Activity 2: Clearing the Air
Explaining the Evidence Presentation: Teacher Notes

<table>
<tr><th>Slide</th><th>Notes</th></tr>
<tr><td>1</td><td>These notes provide information that may help you comfortably use or know how to adapt this slide presentation. Additional background information can be found in Activity 2 of the module.</td></tr>
<tr><td>2</td><td>A variety of ideas, opinions, and beliefs surround the topic of climate change. Some information that we hear or read is based on scientific evidence, while other information is based on opinions or beliefs, which may or may not be supported by scientific evidence.

This presentation explores some of the scientific evidence supporting climate change and how the public can have varying opinions about climate change that don't always agree with the science. Understanding scientific evidence and the reasons that people might hold ideas that conflict with the scientific consensus are key steps for working together to move toward solutions for reducing and adapting to climate change.

Note: If you begin this activity with the Fact or Fiction quiz, you may wish to skip this slide.
If you want some answers:
Climate change is due to both natural and human causes, but most of the change is attributed to people.
While most climate scientists agree, scientists in general may be as divided as the general public.</td></tr>
<tr><td>3</td><td>Beliefs are ideas that we hold to be true and can be based on many things, such as past experiences, observations, facts, culture, faith, or beliefs of others. Beliefs are tentative and can change.

Assumptions are the underlying ideas that connect certain information to a certain conclusion. Assumptions may or may not be based on proven facts, and they may or may not be the result of rational or scientific thinking. Knowing what assumptions shape people's beliefs can help us comprehend why people believe what they do.</td></tr>
<tr><td>4</td><td>People are free to develop their own beliefs and assumptions about climate change. This slide contains two opposing beliefs that people might have about climate change. Possible assumptions supporting each belief are presented. Note how the assumption for the top belief contains a misconception (that we are not adding enough carbon dioxide to change the climate system).

The issue of climate change is complex and multifaceted, which makes it a difficult topic to explain and comprehend. Understanding the science is an important first step in deciding what to believe.</td></tr>
<tr><td>5</td><td>Scientific investigations use a variety of methods to help us understand what is happening in the natural and material world and allow us to evaluate our assumptions. Science involves observing events, asking questions and testing hypotheses, collecting data through</td></tr>
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	standardized measurements and observations, and stating assumptions that are used to link evidence to conclusions. • Hypothesis: Proposed explanation to a question • Data: Observations and measurements, collected systematically • Evidence: Interpreted data that supports or challenges a scientific idea • Conclusions: Beliefs based on evidence
6	Scientific evidence presented in the following slides will help answer this question: Is climate changing?
7	Weather and climate affect us every day. Weather describes the atmospheric conditions at a specific place at a specific point in time. Weather is what is happening outside right now. Climate is the long-term average weather conditions in a particular location or region at a particular time of the year. It is determined by long-term trends in weather. A helpful analogy to remember the difference between weather and climate is that weather tells you what you wear on any given day; climate tells you what wardrobe to have. This short video shows the relationship between weather and climate. http://www.youtube.com/watch?v=e0vj-0imOLw
8	The Earth's climate has changed over millions of years and is affected by many things. Due to the number of variables involved in climate, the evidence of climate change will not be the same across the globe. Polar regions are projected to experience more increased temperatures than tropical regions. Increases in greenhouse gas emissions result in more heat being trapped in Earth's atmosphere. This increase in heat will mean more evaporation from the Earth's surface, which can reduce soil moisture and increase drought in some places, while increasing rainfall and extreme storm events in other places. Evidence of climate change can be seen in long-term alterations to temperature, precipitation patterns, ice and snow cover, sea level, and the frequency of extreme weather events. Data about these variables are collected through weather instruments and records, tree rings, ice cores, satellite images, sedimentary layers, and other observations.
9	Collectively, data from meteorological weather stations, at airports, on mountains, on ships in the ocean, and by satellites, indicate that over the past 100 years the average surface temperature on Earth has increased by more than 1.4° F (0.8° C) (NRC, 2012). In this figure, the *x*-axis displays years (from 1880 to 2010) and the *y*-axis measures temperature anomaly, which is a comparison of average temperatures over a set time period to a long-term average temperature (called a base period; see following text for more information). The four colored lines represent four major global surface temperature analyses (based on temperature data from monitoring stations around the globe). The differences in the colored lines are the result of the varying ways data are analyzed by each institution. All four analyses (represented by the four lines) show that Earth has warmed since 1880. Most of this warming has occurred since the 1970s, with the 20 warmest years having occurred since

