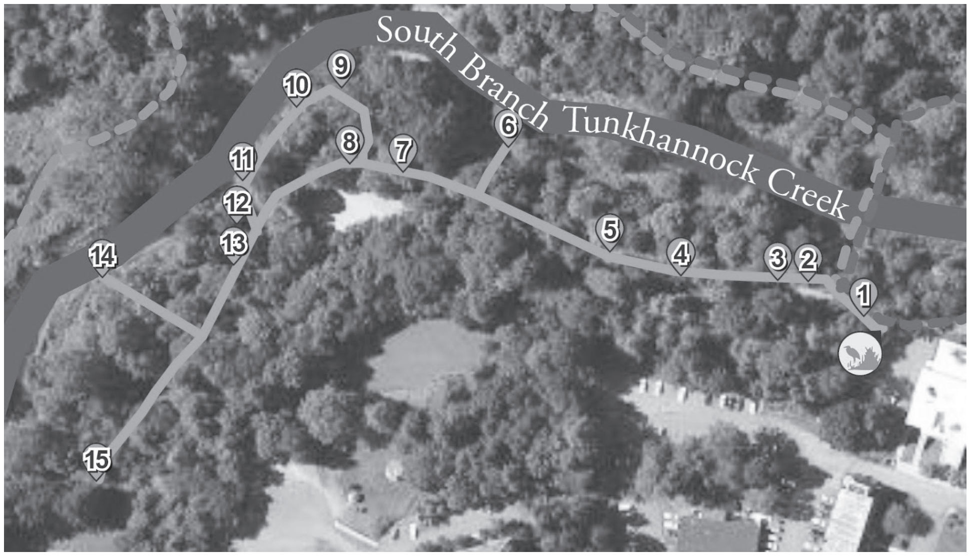
Water Discovery Trail

Interpretive Guide

Keystone College
La Plume, PA

Map of the Water Discovery Trail



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Station 1. All Hands On Deck

Welcome to the Water Discovery Interpretive Nature Trail at Keystone College!

Water Discovery Trail logo

You will begin your Discovery experience here on the deck of Lackawanna Hall. Throughout you will be guided by the Water Discovery Trail logo. This trail is approximately 1/2 mile long.

The theme of this trail guide is to dive into water in all its aspects, from the water cycle to the concept of the watershed. Why make such a big deal about water? It's pretty common stuff, isn't it? Yes, but with many *uncommon* properties. We use the words 'most, highest, and best' about water more often than for any other liquid. And all of these properties are a result of the **polar** nature of the molecule, more positive at one end while being more negative at the

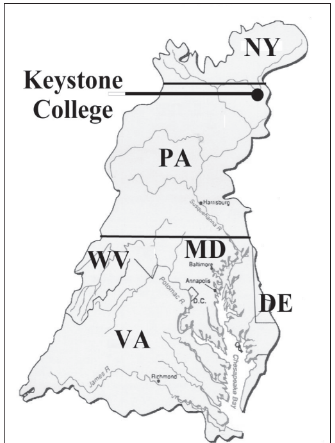
extensive shallow water habitat is ideal for the Bay's world famous harvest of oysters, soft-shell clams, and blue crabs. In recent decades, however, large areas of the bay's bottom have been without oxygen due to pollution. Thankfully, conditions are improving due to intensive programs throughout the watershed.

CONCLUSION…

We've tried to expose you to many aspects of water, and hope you have a better understanding of this most valuable of resources.

For more information about topics in this trail guide, and other Woodlands Resources visit the:

http://www.keystone.edu/woodlands



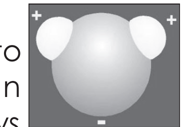
The Chesapeake Bay watershed drains 64,000 mi² of six states.

and coastal Oregon by temperate rain forest. What leads to these differences? Moisture! PA averages about 38 inches of precipitation per year, while Nebraska receives about 30, and coastal Oregon gets from 60-180+ inches. Trees require more moisture than grasslands, and rain forest requires even more.

We all live downstream from someone. Those who live upstream from us have profound effects on our water quality, health, and quality of life, as we do for those further downstream.

The ultimate 'downstream' for us is the Chesapeake Bay, the largest estuary in the US. Formed 12,000 years ago when the last ice sheet melted drowning the mouth of the ancestral Susquehanna River, it is fed by 19 principle rivers. The Susquehanna River makes the greatest freshwater contribution to this long (180 mi.) but shallow (20 foot average) body of water. The

other.



