The Effect of a Stream on Soils and Plants In Their Surrounding Ecosystems

Stream Team

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Abstract

A study was conducted in the Roland Park backwoods to measure the effect that a stream has on nearby soil and organisms in forest ecosystems. Chemical testing was conducted and consisted of measuring soil pH, nitrate-nitrogen levels, and phosphorus levels, as well as comparing the results to tests done on plant tissue nitrate-nitrogen and phosphorus levels. Along with the chemical tests, mold colonies were counted in the soil samples that were collected from each plot. During the 10-day study, three plots were made. Two plots were located on the stream and one off the stream bed equidistant from both of the other plots. Three soil samples were collected from each plot, every day, over the course of three days. It was hypothesized that the plots along the stream would display significantly higher levels of nitrate-nitrogen and phosphorus levels in both the soil and plant tissue samples compared to the control plot. In addition, it was thought that there was a direct correlation between levels of mold and pH that would affect levels of nitrate-nitrogen and phosphorus in plant tissue samples. At the conclusion of the experiment, it was determined that there was a significant difference between the control plot and plot one in pH, plant nitrate-nitrogen, and soil phosphorus, as well as plant nitrate-nitrogen levels between plots one and two. The data showed that there was an inverse correlation between the pH and the plant-nitrate. To summarize, the data shows that plot three (the control) had been affected in some way that made the results similar to plot one and plot two. It was concluded that the similarities between all three plots were due to the rainfall the area obtained previous to starting the experiment because multiple factors such as flooding or runoff can affect the macronutrients, pH, and mold levels in soil and plant tissue.

Introduction

Environments in a forest near a stream are often different from those away from water because the flow of the stream can affect many factors in and around it, such as levels of mold, macronutrients, plant health, and pH. Macronutrients are an important factor in the health of a forest ecosystem, and the water provides different amounts of nutrients such as phosphorus and nitrate-nitrogen for the plants and the soil in that area. This excess of macronutrients in the soil near forest streams can also lead to the plant life near these bodies of water being malnourished. Research shows that when high levels of phosphorus are introduced to plants through water intake can lead to unhealthy plants that show signs of phosphorus buildup through brown leaves or aboveground phosphorus content. (Sardans et al, 2004). Phosphorus and nitrate-nitrogen levels are great indicators for the health of plants in a forest, therefore it is important to test for the parts per million (ppm) of these macronutrients in the soil near streams to understand how the water affects them. Studies have shown that nitrate-nitrogen is known to contaminate stream water specifically in Maryland, which can also be detrimental to plant health near the water (USGA, 2017). An experiment was conducted to study phosphorus and nitrate-nitrogen levels, pH, and mold in the soil near stream water and how they affect the plant matter through a transect of the area. The amounts of phosphorus and nitrate-nitrogen are important to measure in both the soil and the plants to accurately study how the stream water is affecting the levels of these macronutrients. Stream water increases phosphorus and nitrate-nitrogen content in the soil. (EPA, 2022). Too much or too little mold can be harmful in soil because it helps to break down the materials in organic matter to make the soil healthier for plant growth and provide space for new plants to grow. Too little mold prevents organic matter from decomposing as fast, but too much mold can cause the over-removal of important nutrients (Schira, 2018). The pH of the soil can also have a big effect on plant health because it affects the plant's intake of important

nutrients, like phosphorus and nitrate-nitrogen. If no correlation exists between nitrate-nitrogen and phosphorus levels and plant health, mold and pH are additional indicators that explain the health of plants near streams. Based on this knowledge, there will be abnormal pH and mold levels in the soil near the stream in addition to higher levels of phosphorus and nitrate-nitrogen in plant matter and soil compared to the samples away from the stream.

Materials and Methods

A study was conducted to analyze how varying levels of phosphorus, nitrate-nitrogen, pH, and mold in soils near streams affect the health of plants in forest ecosystems. For a map of the plot arrangement, see Figure 1. Three locations were identified with two plots along the stream at the same elevation and one plot 24.5 meters from the stream. Two of the plots, Plots 1 and 2, were located in Site Four of the ESSRE 2023 Soil Biota Analysis setup. Each plot had a corresponding map to mark where soil and leaf samples were extracted. Each plot measured 5m by 5m. Over three days, three 15-centimeter deep, 2-centimeter wide soil samples were taken from each plot using a soil core extractor and bagged separately avoiding cross-contamination. Between each sample, the soil extractor was washed out to prevent cross-contamination. Each location was marked with a flag of the soil sample including the sample number and letter. Each sample was collected from a different location every day and was put into a corresponding petri dish to dry in the sun for 1-2 days.

