Climate Literacy

Essential Principles for Understanding and Addressing Climate Change



A Guide for Educators, Communicators, and Decision-Makers



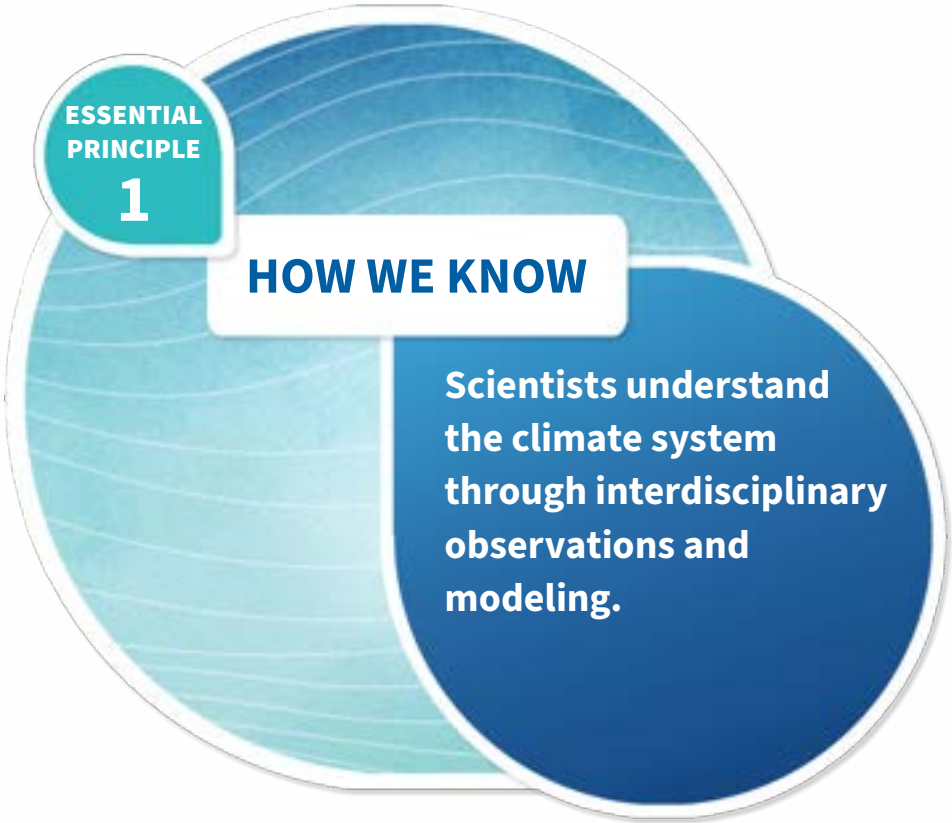


U.S. Global Change Research Program

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Essential Principles for Understanding and Addressing Climate Change



A. Climate is not the same thing as **weather**. Weather is the minute-by-minute condition of the atmosphere (such as temperature and precipitation) on a local scale. Climate is the long-term average weather conditions of an area. The term climate change refers to significant and persistent change in an area's average climate conditions or their extremes.

>> Learn more about climate science

B. The components and processes of Earth's climate system are governed by the laws of science. Therefore, the behavior of the climate system can be understood and modeled through careful, systematic study. Our understanding of the climate system will only continue to improve as science advances.

>> Learn more about recent advancements in climate science

C. To learn about how climate has changed in the distant past, scientists use natural records, such as tree rings, ice cores, and sedimentary layers. Indigenous Knowledges and historical observations such as personal journals also document past climate change.

D. Scientific observations indicate that the global climate varies over time; it has changed in the past, is changing now, and will change in the future. The natural processes driving Earth's long-term **climate variability**, such as changes in solar energy reaching Earth, do not explain the rapid climate change observed in recent decades. The only credible explanation for recent climate change is human activities.

>> Learn more about how natural causes alone do not explain climate change



Artist's statement: "Climate change has compressed and conflated human and geologic time scales, making it essential to find ways to conceptualize 'deep time.' This work seeks to make notions of deep time comprehensible through visual exploration of glacier ice, as well as other earthly archives. This project includes intimate collaborations with paleoclimatologists by having them annotate directly onto my photographic prints—a contemporary taxonomy of ice and climate. This portrait was photographed in a cold/clean lab at Montana State University. The ice shown is 10,827 (left side) to 10,833 years old."
CREDIT: Ian Van Coller, Art x Climate, Dr. Avila Holding Cut Antarctic Icecore (2017, pigment print on washi with annotations)

E. The magnitude and trends of climate change are not the same at all locations on Earth. For example, the land warms faster than the ocean, and the polar regions warm faster than the tropics.

F. Research into past climate changes has shown that there are parts of the Earth system that change gradually until they reach a **tipping point**, after which they change more quickly. Some of these changes may be irreversible. The risk of crossing these tipping points increases as climate change intensifies. Ecosystems, ice sheets, and ocean currents may all have tipping points.
>> Learn more about tipping points

G. **Climate models** have been constructed using observational data and physical laws. These models can project a range of potential future climate conditions that result from different assumptions about the future, such as the amount of greenhouse gas



