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DATA Nugget

Which tundra plants will win the climate change race?

Featured scientists: Gus Shaver (he/him), Jim Laundre (he/him), Laura Gough (she/her), and Ruby An (she/her) from Toolik Field Station, Arctic Long-Term Ecol. Research Site

Research Background:

The Arctic, the northernmost region of our planet, is home to a unique biome known as **tundra**. While you might think of the arctic tundra as a blanket of snow and polar bears, this vast landscape supports a diversity of unique plant and animal species. The tundra is an area without trees that supports many species of plants, mammals, birds, insects, and microbes.

Arctic environments present many challenges to plants. Temperatures only creep above freezing for about three months each year. This short arctic summer means that the species that live there only have a brief period to grow and reproduce. From mid-May to the end of July the sun doesn't set, so there's plenty of light available. Plants need this light for photosynthesis to make sugars for food.

Even when there is light, plants need to wait until the snow has melted and the soil has thawed enough for them to grow. Tundra plants have short roots since they can't grow through frozen ground. These roots try to get nutrients the plant needs from the soil. But with the soil so cold, decomposition is very slow. This means that microbes cannot easily convert dead plant material into nutrients that plants need such as nitrogen and phosphorus. For this reason, the growth of tundra plants is usually limited by nutrients.

Gus (left) and Jim (right) set up a weather station to monitor air temperature and humidity on the tundra.

Climate change is altering the arctic environment. With warmer seasons and fewer days with snow covering the ground, soils are thawing more deeply and becoming more nutrient-rich. With more nutrients available, some plant species may be able to

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outcompete other species by growing taller and making more leaves than other plant species. This means that climate change may alter the whole ecosystem game in the tundra. Instead of nutrients limiting plant growth, it may shift to a game of **competition** between plants reaching for light.

To simulate the environmental conditions, we can look at long-term data from two scientists, Gus and Terry, who started working at the Toolik Field Station in northern Alaska in the 1970s. They conducted a series of experiments and learned that two nutrients, nitrogen and phosphorus, limited plant growth in the tundra. Then, in 1981, they set up a new experiment where they added both nutrients to experimental plots every year. Gus and Terry compared plant growth between these fertilized plots and control plots that were not fertilized. They wanted to figure out how each plant species would respond to more nutrients over the long term and what would happen to the plant community to see if some species would outcompete others in the fertilized conditions. This experiment is one way to mimic future conditions and test hypotheses about what we might expect to see.

Ruby (left) collecting samples of tundra from the field.
Laura (right) plucking plants from a sample of tundra back in the lab.

The fertilizer was added every year in early June after the snow melted off the plots. Beginning in 1983, other scientists, such as Laura and Ruby, began to sample these plots. They dug out small 20-centimeter by 20-centimeter samples of tundra and brought them back to the nearby Toolik Field Station. In the lab, the tundra sample was separated into individual plant species and “plucked” to sort by different plant tissue types: leaves, stems, and roots. Then these plants were dried and weighed to determine the **biomass** (mass of living tissue) of each species in the sample. The fertilized and non-fertilized plots were sampled and plucked six times between 1983 and 2015. This means that many of the scientists who sampled the plots in 2015 had not yet been born when the experiment started in 1981!

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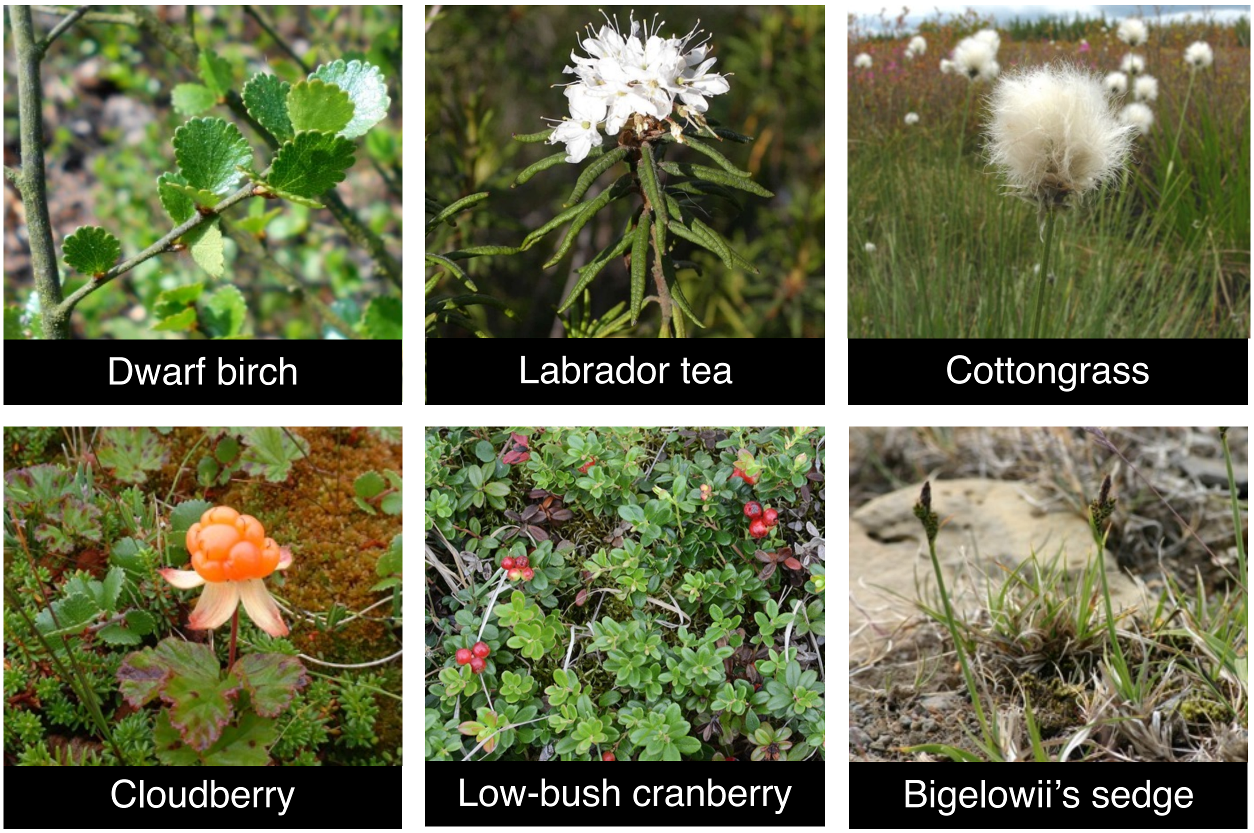
Scientific Question: Which tundra plant species will benefit most from greater nutrient availability over time?

