ACTIVITY 1

Stepping through Climate Science

This activity provides an overview of the connections between forests and climate. Students create a timeline of climate science over the past 200 years and gather information from a U.S. Forest Service video about climate mitigation and adaptation strategies for forests.

Subjects
Agriculture, Biology, Earth Science, Environmental Science, Language Arts, Mathematics, Social Studies

Skills
Communication, Discussing, Graphing, Inferring

Materials
Student pages, answer keys, and video (see Activity Webpage link below); 7 wire coat hangers and tape

Space Considerations
Area (inside or outside) large enough for students to form a 60-meter (or 200-foot) timeline

Time Considerations
Two to three 50-minute class periods

Related Activities
This activity helps introduce the module. It can be followed by any of the activities that help students explore climate (Activity 2) and forests (Activities 3, 4, and 5).

Research Connection
Scientists have been exploring the greenhouse effect and climate change for nearly two centuries. Many current projects are testing strategies for reducing the impact of climate change and for helping people adapt to these changes.

Activity Webpage
Find online materials for this activity at https://sfcc.plt.org/section1/activity1

Objectives

By the end of this activity, students will be able to

- explain three connections between forests and climate,
- describe the progression of scientific understanding of climate change, and
- define the terms adaptation and mitigation as they relate to climate change.

Assessment

- Review the Forest Service and Climate Change Video student page to see if the students understood the information from the video.
- Ask students to respond to the following writing prompt: The idea that the Earth's climate might be affected by human activities began in the late 1800s and continues to be a topic of research and investigation. What are three pieces of information that we know about climate science? What is one thing you would like to know more about?

Background

Over the past decade, many scientific studies and reports have been published on ***climate change***. This subject has been covered by the media, debated by politicians and community leaders, and discussed over dinner tables. But this doesn't mean that climate change is a "new" topic. In fact, scientists began to think about the science of ***climate*** as early as 1824, when a French scientist, Jean Baptiste Joseph Fourier, began studying ***greenhouse gases*** in our ***atmosphere*** and coined the term "***greenhouse effect***." Since that time, our understanding of the atmosphere, the greenhouse effect, the ***carbon cycle***, and climate change has continued to grow.

As scientists continue to study and understand climate change, they are also discovering how climate change might affect forest ***ecosystems***. Forests are inseparably linked to Earth's climate, as trees need water (usually in the form of rain) and sunlight to grow. Different ***species*** prefer different ***habitats*** and grow best within specific ranges of soil moisture, atmospheric moisture, and temperature. These conditions vary by region and with changes in ***topography***, so the ***structure*** and ***composition*** of forests also vary—creating diverse ecosystems in your own state and around the world. Forests can also influence climate. On a small scale, they create shade and microclimates. On a larger scale, they intercept and absorb energy emitted by the sun. Through the process of ***transpiration***, water is released from the surface of leaves, which in turn influences humidity in the atmosphere. Trees also remove ***carbon dioxide*** from the atmosphere during ***photosynthesis,*** release it into the atmosphere during ***respiration***, and store it in trunks, branches, leaves, and roots. Because of the large amounts of carbon that can be stored in forests, trees have a key role in the carbon cycle, and the reduction of forested land cover is one factor in the Earth's increasing global temperature.

Additional background information can be found in the **Section 1 Overview**.

LUDOVIC BRUCKER, NASA GODDARD SPACE FLIGHT CENTER

Ice core segments are used to study the amount of carbon dioxide present in the atmosphere at different points throughout history.

Since forests and climate are interconnected ***systems***, as the climate changes, some trees may be stressed while others may thrive. Long-term changes in average temperature and ***precipitation*** can influence ***forest health*** and survival by affecting tree growth, ***productivity***, and other disturbances such as insects and disease.

Changes in climate also affect wind and water currents, which can indirectly affect forests by influencing the frequency and severity of storms.

Resource management agencies, such as the U.S. Forest Service, are monitoring forest ecosystems to better understand what is changing and how forest managers could respond with ***adaptation*** and ***mitigation*** strategies (see activities in Section 2 and Section 3 for more details). Adaptation is an adjustment, made by natural or human systems, to environmental changes. In terms of climate change, this includes taking actions to avoid, benefit from, or deal with actual or expected impacts associated with changes in the planet's climate. Selecting species to plant or ***thinning*** a forest are two examples of forest management adaptations. Mitigation, on the other hand, includes actions that seek to decrease ***greenhouse gas emissions*** or to increase their removal from the ***atmosphere***. Communities, governments, and organizations are exploring adaptation and mitigation strategies and beginning to plan for future climate stressors. These actions can be seen in international agreements, national and local policies, and even within government agencies. The video in this activity shows students how one agency, the U.S. Forest Service, is developing adaptation and mitigation strategies as they plan and prepare for managing national forests in the face of climate change.

