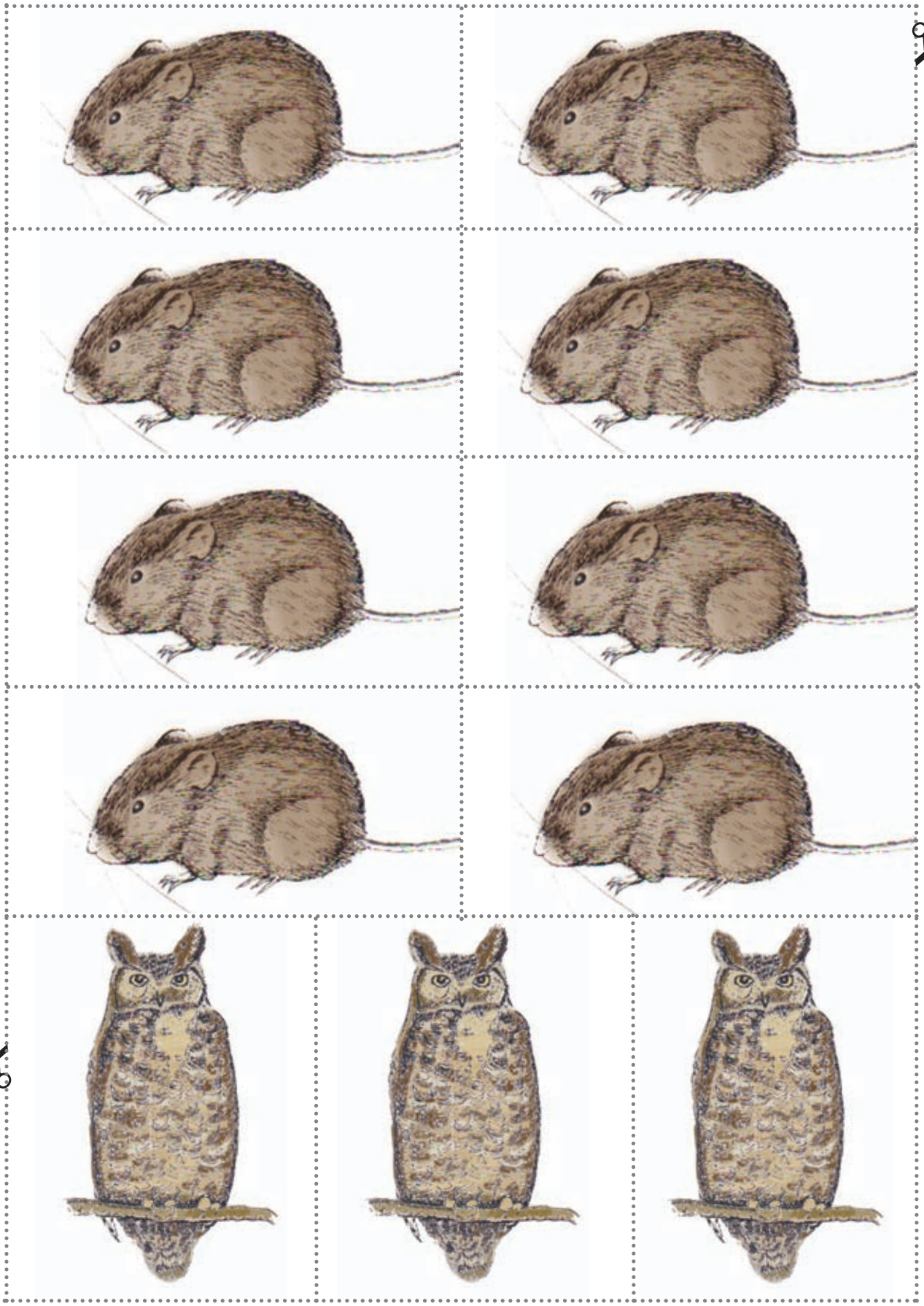
New Jersey Core Curriculum Standards

5.1, 5.4, 5.10

Glossary

Biota: The plant and animal life of a region or area.
Commensalism: A symbiotic relationship in which one species benefits and the other is not affected.
Competition: A relationship where both organisms are affected in a negative way with usually neither of the interacting organisms benefiting.
Mutualism: A symbiotic relationship in which both organisms benefit.
Parasitism: A relationship where one organism lives on or in another organism and uses that organism as a food source.
Predation: Occurs when one organism eats another.
Saprophytism: When an organism, especially a fungus or bacterium, grows on and derives its nourishment from dead or decaying matter.

