Inv	Inv Title	Part	Part Summary	Sessions	Content	NGSS Standards Addressed	Disciplinary Core Ideas (Framework)	Crosscutting Concepts	Scientific and Engineering Practices (SP / EP): Asking questions (SP) / Defining problems (EP)	Developing and using models	Planning and carrying out investigations	Analyzing and interpreting data	Using mathematics and comp. thinking	Constructing explanations (SP) / Designing solutions (EP)	Engaging in argument from evidence	Obtaining, evaluating, and communicating information
1	Milkweed Bugs	1	**Introducing Milkweed Bugs** Students are introduced to adult milkweed bugs. They observe the milkweed bugs carefully in order to discover gender differences.	1	• An organism is any living thing. • A kind of organism that is different from all other kinds of organisms is called a species.	**Foundational for 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.	**LS2.A: Interdependent Relationships in Ecosystems** • Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)	**Patterns** • Patterns can be used to identify cause and effect relationships.			SP					
1	Milkweed Bugs	2	**Milkweed-Bug Habitat** Students assemble zip-bag habitats to house milkweed bugs during the reproduction study. Each class completes one task in the assembly project. The last class of the day puts the milkweed bugs into the finished habitat. Students are also introduced to the class worm habitat and what they will do to maintain the redworm population.	1	• An organism's habitat is where it lives—the place where it can meet all of its requirements for life.	**Foundational for 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.	**LS1.B: Growth and Development of Organisms** • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1) **LS2.A: Interdependent Relationships in Ecosystems** • Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)	**Systems and System Models** • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.			SP					
1	Milkweed Bugs	3	**Observing Milkweed-Bug Habitats** For several weeks students observe and record events in the milkweed-bug habitats. Students should observe feeding and drinking, movement, mating, egg laying, hatching, and molting. After 6–8 weeks, students have observed the entire milkweed-bug life cycle and have seen a multitude of offspring.	1	• An organism's habitat is where it lives—the place where it can meet all of its requirements for life. • A kind of organism that is different from all other kinds of organisms is called a species. • A population is all the individuals of a species in an area at a specified time.	**Foundational for 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.	**LS1.B: Growth and Development of Organisms** • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1) **LS2.A: Interdependent Relationships in Ecosystems** • Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)	**Patterns** • Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.		SP	SP					SP
2	Sorting Out Life	1	**Ecosystem Card Sort** Students are introduced to basic definitions used in ecological studies: individual, population, community, ecosystem, and biotic/abiotic factors. They deepen their understanding by sorting the picture cards into categories based on the definitions. After discussing the sorting activity, students record their results in their notebooks.	1	• An individual is one single organism. • A community is all the interacting populations in a specified area. • An ecosystem is a system of interacting organisms and nonliving factors in a specified area. • Biotic factors are living factors in an ecosystem; abiotic factors are nonliving factors.	**Foundational for MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.	**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. (MS-LS2-1)	**Patterns** • Patterns can be used to identify cause and effect relationships.						SP		
2	Sorting Out Life	2	**Video Population Study** Students watch a video of Jane Goodall's experience developing her population field study on chimpanzees. Students answer questions about Goodall's experience.	2	• A community is all the interacting populations in a specified area. • An ecosystem is a system of interacting organisms and nonliving factors in a specified area.	**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.	**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. (MS-LS2-1) • 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. (MS-LS2-1) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)	**Scale, proportion, and quantity** • Phenomena that can be observed at one scale may not be observable at another scale **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.		SP	SP					SP
2	Sorting Out Life	3	**Ecoscenarios** Students are introduced to ten ecoscenarios representing major biomes of North America. Each group begins the study of a different ecosystem by identifying its populations and the abiotic factors that define the region.	4	• A community is all the interacting populations in a specified area. • An ecosystem is a system of interacting organisms and nonliving factors in a specified area. • Biotic factors are living factors in an ecosystem; abiotic factors are nonliving factors. • Ecosystems around the world have different sets of biotic and abiotic factors. • Ecosystems provide ecosystem services for humans. • Biomes are large areas on Earth with similar abiotic factors.	**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.	**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. (MS-LS2-1) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)	**Patterns** • Patterns can be used to identify cause and effect relationships. .								SP