	1981 and with all 10 of the warmest years having occurred in the past 12 years. "It is not possible to calculate absolute global average surface temperatures for the GISS [Goddard Institute for Space Studies] analysis because weather stations aren't spread evenly enough across the globe to offer meaningful measurements. Scientists instead calculate a relative measure called a 'temperature anomaly' to track whether global temperatures are changing. To calculate temperature anomalies scientists compare average temperatures over any given time period—a month or year, for example—to a long-term average, or base period. The base period serves as a point of reference against which climate change can be tracked." (Voiland, 2011) In the Southeast, as with the global averages, the annual average temperature has increased the most since 1970, by approximately 2°Fahrenheit (1.1° Celsius) (USGCRP, 2009). This average increase in global surface temperature is known as global warming and can create other changes in climatic conditions, such as rainfall.
10	This graph shows the increase in temperature for the Northern Hemisphere using 1000 years of reconstructed data shown in blue (data from tree rings, corals, ice cores, and historical records) and instrumental data shown in red (data from thermometers). The *x*-axis shows the year (1000 to 2000), and the *y*-axis displays the difference in the average temperature for a given year as compared to the average temperature from 1961 to 1990 (the base period). Notice that temperature has changed over time and has increased in the last 50 years. The graph is further explained on the IPCC website (http://www.ipcc.ch/ipccreports/tar/wg1/figspm-1.htm): "Additionally, the year by year (blue curve) and 50 year average (black curve) variations of the average surface temperature of the Northern Hemisphere for the past 1000 years have been reconstructed from proxy data calibrated against thermometer data (see list of the main proxy data in the diagram). The 95 percent confidence range in the annual data is represented by the grey region. These uncertainties increase in more distant times and are always much larger than in the instrumental record due to the use of relatively sparse proxy data."
11	While the total precipitation in the U.S. has increased by about 5 percent in the past 50 years, this increase has not been consistently experienced by all locations in the country (NRC, 2012). Precipitation frequencies and distributions vary widely with short distances, so it is more helpful to look at regional changes in precipitation rather than global changes. The figure on the left illustrates observed precipitation changes from 1901 to 2007 in the Southeast. The data show that average fall precipitation increased by 30 percent since the early 1900s, and that summer and winter precipitation decreased by almost 10 percent in the eastern part of the region. Southeastern Florida has experienced a nearly 10 percent drop in precipitation in spring, summer, and fall. The percentage of the Southeast region in drought has increased over recent decades (USGCRP, 2009). If this long-term trend is statistically significant, we can say that this is evidence of climate change. The table presents data to address the statistical significance of precipitation trends in the Southeast (Kunkel et al, 2013). Values for each season are presented in the table only if they

	are statistically significant at the 95 percent confidence level (significance was tested using Kendall's tau coefficient). In the Southeast from 1895 to 2011, two seasons (summer and fall) experienced statistically significant precipitation anomalies (changes from a base average). Note that significant yet opposing seasonal trends (in this case, less precipitation in the summer and more in the fall) result in there being no significant trends when it comes to an annual change in precipitation.
12	Arctic sea ice is ice found in the Arctic Ocean. Some of this ice melts every year due to the change of seasons, but some of this ice remains even in the summer and then continues to grow in the fall. Comparing how much ice there is at the same time each year (using ice extent or ice area) can potentially provide evidence of climate change. Antarctica has sea ice as well, but almost all of the sea ice that forms in the winter melts in the summer months. In addition, annual sea ice patterns at the South Pole are variable, due to differences in geography and weather patterns in this region. In some areas, the ice is expanding; in others, the ice is shrinking. The North Pole shows more consistent trends, with sea ice generally declining annually *(see Current Status and Trends on this NASA webpage on Antarctic Sea Ice http://earthobservatory.nasa.gov/Features/SeaIce/page4.php).* The National Snow and Ice Data Center (NSIDC, 2013) explains sea ice and its importance: "Sea ice is frozen ocean water. It forms, grows, and melts in the ocean. In contrast, icebergs, glaciers, and ice shelves float in the ocean but originate on land. For most of the year, sea ice is typically covered with snow. Arctic sea ice keeps the polar regions cool and helps moderate global climate. Sea ice has a bright surface; 80 percent of the sunlight that strikes it is reflected back into space. As sea ice melts in the summer, it exposes the dark ocean surface. Instead of reflecting 80 percent of the sunlight, the ocean absorbs 90 percent of the sunlight. The oceans heat up, and Arctic temperatures rise further. A small temperature increase at the poles leads to still greater warming over time, making the poles the most sensitive regions to climate change on Earth. According to scientific measurements, both the thickness and extent of summer sea ice in the Arctic have shown a dramatic decline over the past thirty years. This is consistent with observations of a warming Arctic. The loss of sea ice also has the potential to accelerate global warming trends and to change climate patterns." NSIDC (2008) defines sea ice extent and compares it to sea ice area: "Area and extent are different measures and give scientists slightly different information. Some organizations, including Cryosphere Today, report ice area; NSIDC primarily reports ice extent. Extent is always a larger number than area, and there are pros and cons associated with each method. A simplified way to think of extent versus area is to imagine a slice of Swiss cheese. Extent would be a measure of the edges of the slice of cheese and all of the space inside it. Area would be the measure of where there is cheese only, not including the holes. That is why if you compare extent and area in the same time period, extent is always bigger." It is important to compare the same months across years, as comparing the ice extent in December to the ice extent in July would represent a change in season rather than a change in climate. This figure shows the average Arctic sea ice extent in December for the years 1979 to 2012. From the graph, you can see that the average Arctic sea ice extent for December 2012 was the

