An Analysis on the Effects of Runoff on the Health of the Nitrogen Cycle in the Roland Park Country School Backwoods

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Abstract

Nitrogen, an element that is vital to all sources of life on Earth, is made reusable through an important process known as the nitrogen cycle (Ho, 2002). Part of the nitrogen cycle involves a food chain between soil bacteria and protozoa whose proper balance is ultimately responsible for the success of the nitrogen transformation. Three soil core samples 15cm long by 2cm in diameter were taken from the center of the E.S.S.R.E. Microclimate sites as well as from the hilltop campus of Roland Park Country School. Bacteria and protozoa densities were determined for each sample, along with the levels of nitrite, ammonia, and nitrate. Data was examined for the known nitrogen cycle correlation between all of the above elements. We found that as the sites increased in distance from the school building, the organisms and chemicals within the cycle showed less of the correlation than those within the sites closer to the top of the hill. Based on our findings, we recommend this experiment be replicated next year after the artificial fields have been inserted, to see if the reduced application of fertilizers would positively affect the health of the nitrogen cycles of the backwoods.

Introduction

Nitrogen, an element that is vital to all sources of life on Earth, is made reusable through an important process known as the nitrogen cycle (Ho, 2002). The cycle itself is commonly broken down into five steps: fixation, nitrification, assimilation, ammonification, and denitrification (Bruno and Carnegie, 2007). During fixation, bacteria convert the previous nitrogen gas into the usable form of nitrogen compound, most commonly known as ammonia. During the process of nitrification, the ammonia is converted by the bacteria into nitrite and then into nitrate which can be more readily used by a wider variety of organisms. Through assimilation, the nitrate, nitrite and ammonia are used by the plants to create proteins and nucleic acids which eventually renter the soil during ammonification after the organisms die (Environmental Literacy Council, 2006). Denitrification is when the nitrate in the soil is converted back into gaseous nitrogen.

Part of the nitrogen cycle involves a food chain whose proper balance is ultimately responsible for the success of the nitrogen transformation. The bacteria that complete the conversion during fixation and nitrification are the food source for microorganisms; in particular, protozoa. Therefore, as the number of protozoa decrease, the number of bacteria increase because they are not being preyed upon. Since the bacteria are the transformers of the nitrogen in the cycle, the amount of nitrite, ammonia, and nitrate compounds in the soil are directly dependent on the number of bacteria. However, the levels of nitrite, ammonia, and nitrate also depend on the health of the protozoa/bacteria relationship. Some compounds, such as nitrate, are only released in large amounts when protozoa prey on the bacteria and then release them as metabolic byproducts. Therefore, a healthy correlation between protozoa and bacteria populations is vital for a balanced nitrogen cycle (Soil Biology Primer, 2007).

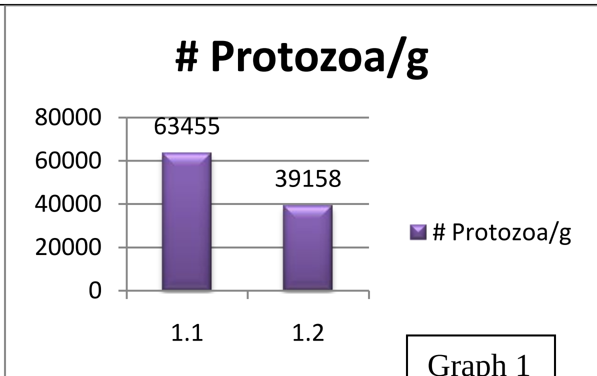
Ideally, the compounds and organisms within the nitrogen cycle correlate with one another: as the levels of ammonium levels decrease, the levels of nitrite and nitrate increase and as bacteria levels decrease, protozoa density increases. However, existing longitudinal data collected from the Environmental Science Summer Research Experience microclimates in Baltimore Maryland have failed to show the correct correlation. Our research team chose to work with the same four microclimates of E.S.S.R.E in the backwoods and we created a negative control by making a 'fifth site' closer to the school building. Because run off can greatly disturb the normalcy of nitrogen cycle (World Resources Institute, 2007) and Abrams, etal (2007) support this explanation as potential hypothesis for E.S.S.R.E data, our experiment was designed to determine whether the cycle regained the natural balance as the sites got farther away from the school building where run off may be less prevalent then it would be at the top of the hill where the school is located.