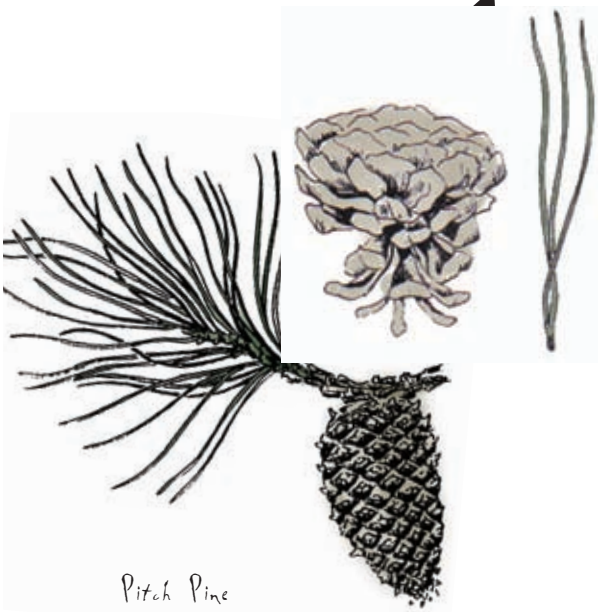
PREDATOR & PREY ACTIVITY SHEET



Food Web Activity Sheet

List of Species

Pitch Pine	Black Huckleberry
Red Squirrel	Chestnut Oak
White-tail Deer	American Cranberry
Timber Rattlesnake	Black-banded Sunfish
Pine Warbler	Chain Pickerel
Rufous-sided Towhee	Detritus
Red-backed Vole	Fowler's Toad
Pine Barrens Treefrog	Norther Fence Lizard
Great Horned Owl	Gray Fox
Dragonfly	Mayfly
Great Blue Heron	River Otter
Ground Beetle	Northern Water Snake
Wild Rice	Treehopper




Red Squirrel


White-tail Deer


Timber Rattlesnake


Pine Warbler


Rufous-sided Towhee


Red-backed Vole

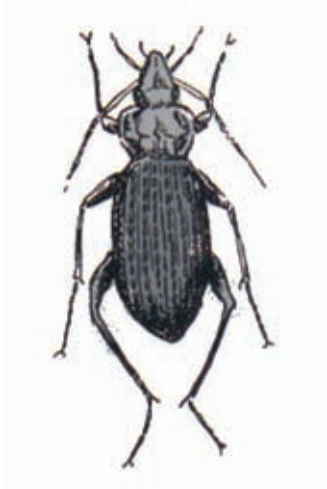
Food Web Activity Sheet

Pine Barrens Treefrog

Great Horned Owl

Dragonfly

Great Blue Heron



Ground Beetle

Wild Rice

Black Huckleberry

Chestnut Oak

American Cranberry

Food Web Activity Sheet

Blackbanded Sunfish

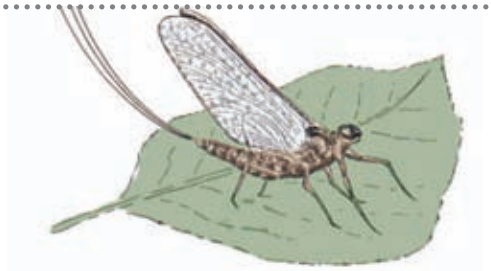
Chain Pickerel

Detritus

Fowler's Toad

Northern Fence Lizard

Gray Fox



Mayfly

River Otter

Northern Water Snake

Treehopper

FOOD WEB

Student Activity

Inquiry

Investigating biodiversity

1. What is biodiversity?
2. Why is biodiversity important?
3. What is threatening biodiversity in the Pine Barrens today?
4. What organisms are in "trouble" in the Pine Barrens?
5. Is global warming, loss of habitat or pollution having any effect on the biodiversity of life in the Pine Barrens?
6. What can be done to protect the biodiversity in the Pine Barrens?
7. What do you think should be done to protect the biodiversity in the Pine Barrens? Support your argument with data and examples.

