2017

Interdependent Relationships and Biodiversity

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Interdependent Relationships and Biodiversity
M.S. Degree Project
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This project is a composite of three Next Generation Science Standard(NGSS) aligned lessons aimed at middle school science students. Three E-Learning modules have been developed and uploaded to www.DiscoverEntomology.com to supplement the classroom lessons in a flipped model, whereby students complete the online lesson prior to attending class, application of concepts are explored through activity. Over the course of five to six class sessions and a field trip, students will build their understanding of interactions within ecosystems, the interdependent relationships that form between and among organisms, and the importance of biodiversity, using insects as model study subjects.

This project serves to show application of techniques, skills, and understanding gained from Insects as Educational Tools, Presentation Methods, Developing Distance Education, and Program Planning and in conjunction with the skills and processes I use daily as an Instructional Designer. The quality and quantity of available lesson plans aligned to the NGSS standards has been gaining impetus since its implementation in 2013. In reviewing articles, discussions occurring in online forums, and speaking informally with middle school science teachers, I wanted to design this micro-unit to be thorough, but user-friendly so that teachers, already pressed for time in trying to develop new material for class, can locate each lesson, a checklist for preparation, and the handouts for classroom activities.

Interdependent Relationships and Biodiversity

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Grade Level: Middle School 6-8
Number of Lessons: 3

Overview

This micro-unit explores the interactions between and among the biotic and abiotic components of ecosystems and how those interactions influence biodiversity. Three E-Learning modules serve to reinforce existing understanding and introduce new concepts so that, in the classroom, students can extend their knowledge by predicting patterns of predatory, competitive, and mutual relationships in a designed ecosystem. Through analyzing the short-term and long-term effects of disturbance on these ecosystems, students will come to recognize the importance of biodiversity in maintaining ecosystem stability. Culminating in a field day, students will record observations and articulate the value of maintaining local biodiversity using insects as keystone species and biological indicators of ecosystem health.

Lesson Progression

E-Learning Module Classroom Lesson Field Observation

Lesson	Mode	Skills	Assessment
Lesson 1 Ecosystems		**Restate** prior understanding of energy flow and cycling of matter that characterizes ecosystems and **identify** the biotic and abiotic components therein. **Explain** interdependent relationships and their influence on organism abundance and distribution.	**Categorize** biotic and abiotic factors influencing ecosystems. **Label** and **describe** interdependent relationships between organisms in an ecosystem.
		Describe the role of energy flow and resource availability on predicting patterns of interactions for different ecosystems.	**Create** a unique ecosystem poster illustrating energy flow and the interdependent relationships.
Lesson 2 Disturbance		**Cite** examples of, natural and anthropogenic disturbances on ecosystems.	**Classify** disturbances as either natural or anthropogenic.
		Analyze the effects of both natural and anthropogenic disturbance on designed ecosystems.	**Articulate** the role of ecosystem resistance and resilience in predicting short and long term effects of disturbances.
Lesson 3 Biodiversity		**Establish** the benefits of maintaining biodiversity in terms of economic, scientific, and cultural values. **Calculate** biodiversity using Simpson's Diversity Index.	**Present** a case for delegating conservation funding to 3 different ecosystems based on biodiversity calculations.
		Discover indirect methods of measuring biodiversity and describe the value of using insects as bioindicators of ecosystem health. **Identify** 3-5 orders that are either keystone species or bioindicators.	**Complete** insect field guide and **record** insects observed in the field. **Argue** the value of maintaining local biodiversity using observations of keystone and indicator species.

Next Generation Science Standards

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

- MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

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 nonliving factors. (MS-LS2-1)
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, and 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, 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 of integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

LS2.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)

Cross-Cutting Concepts

Patterns

- Patterns can be used to identify cause and effect relationships. (MS-LS2-2)

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)

Energy and Matter

- The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)

Stability and Change

- Small changes in one part of a system might cause large changes in another part. (MS-LS2-4),(MS-LS2-5)

LESSON 1
ECOSYSTEMS

LESSON 1: ECOSYSTEMS

Overview

In this flipped-classroom lesson, students will begin by revisiting concepts of energy flow , the cycling of matter in ecosystems, and the biotic and abiotic components that comprise ecosystems through an E-Learning module. In class, and as an extension of that knowledge, students will then be tasked to work in groups to create a unique abiotic environment into which organisms will be added using the design parameters described through a card activity. Upon completion of a second E-Learning Module focusing on interdependent relationships in nature, students will return to class to create and defend a poster illustrating species richness, species abundance, food webs, and any interdependent relationships that are at play in their designed ecosystem.