Methods and Critical Materials

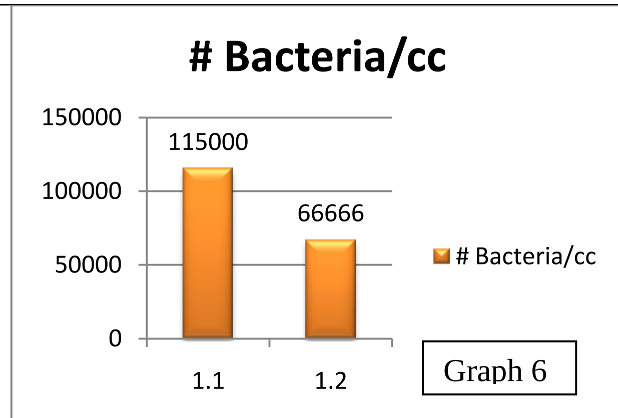
Three soil core samples 15cm long by 2cm in diameter were taken from the center of the E.S.S.R.E. Microclimate Sites 1-4 at N 39.35794, W 76.63977; N 39.3574, W 76.63893; N 39.35797, W 76.63836; N 39.35733, W 76.6384, respectively. An additional three samples were taken on the hilltop Campus of Roland Park Country School at N 39.35779, W 76.63766 adjacent to sites 1-4. A modified Foissner/Uhlig process (Brockmeyer et al, 2007) was used to extract and estimate the number of protozoa in each sample while serial dilutions were made up to 10^{-4}, and 100μL of the 10^{-1} though 10^{-4} solutions were plated on the 3M Petrifilm™ Aerobic Count Plate bacteria plates. Nitrite, Nitrate, and Ammonium tests were preformed simultaneously on each soil sample using the La Motte Kit Model STH 14 and recorded in ppm.

Results

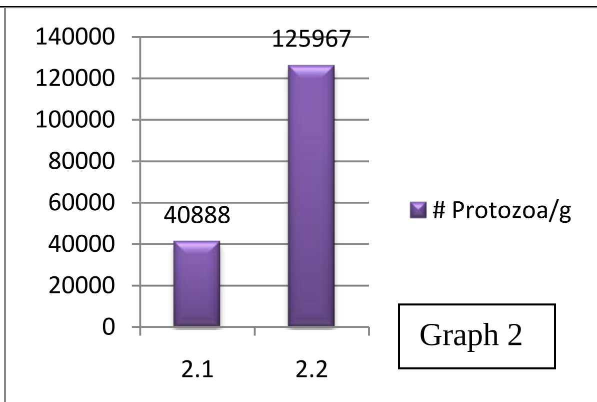
The following graphs show the average levels of protozoa, bacteria, nitrite, nitrate, and ammonium from the first and second collections. From closest to farthest from the school the sites are: 5, 3, 4, 2, 1.