Water's polar nature makes it unique.

- Water is a wonderful **solvent**, able to dissolve more substances than anything else we know. It allows materials to be carried throughout ecosystems and organisms' bodies. Unfortunately, this is also why it is one of the most easily polluted substances: so many contaminants can be dissolved in it.
- It is the only natural substance which exists at the surface of the earth in all three states: solid, liquid, and gas.
- It is the only substance whose solid form floats atop its liquid form.
- It has very high **cohesion**, i.e., water molecules like to stick together. This causes water's very high **surface tension** allowing some insects to "walk on water." It is also essential to **transpiration**, a plant's ability to pull water from below ground to the top of a tall tree.
- Water also has important thermal properties. It takes a lot of energy to change the temperature of water or to change it from one state to another (for example, from water to steam). This makes water quite a

stable environment for living . . . it heats and cools slowly.

Our search for extraterrestrial life as we know it in the universe always begins with a search for water. Now we begin our investigation of the Water Planet.

Before we get started, take a look at the map of the Tunkhannock Creek Watershed that's on the deck of this building. Do you live in this watershed? If so, can you find your location?

Station 2. Classroom by the Stream

A shady spot, a gurgling brook . . . What could be a better outdoor classroom? This view of the stream allows us to sit and consider the source and destination of the water flowing by below us, and to consider the concept of the **watershed**.

A **watershed**, or drainage basin, is the land area which contributes water to a stream or lake. You can delineate one by connecting points of highest elevation around the body of water.

The Tunkhannock Creek watershed drains 413 square miles of 32 municipalities in northeastern Pennsylvania. Of that land, 60% is forested, 33%

With extensive community and volunteer support, this award-winning project has been a great success and has attracted professional restoration biologists eager to see mitigation techniques at work.

Station 17. On the Way to the Bay

Consider the interconnectedness of all parts of the watershed ecosystem you have been observing. The rocks help determine what the soils will be. The soils and climate determine what plants can live here. Plants, to large extent, determine which animals can live here.

Have you ever wondered what determines the dominant vegetation type in this area? Generally, it is precipitation and temperature, with the former being the more important.

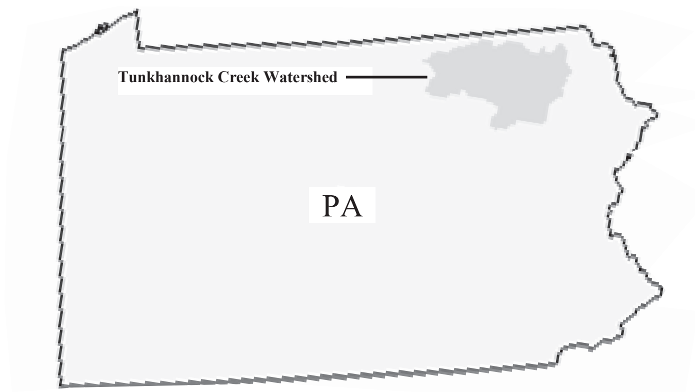
As an example, consider three states: Pennsylvania, Nebraska, and Oregon. At approximately the same latitude, they all have the same amount of sunlight available to them. Although they have nearly identical average temperatures, they differ widely in the type of dominant vegetation. Pennsylvania is dominated by forests, Nebraska by grassy prairie, help to reduce and catch erosion and runoff that was now going directly into the stream. Additionally, shade would cool and moderate the water temperature. The vegetation also provides wildlife habitat.

To restore the area and reestablish the riparian buffer zone would require stabilization of the streambank. A mixture of techniques was chosen. “Hard armor,” such as riprap (large rocks), was deployed along part of the bank. 'Soft armor' bioengineering techniques were also incorporated, including biologs constructed of plant materials to help hold the bank. Fabric mesh was laid on the graded banks to stabilize the bare soil. Water-loving vegetation such as willows were planted directly into the bank. Quickly developing root masses will provide integrity to the banks. Red-osier Dogwood and Arrowwood Viburnum are among the water tolerant plants that were integrated into the stabilization plans.

Downstream several large downed trees were buried in the streambank with their roots protruding into the channel. These **rootwads** deflect and slow the current, and provide fish cover.

agricultural, 5% urban/commercial, and 4% wetlands.