Soil dilutions were made to count the mold colonies from the 9 samples. For each sample, dilutions were made for 10^{0}, 10^{-1}, and 10^{-2}, however, only 10^{-1} and 10^{-2} were plated. In order to do this, a transfer pipette extracted 10 mL of distilled water and added it to the 15 mL culture tube labeled "10^{0}". The same transfer pipette added 9 mL of water to the 10^{-1} and 10^{-2}

culture tubes. A measurement of 1 cc of the soil sample was added to the 10^0 culture tube and shaken using a thumb as a cap. With a new pipette, 1mL of soil water was extracted and added to the 10^{-1} culture tube. After shaking the 10^{-1} culture tube, the same pipette removed 1mL of soil water to be added to the 10^{-2} culture tube and shaken. This process was repeated for the remaining eight soil samples. On their corresponding 3M Petrifilm Yeast and Mold Count Plates, 100µl of each of the 10^{-1} and 10^{-2} samples were plated and placed in a dark place to grow for at least 72 hours.

For all of the chemical tests, LaMotte Model STH-14 Outfit (Code 5029) Chemical testing materials and informational books were used. To test the pH of each soil sample, a test tube was filled approximately one-third of the way with soil. Then, demineralized water was added, leaving about a half-inch of the test tube empty. The mixture was shaken. Next, five drops of soil flocculating reagent were added, and the mixture was shaken again. After letting the solution settle, a 1mL pipette extracted 1mL of fluid from the top of the test tube to be dropped into the large depression on a spot plate. Two drops of the Duplex chemical indicator were added, and results were compared against a color chart. This procedure was repeated for all nine soil samples.

To assess the levels of nitrate-nitrogen per soil sample, a 1mL pipette transferred 1mL of the general soil extract to a large depression in a spot plate. Ten drops of nitrate test reagent #1 and .5 grams of nitrate reagent #2 were added. These reagents were then mixed with a clean stirring rod. The solution stood for five minutes before being compared to a nitrate nitrogen color chart.

To assess levels of phosphorus in the soil, a transfer pipette filled a “Phosphorus B” tube to the mark with general soil extract. Six drops of phosphorus test reagent #2 were added. Next,

one phosphorus reagent #3 tablet was added to the solution and shaken until dissolved. The resulting color was compared to a phosphorus color chart under natural light.

To collect leaf samples for chemical testing, a plant transect was conducted in each plot. For plots with a stream, 5-meter long transects ran parallel to the stream on both sides. All samples from the same plot were bagged together. For every meter, one leaf sample was collected, intentionally taking the lowest quality plant since it displayed the most nutrient deficiency. For the control plot, transects run diagonally NE to SW and NW to SE, taking the lowest quality leaf sample per meter. Then, each plant was cut into 1/16 inch pieces and added to a test tube containing 14 mL of Universal Extraction Solution. The tube was capped and shaken for five minutes. The resulting solution was filtered into an extraction tube. This process was done for all thirty leaf samples.

To assess the levels of nitrate-nitrogen per plant tissue sample, a 1mL pipette transferred 1mL of the general plant tissue extract to a large depression in a spot plate. Ten drops of nitrate test reagent #1 and .5 grams of nitrate reagent #2 were added. These reagents were then mixed with a clean stirring rod. The solution stood for five minutes before being compared to a nitrate-nitrogen color chart.

To assess levels of phosphorus in plant tissue, a transfer pipette filled a “Phosphorus B” tube to the mark with general plant tissue extract. Six drops of phosphorus test reagent #2 were added. Next, one phosphorus reagent #3 tablet was added to the solution and shaken until dissolved. The resulting color was compared to a phosphorus color chart under natural light.