	second lowest for the month in the satellite record. Through 2012, the linear rate of decline for December ice extent is -3.5 percent per decade relative to the 1979 to 2000 average. While the winter ice extent for the Arctic as a whole shows only modest declines, large negative trends are now found in nearly all of the peripheral seas, with the exception of the Bering Sea.
13	The rise in sea level is attributed to two main causes: ocean expansion due to warmer temperatures and the melting of glaciers and polar land ice. Like any body of liquid, a warmer ocean expands as the molecules move at greater speeds, and bigger oceans lap higher along shorelines. This expansion of warm water has contributed to global sea level rise, which is estimated to be about 8 inches higher than it was in 1870 (NRC, 2012). Sea levels are also affected by melting glaciers and polar land ice–both of which originate on land and therefore contribute additional water to the ocean when melted. On the other hand, melting sea ice (ice already in the ocean, such as icebergs and ice sheets), does not contribute to changes in sea level because the ice is already displacing water in the ocean and, therefore, does not contribute to overall changes in the volume of the ocean when melted. The figure on the left shows global sea level rise from 1870 to 2000, with a rate of change of 1.70 millimeters per year in the 20th century. The figure on the right show global sea level rise from 1993 to 2014, with a rate of change nearly double, at 3.17 millimeters per year. This is evidence of climate change. Note that while the *x*-axes both measure year, the scales on both axes are different. If the recent data were graphed onto the left graph, the line would increase at a greater rate. The two graphs also differ in that different measurement tools were used to collect the data displayed. Sea levels are measured with tide gauges (as in the graph on the left) and satellite images (as in the graph on the right).
14	Climate change can also be seen through long-term alterations to the frequency and intensity of weather events, such as periods of extreme heat and cold, droughts, floods, winter storms, thunderstorms and tornados, and hurricanes. This figure shows that the number of recorded global catastrophes has been increasing since the 1980s. The black line represents the general trend of reported disasters that fall into four broad categories: geophysical events (e.g., earthquake, tsunami, volcanic eruption), meteorological events (e.g., storms), hydrological events (e.g., flood, mass movement of land/snow/debris associated with water flow) and climatological events (e.g., extreme temperature, drought, forest fire). Some of the increase may be attributed to better recording and reporting of natural disasters. An array of other factors affects each kind of disaster and these confounding factors make it difficult to pinpoint climate change as the primary cause of the trend, including the definition of a catastrophe, which reflects impacts to people and costs to insurance providers. Geophysical events are shown in red, at the bottom of each bar. You can see that these types of events do not have an obvious increase over the years as compared to the other types of events (green, blue, and yellow parts) that have been occurring more frequently. Again, a