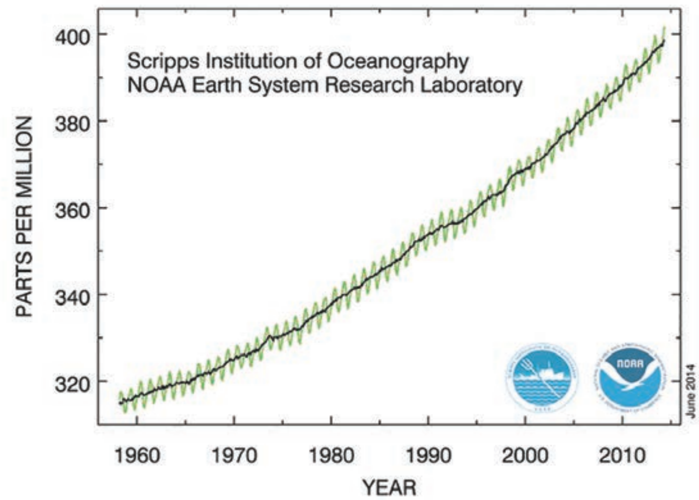
Systems Thinking Connection

SYSTEMS THINKING is a shift in focus from thinking about individual things (e.g., trees, people, products) to thinking about how those things are interconnected. It also involves a shift from focusing only on direct, linear connections—which are often easiest to see—to including multiple, indirect connections. To help students make these shifts, we suggest beginning this activity with a slight deviation by completing the **Learning about a Tree** systems exercise on the Activity 1 webpage. This supplementary discussion will help students understand how systems thinking can change the way that we think about a tree. An additional systems exercise, **Dynamic Systems Dance**, is described in the Systems Enrichment Exercise section.

ANNIE OXARART, UNIVERSITY OF FLORIDA

You can make timeline signs by folding the Interval Sign over a wire coat hanger and straightening the hanger hook to stick into the ground.

Atmospheric CO_2 at Mauna Loa Observatory



Data and Figure by Dr. Pieter Tans, NOAA/ESRL Keeling, Scripps Institution of Oceanography (scrippsco2.ucsd.edu)

Teaching This Content

This activity provides an introduction for the module—no matter which activities you choose to use next. If you are introducing the topic of climate change in your classroom, we suggest starting with this activity. If you are unsure of how your students will react to the topic of climate change, making a timeline is an easy, fact-based introduction to the subject. None of the items on the timeline are controversial; they are part of history. Still, students may find different ways to interpret these facts, which Activity 2 explores in greater detail.

Getting Ready

The Activity 1 webpage provides **Teacher Tools** that you can use to become more familiar with this activity's background and procedure (https://sfcc.plt.org/section1/activity1).

Select an area that enables you to make a timeline that is approximately 60 meters (200 feet) long. It can be in the schoolyard, a field, a hallway, or the interior of the school gym. The timeline can be linear or can wrap around the perimeter of a room or large circle.

Set up your timeline by posting interval signs to designate the amount of carbon dioxide measured in the atmosphere at key years. To create these signs, visit the Activity 1 webpage to download and print the Timeline Interval Signs. If you make your timeline outdoors, print the carbon dioxide labels on a piece of paper and fold them over the long part of a wire coat hanger (as shown in the photo). Straighten the hook of the hanger to form the stake. If you conduct the timeline activity inside, tape the signs on the wall. Space the carbon dioxide signs along your timeline, with each year representing one step (numbers of steps are listed on the Master Timeline).

Print and cut the Timeline Cards student page. They can be laminated for multiple uses. There are 25 event cards in the timeline. If you have more than 25 students, check the Activity 1 webpage for extra cards or have your students look up other world events within the designated years. Use the Master Timeline to help you provide verbal prompts and guidance to the students.

This figure, known as the Keeling Curve, shows the atmospheric carbon dioxide concentrations measured at Mauna Loa, Hawaii from 1958 to 2014. The green curve represents seasonal fluctuations in carbon dioxide, and the black curve represents seasonally corrected data.

U.S. FOREST SERVICE

This activity begins with a discussion about climate change. You might wish to take this conversation outdoors!

Make copies of the Climate Science Timeline student page and the Forest Service and Climate Change Video student page (one per student).

Be sure you can access the U.S. Forest Service video on the Activity 1 webpage.

Doing the Activity

Part A: Climate Change Timeline

1. Begin this activity with a discussion, which can take place inside or outside for inspiration. If outside, pick a tree to sit or stand near. Tell students that they are beginning a unit to explore climate, climate change, and forests. Then lead a class discussion with these questions.