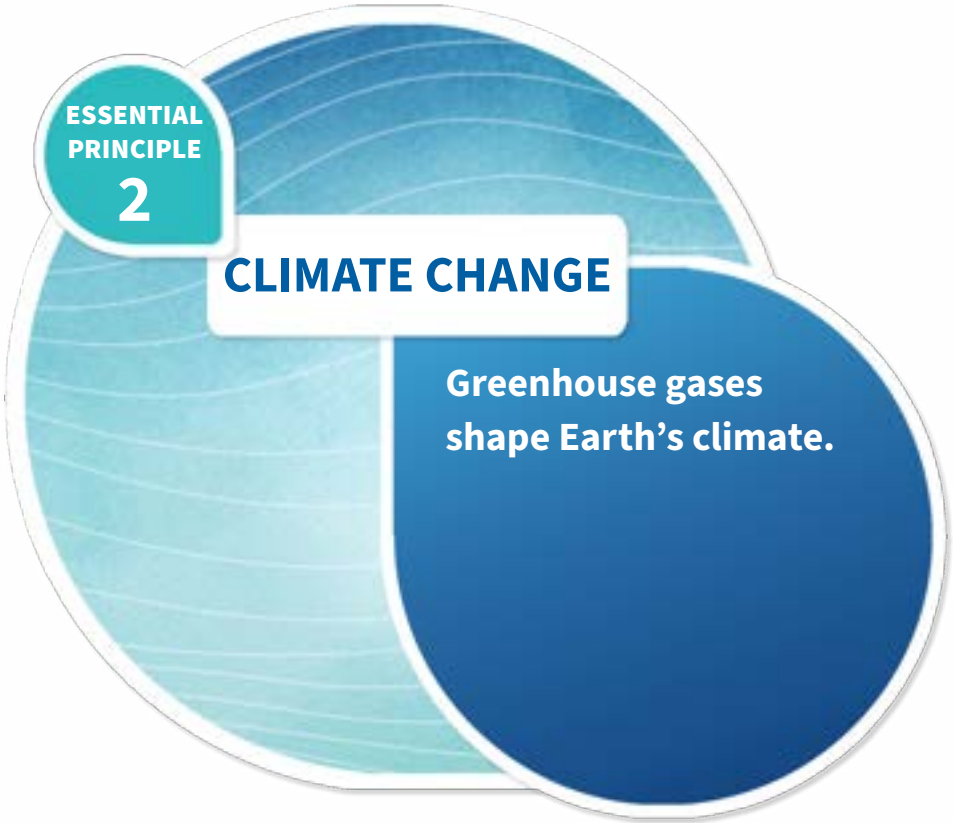
A citizen scientist measures precipitation after a very long summer drought over a two-day period in Alberta, Canada. Citizen science involves the public and aids in bridging the gap between communities and scientists to make informed decisions.
CREDIT: Susan Risk

emissions. Models that include both human and natural systems examine how climate impacts cascade across sectors and scales and, in turn, how human systems and choices influence climate.
>> Learn more about climate modeling

H. Integrated approaches that bring together knowledge from many contexts and areas of study are essential to understanding the full picture of climate change. Considering the perspective of only a single sector, topic, or region may cause climate impacts or solutions to be overlooked.
>> Learn more about interdisciplinary climate research

I. Coproduced climate change research projects integrate both community-based and science-based insights and solutions to climate change. Coproduced research often includes experts within relevant knowledge contexts, such as Indigenous Knowledge holders or multi-generational farming communities. This kind of research can give rise to community-based climate solutions.
>> Learn more about coproduction of climate research

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A. Nearly all the energy that flows through the Earth system comes from sunlight. Earth's climate is determined by the movement of energy through the Earth system—the ocean, atmosphere, clouds, ice, land, and life—and also includes energy and heat produced by humans and human activity.
>> **Learn more about Earth's energy balance**

B. Some of the sunlight that reaches Earth is reflected back to space by Earth's atmosphere and surface, but about 70% of it is absorbed by the atmosphere, land, and ocean. The warmed Earth radiates heat back into the atmosphere, where the heat is absorbed by greenhouse (also known as heat-trapping) gases that radiate some of this heat back toward Earth. This leads to the overall heating of Earth's surface—known as the **greenhouse effect**.
>> **Learn more about the greenhouse effect**

C. Greenhouse gases added to the atmosphere by human activities intensify the greenhouse effect and drive global warming. The greenhouse gases produced by human activities include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.
>> **Learn more about greenhouse gas emissions**

D. Water vapor (H_2O) also traps heat, and a warmer atmosphere holds more moisture than a cooler one. As a result, water vapor amplifies the warming caused by the addition of human-produced greenhouse gases.
>> **Learn more about water vapor and the greenhouse effect**

E. Some greenhouse gases are more effective at warming the planet than others. The heat-trapping ability of a greenhouse gas, plus how much of it is in the atmosphere and how long it endures,



Artist's statement: "My drawing depicts 11 endangered species and their different ecosystems found in the Western United States. The most difficult challenge was making this piece cohesive, even across different habitats that normally wouldn't be found together. I live in Boise, Idaho, and am surrounded by wild places that I consider part of my home. I want to ensure that these ecosystems are protected. I hope viewers come away with an appreciation for our Western wild places and the importance of biodiversity and healthy ecosystems threatened by climate change and habitat loss."
CREDIT: Taelyn B., Art x Climate, Endangered West (2022, colored pencil)

determines its contribution to total warming. For example, even though there is about 200 times more carbon dioxide in the atmosphere than methane, and carbon dioxide stays in the atmosphere for much longer, methane has contributed 20% to 30% of global warming to date.
>> Learn more about the strength of greenhouse gases

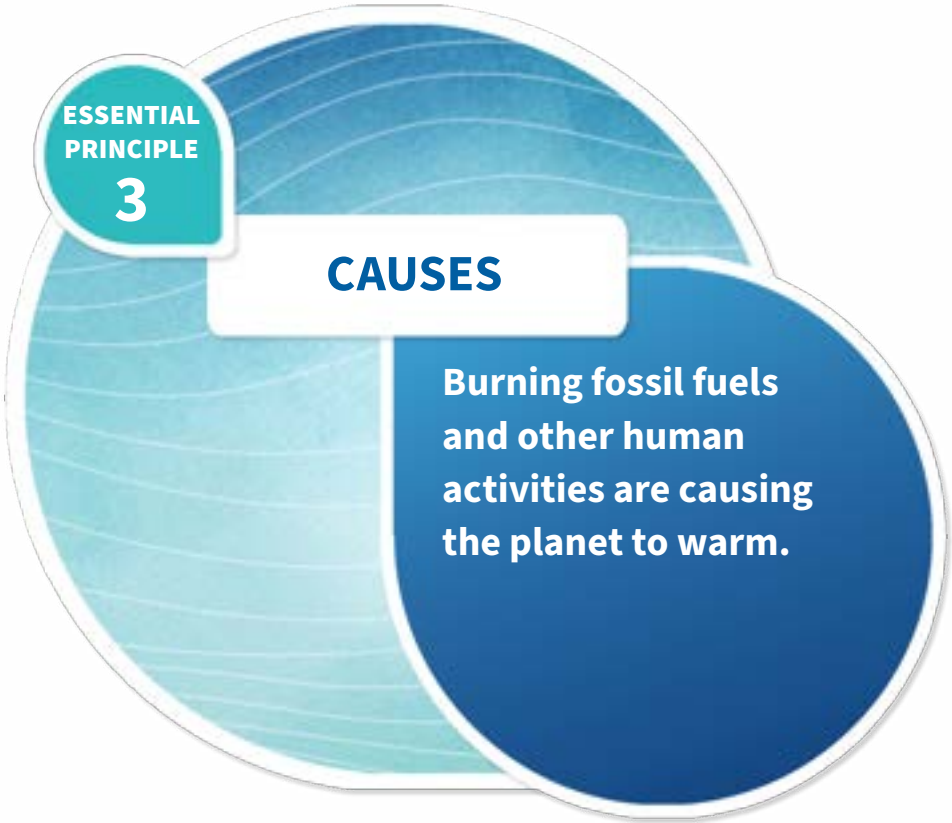
F. Life—including microbes, plants, animals, and humans—is a major driver of the global **carbon cycle** and can influence global climate by modifying the chemical makeup of the atmosphere. The geologic record shows that life has significantly altered the atmosphere during Earth's history.