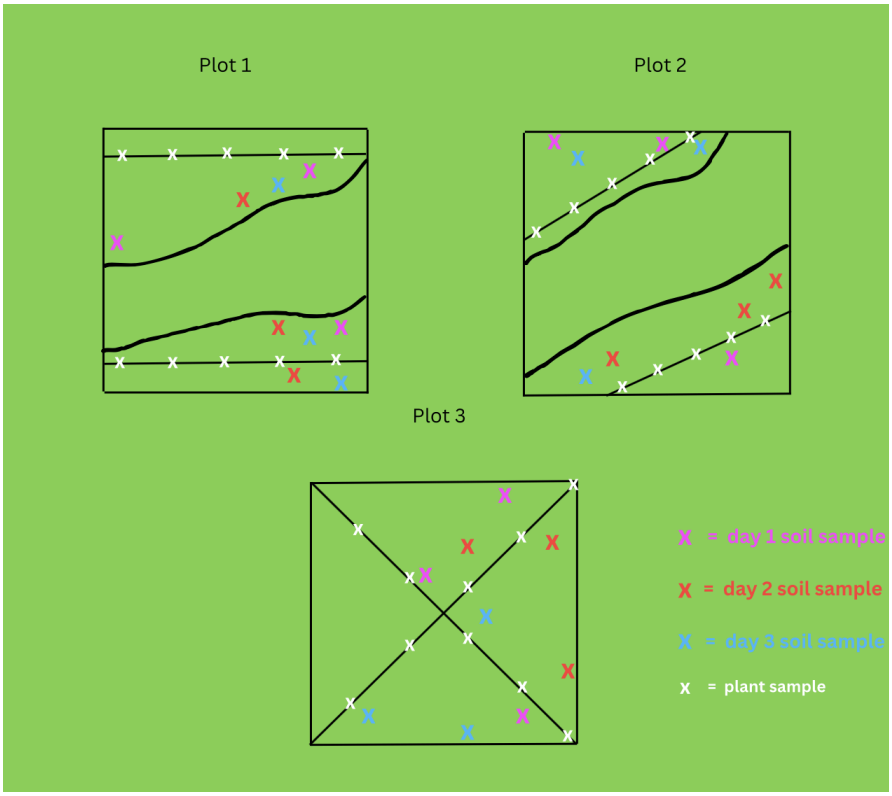


Figure 1: This diagram shows the three plots' soil sample locations and sample locations were taken (2 plant transects in each plot).

Results:

Table 1. Plot Statistics						
	Plot 1		Plot 2		Control	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
pH	6.27	0.17	6.24	0.13	6.12	0.25

Mold (microbes/cc of soil)	1.18E+04	1.40E+04	5.22E+03	6.53E+03	1.53E+04	2.38E+04
Soil Nitrate (ppm)	18.89	11.67	21.11	14.53	16.67	12.99
Soil Phosphorus (ppm)	70.83	26.52	61.11	30.90	50.56	27.58
Plant Nitrate (ppm)	10.00	0.00	20.00	23.21	24.00	27.06
Plant Phosphorus (ppm)	32.50	32.38	33.25	25.98	45.50	37.65

This is a statistical analysis of the plots based on the raw data collected over 3 days.

