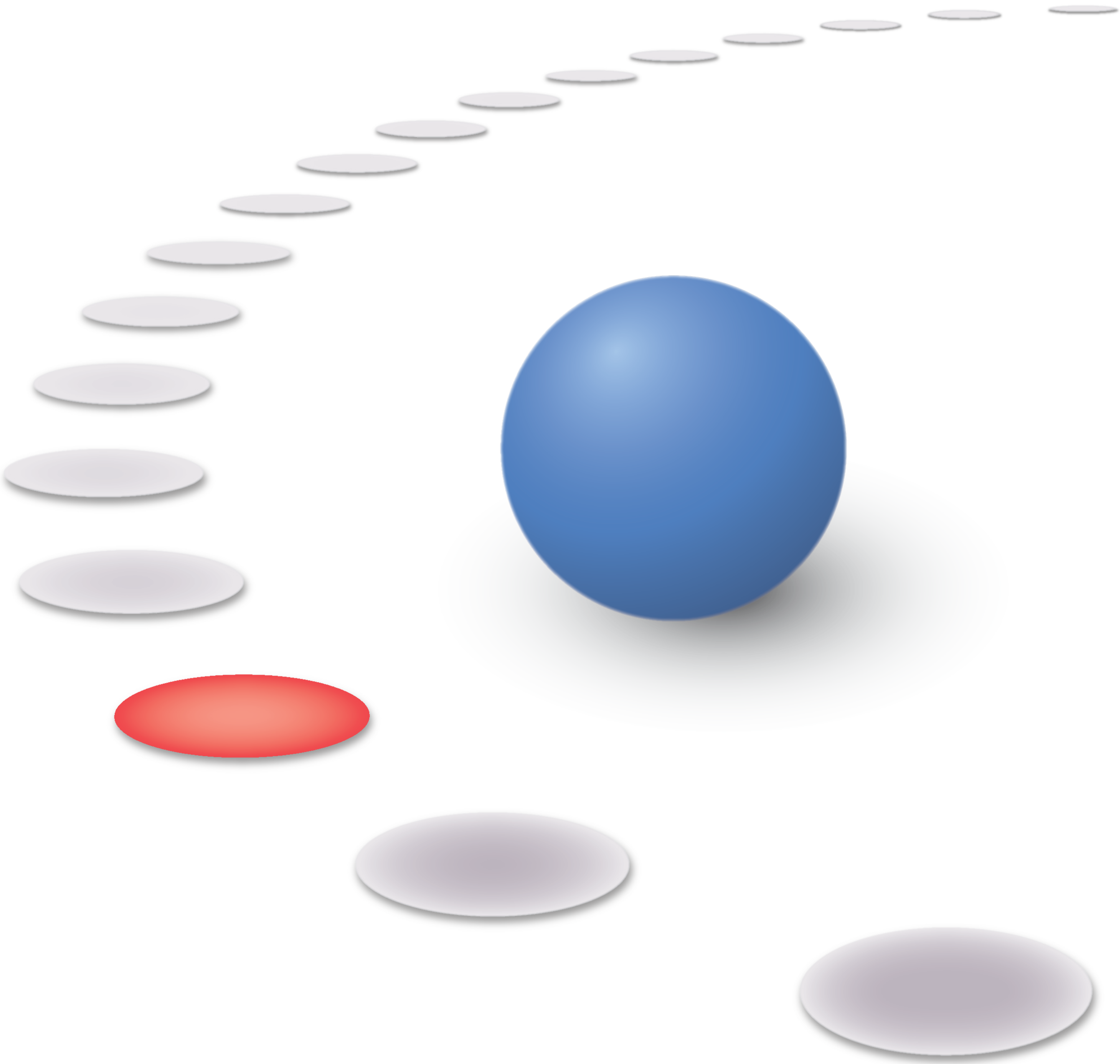
CLIMATE CHANGE

AND THE CAMPUS



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Welcome:
Issues and Public Deliberation

Since the earliest days, citizens of the United States have addressed challenging questions by engaging in public deliberation. Through public deliberation, people develop a fuller understanding of issues and come to appreciate how these issues are experienced differently by different people. Public deliberation also helps citizens to develop a shared resource of expanded knowledge, which emerges as people express their own perspectives and learn from the perspective of others. Drawing on this enriched understanding and the shared resource of knowledge enabled by deliberation, people can develop informed opinions. These informed opinions can, in turn, provide guidance to public officials who have the responsibility of devising public policy.

The event to which you have been invited seeks to capitalize on the value of public deliberation in ways that account for the increasing complexity and diversity of the United States. By providing a representative group of people with balanced background information, the opportunity for small-group deliberation, and access to a resource panel of experts, we seek to provide you with a unique opportunity to work together as you develop the informed opinions that are a necessary resource for policy-makers as they work to respond to critical issues.

Today climate change is one of the most critical issues facing the United States and the world. Over the course of the 21st century, in every region of the globe, the climate on which humans rely—the climate to which they have adapted their lives—will be changing. Climate change is a global phenomenon, but its impacts will be local; these impacts will vary by region, even within nations. For some regions these impacts may be positive. For example, warmer temperatures and increased rainfall may open up new areas for agriculture or extend growing seasons. For other regions, these impacts may be catastrophic. Already dry areas may experience more frequent periods of drought, increased precipitation in already wet areas may cause more flooding, or rising sea levels may make islands and some coastal areas uninhabitable. Whether the impacts are positive or negative, as a result of climate change humans will face the challenge of adapting or altering established ways of providing the resources they need to live: growing food, attaining fresh water, and supplying energy.

Scientific research can reveal how the Earth's climate is changing and why. Climate scientists use this research to make projections about how climate change may affect the Earth's natural systems and impact human lives. However, no one can predict how humans will respond. Science can reveal the facts about climate change, but only we can determine what we do with these facts.

Climate change requires us to make policy decisions at every level: our homes, our campus, our city, our nation, and our world. Ultimately, in response to climate change, we will need to address challenging questions about some of our most fundamental ways of doing things. This booklet has been developed to help you prepare for a public deliberation about these challenging questions. In the following sections we review the accepted scientific knowledge related to climate change, we review the projections that climate researchers have made about how climate change may affect the Earth's natural systems and impact human lives, and we present some of the challenging decisions that people will need to consider as they develop policies that address climate change. At the end of this booklet, we present some questions we hope to consider when we gather for public deliberation.

Students Deliberate

Students discuss academic rights and responsibilities during a deliberative event held in the spring of 2006.

Introduction:
A Word About Scientific Knowledge

Scientific inquiry is a highly collaborative activity. Scientific knowledge emerges through a process of inquiry and analysis called peer review. This process involves many individuals and teams of researchers working in a local, national, and international scientific community. This community is made up of professionals who have earned advanced degrees in the areas of their expertise. Scientists rely on this community to raise questions and conduct tests that will verify the results of individual scientific experiments.

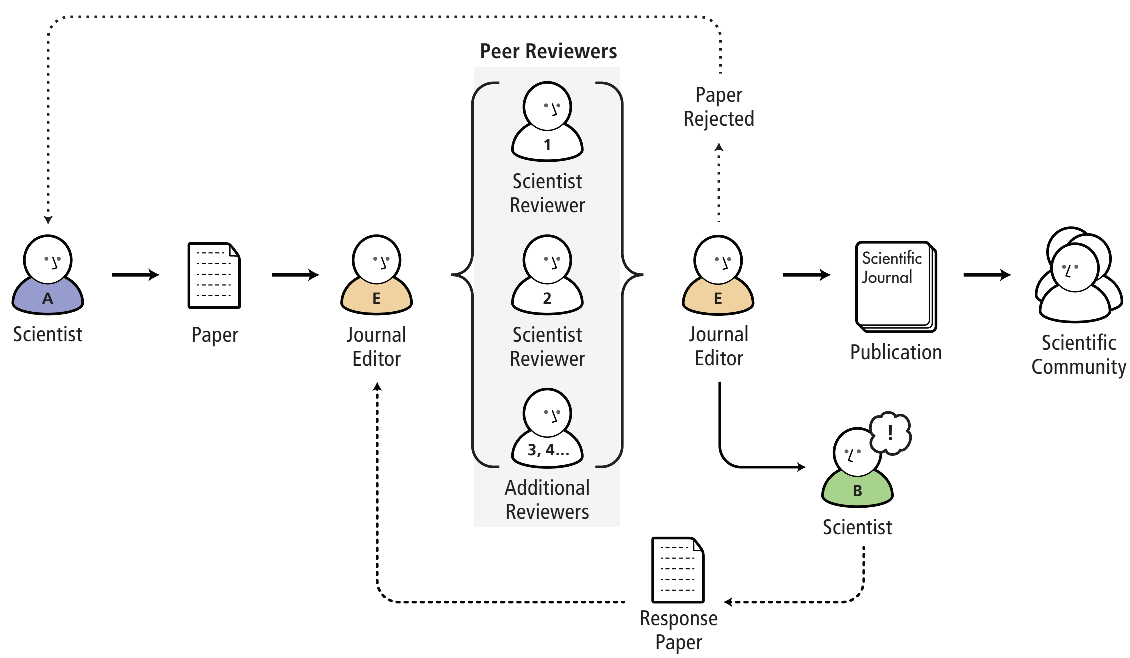
The accepted scientific knowledge related to climate change has been subjected to this peer review process. Scientists specializing in the study of various elements of the Earth's climate system, such as meteorology, glacial geology, or oceanology, develop hypotheses and then perform experiments to test them. For example, researchers wishing to understand changing temperatures might devise a simulated experiment to test whether the increased concentration of carbon dioxide in the atmosphere since the Industrial Age is causing the observed increase in temperatures. After getting results, the researchers write a paper that explains their experiment and provides an analysis of the results. This paper is then submitted for publication in a peer-reviewed journal like the "Bulletin of the American Meteorological Society."