G. Carbon naturally moves very slowly between the atmosphere and reservoirs in the Earth, including rocks, soils, and the deep ocean. Human activities are disrupting this cycle by taking carbon out of storage underground and releasing it into the atmosphere, primarily by burning fossil fuels such as coal, oil, and natural gas.
>> Learn more about how humans are changing the carbon cycle

H. While some of these human-caused carbon dioxide emissions are absorbed quickly by the ocean and forests, much of the carbon dioxide will remain in the atmosphere before it is absorbed by the ocean over thousands of years.

I. As concentrations of carbon dioxide and other greenhouse gases increase, Earth's average temperature rises in response. This rise in temperature causes a significant change in the climate averages and extremes that people and the natural environment experience.
>> Learn more about carbon dioxide's role in Earth's climate

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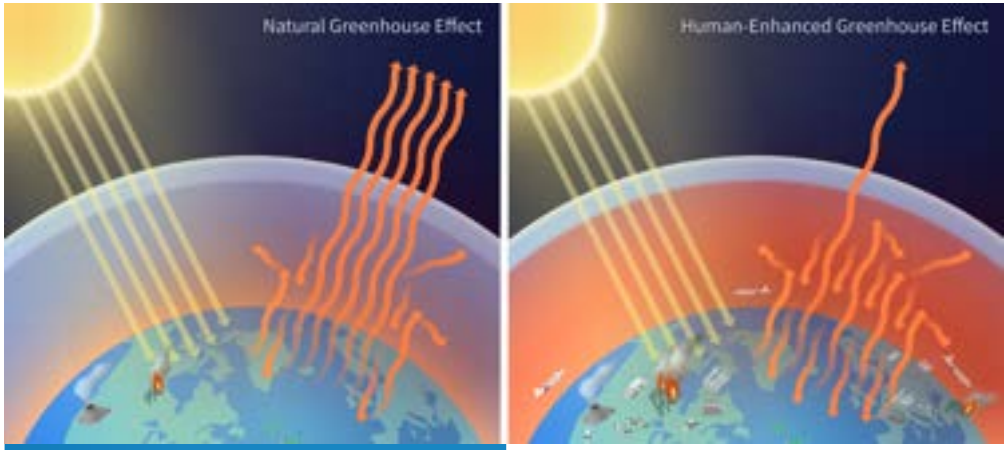
A. Human activities have unequivocally caused the global warming observed over the **industrial era** by increasing the levels of carbon dioxide and other greenhouse gases in the atmosphere.
>> Learn more about how human activities cause global warming

B. Three-quarters of all greenhouse gases emitted by human activities come from the use of fossil fuels, primarily coal, oil, and natural gas, for transportation and energy. The rest come from industrial processes, agriculture, landfills, and land-use changes such as deforestation.
>> Learn more about sources of greenhouse gas emissions

C. **Social systems**—including institutions, policies, practices, values, and behaviors—determine the amount of greenhouse gases emitted. Social systems also inequitably distribute the economic benefits of energy consumption and the impacts of greenhouse gas emissions and climate change.
>> Learn more about how social systems drive climate change

D. The global climate will continue to warm in the future. How much it warms depends primarily on current and future emissions of greenhouse gases from human activities. By far the biggest **uncertainty** in terms of future climate change is the human factor—how much action global society will take to limit greenhouse gas emissions.
>> Learn more about future climate change

E. Many of the human activities that produce greenhouse gases also produce small airborne particles called **aerosols**. Aerosols generally cool the planet by reflecting sunlight back into space, and by seeding clouds that reflect sunlight. This cooling effect is currently not big enough to fully counteract human-caused warming. Most



Greenhouse Effect Diagram
CREDIT: NOAA Climate Program Office, Graphic by Anna Eshelman

human-produced aerosols, such as smoke from power plants and biomass burning, also have negative effects on air quality and human health.

>> **Learn more about climate change and air quality**

F. Human activities continue to increase the levels of greenhouse gases in the atmosphere, although contributions vary across regions, sectors, and populations.

>> **Learn more about global greenhouse gas contributions**

G. Carbon dioxide remains in the atmosphere for centuries or longer. This means that carbon dioxide emitted decades ago continues to contribute to climate change today. Among countries, the United States is the largest emitter of the carbon dioxide that has accumulated in the atmosphere since the Industrial Revolution. From 1850 to 2021, total emissions from the United States are estimated to have caused around 17% of global warming, China 12%, European Union 10%, and the 47 least-developed countries collectively 6%.

