Unless otherwise specified, "descriptions" referenced in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.

MS-LS2-1 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

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. [Clarification Statement: 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.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to provide evidence for phenomena.

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Observable features of the student performance by the end of the course:			
1	Organizing data		
	a	Students organize the given data (e.g., using tables, graphs, and charts) to allow for analysis and interpretation of relationships between resource availability and organisms in an ecosystem, including:	
		i.	Populations (e.g., sizes, reproduction rates, growth information) of organisms as a function of resource availability.
		ii.	Growth of individual organisms as a function of resource availability.
2	Identifying relationships		
	a	Students analyze the organized data to determine the relationships between the size of a population, the growth and survival of individual organisms, and resource availability.	
	b	Students determine whether the relationships provide evidence of a causal link between these factors.	
3	Interpreting data		
	a	Students analyze and interpret the organized data to make predictions based on evidence of causal relationships between resource availability, organisms, and organism populations. Students make relevant predictions, including:	
		i.	Changes in the amount and availability of a given resource (e.g., less food) may result in changes in the population of an organism (e.g., less food results in fewer organisms).
		ii.	Changes in the amount or availability of a resource (e.g., more food) may result in changes in the growth of individual organisms (e.g., more food results in faster growth).
		iii.	Resource availability drives competition among organisms, both within a population as well as between populations.
		iv.	Resource availability may have effects on a population's rate of reproduction.

MS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-2. **Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.** [Clarification Statement: 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.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

Crosscutting Concepts

Patterns

- Patterns can be used to identify cause and effect relationships.

Observable features of the student performance by the end of the course:			
1	Articulating the explanation of phenomena		
	a	Students articulate a statement that relates the given phenomenon to a scientific idea, including that similar patterns of interactions occur between organisms and their environment, regardless of the ecosystem or the species involved.	
	b	Students use evidence and reasoning to construct an explanation for the given phenomenon.	
2	Evidence		
	a	Students identify and describe* the evidence (e.g., from students' own investigations, observations, reading material, archived data) necessary for constructing the explanation, including evidence that:	
		i.	Competitive relationships occur when organisms within an ecosystem compete for shared resources (e.g., data about the change in population of a given species when a competing species is introduced).
		ii.	Predatory interactions occur between organisms within an ecosystem.
		iii.	Mutually beneficial interactions occur between organisms within an ecosystem. Organisms involved in these mutually beneficial interactions can become so dependent upon one another that they cannot survive alone.
		iv.	Resource availability, or lack thereof, can affect interactions between organisms (e.g., organisms in a resource-limited environment may have a competitive relationship, while those same organisms may not be in competition in a resource-rich environment).
		v.	Competitive, predatory, and mutually beneficial interactions occur across multiple, different, ecosystems
	b	Students use multiple valid and reliable sources for the evidence.	
3	Reasoning		
	a	Students identify and describe* quantitative or qualitative patterns of interactions among organisms that can be used to identify causal relationships within ecosystems, related to the given phenomenon.	

	b	Students describe* that regardless of the ecosystem or species involved, the patterns of interactions (competitive, mutually beneficial, predator/prey) are similar.
	c	Students use reasoning to connect the evidence and support an explanation. In their reasoning, students use patterns in the evidence to predict common interactions among organisms in ecosystems as they relate to the phenomenon, (e.g., given specific organisms in a given environment with specified resource availability, which organisms in the system will exhibit competitive interactions). Students predict the following types of interactions:
		i. Predatory interactions.
		ii. Competitive interactions.
		iii. Mutually beneficial interactions.

MS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [*Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to describe phenomena.

Disciplinary Core Ideas

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

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

Crosscutting Concepts

Energy and Matter

- The transfer of energy can be tracked as energy flows through a natural system.

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Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	To make sense of a given phenomenon, students develop a model in which they identify the relevant components, including:	
		i.	Organisms that can be classified as producers, consumers, and/or decomposers.
		ii.	Nonliving parts of an ecosystem (e.g., water, minerals, air) that can provide matter to living organisms or receive matter from living organisms.
		iii.	Energy
	b	Students define the boundaries of the ecosystem under consideration in their model (e.g., pond, part of a forest, meadow; a whole forest, which contains a meadow, pond, and stream).	
2	Relationships		
	a	In the model, students describe* relationships between components within the ecosystem, including:	
		i.	Energy transfer into and out of the system.
		ii.	Energy transfer and matter cycling (cycling of atoms):
			1. Among producers, consumers, and decomposers (e.g., decomposers break down consumers and producers via chemical reactions and use the energy released from rearranging those molecules for growth and development).
			2. Between organisms and the nonliving parts of the system (e.g., producers use matter from the nonliving parts of the ecosystem and energy from the sun to produce food from nonfood materials).
3	Connections		
	a	Students use the model to describe* the cycling of matter and flow of energy among living and nonliving parts of the defined system, including:	

		i.	When organisms consume other organisms, there is a transfer of energy and a cycling of atoms that were originally captured from the nonliving parts of the ecosystem by producers.
		ii.	The transfer of matter (atoms) and energy between living and nonliving parts of the ecosystem at every level within the system, which allows matter to cycle and energy to flow within and outside of the system.
	b	Students use the model to track energy transfer and matter cycling in the system based on consistent and measureable patterns, including:	
		i.	That the atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
		ii.	That matter and energy are conserved through transfers within and outside of the ecosystem.