The journal's editor or editorial committee reviews the paper and decides whether it is ready to be sent out for a review by others in the scientific community. If they consider the paper ready for review, a few scientists in the appropriate field are sent copies of the paper. In most cases the paper is sent out without the author's name and the reviewers remain anonymous. Reviewers look for errors or weaknesses in the paper. These may include bad data, faulty calculations, flawed experimental designs, or misinterpretations of results. Over a period of weeks each reviewer writes an evaluation of the paper and submits it to the editor. Based on these evaluations, the editor may reject or accept the paper; the editor may also request that the scientist who submitted the paper do further work.

If a paper survives this process of peer review, it gets published. The publication of the paper is only one step. Once it is published, the paper is read by other groups of scientists, and these scientists will seek to confirm or refute the paper's findings. They do this by attempting to replicate the findings in their own experiments, writing their own papers, and submitting these papers to the peer review process. A bad result or even a fraudulent paper can get past the peer review process. However, the process creates conditions that make the acceptance of bad results and fraudulent papers an unlikely exception. In addition, because of the process of ongoing peer review even after publication, it becomes increasingly unlikely that bad data or erroneous analyses will continue to be accepted.

The Peer Review Process

The peer review process is designed to ensure the integrity of scientific research by subjecting all published work to extensive review prior to publication.



Having emerged from this extensive peer review process, scientific knowledge is described as an accepted view, because particular results have been verified and been found acceptable by many individual scientists and teams of researchers.

Today the accepted view regarding climate change represents a consensus from peer-reviewed journals. This consensus holds that the climate is changing and that human activity is the cause of such change. All of the claims in the following sections that relate to the science of climate change are based upon findings that have appeared in peer-reviewed scientific journals.

> "...scientists publishing in the peer-reviewed literature agree with [the Intergovernmental Panel on Climate Change], the National Academy of Sciences, and the public statements of their professional societies. Politicians, economists, journalists, and others may have the impression of confusion, disagreement, or discord among climate scientists, but that impression is incorrect."
>
> Naomi Oreskes,
> The Scientific Consensus on Climate Change (Science, 2004)

There is, however, disagreement within the scientific community regarding how certain we can be about predicting the near and long-term impacts of climate change. All of the discussions about the potential impacts of climate change in this booklet acknowledge uncertainty.

As discussed later in this booklet, public policy decisions regarding what to do in light of climate change and its causes will involve consideration of a variety of competing and respectable positions.

The Scientific Consensus

Since 1988, a group of leading climate scientists from around the world have been gathered in a special study group called the Intergovernmental Panel on Climate Change (IPCC). The IPCC is a set of committees that include leading climate scientists from around the world. These scientists periodically review relevant research and produce reports that describe the current state of understanding of the climate problem.

The assessments made by the IPCC are widely viewed as the best consensus judgment about the science of climate change. In 1990, IPCC Working Group 1 on climate change science issued its first "consensus report." This report has been updated every few years. The most recent update is the Fourth Assessment Report, which was released in 2007. In this report the IPCC presents a number of projections concerning changes in temperature, snow and ice cover, and weather patterns.

The projections of the IPCC represent the consensus opinion from a group of the world's top climate scientists. As more research is done, scientists improve their understanding, which helps them make better projections. The current scientific consensus maintains that the climate is changing, that carbon dioxide is a significant factor in the changing climate, and that human activities are increasing the amount of carbon dioxide in the Earth's atmosphere. These scientific findings provide the foundation for policy decisions concerning climate change.

However, public deliberations and policy decisions can be difficult if people fail to appreciate the value of the peer review process. Many public controversies surrounding the issue of climate change emerge when people rely on old information, accept findings that have not survived scrutiny, or when they fail to critically evaluate media reports of scientific findings.

For example, some skeptics have pointed to differences between surface, atmospheric, and satellite temperature measurements as a reason to discredit the consensus view. However, a 2006 report from the U.S. Climate Change Science Program reconciled data from surface measurements, satellites, and weather balloons, and concluded that "(t)he previously reported discrepancy between surface and the atmospheric temperature trends is no longer apparent on a global scale." In this case, the peer review process inspired further research that addressed concerns about earlier research. Alternately, some have claimed that the climate change we are now experiencing is the result of naturally occurring climate variability. This claim has not survived the scrutiny of peer review and is therefore not accepted as part of the consensus view on climate change.

Public deliberations about policy are also frustrated because of how people receive much of their information about climate change. Media outlets often create what is called "false balance" when reporting on climate research. False balance occurs when people inappropriately contrast information from peer reviewed research with information that has not been subjected to, and would not likely survive, the scrutiny of the peer review process.

An altogether different problem emerges when people read of some controversy over the personal statements or correspondence of climate researchers and then allow this controversy to color how they view the findings of these researchers. The peer review process is designed to ensure the validity of research methods and findings. These remain valid regardless of any personal views expressed by those who conducted the research.

The following booklet relies solely on information contained in peer-reviewed literature. On the day of deliberation you will have the opportunity to ask questions of a resource panel of experts. These experts can help address any questions you have about the information in this booklet or about information you have received from other sources.

Section 1:

What Is Climate Change?

Climate is not the same thing as weather. Weather is the condition of the atmosphere at a particular place and time, measured in terms of temperature, humidity, and precipitation (rain, snow, etc.). Weather does not usually remain constant for long periods of time and in most places changes from hour-to-hour, and day-to-day.

While weather can change frequently, a region's climate may remain stable for periods lasting hundreds or even thousands of years. This is because climate is the average pattern of weather in a region over time. For example, Pittsburgh's climate is classified as a Humid Continental Climate, which means that the city can expect cool, sometimes cold winters, and warm, humid summers with frequent clouds and precipitation.

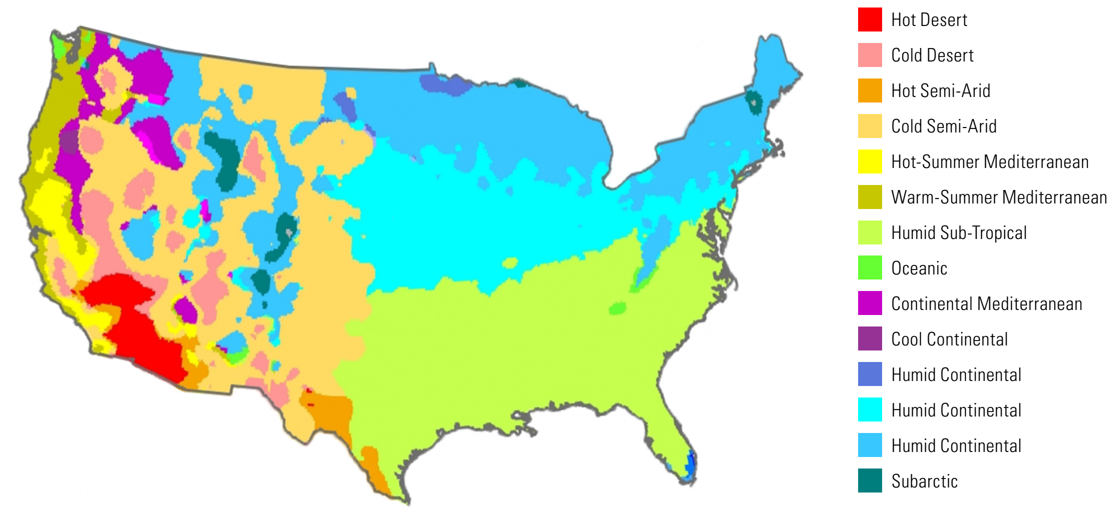
Climates around the world are projected to change over the next 100 years due to the increase in greenhouse gasses. As a result, researchers project that plants and animals may need to migrate and communities whose economies depend on climate for agriculture, tourism, or other reasons will face the challenge of adapting to new conditions. In fact, climate change is already having an impact. For example, city planners in urban areas like Chicago expect they will have to plant trees from warmer, more southern climes in the near future.

Figure 1.1: Climate Variation

There are a wide variety of climates found in the continental United States. The map at right indicates climate regions according to the Köppen-Geiger climate classification system.

(data for 1951-2001 shown)

source: Updated world map of the Köppen-Geiger climate classification: Hydrology & Earth System Sciences, 2007.



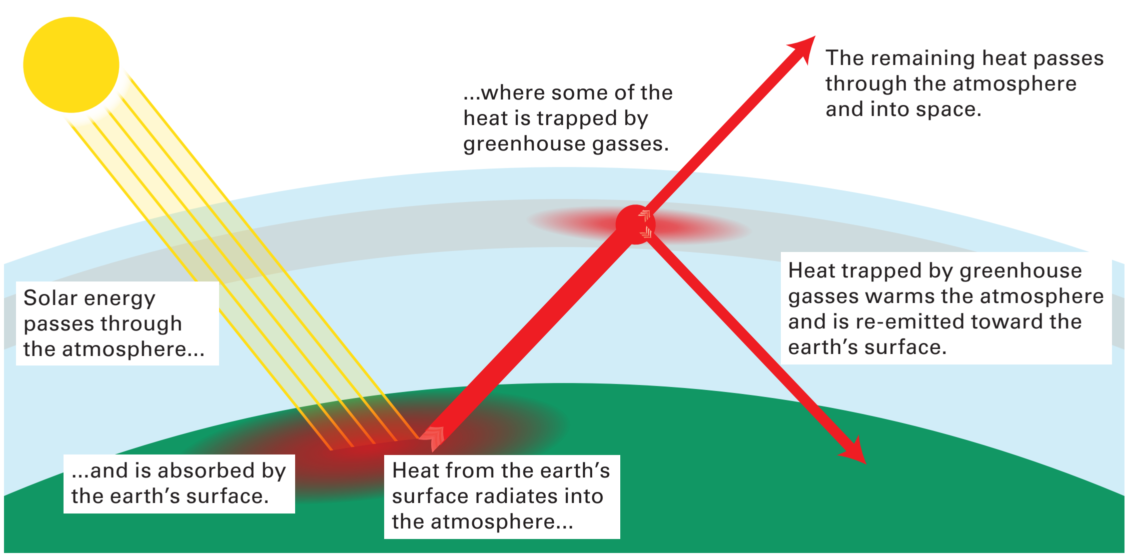
Carbon Dioxide and the Climate

The single human activity that has the largest impact on the climate is the burning of "fossil fuels" such as coal, oil and gas. These fuels contain carbon and burning them makes carbon dioxide gas. Carbon dioxide gas traps heat in the atmosphere, somewhat like the way glass in a greenhouse lets in light but traps heat, creating a warmer environment for the plants inside (see Figure 1.2). For this reason, carbon dioxide is called a "greenhouse gas." Since the early 1800s, when people began burning large amounts of coal and oil, the amount of carbon dioxide in the Earth's atmosphere has increased by nearly 30%, and average global temperature appears to have risen between 1 and 2°F. This may not seem like much, but minor changes in average global temperature can lead to significant changes in overall climate. For example, during the last ice age, the average global temperature was only 9°F lower than it is today.

