project WEB
fall 2003
Connecting Projects WILD, WET and Learning Tree in New Hampshire

Geology: Still Shaping New Hampshire

As we bid farewell to the Old Man of the Mountain, it is a good time to reflect on the power of the earth, or of nature, as we're more apt to think of it. No matter the number of hours humans struggled to keep New Hampshire's state symbol at its lofty height above Profile Lake, or the number of turnbuckles that were installed, or the amount of epoxy applied, it's gone. There are times when the forces of nature make our struggles to "hold back the tide" seem like meager manipulations. No matter how many resources go into breakwaters and bank riprap on the coast, high storm seas will eventually win. Severe floods will breach the toughest dams, and avalanches, landslides and volcanoes will destroy whatever has been set in their paths.

It is times like these that our society, as modern and seemingly as removed from nature as it is, is forced to look closely at its connection with both the earth and science. According to Webster, geology is "a science that deals with the history of the earth and its life, especially as recorded in rocks." As we have witnessed, that history is still being written.

"The outdoors bursts with entertainment, refreshment and surprise."
– Enos Mills

The Geology of the Old Man of the Mountain

Some 1,200 feet above Profile Lake, in Franconia Notch State Park, the Old Man of the Mountain looked out over the valley below. This famous rock profile was formed from five horizontal ledges of rock, stacked one upon the other. From the top of the forehead to the bottom of his chin, he measured about forty-five feet and weighed approximately 7,200 tons. During the night of May 2-3, 2003, the Old Man of the Mountain tumbled from the cliffs of Cannon Mountain and was gone forever. To understand his demise, we first must look at how the rock profile was formed.

Formation of Conway Granite

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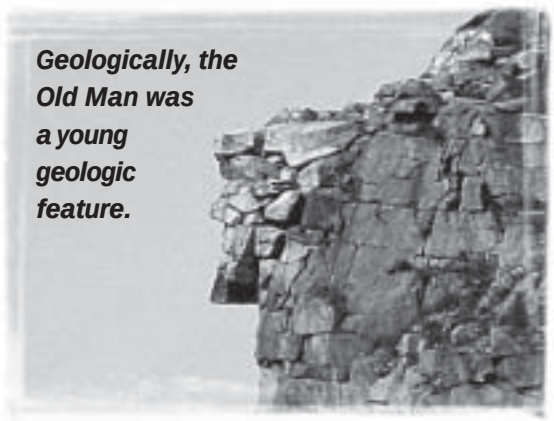
NH Geological Survey

Geologically, the Old Man was a new (young) geologic feature. It may have been as old as 12,000 years and as young as several thousand years. But the rock itself, Conway Granite, is very old and goes back to the Jurassic Period.



The Old Man of the Mountain before May 2-3, 2003. (Photo by Dennis Vienneau's eighth grade Earth Science Students, Moultonborough Academy, NH)

By the Jurassic Period, all the continents had collided to form a "super continent" that geologists call Pangaea. The Jurassic was also the time that the dinosaurs were a common life form on Earth...about 175 million years ago. The collision that formed Pangaea forced the crust into large mountains of folded and faulted rock–the Appalachian chain

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which includes our White Mountains. These mountains may have been as high as the current Himalayan range. But Pangaea was not to last. Convection currents (rising swirls of hot rock) within the lower crust were pulling Pangaea apart in a process known as "rifting." With this rifting process, large masses of molten rock called magma, deep within the crust, cooled, crystallized and hardened into intrusive igneous rock. Some of these igneous intrusions formed a coarse-grained pinkish colored granite, known as Conway Granite, that is found in several locations in New Hampshire and Maine. Obviously, lots of weathering and erosion occurred over the last 175 million years, removing thousands of feet of overlying rock. Today, what we see as the Conway Granite of Cannon Mountain are rocks that were once formed deep in the Earth's crust.