Predator & Prey Simulation

- Using the masking tape, mark a one-meter square on the floor.
- Spread 10 vole cards evenly inside the square. These cards represent the beginning vole population. The cards should not touch each other!
- Toss two owl cards on top of the vole cards. This is the beginning owl population.
- Pick up any "captured" vole cards. "Captured" voles are vole cards touched by owl cards. Record the number of voles captured in the Data Table.
- Every vole that is remaining reproduce and the population doubles. Record the new number of voles in the data table.
- Owls that do not capture voles die from hunger. In the first round, owls that capture one vole live and reproduce. Their number also doubles. Record the final number of owls.
- Repeat procedure 5 more times except...
    - Owls that capture one vole live
    - For an owl to reproduce, it must capture 2 voles!

* Discuss with your group the most appropriate way to graph the data and do so.

Great Horned Owl

Predator & Prey Data Table

	Trial 1	Trial 2	Trial 3	Trial 4
# of voles at start				
# of owls at start				
# of voles captured				
# of owls that live				
# of owls that reproduce				

Red-backed Vole

Inquiry

1. What happened to the owl population when the vole population decreased?
2. Why might the population of the voles decrease even if the population of the owls decreased?
3. What might happen to both the owl and vole populations if a new animal population of exotic hawks joined the community?
4. Which animal is more likely to live based on your data, an owl or a vole?
5. Does this seem reasonable? Explain?

BIODIVERSITY | Lesson Plan: Decomposition & Resource Value

Length: variable periods throughout term | Grade: 9-12

Objectives

Students will be able to…

- Create a simple experiment on biological decomposition of forest and food plant materials using mini-composters.
- Observe the decomposition of these plant materials, including changes over time in color, smell, texture, shape and moisture.
- Make qualitative comparisons of decomposition of differing plant materials.
- Draw inferences about the reasons for different decomposition rates observed with different plant materials.

Overview

This simple lab activity involves making mini-composters from the containers typically used for yogurt and cottage cheese, adding soil and different kinds of forest plant materials, then observing the decomposition of the plant material by organisms coming in with the soil and plant materials. Different kinds of plant materials – such as pine needles, oak leaves, tree branches, moss, potato skins or orange peels – have differing resource qualities for decomposing organisms. The key variables affecting resource value are (a) the ratio carbon to nitrogen, with a low carbon:nitrogen ratio making a plant a more efficient source of nutrients, (b) the amount of lignin in the plant structure, since lignin is difficult to break down, and (c) the presence of polyphenols, like tannins, which are both difficult to break down and frequently toxic to other organisms. The process of decomposition and the differing resource qualities of various plant materials can be observed and studied in the mini-composters.

The effects of the differing resource values of plant materials can be observed by comparing Pine Barrens forests, agricultural and grassland fields, and non-Pine Barrens forests. Other things being equal, the relatively lower resource value of pine needles means that they are decomposed slowly, leading to a greater accumulation of dead plant material on the forest floor, when compared with the herbaceous cover of a grassland or the leaf litter of a deciduous forest. Greater accumulation of litter on the forest floor will in turn be one factor making a Pine Barrens forest highly prone to intense wildfires, a disturbance to which species like pitch pine and scrub oaks have adapted well. Accumulation of litter is also a factor that tends to create more acidic soil, another characteristic of Pine Barrens forests. Of course, other factors beyond resource value of the plant material affect decomposition rate and litter accumulation. Most importantly for the Pine Barrens, water-logged conditions in bogs and cedar swamps discourage decomposition and lead to massive accumulation of dead plant material through time.

Procedure

❍ Each student should have a large plastic yogurt-type container, with lid, that has been thoroughly cleaned. Punch holes (to prevent water-logging and anaerobiosis) in the bottom of the container and in the lid.

❍ Gather plant materials from the forest and the kitchen, such as pine needles, tree or shrub leaves, moss, lettuce leaves, potato skins and orange peels.