As people burn more fossil fuel for energy they add more carbon dioxide to the atmosphere. As more carbon dioxide is added to the atmosphere, heat radiating from the Earth has more trouble getting out. The result is that, if everything else remains unchanged, the best available projections suggest that by the end of the 21st century, the Earth will have warmed by another 3-7°F.

However, not all things that enter the atmosphere cause warming. Dust from volcanoes and human activities can reflect sunlight (like a window shade) and cool the Earth. Researchers estimate that the amount of greenhouse gases in the atmosphere should have already increased the average temperature of the Earth by slightly more than 2°F. However, it appears that the average temperature of the Earth has only increased by between 1 and 2°F. Thus, it is likely that some other things have also changed. For example, small particles, such as sulfur compounds, that are emitted when we burn coal, may help to cool the Earth by reflecting sunlight.

FIGURE 1.2:
THE GREENHOUSE EFFECT



The Potential Impact of Feedbacks

The systems that regulate the Earth's climate are dynamic. The climate results from each element of this system interacting with other elements. Researchers use the term "feedbacks" to describe these interactions. Feedbacks come in two kinds: negative feedbacks that will work to slow down or offset climate change and positive feedbacks that work to speed up or amplify climate change.

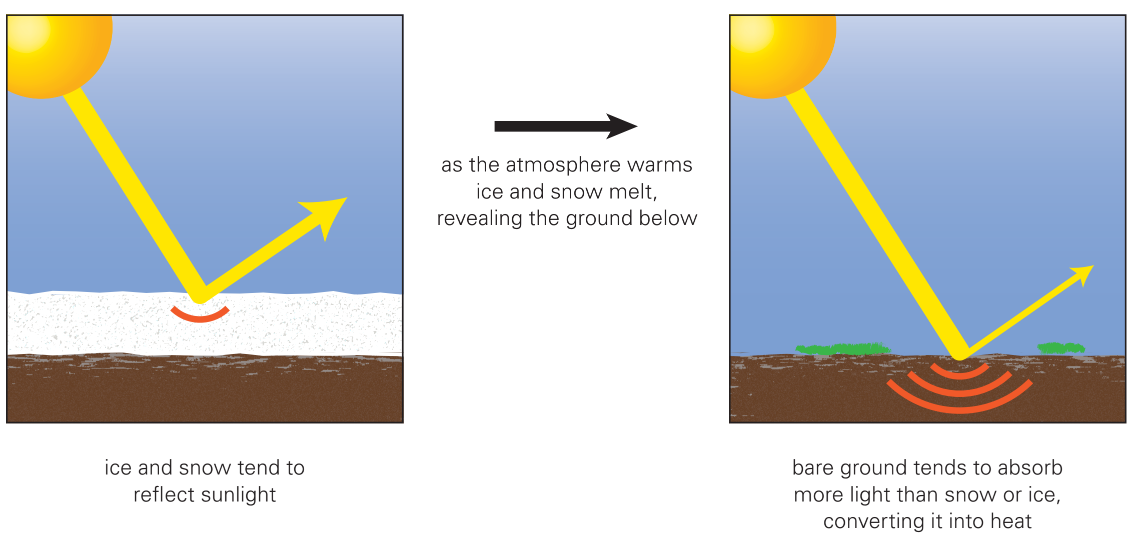
For example, as the concentration of carbon dioxide in the atmosphere increases, some plants may grow faster and as a consequence take more carbon dioxide out of the atmosphere. This would result in a negative feedback, slowing the rate at which carbon dioxide increases, and hence slowing the rate of warming.

On the other hand, as the Earth warms, some ice and snow are likely to melt. Ice and snow are good reflectors of sunlight. The dark ground that is exposed when the snow and ice melts absorbs light. When the ice and snow melt, less light energy from the sun will be reflected and more will be absorbed by the Earth. This would result in a positive feedback that would tend to speed up the rate at which the Earth warms.

Climate scientists have identified a number of positive and negative feedbacks in the climate system. Some of them are well understood. Others are still only partly understood. It is largely uncertainties about how these feedbacks will respond to changes—how changes in one element will change the whole system—that make the science of climate change so uncertain and controversial. Scientists use computer models of what they know about how feedbacks work to make projections about temperature and precipitation distributions, among others.

Figure 1.3: Feedbacks In Practice

Snow is highly reflective, so areas covered in snow and ice reflect more light back into space. When this ice melts, the exposed ground absorbs more light and heats up. This heat adds to the greenhouse effect.



Section 2:
The Impacts of Climate Change

The scientific consensus maintains that the earth's climate is changing, and that the emission of greenhouse gases, especially carbon dioxide, is the single most significant contributor to climate change. Gas molecules can remain in the atmosphere for decades or even centuries, and more recent emissions get added to those of the past. Human activities over the last several hundred years, most especially the burning of fossil fuels (e.g., coal, oil, natural gas), have increased the amount of greenhouse gases concentrated in the earth's atmosphere. As a result, human activity is largely responsible for the climate change we are currently experiencing and ongoing emissions from human activity will continue to affect climate change in the future.

Climate change will cause changes in the natural environment, and changes to the natural environment affect human lives. Scientists, however, cannot be certain exactly how the natural environment will change. Historical evidence and more recent observational data provide the information scientists can use to make projections. However, scientists cannot predict how climate change will ultimately impact human lives. Impacts on human lives will depend upon how much change there is, how fast it occurs, and how humans choose to respond to these changes.

Throughout the next century, humans will be forced to adapt to a changing world. Climate change will affect where people are able to live, it will affect people's health, and it will affect agriculture, food supplies, and the availability of fresh water. While there is no way to avoid the impacts of climate change caused by past human activities, researchers believe that the worst impacts of climate change can be avoided if action is taken soon.

Climate change results from complex interactions among the various elements of the Earth's climate system, as well as from interactions between the climate system and human activity. This complexity makes it very difficult for humans to comprehend the relationships of cause and effect that affect climate change or to discern the consequences of their actions. Scientists in many fields are continually working to understand these interactions, and climate researchers use the findings of research from various fields to make projections about how climate change will affect the Earth's natural systems and impact human lives. The following section reviews these projections. When considering any specific projection, it is always necessary to keep in mind that the full effect of any individual impact can only be appreciated when it is placed within the context of complex interactions among the Earth's many natural and human systems.

How Scientists Make Projections

The climate in different regions depends upon complex interactions within and among the various elements of the Earth's climate system, which includes the atmosphere, the hydrosphere (oceans, lakes, rivers), the cryosphere (sea ice, glaciers), the biosphere (marine and terrestrial plants and animals), and land surface. Climate researchers use computers to help them make projections about how changes to one element of this complex system, such as changes to the atmospheric concentration of greenhouse gases, may affect other elements of the system and therefore affect the climate.

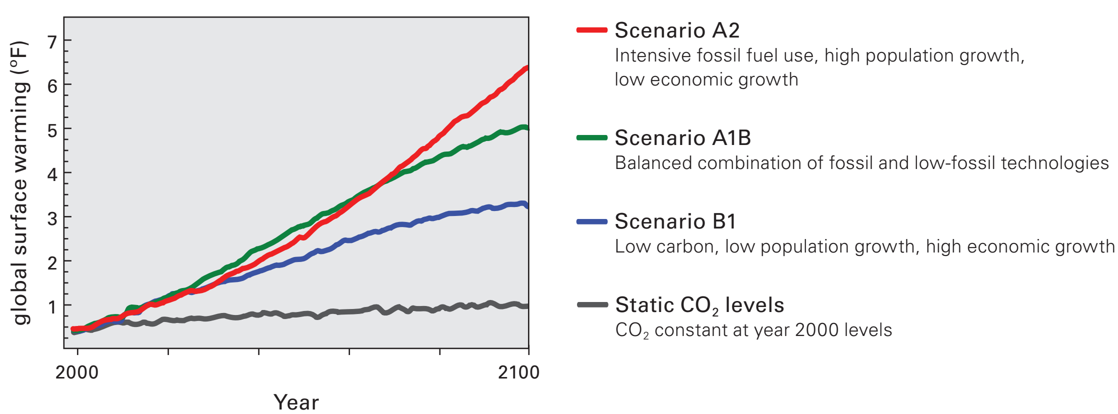
Computerized climate models make use of two types of data. The first are data that reflect what researchers know about how the climate differs when the atmospheric concentration of greenhouse gases differs. For example, during the Eocene (50 million years ago), tropical plants and animals ranged as far northward as the subarctic and carbon dioxide concentrations were 1000 parts per million (ppm). By comparison, the current concentration is 389 ppm. The second types of data are socioeconomic. These include demographic data (for example, population), economic data, and data about the effects of technological change. Researchers who study socioeconomic change construct models that reflect different but equally plausible assumptions about future socioeconomic conditions. These models offer different profiles for greenhouse gas emissions over time. Earth scientists, who focus on the physical responses of the Earth's climate system, incorporate the emissions profiles from different socioeconomic models into their own computerized models. As a result, computerized modeling provides various projections for climate change in different regions of the world, and these reflect different assumptions about population size, economic activity, and use of technology.