Let's trace the path of a drop of rainwater falling in the upper part of the watershed. After hitting the ground, it might **runoff** into a rill, feeding into ever larger channels. Or, it may **percolate** through the soil until it reaches the water table and becomes part of the



Location of the Tunkhannock Creek watershed

groundwater. It would enter the lake at Lackawanna State Park where it might stay for a while. The average residence time of a molecule of water in a lake is about seven years!

One day it would pass over the spillway and continue the journey downstream in the Tunkhannock Creek. It would then take less than a day to flow past you at this spot. A few miles more and it would join waters from the East Branch of the Tunkhannock Creek, together flowing into the Susquehanna River in Tunkhannock.

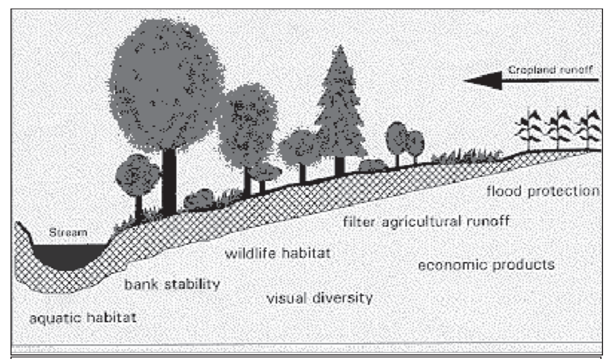
Now a part of the largest river in Pennsylvania (and the 16th largest in the US), the drop will flow through Wilkes-Barre, Sunbury, and Harrisburg crossing the Mason-Dixon line into Maryland. The Susquehanna ends at Havre de Grace, MD where it enters the Chesapeake Bay, delivering 90% of the freshwater flowing into the upper bay at a normal rate of 18 million gallons per minute!

It's easy to see why programs to clean up the Bay look upstream for solutions. Pennsylvania and New York State contribute significantly to the quality of the water flowing to the Bay. Homeowners fertilizing lawns, dairy farmers spreading manure on fields, and backyard mechanics draining oil from cars onto the ground all impact the quality of groundwater, drinking water, and the health of the Chesapeake Bay.

original Nokomis bridge behind the library. More unstable stream banks were poised to collapse into the stream. A grant from the Northeastern Pennsylvania Urban Forestry Program allowed the College to repair the damage and develop a model project for restoration techniques.

The **riparian zone** is that area between the stream bank and adjacent forest. This area had been historically degraded by removing much of the vegetation for farming and recreational purposes. In part, this set the stage for the flood damage.

Repair meant reestablishing a more natural riparian buffer zone. This vegetated area would



The benefits of an intact riparian buffer zone

benefit from the added soil and nutrients that often come with flooding. In many areas the richest agricultural soils are in river bottom areas. Are crops likely to be ruined? Only if flooding occurs during the growing season. Statistically, however, most floods occur during the winter (when frozen ground promotes quick runoff) and spring (the wettest time of the year). Crop damage is less likely and less severe at these times.

Why do we so often see severe damage from flooding? People love to live near water! Many early settlements were built near rivers because, in the absence of adequate roads, most goods and commerce traveled via rivers. A 1991 study found 17,000 US communities occupying floodplains, including 10 million households and $390 billion in property.

Northeastern Pennsylvania has faced flood situations many times in its past, most notably the 1972 Wyoming Valley disasters associated with Hurricane Agnes.

The flood of January 1996 caused extensive erosional damage in this area. Fast moving flood waters tore away tens of feet of stream bank, cutting into the athletic fields and tearing out the

It really makes you hope that your upstream neighbors are being as careful and considerate as you! **Please cross the suspension bridge. At the bottom, turn 180 degrees right to travel to the stream's edge.**

Station 3. Water Quality

Young and old can easily perform simple tests to measure water quality in your local stream.

How good is the water in this stream? What is in the water depends on what happens upstream. The types of rocks and soil, as well as land use in the watershed greatly effect the water.

Overall, water quality here is generally good. It is usually saturated with dissolved oxygen (**D.O.**) due to the bubbling of the water through the riffles. Cooler water can hold more oxygen, so the levels vary seasonally; however, oxygen is rarely a problem in an unpolluted stream. (Although water is made from hydrogen and oxygen, H_2O, this oxygen is tightly held and cannot be used for breathing. Only oxygen that is dissolved in the water as O_2 can be used for that.)

Temperature, too, varies seasonally. In winter it is barely above freezing, while in summer it may exceed 70°F. Though rarely too cold for stream life, it can easily get too hot.