- What do you think of when you hear the words climate change?
  Responses will vary. If you believe this could be a contentious issue, remind students of ground rules such as students have a right to their opinions and that this is a safe forum to speak their minds.
- How long do you think scientists have been talking about the greenhouse effect and climate change?
  Responses will vary. Start the timeline activity so they can learn the answer!

2. Give each student a card for the timeline. Also give each student a copy of the Climate Science Timeline student page. Walk them to the area where you have arranged the atmospheric carbon dioxide signs. Explain to students that they will be creating a climate science timeline by reading their cards one by one in order. Their cards represent two categories of events (1) scientific inventions, achievements, or discoveries and (2) domestic or international environmental policies. If your students are not familiar with the term *parts per million* (ppm), introduce this unit of scientific measurement, which is used to describe carbon dioxide concentrations in our atmosphere.

3. From the starting point of the first carbon dioxide sign at 1823, instruct the entire class to take one step to 1824 and ask for the student with the card labeled 1824 to read it aloud. Moving one step for every year, your next stop will be 35 steps to 1859. As each card in the timeline is read, ask the class if this was a scientific finding or a contribution related to policy and to mark an X on the appropriate timeline on their student pages. Help students plot the carbon dioxide levels on the graph on the Climate Science Timeline student page as they come across interval signs on the timeline. The Master Timeline tells you how many steps to take, identifies the card as science or policy, and provides reinforcing prompts for you to help students make sense of the events.

4. When the timeline is complete, provide a few minutes for students to finish the Climate Science Timeline student page. You can then use the questions on the student page to guide a discussion about the timeline.

- What event or piece of information surprised you the most?
  Responses will vary.
- Are there any events or pieces of information that were confusing to you?
  Responses will vary.
- What is happening to the amount of atmospheric carbon dioxide?
  The annual average measurement of atmospheric carbon dioxide has been increasing; levels have increased from 290 ppm in 1823 to 396 ppm in 2013, with much of the increase occurring in the later period of the timeline. You could ask students to calculate the percent change so they can understand that from 1823 to 1963, levels rose by 9.7 percent, and that from 1963 to 2013, levels rose by 24.5 percent. The example below outlines the steps in this calculation.

To calculate percent change from carbon dioxide in 1963 at 318 ppm to carbon dioxide in 2013 at 396 ppm, complete the following steps:
1) Calculate the change by subtracting the old value from the new value 396 – 318 = 78
2) Divide the change by the old value 78 ÷ 318 = 0.245
3) Convert to a percentage by multiplying by 100. The percent change is 24.5%.

- What trends do you notice about the dates of the science and policy events? Provide an explanation for why this might have happened.
  The science events occur throughout the timeline, while most of the policy events occur toward the end of the timeline. The first policy card did not appear on the timeline until 1988, and international policy preceded U.S. policy. Policy follows science.

Part B: Climate and Forests Video

1. Back in the classroom, ask students to describe some connections between trees and climate. How do they think changes in climate can affect trees? How do trees affect climate?
Trees create a microclimate with shade and moisture; trees are affected by climate conditions such as temperature, moisture, and storms. Climate can impact trees in many ways such as which trees live where, growing cycles, and resilience. The growth rate of trees could be affected if there is less water available because of droughts and warmer temperatures for longer periods of time.

2. Distribute the Forest Service and Climate Change Video student page and ask students to review the questions prior to watching the video to help them recognize the answers when they hear them.

3. Then show the video from the Activity 1 webpage and ask the students to complete the student page. The video is approximately 13 minutes long; suggested stopping points are at 8:17 and 10:35 for discussion. Alternatively, you may decide to have students watch the video for homework.

4. After the video, allow time for students to answer these discussion questions in small groups or individually and then review as a class. Use the following question to review this important concept:

- The video states, "If trees are destroyed, they release carbon into the atmosphere and thus become a source of greenhouse gas emissions." This is a problem in the short term. What could happen that would reduce this problem in the long term?
  The forest could be replanted and young trees could store the carbon that the harvested forest released. Or if the trunks of the harvested trees were made into wooden furniture or homes, those products could continue storing the carbon for a long period after the harvest.

TEACHERS SAY ...

The timeline allows for movement and has students working cooperatively. It also has the potential for further research of topics within the timeline.

—AP Environmental Science Teacher, Florida

My students liked the video. It was a good way to introduce my students to forestry and climate change.

—Environmental Science Teacher, Virginia

MORGAN CHEEK, NORTH CAROLINA STATE UNIVERSITY

5. Summarize this activity by asking students to review three things they learned about the history of climate. What concerns them about climate and forests? You might emphasize that scientists have been thinking about the impacts of increasing atmospheric carbon on the global climate for more than 200 years. Let students know that adaptation and mitigation strategies are currently being implemented to reduce the impact of climate change on forests. At this point, you can introduce the next activity from this module that you will be using with your students to explore these ideas further.

