

Wildlife in a Warming World: 5th-12th

- Students learn the mechanisms by which humans are causing global climate change.
- Students learn the diverse impacts climate change has on the globe including increasing temperatures, drought, floods, increased storms, and ocean acidification.
- Students learn how many of the impacts of climate change can harm animals but some animals will benefit in a changing climate. Other animals like the beaver can mitigate some of the impacts of climate change.
- Students will learn that global climate change is an anthropogenic problem and humans can change their actions to prevent and mitigate climate change. Some places like California have already committed to carbon neutrality in the near future.

Grade	NGSS Disciplinary Core Idea	Examples
5th	<p>PS1.B: Chemical Reactions - When two or more different substances are mixed, a new substance with different properties may be formed. (5-PS1-4)</p> <p>PS3.D: Energy in Chemical Processes and Everyday Life - The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5-PS3-1)</p> <p>LS1.C: Organization for Matter and Energy Flow in Organisms - Plants acquire their material for growth chiefly from air and water. (5-LS1-1)</p> <p>LS2.A: Interdependent Relationships in Ecosystems - Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as “decomposers.” Decomposition</p>	<p>PS1.B: <i>Students will learn how ocean water and excess carbon dioxide that diffuses into the ocean from human sources react to form carbonic acid, causing ocean acidification.</i></p> <p>PS3.D: <i>Students will learn that plants use photosynthesis to form plant matter using energy from the sun, which is the source of all energy within fossil fuels.</i></p> <p>LS1.C: <i>Students will learn that plants use the sun, water, and carbon dioxide to produce plant matter through photosynthesis.</i></p>

	<p>eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (5-LS2-1)</p> <p>LS2.B: Cycles of Matter and Energy Transfer in Ecosystems - Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gasses, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)</p> <p>ESS3.C: Human Impacts on Earth Systems - Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)</p>	<p>LS2.A: <i>Students will learn that the oceanic food web largely depends on the heterotrophs at the base of the food chain that are in danger from ocean acidification; removing those heterotrophs may cause oceanic food web collapse.</i></p> <p>LS2.B: <i>Students will be introduced to the carbon cycle and the way carbon cycles between organisms naturally before human influence.</i></p> <p>ESS3.C: <i>Students will learn about how human industry is the leading cause of climate change and the variety of impacts it can have on different habitats, plants, animals, and the ocean. Students will also learn how places like California have made promises to fight climate change via carbon neutrality.</i></p>
6th-8th	<p>PS1.B: Chemical Reactions - Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5)</p> <p>LS1.C: Organization for Matter and Energy Flow in Organisms - Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1- 6)</p> <p>PS3.D: Energy in Chemical Processes and Everyday Life - The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary to MS-LS1-6) - Cellular respiration in</p>	<p>PS1.B: <i>Students will learn how ocean water and excess carbon dioxide that diffuses into the ocean from human sources react to form carbonic acid, causing ocean acidification.</i></p> <p>LS1.C: <i>Students will learn that plants and algae use energy from sunlight, water, and carbon dioxide to make their own food and store energy in their tissues.</i></p> <p>PS3.D: <i>Students will learn that plants and algae use energy from sunlight, water, and carbon dioxide to make their food and their bodies. Other creatures consume plants and release that stored energy. Other times, the stored energy can be fossilized to form fossil fuels.</i></p>

plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary to MS-LS1-7)

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems - Food webs demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-1)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)

Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-4)

LS4.C: Adaptation - Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS1-4)

ESS3.C: Human Impacts on Earth Systems - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)

ESS3.A: Natural Resources - Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are

LS2.B: *Students will learn that the oceanic food webs can be damaged due to ocean acidification harming shelled creatures, which act as a vital part of the base of the food web.*

LS2.C: *Students will learn that shifts in Earth's climate are changing some ecosystems, causing disruptions like drought, fires, and floods that can harm the populations of animals living there.*

LS4.C: *Students will learn that animals like the Long-tailed Weasel and the Black-tailed Jackrabbit that live in higher latitudes have adapted to grow in white fur in the winter to camouflage in the snow. As Earth's climate warms, the weasels and hares are turning white when there is no snow yet. They are more likely to get eaten by predators because they are unable to camouflage.*

ESS3.C: *Students will learn human activities are causing global climate change, which is causing some animals to be harmed. Other animals, like the Virginia Opossum, actually benefit from the changing climate and are able to spread their range.*

ESS3.A: *Students will learn humans depend on fossil fuels for energy in a large portion of the globe. The supply of fossil fuels on Earth is limited and non-renewable within the time frame of human lifetime. Fossil fuels are the fossilized remains of ancient plants.*

