Performance Expectation *and Louisiana Connectors*
HS-EVS1-1 Analyze and interpret data to identify the factors that affect sustainable development and natural resource management in Louisiana. **LC-HS-EVS1-1a Identify factors (e.g., human activity, population size, types of crops grown) that affect sustainable development in Louisiana.** **LC-HS-EVS1-1b Identify factors (e.g., human activity, population size, types of crops grown) that affect natural resource management in Louisiana.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Analyze data using tools in order to make valid and reliable scientific claims.** **Analyze data using tools in order to determine an optimal design solution.** **Analyze data using technology in order to make valid and reliable scientific claims.** **Analyze data using technology in order to determine an optimal design solution.**	**LOUISIANA'S NATURAL RESOURCES** Ecosystem capital can be characterized as goods (removable products) and services such as the functions and values of wetlands. (HS.EVS1A.a) **Ecosystem attributes or services are important to value.** **Ecosystem capital are the resources or benefits provided by ecosystems that are needed for economic development.** **Ecosystems provide different goods or removable products such as timber, food, medicines, and fuel.** **Ecosystems serve important functions for human and wildlife (e.g., natural water filtration, control of floods by absorbing extra runoff from heavy rains, providing animal habitats).** **Ecosystems provide social and cultural services such as recreation.** **Changes to ecosystems (e.g., wetlands, forests) for commercial development, tourism, or agriculture to produce ecosystem capital can threaten and degrade those ecosystems.**	**STABILITY AND CHANGE** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. **Change and rates of change can be quantified over very short or very long periods of time.** **Change and rates of change can be modeled over very short or very long periods of time.** **Some system changes are irreversible.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyze data using models in order to make valid and reliable scientific claims. **Analyze data using models in order to determine an optimal design solution.**		

Clarification Statement
Evidence of Louisiana's natural resource wealth is found in understanding functions and values of varied ecosystems and environments, supply of non-renewable mining products and profitable agricultural commodities. Examples of key natural resources include state waterways (such as rivers, lakes, and bayous) and the aquatic life found in them, regions of agriculture (pine forests, sugar cane, and rice fields) and high concentrations of minerals and fossil fuels on and off shore. Factors to consider in reviewing the management of natural resources include a review of historical practices, costs of resource extraction and waste management, consumption of natural resources, ongoing research and the advancements in technology.

Performance Expectation *and Louisiana Connectors*
HS-EVS1-2 Obtain, evaluate and communicate information on the effectiveness of management or conservation practices for one of Louisiana's natural resources with respect to common considerations such as social, economic, technological, and influencing political factors over the past 50 years. ***LC-HS-EVS1-2a Identify the effectiveness of management practices for one of Louisiana's natural resources related to social factors over the past 50 years.*** ***LC-HS-EVS1-2b Identify the effectiveness of management practices for one of Louisiana's natural resources related to economic factors over the past 50 years.*** ***LC-HS-EVS1-2c Identify the effectiveness of management practices for one of Louisiana's natural resources related to technological factors over the past 50 years.*** ***LC-HS-EVS1-2d Identify the effectiveness of management practices for one of Louisiana's natural resources related to political factors over the past 50 years.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success. ***Analyze data using tools in order to make valid and reliable scientific claims.*** ***Analyze data using tools in order to determine an optimal design solution.*** ***Analyze data using technology in order to make valid and reliable scientific claims.***	**RESOURCE MANAGEMENT FOR LOUISIANA** Some changes to our natural environment such as the building of levees and hydrological modification have provided for economic and social development but have resulted in unintended negative impacts. (HS.EVS1.B.b) ***The natural environment can be changed by human activity.*** ***Human activity can have both positive and negative effects on the natural environment.*** ***The economic and social development benefits from building levees and hydrological modification include supplying sources of power (i.e., clean, inexpensive, and renewable energy), water for irrigation and drinking, and reduction of flooding downstream.*** ***Negative impacts of hydrological modification (e.g., building dams and levees) can include altering the temperature and speed of water, reduction in organisms and in-stream vegetation, movement of fish populations, increased flooding downstream, and preventing seasonal overbank flooding that can provide needed nutrients to soils.*** ***Humans can take steps to restore some damaged ecosystems (e.g., fish ladders, consideration of environmental impacts of new or renewed licenses for hydroelectric dams).***	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ***Cause and effect relationships can be suggested for complex systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.*** ***Cause and effect relationships can be***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyze data using technology in order to determine an optimal design solution. ***Analyze data using models in order to make valid and reliable scientific claims.*** ***Analyze data using models in order to determine an optimal design solution.***		***predicted for complex systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.***

Clarification Statement
The rate of land loss and habitat conversion from a variety of forces results in stresses and constraints that influence decisions and carry consequences that affect quality of life and have a bearing on sustainability. Increases in commercial and recreational uses may result in the need for environmental policies and call for changes in long established practices. Community efforts to address changes to secure growth while preserving the resources depend on education and collaboration between groups. Examples may include ground water conservation, erosion/flood control, forestry stewardship, game and wildlife, commercial fishing, oil and gas industry, dredging, or regulatory factors.