Artist's statement: "Originally trained as a landscape architect, I rework abandoned sites, invasive species zones and decaying ruins as a way of navigating human folly. Individual works juxtapose something highly artificial with something organic, and/or something jarring with something reassuring. Forged from multiple medium format images, this scene of industry in a forested, mountainous area combines landscape visualization techniques (infrared sensors) with more traditional light photography (dodge/burn, compositing) to bring out atmospheric details and place the manmade and vegetation in high contrast."
CREDIT: Casey Lance Brown, Art x Climate, Jackson County Industry (2022, infrared photography composite)





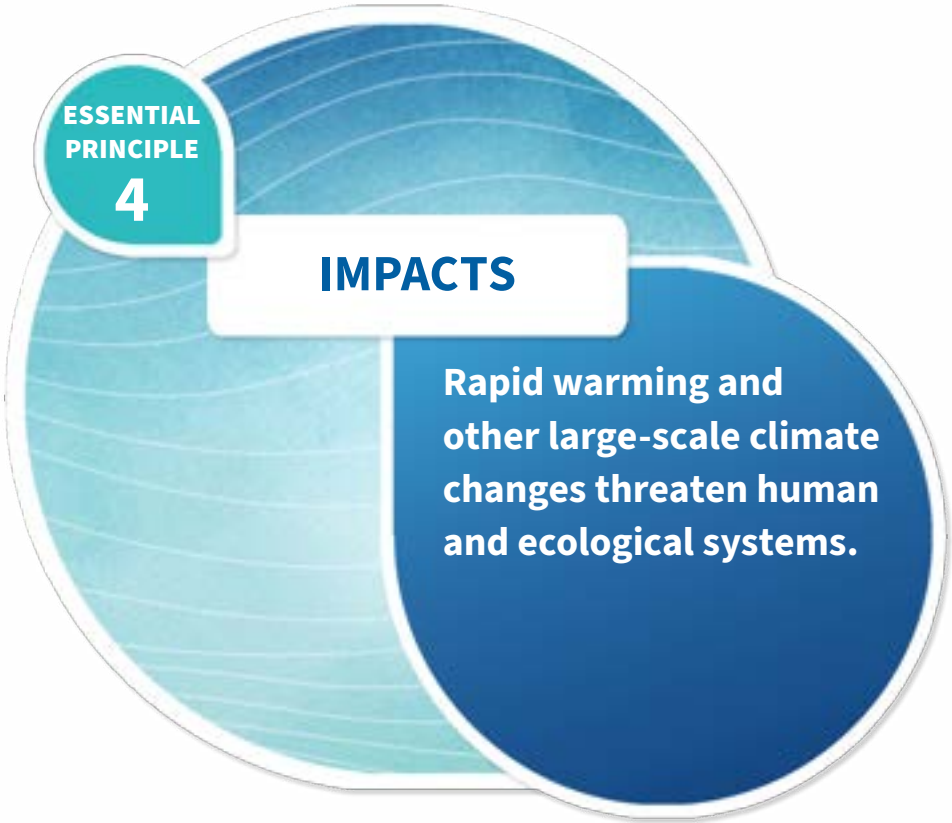
Cause and effect are represented here in southern Delaware, where temperatures rose to triple digits in a period of excessive heat due in large part to emissions from transportation and energy use and production.
CREDIT: NOAA Climate Program Office, Photo by Katy Perrault

H. Annual U.S. greenhouse gas emissions have been slowly declining since 2007, while emissions have increased rapidly in China, India, and other nations with rapidly industrializing economies. China is currently the top annual emitter as a nation.
>> Learn more about global greenhouse gas emissions

I. Reducing emissions of greenhouse gases can limit future global warming and its impacts. Parties to the 2015 Paris Agreement set a goal of holding the global average temperature to well below 2°C (3.6°F) above preindustrial levels, and pursuing efforts to limit warming to 1.5°C (2.7°F).
>> Learn more about the Paris Agreement

J. The Paris Agreement also sets an aim to make financial flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development. However, public and private financial systems continue to support investment in fossil fuels. Currently, global spending on fossil fuels outweighs investments in adaptation and mitigation. Current investments in reducing greenhouse gas emissions are not large enough to keep warming below 2°C (3.6°F).

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A. As of 2021, Earth had warmed by about 1.1°C (2°F) above pre-industrial levels. Most of this warming has occurred since 1980. The current rate of warming is roughly 30 times faster than the rate at which Earth warmed as it emerged from the last ice age.

B. The last time the amount of carbon dioxide in the atmosphere was as high as it is today was about 3.2 million years ago, when the world was significantly warmer and sea levels were between 18 and 63 feet (5.5 to 19 meters) higher than today.
>> Learn more about past climate

C. Human societies developed over the past 10,000 years during a very stable period in Earth's climate history. The rapid rise in temperatures and resulting climate changes since 1980 mean that the economic, transportation, agricultural, and social systems we rely on are **vulnerable**.
>> Learn more about climate change impacts on social systems

D. Climate change is already increasing the severity, geographic scale, and frequency of **extreme events**, such as **heatwaves**, floods, strong storms, droughts, and wildfires around the United States and the world. As the world warms, these events will become even more extreme, worsening existing social inequalities and leading to greater health, resource, and **migration** challenges. Existing societal challenges, intensified by increasing climate change, will exacerbate the drivers of instability and threaten both national and global security. To deal with the direct effects of extreme events, as well as the increased instability resulting from them, the need for humanitarian assistance will increase worldwide.
>> Learn more about changes to extreme events

E. Globally, a warmer atmosphere holds more total water vapor, and some areas will get wetter. Warmer air with more water vapor also causes heavier rainfall during storms, which can lead to flooding. However, over many regions, temperature changes will outpace the effects of increases in humidity, making dry places even drier and droughts more intense.

F. Changing precipitation and snowmelt patterns are altering the distribution of Earth's freshwater and the timing of runoff. Droughts are becoming more frequent and severe in many regions, while, at the same time, extreme precipitation events are becoming more frequent and intense in other regions. Some regions are experiencing both—more frequent or severe droughts in the summer, and more extreme precipitation events in the winter. These and other climate change impacts threaten the quality and reliability of water supplies.

>> **Learn more about the changing water cycle**

G. Global warming is causing the global average sea level to rise. As ocean water warms, it expands, taking up more space. Water from melting land ice is also being added to the ocean, raising sea levels. As the **sea level rises**, salt water contaminates coastal freshwater sources, damages coastal homes and infrastructure, harms coastal ecosystems, and inundates islands and low-lying land. Sea level rise also increases the risk of damage to buildings and infrastructure from **high tide flooding** and **storm surge**.