ESS3.C: *Students will learn humans are*

	<p>limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)</p> <p>ESS3.C: Human Impacts on Earth Systems - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MSESS3-3),(MS-ESS3-4)</p> <p>ESS3.D: Global Climate Change - Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)</p>	<p><i>causing large-scale global climate change that is harmful for some animals, like the Red-legged Frog, who may experience increased pressure from droughts. Other animals, like the Virginia Opossum, are surviving better in a warming climate and are able to further their range. The more resources used per person, the more intense and quick climatic changes come about.</i></p> <p>ESS3.D: <i>Students will learn that the burning of fossil fuels is one major factor causing the Earth’s climate to change. Humans can use other forms of electricity, like solar and wind power generation, to lessen the release of greenhouse gases in the atmosphere.</i></p>
<p>9th-12th</p>	<p>PS3.D: Energy in Chemical Processes - Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy. (secondary to HS-PS4-5)</p> <p>LS2.B: Cycles of Matter and Energy Transfer in Ecosystems - Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3) Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4) Photosynthesis and cellular respiration are</p>	<p>PS3.D: <i>Students will learn that humans can get energy directly from the sun using solar panels that capture the sun’s energy and convert it to electrical energy.</i></p> <p>LS2.B: <i>Students will learn that animals and plants participate in the Carbon Cycle. Plants use sunlight, water, and carbon dioxide to undergo photosynthesis and make sugars and plant materials in their bodies. When animals consume plants, they are able to harness the energy that plants get from the sun in a process called respiration. Normally, the carbon cycle is balanced in the world.</i></p> <p>LS2.C: <i>Students will learn that disturbances to ecosystems from climate change can disrupt ecosystems and threaten some species’ ability</i></p>

important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience - A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6) Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

LS4.D: Biodiversity and Humans - Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HSL2-7) Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary to HS-LS2-7) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)

PS3.D: Energy in Chemical Processes - The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary to HS-LS2-5)

LS4.C: Adaptation - Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3) Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of

to survive. For example, increased carbon dioxide in the atmosphere diffuses into the oceans. In the ocean, carbon dioxide reacts with water to form carbonic acid. Carbonic acid is harming shelled creatures in the ocean, which make up a large portion of primary consumers in the oceanic food web. If ocean acidification continues without intervention, there is the potential for oceanic food web collapse.

LS4.D: *Students will learn that climate change is harming the biodiversity of some habitats, which can harm the ecosystem's ability to function. It is important to reduce the impacts of climate change and prevent it as much as possible to help sustain biodiversity across many ecosystems.*

PS3.D: *Students will learn that plants and algae use energy from sunlight, water, and carbon dioxide to make their own food and store energy in their tissues. This process is called photosynthesis.*

LS4.C: *Students will learn that animals like the Long-tailed Weasel and the Black-tailed Jackrabbit that live in higher latitudes have adapted to grow in white fur in the winter to camouflage in the snow. As Earth's climate warms, the weasels and hares are turning white when there is no snow yet. They are more likely to get eaten by predators because they are unable to camouflage. Animals impacted by these changes may or may not be able to adapt to changing climate conditions to continue to survive.*

some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species.

(HS-LS4-5),(HS-LS4-6)Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5)

ESS1.B: Earth and the Solar System - Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary to HS-ESS2-4)

ESS2.D: Weather and Climate - The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2),(HS-ESS2-4) Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7) Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2- 6),(HS-ESS2-4) Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere.

(secondary to HSESS3-6)

ESS3.A: Natural Resources - Resource availability has guided the development of human society. (HS-ESS3-1) All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)

ESS1.B: *Students will learn that the main force driving Earth's climatic changes in the past was the amount of solar insolation received by the surface of the Earth. Normally, the amount of insolation is changed by a series of interconnected phenomena, including changes in the shape of Earth's orbit, changes to the tilt of the planet, and the direction Earth's axis is pointed, known as Milankovitch Cycles. The current changes to the Earth's climate are being altered by the anthropogenic release of carbon into the atmosphere.*

ESS2.D: *Students will learn that due to the increased amount of carbon dioxide in the atmosphere, more heat is being trapped in the atmosphere and reflected back to Earth, increasing Earth's temperature. Current models of the Earth's climate predict that without intervention, Earth's climate will continue to warm. If humans can reduce their carbon outputs and remove carbon dioxide from the atmosphere, global temperature averages may not increase as severely.*

ESS3.A: *Students will learn that each type of energy source has pros and cons. This program advocates for a focus on renewable energy forms like solar, wind, and geothermal power to use less fossil fuels.*

ESS3.C: *Students will learn that humans have already developed multiple forms of power that are renewable and do not require the burning of fossil fuels. Places like California have promised to be carbon neutral by 2045,*

	<p>ESS3.C: Human Impacts on Earth Systems - The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3) Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.</p> <p>(HS-ESS3-4) ESS3.D: Global Climate Change - Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)</p>	<p><i>switching the sources of their electricity generation to add less carbon pollution to the environment.</i></p> <p>ESS3.D: <i>Students will learn that humans are altering the climate in a number of ways, including droughts, floods, increased storms, wildfires, and ocean acidification. Humans have sophisticated abilities to monitor and predict these impacts.</i></p>
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