Glacial Action

About one million years ago, as the Earth's climate cooled (maybe as little as nine degrees Farenheit below the averages of today), snow began accumulating in three "ice centers" in North America: the Cordilleran (in the Rockies), the Keewatin (near Hudson Bay) and the Labrador (near the east coast of Canada). Each year, some of the winter's snows would melt at the ice centers, but some snow would persist through the cooler summers. As this snow piled up, the lower portions of the accumulated snow-pack would melt and refreeze under the pressure exerted by the upper snow. This melting and refreezing changed the lower snow accumulations to glacial ice. Snow accumulating at the Labrador Ice Center became the continental glacial ice that would advance over New England.

A great thickness of ice, under pressure of its own weight, flows like "silly putty." When the accumulated ice is thick enough to flow, it "oozes" out from these ice centers. As the edge of the spreading ice advances, soil and rocks become embedded in the moving ice. This continental ice sheet now had the tools it needed to act like a huge sheet of sandpaper moving over the land surface. The rocks and soil frozen into the ice scraped the now-exposed bedrock.

As the ice advanced over New Hampshire's White Mountains, this "sandpaper action" smoothed and rounded the bedrock summits. In some cases, the rocks that the ice carried left scratches known as glacial striae in the bedrock. These striae were generally parallel with the direction of the glacial flow. Most striae in New Hampshire bedrock are orientated NW to SE, the general direction of the ice flow. This left smoothed and polished bedrock surfaces that are still visible in some places today.

As the ice flowed through the Franconia area, it moved though existing stream valleys. Under normal conditions, streams flow in the bottom of their valley, removing material and causing the slopes above the stream bed to slide down into the stream, creating V-shaped valleys. However, glacial ice moving through these existing stream valleys scrapes the bottom AND sides of the valley. This abrasion process makes glacial valleys U-shaped. In New Hampshire, we call the U-shaped valleys left by the glacier's erosional processes notches. Besides

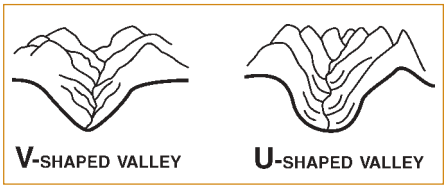

Fig.1: A comparison of V-shaped vs. U-shaped valleys. Sketch from http://wrgis.wr.usgs.gov/docs/parks/glacier/uvalley.html

Franconia Notch, there are Crawford, Pinkham, Jefferson and Dixville notches, plus several smaller U-shaped valleys.

The glacial ice that covered New Hampshire may have been up to one mile deep. Ice this deep would have covered all of the tops of the White Mountains as it flowed to the southeast. Where the forces of weathering haven't removed them entirely, glacial striae and polish can still be found on the bedrock of many New England mountains.

About 15,000 years ago, the glacial ice began melting away as the Earth's climate warmed up. The total time in which the ice was here (1 million to 10,000 years ago) is called the Pleistocene Epoch or Ice Age. During the Pleistocene, the ice may have advanced and melted back (retreated) across New England up to four times. The last advance went as far south as Cape Cod and the southern edge of Long Island, NY. The ice began retreating from there about 15,000 years ago and was gone from north central New Hampshire by about 12,000 years ago.

Some of the rock structure that made up the Old Man may have existed at the end of the Pleistocene...left by the plucking action of the glacial ice. As the ice flowed over the top of the mountain, melt water under the ice would freeze into rock fractures and the moving ice would rip or pluck pieces of the bedrock from the cliff face as the ice flowed forward. Glacial plucking left Cannon Mountain with its

Fig. 2. Classic roche moutonnee shape of Profile/Cannon Mountain – a gentle slope in the direction the ice came from and a steep slope on the down-ice side. (Photo by Eric Aldrich)

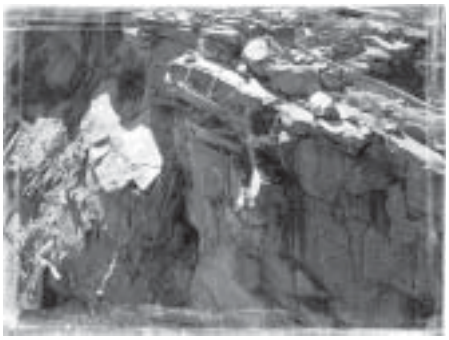

Fig. 3. All that remains of the Old Man after May 2-3, 2003. Note the three remaining steel rods that had been installed to hold the rocks of his forehead from sliding. (Photograph courtesy of George Bliss.)

