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DATA Nugget

Are forests helping in the fight against climate change?

Featured scientist: Bill Munger from Harvard University
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Research Background:

As humans drive cars and use electricity, we release carbon in the form of carbon dioxide (CO_2) into the air. Because CO_2 helps to trap heat near the surface of the earth, it is known as a **greenhouse gas** and contributes to climate change. However, carbon is also an important piece of natural ecosystems, because all living organisms contain carbon. For example, when plants **photosynthesize**, they take CO_2 from the air and turn it into other forms of carbon: sugars for food and structural compounds to build their stems, roots, and leaves. When the carbon in a living tree's trunk, roots, leaves, and branches stays there for a long time, the carbon is kept out of the air. This **carbon storage** helps reduce the amount of CO_2 in the atmosphere. However, not all of the CO_2 that trees take from the air during photosynthesis remains as part of the tree. Some of that carbon returns to the air during a process called **respiration**.

Another important part of the forest carbon cycle happens when trees drop their leaves and branches or die. The carbon that the tree has stored breaks down in a process called **decomposition**. Some of the stored carbon returns to the air as CO_2, but the rest of the carbon in those dead leaves and branches builds up on the forest floor, slowly becoming soil. Once carbon is stored in soil, it stays there for a long time. We can think of forests as a balancing act between carbon building up in trees and soil, and carbon released to the air by decomposition and respiration. When a forest is building up more carbon than it is releasing, we call that area a **carbon sink**, because overall more CO_2 is "sinking" into the forest and staying there. On the other hand, when more carbon is being released by the forest through decomposition and respiration, that area is a **carbon source**, because the forest is adding more carbon back into the atmosphere than it is taking in through photosynthesis.

In the 1990s, scientists began to wonder what role forests were having in this exchange of carbon in and out of the atmosphere. Were forests overall storing carbon (carbon sink), or releasing it (carbon source)? Bill is one of the scientists who decided to explore this question. Bill works at the Harvard Forest in central Massachusetts, a Long-Term Ecological Research site that specializes in setting up big experiments to learn how the environment works. Bill and his team of scientists realized they could measure the CO_2 coming into and out of an entire forest. They built large metal towers that stand taller than the forest trees around them and use sensors to measure the speed, direction, and

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CO_2 concentration of each puff of air that passes by. Bill compares the CO_2 in the air coming from the forest to the ones moving down into the forest from the atmosphere. With the CO_2 data from both directions, Bill calculates the **Net Ecosystem Exchange (or NEE for short)**. When more carbon is moving into the forest than out, NEE is a negative number because CO_2 is being taken out of the air. This often happens during the summer when trees are getting a lot of light and are therefore photosynthesizing. When more CO_2 is leaving the forest, it means that decomposition and respiration are greater than photosynthesis and the NEE is a positive number. This typically happens at night and in the winter, when trees aren't photosynthesizing but respiration and decomposition still occur. By adding up the NEE of each hour over a whole year, Bill finds the total amount of CO_2 the forest is adding or removing from the atmosphere that year.

Bill setting up a large metal tower in Harvard Forest in 1989, used to measure long-term CO_2 exchange.

Bill and his team were very interested in understanding NEE because of how important it is to the global carbon cycle, and therefore to climate change. They wanted to know which factors might cause the NEE of a forest to vary. Bill and other scientists collected data on carbon entering and leaving Harvard Forest for many years to see if they could find any patterns in NEE over time. By looking at how the NEE changes over time, predictions can be made about the future: are forests taking up more CO_2 than they release? Will they continue to do so under future climate change?

Fill in the table below with information and definitions from the Research Background.

Forest processes	Forest is a carbon source or sink?	Net Ecosystem Exchange (NEE) is positive or negative?
More carbon given off by respiration and decomposition than is taken in by photosynthesis.		
More carbon taken in by photosynthesis than is given off by respiration and decomposition.		

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Scientific Question: Is the Harvard Forest a carbon source or a carbon sink, and how has the net ecosystem exchange (NEE) changed over time?