	number of variables come into play. For example, floods are driven not just by climate but by land surface processes, such as urbanization. Climate change is potentially one of the factors contributing to the increase of all of the events in the green, blue, and yellow bars, as well as to a host of other climate-related disasters such as famine and insect infestations. Climate change would not affect the frequency of geophysical events. Trends in extreme weather events are best identified regionally and must be considered in the range of weather patterns that typically affect the area. In the southeastern region, the trends in weather events vary. The frequency of flood events has been increasing since the late 1800s, particularly within the last two decades. This may be due, in part, to increases in impermeable surfaces in cities across the region. At the same time, decadal frequencies of hurricane landfalls in the region have slightly decreased over the past 100 years. The frequencies of extreme maximum temperatures and extreme minimum temperatures have been decreasing across much of the region since the early 20th century, perhaps due to reforestation practices. However, the frequency of minimum temperatures above 75°F (24°C) has been increasing across the majority of the Southeast (Ingram, Carter, & Dow, 2012).
15	To make projections about the future, it is important to know why climate change is happening. Research shows that there are two major sources of climate change–natural changes and human-induced changes.
16	Changes in climate are driven by many factors, both human and natural. These factors include solar radiation, ocean composition, greenhouse effect, albedo effect, continental land arrangement, volcanic eruptions, fossil fuel combustion, and land-use change from human activities. Natural factors that affect climate are always present and have changed climate over millennia. For example, historical climate change that created ice ages was due to fluctuations in forces such as solar energy coming to Earth (solar radiation) and the amount of solar radiation that was reflected off Earth (albedo). More solar energy coming to Earth tends to increase temperatures, and more solar radiation reflected off Earth tends to decrease it. While natural forces explain historical climate shifts, those same factors do not account for the changes that are now being observed. Recent models of climate change suggest that both natural and human-induced changes are responsible for recent increases in global temperature. The next few slides examine some of these factors in more detail.
17	The greenhouse effect is a natural process that supports life on Earth. It can be thought of as a blanket that warms the Earth. Energy from the sun hits the Earth. Some of it is absorbed, and some of it is re-radiated back from the warmed-up surface of the Earth as infrared radiation. The energy that is re-radiated back either returns to space, or greenhouse gases “trap” or absorb the infrared radiation. Then, they re-emit the radiation, which acts to warm Earth’s surface and the lower atmosphere. This moderates the Earth’s temperature and allows life on Earth, as we know it, to survive (even thrive). More greenhouse gases, however, has been shown to lead to more warming.
18	This graph shows the relationship between energy from the sun, even as it is moderated by the

	greenhouse effect, and global temperature. The thick red line shows 11-year average global temperature and corresponds to the red scale on the right *y*-axis. The thick blue line is 11-year average of incoming solar radiation and is measured in the scale on the left *y*-axis. Since the sun's energy is the main driver of Earth's climate, it is no surprise that studies have shown a historical trend that when solar radiation increases or decreases, global temperature increases or decreases in the same direction. As the graph shows, however, around 1975 this trend stopped. Cook (2013) reports the following: "In fact, a number of independent measurements of solar activity indicate the sun has shown a slight cooling trend since 1960, over the same period that global temperatures have been warming. Over the last 35 years of global warming, sun and climate have been moving in opposite directions."
19	This graph indicates how several factors (both natural and human-caused) affect the composition of the atmosphere and the changes in incoming and outgoing energy (measured as radiative forcing). Forster et al. (2007) define radiative forcing as "a measure of how the energy balance of the Earth-atmosphere system is influenced when factors that affect climate are altered. The word 'radiative' arises because these factors change the balance between incoming solar radiation and outgoing infrared radiation within the Earth's atmosphere. This radiative balance controls the Earth's surface temperature. The term "forcing" is used to indicate that Earth's radiative balance is being pushed away from its normal state. When radiative forcing from a factor or group of factors is evaluated as positive, the energy of the Earth-atmosphere system will ultimately increase, leading to a warming of the system. In contrast, for a negative radiative forcing, the energy will ultimately decrease, leading to a cooling of the system." A cooling effect in the atmosphere (called a "negative radiative forcing") is represented when any of the lines fall below the 0 on the *y*-axis. A warming effect (called a "positive radiative forcing") is indicated when a line rises above 0. One factor affecting the composition of the atmosphere that is easy to explain: volcanoes. The radiative forcing related to volcanoes is represented by the dark purple line in the graph above. Volcanic eruptions can affect global climate by spewing sulfuric gases that become sulfate aerosols in the stratosphere. These aerosols reflect back significant amounts of solar radiation for two to three years after an eruption, causing a sudden but short-lived cooling effect (indicated by the large dips in the purple line). Looking at the graph, you can see that in the early and mid-1900s there was little volcanic activity (volcanic activities are near 0). Scientists suggest that this lack of a cooling effect from a lack of volcanic activity and eruptions contributed to the global warming in the early 1900s. Major volcanic eruptions took place after 1960 (as seen in dips of the purple line) and should have resulted in a cooling trend, but that global cooling did not occur. This suggests that other factors negated the cooling effect that volcanic eruptions should have had on the atmosphere. The red line labeled "LLGHG" represents long-lived greenhouse gases, such as carbon dioxide, methane (CH_4), and nitrous oxide (N_2O) that stay in the atmosphere for periods of ten years or longer. The recent rise of the red line in the graph represents the warming influence (positive radiative forcing) caused by the increased emissions of LLGHGs. The thick black line is a measure of the combined radiative forcing of human-caused factors of LLGHGs, ozone,