❍ Place plant materials in any desired combination in each pot. Students can create composters with just materials taken from the forest floor or with a combination of forest and food materials. As students add materials, they should record the amount of each different type of plant material they put in each composter.

❍ Add soil to the composter, in order to inoculate the composter with soil organisms.

- ❍ Beginning about two weeks after creating the mini-composters, students should observe their composters and record their observations about the decomposition process taking place with each different type of plant material, including changes in volume, color, smell, texture, liquidity, shape and observable organisms.
- ❍ Towards the end of the term, students will give a brief presentation to the class on their observations. Students can be teamed into small groups to write and deliver their presentations. All results can be collated on a large chart with a row for each kind of material and columns for factors such as rate of change of volume, color change and organisms observed, and inferred nutritional quality of each material.

Materials

- ❑ Large plastic yogurt-type containers, cleaned in a dishwasher, with lids.
- ❑ A variety of plant materials taken from nature and the kitchen.
- ❑ Soil taken from just about anywhere.
- ❑ Student Activity Sheet

New Jersey Core Curriculum Standards

5.1, 5.6, 5.7, 5.12

Glossary

Compost: A mixture of organic material, such as leaves, discarded food and manure, allowed to decompose. Compost is usually used as a natural fertilizer, because the decomposition process produces a mulch that is rich in simple, inorganic nutrients.
Decomposition: The breaking down of complex organic molecules in dead plant or animal tissues by decomposer organisms into simpler organic and inorganic molecules, Decomposers include bacteria, fungi, worms and other soil organisms.
Lignin: Complex organic molecules that give strength and stiffness to plant cell walls, provide protection from microorganisms, and bind cellulose in wood.
Polyphenols: Complex organic molecules found in varying degrees and varieties in plants. Polyphenols give color to many flowers. Some polyphenols are toxic to herbivores, providing protection to those plants which deploy this form of defense.
Tannin: A synonym of the modern scientific term polyphenol.

Student Activity

Inquiry

1. How does the nutritional quality of plant material affect the rate of decomposition? Why?
2. Are there observable changes in the organisms inside the composter over time?
3. What causes the smell and color changes they observe as decomposition progresses?
4. Do the different rates of decomposition observed for different plant materials tell us anything about the differences in how useful these materials may be as food for humans or other animals?

Decomposition Table

Day	Appearance	Smell	Organisms	Other observations

BIODIVERSITY | Serrotiny in the Pines

Length: 1-2 class periods | Grade: 9-12

Objectives

Students will be able to…

- Analyze and interpret data collected from heating pine cones from the Pine Barrens.
- Determine how the serrotiny of pine cones varies in different areas of the Pine Barrens.
- Make a conclusion that can be used to support the adaptive hypothesis pertaining to the Pygmy Pine forest.
- Explain how moderate levels of disturbance may enhance diversity.

Overview

Students will work together in collaborative groups to complete the lab. They will record the time it takes for four different sets of Pitch Pine cones to open in the presence of fire by placing the cones in the flame of a Bunsen burner. The four sets of pine cones have been taken from the Pygmy Pine Forest, and 5 miles from, 10 miles from, and 15 miles from the Pygmy Pine Forest respectively. The average time to open will be calculated and conclusions will be drawn about how the serrotiny of pine cones varies in different areas of the Pine Barrens.

Directions to Pygmy Pine Forest locations:

- Along Route 72 west of the intersection with Route 539 in Woodland Township, Burlington County, Barnegat Township, and Ocean County.
- Along Route 539 south of the village of Warren Grove in Stafford Township, Ocean County.
  In both cases, you will see you are driving through the Pygmy Pine Forest after the road rises to a high plain. If you pull off onto the shoulder, be very careful, as cars and trucks drive fast on both of these roads. You will see various sand roads leading off the highway, which can be used to pull out of traffic in order to collect cones and examine the forest.

Procedure

Part 1

❍ Take one pine cone from one of the locations and hold it by the base.

❍ Hold it over the flame produced by the Bunsen burner and begin to time.

❍ When pine cone opens, stop time and record time on data sheet.