Modifications

Depending on the needs and abilities of your students, you may want to edit the timeline cards to simplify the information provided or to select only certain cards from the list. You can download the file from the Activity 1 webpage.

Review unfamiliar terms prior to doing the timeline with students.

The supplemental exercise, **Dynamic Systems Dance**, can help you explain systems and their behavior to students.

■ Systems Reflection: Name one of the systems discussed in the timeline or video and a variable that impacts that system.
The ocean is a system and additional carbon dioxide affects ocean health; forests are a system and variations in rainfall may affect tree health or groundwater supplies; the atmosphere is a system and additional carbon dioxide affects global temperature.

Enrichment

Students can add other events to the timeline to provide a frame of reference for climate events. Additional events could include domestic or international legislation, historical world events such as wars, other scientific achievements and discoveries, or environmental events such as the first Earth Day. Students can write a biography or vignette

Systems Enrichment Exercise

IMPROVED SYSTEMS THINKING SKILLS should help students better understand climate change, the role of forests in affecting climate change, and how people can mitigate and adapt to climate changes. In several activities, supplemental systems exercises are available on the activity webpages to enable teachers to focus attention on various aspects of systems and draw attention to how students can think about them. The **Dynamic Systems Dance** is a short exercise that can be conducted outdoors and can help you explain systems and their behavior to students. It can give you a foundation to refer to as you help students understand how complex systems respond to changes. This exercise can be found on the Activity 1 webpage and is based on a similar process described in the "Triangles" activity in The Systems Thinking Playbook by Linda Booth Sweeney and Dennis Meadows, 2010.

about one of the climate scientists featured in the timeline.

Additional Resources

Adapting to Climate Change: A Short Course for Land Managers
U.S. Forest Service, Climate Change Resource Center
http://www.fs.fed.us/ccrc/hjar/index_st.html
A series of videos and graphics illustrating the key concepts of climate change, possible impacts on U.S. forests and grasslands, and various strategies for adapting terrestrial systems to climate change.

Climate Change Resource Center
U.S. Forest Service
http://www.fs.fed.us/ccrc/
The Climate Change Resource Center provides information about basic climate sciences and compiles knowledge resources and support for adaptation and mitigation strategies. The site offers educational information, including basic science modules that explain climate and climate impacts, decision-support models, maps, simulations, case studies, toolkits, and videos.

Climate Connections Special Series
National Public Radio
http://www.npr.org/series/9657621/climate-connections
This NPR special features videos, articles, and interactive maps to look at the causes and signs of climate change, along with stories about solutions and adaptation.

The Climate Reality Project, Videos
The Climate Reality Project
http://climaterealityproject.org/video/
This website has several videos about climate change, carbon emissions, and solutions. Be sure to check out "Climate 101 with Bill Nye" to get a brief explanation of climate change and its potential effects on our planet.

Global Climate Change
NASA
http://climate.nasa.gov
This website provides information on the evidence, causes, effects, and uncertainties of climate change. There is also recent data on Earth's "vital signs" including global temperature, carbon dioxide levels, and the rate of sea level rise.

Natural Inquirer Science Education Journal
U.S. Forest Service
http://www.naturalinquirer.org/Natural-Inquirer-Climate-Change-Articles-v-80.html
The Natural Inquirer is a middle-school science education journal that is based on U.S. Forest Service research. Many issues have articles related to climate change, and all resources are available for download or you can order free copies.

References Cited

Caldeira, K., & Wickett, M. E. (2003). Oceanography: anthropogenic carbon and ocean pH. *Nature*, *425*(6956), 365–365.

Mason, J. (2013). The history of climate science. Retrieved from http://www.skepticalscience.com/history-climate-science.html

National Snow and Ice Data Center. (2014, April 2). Arctic sea ice at fifth lowest annual maximum. Retrieved from https://nsidc.org/arcticseaicenews/

Stroeve, J., Holland, M. M., Meier, W., Scambos, T., & Serreze, M. (2007). Arctic sea ice decline: Faster than forecast. *Geophysical Research Letters*, *34*(9).

Tans, P., & Keeling, R. (2014). Trends in atmospheric carbon dioxide. NOAA Earth System Research Laboratory. Retrieved from http://www.esrl.noaa.gov/gmd/ccgg/trends/

Weart, S. (2010). The discovery of global warming. Retrieved from http://www.aip.org/history/climate/summary.htm

TEACHERS SAY ...

When I taught this lesson, the kids wanted more. They enjoy these engaging activities.

—Earth Science Teacher, Florida

The discussions on climate science we had in class were powerful. Lots of debating on the position of science vs. government vs. stakeholders. I think this activity got them thinking and evaluating current climate science research and legislation.

