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Colchester Public Schools Water and Forest Health Report

Colchester Public Schools (Bacon Academy Highschool, William J. Johnston Middle School, Jack Jackter Intermediate School and Colchester Intermediate School) all lie in the Salmon river/ Connecticut River Watershed. The two main streams that flow on the properties are Sherman Brook and Judd Brook, which both are surrounded by forested land. The overall quality of the water is impacted by the health of the surrounding land.

Forest Health:

When looking at forest health, there are many indicators used to determine how healthy a forest is. These include the following:

- Crown Condition
- Tree Damage
- Tree mortality and Standing Dead Trees
- Lichen Communities
- Down Woody Materials
- Vegetation Profile
- Soil Quality
- Non-Native Invasive Plants
- Regeneration and Browse Impact
- Fragmentation and Landscape Context

For the purpose of this assessment, only soil quality was used to determine the health of the forested land around Sherman and Judd brooks, however it is still important to understand how Lichen communities and Non- Native Invasive species play a role in forest health.
Four tests were run on each soil sample taken next to the water sources:

- pH
- Nitrates
- Phosphates
- Potassium

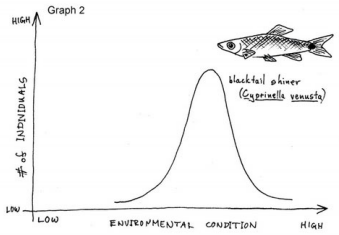
pH

Most organisms are able to live in a neutral pH (close to 7.0). If soil has a pH that is too high or low, the soil becomes toxic and inhabitable for many plants, bugs, and bacteria, which are all vital components of a forest ecosystem. Causes of soil acidification might come from acid rain, decay of organic matter, and nitrification of ammonium. According to Oklahoma State University, “When the soil pH is above about 5.5, the aluminum in soils remains in a solid combination with other elements and is not harmful to plants. As the pH drops below 5.5, aluminum containing materials began to dissolve.” In high amounts, aluminium will become toxic to plants, causing shorter roots, and is connected to nutrient deficiencies. Other metals like

magnesium can create similar problems. This pH of soil is an integral part of forest and water health for a variety of reasons.

Riparian buffer zones, or strips of vegetation between land and water act as filters for runoff. The vegetation will absorb excess nutrients like nitrogen and phosphorus, and prevent from erosion, however, if the soil becomes acidic these buffer zones will die off, thus, the water source loses its filter. All of the chemicals that would be absorbed by the vegetation then goes into the water directly, which will damage the ecosystem and can take much longer to fix than it did to create the problem.

If the soil is too low or high in pH many of the living organisms life earthworms, bacteria, bugs, insects, and plants will start to die off. As previously mentioned, all living beings tend to live better in a neutral pH. This is because of each individual's tolerance range, which is a scale of the most extreme conditions something can survive within. Living organisms like decomposers, or bacteria all help provide nutrients to the soil, which keeps plants healthy.



Nitrates

Nitrogen is a vital nutrient for plant health, as it is a major component in chlorophyll, and amino acids in both plants and animals alike. 40ppm of nitrogen is a healthy level for most soils to have. Nitrogen levels that lay too far outside of this 40 ppm, whether it be too little or too much, will cause environmental problems.

Oftentimes, nitrates will become introduced into soils through runoff that has once passed through farms, and even suburban areas which use fertilizers on their lawns. The nitrogen cycle is another source of nitrates for soils.

When the soil has high levels of nitrogen will make plants lush and green- as it is a key ingredient in chlorophyll, the green pigment in the chloroplasts, however there is only so much nitrogen a plant can use. University of Minnesota Extension states, “Nitrate-N is a negatively charged ion and isn’t attracted to soil particles or soil organic matter like NH4+-N. Nitrate-N is water-soluble…” Because it is water soluble, it will easily end up in runoff, and into bodys of water, and from there, lead to problems like eutrophication.