>> **Learn more about the impacts of climate change on coastal communities**

H. The ocean has slowed climate change by absorbing huge amounts of heat and carbon. About 90% of the warming caused by greenhouse gas emissions has been absorbed by the ocean, altering its global **circulation** patterns and threatening marine



Warming temperatures and changes in light and nutrients cause coral to expel their colorful symbiotic algae in a process called coral bleaching, leaving them without a major food source and vulnerable to disease.
CREDIT: Daniela Macaya, Ghost Reefs



A firefighter goes to work in a smoke-filled environment at the Pioneer Fire in Washington State. Wildfires have increased in frequency and intensity due to human activity.
CREDIT: U.S. Forest Service

life. The ocean has also taken up 25% of all carbon dioxide produced by human activities, making it more acidic and leading to harmful impacts on marine species, **food webs**, and coastal economies. As climate change continues, the ocean's capacity to store heat and carbon is likely to weaken, reducing its ability to buffer the effects of greenhouse gas emissions.
>> **Learn more about the ocean and climate change**

I. All species, including humans, survive within specific ranges of temperature, precipitation, humidity, sunlight, and other climate conditions. Organisms exposed to climate conditions outside their normal ranges must adapt or move elsewhere, or they may face negative health impacts. If climate conditions sufficiently alter a species' habitat, consequences can include extinction. Changes to the abundance of different species can threaten the stability and survival of their ecosystems.
>> **Learn more about ecosystem changes**

J. As local climate conditions change, many organisms, including animals, plants, and microbes, are attempting to move to areas with more favorable conditions. However, their movement can be limited or prevented by natural barriers such as mountains, human-built infrastructure such as roads, or competition with other species. The timings of blooms, migrations, and hibernations have changed and will continue to change, sometimes dramatically, potentially altering food webs and spreading infectious diseases. These processes disrupt existing ecosystems and can threaten the survival of entire species, biomes, and human livelihoods.
>> **Learn more about ecosystem impacts**

K. The impacts of climate change and other stressors may drive people to leave their homes temporarily or permanently, either within the same country or across a border. For example, rising temperatures and shifting rainfall could lead to increased crop failures, compelling farmers to seek more reliable livelihoods in nearby cities or neighboring regions. Climate migration is one type of human migration, which can have many complex causes and impacts. If migration is sudden and unplanned, it may increase demand for scarce resources and potentially exacerbate tension between migrants and local communities. Governments may also struggle to provide adequate services amid large-scale displacement.

>> Learn more about climate change and migration

L. Climate change negatively impacts human health through more frequent and severe **extreme heat** and other extreme events; increased transmission of infectious and vector-borne diseases; declines in food and water security; and degraded air and water quality. Exposure to extreme events can result in feelings of **vulnerability**, uncertainty, and anxiety or depression, with negative impacts on mental health. **Marginalized** and low-income populations tend to be more exposed to climate hazards and associated health impacts than other groups.

>> Learn more about climate change and human health

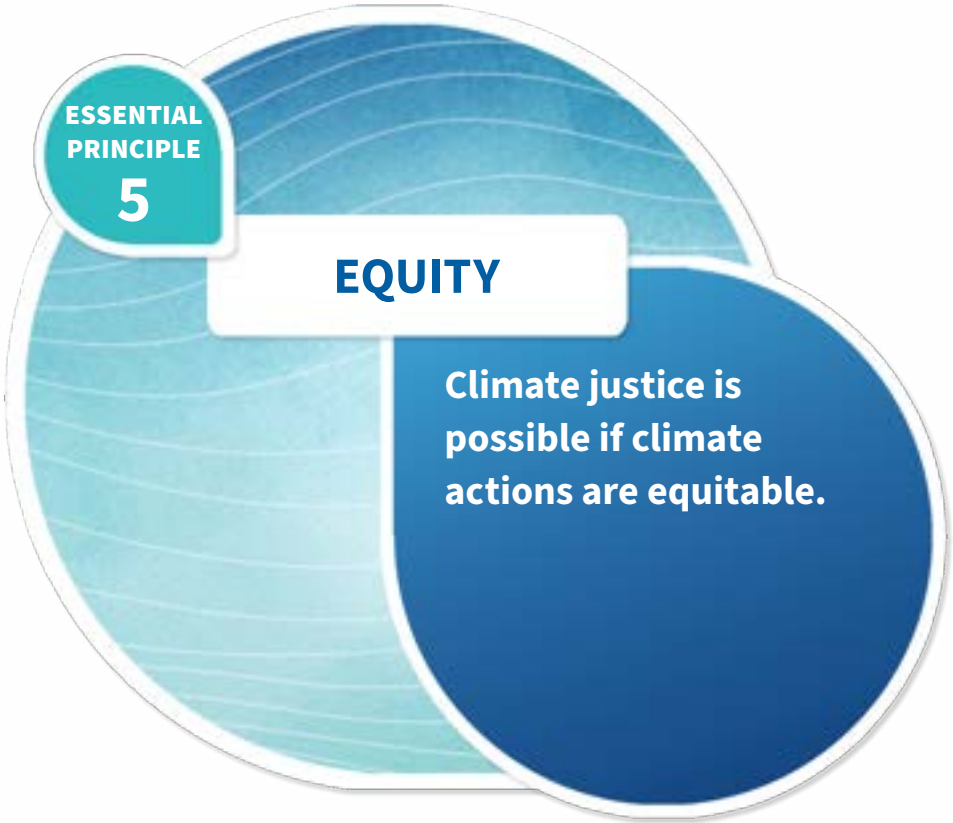
M. Climate change can harm businesses, governments, and economies through costly disruptions to services and supply chains, damage to infrastructure, and lost productivity. At the same time, climate solutions will create new economic opportunities for organizations.

>> Learn more about climate change and the economy



Ecogenia, the first NGO in Greece to promote sustainability through civic service, is working to mobilize young people to accelerate localized climate action. Inspired in part by AmeriCorps, collaboration with the California Conservation Corps enabled both programs to build capacity for increased climate action.
CREDIT: Ecogenia

Essential Principles for Understanding and Addressing Climate Change



A. With careful planning and execution, actions to reduce greenhouse gas emissions and adapt to climate risks can be carried out in ways that promote climate justice in the United States, which involves ensuring benefits from climate action are shared equitably and fairly. Achieving sustainable outcomes that promote **equity** in the United States, rather than exacerbate inequities, involves understanding how the impacts of and responses to climate change affect different groups of people, including those who have been marginalized and **underserved**. Including affected communities in decision-making can help reduce risks and distribute benefits equitably.