These factors interact with each other. For example, the amount of oxygen present is dependent on temperature. In winter, with water temperatures hovering near freezing, the stream can hold more than 14 mg/L* of O_2. In summer, if stream temperatures reach 80°F, the maximum amount of oxygen the water can hold is about 8 mg/L. Cold water fish like trout would not only find the temperatures excessive, but would find the oxygen levels to be dangerously low.

pH, a measure of acidity, usually varies from about 6.5 to 8.5 in natural waters. Hand in hand with this is **alkalinity**, a measure of the ability of the water to maintain a constant pH. Stream life cannot tolerate extremes or rapid changes in pH.

drops the heavier particles it has been carrying. This leaves a higher bank along the stream's edge, known as a natural **levee**. So far there is little levee development along this young stream. As the water spreads farther from the channel and slows even more, it drops its sediment load, adding silt and sand to the soils present there. Excavating a soil pit in this area will reveal layer upon layer of silt, sand and other telltale signs of past flooding.

Flooding is a natural and expected aspect of the life of a stream. To think that we can stop it is naïve. With luck we may be able to exert limited control over it and minimize the damage. For this reason, many communities have zoning ordinances regarding building on flood plains.

Consider the land usage here. On one side of the stream are Keystone College's athletic fields. Minor flooding would have relatively minor consequences to this facility. Major flooding could deposit layers of mud and perhaps erode the stream bank, as occurred in the flood of January, 1996.

On the other side of the stream are former agricultural fields. Is agriculture an appropriate use for a floodplain? Farmers may actually

Its invasive nature comes with its ability to outcompete nearly everything else in a wetland, leaving what some have termed a "biological ghetto." And a single plant can produce more than a million tiny, airborne seeds.

Unfortunately, it lacks the wildlife value of the native species it replaces.

Station 10. Floodplain

Below is the confluence of Ackerly Creek and the South Branch of Tunkhannock Creek. Today they are probably flowing peacefully in their channels. At other times, so much water is moving past that they overflow their banks spilling out onto their **floodplains**, the flat areas alongside the stream.

Fast moving water has enough energy to carry a large amount of materials, known as the stream's **load**. Raging floodwaters can pick up small-to-large sized particles and carry them until they no longer have the energy.

When the stream water level rises, it will overflow its banks, spreading out into the adjacent fields. The water slows quickly and

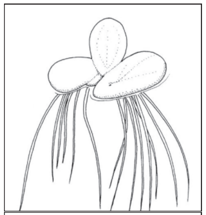
Depending on the rocks in the watershed, a stream may have a high alkalinity rating, and be well-buffered from pH changes. Generally, streams in limestone areas are well buffered, while those in granite or shale areas are not. We are in the latter category. Alkalinity here is usually less than 50 mg/L, a satisfactory level for a freestone stream.

Nutrients, such as **phosphorous** and **nitrogen**, play major roles in water quality, acting as fertilizers which stimulate plant growth, fueling the food chain. However, too much fertilizer can lead to algae and plant-choked streams or lakes. When the plants die, their decomposition can lead to oxygen deficits and fish deaths.

Station 4. Nose to Water

If you're willing to get your knees damp and dirty, you can get 'nose-to-water' with a wetland. By leaning over the side a little, you'll be immersed in the multi-sensory experience of the wetland.

Perhaps your sense of smell will be awakened first. Wet areas have a unique odor. Perhaps it is the aroma of wet mud . . . or the plants floating on top. Wetlands are more odiferous on days of low atmospheric pressure. When a high-pressure system predominates, there is enough air stacked up in the atmosphere to keep marsh gases pushed down in the mud. However, on low-pressure days, the gases more easily rise to the surface making their ways to our noses. The smelly gasses are mostly methane and sulfur-gases formed by bacteria living in the oxygen depleted bottom muds. They give swamps their characteristic 'rotten-egg' smell.



Giant Duckweed
Spirodela polyrhiza

You may have to part the duckweed canopy to look down into the water. Duckweeds, among the smallest flowering plants in the world, rarely flower and reproduce mainly by vegetative means.

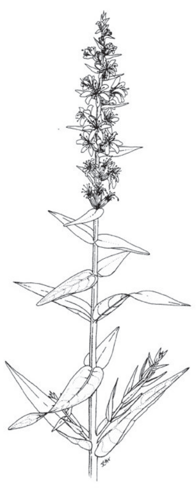
The water isn't easy to look through. It is probably clear, but stained brown by natural acids from the decomposition of plant materials.