characteristic roche moutonnee shape – a gentle slope in the direction that the ice came from and a steep slope/cliff on the down-ice side. *(See Fig. 2.)*

The Work of Weathering

Remember, the Old Man was made by weathering and erosion. The western side of the U-shaped valley that is Franconia Notch is tall and very steep – nearly vertical. Geologically, this is a very unstable slope. Thus, weathering and erosion are a very active process here. Weathering is the actual breaking down of the rock by mechanical and chemical processes. Mechanical weathering, the physical breakdown of the rock due to physical abrasion by water, ice, wind and plants, includes processes such as frost action, exfoliation and root pry. Chemical weathering occurs when water, combined with oxygen and carbon dioxide, forms chemicals that dissolve the minerals in the rock. The plentiful rain water and cloud droplets high on the Cannon cliffs help chemical weathering dissolve the feldspar minerals in the Conway Granite. With the feldspar minerals weakened, other minerals in the granite loosen and the rock crumbles apart.

Removal of these broken rock pieces and loosened minerals is called erosion. Geologists recognize four erosional agents: running water, glacial ice, wind and gravity. On the steep cliffs of Cannon Mountain, gravity is the chief erosional agent. Wind and running water from rains and snow melt, eroding weathered pieces. Glacial ice has NOT been a recent erosional agent, since the ice melted back from Franconia Notch 12,000 years ago.

After the glacial ice melted out of Franconia Notch, the freezing of water in the many fractures of Cannon Mountain caused the rocks of the cliff to break off through frost action. Similar to how freezing water produces "frost heaves" in our roads, freezing water in the fractures of the Conway Granite split the rock into smaller pieces. When the ice melts, broken bedrock pieces fall to the floor of the notch due to gravity. As accumulated fallen pieces pile up, a talus slope of broken bedrock forms against the lower face of the cliff. The large accumulation of talus at the base of the Cannon cliffs, where the Old Man was located, is evidence that the cliff has been undergoing lots of weathering.

The Conway Granite in the cliff area of the Old Man had a series of nearly equally spaced horizontal fractures that ran back into the face of the cliff top. *(See Fig. 3.)* The Old Man profile was a chance formation from the weathering of these five ledges of Conway Granite. Standing in just the right place (to the north of Profile Lake) on the floor of Franconia Notch and looking up toward the top of the Cannon cliffs, a very life-like profile of an "Old Man" could be seen. The first reported sighting of the Old Man was made in 1805 by two surveyors working in Franconia Notch.

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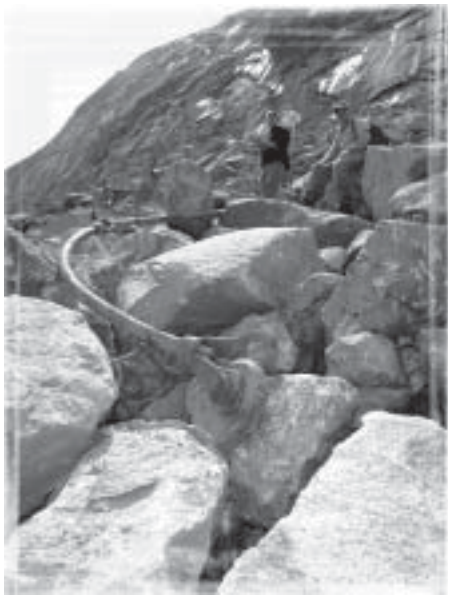

Fig. 4. New Hampshire Geological Survey (NHGS) staff using a Global Positioning System (GPS) Unit to plot the location of one of the steel rods from the Old Man found on the talus slope. (Photo from NH Geological Survey)

Geology Terms

Bedrock – the solid rock of the Earth's crust under the soil.

Chemical weathering – process by which rock is dissolved due to reactions between the rock surface and water that has combined with other substances, particularly carbon dioxide.

Erosion – removal of broken pieces of rock by running water, glacial ice, wind or gravity.