—IB Biology II Teacher, Florida

Master Timeline (1 of 4)

Most of the events listed in the timeline below came from *The Discovery of Global Warming* by S. Weart (2010) and *The History of Climate Science* by J. Mason (2013). Events from additional references are cited in text. The carbon dioxide levels came from NOAA's Global Greenhouse Gas Reference Network (Tans & Keeling, 2014). Full citations can be found in the References Cited section of this activity.

Year	Event	Science or Policy	Reinforcing Prompt	Steps
1823	Carbon dioxide in the atmosphere was about 290 parts per million.	Interval Sign	While tools were not available at the time to measure atmospheric carbon dioxide levels, in the 1980s scientists learned how to measure air bubbles trapped in ice cores to determine atmospheric carbon dioxide levels from the past.	Walk 1 step
1824	Jean Baptiste Joseph Fourier (FOO-ree-ey), a French scientist, described Earth's atmosphere as an insulating blanket for the planet. He was the first to use the phrase the "greenhouse effect" to illustrate how the greenhouse gases keep the Earth a comfortable temperature despite our great distance from the sun.	Science		Walk 35 steps
1859	John Tyndall (TIN-dull), an Irish physicist, discovered that carbon dioxide is very good at trapping heat in the atmosphere. He worked with a variety of gases found in the atmosphere and found that carbon dioxide can block heat radiation.	Science		Walk 37 steps
1896	Svante Arrhenius (Suh-VAN-tay Are-REY-nee-oos), a Swedish scientist, was the first to say that increases in carbon dioxide in our atmosphere due to burning coal would cause a global warming effect.	Science	Coal replaced wood as the predominant energy source in the United States.	Walk 21 steps
1917	Alexander Graham Bell, a Scottish scientist and inventor of the telephone, wrote, "The unchecked burning of fossil fuels would have a sort of greenhouse effect" and "The net result is the greenhouse becomes a sort of hot-house."	Science	While Bell was most famous for the invention of the telephone, he worked in many fields of science. The 1917 paper was about natural resource depletion and demonstrated that many scientists were concerned about the impacts of green-house gases.	Walk 14 steps
1931	E.O. Hulburt, an American scientist, continued the work of Arrhenius (Are-REY-nee-oos), to include atmospheric water vapor and found that increases in carbon dioxide levels would increase global average temperatures by as much as approximately 4 degrees Celsius.	Science	This is equivalent to 7.2 degrees Fahrenheit.	Walk 7 steps

Master Timeline (2 of 4)

Year	Event	Science or Policy	Reinforcing Prompt	Steps
1938	Guy Callendar, an English engineer, looked at historical temperature records and carbon dioxide levels from around the world and concluded that levels had increased almost 10 percent since the 19th century and temperatures were warming globally.	Science		Walk 18 steps
1956	Gilbert Plass, an American physicist, published *The Carbon Dioxide Theory of Climate Change,* and said that more carbon dioxide in the atmosphere would increase global warming.	Science		Walk 1 step
1957	Roger Revelle (Ra-VELL), a scientist in California, said that there is a limit to how much carbon dioxide the ocean could absorb from the atmosphere and remain healthy.	Science	Previously, scientists thought the ocean could absorb unlimited amounts of carbon dioxide.	Walk 1 step
1958	Charles David Keeling (KEY-ling), a scientist from California, used new technology to measure levels of carbon dioxide in the atmosphere. Keeling measured atmospheric carbon dioxide levels to be 315 parts per million in 1958.	Science	The measurement stations that Keeling established in Antarctica and Mauna Loa, Hawaii, still function. They have allowed scientists to keep track of carbon dioxide levels and establish an increasing trend.	Walk 5 steps
1963	The annual average of carbon dioxide in the atmosphere was measured at 318 parts per million.	Interval Sign	Remember, the timeline started at 290 parts per million in 1823.	Walk 4 steps
1967	Syukuro Manabe (Shoo-KOO-roo Mah-NAH-bay), a meteorologist from Tokyo University, created the first computer model simulation of Earth's climate. This complex model included many variables and reaffirmed that the climate was changing, not only at Earth's surface but also throughout the atmosphere.	Science		Walk 6 steps
1973	The annual average of carbon dioxide in the atmosphere was measured at 330 parts per million.	Interval Sign		Walk 8 steps
1981	Climatologists Tom Wigley and Phil Jones wrote that "the effects of carbon dioxide may not be detectable until around the turn of the century. By this time, atmospheric carbon dioxide concentration will probably have become sufficiently high that a climatic change significantly larger than any which has occurred in the past century could be unavoidable."	Science		Walk 2 steps
1983	The annual average of carbon dioxide in the atmosphere was measured at 343 parts per million.	Interval Sign		Walk 2 steps
1985	A group of Russian scientists at the Vostok (VAH-stock) Station in Antarctica drilled an ice core about 2 kilometers (more than 1,980 meters or 6,500 feet!) deep. This ice core held approximately 150,000 years of climate history trapped in air bubbles.	Science	This is how we knew the carbon dioxide levels in 1823 when we started the timeline.	Walk 3 steps