❍ Repeat the first 3 steps with each of the pine cones collected. Complete three trials for each of the three locations.

❍ Determine average time required to open.

Part 2

❍ Read the article, "New Jersey: Ahead of Its Time in Fire Management" and answer the questions on the student activity sheet.

Materials

❑ Pitch pine cones taken from four different locations:
- ❑ Pygmy Pine Forest
- ❑ 5 miles from pygmy pine forest
- ❑ 10 miles from pygmy pine forest
- ❑ 15 miles from pygmy pine forest

❑ Bunsen Burner
❑ Tongs
❑ Stopwatch

New Jersey Core Curriculum Standards

5.1, 5.3, 5.5, 5.8, 5.10

Glossary

Serrotinous: In the Pine Barrens, referring to cones that open after exposure to fire.
Limiting Factor: Any essential resource that limits population growth.

Serrotiny in the Pines

Student Activity

Hypothesis

Make a prediction to answer the following question…

How will the three different types of pine cones react when they are heated by fire?
Consider the following…Time to open? Amount of heat required? Distance from pygmy pine forest?

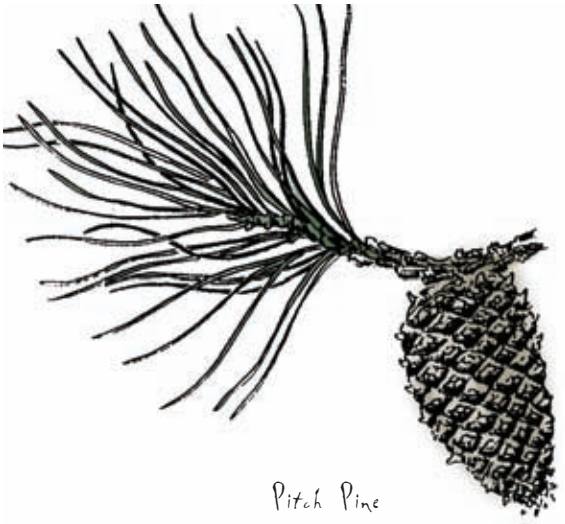
Inquiry

Part 1:

1. How did the average time to open compare among the pine cones taken from each location? Which took the longest? Which took the shortest?
2. How did your hypothesis compare with the results obtained?
3. Why did we get the results that we did? How does location from the pygmy pine forest affect the serrotiny?
4. Does this evidence support the adaptive hypothesis? If so, how? If not, why not?

Part 2:

1. When was the first time fire was was used to manage the state's ecology?
2. What are the predominant pines and current fire ecology attributed to?
3. What is the optimum burning interval to reduce fuel accumulation?
4. What are the specific purposes for prescribed burning?
5. Why do plant accumulations occur so rapidly in the Pine Barrens?
6. What are the five steps necessary to carry out a successful prescribed burning? Briefly describe each one.
7. When does prescribed burning occur?
8. What is a backing fire? When is this type of fire used?
9. How many acres are controlled burned in NJ each year?
10. How does controlled burning affect biodiversity?



Student Activity

Serrotiny Data Table

	Pygmy Pine Forest	5 mile distance	10 mile distance	15 mile distance
Trial 1				
Trial 2				
Trial 3				
Average				

By: Joseph R. Hughes, *a resident of Mercerville and periodic contributor to New Jersey Outdoors, retired from the State Forest Fire Service in 1996.*

Article from: New Jersey Outdoors, Spring 1997

After decades of trying to snuff out forest fires, agency heads, policy makers and even some of the more diehard wildland firefighters have come to the realization that a new approach is needed to halt a growing trend of increasingly large, more expensive and devastating wildfires that have ravaged our western forests for the last 10 years.

This series of conflagrations has burned millions of acres. Thousands of homes have been destroyed and many more have been threatened. Increasingly severe and possibly irreversible environmental damage has been caused to our western wild lands. And more firefighters have died or been injured during fire suppression operations.

In December 1995, the U.S. departments of Agriculture and Interior issued a report on federal wildland fire management. One of the document's key points is that wildland fire, as a critical natural process, must be reintroduced into the ecosystem on a controlled basis. A number of other points also were made, including a reaffirmation of the need for the protection of life, property and cultural resources from fire. However, the document represented a major change in the national fire policy and the way that federal agencies will look at and use fire in the future management of our natural parks and forests.