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3	Mono Lake	1	**A Visit to Mono Lake** Students are introduced to a new ecosystem, alkaline lakes. They begin an in-depth study of the Mono Lake ecosystem. They identify relationships between the organisms and abiotic factors.	1	• Mono Lake is an example of an alkaline-lake ecosystem. • The Mono Lake ecosystem is defined by the interactions among organisms and abiotic factors that exist in the Mono Lake basin.	**MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.	**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. (MS-LS2-1)) • 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. (MS-LS2-2)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.	SP							SP
3	Mono Lake	2	**Mono Lake Food Web** Students study the natural history of the major organisms in Mono Lake through feeding relationships and interactions. The concepts of food chains and more complex food webs are introduced. Students learn the ecological roles played by organisms in an ecosystem—producer, consumer, and decomposer—and reorganize the Mono Lake organisms into layers with producers at the base and consumers above.	3	• The path that food takes as one organism is eaten by another is a food chain. • The feeding relationships in an ecosystem can be represented as a food web. • The Mono Lake ecosystem is defined by the interactions among the organisms and abiotic factors that exist in the Mono Lake basin.	**MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**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. (MS-LS2-1) • 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. (MS-LS2-2) **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. (MS-LS2-3)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system. **Stability and Change** • Small changes in one part of a system might cause large changes in another part.		SP		SP				SP
3	Mono Lake	3	**Ecoscenario Food Webs** Students return to their assigned ecoscenario from Investigation 2. They identify and chart the feeding relationships for their ecoscenario.	3	• The path that food takes as one organism is eaten by another is a food chain. • The feeding relationships in an ecosystem can be represented as a food web. • All ecosystems are defined by the interactions among the organisms and abiotic factors that exist in the region.	**MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**LS2.A: Interdependent Relationships in Ecosystems** 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. (MS-LS2-1) • 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. (MS-LS2-2) **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. (MS-LS2-3)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system. **Stability and Change** • Small changes in one part of a system might cause large changes in another part. **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.		SP		SP				SP
4	Minihabitats	1	**The Physical Environment** Students categorize organisms into two sets, based on the kind of physical environment in which the organisms might live: aquatic or terrestrial. They assemble an aquarium and a terrarium in preparation for introducing organisms in Part 2.	1	• An aquatic ecosystem functions in water. • A terrestrial ecosystem functions on land. • Organisms depend on the abiotic elements in their ecosystem.	**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. .	**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. (MS-LS2-1) • 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. (MS-LS2-1)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.		SP	SP					SP

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4	Minihabitats	2	**Introducing Life** Students observe aquatic organisms and terrestrial organisms in isolation and record observations. They predict how the organisms will interact when they are placed in their minihabitats.	2	• Organisms depend on the abiotic elements in their ecosystem.	**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.	**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. (MS-LS2-1) • 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. (MS-LS2-1)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Stability and Change** • Small changes in one part of a system might cause large changes in another part.		SP		SP				
4	Minihabitats	3	**Observing Minihabitats** Students begin a long-term observation of the minihabitats. They attend to basic maintenance procedures like removing dead organisms and feeding, and discuss the interactions that they observe.	1	• An aquatic ecosystem functions in water. • A terrestrial ecosystem functions on land. • Organisms depend on the abiotic elements in their ecosystem.	**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. **MS-LS2-4**. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	**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. (MS-LS2-1) • 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. (MS-LS2-1) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1) **Stability and Change** • Small changes in one part of a system might cause large changes in another part. **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.		SP		SP				SP
5	Producers	1	**Growing Producers** Students plant seeds in light and dark conditions. They monitor and compare the seed growth over ten days to determine the role of light in biomass production. Students go on to complete the investigation while the plants grow.	1	• Producers need light to carry out photosynthesis.	**MS-LS1-6.** Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6) **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. (MS-LS2-3) **PS3.D: Energy in Chemical Processes and Everyday Life** • The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary to MS-LS1-6)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system.			SP	SP		SP		