Exfoliation – mechanical weathering process where the expansion of the outside of the rock due to heating and cooling causes sheets to "peel" off the rock surface.

Frost action – mechanical weathering process where water freezing in the cracks of rock expands it by 10% and breaks the rock apart.

Glacial striae – scratches on bedrock caused by glacial abrasion. The direction of the scratches indicates the direction of glacial movement.

Igneous intrusion – bodies of igneous rock which form due to the crystallization of magma underground.

Mechanical weathering – process by which rock is broken down due to physical abrasion by water, ice, wind or plants.

Notch – U-shaped river valley created as a result of a glacier moving through a stream bed and scouring the sides of the valley.

Plucking – A process of glacial erosion by which blocks of rock are loosened, detached and borne away from bedrock by the freezing of water in fissures.

Rifting – tearing apart of a continental plate to form a depression in the Earth's crust which often separates the plate.

Rouche moutonnee – rock hills shaped by the passage of ice, which leaves a gentle abraded slope on the up-ice side and a steep, rough slope on the down-ice side.

Talus – a sloping mass of rock debris at the base of a cliff.

Root pry – mechanical weathering process where tree roots grow into the cracks in the rock, pushing the rock apart.

National Natural Landmarks in New Hampshire

Franconia Notch, long-time home of the Old Man of the Mountain, is listed on the National Registry of Natural Landmarks. The National Registry Program was established in 1962 to "identify and encourage the preservation of the full range of ecological and geological features that are nationally significant examples of the nation's natural heritage." It is currently administered by the U.S. Department of the Interior. Did you know that in addition to Franconia Notch, there are eight other national natural landmarks in New Hampshire and that most are either directly or indirectly related to the state's geology? Here's what we have in our own backyard.

Floating bog islands with the Presidential Range in background at Pondicherry National Fish and Wildlife Refuge. (Photo by David Govatski for ASNH)

All of the landmarks are in public ownership, with five of those included within the New Hampshire state park system. Franconia Notch, surely the best known of our natural landmarks and state parks, was selected because of its classic U-shaped valley formed by glacial scouring and its associated landslide scars, talus slopes and stream-cut gorges. A lesser known national natural landmark is Madison Boulder, the largest glacial erratic in North America. The huge boulder was carried to its present forested location in Madison by glacial ice some 11,000 years ago. It measures 83 feet long, 37 feet wide and 23 feet high. White Lake Pitch Pines in White Lake State Park in Tamworth, is a particularly fine example of a mature pitch pine forest type, one that is becoming increasingly rare in the northeast. The sandy soils left by glaciers between 10,000 and 14,000 years ago provide ideal conditions for the species. Heath Pond Bog near the Ossipee-Effingham town line is a classic example of bog succession from open water to sphagnum-heath-black spruce bog. Rhododendron State Park in Fitzwilliam is home to the largest and most viable stand of *Rhododendron maximum* known at the northern extension of its range

Students from Moultonborough Academy pose in front of the Madison Boulder.

Three national natural landmarks are located in the state's remote and wild north country. They provide diverse habitats for many plant and wildlife species. Pondicherry National Fish and Wildlife Refuge in Jefferson and Whitefield is a relatively stable bog-forest that supports an unusual variety of birds. It is jointly owned and managed by the N.H. Fish and Game Department, the Audubon Society of New Hampshire and the U.S. Fish and Wildlife Service.

Included within Umbagog National Wildlife Refuge, Floating Island in Errol is an ecological community illustrating characteristics of a bog, pond and river complex. East Inlet Natural Area northeast

of Second Connecticut Lake is a virgin spruce-fir forest and spruce-tamarack bog in one unit. It is jointly owned by the N.H. Fish and Game Department and the Nature Conservancy.

Spruce Hole Bog in Durham is a complete ecological community occupying a true kettle hole, the last of its type in the state. It is in municipal ownership.

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Rhododendron maximum blooms at Rhododendron State Park.