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.



Some arctic tundra plant species monitored in this experiment. Dwarf birch is a deciduous shrub. Cloudberry is a flowering plant that does not make wood so it cannot get tall. Labrador tea and low-bush cranberry are evergreen shrubs. Cottongrass and Bigelowii's sedge are grass-like plants.

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Scientific Data:

Use the data on average aboveground biomass for 6 arctic tundra species to answer the scientific question:

			Tundra plant species - average aboveground biomass (g/m2)					
Years since beginning of experiment	**Year**	**Treatment**	Dwarf birch	Bigelowii's sedge	Cottongrass	Labrador tea	Cloudberry	Low-bush cranberry
3	1983	control	70.7	10.1	81.4	60.8	4.2	60.7
4	1984	control	51.0	10.4	40.1	64.2	2.7	63.6
9	1989	control	53.0	11.9	25.3	72.6	3.7	61.9
15	1995	control	68.8	4.1	46.1	102.4	3.0	71.1
20	2000	control	169.0	23.7	43.7	87.5	22.1	103.6
35	2015	control	152.2	12.0	18.1	80.9	29.7	41.4
3	1983	N+P added	124.1	19.9	133.0	75.1	11.2	40.0
4	1984	N+P added	74.4	16.5	103.2	71.8	8.2	61.2
9	1989	N+P added	360.0	4.9	32.3	56.2	32.8	14.8
15	1995	N+P added	730.7	2.8	7.1	27.8	20.5	1.0
20	2000	N+P added	762.9	2.1	0.4	7.6	36.0	0.3
35	2015	N+P added	956.5	0.0	0.1	6.2	21.4	0.0

What data will you graph to answer the question?

Independent variable(s): ______________________________

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Dependent variable(s): ______________________________