>> Learn more about climate justice

B. Climate change is both a product of society and a force that is shaping it. Its effects both reflect and exacerbate existing social inequities, with some people and communities suffering disproportionate harm. Societies can help address these issues by acknowledging the intersections between climate change and key social challenges, such as those relating to racial, economic, and gender **inequity**; rural communities; public health; migration; and ecosystem health.

>> Learn more about intersecting challenges

C. Although climate change affects everyone, marginalized and underserved communities are more likely to experience harmful impacts. The long-lasting effects of discriminatory investment practices, unequal distribution of resources, and exclusionary laws have pushed Indigenous communities, communities of color, and low-income communities into locations where they are more vulnerable to climate change. These communities are often **overburdened**, experiencing one or more types of **environmental injustice** in the form of disproportionate health-related impacts

from fossil fuel-based energy systems, reduced capacity to prepare for and recover from extreme events, settlement in hotter or more flood-prone areas, or lower-quality infrastructure and services.

>> **Learn more about inequitable climate impacts**

D. Certain groups of people are at higher risk of negative health impacts from climate change. Those likely to experience elevated health impacts include the very young, the very old, people with disabilities or chronic health conditions, low-income individuals and communities, and other marginalized communities.

>> **Learn more about climate change impacts on human health**

E. Rural communities face unique challenges from climate change. Rural areas are often under-resourced and therefore less resilient to climate impacts. Climate change also worsens stressors they already face, including physical isolation, limited economic diversity, and higher poverty rates, combined with an aging population. At the same time, rural communities are key to many climate adaptation and mitigation efforts, from climate-smart agricultural practices, to new sources of **renewable energy**, to restoring critical habitats for wildlife.

F. Indigenous Peoples hold unique knowledges and experiences about how to live sustainably on their lands. Their ways of life are threatened as local climates change and the ecosystems they rely on are altered. Tribal education systems are engaged in building community **resilience** and supporting the next generation of climate leaders.

>> **Learn more about how Indigenous leadership is guiding climate responses**



Members of the San Carlos Apache Tribe, Klamath Tribe, and White Earth Nation, alongside a representative of the DOI-Bureau of Indian Affairs, collaborate on potential Tribal renewable energy projects at the National Renewable Energy Laboratory.
CREDIT: DOE, Photo by John De La Rosa (NREL)



Artist's statement: "Cheryl is a very real person in Milwaukee, Wisconsin. She works at a social services non-profit and is a member of our gay community. I painted her to show her confidence and triumph over urban challenges. This painting depicts the density of urban life and the spirit of the individual in it. The power of the individual, for climate change, social change, and personal change is embodied in this painting." CREDIT: Ellen Anderson, Art x Climate, Cheryl (2021, oil on canvas)

G. An equitable and sustainable U.S. response to climate change has the potential to reduce climate impacts while improving well-being, strengthening resilience, benefiting the economy, and, in part, redressing legacies of racism, injustice, and inequity within the nation.

>> Learn more about just climate solutions

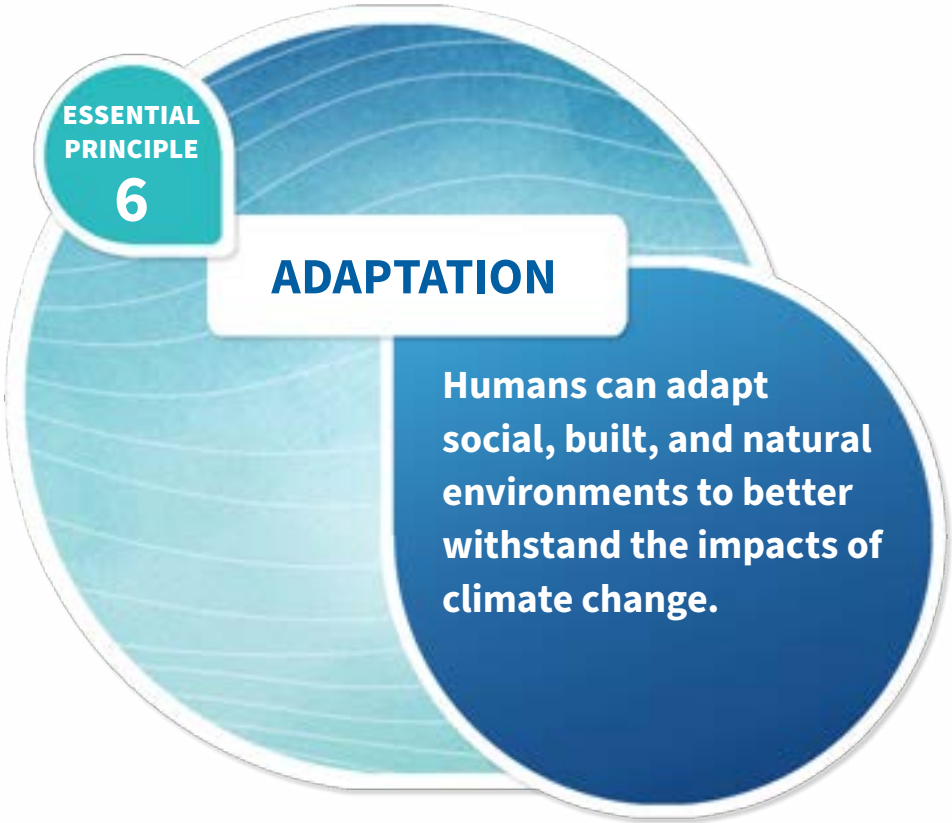
H. Participatory research and planning processes can help reduce inequities and the chances of causing unintended harm through climate actions. Taking inclusive and equitable approaches to addressing climate change in the United States requires that the characteristics of a community, the factors that shaped them, and the interests of those affected are central to designing and implementing climate solutions. Approaches to decision-making that are based on broad and meaningful participation by all affected groups can build trust, promote social cohesion, and increase support, implementation, and efficacy for adaptation and mitigation strategies and plans.

>> Learn more about how inclusivity improves climate responses

I. A **just transition** within the United States is the process of responding to climate change with transformative actions that address the root causes of climate vulnerability while ensuring equitable access to **decent work** and quality jobs; affordable, low-carbon energy; environmental benefits such as reduced air pollution; and improved quality of life for all. This type of transition has the potential to enable more ambitious, effective, and lasting adaptation, resilience, and mitigation actions, including by creating good-paying jobs in renewable energy industries.