In 2007, the IPCC issued its Fourth Assessment Report. This report contains projections that offer a consensus view about climate change and its impacts over the next century. Taken together, the models project that average global temperatures will increase somewhere between 1-11°F by the end of the 21st century. Figure 2.1 reflects what the IPCC identifies as the best estimates for a variety of socioeconomic assumptions. These project an increase somewhere between 3-7°F. These projections represent global average temperature increases. Temperature increases in specific locations can be more or less than these averages. In general, as warming continues, land areas will warm more rapidly than oceans, and higher latitudes will warm more quickly than lower latitudes. Thus, for example, the continental United States is expected to experience more warming than average, and the Arctic is expected to experience the most warming.

Figure 2.1: Average Global Temperatures

These scenarios each combine the results of 19 different temperature models. Models use variables such as fossil fuel use to estimate changes in average global temperature. While many scenarios have been developed, these exemplify a range of potential outcomes. The bottom (grey) line represents temperature change if CO2 production levels had remained static after the year 2000.

source: IPCC 4th Assessment



Agriculture

Of all human activities, agriculture is potentially most vulnerable to climate change. How climate change will effect agriculture is very difficult to project. In addition, there is uncertainty about whether the net effects of climate change will be positive or negative. Nevertheless, plants are very sensitive to changes in the environment. As plants respond to climate change, humans can be expected to alter how they use the land, which will alter local industries and trade patterns. These changes, in turn, will likely affect the global food supply, and a resulting fluctuation in food prices could place more people at risk of hunger.

As the climate changes, plant development, plant growth, and the productivity of crops will be affected. Plants require carbon dioxide, so some believe that increased atmospheric concentrations of carbon dioxide may, ultimately, increase productivity. However, plants will also need to respond to higher average temperatures and changing precipitation patterns. In addition, as the climate changes plants and animals may naturally migrate to more suitable climates. As a result, ecosystems may be disrupted and plants will likely face new pressures. As plants and animals come to establish themselves in new regions, the mix of weeds, pests, and diseases with which plants must contend will likely change.

Scientists are currently working to understand how these changes might affect crop yields and food supplies over the long-term. Scientists project that, overall, the effects of climate change will be experienced regionally. For example, northern regions of the globe may benefit as warming allows for longer growing seasons and opens new areas for agriculture. In contrast, extended periods of higher average temperatures and an increase in heat waves may lead to drought. As a result, certain crops may no longer be able to be grown in some regions. In many regions, an increase in extreme weather events, such as hurricanes or floods, may lead to more frequent crop losses. In addition, natural migrations might affect overall pest populations, or the levels of destruction pests cause.

All projections suggest that, across the globe, climate change will require farmers to adapt their practices to the changing climate. The most optimistic projections suggest that productivity may increase in the northern regions of developed countries and farmers in other regions will be able to adapt by changing planting times and seed varieties to match the changed local climates. Less optimistic projections suggest that major changes may be needed, such as the construction of new irrigation systems, large shifts in planting times, increased fertilizer application, and the development of new crop varieties. In any region adaptation strategies will require investments in new seeds, new crop varieties, new infrastructure and further research. Projections suggest that poorer communities across the globe, especially those in developing countries, will likely experience the worst impacts from climate change.

Carbon Dioxide and Plant Growth

Will more carbon dioxide in the atmosphere cause trees and other plants to grow more? Maybe. Plants need carbon dioxide to grow. Using sunlight and photosynthesis, plants change carbon dioxide and water into food. If plants have all the nutrients they need, then giving them more carbon dioxide will cause many to grow more. Commercial growers often do this in greenhouses. However, plants growing in natural environments often do not have all the nutrients they need, and may not grow faster, even if there is more carbon dioxide. If some plants on land and in the oceans are naturally able to take more carbon dioxide out of the atmosphere, they will grow faster. This would change the mix of plants, but might also slow global warming.

Water Supply

Fresh water is a necessary and valuable resource. However, across the globe, many people find it difficult to locate fresh water of sufficient quality and in sufficient quantities. Climate change will make this challenge more difficult. In addition, it may increase the frequency and duration of floods, droughts, and heavy precipitation. In general, as these changes occur, dry regions may get drier and wet regions may get wetter.

Water Availability

Warmer temperatures are projected to threaten water supplies across the globe. Hundreds of millions of people depend on water from the seasonal melting of ice and snow. Climate change is expected to increase the amount of seasonal melt from glaciers and snowpack, increase the amount of precipitation that falls as rain instead of snow, and alter the timing of snowmelt. In the near term, melting of mountain ice and snow may cause flooding; in the long term, the loss of these frozen water reserves will significantly reduce the water available for people, agriculture, and energy production. Earlier snowmelt contributes to other impacts. In the U.S., Western states have experienced a six-fold increase in the amount of land burned by wildfires over the past three decades because snowmelt has occurred earlier and summers are longer and drier.

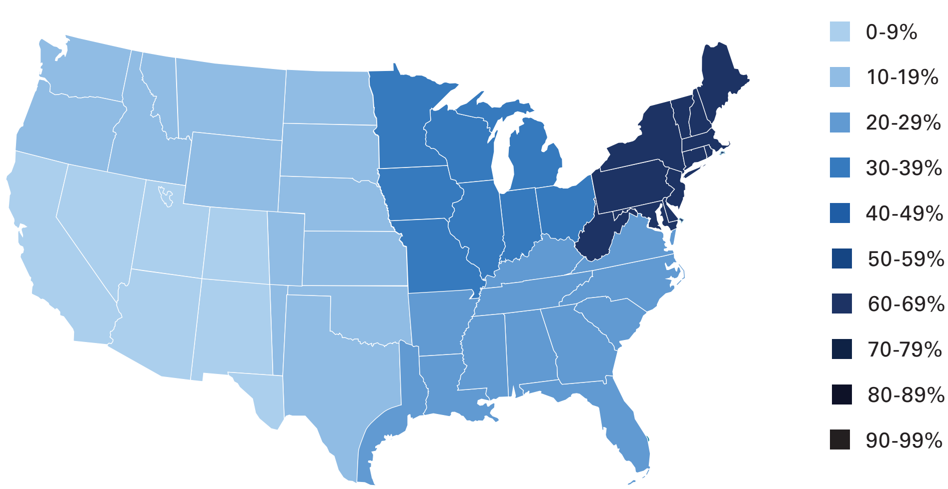
Water Quality

Climate change will affect the quality of drinking water and impact public health. As sea level rises, saltwater will infiltrate coastal freshwater resources. Flooding and heavy rainfall may overwhelm local water infrastructure and increase the level of sediment and contaminants in the water supply. Increased rainfall could also wash more agricultural fertilizer and municipal sewage into coastal waters, creating more of what are called low-oxygen "dead zones" in places such as the Chesapeake Bay and the Gulf of Mexico.

More Floods and Droughts

A number of factors are expected to contribute to more frequent floods. More frequent heavy rain events will result in more flooding. Coastal regions will also be at risk from sea level rise and increased storm intensity. While some regions will have too much water, others will have too little. Diminished water resources are expected in semi-arid regions, like the western United States, where water shortages often already pose challenges. Areas affected by drought are also expected to increase. As the atmosphere becomes warmer, it can hold more water, increasing the length of time between rain events and increasing the amount of rainfall in an individual event. As a result, areas where the average annual rainfall increases may also experience more frequent and longer droughts.

Figure 2.3: Increases in Very Heavy Precipitation (1958 - 2007)
source: USGCRP Global Climate Change Impacts in the United States, 2009.



Extreme Temperatures

Extreme temperatures, changing precipitation patterns, and extreme weather events have become more common in recent years. This trend is expected to continue, and these changes will seriously impact the natural environment, along with human health and human activities, such as agriculture. Although there is no way to determine whether individual weather events are caused by climate change, the types of extreme weather events discussed below are the types of events scientists predict will become more common in a warming climate.

The 27 warmest years since 1880 (in terms of average global temperature), occurred between 1980 and 2009. This includes 2005, which was the warmest year overall. This warming trend has continued in recent years—across the world, the first five months of 2010 were the warmest ever recorded.

While average temperatures are rising, extreme temperature events are also increasing. According to a report by the U.S. Global Climate Change Research Program, "extreme weather events, such as heat waves and regional droughts, have become more frequent and intense over the last fifty years." In 2003, a heat wave across Europe caused 30,000 deaths, and, in 2010, a heat wave in Russia and Eastern Europe killed thousands of people and destroyed a large fraction of Russia's wheat crop. In addition to deaths of people and crops, heat waves also increase demands on government services and utility companies. During a heat wave that hit the U.S. East Coast and Mid-Atlantic states in 2010, cities devoted public safety resources to establishing "cooling centers" for vulnerable populations and isolated blackouts occurred, as people attempting to cool off made increased demands on existing power supplies.

Recently, climatologists at Stanford University projected that exceptionally long heat waves and other hot events could become commonplace in the United States in the next 30 years, and by the middle of this century, even the coolest summers will be hotter than the hottest summers of the past 50 years.

Potential Impacts: U.S. Southwest

- Scarce water supplies call for trade-offs among competing uses
- Increasing temperature, drought, wildfire, and invasive species accelerate landscape transformation
- Increased frequency and altered timing of flooding increases risks to people, ecosystems, and infrastructure
- Unique tourism and recreation opportunities are likely to suffer

Rising Sea Level

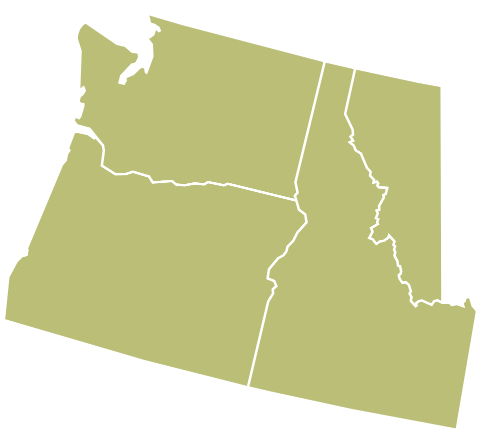
As global temperatures have increased, so have sea levels. Almost fifty percent of the world's population lives close to the seashore, and rising sea levels will impact humans, animals, and plants living on or near the coast.