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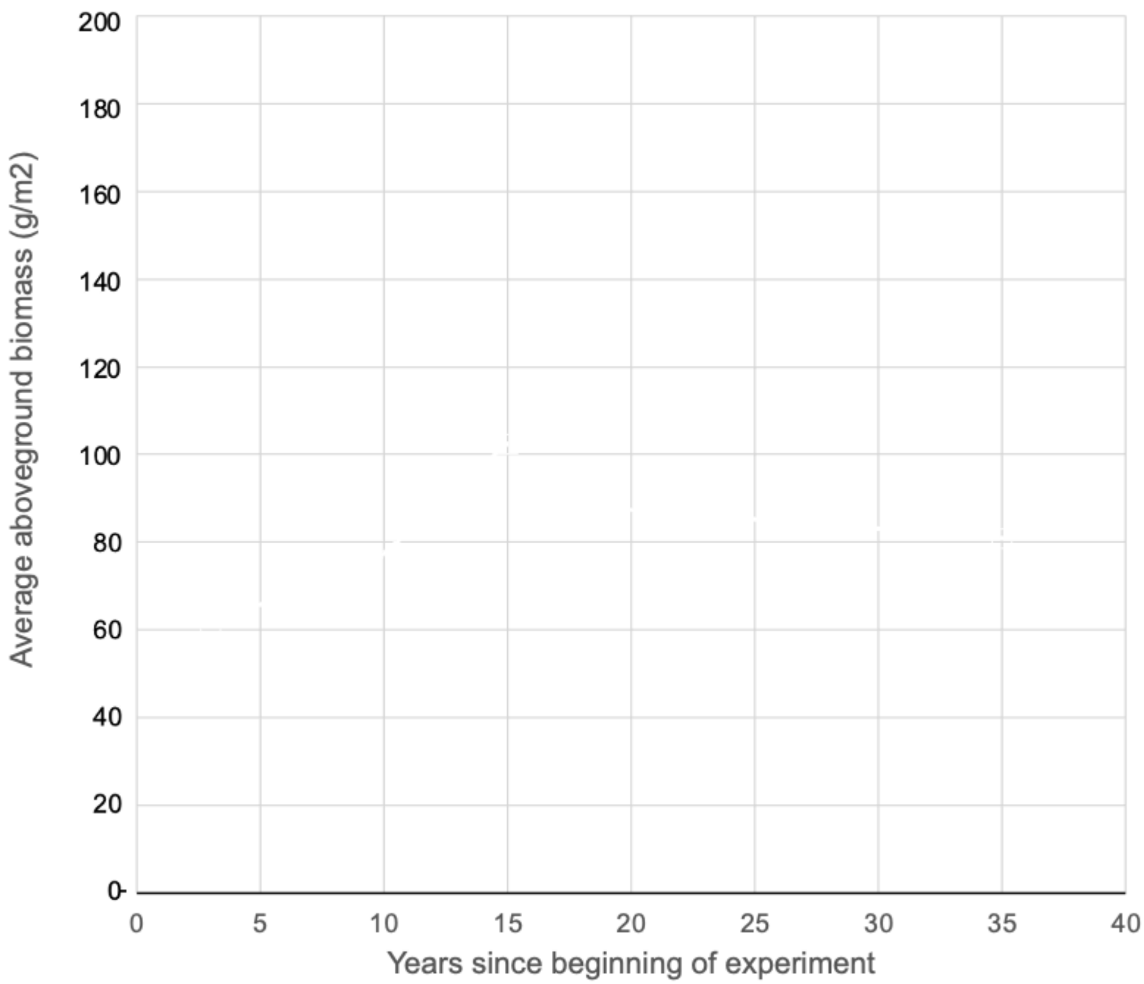
<u>*Below are graphs of the data*</u>: Identify any changes, trends, or differences you see in your graphs. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



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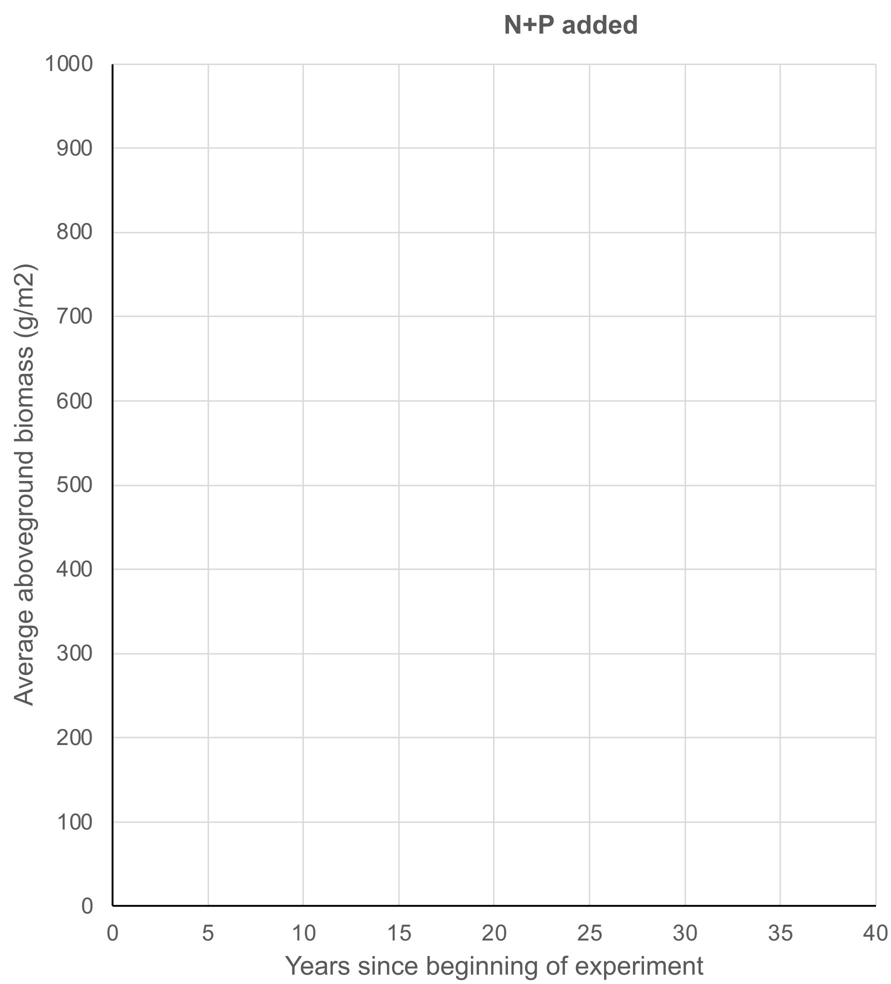

Interpret the data:

Make a claim that answers the scientific question, which tundra plant species will benefit most from greater nutrient availability over time?

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

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Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about limited nutrients and plant growth in the arctic tundra.

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

Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on Gus and Terry's research? How do your questions build on the research that has already been done?