	aerosols, and land use changes. The black line does not show as much of an increase as LLGHGs alone (the red line) because of the cooling influences of aerosols and ozone in the stratosphere.
20	Unlike the rest of the United States, the Southeast shows a somewhat surprising temperature DECREASE over the last 100 years. Climatologists think this can be explained by the changes in land use over time. Back when the South was covered in cotton, the bare soil between the rows would have absorbed heat and radiated it to the atmosphere. Now that 70 percent of the region is covered in pine trees, the green surface reflects more light and puts out more water vapor, resulting in a cooler environment. But since about 1970, temperatures in the Southeast have been rising, too, in concert with the rest of the world, even though land use has stabilized.
21	The levels of greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4), ozone (O_3), and nitrous oxide (N_2O), act to insulate the Earth through the greenhouse effect. More of these gases mean warmer temperatures. Less of these gases mean cooler temperatures. Measurements from ice core samples representing the past several thousand years indicate that until the late 1800s, carbon dioxide levels in the Earth's atmosphere had been fairly stable at about 280 parts per million (ppm). Recent annual levels of 393 ppm have been recorded (with seasonal fluctuation as high as 401 ppm), indicating a 40 percent increase since pre-industrial times. Researchers have noted that the rise in carbon dioxide and other greenhouse gases coincides with a rise in average global temperature. Water vapor is another greenhouse gas but is not included in the table because of the inherent difficulties in presenting a single number representing the amount of water vapor in the atmosphere (this amount varies based on time and region). Cook (2013) explains it this way: "Water vapor is the most dominant greenhouse gas. Water vapor is also the dominant positive feedback in our climate system and amplifies any warming caused by changes in atmospheric CO_2. This positive feedback is why climate is so sensitive to CO_2 warming." Basically, as carbon dioxide and other greenhouse gases increase, they cause the temperature to rise, leading to an increase of water vapor, which leads to even more warming. Note: There are two units of measurement for the greenhouse gases in this table: ppm is parts per million; ppb is parts per billion.
22	These charts show the recent increase in greenhouse gases compared to the past 20,000 years. The greenhouse gas increases are from fossil fuels combustion, pesticides, and fertilizers as well as other human activity. Scientists can determine the source of some greenhouse gases by tracking different isotopes (i.e., a variation of a chemical element with a different number of neutrons in each atom). For example, carbon from fossil fuels contains a different isotope from that found in trees and other living things. For more information about carbon isotopes: www.esrl.noaa.gov/gmd/outreach/isotopes. In graphs a, b, and c, which display information about carbon dioxide, methane, and nitrous oxide, the left *y*-axis shows the concentration level of the greenhouse gas in question. The right *y*-axis measures the radiative forcing (see previous slide on volcanic eruptions for information about radiative forcing). The *x*-axis shows how many years ago (pre-2005) the levels occurred. The grey bars give an additional piece of information showing the range of levels at which the