MS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-4. **Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** [Clarification Statement: 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.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

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Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science disciplines share common rules of obtaining and evaluating empirical evidence.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

Crosscutting Concepts

Stability and Change

- Small changes in one part of a system might cause large changes in another part.

Observable features of the student performance by the end of the course:			
1	Supported claims		
	a	Students make a claim to be supported about a given explanation or model for a phenomenon. In their claim, students include the idea that changes to physical or biological components of an ecosystem can affect the populations living there.	
2	Identifying scientific evidence		
	a	Students identify and describe* the given evidence (e.g., evidence from data, scientific literature) needed for supporting the claim, including evidence about:	
		i.	Changes in the physical or biological components of an ecosystem, including the magnitude of the changes (e.g., data about rainfall, fires, predator removal, species introduction).
		ii.	Changes in the populations of an ecosystem, including the magnitude of the changes (e.g., changes in population size, types of species present, and relative prevalence of a species within the ecosystem).
		iii.	Evidence of causal and correlational relationships between changes in the components of an ecosystem with the changes in populations.
	b	Students use multiple valid and reliable sources of evidence.	
3	Evaluating and critiquing the evidence		
	a	Students evaluate the given evidence, identifying the necessary and sufficient evidence for supporting the claim.	
	b	Students identify alternative interpretations of the evidence and describe* why the evidence supports the student's claim.	
4	Reasoning and synthesis		
	a	Students use reasoning to connect the appropriate evidence to the claim and construct an oral or written argument about the causal relationship between physical and biological components of an	

		ecosystem and changes in organism populations, based on patterns in the evidence. In the argument, students describe* a chain of reasoning that includes:	
		i.	Specific changes in the physical or biological components of an ecosystem cause changes that can affect the survival and reproductive likelihood of organisms within that ecosystem (e.g., scarcity of food or the elimination of a predator will alter the survival and reproductive probability of some organisms).
		ii.	Factors that affect the survival and reproduction of organisms can cause changes in the populations of those organisms.
		iii.	Patterns in the evidence suggest that many different types of changes (e.g., changes in multiple types of physical and biological components) are correlated with changes in organism populations.
		iv.	Several consistent correlational patterns, along with the understanding of specific causal relationships between changes in the components of an ecosystem and changes in the survival and reproduction of organisms, suggest that many changes in physical or biological components of ecosystems can cause changes in populations of organisms.
		v.	Some small changes in physical or biological components of an ecosystem are associated with large changes in a population, suggesting that small changes in one component of an ecosystem can cause large changes in another component.

MS-LS2-5 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* [Clarification Statement: 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.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

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

LS4.D: Biodiversity and Humans

- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.*(secondary)*

ETS1.B: Developing Possible Solutions

- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. *(secondary)*

Crosscutting Concepts

Stability and Change

- Small changes in one part of a system might cause large changes in another part.

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

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Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Observable features of the student performance by the end of the course:			
1	Identifying the given design solution and supporting evidence		
	a	Students identify and describe*:	
		i.	The given competing design solutions for maintaining biodiversity and ecosystem services.
		ii.	The given problem involving biodiversity and/or ecosystem services that is being solved by the given design solutions, including information about why biodiversity and/or ecosystem services are necessary to maintaining a healthy ecosystem.
		iii.	The given evidence about performance of the given design solutions.
2	Identifying any potential additional evidence that is relevant to the evaluation		
	a	Students identify and describe* the additional evidence (in the form of data, information, or other appropriate forms) that is relevant to the problem, design solutions, and evaluation of the solutions, including:	
		i.	The variety of species (biodiversity) found in the given ecosystem.
		ii.	Factors that affect the stability of the biodiversity of the given ecosystem.

		iii. Ecosystem services (e.g., water purification, nutrient recycling, prevention of soil erosion) that affect the stability of the system.
	b	Students collaboratively define and describe* criteria and constraints for the evaluation of the design solution.
3	Evaluating and critiquing the design solution	
	a	In their evaluations, students use scientific evidence to:
		i. Compare the ability of each of the competing design solutions to maintain ecosystem stability and biodiversity.
		ii. Clarify the strengths and weaknesses of the competing designs with respect to each criterion and constraint (e.g., scientific, social, and economic considerations).
		iii. Assess possible side effects of the given design solutions on other aspects of the ecosystem, including the possibility that a small change in one component of an ecosystem can produce a large change in another component of the ecosystem.