East Inlet offers access to unique natural areas, as well as many wildlife viewing opportunities. (Photo by Pamela Riel)

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The Old Man's Collapse

Weathering and erosion are relentless, and the same processes that created the Old Man are what took him away. Surveys done in the 1970s during the construction of I-93 through Franconia Notch showed that the five ledges making up the Old Man were "balanced" on a small point under the profile's "chin." Over the years, several metal bolts and steel rods had been placed into some of the loose rocks that made up the forehead to prevent them from sliding off the mountain. (You can see these five ledges and a couple of the steel rods in the cover photo).

It now appears that the rocks under the chin, at the center of gravity of the five ledges, gave away. Weathering had finally deteriorated the rock so much that it had lost strength and was unable to hold the massive weight of the five ledges above. Breakaway of the supporting rock under the chin caused the ledges to tumble forward and pitch headlong onto the talus slope below. The steel rods and bolts were no match for the great weight of the rocks making up the Old Man. The rods pulled from the falling rock – some remain sticking out from the top of the cliff *(See Fig.3)*, while others were found in a mass of broken rock pieces strewn down the talus slope below. *(See Fig.4.)*

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Activities Related to Articles in This Issue

Project WET suggests:

Old Water involves students constructing a timeline to illustrate and interpret the influence of water on the Earth's history. Be sure to include the formation of the Labrador ice center and glacier and the Old Man of the Mountain on your timeline!

By role-playing the structure of water as a solid, liquid and gas in *Molecules in Motion*, students can understand how the freezing of water can be a force of mechanical weathering.

In *Water Messages in Stone*, students replicate rock paintings and carvings to learn about ancient cultures' relation to water and to create their own water-related expressions.

Project WILD suggests:

In the WILD Aquatic activity, *Watersheds*, students measure the area of a small watershed and learn how watersheds change over time through natural processes.

Students work with state highway and vegetative maps in *Rainfall and the Forest* to determine relationships between rainfall, land formations, vegetation and animal habitats.

Referring to topographic maps in *Migration Barriers*, students draw murals and three-dimensional models of a land area and associated deer migration routes. They show consequences to the deer of the development of highways through the area.

Project Learning Tree suggests:

By studying sunlight, soil moisture, temperature, wind and the presence of plants and animals in *Field, Forest and Stream*, students begin to consider how nonliving factors affect the living elements in three different ecosystems.

People often wonder why certain plants grow in some places and not in others. In *Soil Stories*, students explore differences in soil types and what they mean to both plants and us.

In *Did You Notice?*, students study changes in their local environment during short and long periods of time and begin to identify patterns of change.

Chance for students to participate in a water use study!

Do you know how much water the average household uses in a day? Estimates range anywhere from 50 gallons per person to over 1,000 gallons per household, but no one knows for sure. A study is currently underway in the seacoast area that is trying to answer this question, along with several others concerning how much groundwater is available in the area.

Seacoast-area teachers and students are being invited to participate in this project. Participating classes will first receive a hands-on presentation about where their drinking water comes from. Each student will then be asked to complete (with the help of their parents) a home survey/audit of their home's water fixtures and use to be returned to the researchers. Age-appropriate follow-up activities will be provided to teachers so that students can compile, graph, and analyze their data. Once compiled, the seacoast-area data from all participating schools will be made available to those that participated.

For more information about the project, or to learn how your class can participate, please contact Nicole Clegg at (603) 271-4071 or nclegg@des.state.nh.us.

Silverberg honored by NEEEA

The New England Environmental Education Alliance (NEEEA) honored Judy Silverberg, PhD, of the New Hampshire Fish and Game Department, for her leadership and dedication to the field of environmental education by presenting her with its prestigious President's Award at its 37th annual conference, September 19, in Woodstock, Connecticut. Judy was cited for having exhibited leadership and innovation on state, regional and national levels during her 27 years in the field of environmental education.

Granite State Distance Learning: A good resource for educators

N.H. Fish and Game's Wild New Hampshire Series, broadcast through New Hampshire Public Television's (NHPTV) Granite State Distance Learning Network, is in the middle of its third season. Programs are scheduled the third Thursday of every month of the school year (except December and June), from 4:00 to 5:30 p.m., at locations in Bow, Lincoln, Greenfield, Durham and Gorham. Upcoming topics include white-tailed deer populations, information about natural resources available for educators, predator/prey relationships, the use of native plants to enhance backyard habitats, and migratory birds. Interested teachers and non-formal educators are welcome to attend any or all of the programs. Visit the NHPTV website, www.nhptv.org (click on Teach and Learn, Knowledge Network and Professional Development) for more information and to register.