Too little nitrogen is another issue, and leaves many plants without that key component for chlorophyll and amino acids. A lack of nitrogen fixing bacteria might be to blame, or the soil type can cause low levels of nitrogen as well. Since nitrates are water soluble, in certain soils that drain easily, like ones with high sand content, those key nutrients get washed away after a rainstorm. In terms of how soil quality is connected to water quality, soils with too low of nitrogen levels cannot sustain large amounts of vegetation, which act as filters for water ways, limiting the amount of pollutants that might end up in a stream, river, lake, ect.

In the winter, nitrates are expected to be lower, as the nitrogen fixing bacteria are less active. There are also less lightning storms, which are a component to the nitrogen cycle, and turns the atmospheric nitrogen into nitrates (NO).

Phosphates

Phosphates pose a similar problem and function as nitrates. Phosphorus is a vital component in ATP, main source of energy in cells, and is a prime part in many other processes. “Phosphorus (P) is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next.” (inpni.net) A healthy range of phosphorus to have in soils is 30ppm-50ppm.

The issues with too much phosphorus are very similar to those with nitrogen, however, a build up of phosphorus in the soil can lead to limiting a plants ability to take in needed macro nutrients like iron and zinc. These plants then are unable to survive without those nutrients.

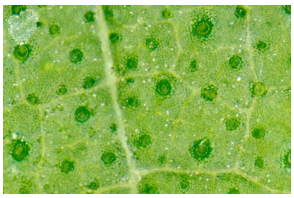
With too little phosphorus in the soil (less than 30 ppm) plants are not supplied with enough of this vital nutrient, needed in so many of its functions. These plants in the riparian buffer zone die off, and the water source loses its filter.

Lower levels of phosphorus are to be expected for the winter months, as there is little decomposition of organic matter happening, so less phosphorus is being reintroduced into the soil. This is okay however, as plants are photosynthesizing less with the sunlight being much less direct and more limited than in the summer or spring, thus, they are growing less, and don’t require as much phosphates.

Potassium

Potassium is used in many of the functions a plant does to maintain homeostasis. “Potassium also helps regulate the opening and closing of the stomata, which regulates the exchange of water vapor, oxygen and carbon dioxide.” (University of Minnesota)

Too much potassium in the soils can lead to limited uptake of nutrients like nitrogen and phosphorus, which as explained above, leads to issues in plant growth. If the excess nitrogen and phosphorus is absorbed by the plants, it will runoff into nearby waterways and streams, which can lead to eutrophication.



Too little potassium impacts plant growth, as the stomata won’t function as efficiently. Without this key role, the plant is limited on how the water vapor, carbon dioxide, or oxygen moves in and out of the leaf, thus stunting its growth. Without a strong vegetation cover, the soil is prone to degradation and erosion, further lowering its quality.

Lichen Communities

Lichens are very unique organisms, and are the earliest indicator of disrupted forest health. These are a complicated life form, created by the mutual relationship between an algae and a fungi. Unlike most plants, lichens don’t have roots, which is why they are often seen on rocks, or on the trunk of a tree. They gain their nutrients from the air, which is why they are particularly sensitive to air pollution.

Because they are so sensitive to changes in the environment, specifically the air, they are used as one of the first indicators of forest health, and can show warning signs early enough for proactive measures to be put in place.

Non-Native invasive species

Non- Native Invasive species often outcompete native species for resources, like water, nutrients, or sunlight. These species, like trees, or bacteria, or even animals like wolves all have devastating impacts on the food chain, and habitat of the ecosystem it was introduced to.

Trees like the Tree of Heaven are a prime example of invasive species found in New England. These trees, originally from China, grow fast, and have connected root structures. They outcompete many native species for sunlight, which impacts the photosynthesis process.

Invasive animals also outcompete each other for resources, and throw off the food food web. When a new organism is introduced to an area where it has no natural predators, it will often use up the resources that other organisms need to survive. It disrupts how much food is available for the entire food web.

Results

Each sample from the School properties were tested for the above factors (pH, Nitrates, Phosphates, Potassium). The results are shown in the table below.

Soil quality test results for Bacon Academy, William J. Johnston/ Colchester Elementary, and Jack Jackter

Soil Quality	Nitrates	Phosphates	Potassium	pH
BAHS	Low	Low	Medium	6.42
WJJMS/ CES*	Low	Low	Medium/High	6.65
JJIS	Low	Low	Medium	7.07

*Both WJJMS and CES are on the same campus, with the water source laying in between both schools.