Leading the Way

New Jersey, which has had a highly successful prescribed burning program since the 1930s, is well in the forefront of these types of efforts.

The actual history of using fire to manage the state's ecology goes back to the Lenni-Lenape Indians. They burned the woods and grassland in the spring and fall and accidentally at other times. Fire was used to drive game, improve visibility and hunting success, facilitate travel, drive away insects and reptiles and increase the supply of grass seeds and berries. Native Americans were the first known people to use fire to shape and change their environment. The predominant pines and fire ecology of the New Jersey Pinelands have been attributed to this early bumming.

The use of fire as a management tool was lost for a time, but resurfaced in the 1920s and 1930s when cranberry and blueberry farmers used it to protect their lands. A pioneer in the use of managed fire was Alfred LeDuc. LeDuc was a landowner and firewarden with the State Forest Fire Service. He used fire to protect his land holdings and introduced the practice of annual wood bumming to others.

The preeminent individual in the early use of fire was Dr. Silas Little. Dr. Little was employed by the U.S. Forest Service and was chief research scientist at the Northeastern Experiment Station, located at New Lisbon in Lebanon State Forest. The station now bears his name in commemoration of his early work.

Dr. Little recognized the link between fire and pinelands ecology. He set up a series of experimental plots in 1936 at the station. A variety of fire "prescriptions" were applied at different annual intervals. Burning at a three-to five-year cycle was found to be the optimum level to reduce fuel accumulations, improve fire protection, control under story hardwoods and favor the predominant pine, which was more commercially valuable at the time.

The practice of prescribed burning was introduced to the public in 1948 and the state has conducted an ongoing program ever since. The program currently is under the administration of the State Forest Fire Service, Forestry Services, Division of Parks and Forestry.

Prescribed fire is: "Fire applied in a skillful manner, under exacting weather conditions, in a definite place, for a specific purpose, to achieve results.î The specific purposes for prescribed burning are:

- to reduce hazardous fuel accumulations;
- to prepare sites for seeding and planting;
- to improve wildlife habitat;
- to manage under story hardwoods;
- to control disease;
- to improve forage for grazing;
- to enhance appearance; and
- to improve access.

The state's air pollution code only permits prescribed burning to reduce hazardous fuel accumulations. The other objectives can be identified only as secondary benefits.

The soils of the Pinelands are acidic and have too little organic material to support earthworms and other species that normally would break down fallen leaves and pine needles. As a consequence, the plant materials accumulate to as much as a foot thick in some locales. This causes wildfires to start more easily, burn harder and be more difficult to control. Prescribed burning reduces fuel accumulations, making fires less likely to start and easier to control.

Five steps are necessary to carry out a successful prescribed burn: planning, preparation, prescription, execution and evaluation.

Burning by the Book

The planning phase in New Jersey begins during the summer. Burning maps are distributed to section forest firewardens. The wardens designate the areas or blocks to be burned. Selection is based on knowledge of the area, fuel buildup, years since the last burn, how the area fits into the overall forest protection plan and special considerations or land uses.

Burning plans are submitted for review to a technical management team made up of representatives from various natural resource disciplines. The review process has reduced conflicts and provided for better coordination of overall land management objectives.

The preparation of approved burning blocks is the second phase in the process. This consists of making sure the area is completely surrounded by roads or fire breaks. This ensures better control and reduces the risks of escaped fires.

Large blocks are further broken up into manageable size by laying out and plowing a series of north/south lines. The lines are spaced at 330' to 660' apart and aid in control and ignition. The latter distance is the average that fire can back against the wind in an 8- to 10-hour burning period. The blocks are plowed following the fall leaf drop and prior to the ground freezing.

Burning can commence as soon as the site is prepared, but normally is delayed until the completion of the firearm deer season (the first full week of December). Prescribed burning usually is conducted until March 15, the beginning of the spring forest fire season.