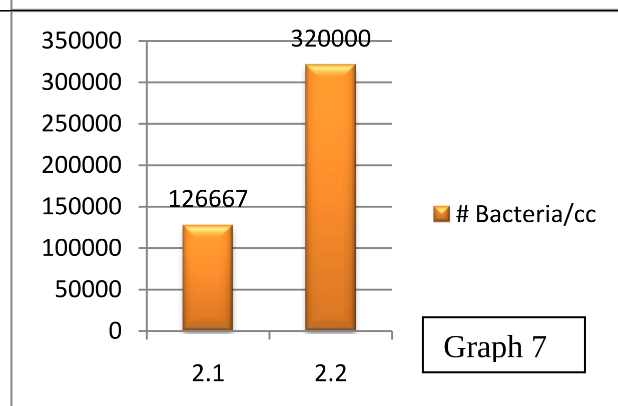
Graph 1



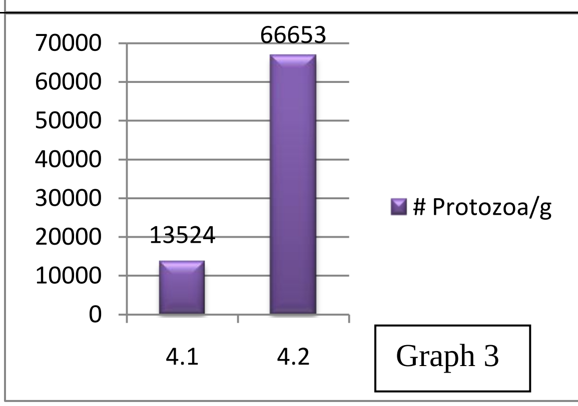
Graph 6



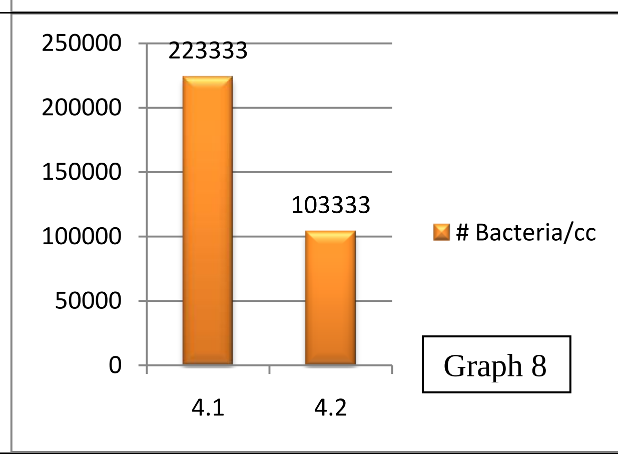
Graph 2



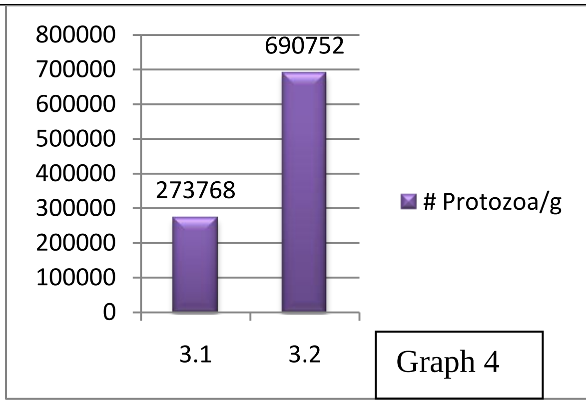
Graph 7



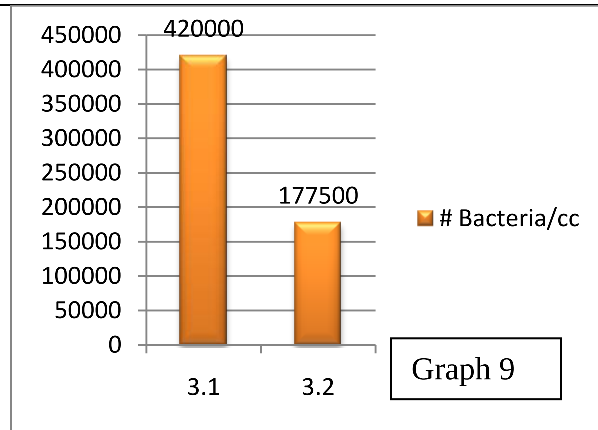
Graph 3



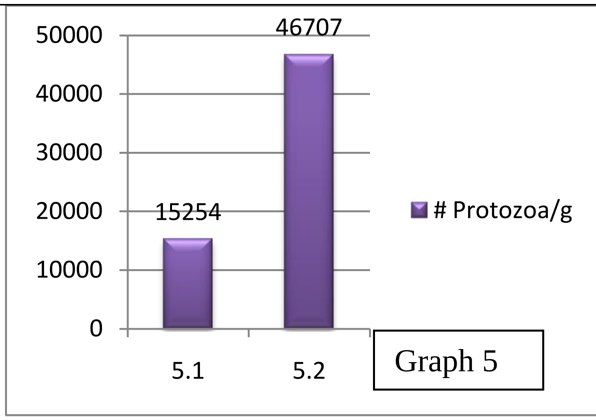
Graph 8



