Level 3: Stream Chemistry - Wappinger Creek 1985-2016

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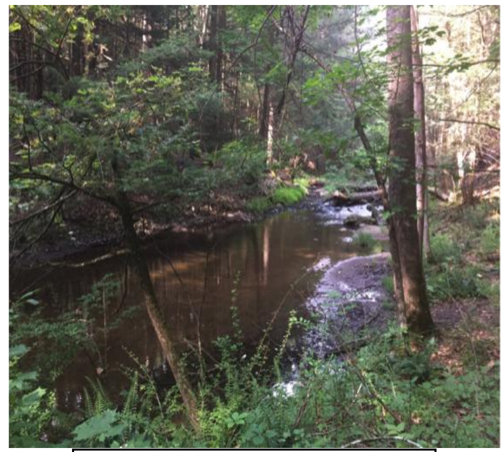
- **Background Information:** Rivers and streams can tell a story about what happens on the land surrounding them. As the land changes, those changes are reflected in the chemistry of the water. A region that drains into a body of water is known as a watershed. Watersheds can move water, waste, and nutrients into a river or stream. This means that streams are an influential indicator of the local environment's overall health. Looking at a river's water chemistry can indicate the health of the stream as well as the surrounding land. This is extremely valuable when researching human impact on certain ecosystems.

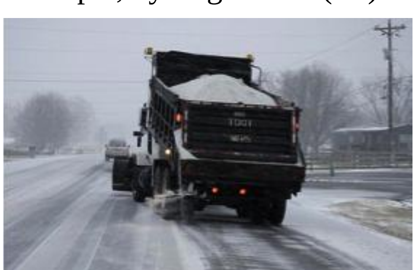


Wappinger Creek in August

Vicky Kelly is the principal scientist involved in stream monitoring at the Cary Institute. She manages Cary's Environmental Monitoring Program, which includes climate; air, precipitation and streamwater quality; solar radiation; phenology and the behavior of water in the landscape. Data from the program have been used to understand the dynamics of road salt and the effects of climate change on precipitation chemistry.

Vicky Kelly, manager of Cary Institute Environmental Monitoring Program

In the research described here, Ms. Kelly looked at eleven ions and molecules in Wappinger Creek. These chemicals are indicators of the stream's health, and many of them help scientists understand the effect of acid rain on ecosystems such as Wappinger Creek. For example, hydrogen ions (H^+) are a direct indicator of the creek's pH level, and calcium ions (Ca^{2+}) indicate how much the surrounding soil is exposed to acid rain, as Ca leaches from acidic soil and then enters the creek.



Salt truck de-icing the streets
Source: Thomas Brueckner

Sodium (Na+) and chloride (Cl-) levels indicate the salinity of the water, and looking at trends over time helps scientists to understand if rising salinity levels are due to human activity, such as salting roads or releasing wastewater.


Leaves in the fall

Potassium (K) and magnesium (Mg) are important components in leaves. Examining variability and trends over time of these ions helps scientists to paint a picture of the trees' cycles of growth and dormancy. Ammonium (NH_4^+), nitrate (NO_3^-), and phosphate (PO_4^{3-}) are important plant nutrients. If the levels of these molecules become either too high or too low, this could indicate that plants cannot survive in the environment. High levels of these nutrients can also indicate pollution and eutrophication caused by sewage leakage, fertilizer or agricultural inputs.

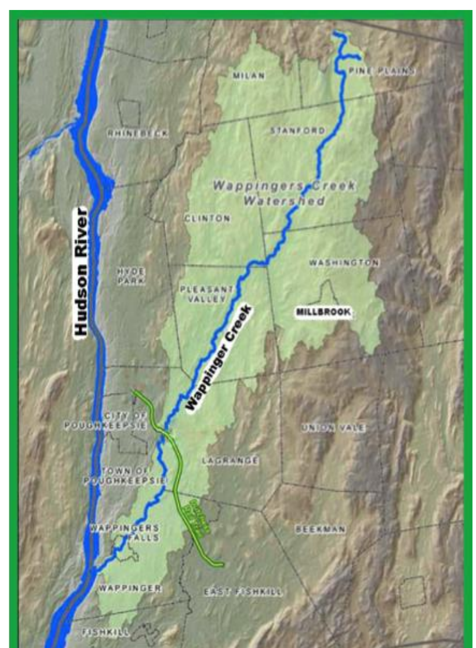
Sulfate (SO_4^{2-}) can help scientists understand the effect of coal-burning electric power plants, as sulfate is the main component of sulfuric acid. Silica (SiO_2) is actually sand. It is an important aspect to understanding the health of the soil.