Master Timeline (3 of 4)

Year	Event	Science or Policy	Reinforcing Prompt	Steps
1988	The Intergovernmental Panel on Climate Change (IPCC) was started. This international organization includes scientists and government officials from around the world who help synthesize climate science and make recommendations about how greenhouse gas emissions and climate change will impact the Earth and its inhabitants.	Policy		Walk 4 steps
1992	A significant number of the world's nations recognized that climate change needed to be addressed globally and formed the United Nations Framework Convention on Climate Change. Nearly every country, including the United States, signed the agreement.	Policy		Walk 1 step
1993	The annual average of carbon dioxide in the atmosphere was measured at 357 parts per million.	Interval Sign		No steps
1993	Ice cores from Greenland showed that in the past, drastic climate changes occurred in a span of only 10 years. This greatly changed impressions that a changing climate only happens on a slow, gradual basis.	Science		Walk 4 steps
1997	Negotiations at the United Nations' Conference on Climate Change in Kyoto, Japan, resulted in the Kyoto Protocol, an international agreement to reduce greenhouse gases.	Policy	The U.S. signed the Kyoto Protocol on November 12, 1998. However, the Protocol met opposition in the U.S. Congress and was never ratified.	Walk 6 steps
2003	The annual average of carbon dioxide in the atmosphere was measured at 376 parts per million.	Interval Sign		No steps
2003	Scientists reported that the increase in atmospheric carbon dioxide resulted in increased absorption of carbon dioxide in the oceans, causing a change in the pH of the oceans. The change in pH, which continues today, is larger than anything in the geological record for the last 300 million years (Caldeira & Wickett, 2003).	Science	Recall Roger Revelle from 1957, who thought the oceans can only absorb so much carbon and be healthy. This was proof that he was correct!	Walk 2 steps
2005	The European Union Emissions Trading System was launched to reduce greenhouse gas emissions through a "cap and trade" program.	Policy	A cap and trade program creates incentives for companies to reduce emissions and forces companies who pollute to pay for the privilege.	Walk 2 steps

Master Timeline (4 of 4)

Year	Event	Science or Policy	Reinforcing Prompt	Steps
2007	Scientists reported that the melting of Arctic sea ice has been faster than models originally predicted. They showed the rate of melting was accelerating (Stroeve et al., 2007).	Science		No steps
2007	The United Nations Framework Convention on Climate Change made important decisions on a climate change mitigation solution that seeks to reduce emissions from deforestation in developing countries. That initiative is called REDD+ (Red Plus).	Policy	This policy agreement is helping countries that still have forests to keep them.	Walk 1 step
2008	The U.S. Forest Service published a report called a "Strategic Framework for Responding to Climate Change," which outlined strategies that support adaptation to climate change in our national forests.	Policy		Walk 1 step
2009	The U.S. Interagency Climate Change Adaptation Task Force was created to develop recommendations for the U.S. president to prepare for and adapt to the effects of climate change at the national level.	Policy		Walk 4 steps
2013	The annual average of carbon dioxide in the atmosphere was measured at 396 parts per million.	Interval Sign	In May 2014, the daily average for atmospheric carbon dioxide exceeded 400 parts per million for the first time in recorded history. The level of carbon dioxide in the atmosphere varies by season, peaking in May just before many trees in the northern hemisphere get new leaves and begin to photosynthesize. The average annual level is not yet at 400 parts per million.	No steps
2013	Scientists measured the mean global temperature at 14.6 degrees Celsius, the warmest it has been in thousands of years.	Science	This average global temperature is equivalent to approximately 58 degrees Fahrenheit.	No steps
2013	The United States president, Barack Obama, signed an executive order that created the Council on Climate Preparedness and Resilience. The council works to help federal programs prepare for climate-related changes and provide information for the public.	Policy	This new Council replaced the Interagency Climate Change Adaptation Task Force.	Walk 1 step
2014	While much of the eastern United States experienced a colder than normal winter, it was warmer than normal in the Arctic (National Snow and Ice Data Center, 2014).	Science	It was so warm in the Arctic that the sea ice did not extend as it typically does. The winter of 2014 was the fourth lowest extent of Arctic sea ice ever recorded by satellites during February.	Done!