Duration: **2 – 3 class sessions** (50 minutes each)

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 nonliving factors. (MS-LS2-1)
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, and 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, both living and nonliving, are shared. (MS-LS2-2)

Cross-Cutting Concepts

Patterns

- Patterns can be used to identify cause and effect relationships. (MS-LS2-2)

Energy and Matter

- The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)

Vocabulary: **Ecosystem, Abiotic, Biotic, Limiting Factors, Predation, Competition, Mutualism**

Learning Objectives

- Categorize biotic and abiotic components comprising ecosystems.
- Label trophic levels and energy flow in an ecosystem.
- Describe the role of limiting factors in shaping adaptations of organisms.
- Define and explain predation, competition, mutualism, and mutual dependence.
- Articulate the role of energy flow and resource availability on predicting patterns of interactions in different ecosystems.

Assessment Opportunities

- Completion of homework in conjunction with E-Learning modules.
- Creation and presentation of unique ecosystem poster illustrating energy flow and interdependent relationships.

Background

As a living organism on this planet, there is no escaping interaction. Whether its among the biological community, or with the physical environment itself; interaction defines an ecosystem. As British ecologist Arthur Tansley (1935) said, “Though the organisms may claim our primary interest, when we are trying to think fundamentally we cannot separate them from their special environment, with which they form one physical system.” The nonliving, or abiotic, components of an ecosystem, namely temperature and precipitation and land surface, affect the attributes of the biological community and, reciprocally, the biological community can also influence the physical characteristics of the environment. For instance, the vegetation found in an ecosystem can act to block wind from an ecosystem and promote adaptation of seed dispersal that does not rely on wind for pollination (Primack 2002). Food webs serve as a model for understanding the transfer of energy between trophic levels and a basis for understanding relationships beyond predation among organisms.

The interdependent relationships between and among the living, or biotic, components of an ecosystem can characterized by whether they benefit, harm, or leave no impression on the organisms involved. Predation and parasitism are both positive-negative relationships, where either one individual or one population of individuals benefits at the detriment of the other individual or population. Predation is an effective mechanism for controlling population growth, resource depletion, and maintaining ecosystem stability. In some instances, predation can indirectly aid in population growth as the prey population is reduced below a point that competition will no longer occur and the population of prey then increases (Primack 2002).

When species share a common resource need, such as food, water, shelter, or mates and that resource becomes limited, competition will occur (Kormondy 1996). Competition is considered a negative-negative interaction whereby the individuals or populations involved suffer as a result of the relationship. Competition can be interspecific, between different species, or intraspecific, between the same species and the latter is often exemplified by mate competition. There are certain resources, such as watering holes or burrows, that may only occupy a small area within the ecosystem but can be crucial to the persistence of various species (Primack 2002). Additionally, positive-positive relationships also form as mutualism in ecosystems, whereby both organisms benefit as a result of the relationship. These mutually beneficial relationships can be a boon to the population size of both organisms, but in certain instances, the organisms become mutually dependent – no longer able to survive without one another.

In understanding the driving forces that shape these interdependent relationships, middle school students will be better able to predict these interactions across multiple natural and designed ecosystems. A stepping stone to eventually planning solutions for a breakdown in ecosystem stability or health, including those that occur in urban areas where ecosystem engineers are most certainly human.

Essential Questions

- How do the abiotic components of an ecosystem affect the organisms living there?
- How do predation and resource availability influence competition in an ecosystem?
- What are the ecosystem advantages of predation, competition, and mutualism and how do you predict these relationships across multiple ecosystems?
- When does mutualism turn into mutual dependence and when would this be a detriment to the individuals involved?