Ms. Kelly sums this project up best when she writes, "A key component of our program is long-term monitoring of the chemistry of our environment. Our monitoring allows us to understand the dynamics of the pollution produced in industrial processes, especially pollution from the burning of fossil fuels such as coal and gasoline, and includes a broad range of pollutants. Our stream monitoring program is a long-term data collection program that allows us to understand local as well as regional changes in the environment feeding our stream. The program began in 1985 and is the longest continuous chemistry dataset about the quality of streamwater in our region. "

- **Dataset Timeframe:** 1985-2016

- **Data Collection Methods:** Monthly grab samples are collected at two sites on the East Branch of Wappinger Creek on the Cary Institute property. Stream samples are collected at the end of every month at low flow and are tested in the Cary analytical lab for a suite of chemicals that are important to ecosystem function. The data are summaries of these two sites.

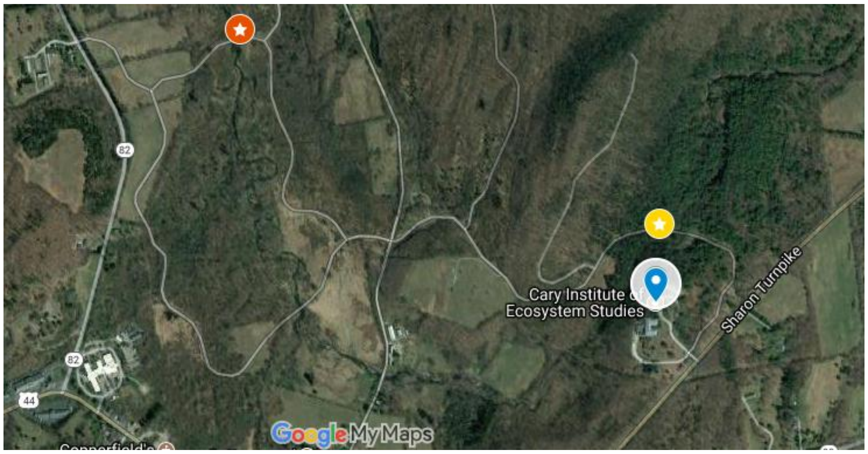
- **Information about Site:**
  The stream is a tributary to the main branch of Wappinger Creek, which flows into the Hudson River at Wappingers Falls. The creek as it passes through the Cary Institute property is a relatively clean, unimpaired forest stream. It harbors reproducing populations of brown trout as well as other important native fish and is habitat for breeding birds including



Wappinger Creek watershed

common merganser and wood duck. About 1.6 km upstream from our monitoring site is the Village of Millbrook sewage treatment plant. Millbrook (population 1400) and the roads in the watershed of the stream are important sources of road salt to the stream.

This stream data is collected at two different sites on the Wappinger Creek: the Fern Glen and the Lowlands. Both are located on the Cary Institute property. Fern Glen (marked in yellow) is upstream of the Lowlands (marked in orange). The creek has a narrow, straight bed in Fern Glen and runs through a thick, shaded forest of hemlock, ash, and maple trees. Fern Glen is closer to the Millbrook sewage treatment plant than the Lowlands are. The creek is flatter and more meandering in the Lowlands, with more pools. The sampling site is downstream of a wetland and the tree coverage is mostly sparse sycamores and dense willow shrubs.



- **Dataset Variables:**

  ***Note that these ions are found in the environment at very different concentrations, as a result of their chemical properties. Ex: hydrogen concentrations will be much lower than calcium.*

  - **H+ (hydrogen ions):** Hydrogen ions measure the pH of the creek. The more hydrogen ions there are, the more acidic the creek is.
  - **Ca (calcium):** Calcium is a background mineral in soils. It is leached from the soil when the land is exposed to acid.
  - **Cl- (chloride):** Chloride is a component of salt, and high levels can indicate pollution.
  - **K (potassium):** Potassium is an important component of leaf matter. As leaves decompose, potassium is leached into the watershed.
  - **Mg (magnesium):** Magnesium is an important component in chlorophyll molecules. As leaves decompose, magnesium leaches into the watershed.
  - **Na (sodium):** Sodium is a component of salt.
  - **NH_4+ (ammonium):** Ammonium is a waste product for animals and an important nutrient for plants.
  - ***NO_3 (nitrate):** Nitrate is an important nutrient for plants. It is used in agriculture.
  - ***PO_4 (phosphate):** Phosphate is an important nutrient for both plants and animals.
  - ***SO_4 (sulfate):** Sulfate is the main component of sulfuric acid. Sulfuric acid is created by coal-burning electric power plants.
  - **SiO_2 (silica or silicon dioxide):** Another name for silica is sand. It is an important component of sand.