Performance Expectation *and Louisiana Connectors*
HS-EVS1-3 Analyze and interpret data about the consequences of environmental decisions to determine the risk-benefit values of actions and practices implemented for selected issues. ***LC-HS-EVS1-3a Identify the risk-benefit values of implemented actions using data for selected environmental issues.*** ***LC-HS-ESV1-3b Identify the risk-benefit values of implemented practices using data for selected environmental issues.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success. ***Analyze data using tools in order to make valid and reliable scientific claims.*** ***Analyze data using tools in order to determine an optimal design solution.*** ***Analyze data using technology in order to make valid and reliable scientific claims.*** ***Analyze data using technology in***	**RESOURCE MANAGEMENT FOR LOUISIANA** Some changes to our natural environment such as the building of levees and hydrological modification have provided for economic and social development but have resulted in unintended negative impacts. (HS.EVS1B.b) ***The natural environment can be changed by human activity.*** ***Human activity can have both positive and negative effects on the natural environment.*** ***The economic and social development benefits from building levees and hydrological modification include supplying sources of power (i.e., clean, inexpensive, and renewable energy), water for irrigation and drinking, and reduction of flooding downstream.*** ***Negative impacts of hydrological modification (e.g., building dams and levees) can include altering the temperature and speed of water, reduction in organisms and in-stream vegetation, movement of fish populations, increased flooding downstream, and preventing seasonal overbank flooding that can provide needed nutrients to soils.*** ***Humans can take steps to restore some damaged ecosystems (e.g., fish ladders, consideration of environmental impacts of new or renewed licenses for hydroelectric dams).***	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ***Cause and effect relationships can be suggested for complex systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.*** ***Cause and effect relationships can be predicted for complex***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
order to determine an optimal design solution. ***Analyze data using models in order to make valid and reliable scientific claims.*** ***Analyze data using models in order to determine an optimal design solution.***		***systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.***

Clarification Statement
Examples could be taken from system interactions: (1) loss of ground vegetation causing an increase in water runoff and soil erosion; (2) dammed rivers increasing ground-water recharge, decreasing sediment transport, and increasing coastal erosion; (3) loss of wetlands reducing storm protection buffer zones allowing further wetland reduction; and (4) hydrological modification such as levees providing protection to infrastructure at a cost to ecosystems.

Performance Expectation *and Louisiana Connectors*
HS-EVS2-1 Design and evaluate a solution to limit the introduction of non-point source pollution into state waterways. ***LC-HS-EVS2-1a Use data or qualitative scientific and technical information to evaluate a solution to limit a non-point source pollution (e.g., land or urban runoff, abandoned mines) into state waterways.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria and trade-off considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.*** ***Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-***	**POLLUTION AND THE ENVIRONMENT** Pollution includes both natural and man-made substances which occur at rates and levels which incur harm (i.e., combustion of fossil fuels, agricultural waste, and industrial byproducts). Pollution can be categorized as point-source pollution and non-point source pollution. (HS.EVS2A.a) ***Pollution is any change to the environment that has a negative effect on living things. Natural pollution includes events that pollute the air including forest fires, volcanic eruptions, dust storms, and wind erosion.*** ***Pollution (e.g., air pollution) is often the result of an activity that benefits humans (e.g., generating electricity by burning coal, building and maintaining factories, burning fossil fuels, carbon dioxide from vehicles, and other fine particles suspended in the air).*** ***Some data suggest that the levels of pollution are increasing rapidly (i.e., increase in greenhouse gases).*** ***Pollution can be categorized as point-source pollution which are identifiable sources of pollution from which pollutants are discharged such as a pipe, ditch, ship, refineries, automobile manufacturers, factories or sewage treatment plants.*** ***Pollution can also be categorized as non-point source pollution which results from runoff or rain or melted snow as it moves over the ground (e.g., following a heavy rain, water flows across the surface of a road and picks up oil and gas left by car or chemicals used in agriculture or lawn care flow into storm drains and then into nearby by bodies of water).*** **ENVIRONMENTAL CHOICES** Different approaches can be used to manage impacts to our environment. Generally speaking, we can change human activities to limit negative impacts. Alternately, we can use technologies that reduce impact or we can perform restoration work to recover natural functions and values. (HS.EVS2C.a)	**STRUCTURE AND FUNCTION** Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. ***Designing and/or investigating new structures/systems requires knowledge of the properties (e.g., rigidity and hardness) of the materials needed for specific parts of the structure.*** ***Designing and/or investigating new structures/systems***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
generated sources of evidence, prioritized criteria, and trade-off considerations. ***Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.***	***Exponential growth of the global human population and the resulting increase in consumption places severe stress on finite resources.*** ***Advances in technology can help mitigate human impact on the environment.*** ***Changes in human behaviors and activities (e.g., reduce the use of coal and other fossil fuels) and laws that control air and water quality and promote development of new technology can limit negative impacts on the environment.*** ***Technological solutions (e.g., wet scrubber; baghouse, solar panels, emission controls) can result in lower levels of pollution (e.g., cleaner air) and reduce the environmental impact.*** ***Technological solutions (e.g., desalination of water to provide clean drinking water, vehicle fuel efficiency) can also restore or recover natural functions and values in the environment.*** Trade-offs occur when we make environmental choices. (HS.EVS2C.b) ***Environmental choices often requires making trade-offs among competing criteria (cost, reliability, and aesthetic, social, cultural, and political impacts).*** ***Many factors, including environmental or health impacts, change over time and vary from place to place.*** **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS.ETS1A.b) ***There are common challenges faced by humans living across the world.*** ***Human survival depends on developing practices that will achieve sustainable systems.*** ***Common problems include the need for clean water and air, food (decreased crop yield), and sources of energy that minimize pollution (e.g., solar energy).*** ***These common problems faced by humans living across the world may also create issues in local communities including illness (asthma), lack of clean drinking water, reduction in ecosystems and plants and animals.***	***requires knowledge of the structures of different components.*** ***Designing and/or investigating a new structure requires a detailed examination of the connections of components to reveal its function.*** ***Designing and/or investigating a new structure requires a detailed examination of the connections of components to reveal any problems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept

Clarification Statement
Examples of non-point source water pollution could include nitrogen and phosphorus compounds from agricultural activities and sediments from poor land-use practices. Nitrogen and phosphorus contribute to eutrophication and are anthropogenic drivers of the Gulf of Mexico hypoxic area known as the dead zone.