Late fall and winter are the times of the year when weather is the most suitable for carrying out successful prescribed burns. Weather is a critical factor, and specific weather criteria are followed to ensure success, reduce the chance of escaped fires and minimize air pollution and smoke emissions. There are very few days - only 10 to 15 days on average during most burning seasons - when all the weather conditions are suitable.

Weather forecasts are monitored daily. When a good day is forecast, plans are initiated. Manpower and logistical support are lined up by section firewardens in charge of burning specific areas within state forests.

On the day of the burn, crews are assembled and briefed and maps are distributed. Forecasts and weather conditions are checked and reviewed.

A small test fire is set to check burning conditions and smoke drift. The fuels must be dry enough to burn; wet fuels create poor burning conditions. A heavy frost may delay a burn until later in the day. Smoke drift must be adequate and away from highways and built-up areas.

A decision to proceed with a prescribed burn is based on successful test fire results. Authorities and residents are notified prior to a burn; this reduces complaints and false alarms.

The next phase in the process is to select a proper prescription, or method, for burning. The backfire method is used on all new burns, second burns and areas with heavy fuel accumulations. (Backing fire is setting fire *against* the wind.) Backing fires are 35 percent more efficient than head fires (setting fire *with* the wind) and produce less particulate matter and smoke.

After a prescription is selected, the burn is executed. The proper method of conducting a backing fire is to ignite a baseline (anchor point) such as a road, plow line, stream or other barrier on the down-side of the area to be burned. The fire is allowed to back into the wind a distance of 10 to 15 feet or more. Once the baseline is secure, the interior lines are ignited, starting on the downwind side of the first line and progressing from the easternmost line to the west across the block until all lines are lit.

A properly executed backing fire generally will have flames no higher than two to three feet. Smoke and heat wil1disperse downwind with little or no damage to the overhead tree canopy.

Once all lines are ignited, it is simply a matter of letting the fire eat back against the wind, devouring fuel as it goes. An initial attack engine is left to patrol the block and crews go on to ignite other blocks, repeating the process. A crew of five or six people can burn 1,000 acres on a good day.

An average of 10,000 to 15,000 acres are treated on state lands each year and an additional 3,000 to 5,000 are burned (at the owner's expense) on private lands.

BIODIVERSITY | Bears, Berries and Barrens

Length: Population Ecology Study: 1-2 periods | Grades: 9-12

Town Meeting: 3 periods | Grades: 6-12

Objectives

Students will be able to…

- Investigate the procedures used in studying population dynamics.
- Use graphing to calculate population density, number and dispersal.
- Establish the multiple opinions surrounding species management and reintroduction of predatory species by representing different interest groups at a mock town meeting.

Overview

Students calculate basic population parameters and explore the implications of these factors for black bears. By participating in a town meeting students explore the various opinions and perspectives regarding species re-introduction and management.

Procedure

❍ Students calculate population size, dispersal and density for sample population.

❍ Students discuss sampling methods and factors that affect population dynamics.

❍ Students review town meeting overview.

❍ Students are assigned to one of six special interest groups.

❍ Students prepare presentation based on group to which they are assigned.

❍ Students present and debate on the issue of bear re-introduction.

❍ Students vote on whether the re-introduction is to be fulfilled.

Materials

❏ Bears, Berries and Barrens handouts

❏ Graphing calculator.

New Jersey Core Curriculum Standards

5.1, 5.3, 5.5, 5.10

Glossary

Population Dynamics: All the qualities of a population.
Population Dispersal: The physical arrangement of a population in physical space.
Population Density: Number of individuals per unit area.
Species Re-introduction: The act of introducing a species to an area where it was formerly found.

BEARS, BERRIES & BARRENS

Student Activity

In preparation for the proposed re-introduction of black bears into the NJ Pinelands, DEP officials, in conjunction with the Pinelands Commission and NJ Audubon, have mounted a research project to evaluate the efficacy of the proposal. One of the main concerns focuses on the berry interests in the core of the Pinelands. Though carnivores by classification, black bears eat much more vegetation than meat, and these ursines have a penchant for blueberries and cranberries.

Four hundred miles northeast of the Pinelands on the coast of Maine is a similar wilderness with berry farms scattered throughout. Curious as to the #, density and dispersal of the bears in a similar habitat, researchers obtained the following data in the 1900 km^2 region. Each quadrat sampled was 20 km^2.