If you're lucky, you'll be able to see leaves covering the mucky bottom. Could anything possibly be living here? Yes, indeed! Stare at a

when it grows to nine feet tall!

This is a highly invasive and prolific species. Many attempts have been made to eradicate it from this spot as well as along stretches of the stream bank. It's easy to chop back the above ground growth, but the underground stem, or rhizome, grows to five feet in length, making removal quite difficult. A systemic herbicide applied on emerging shoots in the spring is one recommended way to get rid of this plant. How successful have we been?

Yet another invasive species, Purple Loosestrife (*Lythrum salicaria*) is colonizing the streamsides and wetlands on campus. It, too, is an escaped cultivar. It produces beautiful purple flowers over an extended period of time. One author claims to feel compelled to "pull off the road just to stop and stare at the flaming beauty of a pond in early autumn when it seems one mass of purple."



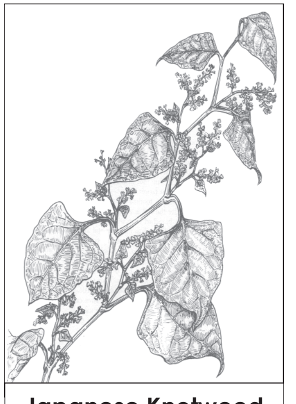
Purple Loosestrife

construct the outdoor amphitheater you just passed.

When large trees come down they leave a hole in the canopy through which light now streams to the forest floor. This increases soil temperatures and decreases soil moisture in the area. It also triggers a race among trees to take over this hole in the sky. Who will win? Look around. Are there smaller trees poised to take over for their fallen elder? Don't bother pulling up a chair... this race may take decades!

Station 9. Wetlands & Invaders

One of the plants growing in this area is Japanese Knotweed (Bamboo), (*Polygonum cuspidatum*). It is a garden species escaped from cultivation and now a common inhabitant of roadside ditches and stream banks in this area. Although not actually a bamboo, it does resemble its namesake

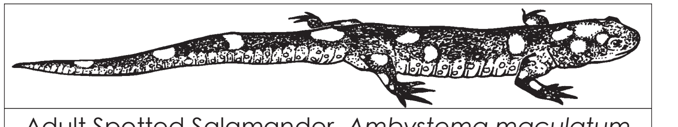


Japanese Knotweed

patch of bottom for a while. You may see a Red-spotted Newt (an aquatic salamander) or Spotted Salamander larva crawling along the bottom. Both are carnivorous, always in search of creatures smaller than themselves to eat. A profusion of microscopic organisms live here, too. Water fleas, copepods, and snails make their home in these waters.

A parade of frogs comes here to breed. Wood Frogs, quacking like ducks, may begin breeding before the ice has melted in the spring. They are soon joined by thumbnail-sized Spring Peepers, singing in deafening choruses. Pickerel, Green, Bullfrogs and Gray Tree Frogs each take their turn breeding here.

Northern Water Snakes live both here and in the stream. They're not poisonous, but they're also not nice! Occasionally a Snapping Turtle moves in to take advantage of the abundant tadpoles, so don't get your nose *too* close to the water!



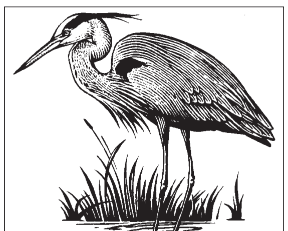
Adult Spotted Salamander, *Ambystoma maculatum*

Winter finds a greatly different scene. The slough freezes over solidly. Beneath inches of ice life continues, but at a much slower pace. Some animals hibernate, but others continue their way of life in the cold, dark waters. This area remains frozen much longer into the spring than others nearby. The shade of the overhanging hemlocks may keep this area frozen into April.

Station 5. What Makes This a Wetland?

A wetland can often be defined by the 'seat of your pants'. If you sit down and the seat of your pants gets wet, then it's a wetland! Also known by names such as **bog**, **swamp**, **fen**, **marsh**, and **vernal pool**, wetlands are sometimes difficult to recognize.

For regulatory purposes the Environmental Protection Agency (EPA) defines wetlands as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances *do*



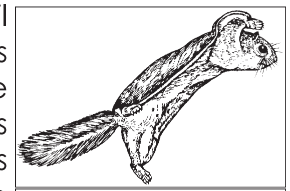
Great Blue Heron

much timber as possible. We can remove diseased or stunted trees to benefit the healthy ones.