Timeline Cards (1 of 3)

1824	Jean Baptiste Joseph Fourier (FOO-ree-ey), a French scientist, described Earth's atmosphere as an insulating blanket for the planet. He was the first to use the phrase the "greenhouse effect" to illustrate how the greenhouse gases keep the Earth a comfortable temperature despite our great distance from the sun.
1859	John Tyndall (TIN-dull), an Irish physicist, discovered that carbon dioxide is very good at trapping heat in the atmosphere. He worked with a variety of gases found in the atmosphere and found that carbon dioxide can block heat radiation.
1896	Svante Arrhenius (Suh-VAN-tay Are-REY-nee-oos), a Swedish scientist, was the first to say that increases in carbon dioxide in our atmosphere due to burning coal would cause a global warming effect.
1917	Alexander Graham Bell, a Scottish scientist and inventor of the telephone, wrote, "The unchecked burning of fossil fuels would have a sort of greenhouse effect" and "The net result is the greenhouse becomes a sort of hot-house."
1931	E.O. Hulburt, an American scientist, continued the work of Arrhenius (Are-REY-nee-oos), to include atmospheric water vapor and found that increases in carbon dioxide levels would increase global average temperatures by as much as approximately 4 degrees Celsius.
1938	Guy Callendar, an English engineer, looked at historical temperature records and carbon dioxide levels from around the world and concluded that levels had increased almost 10 percent since the 19th century and temperatures were warming globally.
1956	Gilbert Plass, an American physicist, published *The Carbon Dioxide Theory of Climate Change,* and said that more carbon dioxide in the atmosphere would increase global warming.
1957	Roger Revelle (Ra-VELL), a scientist in California, said that there is a limit to how much carbon dioxide the ocean could absorb from the atmosphere and remain healthy.
1958	Charles David Keeling (KEY-ling), a scientist from California, used new technology to measure levels of carbon dioxide in the atmosphere. Keeling measured atmospheric carbon dioxide levels to be 315 parts per million in 1958.

Timeline Cards (2 of 3)

1967	Syukuro Manabe (Shoo-KOO-roo Mah-NAH-bay), a meteorologist from Tokyo University, created the first computer model simulation of Earth's climate. This complex model included many variables and reaffirmed that the climate was changing, not only at Earth's surface but also throughout the atmosphere.
1981	Climatologists Tom Wigley and Phil Jones wrote that "the effects of carbon dioxide may not be detectable until around the turn of the century. By this time, atmospheric carbon dioxide concentration will probably have become sufficiently high that a climatic change significantly larger than any which has occurred in the past century could be unavoidable."
1985	A group of Russian scientists at the Vostok (VAH-stock) Station in Antarctica drilled an ice core about 2 kilometers (more than 1,980 meters or 6,500 feet!) deep. This ice core held approximately 150,000 years of climate history trapped in air bubbles.
1988	The Intergovernmental Panel on Climate Change (IPCC) was started. This international organization includes scientists and government officials from around the world who help synthesize climate science and make recommendations about how greenhouse gas emissions and climate change will impact the Earth and its inhabitants.
1992	A significant number of the world's nations recognized that climate change needed to be addressed globally and formed the United Nations Framework Convention on Climate Change. Nearly every country, including the United States, signed the agreement.
1993	Ice cores from Greenland showed that in the past, drastic climate changes occurred in a span of only 10 years. This greatly changed impressions that a changing climate only happens on a slow, gradual basis.
1997	Negotiations at the United Nations' Conference on Climate Change in Kyoto, Japan, resulted in the Kyoto Protocol, an international agreement to reduce greenhouse gases.
2003	Scientists reported that the increase in atmospheric carbon dioxide resulted in increased absorption of carbon dioxide in the oceans, causing a change in the pH of the oceans. The change in pH, which continues today, is larger than anything in the geological record for the last 300 million years.

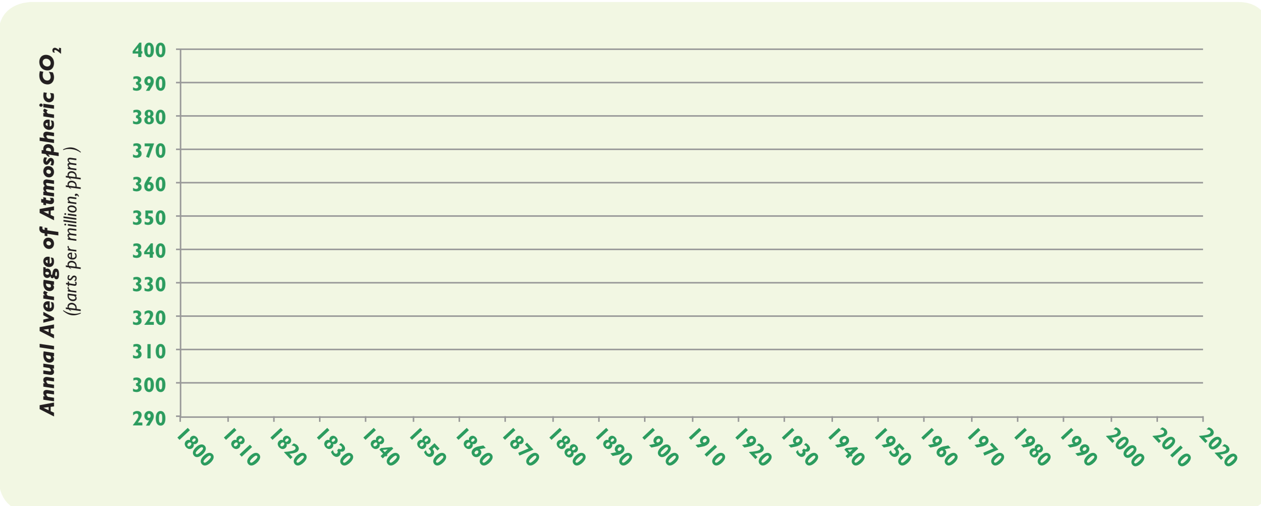
Timeline Cards (3 of 3)