New publications from Fish and Game

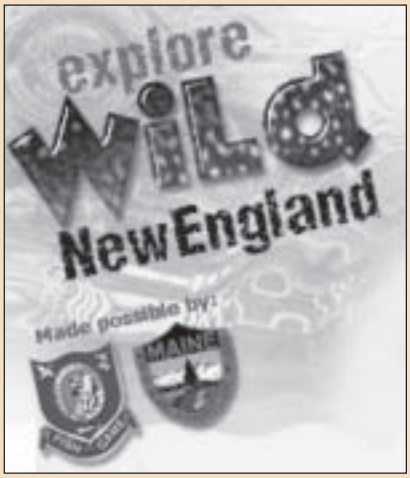
Fish and Game's new wildlife flyers and posters are here! The four-color, glossy publications are great for the classroom, depicting the state's wildlife in its appropriate habitat and including information about each species shown. Requests for the new, free publications may be made via email at info@wildlife.state.nh.us.

New ecology course for educators

A new graduate-level 4- credit course that will explore the concept of Earth as a System for teachers will be offered at UNH Durham starting in January 2004. Topics include ecosystems, habitats, biomes, biodiversity, weather, climate, water and air quality, watersheds, remote sensing, the flow of matter and energy through the universe, water and nutrient cycles, wildlife identification, wetlands, interdependence and more. The course will focus on content being taught through Project WILD, WET, Learning Tree and Project HOME activities. The GLOBE protocols are in integral part of all lab exercises. This will provide you an opportunity to learn science methods and content through the use of classroom friendly techniques that can then be used to integrate into units for your students. For more information, contact Jennifer Bourgeault at jen.bourgeault@unh.edu.

Explore Wild New England: new online magazine for kids

For students and educators in New Hampshire, the web is getting wilder! The New Hampshire Fish and Game Department and the Maine Department of Inland Fisheries and Wildlife have joined forces to produce *Explore Wild New England*, an online children's magazine at www.wildnewengland.org. Each issue covers two months of wildlife topics related to the seasons, along with interactive activities to educate and entertain. Kids can participate in wildlife surveys, track wildlife activity with a monthly calendar, and learn about actions they can take to benefit local wildlife. Each issue will feature a particular animal or group of animals found in New England and an ecological concept, from wildlife myths to winter adaptations and habitat. The magazine is designed with kids from grades 4-7 in mind, and is written in short sections with language and graphics geared toward that age group.



ON THE

H.O.M.E. FRONT

Plants, Bedrock and Soils: What Grows Where, and Why

BY MARILYN WYZGA

Plants don't stand on their own. They are a part of ecological systems – ecosystems – in which they establish, grow and reproduce. They are rooted in the soil from which they draw water and nutrients, and extend into the atmosphere that provides vital sunlight and gases.

Plants differ in their requirements for nutrients and moisture, and sites differ in their ability to supply these needs. Consequently, each species tends to be specific to one or more characteristic ecosystems. Using this knowledge, you can identify plant habitats by examining the topography and the soils that lie beneath the surface of your schoolyard.

The New Hampshire Landscape

Nearly 85% of our New Hampshire landscape is forested. Over human history, this landscape has been disturbed by fire, windthrow, agriculture and logging. Prior to that, the powerful forces of glaciers shaped the landscape. Further back in geologic time, the landscape was formed by bedrock, which gave rise to the first soils. All of these factors yield the forest types we see in the state today.

Our forests can be divided into six major regions: spruce-fir, found mostly in the White Mountains; northern hardwoods and northern hardwoods-spruce combinations in northern and central areas; transition hardwoods-white pine in the Connecticut River valley and southeast New Hampshire; central hardwoods-hemlock-white pine in the southeast and coastal areas; and pitch pine-oak in the Ossipee barrens.