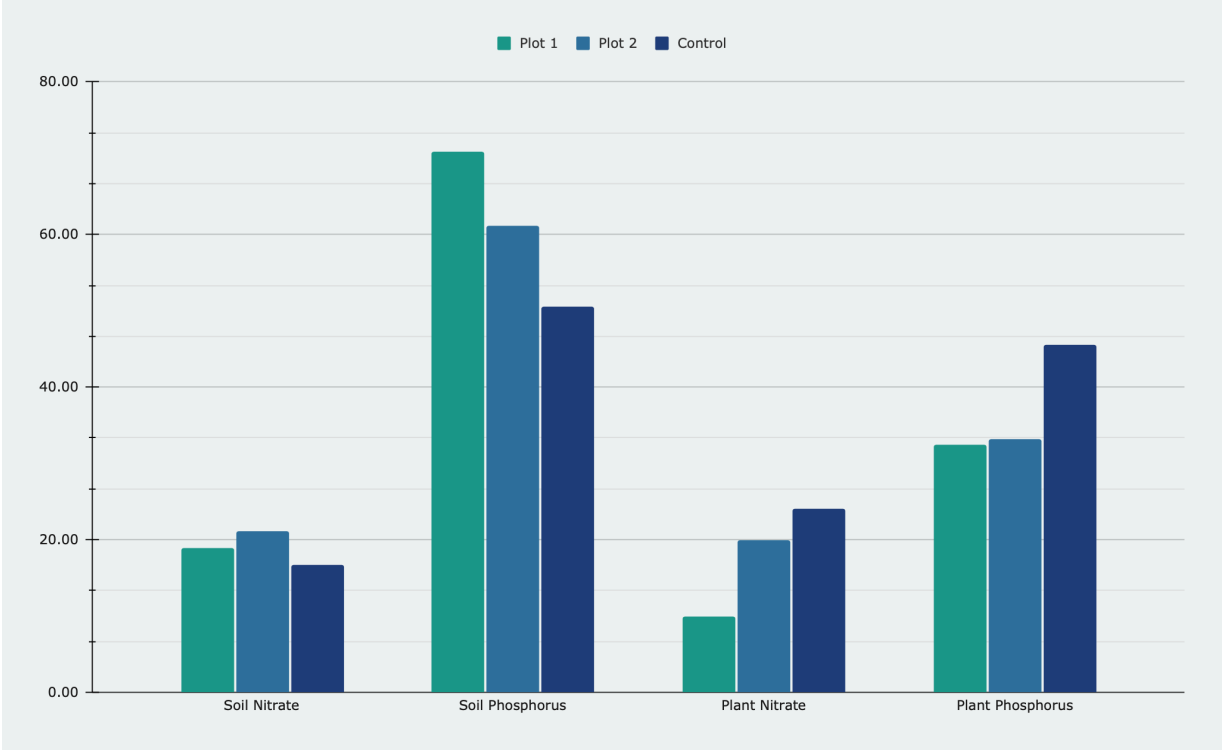


Figure 2. The Levels of Inorganic Nutrients in the Soil and the Plants (ppm)

This is a graph showing the levels of nitrate-nitrogen and phosphorus in the soil and plants in each of the plots.

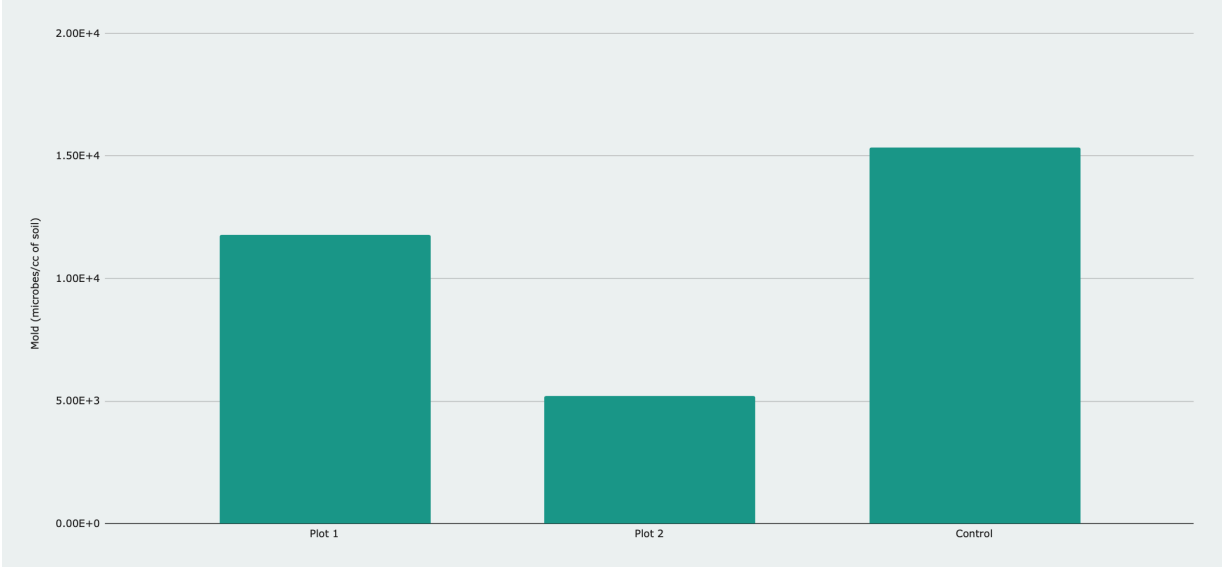


Figure 3. Amount of Mold in Soil Plots

This shows the average amount of mold in each of the plots.