In its latest report, the IPCC attributes sea level rise to both thermal expansion and the melting of land-based glaciers, ice caps and polar ice sheets. Thermal expansion occurs when the ocean temperature rises and the particles that make up the ocean start to move more vigorously. This increases the overall volume of the ocean, causing a rise in average sea levels. Researchers have found, however, that the recorded sea level rise is larger than could be expected from thermal expansion alone. Over the last fifty years, mountain glaciers and snow cover has declined on average, and the widespread decrease in glaciers and ice caps has also been found to contribute to current sea level rise. Data shows that losses from the ice sheets of Greenland and Antarctica have also likely contributed to an increased rate of sea level rise from 1993 to 2003.

Scientists project that if nothing is done to decrease greenhouse gas emissions, thermal expansion and melting ice may increase the global sea level by three to six feet by the end of the 21st century. In addition, some experts project that higher average temperatures of the oceans will result in more intense hurricanes. As a result, these storms could do more damage than in the past. When storm winds blow onto shore they cause water to "pile up." As the sea level rises, the amount of this "storm surge" will increase, with the result that coastal ecosystems may be flooded more often, some beaches may be eroded more rapidly, and buildings and other structures along the coast may suffer greater damage. However, other experts doubt such changes will occur and maintain that the projected rise in sea level should mean that changes in storm surge under normal weather conditions might be small.

Wealthy communities may be able to adapt to rising sea levels using a combination of land-use laws and technologies such as dikes and storm surge barriers to minimize damage. In contrast, heavily populated coastal areas in poorer communities might suffer enormous losses of life and property. In the long run, if sea level continued to rise, even wealthy communities might begin to experience serious costs. Many of the world's biggest cities, including Jakarta, Mumbai, New York, Tokyo, and Shanghai, are in low-lying coastal locations. If, as seems likely, these cities respond to sea level rise by constructing dikes and storm barriers, rather than by relocating, the result over hundreds of years could be that a growing proportion of the world's population would live in locations below sea level that are vulnerable to sudden catastrophic floods.

Potential Impacts: U.S. Northwest



- Declining snowpack reduces summer streamflows, straining water resources including those needed for hydroelectric power
- Increasing wildfires, insects, and species shifts pose challenges for ecosystems and the forest products industry
- Rising water temperatures and declining summer streamflows threaten salmon and other cold water fish species
- Sea-level rise increases erosion and land loss

Ocean Acidification

Researchers have found that almost half of the carbon dioxide emitted by humans' increased burning of fossil fuels has been absorbed by the oceans. This has helped to slow global warming, but it has also increased the acidity of the world's oceans. Ice core measurements show that oceans have not been as acidic as they now are for at least 650,000 years. Although they know that the current acidity is greater than that of the past, scientists are not able to determine how specific species will be affected by the increasingly acidic water.

However, scientists have raised concerns about certain species that are a vital part of the ocean's food web. First, researchers have identified coral reefs as particularly vulnerable to ocean acidification. Coral reefs sustain two-thirds of all marine fish species and they support human communities by providing fisheries and storm protection. Increasing acidification weakens existing coral and makes it difficult for new coral to form. In addition, over time, raised acidity can dissolve the shells of many organisms, deforming them and leaving them defenseless to predators. This process will not only harm species, such as lobster and mussels, but it will also injure smaller organisms that provide food for larger animals.

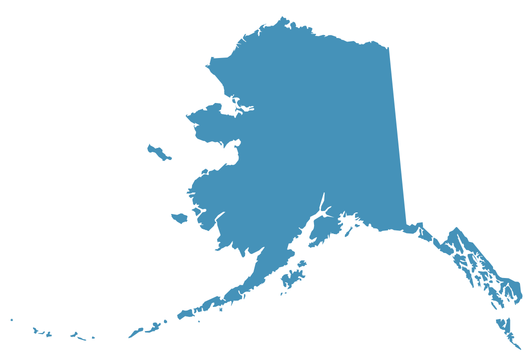
Sea Ice, Glaciers and Ice Sheets

Arctic sea ice and land-based ice, such as glaciers, play an important role in the climate system. Snow and ice reflect sunlight, while open water and land tends to absorb it. A loss of ice on land and sea will mean that the earth absorbs more sunlight. As a result, a loss of ice can intensify and accelerate climate change.

Shrinking Arctic Sea Ice

Since the 1950s, the area covered by summer sea ice has declined three times faster than projected by climate models. In 2007 Arctic sea ice shrank to the smallest summertime extent ever observed, opening the Northwest Passage for the first time in human memory. In 2010 Arctic sea ice decreased to the lowest volume ever observed. That is, the area covered by sea ice was slightly larger than in 2007, but the ice itself was thinner. Scientists are concerned that thinner ice is more susceptible to melting in the future, which may accelerate sea ice loss. As warming continues, scientists project that the Arctic Ocean will become largely free of ice during the summer, with some climate models projecting that the opening of the Arctic will occur before 2080.

Potential Impacts: Alaska



- Declining snowpack reduces summer streamflows, straining water resources including those needed for hydroelectric power
- Increasing wildfires, insects, and species shifts pose challenges for ecosystems and the forest products industry
- Rising water temperatures and declining summer streamflows threaten salmon and other cold water fish species
- Sea-level rise increases erosion and land loss

The loss of Arctic sea ice is likely to have serious global implications. Many marine animals, such as seals, polar bears, and fish, depend on sea ice. With a loss of sea ice, these animals will lose access to their feeding grounds for long periods, which will make it difficult for these populations to be sustained. In addition to the effect on Arctic ecosystems, impacts from the loss of sea ice may include dramatic ecological shifts or even new security issues as nations attempt to extend their economic and military influence into previously closed Arctic seaways.

Loss of Glaciers

Glaciers serve as an important resource of fresh water that supports people and agricultural production. As glaciers retreat, these communities will lose this resource and they may also experience floods, avalanches, or landslides triggered by glacial melt.

Research shows that glaciers are already declining. Mountain glaciers at all latitudes have retreated, including those in the Himalayas of Central Asia, the Andes of South America, and the Rockies and Sierras in the United States. Montana's Glacier National Park is expected to lose its glaciers by 2030. Scientists project that, as a result of climate change, many mountain glaciers will be gone by the middle of the 21st century.

Loss of Land-Based Ice Sheets

Greenland and Antarctica are both covered by ice sheets that have experienced net losses in recent years. Recent research finds that this loss has been accelerating and Greenland is losing ice twice as fast as scientists had previously estimated. Melting ice sheets add billions of tons of water to the oceans each year. In the future, a warming ocean may accelerate the loss of ice, leading to a more rapid sea level rise.

Natural Ecosystems

Scientists have reconstructed the history of past climates, such as ice ages, and shown that the ecology of entire continents has undergone profound changes. In general, researchers find that natural systems have often adapted to gradual climate change that occurred over many thousands of years. However, they also find instances in which rapid change, such as sudden shifts in ocean currents, have caused widespread species extinctions and the collapse of natural ecosystems.

If change occurs slowly, the mix of species that inhabit a particular ecosystem may change as the climate changes. As the climate changes, species can be expected to migrate to more suitable climates. However, some species may become trapped by barriers such as mountain ranges or large cities and be unable to move. As a result, species that have developed a relationship of dependence with other species may face new challenges. For example, some birds have evolved a breeding cycle that is connected to the breeding cycle of certain butterfly species. These butterflies provide a resource of food for the birds. If climate change alters the time of year when the butterflies or the birds breed, these birds may lose their food source.

On the other hand, the ecological disruptions caused by climate change may not be as large as those caused by major changes in human activities. Historically, humans have had a profound effect on ecosystems. Changes in human land use are probably the most significant. For example, there have been enormous ecological impacts associated with the European settlement of North America over the past 300 years.

Yet, while the ecological disruptions caused by climate change may not be as large as those caused by major changes in human land use, they still could be severe. The impact of these disruptions depends critically on how rapidly the climate changes.

Public Health

Health effects from climate change can be direct or indirect. Peoples' health might be impacted by the changing climate itself, or they may experience health impacts from the ways climate change alters the natural environment, ecosystems and human activities such as agriculture.

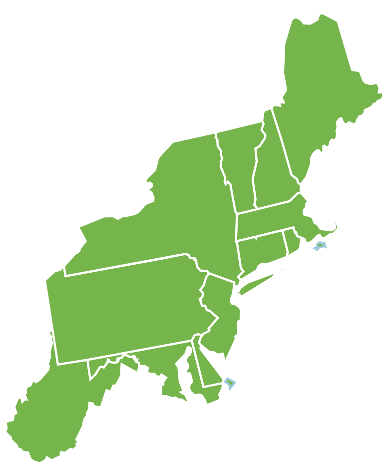
The U.S. Centers for Disease Control and Prevention have identified a number of health effects likely to be associated with climate change, including an increase in heat-related illnesses and deaths from more frequent heat waves, a rise in asthma and other respiratory illnesses due to increased air pollution, higher rates of food and water related diseases, and an increase in the impacts of extreme weather events such as hurricanes.

In addition, some scientists have suggested that diseases borne by insects, such as mosquitoes, might become more common in a warmer world, or that these diseases may shift their ranges into populations that do not have as many natural defenses or familiarity with managing such outbreaks.

Some researchers are also concerned that in some regions of the world malnutrition, hunger, and diseases associated with these conditions will increase as climate change causes changes in food supplies and food prices.

Alternately, some researchers suggest that, when compared to current threats to human health such as viral epidemics and environmental pollution, the risks from gradual climate change are likely to be modest. However, the U.S. Global Climate Research Program cautions that children, the elderly, and the poor are at the greatest risk for negative health impacts from even modest climate change.