The various forest regions in turn create different habitat types for wildlife. The distribution or mixing of vegetative types, size classes and other features largely determines the wildlife communities that occur in an area. More diversity in size classes and in the layering of different types of plants and growth forms (trees, vines, shrubs, herbs, mosses and lichens) yields more diversity in the wildlife species present.

Bedrock and Soil Form the Framework

Topography and substrate are the primary forces that determine plant community composition. Topographic slope exposes land to more or less sun, influencing its temperature and moisture. So a north-facing slope is cool and moist, and often growing with balsam fir and hemlock.

A much stronger impact is exerted by substrate – the mineral materials on which soil forms. The type and arrangement of plants mirrors the mixture of clay, silt, sand, glacial till and rock lying beneath them. These range from wet to dry, fine to coarse grained, neutral and nutrient-rich to acidic and nutrient-poor. Soils determine plant material by affecting the amount of water, nutrients and soil gases available.

Let's look at an example. The woodlands around the Concord Fish and Game headquarters are dominated by red oak, white pine and pitch pine, with gray and paper birch and white oak, a groundcover of wintergreen and low bush blueberry, and sweetfern in the sunny margins. Pitch pine is a good indicator of the warmest, driest topographic sites in central New England; it is also a remnant of pine barrens, which, when not burned, revert to pine/oak stands. Sweetfern is a strong eco-indicator of sand and gravel. Disturbed sand or gravel substrates often colonize with gray birch, paper birch and white pine. These factors combined suggest we are on very sandy soils in the former pine barrens of the Merrimack River Valley. A visit to a Natural Resources Conservation Service soils map confirms that this area is dominated by Hinkley/Windsor sandy soils types.

Glaciers Shaped the Soils

The pine barrens of the Concord area

Pine/oak forests along the high Merrimack River banks indicate sandy soils, likely deposited by a glacial lake. (Photo by Marilyn Wyzga)

likely resulted from glacial activity. About 10,000 to 15,000 years ago, the land of New Hampshire emerged from the glacial age. The melting ice revealed dramatic changes in the landscape. Mountains were rounded off. Chunks of bedrock were picked up and dragged for miles, then left behind as the large glacial boulders we call erratics. The glaciers scraped soil off bedrock and compressed other soils with their massive weight. They gathered and

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Recommended reading:

Reading the Forested Landscape, Tom Wessels, The Countryman Press, VT, 1997

Why Trees Grow Where They Do, by Bill Leak and Jane Riddle, on the USDA Forest Service website at **http://www.fs.fed.us/na/durham/coopforest/stewardship/text/whytrees.shtml**

New England Wildlife: Habitats and Distribution, Richard DeGraaf and Mariko Yamasaki, University Press of New England, Hanover, 2001

New Hampshire Geologic Survey – **www.des.state.nh.us/asp/Geology/links.asp**

NH Geology on the World Wide Web – **http://nhgs.org/NHGS/Nhgeol.html**

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dumped piles of sand and gravel, visible today as drumlins or moraines. These deposits, along with the melting ice, formed glacial lakes in which sediments gradually collected, forming new layers of soil. One of these lakes bordered the Concord Heights, and likely deposited the sands on which grew the pine barrens.

Wildlife common to the pine barrens include an array of moths and butterflies, specifically the endangered Karner Blue, our state butterfly, which feeds on the wild lupine that thrives in the pine barrens' sun and sand. This plant community also supports northern harriers, hognose snakes, Fowler's toads and nighthawks.

Plant Communities in Your Schoolyard

You can apply this study to your schoolyard habitat enhancement plans. As you take inventory of your school grounds, look at the types of plants growing there, especially in wooded areas. Explore the surrounding natural communities for the dominant, secondary and eco-indicator plant species. Use soils maps, geology maps, aerial photographs and other resources to help you determine what types of plant communities your site naturally supports and will support.

Pine barrens demonstration garden at Fish and Game headquarters features plants once common here, including wild lupine. (Photo by Marilyn Wyzga)

WEB Connections for this issue:

www.earthsciweek.org

www.neigc.org\NHGS\NHGEOL.html

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