Performance Expectation *and Louisiana Connectors*
HS-EVS2-2 Use a model to predict the effects that pollution as a limiting factor has on an organism's population density. ***LC-HS-EVS2-2a Recognize the relationship between pollution and its effect on an organism's population size.*** ***LC-HS-EVS2-2b Predict the effects that pollution as a limiting factor has on an organism's population density using a model (e.g., mathematical, diagrams, simulations).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems and/or solve problems. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help***	**POLLUTION AND THE ENVIRONMENT** Different organisms have unique tolerances to pollution hazards. Many of the organisms most tolerant of pollution are the least desirable to humans (e.g., for food, for recreation, for ecosystem services). (HS.EVS2A.b) ***Different organisms (plants and animals) have different abilities to respond to pollution hazards (e.g., some organisms can survive in poor water quality with lower oxygen levels).*** ***In nature, populations of organisms rarely grow uncontrolled.*** ***Each ecosystem has a carrying capacity or number of organisms it can sustain.*** ***Carrying capacities in ecosystems are impacted by pollution and can limit the numbers of organisms or populations they can support.*** ***Tolerance levels refer to the amount of pollution organisms can handle before dying or moving to another habitat.*** ***A system with proportionally dense populations of tolerant organisms indicates poor environmental quality.*** ***Many organisms that are most tolerant of pollution are not desired by humans for food (e.g., aquatic worms) and recreation or are not economically viable.***	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ***Cause and effect relationships can be suggested for complex systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.*** ***Cause and effect relationships can be predicted for complex systems (natural and human-designed) by***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.		***examining what is known about smaller scale mechanisms within the system.***

Clarification Statement
The law of limiting factors is often illustrated as a graphic tolerance curve and can be used to infer the range of tolerance a species has for specific pollution hazards. When combined with real-world data such as field measurements of abiotic factors, these models can be used to help predict the suitability of an ecosystem for a particular species.

Performance Expectation *and Louisiana Connectors*
HS-EVS2-3 Use multiple lines of evidence to construct an argument addressing the negative impacts that introduced organisms have on Louisiana's native species. ***LC-HS-EVS2-3a Evaluate evidence supporting an argument regarding negative impacts of introduced organisms (e.g., zebra mussel, fire ant, nutria) have on Louisiana's native species.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence. ***Construct an oral argument based on data and evidence.*** ***Construct a written argument based on data and evidence.*** ***Construct an oral counterargument based on data and evidence.*** ***Construct a written counterargument based on data and evidence.***	**ECOSYSTEM CHANGE** The introduction of exotic/invasive species causes a disruption in natural ecosystems and can lead to the loss of native species (i.e., threatened/endangered). (HS.EVS2B.a) ***Invasive species are plants, animals, or other organisms that are introduced to a given area outside their original range and cause harm in their new home.*** ***Invasive species can be any kind of a living organism including plant, fungus, or an animal species that is not native to an ecosystem.*** ***Because there are no natural "enemies," invasive species can spread aggressively and can become difficult to control as the factors that influence their survival (e.g., diseases and other organisms) are not present.*** ***Some invasive species (e.g., ornamental plants, kudzu) are intentionally or accidentally released and can cause damage to the ecosystem.*** ***Invasive species impose great costs to agriculture, forestry, fisheries, and other human enterprises, as well as to human health.*** Changes in ecosystems impact the availability of natural resources (e.g. sediment starvation, climate change). (HS.EVS2B.b) ***People compete with each other and other living things for Earth's limited resources.*** ***Changes in human populations have affected the biodiversity of local organisms and availability of natural resources in given ecosystems (e.g., habitat loss, water quality).*** ***The availability of natural resources is impacted by the changes in ecosystems.*** ***Extracting natural resources can affect ecosystems and the organisms within.*** ***Sediment starvation is a lack of sediment transport and is often caused by man-made structures such as dams.***	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ***Cause and effect relationships can be suggested for complex systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.*** ***Cause and effect relationships can be predicted for complex systems (natural and human-designed) by***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Movement of sediment is important in providing habitats for fish and other organisms in rivers. ***Ecosystems undergo major changes as a result of such factors as climate change, introduction of new species, and habitat destruction.***	***examining what is known about smaller scale mechanisms within the system.***

Clarification Statement
The exotic organisms introduced in Louisiana include plants such as Chinese tallow, kudzu, and water hyacinth, and animals including nutria, Asian tiger mosquitoes, and zebra mussels. These organisms can have impacts on scales ranging from the level of the individual (e.g., competition) to that of the landscape (e.g., the destruction of coastal marshes by nutria).