Materials and Planning

Materials Homework Classroom Questions Field

✓	Type	Description
		Obtain the following supplies for each group if your class size is divided into groups of $\leq$ 5. **Poster board, assorted color markers, assorted color construction paper, glue, scissors, envelopes.**
		Print **Handouts 1.1 – 1.3** to pass out as homework to each student prior to Lesson 1 Classroom Session. Includes areas to define, provide examples of, write a sentence using, and draw a picture representing their vocabulary words defined in Ecosystems E-Learning module.
		(OPTIONAL) Print **Handouts 1.4 – 1.10** to give students that may need more practice in comprehension of biotic and abiotic factors in ecosystems. Includes seven different biomes where students list biotic, abiotic, and any limiting factors.
		Prepare **essential questions** list that ask students to define abiotic parameters for their ecosystems. Sample questions include: How much precipitation does your ecosystem get annually? What is the substrate like? Rocky? Sandy? Are there any limiting factors?
		Print **Handouts 1.11 – 1.13** to pass out as homework at the end of class session 1 to be completed in conjunction with Interdependent Relationships E-Learning module.
		Print **Handouts 1.14 – 1.17** to allow arrangement into envelopes as described in the procedure.

Procedure

1. Provide handouts 1.1 through 1.3 to each student at the *end of a class period preceding this micro-unit* and describe to students the process for completing E-Learning Modules.

   A. Students will log on to **www.DiscoverEntomology.com** to complete short E-Learning modules that are interactive and act to aid in completion of handouts.

   B. See the **Appendix** to find out what needs to be clicked or completed in order to progress through all three E-Learning Modules as you complete them yourself as a way to better describe expectations to students.

2. Begin first class session with discussion of key points in the **Ecosystem E-Learning Module** which include distinction between ecosystem and habitat, labeling of trophic levels within ecosystems, and the categorization of abiotic and biotic factors.

3. Conduct brainstorm with entire class asking students to categorize the biotic and abiotic factors for at least three different ecosystems.

4. Divide classroom into random groups of $\leq$ 5 and use prepared **essential questions** to ask that students describe, in writing and subsequently presented at class end, the abiotic components of an imagined ecosystem. Things to be included in consideration are light, temperature, substrate, precipitation, and limiting factors.

5. Provide handouts 1.11 – 1.13 to each student at the end of the first classroom session to be completed in conjunction with the **Disturbance E-Learning Module.**

6. Provide groups with biotic factor envelopes either through rolling of dice, or drawing a group number from a container so that groups pick an envelop e themselves. Prepare envelopes using handouts 1.14 – 1.17 in the following way.

A. Cut out individual cards and include at least one of each trophic level in one envelope. For the remaining envelopes, randomize the placement of one or more of each producers, primary consumers, secondary consumers, tertiary consumers, and decomposers so that there is a range of diversity as each card represents a unique species.

B. See **Appendix** for Key to Using Biotic Factor Cards so that you can describe them to students, which includes drawing species on the card and understanding parameters for use.

7. Task students illustrate the biotic components on poster board using provided materials, taking into consideration the abiotic factors they previously defined and the parameters described on the cards. Students will then draw associated energy flow arrows to represent the food web, label the competitive relationships that might take place and for what reasons, and highlight any mutual relationships, if any.

8. See Lesson 2 to provide students with handouts 2.1 through 2.3 as homework to be completed in conjunction with **Disturbance E-Learning Module**.

Expansion

- Students can complete the E-Learning Modules in pairs using a computer lab rather than at home.

- Conduct a discussion about the relationships highlighted in the Interdependent Relationships E-Learning Module such as predation by mantises, parasitism of bees by varroa mites, competition between and among beetles and for what reason, mutualism between ants and plants, as well as mutual dependence in termites. This might inspire creation of insects within the ecosystem as both primary and secondary consumers.

ECOSYSTEM

Definition	Examples
Use it in a sentence	Draw a picture

BIOTIC FACTORS

Definition	Examples
Use it in a sentence	Draw a picture

ABIOTIC FACTORS

Definition	Examples
Use it in a sentence	Draw a picture

Provide examples of, abiotic factors found in desert ecosystems.

What are the biotic factors in a desert ecosystem – who are the producers, consumers, and decomposers?