>> Learn more about just transitions

Essential Principles for Understanding and Addressing Climate Change



A. Adapting and building resilience to climate impacts in all aspects of society saves lives; reduces structural, environmental, and economic damage; protects natural resources; helps preserve cultures; and often results in improved quality of life.
>> **Learn more about climate adaptation**

B. Adaptation and mitigation are complementary strategies for reducing the risks of climate change. Taking actions to adapt and build resilience to current and future extreme events and other climate changes, while dramatically reducing emissions of greenhouse gases, will also reduce loss of life and property and limit damage to ecosystems and human health.

C. Adaptation will become more expensive and less effective as the planet warms. Building a costly seawall today, for example, will be insufficient if water levels rise above the height of the wall in the future. Without mitigation, there will come a time when the impacts of climate change overwhelm our capacity to adapt.

D. Current adaptation efforts and investments are insufficient to address today's risks and keep pace with future climate change. Adequate adaptation would involve not only scaling up efforts across a wider range of actors, sectors, and systems, but also more **transformative adaptation** involving profound shifts in our institutions, behaviors, values, or technologies. For example, transformative actions could shift housing development to less flood-prone areas to account for rising seas, or redesign buildings and cities to manage heat extremes.
>> **Learn more about transformative adaptation**

E. People may be able to adapt and reduce their vulnerability in different ways, depending on their circumstances. For example,



Artist's statement: "This piece was commissioned by the University of Washington Climate Impacts Group. Developed in collaboration with scientists and tribal representatives, the work acknowledges the inevitable while highlighting how we can cultivate good. From the urban West Coast to the shrubsteppe of eastern Washington, resiliency looks different in every landscape. True resiliency is not bound within the realm of science; social justice is equally as vital to every solution. The piece aims to make climate resiliency concepts more accessible. After all, before any goal can be accomplished, it must first be envisioned."
CREDIT: Claire Seaman, Art x Climate, Imagining Climate Resiliency in the Pacific Northwest (2021, oil on canvas)

some communities and individuals may move to higher ground to avoid flooding and rising sea levels, choose crops that will thrive under new climate conditions, develop **nature-based solutions** such as restoring vegetation to lessen storm impacts, and adopt new technologies or building standards suited for new weather extremes. However, the ability to adapt may be limited by the capacity of a community or individual to address changing conditions, or by a risk or hazard exposure that is too great to overcome.

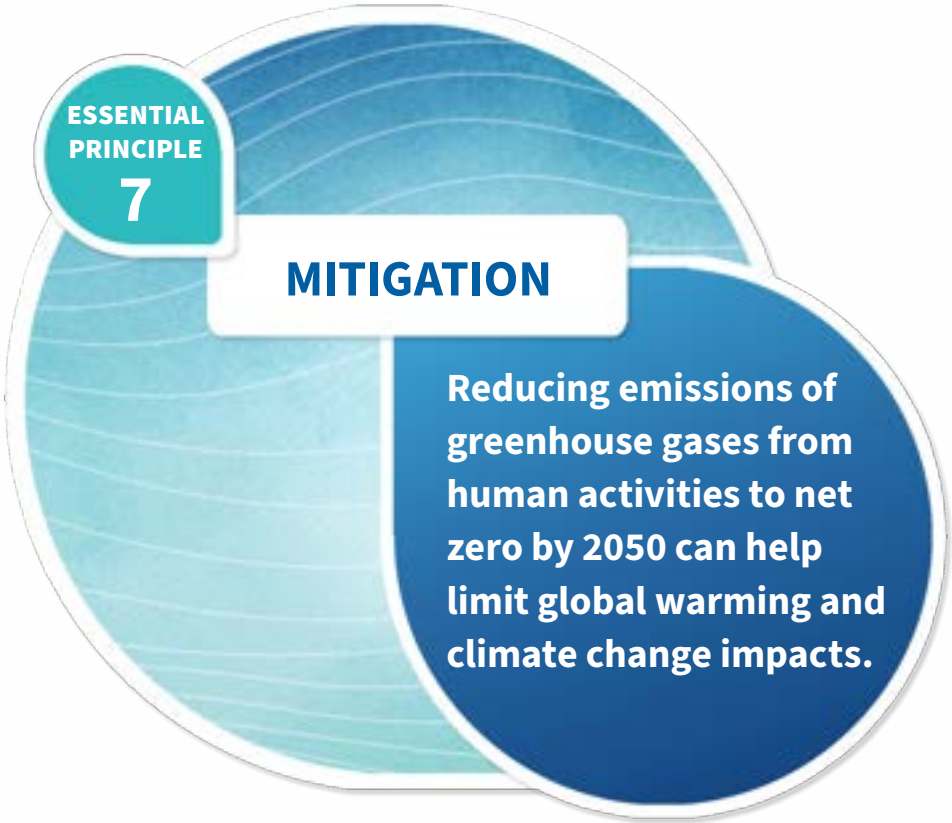
F. There is no one-size-fits-all model for adaptation and improved resilience. Adaptation will look different in different communities because risks, judgments about risk, resources, and potential solutions differ across groups of people and the places where they live and work.

G. Actions that increase risks are called **maladaptation**. For example, maladaptation can occur if infrastructure (like a levee or roadway) or a disaster response program encourages continued development in hazardous areas, leading to higher losses in the event of future disasters. Most often, maladaptation is an unintended consequence.

H. A fair, democratic, and community-based approach to assessing risks and planning adaptation measures can reduce the chances of unintentionally causing more harm to natural systems and the people who are affected by these decisions.
>> Learn more about equity in adaptation

I. Adaptation often requires financial investment in new or enhanced technologies, infrastructure, and education. Investing in adaptation and resilience efforts undertaken by vulnerable populations can contribute to a more equitable future.
>> Learn more about investments in adaptation

Essential Principles for Understanding and Addressing Climate Change



A. Rapid, deep, and sustained reductions in global emissions of greenhouse gases can still limit global temperature changes to well below 2°C (3.6°F), consistent with the goals of the Paris Agreement.
>> **Learn more about climate mitigation**

B. Limiting global warming requires net-zero carbon dioxide emissions— where emissions fall to zero or remaining emissions are balanced by removal from the atmosphere. To keep warming to well below 2°C (3.6°F), global carbon dioxide emissions would need to reach net zero by 2050, along with substantial reductions in emissions of all greenhouse gases. Rapid and sustained reductions in methane emissions are one of the fastest ways to limit near-term warming.