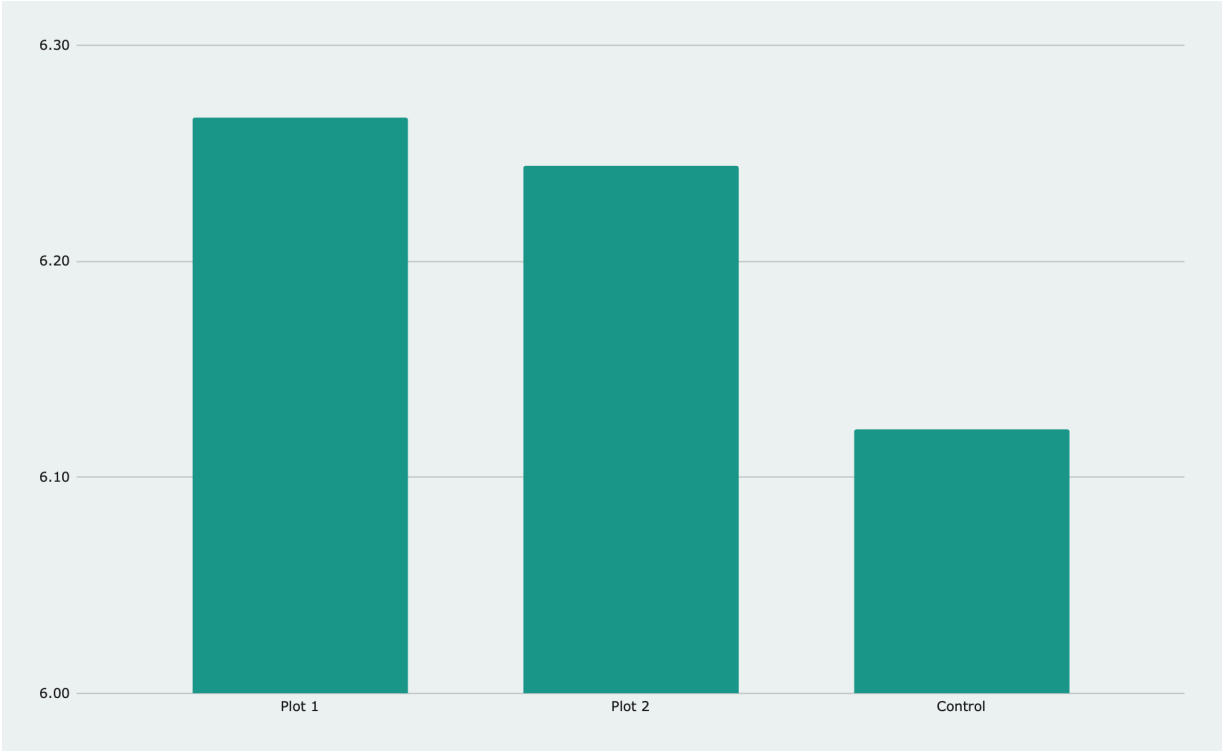


Figure 4. Average pH levels in Soil Plots

This shows the pH in each plot.

Table 2. P-Values for a Significance level of .2			
	Plot 1-Control Comparison	*Plot 2-Control Comparison*	*Plot 1-Plot 2 Comparison*
pH	*0.178*	*0.219*	*0.764*
Mold	*0.705*	*0.237*	*0.221*
Soil Nitrate	*0.708*	*0.504*	*0.725*
Soil Phosphorus	*0.131*	*0.456*	*0.484*

Plant Nitrate	*0.119*	*0.727*	*0.190*
Plant Phosphorus	*0.419*	*0.408*	*0.955*

These are the plot comparisons used to determine which variables were statistically different from each other. Cells that are colored green are statistically significant. Cells that are colored red are not statistically different.

Discussion:

It was hypothesized that there would be higher levels of nitrate-nitrogen and phosphorus in the soil and plant tissue samples near the stream. This is because forest streams are likely to contain higher amounts of phosphorus, in addition to nitrate-nitrogen as these specific nutrients are carried down into streams through runoff (EPA, 2022). In addition, it was thought that there was a direct correlation between levels of mold and pH that would affect levels of nitrate-nitrogen and phosphorus in plant tissue samples. However, the higher levels of macronutrients in the stream presents a problem only when these higher levels start to pollute the Bay and soil near the streams at faster rates than these environments can adapt to (EPA, 2022).