Performance Expectation *and Louisiana Connectors*
HS-EVS3-1 Construct and evaluate arguments about the positive and negative consequences of using disposable resources versus reusable resources. ***LC-HS-EVS3-1 Evaluate evidence supporting the positive consequences of using disposable resources versus reusable resources.*** ***LC-HS-EVS3-2 Evaluate evidence supporting the negative consequences of using disposable resources versus reusable resources.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ***Evaluate the claims behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the claims behind currently accepted solutions to determine the merits of arguments.*** ***Evaluate the evidence behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the evidence behind***	**STEWARDSHIP** Ecosystem sustainability can be used as a model for a sustainable society (e.g., recycling, energy efficiency, diversity). (HS.EVS3A.a) ***A sustainable society is one that can continue indefinitely where the level of consumption reflects environmental and resource balance (e.g., not depleting resources).*** ***A healthy ecosystem is one in which plant and animal populations interact in balance with each other and abiotic factors (e.g., rocks, soil, and water).*** ***Complex systems are systems composed of many different components.*** ***A sustainable human society relies upon natural resources (such as energy, fauna, wood, or water), socioeconomic resources (such as labor or capital), and cultural resources (arts, beliefs, institutions).*** ***As in any ecosystem, a sustainable human society is based on preservation, protection, or restoration of the natural environment as well as the human ecosystem.*** Louisiana citizens are responsible for conserving our state's natural resources. Personal actions can have a positive or negative impact. (HS.EVS3A.b) ***Resources are features of environments that are important and of value to humans in some form.*** ***Protecting the environment and biodiversity helps sustain human life.*** ***Each citizen of Louisiana is responsible for conserving the state's natural resources to ensure that all citizens can have a healthy standard of living (e.g., clean air and water) and the state's ecosystems are sustained.*** ***Reducing, reusing, and recycling materials help to conserve natural resources.*** ***The quality of the lives of future generations may depend on people's use of natural resources today.***	**ENERGY AND MATTER** Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
currently accepted solutions to determine the merits of arguments. ***Evaluate the reasoning behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the reasoning behind currently accepted solutions to determine the merits of arguments.*** • Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence. ***Construct an oral argument based on data and evidence.*** ***Construct a written argument based on data and evidence.*** ***Construct an oral counterargument based on data and evidence.*** ***Construct a written counterargument based on data and evidence.***	***Each citizen can make lifestyle choices that reduce the use of the Earth's natural resources.*** ***Each citizen can reduce his or her demand on natural resources by recycling (replace and reuse products).*** ***Personal actions can have a positive impact on the state's natural resources (e.g., using public transportation and reducing demand for oil).*** ***Personal actions can have a negative impact on the state's natural resources (e.g., not recycling paper products or cans).***	

Clarification Statement
Resources can be both natural and man-made and may include renewable and non-renewable energy sources, soil, ecosystems, forestry, fisheries, plastic, paper, or aluminum products. Energy used to create and dispose of products may also be considered.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth's systems. ***LC-HS-ESS2-2a Identify relationships, using a model, of how the Earth's surface is a complex and dynamic set of interconnected systems (i.e., geosphere, hydrosphere, atmosphere, and biosphere).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. ***Analyze data using tools in order to make valid and reliable scientific claims.*** ***Analyze data using tools in order to determine an optimal design solution.*** ***Analyze data using technology in order to make valid and reliable scientific claims.*** ***Analyze data using technology in order to determine an optimal***	**EARTH MATERIALS AND SYSTEMS** Earth's systems, being dynamic and interacting, include feedback effects that can increase or decrease the original changes. (HS.ESS2A.a) ***Earth's systems are dynamic and interacting.*** ***Earth has interconnected spheres: lithosphere or geosphere, hydrosphere, biosphere, atmosphere and cryosphere.*** ***Changes in one system can cause changes to other systems.*** ***Rates of change of Earth's internal and surface processes occur over very short and very long periods of time.*** ***Many complex linkages and feedbacks among erosional and climatic processes in addition to tectonic ones change Earth's systems.*** ***Such complexities include feedback, stabilizing or destabilizing links between component processes.*** ***A change in one sphere can cause changes to other spheres, resulting in positive or negative feedback loops.*** **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, hydrosphere, and land systems, and this energy's re-radiation into space. (HS.ESS2D.a) ***Sunlight is a portion of the electromagnetic radiation given off by the sun.*** ***Energy from the sun travels to Earth and heats Earth's surface.*** ***Some of this energy is radiated back into Earth's atmosphere.*** ***The sun's energy drives Earth's climate systems.***	**STABILITY AND CHANGE** Feedback (negative or positive) can stabilize or destabilize a system. ***Stability denotes a condition in which a system is in balance.*** ***A feedback loop is any mechanism in which a condition triggers some action that causes a change in that same condition.*** ***The mechanisms of external controls and internal feedback loops are important elements for a stable system.*** ***A change in one part of a system can cause changes to other parts of the system, resulting in positive or negative feedback loops.*** ***The changes (negative***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
design solution. ***Analyze data using models in order to make valid and reliable scientific claims.*** ***Analyze data using models in order to determine an optimal design solution.***	***Uneven heating of Earth's components (i.e., water, land, and air) produces local and global atmospheric and oceanic movement.*** ***Heat energy stored in the oceans and transferred by currents influence climate.***	***or positive) can stabilize or destabilize a system.***

