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ClimateEdResearch@umd.edu

Climate Change in the Next Generation Science Standards (K-12)

Maryland and Delaware Climate Change Education Assessment and Research

UM MADE CLEAR Learning Sciences Research Team

With the final release of the Next Generation Science Standards (NGSS) it is now possible to conduct an analysis of performance standards related to the topic of climate change. Science teachers have stated that standards, like the NGSS, are one of the main reasons for teaching climate change (Wise, 2010). Thus, a detailed analysis can provide insights into where climate change is likely to be taught from grades K-12.

Standards *explicitly* addressing climate change are present at the middle and high school levels. These standards use the terms "global temperatures," "changes in climate," or "climate change." One middle school standard addresses the cause of rising global temperatures (MS-ESS3-5). At the high school level, standards introduce the constructs of evidence for climate change (HS-ESS3-1), climate modeling (HS-ESS2-4, HS-ESS3-5), and geoengineering (HS-ESS3-4). A noteworthy observation is that the topic is not explicitly stated at the elementary level, with the exception of standards 3-ESS2-1 and 3-LS4-4. These performance standards explicitly state that climate change is *not* assessed in grade 3.

Also of importance are standards that are *proximally* related to climate change. Proximal standards are those that are considered "close" to the climate change topic, but are not explicitly related to climate change. These proximal standards are present at all grade levels from K-12. For example, kindergarten standard K-PS3-1 states, "Make observations to determine the effect of sunlight on Earth's surface," which is related to the imbalance between incoming and outgoing radiation—the reason that average global temperatures are rising. Similarly, high school standard HS-ESS2-6 states, "Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere." Anthropogenic climate change is occurring because humans are altering the natural balance of Earth's carbon cycle.

We acknowledge that it is possible that others may identify in the NGSS additional standards that are *distally* related to the climate change topic (i.e., the relationship with climate change is not as close as those that are proximally related). However, in this document, we only present those standards that are explicitly or proximally related to climate change.

Performance Standards with *Explicit* Mention of Climate Change

The first column identifies the code of each performance standard. For example, the code MS-ESS3-5 indicates that the standard is for middle school (MS) Earth and Space Science (ESS). Additionally, the #3 indicates that it belongs to the third set of ESS standards included in the NGSS. Finally, the #5 indicates that this is the fifth standard under the ESS3 sublevel.

Table 1*: Middle School Performance Standard*

Code	Standard	Clarification Statement & Assessment Boundary
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.

Table 2*: High School Performance Standards*

HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.	Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.
HS-ESS2-4	Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition. Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.	Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).
HS-ESS3-5	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.	Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition). Assessment is limited to one example of a climate change and its associated impacts.

The primary source for this analysis was a document labeled *DCI View* and downloaded directly from the NGSS website.

Performance Standards with *Proximal* Connections to Climate Change

Our analysis of the following performance standards reflects proximal connections to climate change. For example, standard MS-ESS3-4 concerns the construction of an argument about how human population growth and consumption of natural resources impact Earth's systems. A close connection to climate change of this standard is that human population growth has been fueled by the burning of fossil fuel resources, including coal, oil, and natural gas. The consumption of these natural resources has resulted in the release of greenhouse gases (e.g. carbon dioxide), altering Earth's atmosphere. The changing composition of the atmosphere, in turn, has altered Earth's other systems (e.g. the hydrosphere), resulting in global climate change.

Our analysis begins with the elementary grades (K-5), where the performance standards address the scientific constructs that are the foundations of climate change science (see Table 3). The kindergarten performance standards involve the scientific constructs of solar energy (K-PS3-1, K-PS3-2), weather patterns (K-ESS2-1), and severe weather (K-ESS3-2). Climate change involves an imbalance between the solar energy reaching Earth and the radiation leaving Earth, which disrupts long-term weather patterns (i.e., climate) and increases the frequency and intensity of extreme weather events.

Two other kindergarten standards concern the relationship among humans, other living organisms, and the environment (K-PS3-2, K-ESS3-3). These standards connect to ideas in climate change science because humans have changed the composition of the atmosphere (K-ESS2-2), which is the primary cause of the acceleration of global climate change (IPCC, 2007). The effects of elevated levels of the greenhouse gas carbon dioxide (CO_2) are intensified when humans cut down trees to manufacture paper, which is mentioned explicitly in one of the standards (K-ESS3-3). The same standard identifies recycling as a solution for reducing human impacts on the environment. Recycling is an action that humans can take to reduce human energy use and the emission of carbon dioxide. Thus, it is considered a climate change mitigation strategy.