Scientific Data:

Use the data below to answer the scientific question:

Year	NEE (grams carbon/ meters2/year)
1992	-164
1993	-179
1994	-173
1995	-282
1996	-194
1997	-163
1998	-157
1999	-213
2000	-261
2001	-426
2002	-270
2003	-212
2004	-458
2005	-543
2006	-458
2007	-537
2008	-612
2009	-358
2010	-36
2011	-150
2012	-339
2013	-218
2014	-459
2015	-194

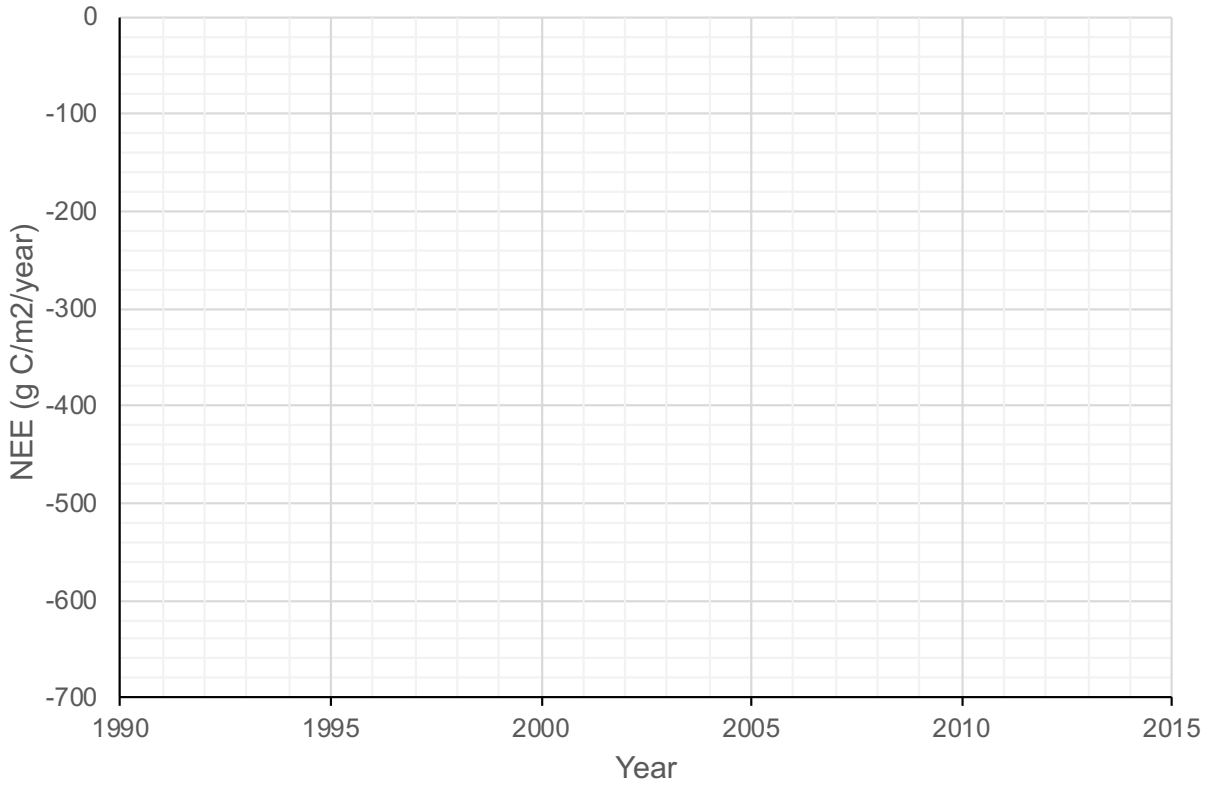
What data will you graph to answer the question?

Independent variable: _____

Dependent variable: _____

Name_____

Draw your graph below: 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 how the processes of photosynthesis, respiration, and decomposition influence the carbon cycle in forests.

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?

Independent variable(s): _____

Dependent variable(s): _____

Name_____

For each variable, explain why you included it and how it could be measured.

What hypothesis are you testing in your experiment? A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.