Clarification Statement
Examples could include climate feedbacks such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice which reduces the amount of sunlight reflected from Earth's surface increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-4 Analyze and interpret data to explore how variations in the flow of energy into and out of Earth's systems result in changes in atmosphere and climate. ***LC-HS-ESS2-4a Identify different causes of climate change and results of those changes with respect to the Earth's surface temperatures, precipitation patterns or sea levels over a wide range of temporal and spatial scales using a model.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. ***Analyze data using tools in order to make valid and reliable scientific claims.*** ***Analyze data using tools in order to determine an optimal design solution.*** ***Analyze data using technology in order to make valid and reliable scientific claims.*** ***Analyze data using technology in***	**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 Earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (HS.ESS1B.b) ***Gradual changes in the shape of Earth's orbit around the sun contributes to phenomena causing ice ages and other gradual climate changes.*** ***Earth's global temperatures can warm up or cool down if the amount of sunlight that enters the atmosphere is significantly altered.*** ***Cyclic variations of Earth's orbit around the sun impact the amount of sunlight that reaches Earth's surface.*** ***Gradual changes to the tilt of Earth's axis relative to its orbit around the sun have produced different weather patterns.*** **EARTH MATERIALS AND SYSTEMS** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, hydrosphere circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS.ESS2A.d) ***All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems.*** ***Changes to climate occur over a wide range of temporal and spatial scales.***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
order to determine an optimal design solution. ***Analyze data using models in order to make valid and reliable scientific claims.*** ***Analyze data using models in order to determine an optimal design solution.***	***The geological record (ice cores, sediment deposits, fossil evidence, and paleo vegetation restorations) shows that changes to global and regional climate can be caused by several factors (Earth's orbit, tectonic events, volcanic glaciers, vegetation, etc.).*** ***Changes to the input, output, storages or redistribution of energy on Earth can occur over a short or extended time frame and can cause extreme weather conditions.*** **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, hydrosphere and land systems, and this energy's re-radiation into space. (HS.ESS2D.a) ***Sunlight is a portion of the electromagnetic radiation given off by the sun.*** ***Energy from the sun travels to Earth and heats Earth's surface.*** ***Some of this energy is radiated back into Earth's atmosphere.*** ***The sun's energy drives Earth's climate systems.*** ***Uneven heating of Earth's components (i.e., water, land, air) produce local and global atmospheric and oceanic movement.*** ***Heat energy stored in the oceans and transferred by currents influence climate.*** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS.ESS2D.b) ***Plants contribute to the make-up of Earth's atmosphere by absorbing carbon dioxide and releasing oxygen.*** ***Carbon continuously cycles from one sphere to another.*** ***In the past, the relative amount of carbon that cycled through the hydrosphere, atmosphere, lithosphere or geosphere, and biosphere was partially due to the activity of plants and other organisms.*** Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS.ESS2D.c)	

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Human activities that add carbon dioxide to the atmosphere may be warming Earth's atmosphere. ***A large amount of carbon dioxide has been released into Earth's atmosphere by human-related fossil fuel combustion.*** ***An increase in atmospheric carbon can increase the amount of heat energy stored in the system.***	

Clarification Statement
Changes differ by timescale, from sudden (large volcanic eruption, hydrosphere circulation) to intermediate (hydrosphere circulation, solar output, human activity) and long-term (Earth's orbit and the orientation of its axis and changes in atmospheric composition). Examples of human activities could include fossil fuel combustion, cement production, or agricultural activity and natural processes such as changes in incoming solar radiation or volcanic activity. Examples of data can include tables, graphs, maps of global and regional temperatures, and atmospheric levels of gases.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-5 Plan and conduct an investigation on the properties of water and its effects on Earth materials and surface processes. ***LC-HS-ESS2-5a Identify a connection between the properties of water and its effects on Earth materials.*** ***LC-HS-ESS2-5b Investigate the effects of water on Earth materials and/or surface processes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation (science) or test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. ***Plan an investigation (science) individually and collaboratively to produce data to serve as the basis***	**THE ROLE OF WATER IN EARTH'S SURFACE PROCESSES** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS.ESS2C.a) ***Water has many unique properties (e.g., capacity to absorb, store, and release large amounts of energy; to expand upon freezing; to dissolve and transport many materials) that play a role in how it affects Earth systems (e.g., ocean thermal capacity contributes to moderating temperature variations, ice expansion contributes to rock erosion).*** ***Water exhibits a polar nature due to its molecular structure.*** ***Patterns of temperature, the movement of air, and the movement and availability of water at Earth's surface can be related to the effect of the properties of water on energy transfer.*** ***Mechanical effects of water (e.g., stream transportation and deposition, erosion using variations in soil moisture content, and expansion of water as it freezes) on Earth's materials can be used to infer the effect of water on Earth's surface properties.*** ***Chemical effects of water (e.g., properties of solubility, the reaction of water on iron) on Earth materials can be used to infer the effect of water on Earth's surface processes.***	**STRUCTURE AND FUNCTION** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. ***There are relationships between structure and function of natural and designed objects.*** ***There are relationships between structure and function of systems.*** ***Relationships between structure and function can be inferred from their overall structure.*** ***Relationships between structure and function***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
for evidence as part of building and revising models. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. ***Test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.*** ***Plan an investigation (science) individually and collaboratively to produce data to serve as the basis for evidence for supporting explanations for phenomena. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.*** ***Test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence for supporting explanations for phenomena. Consider possible confounding variables or effects and evaluate the investigation's design to ensure***		***can be inferred from the way their components are shaped.*** ***Relationships between structure and function can be inferred from the molecular substructures of its various materials.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
variables are controlled. ***Plan an investigation (science individually and collaboratively to produce data to serve as the basis for evidence for testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.*** ***Test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence for testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.)***		

Clarification Statement
Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).