	gases naturally occurred in the past 650,000 years. Graph d shows the combined rate of change for all three of the greenhouse gases in graphs a, b, and c.
23	In the United States, 57 percent of our greenhouse gas emissions are from carbon dioxide. Carbon dioxide is more abundant and stays in the atmosphere for longer periods of time than other gases. From the graph on the right, we can see that in 90 years, if we continue to burn fossil fuels at our current rate, carbon dioxide concentrations will be much higher than they are now.
24	Carbon is a critical element in all life forms; it is part of DNA and all other organic molecules. Carbon is found everywhere, in coral reefs, oceans, soils, plants, the atmosphere, and even in some rocks like limestone and marble. Plant photosynthesis converts carbon dioxide to glucose, which can be converted to energy for that plant, stored in cellulose, eaten by an animal, and so on. This is all part of the carbon cycle. The biological carbon cycle is more or less balanced, with relatively equal amounts of carbon entering and leaving various carbon pools. Notice that 120 gigatons of carbon move into plants through photosynthesis, and 60 move back to the atmosphere through plant respiration and the other 60 move back to the atmosphere through microbial respiration and decomposition. Also notice that for the ocean, the amount of carbon cycling between the atmosphere and the surface ocean are equal. However, burning fossil fuel carbon in coal, oil, or natural gas puts additional carbon in atmosphere. Note the red digits in this figure, which illustrate the human emissions due to the combustion of fossil fuels. Nine gigatons of carbon are released through human emissions. Three of these gigatons are taken up by photosynthesis, and the ocean takes up two. This leaves a net annual increase of four gigatons from human emissions into the atmosphere. The numbers in parentheses measure carbon stored in carbon pools. All numbers refer to gigatons of carbon per year.
25	These graphs show two models: the blue lines are the expected temperature if natural forces alone were responsible for climate. The pink bands combine natural and human causes of climate change. The black line is what has been actually measured. These graphs show that in order to best replicate historical observations of global and continental average temperature (or what has happened in the past), climate models need to include both natural and human-induced impacts. If climate models accurately represent the past observations, we have more confidence that they will be able to model future conditions at the global and continental spatial scale.
26	Scientists use evidence to draw conclusions. In this case, many lines of evidence about climate change point to trends that do not match historical averages and appear to be accelerated. Scientists agree that our climate is changing differently than it has in the past and that these changes are caused, in large part, by human activities that have led to global warming.
27	In this pictograph, the 97 green human figures represent the 97 percent of climate scientists

	who agree that human activity is a major cause of climate change. The two gray human figures represent the 2 percent of climate scientists that are undecided about whether humans play a major role in climate change. The sole red human figure presents the 1 percent of climate scientists who disagree that humans are causing climate change. The 97% statistic is based on two studies: • Doran and Zimmerman (2009) surveyed Earth scientists, and found that of the 77 scientists responding to their survey who are actively publishing climate science research, 75 (97.4%) agreed that “human activity is a significant contributing factor in changing mean global temperatures.” • Anderegg et al. (2010) compiled a list of 908 researchers with at least 20 peer-reviewed climate-related publications and found “about 97% of self-identified actively publishing climate scientists agree with the tenets of anthropogenic climate change.” While other studies have found broad agreement among scientists regarding human-caused climate change, the actual percentage of scientists who agree varies by study because the respondents may represent different groups (e.g., climate scientists, non-climate scientists) and due to variations in questions asked—surveys that ask about recent warming, global warming, or climate change will get different responses.
28	Climatologists use climate models to make projections. We call them projections not predictions because they strongly depend on how humans will act. Whether we enact policies to reduce carbon emissions (and then do so) is the biggest source of uncertainty, so on a global scale we can only project what could happen based on different emission scenarios.
29	Climatologists use climate models to make projections, and some projections have more support and certainty than others. Projections describe how future climate is expected to respond to various scenarios of the factors that might affect climate change, such as population growth, greenhouse gas emissions, and land development patterns. The graph displays several scenarios based on data from climate models that show projected temperature change from 2000 to 2100 in comparison to temperatures in 1990. The different colored lines each represent a different scenario; for example, A1F1 and B2 are the names of two different scenarios. The multicolored bars to the far right of the graph represent the range of uncertainty for each scenario based on model results for 2100. The area of light blue shows the complete range of temperature change for all climate models used in developing the scenarios and the darker blue area shows the range of temperature change for an “average” climate model. Note that all models show an increase in temperature; what is unknown is how much warmer it will get.
30	This map shows projected shifts in the range of species that can occur under low and high emission scenarios for the future. As climate changes over the next century, the northern boreal forest will most likely disappear in the United States, allowing the oak/hickory forest of the mid latitudes to take over as the dominant forest. Note: There is an animation on this slide. Click TWICE. There are three images within this slide: Present, Lower emissions scenario, and Higher emissions scenario.