Are there any limiting factors?

Provide examples of, abiotic factors found in tropical rainforest ecosystems.

What are the biotic factors in a tropical rainforest ecosystem – who are the producers, consumers, and decomposers?

Are there any limiting factors?

Provide examples of, abiotic factors found in grassland ecosystems.

What are the biotic factors in a grassland ecosystem – who are the producers, consumers, and decomposers?

Are there any limiting factors?

Provide examples of, abiotic factors found in mountain ecosystems.

What are the biotic factors in a mountain ecosystem – who are the producers, consumers, and decomposers?

Are there any limiting factors?

Provide examples of, abiotic factors found in ocean ecosystems.

What are the biotic factors in a ocean ecosystem – who are the producers, consumers, and decomposers?

Are there any limiting factors?

Provide examples of, abiotic factors found in wetland ecosystems.

What are the biotic factors in a wetland ecosystem – who are the producers, consumers, and decomposers?

Are there any limiting factors?

Provide examples of, abiotic factors found in arctic ecosystems.

What are the biotic factors in a arctic ecosystem – who are the producers, consumers, and decomposers?

Are there any limiting factors?

What is the difference between predation and parasitism?

In what ways do organisms avoid predation?

What are the benefits of predation in an ecosystem?

List resources that may cause competition:

Provide an example of both interspecific and intraspecific competition.

At what point will competition not occur in an ecosystem?

What are the benefits of this kind of relationship?

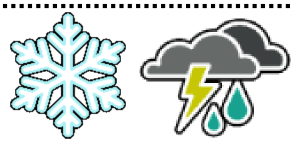
Provide an example of mutualism and describe the benefits.

Describe and provide an example of mutual dependence.

Biotic Factors Activity

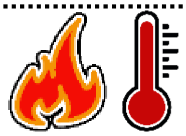
Handout 1.14

PRODUCER SM

Resistance 

Resilience 

PRODUCER SM

Resistance 

Resilience 

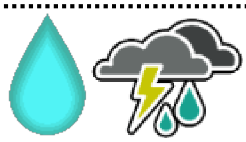
D

PRODUCER MD

Resistance 

Resilience 

PRODUCER LG

Resistance 

Resilience 

M

Biotic Factors Activity

Handout 1.15

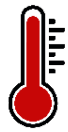
PRIMARY CONSUMER SM

Resistance 

Resilience 

SM SM SM SM SM MD LG

PRIMARY CONSUMER SM

Resistance 

Resilience 

SM SM SM MD LG

PRIMARY CONSUMER MD

Resistance 

D

Resilience 

SM SM SM SM SM SM SM MD LG

PRIMARY CONSUMER LG

Resistance 

Resilience 

SM SM SM SM SM SM SM MD MD MD LG

Biotic Factors Activity

SECONDARY CONSUMER SM

Resistance

Resilience

M

SM SM SM MD LG

SECONDARY CONSUMER MD

Resistance

Resilience

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SECONDARY CONSUMER MD

Resistance

Resilience

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SECONDARY CONSUMER LG

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Resilience

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TERTIARY CONSUMER MD

Resistance 

Resilience

SM SM SM SM MD MD LG

TERTIARY CONSUMER LG

Resistance 

Resilience

SM SM SM SM SM MD MD MD MD LG LG LG

DECOMPOSER SM

Resistance 

M

Resilience 

SM SM SM MD LG

DECOMPOSER SM

Resistance 

Resilience 

SM SM SM SM MD MD MD LG LG

LESSON 2
DISTURBANCE

LESSON 2: DISTURBANCE

Overview

Beginning with an E-learning module, students will be able to cite examples of natural and anthropogenic disturbances impacting ecosystems and describe the role of resistance and resilience in protecting ecosystem stability. To bolster their understanding, students will use the class lesson to analyze the impact of a random natural disturbance on their designed ecosystem based on resistance and resilience characteristics described by the card activity. To underscore concepts of stability and change, students will then design an insect that will be played against their classmate's ecosystems as an invasive species to which they will respond in describing the small and large scale changes this invasion causes.