C. Reaching and sustaining global net-zero greenhouse gas emissions will result in a gradual decline in warming. However, some long-term responses to warming that have already occurred will continue due to the long lifespan of some greenhouse gases in the atmosphere (for example, sea level rise, ice sheet losses, and ecosystem disruptions).
>> **Learn more about the ways to reach net zero**

D. Actively removing carbon dioxide from the atmosphere and using **natural climate solutions** to increase ecosystem **carbon sinks** can help reach net zero even faster. Scientists, entrepreneurs, and communities are working on ways to remove some of these greenhouse gases.
>> **Learn more about carbon dioxide removal**

E. Many countries, states, cities, and corporations have set climate mitigation goals and targets that are aligned with limiting warming to 1.5°C (2.7°F). However, current efforts to meet these goals and



Regional Administrator Jared Blumenfeld, Tribal Council Member and Environmental Director Tommy Siyuja, Sr., and Augie Hanna visit a new solar array at the Havasupai Tribal School. This array will help save the Tribe money and energy, prevent frequent outages, and reduce greenhouse gas emissions.
CREDIT: EPA

targets need to be scaled up and expanded to limit global warming, and it remains likely that warming will exceed 1.5°C (2.7°F) during the 21st century.
>> Learn more about climate mitigation at many scales

F. Technologies and approaches that are already available can dramatically reduce greenhouse gas emissions from the highest-emitting sectors. These include improvements in energy efficiency, electricity generation from solar and wind energy, electrification of transportation and heating, less emissions-intensive diets, and protection and restoration of forests and ecosystems.
>> Learn more about options to reduce emissions now

G. Some other greenhouse gas emissions, such as those from jet fuel, cement production, and certain industrial processes, cannot be avoided at a large scale with current technologies. To reach net-zero emissions, additional mitigation options and approaches, such as natural and engineered **carbon dioxide removal** and low-carbon fuels, may need to be explored.

H. Actions by governments, businesses, organizations, and individuals can support net-zero emissions goals.
>> Learn more about efforts to reduce emissions



This fully electric school bus is part of a new fleet in Virginia and a larger national plan to switch a substantial portion of the nation's 500,000 school buses to renewable energy.
CREDIT: EPA, Photo by Eric Vance

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A. How quickly global carbon dioxide emissions reach net zero will largely determine how much warming can be limited. Every increment of warming that the world avoids reduces the risks and harmful impacts of climate change, including loss of life. Acting sooner on mitigation and adaptation will reduce future warming and associated impacts and produce environmental, economic, and social benefits.

>> **Learn more about the choices that will determine the future**

B. Parties to the Paris Agreement set a collective goal to limit global warming to well below 2°C (3.6°F) above preindustrial levels and to pursue efforts to limit warming to 1.5°C (2.7°F) above preindustrial levels. To meet this goal, countries, companies, communities, and organizations need to implement more ambitious mitigation actions.

>> **Learn more about international climate goals**

C. Even if the world rapidly reaches net-zero emissions, the United States will continue to face climate impacts and risks. Adequately addressing these risks involves longer-term inclusive planning, investments in transformative adaptation, and mitigation approaches that consider equity and justice.

>> **Learn more about potential benefits of climate action**

D. Inclusive, equitable, and just approaches to climate action in the United States can help reduce risks, improve outcomes, encourage ambitious mitigation, and create opportunities to overcome past environmental inequities. Supporting Indigenous and local knowledge holders and their practices can lead to more resilient and sustainable outcomes.

>> **Learn more about just transitions**

E. Human well-being is dependent on natural and managed ecosystems, which provide crucial functions and resources for nearly everything we eat, make, and do. Nature-based solutions can provide climate adaptation and mitigation benefits, protecting ecosystems and the services they provide while also benefiting people.

>> **Learn more about ecosystems, ecosystem services, and biodiversity**

F. Improving climate education, increasing access to information, and communicating effectively can improve people's understanding of risks and their ability to address them.

G. Taking constructive climate action together with other people helps reduce **eco-anxiety** and builds a stronger sense of community.

>> **Learn more about climate change and mental health**

H. Substantially reducing human-caused greenhouse gas emissions and taking actions to adapt and build resilience involves all levels of society. Actions by individuals, organizations, businesses, and governments can support adaptation and mitigation goals. In the United States, states, cities, Tribes, companies, and other organizations have adopted a range of climate actions and policies.

>> **Learn more about mitigation and adaptation actions underway now**

I. Millions of people all over the world are already working to make a safer, healthier, more prosperous, more just, and more stable world for all through climate action.

>> Learn more about how people are **mitigating** and **adapting** to climate change



Artist's statement: "In my art, I try to convey that we can help reverse the effects of climate change. One hand is erasing the pollution caused by industrialization the world over, and the other is redrawing actions to restore the Earth's beauty. I have always tried to help out the Earth, through stream clean ups and more. I hope people learn from my art that they can help change the world by just doing simple things like driving less, not littering, and maybe even setting up solar panels or wind turbines. The effects of climate change are only in our hands, so we should do whatever we can to help."
CREDIT: Ritika S., Art x Climate, Redrawing the Earth (2023, colored pencil)

ABOUT THIS GUIDE

Climate Literacy: Essential Principles for Understanding and Addressing Climate Change presents information that is important for individuals and communities to know and understand about Earth's climate, the impacts of climate change, and solutions. Principles in the guide can serve as discussion-starters or launching points for learning about the climate crisis and what's being done to address it across the world. The guide aims to promote greater climate literacy by providing this educational and communication framework of principles and concepts.

To download this guide and related documents, see **globalchange.gov/reports/climate-literacy-guide-third-edition** and **climate.gov/climateliteracy**.

U.S. Global Change Research Program

For future revisions and changes to this document or to see documentation of the process used to develop this guide, please visit **globalchange.gov/our-work/interagency-groups/cec**.

FURTHER INFORMATION

For an up-to-date list of of science and educational organizations and institutions working to increase climate literacy and further information relating to climate literacy and climate resources, please refer to **climate.gov/teaching**.

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