Performance Expectation *and Louisiana Connectors*
HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. ***LC-HS-ESS2-6a Use a model of photosynthesis to identify that carbon is exchanged between living and nonliving systems.*** ***LC-HS-ESS2-6b Use a model of cellular respiration to identify that carbon is exchanged between living and nonliving systems.*** ***LC-HS-ESS2-6c Develop and/or use a quantitative model to identify relative amount of and/or the rate at which carbon is transferred among hydrosphere, atmosphere, geosphere, and biosphere.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. ***Develop a model based on evidence to illustrate the relationships between systems.*** ***Develop a model based on evidence to illustrate the components of a system.***	**WEATHER AND CLIMATE** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS.ESS2D.b) ***Plants contribute to the make-up of Earth's atmosphere by absorbing carbon dioxide and releasing oxygen.*** ***Carbon continuously cycles from one sphere to another.*** ***In the past, the relative amount of carbon that cycled through the hydrosphere, atmosphere, lithosphere or geosphere, and biosphere was partially due to the activity of plants and other organisms.*** Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS.ESS2D.c) ***Human activities that add carbon dioxide to the atmosphere may be warming Earth's atmosphere.*** ***A large amount of carbon dioxide has been released into Earth's atmosphere by human-related fossil fuel combustion.*** ***An increase in atmospheric carbon can increase the amount of heat energy stored in the system.***	**ENERGY AND MATTER** The total amount of energy and matter in closed systems is conserved. ***When materials interact within a closed system, the total mass of the system remains the same. Energy may change forms, but the total amount of energy cannot change in physical systems.***

Clarification Statement
Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.
Performance Expectation *and Louisiana Connectors*
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. ***LC-HS-ESS3-1a Explain the relationship between human activity (e.g., population size, where humans live, types of crops grown) and changes in the amounts of natural resources using evidence.*** ***LC-HS-ESS3-1b Explain the relationship between human activity (e.g., population size, where humans live, types of crops grown) and changes in the occurrence of natural hazards using evidence.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to	**NATURAL RESOURCES** Resource availability has guided the development of human society. (HS.ESS3A.a) ***The availability of natural resources has influenced where humans have populated regions of Earth.*** ***Environmental factors have affected human populations over the course of history.*** ***Resource availability has driven global development of societies, sizes of human populations, and human migrations.*** ***Evidence (e.g., from text or other investigations) show correlations between human population distribution and regional availability of resources such as fresh water, fertile soils, and fossils fuels.*** **NATURAL HAZARDS** Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS.ESS3B.a) ***Natural hazards such as earthquakes, tsunamis, volcanic eruptions, severe weather, floods, and coastal erosion, have historically affected the sizes and distributions of human populations.***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
do so in the future. *Construct an explanation based on valid and reliable evidence from a variety of sources.* *Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.* *Revise an explanation based on valid and reliable evidence from a variety of sources.* *Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*	*Environmental factors have affected human populations over the course of history.* *Natural disasters and other geologic events have driven global development of societies, sizes of human populations, and human migrations.* *Historical accounts of natural disasters (e.g., Krakatoa eruption, American Dust Bowl, Super storm Sandy, and Hurricane Katrina), resulting human suffering and loss of life could provide empirical evidence of past impacts on human population size and distribution.*	*in a system under study.*

Clarification Statement
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). Natural hazards and other geologic events exhibit some non-random patterns of occurrence. 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.

Performance Expectation *and Louisiana Connectors*
HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. ***LC-HS-ESS3-2a Identify a solution that demonstrates the most preferred cost-benefit ratios for developing, managing, and utilizing energy and mineral resources (i.e., conservation, recycling, and reuse of resources).*** ***LC-HS-ESS3-2b Compare design solutions for developing, managing, and/or utilizing energy or mineral resources.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized***	**NATURAL RESOURCES** 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.ESS3A.b) ***Anything in the environment that is naturally occurring and used by people is a natural resource.*** ***Demand for energy by society leads to continuous exploration in order to expand supplies of fossil fuels.*** ***The increase in energy demand and the new technologies being developed to meet these needs and improve the efficiencies of energy systems have social and environmental consequences.*** ***New technologies of energy production are being developed. For example, the technique of using hydraulic fracturing to extract natural gas from shale deposits versus other traditional means of acquiring energy from natural resources.*** ***New technologies could have deep impacts on society and the environment, including some that were not anticipated.*** ***New technologies are being developed to increase the use of alternate energy sources.*** **DESIGNING SOLUTIONS TO ENGINEERING PROBLEMS** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and	**SYSTEMS AND SYSTEM MODELS** Systems can be designed to do specific tasks. ***Systems can be designed to explain phenomena (scientific).*** ***Systems can be designed to refine solutions (engineering).*** ***Systems can be designed for understanding and testing ideas that are applicable throughout science and engineering.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
criteria, and trade-off considerations. ***Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.*** ***Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.***	environmental impacts. (HS.ETS1B.a) ***It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.*** ***New technologies offer solutions based on cost-benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).***	

Clarification Statement
Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural, soil use, forestry, and mining (coal, tar sands, and oil shales), and pumping (ground water, petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.

Performance Expectation ***and Louisiana Connectors***
HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. ***LC-HS-ESS3-3 Use numerical data to determine the effects of a conservation strategy to manage natural resources and to sustain human society and plant and animal life.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create a computational model or simulation of a phenomenon, designed device, process, or system. ***Create/use a computational model of a phenomenon.***	**HUMAN IMPACTS ON EARTH SYSTEMS** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS.ESS3C.a) ***Responsible use of energy requires consideration of energy availability, efficiency of its use, the environmental impact, and possible alternate sources.*** ***Poor management of natural resources can have negative impacts on human populations.***	**STABILITY AND CHANGE** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. ***Change and rates of change can be quantified over very short or very long periods of time.*** ***Change and rates of change can be modeled over very short or very long periods of time.*** ***Some system changes are irreversible.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Revise a computational model of a phenomenon. *Create/use a simulation of a phenomenon.* *Revise a simulation of a phenomenon.* *Create/use a computational model of a process.* *Revise a computational model of a process.* *Create/use a simulation of a process.* *Revise a simulation of a process.* *Create/use a computational model of a system.* *Revise a computational model of a system.* *Create/use a simulation of a system.* *Revise a simulation of a system.*		

Clarification Statement
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).