But timber production is not the only function of a forest. Can we manage better than Nature for biodiversity, a wide variety of species of all types? Can we do better than Nature for the other ecosystem functions such as decomposition, nutrient recycling, water cycling, and oxygen production? That's doubtful.

Professional foresters prepared a stewardship plan for the entire backcampus with management recommendations. They began by evaluating the current status of the area.

Old growth hemlocks (most over 20" in diameter) make up 60% of the trees in the small patch between the stream and the campus. Unfortunately, they have shallow root systems because of the type of soil they rest upon. This makes them particularly susceptible to being blown over, as was evidenced by tornadic winds in 1998. Many trees were toppled and salvaged. Much of this timber was used to



Flying squirrels, inhabitants of mature timber, are common here

Station 8. Forest Stewardship

How would you evaluate the health, utility, and worth of this forested area? Would you recommend any management program? Should the trees be harvested? Managed for the benefit of wildlife? Just left alone to let Nature take its course?

Of course, timber has value. Building materials, paper, and countless other items are made from trees. Some people see a woodlot as an investment, even a crop, to be harvested. Others see it as a natural area that should be left so. Both are espousing a management plan. The former is apparent. The latter, non-interference, is also a conscious management plan. Each has its own goal.

Eastern Hemlocks dominate this small woodlot

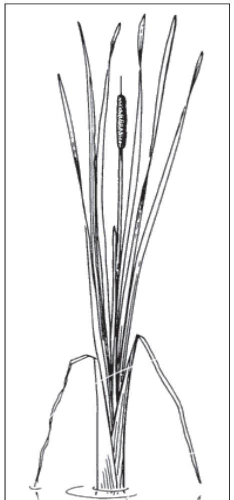
Can humans manage a forest better than Nature? That depends on what the goal is. If you wish to harvest the timber, humans can do a better job. We can ensure that an optimal density of trees is present to allow all of them to produce as

support, a prevalence of vegetation typically adapted for life in saturated soil conditions."

Wetlands delineators use three criteria to mark off wetlands areas: hydrology, soils, and vegetation. **Hydrology**, the most definitive criterion, is the hardest to use. It involves determining the waterflow in an area throughout the year. Rather than drilling expensive test wells, look for signs of flooding. Can you find high water marks on trees, flood debris suspended in branches, or trees with multiple or buttressed trunks?

Soil scientists look for the presence of **hydric** soils, those with a history of being waterlogged. By excavating a pit to reveal a cross-section of the soil profile, they look for evidence of gray, **gleyed** soils near the surface. The grayness indicates a long history of being without oxygen because of inundation by water.

The easiest criterion to document is the presence of **hydrophytes**, or water-loving vegetation. A field botanist looks for species that can live while constantly having their roots in oxygen-poor soils. They have special adaptations that allow them to survive conditions that would drown most other species. Examples at this site include ostrich ferns, sycamore trees, and sedges.



Cattail,
Typha latifolia

What value do wetlands have? For many years, people considered them to be stinky, snake-infested, mosquito havens with no redeeming value. Indeed, our government spent huge amounts of money to drain them in order to make the areas more "productive." Ironically, now we know that they are among the most biologically productive ecosystems on earth, rivaling tropical rain forests in the amount of plant and animal matter they produce.

Scientists have attempted to assign a monetary value to wetlands for services they provide to society. One study estimated their role in flood prevention, wildlife habitat, nutrient recycling, pollution reduction, water quality improvement, tourism, aesthetics, and natural products to be more than $36,500 per acre per year! This value was the highest for any ecosystem in the world, more than seven times

mobilized more easily by low pH. It is unlikely that this has caused any direct mortality of trees. More probable is that chronic acidity stresses plants making them more susceptible to insect pests and weather conditions that healthy trees would better be able to survive.

How does acid precipitation effect aquatic ecosystems? That depends on how well buffered the water is. In this area we have little buffering and our bodies of water are susceptible to acidification. We can look to the many streams in Northeastern PA that have been acidified by acid mine drainage to see what acid precipitation can do.

Because many biological processes take place at a specific pH, changing the pH can have significant effects. Organisms may die directly because of the increased acidity. Others may succumb to high levels of aluminum or mercury. Clams and snails in acidified waters are unable to deposit calcium in their shells making them soft and susceptible to injury and predators.

for nearly a century. Pennsylvania is in the position of being both producer and recipient of acid precipitation.