In later grades, the performance standards elaborate on the scientific constructs of solar energy (1-PS4-3, 4-PS3-2), weather patterns (3-ESS2-1), severe weather (3-ESS3-1), and the relationships between living organisms and the environment (3-LS4-3, 3-LS4-4, 5-LS1-1, 5-LS2-1). However, there is also the appearance of the concept that Earth can change quickly or slowly (2-ESS1-1). This is an important idea in climate change science, since climate change is a gradual process occurring over timescales unfamiliar to normal human experience. Beginning in grade 2 and continuing in grade 4, the performance standards also address aspects of a key climate change impact—sea level rise (2-ESS2-1, 4-ESS2-1). As global average sea level rises, many areas will experience enhanced coastal erosion, and it will be critical for humans to design solutions to limit the effects of sea level rise on coastal lands.

In grade 4, the construct of human energy use appears (4-ESS3-1). Standard 4-ESS3-1 explicitly identifies air pollution as an environmental effect of burning fossil fuels. An important consequence of air pollution from burning fossil fuels is the enhanced greenhouse effect, which has caused average global temperatures to rise. In grade 5, the standard 5-ESS3-1 relates to this notion of humans creating air pollution, as it involves "ways individual communities use science ideas to protect the Earth's resources and environment." Humans have

the potential to mitigate climate change through reducing their fossil fuel consumption and expanding the use of alternative energy.

Also in grade 5, the performance standards introduce students to the practice of modeling phenomena relevant to climate change (5-PS1-1, 5-ESS2-1). Standard 5-PS1-1 has students use models to describe the idea that matter is composed of particles too small to be seen, though the assessment boundary states that students should not be assessed on atomic-molecular models. The idea that matter is composed of invisible particles is a key construct of climate change science, since invisible greenhouse gases cause the greenhouse effect.

Similarly, standard 5-ESS2-1 has students use models to describe the interactions of Earth's systems. Climate change science involves modeling these systems in order to interpret evidence and make projections about how these systems will evolve in the future. For instance, scientists model how the hydrosphere interacts with the atmosphere, cryosphere, and geosphere in order to predict future sea level rise.

The middle school performance standards mark the first introduction of atomic-molecular models (MS-PS1-1). Atomic-molecular models are necessary to understand how the carbon cycle and the thermal expansion of water relate to climate change and its impacts (e.g. sea level rise). The middle school standards also further elaborate on the constructs of alternative fuels (MS-PS1-3), energy transfer (MS-PS1-4, MS-PS3-4, MS-ESS2-5, MS-PS4-2), weather and climate (MS-ESS2-5, MS-ESS2-6), severe weather (MS-ESS3-2), the interaction of Earth's systems (MS-ESS2-4), and the impacts of humans on the environment (MS-ESS3-3, MS-ESS3-4, MS-ETS1-1, MS-ETS-3). In addition, several middle school standards involve sophisticated ideas concerning the relationships among living organisms, ecosystems, biodiversity, and the environment (MS-LS1-5, MS-LS1-6, MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5). Climate change is already having significant affects on the availability of resources for organisms, altering ecosystem dynamics and heightening concerns about losses to biodiversity.

The high school performance standards present an even more sophisticated level of understanding of the constructs associated with climate change. Specifically, these standards address the impact of humans on the environment (HS-LS2-7, HS-ESS3-6), the transfer of energy via electromagnetic radiation (HS-PS4-4), the interaction of Earth's systems (MS-ESS2-4, HS-ESS2-5, HS-ESS2-6), and the relationships among living organisms, ecosystems and the environment (HS-LS2-1, HS-LS2-2, HS-LS2-4, HS-LS2-5, HS-LS2-6, HS-LS2-7, HS-LS4-5, HS-ETS1-1, HS-ETS1-3). The high school standards also formally introduce the carbon cycle (HS-ESS2-6), which is a key central construct in climate change science.

