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DATA Nugget

Limit by limit: Nutrients control algal growth in Arctic streams

Featured scientists: Abigail Rec from Gettysburg College; Frances Iannucci, Alex Medvedeff, and Breck Bowden from University of Vermont; Arial Shogren and Jay Zarnetske from Michigan State University

Research Background:

The Arctic Stream Team. Frances, Breck, Abby, Alex, Jay, and Arial at Toolik Field Station in 2019.

You rely on the nutrients from the foods you eat to grow and thrive. Other organisms, like microbes, do as well! **Aquatic algae**, a type of microbe that live in the water, need to take in nutrients from their surroundings for growth. Two important nutrients for algal growth are nitrogen (N) and phosphorous (P).

Sometimes the environment does not have all the nutrients that aquatic algae need to grow. When one nutrient is less available compared to others, algae can become **nutrient limited**. Research on nutrient limitation started with Justus Liebig, a 19th century scientist who proposed the "law of the minimum." The law states that the nutrient available in the lowest amount relative to demand will limit overall growth and production. This means that growth is not controlled by all the nutrients, but by the scarcest one (the "**limiting factor**"). When more than one nutrient limits growth, algae are considered **co-limited**. This just means that a combination of two nutrients are needed for algae to grow. Knowing what nutrients are limiting growth helps scientists understand how an ecosystem is working.

From other research we know that many ecosystems, including those in the Alaskan Arctic, are phosphorus-limited. Scientists figured this out because they found if they added phosphorus, then algae growth increased. However, climate change could change this. As the Arctic warms, ecosystems on land might start to release nutrients in higher amounts or new proportions into the water. These extra nutrients will likely cause increases in algae growth in streams and ponds, which in turn could change food webs and nutrient cycling. It is therefore important to understand which nutrients are currently limiting algae growth before climate change changes things even more. This starts with

tests to see how Arctic algae grow in response to changes in N, P, and N *and* P in the water.

A team of scientists got to work on this question! Arial, Jay, Frances, Alex, Breck, and Abby are all interested in understanding how climate change may alter nutrient limitations in Arctic streams. Each team member has a unique role in the larger research project. For example, undergraduate researcher Abby spent her 2019 summer at Toolik Field Station in Northern Alaska as part of a research opportunity. She explored nutrient limitation in one particular lake, called Lake I8.

Abby used small **cups** that placed into the streams that fed into Lake I8. These cups were filled with agar gel, a material used in labs to grow microbes. Each cup contained different nutrient treatments. Abby used four different treatments in her cups: (1) a control (agar only), (2) agar + nitrogen, (3) agar + phosphorus, and (4) agar + nitrogen + phosphorus. On the top of each cup, she placed a glass disk to provide a surface for the algae to grow.

Abby put 5 replicate cups for each treatment at both the Inlet and Outlet streams on the I8 Lake. She left them underwater for 4 weeks. She brought the cups back to the lab to measure the algae that grew on each glass disk. Abby measured how much algae grew on each disk by measuring the amount of Chlorophyll *a*, the green pigment that helps plants photosynthesize. The more pigment, the more the algae is growing. Abby compared the data from the control to each of the other treatments. When there is more growth in a treatment compared to the control, that means a particular nutrient was limiting at that location. Abby expected that the streams would be limited by the amount of phosphorus, but not the amount of nitrogen. She predicted algae would grow more when they are given additional phosphorus compared to the control treatment.

A. Cups before going into the stream. **B.** Abby putting out her cup treatments into an Arctic stream. **C.** Cups incubating under water in an Arctic stream. **D.** Analyzing Chlorophyll a extracted from the cups.

Scientific Question: What nutrient is limiting in the Inlet and Outlet streams?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

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Scientific Data:

Use the data below to answer the scientific question:

I8 Inlet				
Treatment	**Control**	**N**	**P**	**N+P**
Mean Chlorophyll a (ug/cm^2)	2.82	0.99	3.80	11.56
Standard Deviation (SD)*	1.01	0.19	1.89	4.39
Response Ratio**	--	0.35	1.35	4.10
I8 Outlet				
Treatment	**Control**	**N**	**P**	**N+P**
Mean Chlorophyll a (ug/cm^2)	0.91	1.44	1.10	7.63
Standard Deviation (SD)	0.21	0.39	0.22	1.85
Response Ratio	--	1.58	1.21	8.38

**Standard deviation (SD) tells us about the amount of variation in the data. A large SD means there is a lot of variation around the mean, while a small SD means the data points all fall very close to the mean.*

***The response ratio is the treatment response divided by the control response for each treatment at each site. When the response is = 1, this means that the treatment response is the same as the control. A response ratio of less than 1 indicates that adding nutrients inhibited algae growth; a response ratio of greater than 1 indicates that adding nutrients stimulated algae growth.*

What data will you graph to answer the question?