A significant finding resulted in a correlation between soil pH and plant nitrate–nitrogen levels. Plot one had the lowest plant nitrate-nitrogen levels while also having the highest soil pH of 6.27. Conversely, the control plot had the highest plant nitrate-nitrogen levels with the lowest pH of 6.12. Each plot displayed similar amounts of soil nitrate-nitrogen levels, which indicated that the soil pH is a modulator in the plants' ability to absorb nitrate-nitrogen from the soil.

The results demonstrate that the hypothesis was not supported. The original hypothesis stated that both plots on the stream would significantly differ in all of the variables from the control plot, but the results do not support this. There were no significant differences between any of the plots for the amounts of mold, plant phosphorus, or soil nitrate-nitrogen. It is thought

that the resulting mold data might be due to the frequent rain the area was exposed to prior to the experiment that was conducted, because mold grows better in wet environments (FSEC, 2022). Not only were there similar levels between plots one and two, but because of the constant rain the backwoods had been getting, plot three (the control) might have also had higher levels of moisture. In terms of soil nitrate-nitrogen, plot two was much higher up on the stream bank than plot one because it had a much taller stream bank. The fact that these samples were taken farther away from the stream due to the height of the stream bank in plot two could have been a reason why it was more similar to plot three. However, plot one also came up with similar results, which could be due to the effects of runoff. The control plot is at the bottom of a hill, where runoff water would run through. Therefore, if the runoff contains high amounts of nitrate-nitrogen in the runoff it could have seeped into the soil in the control plot. The rain could additionally be a factor in determining why the resulting plant phosphorus levels were similar between all of the plots. An excess of water can prevent plants from taking up phosphorus. Excess moisture from flooding and/or the stream could be a possible reason for plant phosphorus levels being similar between all three plots (CTAHR, 2023). In total, the high levels of rain that the backwoods had gotten prior to the experiment started could have skewed the data because the moisture levels in plot three might have been higher than normal.

The soil phosphorus in plot one proved to be statistically different from the control. While this does not support the hypothesis, the position of the stream in each plot could possibly explain higher phosphorus levels in plot one. Not only did plot one sit directly in a stream, but it had low stream banks and the most number of rocks compared to plots two and three. The increased amount of rock erosion could lead to more phosphorus in this plot compared to plots two and three (National Geographic, n/d). This idea is supported by the fact that the control plot,

which is not located on a stream, had the lowest amount of soil phosphorus, supporting the suspected trend that proximity to the stream affects the amount of phosphorus in soils. Moreover, the ways in which stream bank erosion presented itself in plots one and two vary due to the abiotic factors shaping each plot and could explain levels of available inorganic nutrients. Plot two lacked rocks along the stream, and the soils surrounding the stream were vertical slopes which indicated high levels of erosion. However, plot one contained many rocks inside and alongside the stream, so erosion at this plot presented itself in an excess of phosphorus in the surrounding soils (University of Hawai‘i - Mānoa, 2023).

For mold, the results concluded were not significantly different between the plots, as shown in Table 2. However, for pH, the soil in plot one and the control plot did have a significant difference. The soil in plot one had a pH of 6.27 and the soil in the control plot had a pH of 6.12. Ultisols, or red clay soils, are one of twelve orders of soil in the US agriculture soil taxonomy and the type of soil present in Maryland. This type of soil normally has a pH lower than 5, which is commonly acidic. The pH results from the experiment in plots one, two, and three are higher than the typical pH of Ultisol soil. This can affect the nutrients a plant intakes as well as its overall health (Wikipedia, 2023).

Future research that could be done to gain more insight into the results received could be to examine the conditions that plants need to have in order to take up nitrate-nitrogen from the soil. While it has been proven that plants near streams usually have higher levels of nitrate-nitrogen, factors such as heavy rainfall, which the area received during the week the experiment was conducted, can lower plant nitrate-nitrogen levels (University of Nebraska, 2015). These two factors combined would keep the nitrate-nitrogen levels in a healthy range. However, even though the control plot was not near a stream, it was at the bottom of a hill which

means it could receive more nitrate-nitrogen from runoff. A new experiment could offer more clarity on the abiotic factors that influence plants and their ability to take up nutrients.

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