- **Conductivity (µS):** the ability of a given substance to conduct electric current. Salts in water conduct electricity.

* If you are interested in looking at the effects of nitrates, phosphates, and sulfates on Wappinger Creek, and would like to better understand their importance, diagrams of their various cycles can be found on the last page.

- **Source of Datasets:** Data collected by Vicky Kelly at the Cary Institute of Ecosystem Studies in Millbrook, NY in Wappinger Creek.

- **Inquiry Idea Starters:**
  - *Are there seasonal trends among any of the ions or molecules? What might account for that? We recommend looking at chloride, potassium, magnesium, or conductivity as a starting point.*
  - *What might the trend of sulfate indicate about what is happening on land? Does this tell us anything about trends in acid deposition?*
  - *What might the trend of nutrients such as nitrate and/or phosphate indicate about the health of the watershed? *Note that the method for processing samples changed in 1999, which particularly affected ammonium, nitrate and phosphate. For trend analyses, we recommend using data from 1999 onward.*
  - *Is there any correlation between ion levels and stream flow? To answer this question, you can download the flow data from the "Level 2: Hydrology in the Wappinger Creek" dataset.*

- **Additional Resources:**
  - See the appendix for diagrams of the nitrogen, phosphorus, and sulfur cycles.
  - Current research on road salt pollution from the Adirondack Watershed Institute at Paul Smith's College: http://www.adkwatershed.org/road-salt-research
  - Additional lessons on salt pollution from the Cary teaching materials page: http://www.caryinstitute.org/educators/teaching-materials/data-exploration-nos/salt-pollution
  - Research on acid rain from the Cary Institute, which was founded by Dr. Gene Likens (co-discoverer of acid rain): http://www.caryinstitute.org/discover-ecology/acid-rain

- **Extension Ideas:**
  - Is there a correlation among these abiotic factors and biotic factors such as trees or fish?
  - What variables may affect population density of different organisms?
  - Does data from Wappinger Creek correlate with data from the Hudson?
  - The human population in the areas surrounding these sites remained relatively constant during this experiment. Would you expect to see different trends in nutrient levels (such as ammonium, phosphate, nitrate) if the population was growing or if the land use dramatically changed? (ex: more housing developments, more agriculture)