Performance Expectation ***and Louisiana Connectors***
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. ***LC-HS-ESS3-6a Use representations to describe the relationships among Earth systems and how those relationships are being modified due to human activity (e.g., increase in atmospheric carbon dioxide, increase in ocean acidification, effects on organisms in the ocean (coral reef), carbon cycle of the ocean, possible effects on marine populations).***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use a computational representation of phenomena or design solutions to describe and/or	**WEATHER AND CLIMATE** 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. (HS.ESS2D.d) ***Current models of Earth's natural systems include system boundaries, initial conditions, inputs and outputs, and relationships that determine the interaction (e.g., the relationship between atmospheric carbon dioxide and production of photosynthetic biomass and ocean acidification).*** ***The increased carbon dioxide level in the atmosphere traps more heat. This will lead to a gradual increase in the temperature of Earth's atmosphere.*** ***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.*** ***Based on current models, Earth's average global temperatures will continue to rise due to an increase in human-generated greenhouse gases (e.g., carbon dioxide and methane) in Earth's atmosphere and associated feedbacks.***	**SYSTEMS AND SYSTEM MODELS** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. ***When investigating a system, the boundaries and initial conditions of the system need to be defined.*** ***When describing a system, the boundaries***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
support claims and/or explanations. *Use a computational representation of phenomena to describe claims.* *Use a computational representation of phenomena to describe explanations.* *Use a computational representation of phenomena to support claims.* *Use a computational representation of phenomena to support explanations.* *Use a computational representation of a design solution to describe claims.* *Use a computational representation of a design solution to describe explanations.* *Use a computational representation of a design solution to support claims.* *Use a computational representation of a design solution to support explanations.*	*Human impact on climate change must be addressed.* *Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science and engineering capabilities.* **GLOBAL CLIMATE CHANGE** Important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities (e.g., through computer simulations and other discoveries satellite imagery). (HS.ESS3D.b) *Scientists continually learn more about how Earth's systems interact and are changed by human activities.* *Modern civilization depends on major technological systems.* *Through computer simulations and other studies, important discoveries are still being made about how the ocean, atmosphere, and biosphere interact and are modified in response to human activities.* *Scientists and engineers use human-generated models including computer simulations, to predict how the amount of greenhouse gases in Earth's atmosphere impacts the biological and physical processes on Earth (e.g., oceanic acidification, coral bleaching, ocean circulation, etc.).*	*and initial conditions of the system need to be defined.* *When investigating a system, the inputs and outputs need to be analyzed and described using models.* *When describing a system, the inputs and outputs need to be analyzed and described using models.*

Clarification Statement
Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.

Performance Expectation ***and Louisiana Connectors***
HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity, biodiversity and populations of ecosystems at different scales. ***LC-HS-LS2-1a Recognize that the carrying capacities of ecosystems are related to the availability of living and nonliving resources and challenges (e.g., predation, competition, disease).*** ***LC-HS-LS2-1b Use a graphical representation to identify carrying capacities in ecosystems as limits to the numbers of organisms or populations they can support.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on	**INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS** Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges as predation, competition, and disease that affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS.LS2A.a) ***Carrying capacities are limits to the numbers of organisms and populations an ecosystem can support.*** ***The carrying capacity for a specific population in an ecosystem depends on the resources available.*** ***These limits can be a result of shifting living (predators, competition, and available food)***	**SCALE, PROPORTION, AND QUANTITY** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ***The size and time scales relevant to various objects, systems, and processes determine the significance of a phenomena. Specific***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations***	***and non-living (shelter, water, and climate) factors within a specific environment.*** ***Given adequate biotic and abiotic resources and no disease or predators, populations increase at rapid rates.*** ***Resources, (limiting factors), predation and climate, limit the growth of populations in specific niches in an ecosystem.*** Human activity directly and indirectly affect biodiversity and ecosystem health (e.g., habitat fragmentation, introduction of nonnative or invasive species, overharvesting, pollution and climate change). (HS.LS2A.b) ***Humans are an integral part of the natural system, and human activities can alter the stability of ecosystems.*** ***Human-related changes to one or more of these factors can result in an ecosystem breaking down or the creation of an entirely new ecosystem.*** ***Human activities have a major effect on other species. For example, increased land use reduces habitat available to other species, pollution changes the chemical composition of air, soil, and water, and introduction of non-native species disrupts the ecological balance.***	***phenomena correspond to a specific scale (e.g., the size of the nucleus of an atom to the size of the galaxy and beyond).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.		

Clarification Statement
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, or population changes gathered from simulations or historical data sets.