31	This website (www.carbonmap.org) allows users to explore the movable carbon map. You can look at locations responsible for differing amounts of carbon emissions and locations that are particularly vulnerable to climate change impacts.
32	The southeastern region is expected to see increases in temperature, and both increases and decreases in precipitation. In addition, coastal communities in the region are threatened by sea level rise. Warmer temperatures can lead to more invasive exotic organisms, greater risk of wildfire, and losses in forest productivity. At the same time, increased levels of atmospheric carbon dioxide may benefit trees through increasing photosynthesis, but this increase is likely to be temporary. The impacts on forest ecosystems and agriculture are of great concern to many decision makers, researchers, resource managers, and farmers.
33	The peer-reviewed literature and climate scientists agree, but the public still have differing opinions about this issue.
34	The issue of climate change is complex and multifaceted, which makes it a difficult topic to explain and understand. It has been a long time since some adults have had formal science courses, and even then such courses may not have included atmospheric chemistry. Other people may hear conflicting arguments and become confused. In addition, many people do not have the time or background knowledge to understand the data and their implications. In addition, climate change does not affect people equally around the world. Some regions of the world will see little change, some will see a lot. Some changes may happen fast, and some may happen slowly. This also makes it difficult for everyone to recognize or "see" changes similarly. Some people want firm predictions for what will happen before they decide what to believe or what action to take. Firm predictions are not possible because of the quantity of variables involved and because we cannot be certain of how some of those variables will change in the future. Instead, models help scientists project a broad range of outcomes given different scenarios of future conditions. These model outcomes can be used to make policy decisions. In this decision-making process, a number of other factors become involved, such how the policies will affect the economy. For example, some solutions are expensive and may impact different populations of people in different ways. Because climate change impacts vary regionally and with time, moral and ethical factors may be discussed. For example, what are our obligations to others who may be affected more than we are, and what are our obligations to future generations?
35	Different people have different thoughts and opinions regarding climate change. Yale and George Mason universities have conducted opinion polls with the general public over several years and have identified six different categories of beliefs. This figure (2012) shows that the people in the United States express six different opinions about climate change, from alarmed to dismissive. Although the percentage of the population in each category changes slightly with news reports, there are people who are alarmed and concerned about the problem, people who are confused or not interested in learning more, people who doubt whether we should make

	changes, and people who are convinced that we should not make any changes to accommodate what they consider natural shifts in temperature. People in each category have somewhat different priorities and this enables them to emphasize different aspects of the climate problem in ways that make sense to them. The following sample statements are perspectives that represent the six groups: • Alarmed: We are responsible for changing the climate, so we are responsible for fixing the problem. • Concerned: I'm somewhat certain climate change is occurring, and I'm worried about the different impacts it might cause. • Cautious: There are a variety of different reports about climate change, and I'm confused about what to believe. • Disengaged: Climate change could be very important to some people, but it won't affect me very much right now. • Doubtful: If climate change is real, it is occurring because of natural causes, and whatever I do won't really matter. • Dismissive: Climate change is definitely not occurring, and taking any actions, such as reducing fossil fuel consumption, could severely affect our economy.
36	At the root of these various perspectives is the way we process information. We more readily perceive and accept information that matches what we already know. Given a great deal of information, we are likely to pass over that which doesn't fit our existing ideas and focus on the bits that do. Thus, it is hard to begin to change someone's mind because they don't even see the same information! This selective perception makes it possible for people to have partial information about climate change. By having only part of the story, some people may arrive at conclusions that are only true some of the time and are not supported by all the evidence. If people don't have the time to learn about climate change, they are likely to accept the ideas of the political leaders and influential people they trust. Those leaders may only see some of the information, may have reasons to not want to see societal change in response to climate change, or may have beliefs about religion or science that conflict with the conclusions of climate scientists.
37	Adaptation and mitigation are the main two solutions that are typically discussed for climate change. Adaptation to climate change includes actions taken by humans to avoid, benefit from, or deal with actual or expected climate change impacts. Adaptation can take place in advance (by planning before an expected impact occurs) or in response to changes that are already occurring. Mitigation includes actions that reduce sources of greenhouse gases or increase the amount of carbon dioxide being removed from the atmosphere. Limiting emissions will eventually decrease carbon dioxide and some of the effects of climate change. Solutions can be implemented at many levels and scales. We must explore the risks and costs of potential policies. There are different values and opinions about what should be done, and this creates a challenge when making policies for climate change. Many communities are already taking action to mitigate or adapt to climate change; the

	Exploring Solutions presentation showcases a few example of communities or programs already in place.

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