Table #1

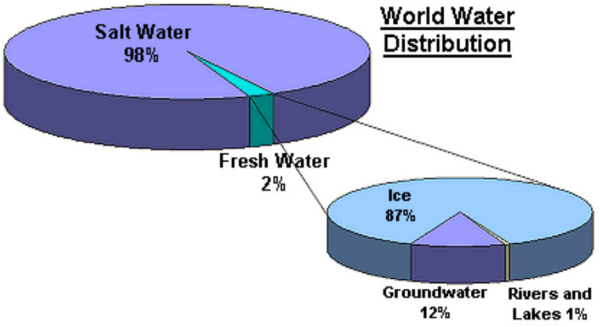
Based on the data shown in Table #1, there is little concern to be had over the health of the soil quality taken from Bacon Academy Highschool, William J. Johnston Middleschool/ Colchester Elementary School, or Jack Jackter Intermediate School. The pH of all the tests are all within a healthy range (6.42-7.07), and low nitrogen and phosphorus levels are to be expected for mid winter. Potassium levels are close to running on the higher side, however, because the soils all were composed of higher clay contents than sand, these levels are also normal. Since soil is the base of all life, measuring soil quality is a top indicator of how healthy a forest might be.

For the rest of the factors (Lichen communities, and non-native invasive species), I noticed nothing out of the ordinary, however, because the the time of year these observations were taken, these qualitative observations may not be as accurate, and that should be taken into consideration when assessing the forest health. There were plenty of lichens, growing on trees, and rocks, none of which looked as though they had been suffering from the impacts of air pollution. It was significantly harder to identify tree species during the winter months, as many of the deciduous trees lost their leaves, which are used for identification.

One factor that is not necessarily specific to a forest, and can be an issue anywhere was human litter. At the location where the soil and water samples were collected at WJJMS/ CES, I noticed plenty of litter, like chip bags, aluminum cans, and plastics. These could introduce harmful chemicals to the ecosystem if left alone long enough, or they could end up in the waterways, and the ocean, where fish and other aquatic life can eat it, and get sick.

Water Quality

Water is the essential component of most life forms. Very few organisms can survive with limited water access. Humans are composed of 70% water, and need it to maintain homeostasis, as do many other organisms. As it is a key component of photosynthesis, plants use it to survive as well. With just 3% of all water on earth being fresh, it is vital that humans take the necessary actions to preserve that. Water contamination kills 485,000 a year according to the WHO.



For the samples I collected, I did five different tests.

- Dissolved oxygen
- Nitrates
- Phosphates
- Turbidity
- pH

Dissolved oxygen

Dissolved oxygen measures the amount of oxygen in the water. The units used are PPM (parts per million). Aquatic organisms need this oxygen for cellular respiration, which keeps them alive. Healthy levels of oxygen in water should be around 8.0 ppm, however it is expected to see differences in these levels throughout the day

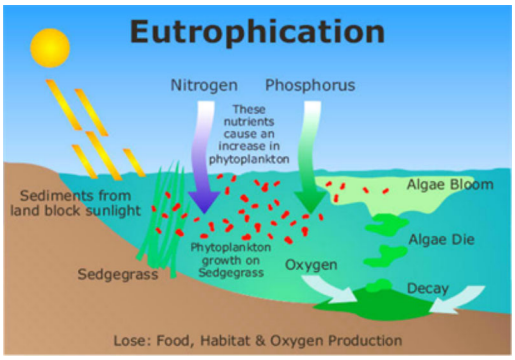
When the DO is too low, around 3.0 ppm, the conditions become hypoxic. With such low levels of oxygen available, organisms begin to suffocate, and eventually die. These levels often correspond with eutrophication. Another contributing factor to lower DO levels would be the water temperature. As water warms up, its ability to hold DO drops, lowering the levels. These fluctuations are normal, as the water on the earth heats up from the sunlight every day. If a significant increase in temperature, caused by thermal pollution occurs, DO levels are expected to drop, and can become hypoxic.