2005	The European Union Emissions Trading System was launched to reduce greenhouse gas emissions through a "cap and trade" program.
2007	Scientists reported that the melting of Arctic sea ice has been faster than models originally predicted. They showed the rate of melting was accelerating.
2007	The United Nations Framework Convention on Climate Change made important decisions on a climate change mitigation solution that seeks to reduce emissions from deforestation in developing countries. That initiative is called REDD+ (Red Plus).
2008	The U.S. Forest Service published a report called a "Strategic Framework for Responding to Climate Change," which outlined strategies that support adaptation to climate change in our national forests.
2009	The U.S. Interagency Climate Change Adaptation Task Force was created to develop recommendations for the U.S. president to prepare for and adapt to the effects of climate change at the national level.
2013	Scientists measured the mean global temperature at 14.6 degrees Celsius, the warmest it has been in thousands of years.
2013	The United States president, Barack Obama, signed an executive order that created the Council on Climate Preparedness and Resilience. The council works to help federal programs prepare for climate-related changes and provide information for the public.
2014	While much of the eastern United States experienced a colder than normal winter, it was warmer than normal in the Arctic.

Climate Science Timeline (1 of 2)

NAME DATE

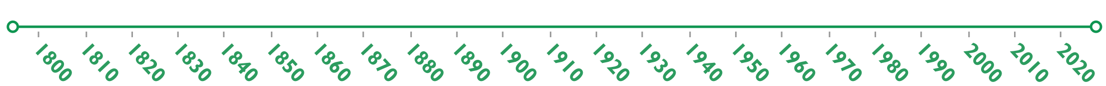
1. On the graph below, plot the measurements of atmospheric carbon dioxide (CO_2) as you step through the timeline of climate science. Once you make it through the entire timeline, connect the dots with straight lines to see how the amount of carbon dioxide in the atmosphere has changed over the past 200 years.



2. Mark the climate history events on the two timelines below. The events are categorized as either science or policy. As you listen to the dates of these events, add an "X" at the appropriate place on the correct timeline to indicate when that event took place.

Science Events:

Policy Events:



Climate Science Timeline (2 of 2)

3. Provide a one to two sentence response for the following questions.
   a. What event or piece of information surprised you the most?

   b. Are there any events or pieces of information that were confusing to you?

   c. What is happening to the amount of CO_2 in the atmosphere?

   d. What trends do you notice about the dates of the science and policy events? Provide an explanation for why this might have happened.

Forest Service and Climate Change Video (1 of 2)

____

NAME DATE

Read over the following questions. Then watch the 13-minute video to learn more about what the U.S. Forest Service is doing to help our forests as we deal with a changing climate. Answer the questions as you watch the video.

Video Questions

1. What is the environmentally friendly machine that helps to trap carbon dioxide (CO_2)? _______________
2. What is the process by which trees remove CO_2 from the atmosphere?
3. Forests cover almost __________________ of the world's total land area and account for ________% of the annual interchange of carbon between the atmosphere and the land.
4. Name the three main roles of the U.S. Forest Service with regard to climate change:

   1) ____

   2) ____

   3) ____

Video Break Discussion

5. What is mitigation? Describe one example of this strategy used by the U.S. Forest Service and explain how it mitigates against climate change.

Video Break Discussion

6. What is adaptation? Describe one example of this strategy and explain why it is an adaptation to future climate change.
7. Finish the quote: "It's not only about changing light bulbs, it's about changing

   ____________________________ and ____________________________ ."

Forest Service and Climate Change Video (2 of 2)

After Video Discussion Questions

1. What is the difference between adaptation and mitigation?

2. What is one practice that the U.S. Forest Service does to operate sustainably that your school could also do?

3. The video mentions both cutting down trees for wood products and planting trees to create new forests as mitigation strategies. How can both actions reduce the amount of CO_2 in the atmosphere?