Acid precipitation is defined in terms of the pH scale, a measure of acidity, ranging from 0 to 14. Values less than 7, defined as neutrality, are acidic; those greater than 7 are basic. The scale is logarithmic, so the difference between any two integers is a factor of 10. For example, the difference between a pH of 5 and 7 is not two, or even twenty, but 10 x 10 = 100!

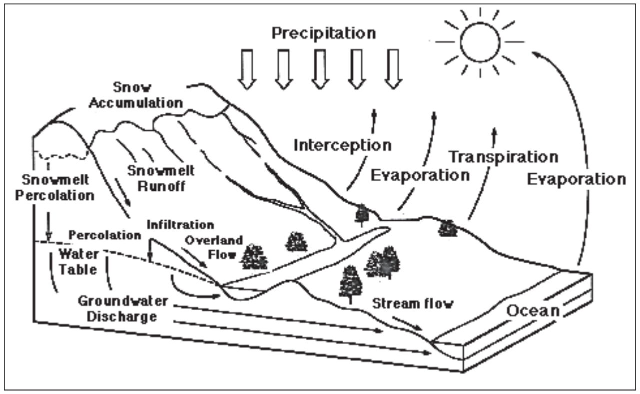
Unpolluted rainfall has a pH of 5.6. Hence, it is slightly acidic due to natural acids formed when it combines with carbon dioxide in the atmosphere. By definition, acid precipitation has a pH less than 5.6. Our local rain averages about pH = 4.3, but some episodes more acidic than this have been recorded.

How does acid precipitation effect forest ecosystems? Much has been written on this topic. Here are some general conclusions. In forested areas, acid rain may leach nutrients from the leaves of plants. It can also wash more nutrients from the soil. Changing the pH of the soil can alter the chemistry there. Some common soil substances, e.g., toxic aluminum, can be

the value of tropical rain forest!

Station 6. Forest Hydrology

What happens to rain falling on a forest? Of course, the leaves and needles of the plants intercept the falling drops, allowing them to hit the ground more gently. On the way, the moisture may deliver nutrients and pollutants washed from the atmosphere. The water may also leach nutrients from the plants and soil and



The hydrological cycle

deliver them to the ground water and streams.

An excellent way to study the role of a forest in a watershed would be to simply remove the forest and measure the effects. Such a study has been carried out in the Hubbard Brook Forest in New Hampshire.

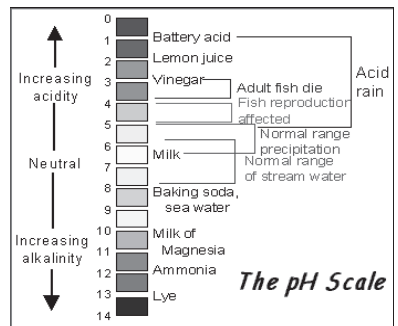
For five years an intensive study of processes in an intact forest was conducted. Researchers found that although precipitation varied over the years, the amount of water evaporated from the trees stayed constant. They also found that soil erosion from the intact forest was negligible.

They then clearcut the entire watershed, leaving adjacent ones intact for comparison purposes. Changes were immediate and significant. Water runoff increased 30%. This led to greatly increased loss of nutrients in the runoff. Nitrate, an important plant fertilizer, was lost 40x faster than in the intact forest. This led to an acidification of the soil, which further depleted other plant nutrients. Soil erosion increased greatly after two years as root systems which had been holding the soil decayed.

Regeneration of the forest was rapid and temperatures and nutrient levels began to approach normal, although different species

were taking over. The study continues today as longterm recovery is monitored.

This study offers us more than curious facts. It helps to explain conditions in a watershed as land use changes from native forests to urban and suburban uses. Forests can act as huge sponges to absorb precipitation and later release it at a slower rate. This makes the moisture more available to plants and decreases flooding. If the same land area is used for housing, buildings, roads, and parking lots, very little water can percolate into the soil, and it runs off into streams. A much greater volume of water moves in a shorter time. This is the recipe for increased flood potential.



Courtesy of Environment Canada (http://www.ns.ec.gc.ca

Station 7. Acid Deposition

Acid precipitation has been recognized as an environmental problem for several decades. The pollutants causing acid rain have been with us