Independent variable(s): _____

_____

Dependent variable(s): _____

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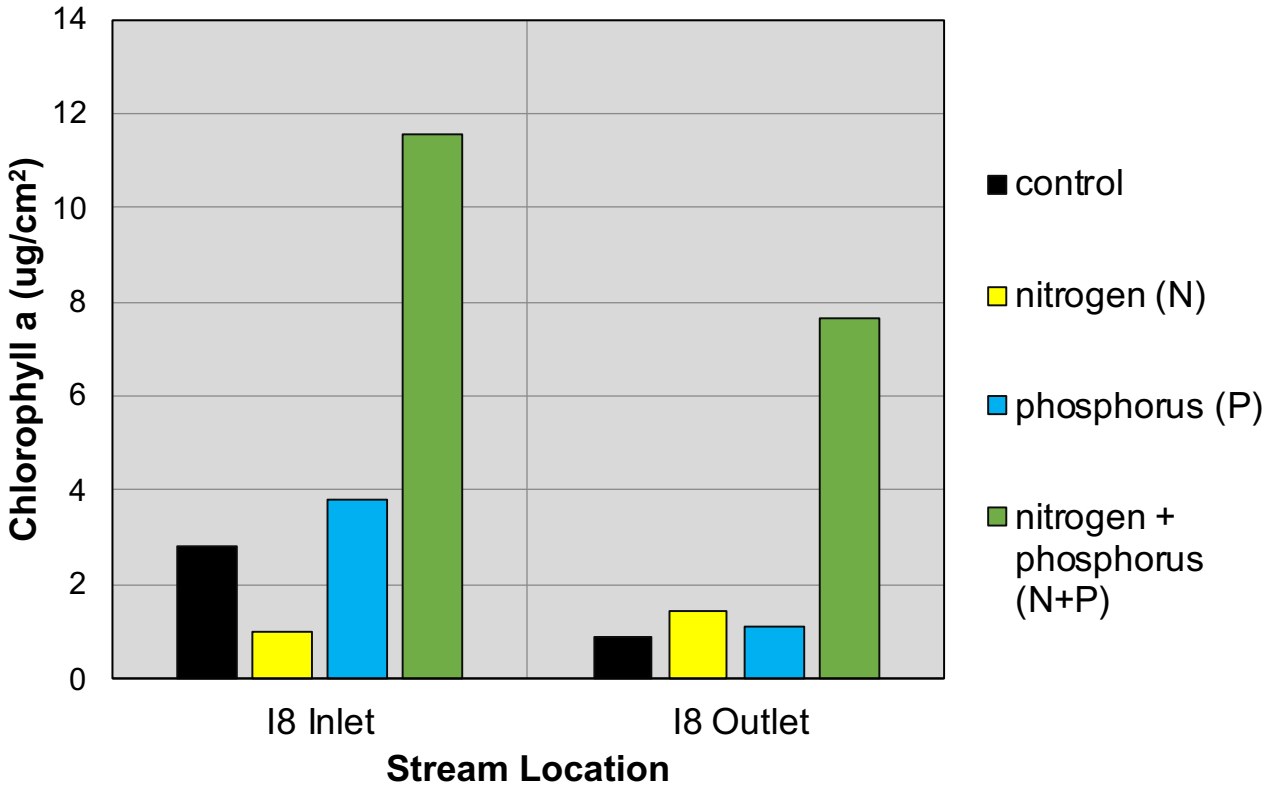
Name_____

Below is a graph of the data: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Interpret the data:

Make a claim that answers the scientific question.

Name_____

What evidence was used to write your claim? Reference specific parts of the table or graph.

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about nutrient limitation.

Did the data support Abby's hypothesis? Use evidence to explain why or why not. If you feel the data was inconclusive, explain why.

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Your next steps as a scientist: Science is an ongoing process. What new question do you think should be investigated? What future data should be collected to answer your question?