5	Producers	2	**Biomass and Producers** Students inquire into where food energy comes from. They process data from a hypothetical experiment to discover the conditions under which plants add biomass. They learn that photosynthesis is the process that produces new energy-rich biomass that can be used as food.	2	• Photosynthesis is the process by which energy-rich molecules (biomass that could become food) are made from water, carbon dioxide, and light. • Photosynthesis produces potential energy and aerobic cellular respiration transfers usable energy to organisms. • Producers increases the biomass of an ecosystem through photosynthesis.	**MS-LS1-6.** Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. **MS-LS1-7.** Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6) **LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** • The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3) **PS3.D: Energy in Chemical Processes and Everyday Life** • The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary to MS-LS1-6) • Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary to MS-LS1-7)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system. **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Modesl are limited in that they only represent certain aspects of the system under study.				SP		SP		SP

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5	**Producers**	3	**Ecoscenario Producers** Students investigate the producers in their ecoscenario and the biomes they represent. They outline the roles played by these producers and identify the ecosystem services they provide.	1	• Photosynthesis produces potential energy and aerobic cellular respiration transfers usable energy to organisms. • Ecosystems are defined by the producers present.	**MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6) **PS3.D: Energy in Chemical Processes and Everyday Life** • The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary to MS LS1-6) • Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary to MS-LS1-7)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system.								SP
5	**Producers**	4	**Energy Transfer from Food** Students use a model to investigate energy transfer in food. They burn snack foods to confirm that there is stored potential energy in food. They use the burning food to heat water in order to quantify food energy and calculate the calories. They learn the difference between small calories and kilocalories used to measure the energy in food. The discuss the limitations of the model.	4	• Food is energy-rich organic matter that organisms need to conduct their life processes. • Energy transferred from food is measured in kilocalories.	**MS-LS1-7.** Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6) • Within individual organisms, food moves through aseries of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. (MS-LS1-7) **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. (MS-LS2-3)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system. **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Models are limited in that they only represent certain aspects of the system under study. **Scale, proportion, and quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.		SP		SP	SP	SP		
6	**Following the Energy**	1	**Using Energy** Students think of the ways organisms use energy to do work and make things happen. They sort energy-use strips into categories: maintenance, growth/reproduction, waste, and movement. They learn that all organism functions require energy.	1	• Every activity undertaken by living organisms involves expenditure of energy.	**MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**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. (MS-LS2-3)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system. • Within a natural system, the transfer of energy drives the motion and/or cycling of matter.						SP		
6	**Following the Energy**	2	**Food-Chain Game** Students act out the roles in a food chain from Mono Lake. They develop a model for a sustainable food chain and consider the concept of bioaccumulation.	2	• Feeding relationships identify trophic roles: producers, consumers, and decomposers. • Biomass moves through an ecosystem from one trophic level to the next.	**MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**LS2.A: Interdependent Relationships in Ecosystems** • 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. (MS-LS2-1) • 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. (MS-LS2-2) **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. (MS-LS2-3)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system. • Within a natural system, the transfer of energy drives the motion and/or cycling of matter. **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.		SP		SP	SP	SP		

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6	**Following the Energy**	**3**	**Trophic Levels** Students learn a convention, called trophic levels, for describing the movement of food energy from organism to organism in a food web. They trace food through Mono Lake trophic levels, and learn about the efficiency of transfer across levels.	2	• Feeding relationships identify trophic roles: producers, consumers, and decomposers. • Biomass moves through an ecosystem from one trophic level to the next. • Only a small fraction of the biomass consumed at a level is used to produce growth (biomass) at that level; much of the biomass consumed is used for energy and much is lost to the environment.	**MS-LS1-6.** Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. **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. **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6) **LS2.A: Interdependent Relationships in Ecosystems** • 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. (MS-LS2-1) **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. (MS-LS2-3)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system. • Within a natural system, the transfer of energy drives the motion and/or cycling of matter. **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Modesl are limited in that they only represent certain aspects of the system under study.		**SP**		**SP**	**SP**			**SP**
