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DATA Nugget

CO_2 and trees, too much of a good thing?

Featured scientists: Kristina J. Anderson-Teixeira (she/her) & Luca Morreale (he/him) at Smithsonian's National Zoo & Conservation Biology Institute. Written by Ryan Helcoski

Research Background:

The amount of **carbon dioxide** (CO_2) in the atmosphere has steadily increased since the start of the Industrial Revolution in 1750. This extra CO_2 traps heat like a blanket, causing the global climate to warm. The resulting **climate change** effect is known and widely accepted in science. While scientists are certain that climate change is happening, they still have many questions about its impacts.

For example, scientists today are exploring whether climate change will help or hurt trees and forests. Many scientists think that elevated CO_2 in the atmosphere can actually help trees. We can see why in the formula for **photosynthesis**:

$$6CO_2 + 6H_2O + Energy \rightarrow C_6H_{12}O_6 + 6O_2$$

Carbon Dioxide + Water + Energy (sunlight) → Glucose + Oxygen

If you add more CO_2 to the atmosphere, trees will have more resources for photosynthesis and can make more glucose. Glucose is food for the trees. Trees can use their glucose for growth, using it to make wood. However, trees sometimes have to put glucose towards other things. Just like us, plants break down glucose for energy through **cellular respiration**:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + Energy$$

Glucose + Oxygen → Carbon Dioxide + Water + Energy (ATP)

Trees need energy for everyday functioning, or to respond to stress. Under climate change, trees might experience more stress. **Stress** for trees might increase if summer temperatures get too hot, or they don't have enough water. More stress means more respiration and less growth. Or, even worse, the trees could die. Dead trees can't photosynthesize, and they also decompose, which releases CO_2 into the atmosphere as microbes break down wood and other materials.

Kristina and Luca are scientists looking at the effects of climate change on trees. They wanted to test whether climate change was benefitting or hurting trees. They set out to find some data that would allow them to test these alternative hypotheses.

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Kristina conducting the tree survey, measuring the size of a tree, which will later be used to calculate the mass of carbon in that tree.

Kristina runs a tree census in a forest at the Smithsonian Conservation Biology Center in Virginia. Since 2008, she and many other scientists have surveyed every tree in their 26-hectare plot. Every five years, they count up how many trees are alive, how much they've grown, and how many have died. Luca joined Kristina's lab in 2022. He and Kristina worked together with many other scientists to collect and process data on tree growth and mortality in 2023.

They used this growth and mortality data for individual trees to calculate levels of carbon gained and lost by the whole forest. The amount of carbon used for growth across the whole forest was measured as the **mass of carbon gained**. They also calculated the weight of the trees that died, which was measured as the **mass of carbon lost**. Both of these measurements were calculated in megagrams (Mg, that's one million grams) of carbon (C) per hectare (ha) of forest per year (yr), or (MgC/ha/yr). The difference between these two values is the **change in carbon**. This value gives the balance between carbon gained and lost. A positive value means there is more carbon being taken in by the forest than lost, and a negative value means that more carbon is being lost back to the atmosphere.

Left: Two large trees stand in the experimental plot after a survey. The tree to the right has been banded to measure its growth.

Right: A dead ash tree stands in the experimental plot after a survey. The carbon in this tree will return to the atmosphere through decomposition.

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Scientific Question: How is the carbon balance in the Smithsonian Conservation Biology Center changing over time?

What is the hypothesis? Find the two hypotheses in the Research Background and underline them. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies. Having two alternative hypotheses means that more than one mechanism may explain a given observation. Experimentation can determine if one, both, or neither hypothesis is supported.

Scientific Data:

Use the data below to answer the scientific question:

Census Interval	Mass of Carbon Gained (MgC/ha/yr)	Mass of Carbon Lost (MgC/ha/yr)	Change in Carbon (MgC/ha/yr)
2008- 2013	2.6	1.5	
2013- 2018	2.3	1.4	
2018- 2023	1.9	3.0	

What data will you graph to answer the question?