Potential Impacts: U.S. Northeast



- Extreme heat and declining air quality are likely to pose increasing health risks
- Production of milk, fruits, and maple syrup is likely to be adversely affected
- More frequent flooding due to sea-level rise, storm surge, and heavy downpours
- Reduced snow negatively affects winter recreation
- Lobster fishery continues northward shift; cod fishery further diminished

Impacts and the Rate of Change

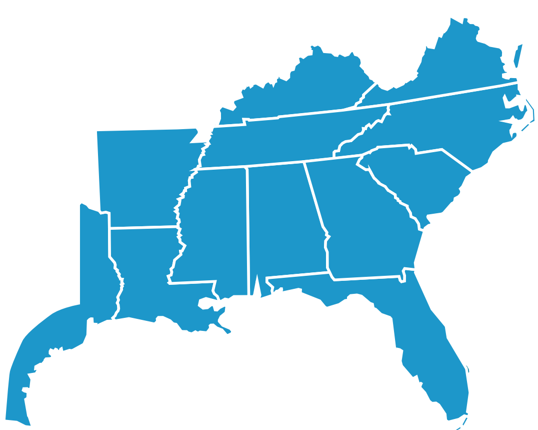
The effects of climate change will differ from place-to-place. How this change will impact people will likely depend on the rate at which the climate changes and the resources people have to adapt to these changes. Most scientists believe that if significant climate change occurs it will take place gradually over a period of many decades. However, there is some chance that climate change will be abrupt, perhaps brought on by a sudden shift in the general pattern of ocean circulation. Most scientists believe that such catastrophic change is unlikely, but not impossible.

If change is gradual, the overall economic impact on wealthy communities will probably be modest. As the climate changes wealthier communities may be able to use technology to reduce direct impacts. For example, they might develop new crop varieties, construct new water management systems, and limit coastal development. Although some regions may experience large costs, others may experience large benefits. Nationally the total costs could add up to many billions of dollars. However, if change happens abruptly, the economic costs to wealthy communities could be very large. Significant new investment might be needed in a very short period of time. Even with new investment, adaptation strategies might be difficult to implement in just a few years.

In contrast, people living in poorer communities have far fewer resources for adapting to even gradual changes. In many poor communities, peoples' lives depend much more directly on a specific climate. Their agricultural practices, their housing, and many other aspects of their way of life are adapted to local climate conditions. These communities lack the resources for implementing adaptation strategies. Change may also be more difficult in these communities because of strong cultural traditions and relatively low education levels.

Whether wealthy or poor, people in all regions may have difficulty adapting. There will be costs associated with farmers' adopting new agricultural practices, and people may find it difficult to adjust as insect and other pests migrate to new habitats. Coastal communities and low-lying islands may experience significant damage from increasingly severe storms and some could be permanently flooded by rising sea levels. Droughts in regions such as Africa, Australia, China and the Southwestern United States might become more serious. Climate change may

Potential Impacts: U.S. Southeast



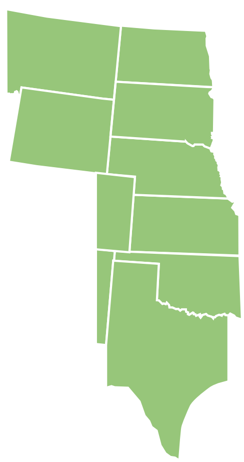
- Increases in air and water temperatures stress people, plants, and animals
- Decreased water availability is very likely to affect the economy and natural systems
- Sea-level rise and increases in hurricane intensity and storm surge cause serious impacts
- Thresholds are likely to be crossed, causing major disruptions to ecosystems and the benefits they provide to people
- Severe weather events and reduced availability of insurance will affect coastal communities

cause disruptions in food supply, increased disease, and permanent or long-term economic dislocation for some. The social tensions resulting from these changes could lead to political unrest and large-scale migrations.

While many of the impacts of climate change are expected to be negative, some might be positive. Heating costs in northern areas might decline, agricultural productivity in northern regions might be improved, and the amount of sunlight available for grain crops might increase as the regions where they grow shifts further north.

Historically people have been able to adapt to natural and man-made changes to the local environment, and across the globe people have been able to establish societies in a range of climates. In the U.S., for example, communities already exist successfully in Alaska, Arizona, and Florida. These states span a range of climates much wider than any projected changes. Nevertheless, whether climate change is gradual or abrupt, any response to it will require people to commit resources towards developing and implementing adaptation strategies.

Potential Impacts: U.S. Great Plains & Midwest



- Increasing temperature, evaporation, and drought frequency compound water scarcity problems
- Agriculture, ranching, and natural lands are stressed by limited water supplies and rising temperatures
- Alteration of key habitats such as prairie potholes affects native plants and animals

- Heat waves, air quality problems, and insect and water-borne diseases increase
- Reduced water levels in the Great Lakes affect shipping, infrastructure, beaches, and ecosystems under a higher emissions scenario
- More periods of both floods and water deficits occur
- Floods, droughts, insects, and weeds hurt agriculture
- Diseases and invasive species threaten native fish and wildlife

Section 3:
Climate Change and the Campus

The climate is changing, and human activities that emit greenhouse gases are having a significant impact on the rate and extent of the change. As we make decisions about how to address climate change, we can rely on this accepted knowledge from the international scientific community, but we must, ultimately, make decisions based on projections that are necessarily uncertain. In the end, climate change requires that we do the public work of citizenship. We must work together to build relationships across several levels, from the interpersonal to the international, and we must make informed decisions about strategies in the present that will have impact in the future.

Universities can play a particularly valuable role in addressing climate change. Universities are economic engines that provide great benefits to their communities. However, universities also can account for a large percentage of a community's greenhouse gas emissions. The energy used each day by thousands of students and employees to commute, to heat and cool buildings, to power sophisticated lab equipment, to light performance spaces and sports facilities, and to power every other function of a University all adds up to create a large "carbon footprint."

At the same time, as "mini-cities" relatively free to set policies to manage their immediate local environments, universities can be a valuable place to develop and test strategies and promote behaviors at a scale that allows students, staff, faculty, and alumni to appreciate how individual action can contribute to significant change.

In addition, within and across the many colleges at a university research can be directed to developing knowledge about the complex and interacting natural, political, and social systems that affect climate change and the ways in which humans might respond to it. Researchers can also rely on established national and international networks to conduct research and disseminate information.

Universities also provide a good environment to promote stewardship and innovation, both on campus and in surrounding communities. Across all the colleges at a university, courses, internships, research programs, and community outreach initiatives can be developed that allow students and residents of surrounding communities to learn about the challenges, discover opportunities for innovation, and realize possibilities for community and economic development that emerge as a result of climate change.

As an economic engine, an incubator of innovation, and as a resource for research, education, and community outreach, universities can have an influence on public policy. The policies and practices adopted at a university can be expected to affect change at the personal and local level, influence policy at the regional level, and, through education and research, the university develops the leaders, the strategies, and the relationships that can influence policies and practices at national and international levels.

Addressing Climate Change

Climate change is a global concern. Any serious effort to address climate change will require international cooperation and coordination. However, greenhouse gases are emitted from local sources (household heating and cooking, automobiles, power plants). Thus, to address climate change, people will need to take action that promotes changes at a number of levels: personal, local (campus, city, and state), regional, national, and international.

Strategies for addressing climate change are generally separated into two categories: mitigation and adaptation.

Mitigation

Mitigation strategies are actions people take to decrease greenhouse gas emissions. They include energy conservation, energy efficiency, and use of energy sources that emit no greenhouse gases, such as solar or nuclear power. When thinking of mitigation strategies, it may be useful to consider that each individual, institution, and community creates a 'carbon footprint' from their use of fossil fuels. Mitigation strategies are designed to decrease the size of that footprint.

Adaptation

Adaptation strategies are actions people take to manage the effects of a changing climate. As a result of past greenhouse gas emissions, the climate is changing, and this change will continue into the future. Climate change will affect where people are able to live, it will affect people's health, and it will affect agriculture, food supplies, and the availability of fresh water. The effects of climate change will differ in various regions, but all regions of the globe will face the challenge of adapting to climate change. Addressing climate change will require planning that coordinates strategies. Choosing the appropriate combination of strategies will be challenging. Each will cost money, pose problems, and offer benefits.

A university and its students, faculty, staff, and alumni can respond to climate change by adapting or altering everyday practices in order to decrease their carbon footprint and become a more sustainable community. In addition, universities can address climate change by focusing research, education, and community outreach in ways that promote innovation and develop knowledge about the challenges of climate change and the strategies that can be used to address it.

Below we profile a number of strategies. As you consider each, we encourage you to consider how universities—as sustainable communities and as institutions of research, education, and outreach—can serve as a testing ground that provides the commitment, knowledge and resources to implement, develop, and improve these strategies.

A Third Strategy: Geo-Engineering

Geo-engineering is a third type of strategy for addressing climate change. Geo-engineering strategies seek to change the earth's natural environment (e.g., atmosphere and oceans) to reduce the amount or effects of climate change. For example, the amount of sunlight that strikes the earth might be reduced either by putting small particles into the high atmosphere or inducing cloud development so that there will be more cloud cover over the earth. The idea of both of these geo-engineering strategies is to reduce the warming effect by reflecting more sunlight back into space.

Geo-engineering strategies may prove to be less costly, and some researchers believe they may provide more rapid and direct ways for addressing climate change. However, currently geo-engineering is not considered an ideal option. Given the earth's complex and dynamic systems, many researchers worry about irreversible or unintended side effects associated with geo-engineering mitigation strategies, such as a change to existing rainfall patterns or damage to the ozone layer. In addition, the belief that geo-engineering is an option may discourage people from making the hard choices that would lead to a reduction of greenhouse gas emissions.

Mitigation Strategies

To mitigate climate change, we will need to take actions that restore our climate to a healthier physical condition. Mitigation strategies attempt to decrease the carbon footprint of individual and collective human activity by decreasing the emission of greenhouse gases.