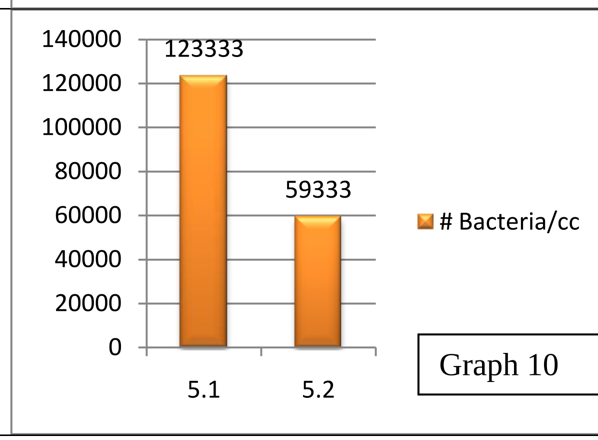
Graph 4



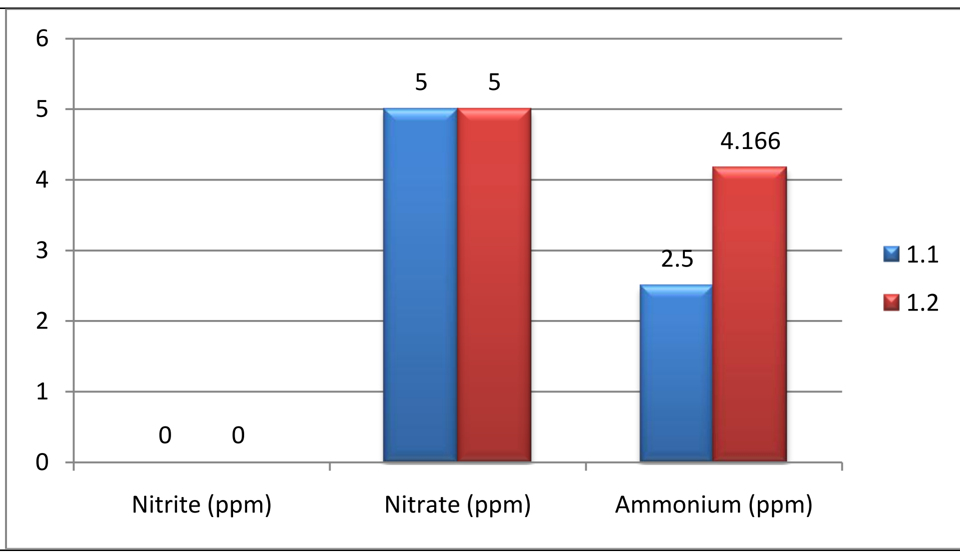
Graph 9



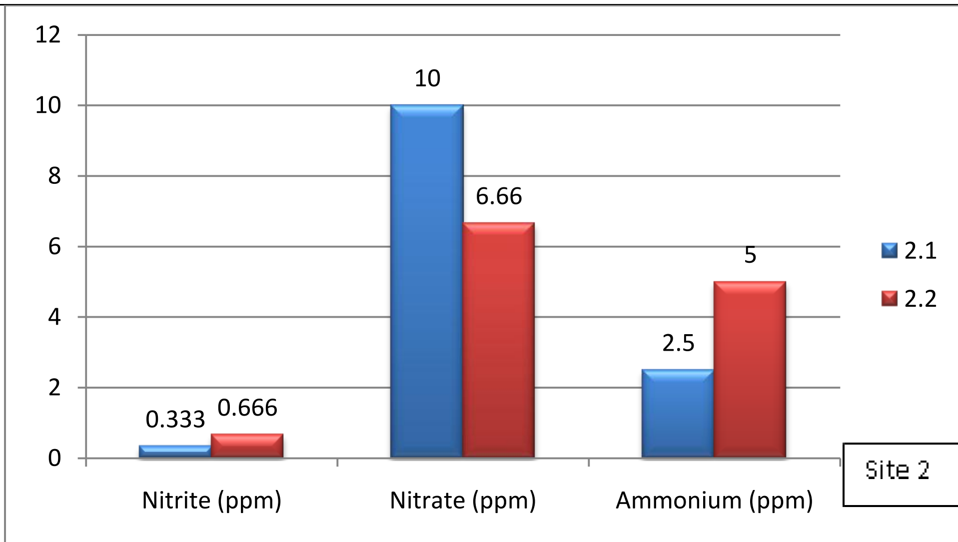
Graph 5



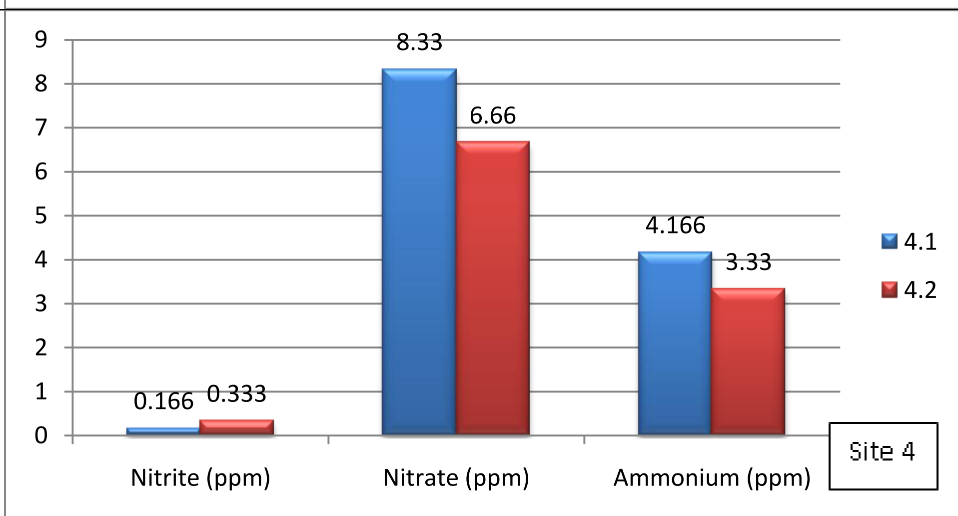
Graph 10



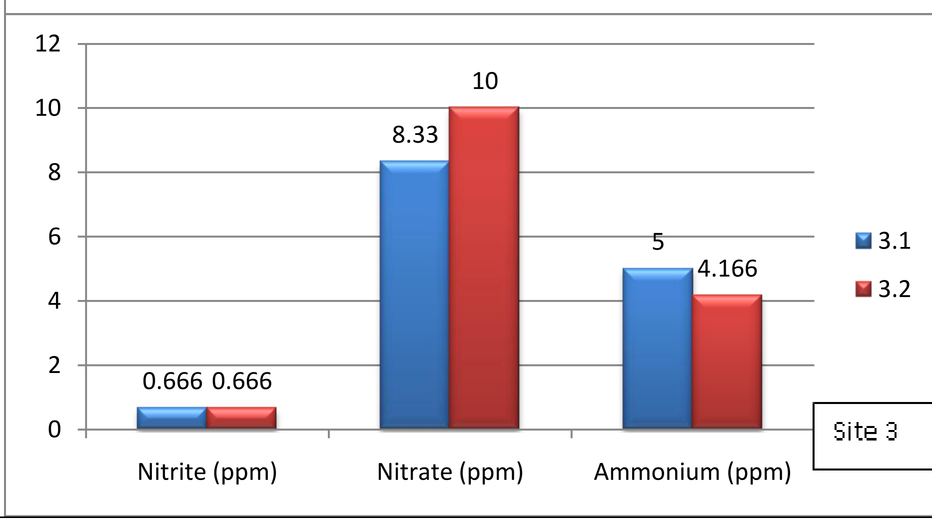
Graph



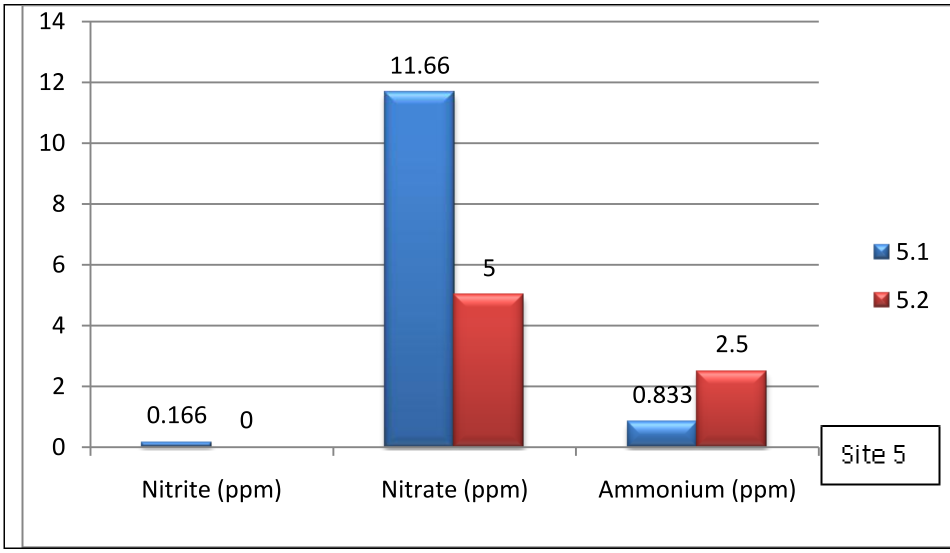
Graph 12



Graph 13



Graph 14



Graph 15

The following are t-tests showing which differences in data are significant. It compares the data from sites one through four from both data collections to the site closest to the school, site 5. The ones with statistically significant difference are highlighted in pink.