Independent variable: _____

Dependent variable: _____

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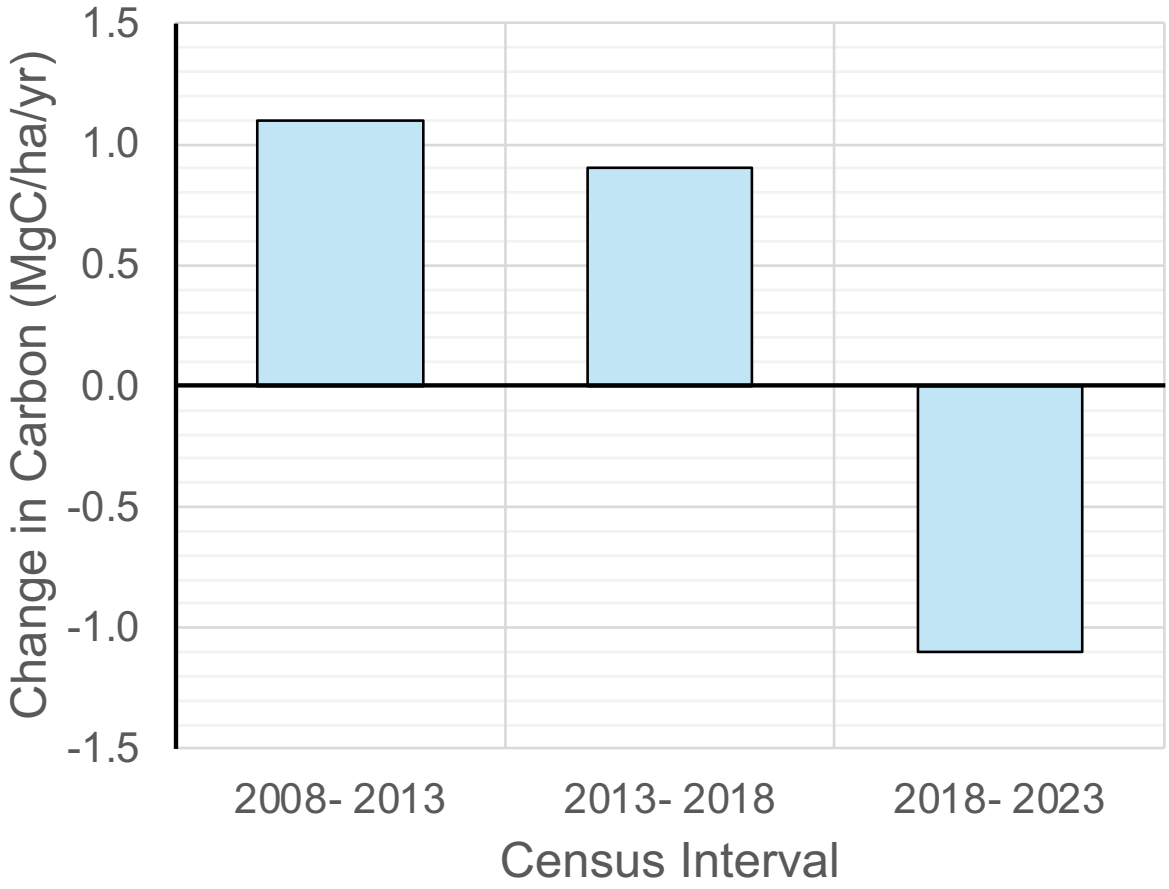
Below is a graph of the data: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.



Interpret the data:

Make a claim that answers the scientific question, how is the carbon balance in the Smithsonian Conservation Biology Center changing over time?

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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 how climate change influences the environmental conditions related to tree growth and survival.

Did the data support one, both, or neither of Kristina and Luca's two alternative hypotheses? Use evidence to explain why or why not. If you feel the data were inconclusive, explain why.

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