6	**Following the Energy**	**4**	**Decomposers** Students investigate the role of decomposers in the ecosystem by adding a small amount of fruit to their minihabitat and monitoring changes to the fruit. They also look at the worm habitat established in Investigation 1 to see what effect decomposers have had in that ecosystem.	2	• Decomposers recycle food molecules to basic particles for use by organisms in the ecosystem.	**MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**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. (MS-LS2-3)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system. • Within a natural system, the transfer of energy drives the motion and/or cycling of matter. **Scale, proportion, and quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.		**SP**	**SP**			**SP**		
7	**Population Size**	**1**	**Reproductive Potential** After observing their milkweed-bug populations, students calculate the potential population growth at 2-month intervals for a year. They use a computer simulation to learn about population limiting factors, and analyze the results of a laboratory study to determine the limiting effects of three abiotic factors.	3	• Reproductive potential is the theoretical unlimited growth of a population over time. • A limiting factor is any biotic or abiotic component of the ecosystem that controls the size of a population.	**MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)	**Stability and Change** • Small changes in one part of a system might cause large changes in another part. **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Modesl are limited in that they only represent certain aspects of the system under study		**SP**			**SP**			
7	**Population Size**	**2**	**Limiting Factors** Students analyze the results of a 1-year study of two important Mono Lake populations, planktonic algae and brine shrimp. They compare populations raised under varying conditions of light and temperature to determine their rate of growth.	2	• A limiting factor is any biotic or abiotic component of the ecosystem that controls the size of a population. • Both lab experimentation and field observation contribute to the study of populations. • Biotic and abiotic factors can limit population size.	**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. **MS-LS2-2**. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. **MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	**LS2.A: Interdependent Relationships in Ecosystems** • 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. (MS-LS2-1) • Growth of organisms and population increases are limited by access to resources. (MS-LS2-1) • 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. (MS-LS2-2)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Stability and Change** • Small changes in one part of a system might cause large changes in another part. • Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms. .				**SP**	**SP**			**SP**
7	**Population Size**	**3**	**Population Dynamics** Students review field data acquired by ecologists working at Mono Lake. They determine that the changes in population sizes of the organisms can be attributed to both abiotic and biotic factors. They find that feeding relationships play an important role in population size. Students learn that population fluctuation is not necessarily an indication that an ecosystem is unhealthy or weak.	3	• A limiting factor is any biotic or abiotic component of the ecosystem that controls the size of a population. • Both lab experimentation and field observation contribute to the study of populations. • Biotic and abiotic factors can limit population size.	**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. **MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	**LS2.A: Interdependent Relationships in Ecosystems** • 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. (MS-LS2-1) • Growth of organisms and population increases are limited by access to resources. (MS-LS2-1) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Stability and Change** • Small changes in one part of a system might cause large changes in another part. • Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.				**SP**	**SP**	**SP**		**SP**

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8	**Human Impact**	1	**Biodiversity** Students learn about the concept of biodiversity and how it relates to the health of an ecosystem. They conduct a biodiversity study of their schoolyard to determine the health of the schoolyard ecosystem.	2	• Biodiversity is the variety of organisms in an ecosystem. • A biodiversity index is one measure of the ability of an ecosystem to deal with stress. In a sustainable ecosystem, the system is resilient to change.	**MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	**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. (MS-LS2-2) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Stability and Change** • Small changes in one part of a system might cause large changes in another part.			SP	SP	SP			SP
8	**Human Impact**	2	**Invasive Species** Students are introduced to the Hawaiian ecosystem and learn how humans have affected it for thousands of years. They consider the effect of introduced species on native species and identify invasive species.	2	• Introduced species compete with native species in an ecosystem. • If an introduced species has no predators in the new ecosystem, it can thrive and become invasive.	**MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. **MS-ESS3-4**. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.	**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. (MS-LS2-2) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) **ESS3.C: Human Impacts on Earth Systems** • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Stability and Change** • Small changes in one part of a system might cause large changes in another part. • Stability might be disturbed either by sudden events or gradual changes that accumulate over time. • Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.								SP