Nitrite

	p value Day 1	Day 2
1-->5	0.42	1
2 --> 5	0.69	0.18
3-->5	0.27	0.18
4-->5	1	0.42

Nitrate

p value

	Day 1	Day 2
1-->5	0.27	1
2 --> 5	0.74	0.42
3-->5	0.58	0.42
4-->5	0.54	0.42

Ammonium

p value

	Day 1	Day2
1-->5	0.18	0.18
2 --> 5	0.18	0.23
3-->5	0.23	0.18
4-->5	0.08	0.42

Bacteria

p value

	Day 1	Day 2
1-->5	0.86	0.62
2 --> 5	0.95	0.09
3-->5	0.25	0.59
4-->5	0.19	0.32

Protozoa

p value

	Day 1	Day 2
1-->5	0.32	0.82
2 --> 5	0.35	0.07
3-->5	0.18	0.00098
4-->5	0.87	0.63

Discussion/Conclusion

An Analysis of the Affects of Runoff on the Health of the Nitrogen Cycle in the Roland Park Country School Backwoods

Our original hypothesis stated that the E.S.S.R.E research sites farther from the Roland Park Country School building (a known source of run off) would have levels of nitrite, ammonia, nitrate, as well as protozoa and bacteria densities that more closely correlated with those of a healthy nitrogen cycle. However, upon analyzing the data, we found that the opposite was true: as the sites increased in distance from the school building, the organisms and chemicals within the cycle showed less of the correlation than those within the sites closer to the top of the hill.

Graphs 5 and 10 (concerning site 5) show that the expected predator-prey cycle of the protozoa and bacteria between day 1 and day 2 correctly correlate with of the levels of chemicals. Hence, the microbes and chemicals in site 5 (our negative control plot at the top of the hill) showed the expected fluctuations, indicating that there is a healthy working nitrogen cycle at the top of the hill.

As can be seen from Graphs 4 and 9, site 3 also shows the normal change in protozoa and bacteria densities from day 1 to day 2. However, the nitrite levels were unexpected. As the bacteria numbers decreased from day 1 to day 2, there were fewer transformers to convert the ammonia into the nitrite form. Therefore, the nitrite levels of day 2 should have been lower than those of day 1. Since they were not, this is indicative that there is a small disruption in the nitrogen cycle in site 3.

Graphs 3 and 8 show that site 4 has a correct correlation from day 1 to day 2 between densities of protozoa and bacteria. However, because the number of bacteria decreased on the second day, we would have expected there to be a build up of ammonia, since the number of transformers had decreased. Instead, Graph 13 shows that the amount of ammonia actually decreased from day 1 to day 2. Therefore we must conclude that the nitrogen cycle of site 4 has been disrupted as well.

Through statistical analysis, we found that there was only one significant difference that we needed to analyze for site 2. Because the number of protozoa increased from day 1 to day 2 (see Graphs 2 and 7), we expected that the number of their prey, the bacteria, would decrease. However, Graph 7 shows that the number of bacteria in fact continued to increase, and in spite of this abnormality, the relationship between the levels of chemicals seemed to act as though there was a normal correlation between the protozoa/bacteria. Therefore it seems that the nitrogen cycle of site 2 has also been disrupted.

Finally, Graphs 1 and 6 show a complete disruption in the normal protozoa/bacteria relationship in site 1. Furthermore, as can be seen from the chemical graph for site 1 (Graph 11), there was no nitrite in the site. This finding is significant because although the levels of bacteria decreased, there was still an average of 115,000 bacteria for day 1 and 66,666 bacteria for day 2. Therefore, *some* ammonia should have been converted into nitrite. Hence, contrary to our hypothesis, site 1 actually had the highest number of inconsistencies and therefore the least functional nitrogen cycle.

Although the data refutes our experimental hypothesis, we have found that our gathered information supports the theory that runoff from uphill negatively affects the nitrogen cycles of locations further downstream. It is a known fact that Roland Park Country School applies copious amounts of fertilizer to their playing fields which are located to the top of the hill. Therefore, it seems likely that the correctly functioning nitrogen cycle in site 5 has been artificially enhanced by the nitrite, ammonia, and nitrate in the fertilizer. Research completed by other members of the 2007 E.S.S.R.E. program (E.S.S.R.E. 2007) showed that nutrients are being leached in the soil of the backwoods potentially allowing the chemicals in the fertilizers to travel through the microclimates of the backwoods to pool in the sites at the bottom (sites 1 and 2). Based on our findings, we recommend this experiment to be replicated next year after the artificial fields have been inserted, to see if the reduced application of fertilizers would positively affect the health of the nitrogen cycles of the backwoods.

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