Most greenhouse gases are produced by burning fossil fuels. Fossil fuels, such as oil, coal and natural gas, are used in nearly aspect of our economy. When considering mitigation strategies, it is helpful to conceptualize people's fossil fuel consumption as either direct or indirect. The gasoline people use to power their cars or the coal used to generate electricity are examples of direct energy consumption. However, fossil fuels are also burned to provide energy for manufacturing the goods and services people use. The fossil fuels used in the manufacturing process—such as the energy used to manufacture a computer—contribute to a person's indirect consumption.

Different mitigation strategies can be used to target either direct or indirect consumption. "Supply side" strategies reduce greenhouse gases from the direct use of fossil fuels. For example, using renewable energy sources, such as wind or solar, rather than burning coal to generate electricity is a supply side mitigation strategy that targets direct consumption. Installing energy efficient appliances that consume less energy is a "demand side" strategy that represents an indirect way of reducing greenhouse gas emissions.

People may readily recognize which of their activities contribute to their carbon footprint (for example, their personal use of electricity and gasoline). However, to fully appreciate the impact of their personal choices and actions, people must take into account the fuel used to transport the goods they use, as well as the amount of energy used to create products and provide services.

Below we profile a number of mitigation strategies. This should not be considered an exhaustive list. In profiling these strategies, we also identify some of the common challenges to achieving meaningful greenhouse gas reductions.

Energy Efficiency

Energy efficiency involves reducing the amount of energy needed to provide a given service. For example, older home heating systems (such as boilers) convert about 70% of the energy they use to heat; the remaining 30% is wasted. Newer efficient heaters can convert 90%. Thus, they can provide the same level of service while using less energy. Energy efficiency may require people to spend more money initially (to buy the heater) to get savings later (lower gas/electricity bills). However, consumers generally make choices based on lower initial price. Thus, governments may have to provide incentives that promote energy efficient choices (for example, the hybrid car tax credit). Vermont and California have programs to promote energy efficiency. As a result, people in Vermont and California use less energy than other Americans, without sacrificing the quality or quantity of their energy services.

Energy Conservation

Energy conservation involves people changing their behavior so that individuals, businesses, and institutions consume less energy. For example, homeowners could conserve energy for home heating by lowering thermostat settings. However, this could result in less comfort and it may involve a routine effort that people will find difficult to sustain. That is, homeowners would have to continually check to make sure that their thermostat is set properly.

It is important to recognize that energy efficiency is not the same as energy conservation. Conservation strategies require people to change their behavior and alter their daily routines so that they consume less energy. Efficiency strategies, on the other hand, do not require people to consume less energy. Instead they use less energy to provide people with the same level of service. For example, if people install an energy efficient appliance for heating, they will receive the same level of service and they will use less energy, but they will not have to alter thermostat settings.

Education and outreach can reduce greenhouse gases by informing people how to make impactful decisions that will reduce their energy consumption. Education might, for example, encourage people to buy energy efficient light bulbs, to line dry their clothes, or to use their bike instead of driving.

REDUCE EMISSIONS FROM FOSSIL FUEL-POWERED PLANTS: Electricity generation and use is the largest source of carbon dioxide emissions in the U.S. Currently, there is no single option that will replace existing energy sources while producing the same amount of energy. However, there are several options that can be used together to achieve reduced emissions. As people make choices about mitigation, they will likely have to employ a portfolio of strategies.

CARBON CAPTURE AND SEQUESTRATION (CCS):
Equipment can be added to fossil fuel-powered plants to capture carbon dioxide before it escapes to the air. The carbon dioxide gas is turned into a liquid. A pipeline takes it from the plant and puts it permanently in rock formations more than half a mile underground (more than 10 times deeper than drinking wells). Most of the carbon dioxide will dissolve in the salty water within the rock formations and may eventually turn into minerals.

PRODUCE ELECTRICITY USING LOWER/NO CARBON FUELS:
Natural gas emits less greenhouse gases. Using natural gas plants in place of coal plants would reduce direct greenhouse gas emissions. Replacing coal plants with nuclear plants would eliminate all direct greenhouse gas emissions.

USE RENEWABLE SOURCES TO PRODUCE ELECTRICITY:
Using wind or solar would also eliminate all direct greenhouse gas emissions. However, these fuel sources are intermittent: they cannot make electricity when it is not windy or sunny. In the future, very large batteries could store electricity from solar and wind, but currently such batteries are very costly. Hydropower could be used as a fill-in, but it, too, is not always available. Lower carbon options, such as natural gas power plants, can be built to work with the intermittent energy produced by solar and wind.

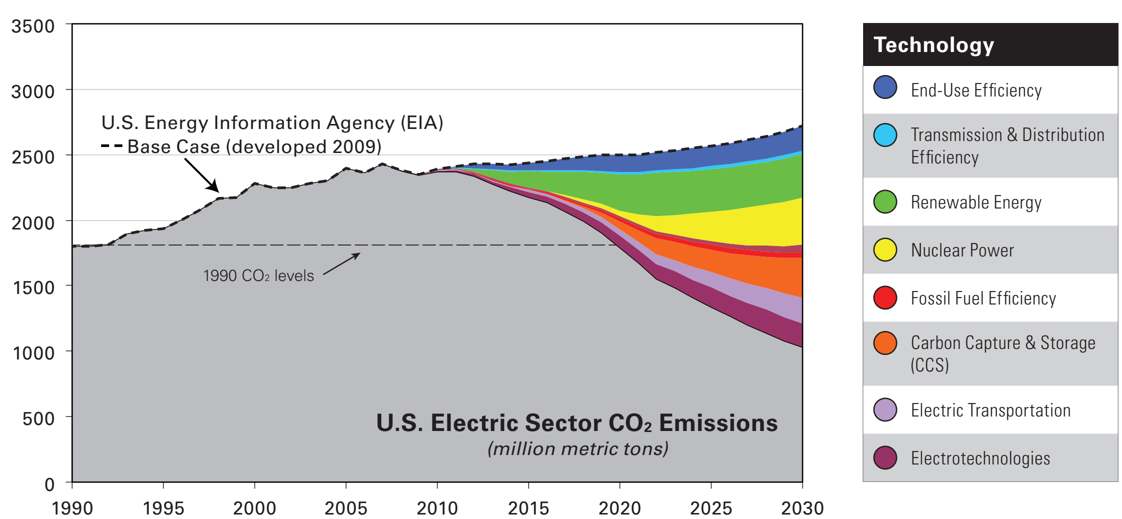
INCREASE FOSSIL FUEL ENERGY PRICES:
A “carbon tax” or “cap-and-trade” system would raise the prices of carbon-intensive products and services (for example, electricity from coal plants). Increasing prices for these products would reduce their demand and stimulate innovation for lower-carbon products and services. Lower-carbon services (for example, electricity from renewable sources) would become more cost-competitive. However, these policies have been politically difficult to achieve.

Figure 3.1 shows one proposed combination of strategies that could cut carbon dioxide emissions from electricity generation in the U.S. by 41% by 2030. The strategies in Figure 3.1 assume significant emissions reductions will be achieved by energy efficiency, use of renewable energy, and use of nuclear power. These strategies would require considerable investments now at a scale that is not currently planned. Without such investments, the reductions shown below will not be realized.

FIGURE 3.1: DECREASING CO_2 EMISSIONS

Adopting changes in these technologies would allow electric utilities to slow, halt or decrease CO_2 emissions by 2030 while still supplying safe, affordable electricity.

source: Electric Power Research Institute (adapted for this document)



Adaptation Strategies

Adaptation strategies are a reaction to the expected or observed impacts of climate change. Even if all greenhouse gas emissions stopped today, the elevated concentrations of greenhouse gasses currently in the atmosphere are contributing to the climate change that is projected to continue for many generations. Adaptation strategies are those strategies people will develop as they attempt to cope with a changing climate.

Adaptation strategies can include:

- Planning water systems and developing new irrigation practices to account for expected precipitation changes,
- Developing new crop strains, changing agricultural practices, and adjusting food supply systems to avoid climate change risks,
- Relocating people, agriculture and industry away from coastal areas,
- Creating "migration corridors" through human settlements such as cities that enable plants and animals to move in response to changes in the natural environment,
- Building more sustainable, adaptable infrastructure systems that will be less sensitive to risks associated with climate or climate change.

Some adaptation is already occurring. People are taking actions to protect coastal areas sensitive to sea level rise, researchers and public officials in many places are developing plans to prevent or respond to the impacts of increasingly intense heat waves, and engineers are designing infrastructure systems for changes to water availability.

It can be very difficult to confidently plan adaptation strategies. The impact of future climate change is uncertain. As result, the feasibility, limitations, and impact of adaptation strategies are all the more uncertain. There are significant opportunities for research that will help determine the potential costs and benefits of various adaptation strategies. Mitigation strategies can prevent climate change, but some researchers suggest that we should also be investing today in research and planning that will help people adapt to the future negative impacts of climate change.

Coordinating Strategies

Many aspects of our economy, our infrastructure systems, our fuel sources, and our daily behavior contribute to greenhouse gas emissions. As a result, people will need to consider many supply and demand side strategies, and multiple strategies will need to be deployed simultaneously to achieve meaningful greenhouse gas reductions. It should also be emphasized that only mitigation strategies—not adaptation strategies—can slow and eventually stop climate change.

Any individual strategy has strengths and weakness. Each strategy is subject to considerable uncertainty, and each strategy will affect various stakeholders differently. Any strategy will have benefits, costs, risks and limitations. For every strategy people may need to consider political, economic, social, environmental, technical, or legal concerns. Thus, effective planning for climate change requires complex analyses that may involve research in many fields. This research will need to be comprehensive and involve careful attention to the likely affects of any strategy.

For example, developing biofuels, such as ethanol from corn, was once embraced as a promising strategy. However, in order to replace the food that is used for biofuel production, people are likely to clear forests in order to create new croplands for food production. Recent research suggests that, as a result, if we were to replace gasoline with biofuels we may actually increase greenhouse gas emissions. Similarly complex analyses would be needed to identify any shifts in environmental burdens from one domain to another. For example, wind turbines and solar arrays require a great deal of open, cleared land. This can be hazardous to some wildlife. Thus, the environmental concern can shift from climate change to the effect of mitigation strategies on wildlife.