Performance Expectation *and Louisiana Connectors*
HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. ***LC-HS-LS2-4a Use a graphical or mathematical representation to identify the changes in the amount of matter as it travels through a food web.*** ***LC-HS-LS2-4b Use a graphical or mathematical representation to identify the changes in the amount of energy as it travels through a food web.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations	**CYCLES OF MATTER AND ENERGY TRANSFER IN ECOSYSTEMS** Energy is inefficiently transferred from one trophic level to another that affect the relative number of organisms that can be supported at each trophic level and necessitates a constant input of energy from sunlight or inorganic compounds from the environment. (HS.LS2B.b) ***Only a fraction of the energy available at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels.*** ***The inefficiency of energy transfer determines the number of trophic levels and affects the relative number of organisms at each trophic level in an ecosystem.*** ***All energy is conserved as it passes from the sun through an ecosystem.*** ***During energy transformations, some energy is converted to unusable heat.*** ***A continual input of energy from the sun keeps the process going.*** ***On average, regardless of scale, 10% of energy is transferred up from one trophic level to***	**ENERGY AND MATTER: FLOWS, CYCLES, AND CONSERVATION** Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. ***Energy cannot be created or destroyed.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support***	***another.*** Photosynthesis, cellular respiration, decomposition and combustion are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, hydrosphere, and geosphere through chemical, physical, geological, and biological processes. (HS.LS2B.c) ***Carbon is an essential element cycled through all levels of life from cellular to ecosystems, and is required for survival of all living organisms.*** ***Photosynthesis (the main way that solar energy is captured and stored on Earth) and cellular respiration are important components of the carbon cycle, in which carbon is exchanged between living and nonliving systems.*** ***Matter needed to sustain life in ecosystems is continually recycled (e.g., carbon cycle, water cycle, nitrogen cycle, mineral cycles) among organisms and between organisms and the environment.*** Photosynthesis, chemosynthesis, aerobic and anaerobic respiration and cellular respiration (including anaerobic processes) provide most of the energy for life processes. Environmental conditions restrict which and when reactions can occur. (HS.LS2B.a) (suggested extension) ***The processes of photosynthesis (making oxygen and sugars) and cellular respiration (making energy from sugar, done in plants and animals) provide most of the energy for life on earth.*** ***The reactants and products of photosynthesis and cellular respiration (aerobic and anaerobic) can be used to relate the Law of Conservation of Matter and the Law of Conservation of Energy to ecosystems, using the carbon cycle can as a reference.***	***Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
explanations. ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.***		

Clarification Statement
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.

Performance Expectation ***and Louisiana Connectors***
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. ***HS-LS2-6a Use evidence to identify how modest biological or physical changes versus extreme changes affect stability and change (e.g., number and types of organisms) in ecosystems.*** ***HS-LS2-6b Evaluate explanations of how living things in an ecosystem are affected by changes in the environment (e.g., changes to the food supply, climate change, or the introduction of predators).*** ***HS-LS2-6c Evaluate explanations of how interactions in ecosystems maintain relatively stable conditions, but changing conditions may result in a new ecosystem.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed	**ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE** The dynamic 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 and may result in new ecosystems. (HS.LS2C.a)	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. ***Science deals with***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ***Evaluate the claims behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the claims behind currently accepted solutions to determine the merits of arguments.*** ***Evaluate the evidence behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the evidence behind currently accepted solutions to determine the merits of arguments.*** ***Evaluate the reasoning behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the reasoning behind currently accepted solutions to determine the merits of arguments.***	 ***Under most circumstances a natural balance is maintained within an ecosystem.*** ***Organisms both cooperate and compete in ecosystems.*** ***The interrelationships and interdependencies of these organisms may generate complex ecosystems that are stable over long periods of time and tend to have cyclic fluctuations around an equilibrium (i.e., the ecosystem is resilient).*** ***Extreme fluctuations, such as from natural disasters, can challenge the functioning of ecosystems in terms of resources and habitat availability.*** ***These changes can result in an ecosystem breaking down or the creation of an entirely new ecosystem.***	***constructing explanations of how things change. Science deals with constructing explanations of how things remain stable.***

Clarification Statement
Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood and extreme changes, such as volcanic eruption or sea level rise. Emphasis should be on describing drivers of ecosystem stability and change, not on the organismal mechanisms of responses and interactions.

Performance Expectation *and Louisiana Connectors*
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. ***LC-HS-LS2-7a Describe how people can help protect the Earth's environment and biodiversity (e.g., preserving ecosystems) and how a human activity would threaten Earth's environment and biodiversity (e.g., pollution, damaging habitats, over hunting).*** ***LC-HS-LS2-7b Evaluate or refine a solution to changes in an ecosystem (biodiversity) resulting from a human activity.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world	**ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE** Ecosystems with a greater biodiversity tend to have a greater resistance and resilience to change. 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.LS2C.b) ***Biodiversity helps maintain stability in ecosystems. However, factors caused by humans (e.g., habitat destruction, pollution, introduction of invasive species) have negative effects on the environment and biodiversity. Some system changes are irreversible.*** **BIODIVERSITY AND HUMANS**	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. ***Science deals with constructing explanations of how things change. Science deals with constructing***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.*** ***Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.*** ***Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.***	Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Humans depend on the living world for the resources and other benefits provided by biodiversity. 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. (HS.LS4D.a) ***Humans depend on the living world for resources.*** ***Thus, protecting the environment and biodiversity helps sustain human life.*** ***Ecosystems undergo major changes as a result of such human-related factors as overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change.*** ***Sustainability of human societies and the biodiversity that supports them require responsible management of natural resources.*** ***Changes in the physical, chemical, or biological conditions of an ecosystem can alter the diversity of species in the system.*** ***Over time, ecosystems change and populations of organisms adapt, move, or become extinct.*** **DEVELOPING POSSIBLE SOLUTIONS** When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (HS.ETS1B.a) ***It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.*** ***The development of solutions is driven by the following factors: economical, political, cultural, social, safety, and environmental.***	***explanations of how things remain stable.***

Clarification Statement
Examples of human activities can include urbanization, building dams, or dissemination of invasive species.