If the dissolved oxygen levels are higher, it is most likely caused by colder temperatures. It is very rare to have a situation where DO levels are dangerously high, and one of the few scenarios that it might occur would be the Hoover dam (120% saturation)

Nitrates and Phosphates

As mentioned in the forest health section, high levels of Nitrates and phosphates in water can lead to a process called eutrophication.

Eutrophication is a chain reaction that can devastate the aquatic ecosystem. Algae feed off of the excess fertilizers, and bloom on the surface of the water. These blooms block out the sunlight required for aquatic plants to carry out photosynthesis, causing them to die. Decomposers in the bottom sediments then break down the new organic matter, and through cellular respiration, use oxygen and emit carbon dioxide. This greatly drops the oxygen levels to low or even hypoxic situations. Organisms like fish cannot survive in these conditions and die off, disrupting the food chain.



Turbidity

Turbidity measures the relative clarity of a liquid. It is important to note that turbidity is measured in NTU(nephelometric turbidity units), and, according to Fondriest Environmental Learning Services, "...clear water is not always healthy, and likewise turbid water does not necessarily indicate an issue." Keeping the context of the sediment profile, and where you took the sample in the stream will help you better understand the results.

pH

pH, as explained in the Forest Health section above, is the measure of how basic or acidic something is. Having a water habitat that is close to neutral keeps all the aquatic organisms living in the water healthy.

A lower pH can come from heavy rainfall in an area that experiences acid rain, and the type of soil in and around the water source. Soils that drain easily, and contain higher levels of magnesium or potassium will often make water more acidic. While for the most part, it is safe to drink from water that is a little bit acidic, or basic, some plants and animals cannot survive in extreme environments because of their tolerance range (see figure #1)

Results

Water quality test results for Bacon Academy, William J. Johnston/ Colchester Elementary, and Jack Jackter

Water Quality	DO (ppm)	Nitrates (ppm)	Turbidity (NTU)	pH	Phosphates (ppm)	WQI
BAHS	8.42 ppm	.2	17.2	7.19	<1	42.9 (Fair)
WJJMS / CES	8.22 ppm	.2	16.6	6.08	<1	39.1 (Fair)
JJIS	8.18 ppm	.2	48.8	6.60	<1	41.3 (Fair)

Based on the results of these tests, along with the figures given by the WQI (water quality index), the water quality for each point along the stream is “Fair”. While it is not excellent, there is little cause for concern for the stream's health. The water quality index takes into account many factors, including Dissolved Oxygen, Nitrates, Phosphates, and pH, among others. WJJMS/ CES had the lowest pH out of all the groups at 6.08, however, the overall number given by the WQI was not much lower than the others. JJIS did have a significantly higher turbidity, however, as previously stated, a high turbidity does not necessarily mean a lower water quality. When taking the sample, the water did have a decent amount of suspended solids, however, the rest of the test results helped solidify the WQI’s results of the water being of fair quality.

Conclusion

Because both the soil, and water health tests resulted in little concern, along with the qualitative assessment done on the other forest health factors such as lichen communities, tree damage, and non-native invasive species, a conclusion to the question of how forest health impacts water quality can be drawn. If the forest is healthy, then the water quality is going to be better. With high quality soils, which are able to sustain plants, the risk of pollutants like excess nitrogen flowing into the stream is reduced. These plants are able to absorb those nutrients, which without them, would flow into the river, and create issues like eutrophication.

If the citizens of colchester would like to see the water quality increase, there are a few measures they could take. Replanting the riparian buffer zones, in areas where they might be thinned out, reducing the amount of fertilizers used, especially in the days leading up to heavy rainfall, and keeping the area free of litter, which can breakdown and release harmful chemicals into the environment.

It is important to note that this is not the only watershed, or forested land in the world, however, the same information holds true for each. It is possible that we can contaminate the salmon river watershed enough to the point where it is too polluted or contaminated to fish, swim, or collect drinking water from, and in order to avoid this, citizens must be aware of their impact, and how to keep our watersheds and forests healthy.

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