Table 3*: Kindergarten Performance Standards*

Code	Standard	Clarification Statement & Assessment Boundary
K-PS3-1	Make observations to determine the effect of sunlight on Earth's surface.	Examples of Earth's surface could include sand, soil, rocks, and water. Assessment of temperature is limited to relative measures such as warmer/cooler.
K-PS3-2	Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.	Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.
K-ESS2-1	Use and share observations of local weather conditions to describe patterns over time.	Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months. Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.
K-ESS2-2	Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.	Examples of plants and animals changing their environment could include a squirrel digs in the ground to hide its food and tree roots can break concrete.
K-ESS3-2	Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.	Emphasis is on local forms of severe weather.
K-ESS3-3	Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.	Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.

Table 4*: First Grade Performance Standards*

Code	Standard	Clarification Statement & Assessment Boundary
1-PS4-3	Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.	Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror). Assessment does not include the speed of light.

Table 5*: Second Grade Performance Standards*

Code	Standard	Clarification Statement & Assessment Boundary
2-ESS1-1	Make observations from media to construct an evidence-based account that Earth events can occur quickly or slowly.	Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly and erosion of rocks, which occurs slowly. Assessment does not include quantitative measurements of timescales.
2-ESS2-1	Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.	Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land.

Table 6*: Third Grade Performance Standards*

Code	Standard	Clarification Statement & Assessment Boundary
3-LS4-3	Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.	Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.
3-LS4-4	Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.	Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms. Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.
3-ESS2-1	Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.	Examples of data at this grade level could include average temperature, precipitation, and wind direction. Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.
3-ESS3-1	Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.	Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lighting rods.

Table 7*: Fourth Grade Performance Standards*

Code	Standard	Clarification Statement & Assessment Boundary
4-PS3-2	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.	Assessment does not include quantitative measurements of energy.
4-ESS2-1	Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.	Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow. Assessment is limited to a single form of weathering or erosion.
4-ESS3-1	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.	Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.

Table 8: Fifth Grade Performance Standards

Code	Standard	Clarification Statement & Assessment Boundary
5-LS1-1	Support an argument that plants get the materials they need for growth chiefly from air and water.	Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.
5-LS2-1	Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.	Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth. Assessment does not include molecular explanations.
5-PS1-1	Develop a model to describe that matter is made of particles too small to be seen.	Examples of evidence could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water. Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.
5-ESS2-1	Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.	Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system. Assessment is limited to the interactions of two systems at a time.
5-ESS3-1	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.	*No information provided in the NGSS.*

Table 9*: Middle School Performance Standards*

Code	Standard	Clarification Statement & Assessment Boundary
MS-PS1-1	Develop models to describe the atomic composition of simple molecules and extended structures.	Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms. Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.
MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.	Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels. Assessment is limited to qualitative information.
MS-PS1-4	Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.	Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.
MS-PS3-4	Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.	Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added. Assessment does not include calculating the total amount of thermal energy transferred.
MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.	Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions. Assessment is limited to qualitative applications pertaining to light and mechanical waves.
MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.	Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds. Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.

MS-LS1-6	Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.	Emphasis is on tracing movement of matter and flow of energy. Assessment does not include the biochemical mechanisms of photosynthesis.
MS-LS2-1	Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.	Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.
MS-LS2-2	Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.	Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.
MS-LS2-4	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.	Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.
MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.	Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.

MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.	Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations. Assessment does not include the dynamics of the Coriolis effect.
MS-ESS3-2	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.	Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado- prone regions or reservoirs to mitigate droughts).
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).
MS-ESS3-4	Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.	Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	*No information provided in the NGSS.*

Table 10*: High School Performance Standards*

Code	Standard	Clarification Statement & Assessment Boundary
HS-PS4-4	Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	Emphasis is on the idea that different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias. Assessment is limited to qualitative descriptions.
HS-LS2-1	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.	Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets. Assessment does not include deriving mathematical equations to make comparisons.
HS-LS2-2	Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.	Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data. Assessment is limited to provided data.
HS-LS2-4	Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.	Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem. Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.
HS-LS2-5	Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.	Examples of models could include simulations and mathematical models. Assessment does not include the specific chemical steps of photosynthesis and respiration.

HS-LS2-6	Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.	Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate or a seasonal flood; and, extreme changes, such as volcanic eruption or sea level rise.
HS-LS4-5	Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.	Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	*No information provided in the NGSS.*
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	*No information provided in the NGSS.*

References

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