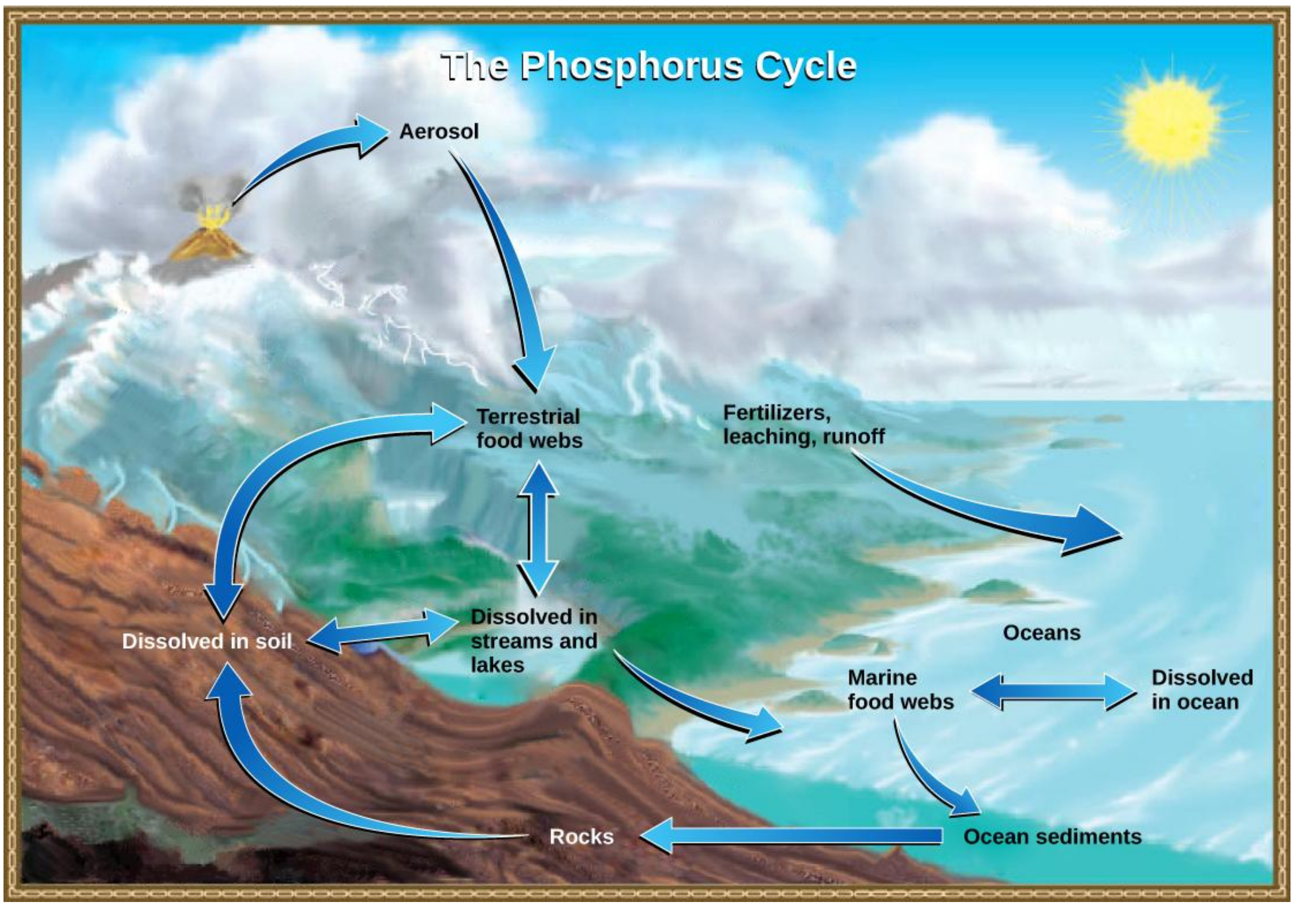
❖ References:

Cary Institute of Ecosystem Studies, Environmental Monitoring Program. 2017. Cary Institute of Ecosystem Studies, Box AB, Millbrook, NY 12545, www.caryinstitute.org.

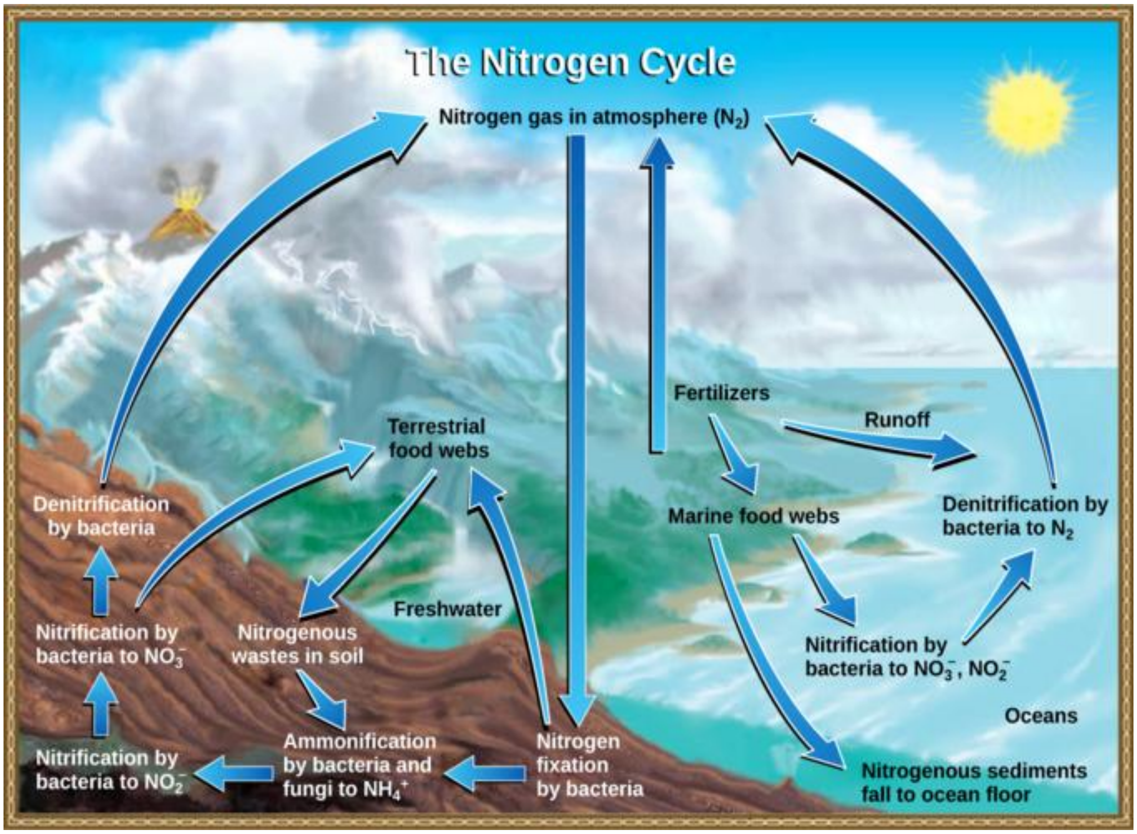
Kelly, Vicky. Personal Interview. 18 Aug. 2017.