8	**Human Impact**	3	**Mono Lake Revisited** Students return to the study of Mono Lake. This time, they explore the positive and negative impacts of humans on this unique ecosystem, and consider the decisions that must be made to preserve ecosystem services.	3	• Humans affect ecosystems in both positive and negative ways.	**MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. **MS-ESS3-4**. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.	**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. (MS-LS2-2) **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Stability and Change** • Small changes in one part of a system might cause large changes in another part. • Stability might be disturbed either by sudden events or gradual changes that accumulate over time. • Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.								SP

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9	Ecoscenarios	1	**Human Involvement** Students work together to summarize the factors that define the ecosystem of each ecoscenario and how humans have affected the ecosystems. Students become familiar with a major problem facing the ecoscenario due to human impact, and explore how it was caused.	1	• Humans rely on ecosystems for ecosystem services (provisioning, regulating, cultural, and supporting services). • Ecosystems are dynamic systems of complex interactions. • Disruptions to abiotic factors in ecosystems can cause shifts in population and changes to ecosystem sustainability. • Changes in ecosystems can affect services essential to humans. • Solutions can be engineered to mitigate human impact.	**MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. **MS-ESS3-3**. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. **MS-ESS3-4**. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) **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. (MS-LS2-5) **ESS3.C: Human Impacts on Earth Systems** • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4 **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 to MS-LS2-5)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Stability and Change** • Small changes in one part of a system might cause large changes in another part. **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.	SP/EP			SP/EP		SP/EP	SP/EP	SP/EP
9	Ecoscenarios	2	**Evaluating Solutions** Each team examines how people have tried to solve their ecoscenario's problem by designing and engineering solutions that benefit the ecosystem while respecting humans' need for resources. Students consider aspects of both ecology and engineering to select a solution that helps balance the health of the ecosystem and the needs of humans that depend on the ecosystem.	3	• Humans rely on ecosystems for ecosystem services (provisioning, regulating, cultural, and supporting services). • Ecosystems are dynamic systems of complex interactions. • Disruptions to abiotic factors in ecosystems can cause shifts in population and changes to ecosystem sustainability. • Changes in ecosystems can affect services essential to humans. • Solutions can be engineered to mitigate human impact.	**MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. **MS-LS2-5.** Evaluate competing design solutions for maintaining biodiversity and ecosystem services. **MS-ESS3-3**. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. **MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) **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. (MS-LS2-5) **ESS3.C: Human Impacts on Earth Systems** • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4 **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 to MS-LS2-5)	**Patterns** • Patterns can be used to identify cause and effect relationships. **Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Stability and Change** • Small changes in one part of a system might cause large changes in another part. **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.	SP/EP		SP/EP	SP/EP		SP/EP	SP/EP	SP/EP
9	Ecoscenarios	3	**Presentations** Each team presents the information from Parts 1 and 2 in a final synthesis of course information. All team members should be able to present and answer all questions.	3	• Humans rely on ecosystems for ecosystem services (provisioning, regulating, cultural, and supporting services). • Ecosystems are dynamic systems of complex interactions. • Disruptions to abiotic factors in ecosystems can cause shifts in population and changes to ecosystem sustainability. • Changes in ecosystems can affect services essential to humans. • Solutions can be engineered to mitigate human impact	**MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. **MS-LS2-5.** Evaluate competing design solutions for maintaining biodiversity and ecosystem services. **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. **MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) **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. (MS-LS2-5) **ESS3.C: Human Impacts on Earth Systems** • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4) **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 to MS-LS2-5)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Stability and Change** • Small changes in one part of a system might cause large changes in another part. **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.	SP/EP		SP/EP	SP/EP		SP/EP	SP/EP	SP/EP