High Bush Blueberry

Bears, Berries & Barrens Data Table

Quadrat #	# Bears
1	7
2	1
3	2
4	0
5	9
6	1
7	0
8	1
9	3
10	11

- Calculate the average # km^2 needed by one bear (density).
- Determine the total population estimate for bears in the 1900 km^2 habitat.
- Calculate the dispersal pattern of the bears (this can be done by determining the variance/mean ratio. Use a graphing calculator to obtain these values. See directions and sample on the next page. A V/M ratio =1 translates to a random distribution. A V/M ratio < 1 translates to a uniform distribution and a V/M ratio > 1 indicates a clumped dispersal pattern.

Population Calculations

Number km^2/bear	
Population size	
Variance	
Mean	
Variance/mean ratio	
Dispersal pattern	

Inquiry

1.What considerations must scientists account for when determining population estimates?
2. Might the dispersal pattern of a bear (or any animal) change? Propose reasons as to why.
3. What information about the study sight referenced above would you like to have? Explain.

Sample Population Dispersal Calculation

Fence Lizards in the New Jersey Pinelands

Quadrat #	# Lizards
1	2
2	7
3	12
4	21
5	5
6	12
7	1
8	23
9	3
10	0

- On a graphing calculator, access the stat function and hit enter on edit–Data lists will appear. Under L1 or other list, enter values above. When all values are entered, hit 2nd function and list (in yellow). Scroll over to math and scroll down to variance, enter L1. Obtain this value. Repeat for mean and set variance to mean value to obtain ratio.

Population Calculations

VARIANCE	
MEAN	
VARIANCE/MEAN RATIO	
DISPERSAL PATTERN	

For sample above V/M ratio = 67.38/ 8.6 = 7.8. This indicates a clumped population dispersal.

Student Activity

Part 2: The Town Meeting

Sample Letter

Dear Friends,

You have been summoned to this meeting so that we can reach a resolution regarding the federal government proposal for black bear reintroduction in the NJ Pinelands. Historically the Pines supported populations of black bear, wolf, cougar and bobcat. Although bobcats still remain and coyotes have made their way here from the west, large predators are largely absent from the region. It is the historical presence of this ursine and the purported need for it's predatory habits that spurred the government to set into motion this plan. They firmly believe that adequate habitat is available and that the re-introduction will not negatively impact humans in any capacity. Six groups have expressed sincere interest in voicing their concerns and/or support for the project and they have gathered here today. After the initial discussion each group will be afforded a period of time to develop a presentation which will be made to the entire forum. In the end, a vote will decide whether or not the people of NJ will fight or embrace this most ambitious endeavor. We look forward to your comments and the lively discussion that will no doubt ensue.

Yours Truly,

Christopher Taulane
Species Reintroduction Coordinator, Northeast Region

Interest Groups

The Nature Conservancy: An organization dedicated to land acquisition, protection and management and ecosystem protection worldwide. They recently opened an office in the Pinelands.

Blueberry Co-op: A united group of farmers whose mainstay is blueberries. Thousands of acres in the Pines are farmed annually. This is their livelihood and the crop has done quite well in the past several decades.

Cumberland County Business Board: Cumberland County is among the poorest in NJ. The county business board is largely responsible for a recent upswing in the local economy based on good marketing, low interest business loans and the coordinated revitalization of Bridgeton and Millville.

Pinelands Protection: A not for profit organization that works to protect the NJ Pinelands and it's inhabitants from development, pollution and the introduction of non-native species. They have a team of lawyers, educators and scientists.

Residents of Berryville: Located in the heart of the Pines, this sleepy village is one of the oldest in the state. Established in the late 1600s, the original town folk lived with the predators and depended on the land for their livelihood. They boast of their peaceful way of life and embrace the tight knit community atmosphere and believe it is the ideal place to raise a family.

Earth Education Ecotours: A regional ecotour company that offers canoeing, hiking, biking and camping programs throughout the Pines. They have enjoyed great success in the last decade as nature observation and ecotourism interest has exploded.