❖ Appendix

Here are a few nutrient cycle diagrams, which may help you to think about the movement of these molecules and ions between the land and stream.



Source: John M. Evans and Howard Perlman, USGS



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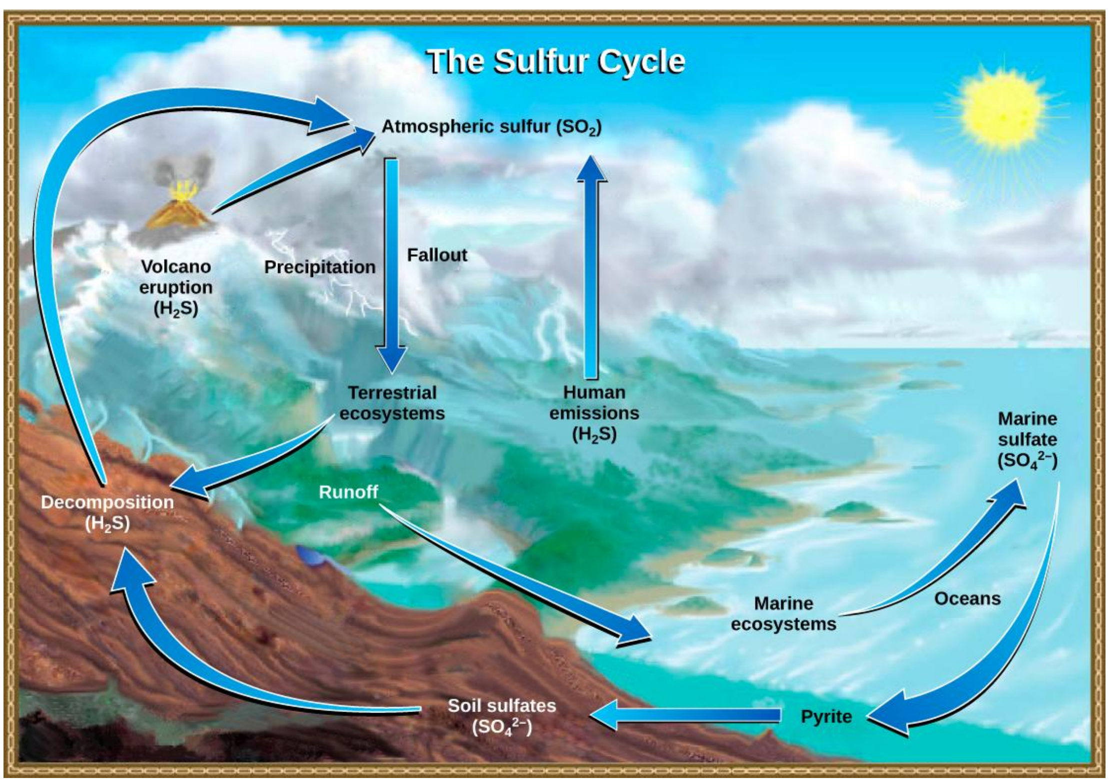

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