Since our society relies so heavily on carbon intensive goods and services, choosing the appropriate combination of strategies will be very challenging. Meaningfully reducing greenhouse gas emissions will likely be costly and take considerable effort. Investing in a combination of strategies will require people to consider many dimensions as they make hard choices.

Climate Change and the Campus

Universities have opportunities to influence climate issues across a broad set of activities. Campuses are leading centers of education, research, and outreach. Moreover, campuses are like small cities, with buildings and other infrastructure that can be operated in a more climate friendly manner.

Demand Side Mitigation: Energy Conservation and Efficiency

Climate change mitigation strategies on campus will mostly depend on demand side mitigation, including energy efficiency and conservation actions. Efficiency and conservation strategies can be pursued through campus policies but these will also need to be supported by education and outreach initiatives.

POLICIES:

Institutional policies are an effective means for reducing energy consumption. For example, campus policies can include setting university owned computers to go into a lower power state when not in use, installing motion sensors to control lighting, replacing inefficient windows, adjusting heating and air conditioning settings, and purchasing more efficient appliances.

BUILDINGS:

Campuses manage a significant number of buildings and support infrastructure that affect energy use. The energy required to support buildings is typically a large fraction of the greenhouse gas emissions from a campus. In addition to addressing climate change, efficiency and conservation strategies can also save money by reducing utility expenses. Thus, universities receive several benefits when they take measures to reduce the greenhouse gas emissions associated with building energy consumption.

Some campuses pursue conservation by holding competitions to see which dorm can reduce the most energy consumption. However, conservation, which achieves energy reduction through behavior changes, often demonstrates a limited energy reduction potential. Many campuses prefer to pursue aggressive energy efficiency alternatives to achieve significant emissions reductions that do not depend on individuals changing their behavior.

TRANSPORTATION:

Universities can mitigate greenhouse gas emissions through strategies aimed at the campus' fleet of vehicles; student, faculty and staff commuting; and business air travel. There are many incentives that a university can create to accommodate commuters, including facilitating and offering incentives for carpooling, subsidizing public transportation for campus community members and providing safe and efficient bike and walking paths. Air travel can also be a large contributor to a campus' carbon footprint. Providing easy access to teleconferencing could reduce greenhouse gas emissions from travel while also making it easier and far cheaper for faculty and staff to connect with colleagues electronically.

LIFE CYCLE CONSUMPTION:

Each university purchases food, as well as other products and services for the benefit of the campus community. Considering the life cycle of these products prior to making purchasing decisions may allow universities to make more sustainable choices. For instance, buying locally grown fruits and vegetables and encouraging less carbon-intensive eating practices (for example, having “meatless Mondays” on campus) may help to reduce the campus’ carbon footprint.

OUTREACH AND EDUCATION:

Campuses are especially well equipped to provide faculty, staff, and students, as well as the local community, with information to promote efficiency and conservation efforts. This can be achieved both in formal classrooms and as informal activities around campus. For example, Indiana University and Harvard recently instituted a dormitory energy conservation competition. This competition, which reduced dormitory energy consumption also acted as a vehicle for students and staff to become more informed about energy consumption and conservation. Larger impacts may also be gained when campuses pursue research in and offer courses or majors related to green design, energy engineering systems and environmental policy.

Supply Side Mitigation

Universities that wish to significantly reduce greenhouse gas emissions will likely have to pursue carbon reductions on the supply side. However, supply side options may increase the operating costs of the university, and these increases could in turn be passed on to the students in terms of tuition or fee increases.

GENERATING LOW-CARBON ENERGY ON CAMPUS:

If a university has the space and infrastructure, it may be able to generate its own energy. Institutions that already generate their own electricity may be able to install technologies for combined heat and power, using the waste heat from electricity generation to heat the campus. Universities that own agricultural land could invest in wind turbines. Building new infrastructure requires an initial cost to the university. However, the university may recoup some of this cost over time from generating its own energy.

BUYING LOW-CARBON ELECTRICITY:

Most universities will only be able to reduce carbon emissions on the supply side through indirect means. Some utility companies offer programs through which universities can buy electricity generated from low-carbon sources, such as wind and solar.

Making Climate Decisions

As climate change moves to the forefront of public attention, colleges and universities are uniquely positioned to make a significant contribution to public discussions about how to address climate change. Universities are already centers for climate change and energy research. In addition, the steps universities take to reduce their carbon footprint will influence the thoughts and habits of students, faculty, staff, and alumni, all of whom may influence the decisions made about climate change in their communities off campus.

Making informed decisions about climate change requires people to understand the science of climate change and to understand something about the strategies that can be used to address it. Given this information, people must weigh the potential costs and benefits of various strategies.

However, climate change also requires people to consider what they value. Climate change affects everyone, and everyone has a stake in deciding what should be done. Some strategies for addressing climate change will involve personal choices about localized actions that may be implemented relatively easily. However, the strategies that will have the most impact will require people to alter the practices, structures, and infrastructures of their institutions and communities. Today, the world is powered by fossil fuels. Globally, our practices, structures, and infrastructures reflect this reality. Climate change, too, is a reality, and significant changes will be necessary if people hope to reduce greenhouse gas emissions to levels that will allow them to avoid the worst impacts of climate change. Some have argued that addressing climate change will require an initiative like the "Manhattan Project," which resulted in the United States' development of the atomic bomb, or the "race to the moon," which led to astronauts walking on the moon in 1969. That is, some suggest that people will need to generate similar levels of political will and commit significant resources of people and money to address climate change.

Climate change will require people to make individual decisions and engage others in decision-making. As individuals, we will decide what actions we should take (at home, in the workplace, for transportation, etc.). As citizens, we will work with other members of our communities to shape public policy. As members of a campus community, students, faculty, staff, and alumni will need to learn what avenues are available for changing individual activities, for working with colleagues and peers to promote changes in teaching and research, for working with a university's administration to promote sustainable practices, and for working with other communities to promote change at the local, regional, national, and international levels.

Public deliberation requires more than people expressing the choices they would make. The most important value of public deliberation is that it provides an opportunity for people to share the reasons why they would make certain choices. Public deliberation provides a venue for people to ask questions, to learn from others, to express their own perspectives, and to share the particular knowledge they have about issues and options. The collective knowledge and fuller understanding of issues, options, and various perspectives that can develop during deliberation becomes the resource necessary for individuals to develop an informed opinion.

Below are several questions that are likely to prove particularly important as people work to shape policies on their campuses and in their communities. There is no one right answer to these questions, but the answers people have to these questions will affect the choices they make about particular policy options. More to the point, people will have different reasons why they will answer these questions in certain ways. These differences are important and valuable.

Suppose you or a friend wants to decide which policies to support. Your decision will likely depend on several considerations. By combining your beliefs about these considerations, you can come to a general conclusion about which policy to support.

1. **How much do you think the climate will change, and what impact do you believe that change will have on the things you care about?**

In responding to these questions, your judgment will not only reflect what you believe about climate change. It will also reflect what you value. For example, you and your friend might agree that climate change will destroy many of the world's most sensitive ecosystems, but you may disagree about how much you value those ecosystems. As a result, you each might rate the impact of climate change differently. The person who values them highly may rate the impacts of climate change as moderately bad or very bad. The other person, who is perhaps mainly concerned with the economic impacts of climate change and doesn't think sensitive ecosystems are of the greatest importance, might consider the overall impact of climate change not as bad.

2. **How much should be spent on strategies to address climate change? Who should be responsible for paying these costs?**

Unlike the case above, where we were dealing with values, here we are dealing with costs that can be quantified. Some people believe that it would be best to spend small amounts of money to reduce emissions moderately in the near-term while we work to gain a clearer picture of the future. Others believe the future is clear, that we must act now, and we should commit significant amounts of money to drastically reduce greenhouse gas emissions. Regardless of how much money you think should be spent, you will also have to consider who should incur the costs and how. Should consumers pay fees, fines, or taxes to advance policy initiatives? At a university, should students be expected to provide the money needed or should the institution look to raise money from other sources, such as alumni, the government, private foundations, or their endowments?

3. **How should individuals and institutions be held accountable for realizing policy decisions aimed at reducing their 'carbon footprint'? Who should be responsible for ensuring accountability: individuals or institutions?**

When thinking about policies, people need to think about how to insure people will adhere to any policies that are adopted. They will need to think about who is responsible for ensuring that people do adhere to policies, and they will need to think about how people should be held accountable if they do not. The most basic option here is to rely on individual choice for the realization of policy initiatives. Other options may involve peer pressure, with community members assuming some level of responsibility for promoting, encouraging, or regulating the behavior of their peers. Alternately, institutions might assume the responsibility for promoting new behaviors and regulating compliance. When the responsibility shifts to institutions, people will need to consider whether they wish to use a carrot or a stick to promote, encourage, and regulate people's adherence to policies. That is, does the institution develop some system that rewards people when they take actions in line with the policies or does the institution develop some system of fines or punishment for those who do not?

4. **How much responsibility do you feel to future generations and to people in communities distant from your own?**

Some regard climate change as an ethical issue. The science of climate change and projections based on this science allow people to imagine what the impact of any public policy might be. However, while any public policy will have local impact, because climate change is a global phenomenon, local policies will also have some level of impact on the future and beyond our local communities. As an ethical issue, climate change requires us to consider what implications any policy proposal will have for future generations and for people living in communities distant from our own.

5. **What strategies would you be willing to actively support?**

There are many strategies explained in this booklet (or elsewhere), but you need to support the ones that make the most sense for you. This might include a transition to more use of renewable energy sources, nuclear power, a commitment to green building practices in all construction, initiatives for student and departmental energy conservation, or some combination of these.

Public deliberation provides a way for individuals to move beyond their own knowledge and understanding, allowing people to benefit from the knowledge and understanding of others. No individual can be expected to have full knowledge of the options available or complete understanding of how others might be affected by the choices he or she makes. In addition, no one can know how others would answer these questions. However, these questions should spur reflection as you prepare to engage in the deliberative process.

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