Duration: **1 – 2 class sessions** (50 minutes each)

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. (MS-LS2-4)

Cross-Cutting Concepts

Patterns
- Patterns can be used to identify cause and effect relationships. (MS-LS2-2)

Cause and Effect
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)

Vocabulary: **Anthropogenic Disturbance, Resistance, Resilience, Invasive Species**

Learning Objectives

- Differentiate between and cite examples of natural and anthropogenic disturbances.
- Explain the roles of resistance and resilience in maintaining ecosystem stability in the face of disturbance.
- Predict the effects of natural and anthropogenic disturbances on a designed ecosystem.
- Describe how invasive species are introduced to ecosystems and summarize the impact of an invasive insect on a designed ecosystem.

Assessment Opportunities

- Completion of vocabulary worksheets in conjunction with E-Learning modules.
- Group presentation describing the effects of a natural disturbance and an invasive species on their designed ecosystem.

Background

Ecosystems in which biological processes are functioning normally are considered to be stable and the extent to which an ecosystem is free from human influence describes its ecosystem integrity, a concept critical to the conservation of biodiversity (Primack 2002). Populations of individuals can decrease to the point of local or global extinction when a disturbance causes a change in the physical environment and the composition and roles of one or more organisms. These changes can be small in one section of the ecosystem while also having far-reaching consequences for other parts.

Disturbances include natural phenomena such as drought, flooding, excessive wind, or insect swarms as well as human-caused, or anthropogenic, phenomena such as pollution, deforestation, fire, and invasive species. Some ecosystems have special features that allow them to survive the damaging effects of a disturbance which include resistance, which is the ability to maintain a stable state despite ongoing disturbance and resilience, which is the ability to quickly return the same state relatively quickly after a disturbance has caused change (Primack 2002). Because biologically diverse ecosystems tend to have a greater variety of organisms filling the same niches detrimental to ecosystem functioning, these systems are better able to recover from disturbance (Macdonald & Service 2007). However, even the most stable, resistant, or resilient ecosystems experience irreparable damage due to speed and severity of anthropogenic disturbances. For example, invasive species, in the absence of natural predators, often outcompete the native flora or fauna for resources and can permanently alter the stability of the ecosystem. Often these species are introduced deliberately or unknowingly by humans and are better suited to grow beyond their normal range and take advantage of areas already disturbed by human activity (Primack 2002). In analyzing the short-term and long-term effects of a natural and an anthropogenic disturbance on a designed ecosystem, students will deepen their understanding of cause and effect relationships and begin to connect their impact on ecosystems on a global scale.

In designing an insect invasive species, students will need to be aware of the general characteristics of insects. As a class of invertebrates, insects are the dominant group of animals on the planet and are estimated to have upwards of 30 million different species (Triplehorn & Johnson 2005). Their small size, and ability to fly allow them to proliferate even the smallest and strangest of habitats, save for the ocean and poles. Nearly everyone can tell you about their experience with at least one type of insect, love them or hate them. A key defining feature of insects is their three body segments; the head containing the eyes, antenna, and mouthparts; the thorax which is the center of locomotion containing the legs and wings, if present; and the abdomen which is simple in structure, but holds components of reproductive, digestive, and excretory systems (Triplehorn &Johnson 2005). Many insects are herbivores, eating the various parts of plants throughout different stages of their lives and some, voraciously so. At its simplest, insect metamorphosis can be categorized as either simple or complete where the immature stages of the former are similar to the adults while in the latter, the immature and adult stages are usually very different and occupy different habitats. Generation time in insects can vary widely between days, as is the case for the fruit fly, or even years as we see in the 17-year periodical cicadas. Because of their ubiquity, insects are ideal for studying local conservation and biodiversity issues that connect middle school students with nature and the concept that small changes, even from the smallest of animals, can effect change of great magnitude across an ecosystem.

Essential Questions

- What are some human-caused disturbances that threaten ecosystem stability and why is it more difficult for an ecosystem to withstand these types of disturbance?
- When might ecological resistance be an unfavorable characteristic in an ecosystem?
- What are the defining characteristics of invasive species?
- What are the short-term and long-term effects of disturbance on ecosystems that are less diverse than others? More diverse?

Materials and Planning

Materials Homework Classroom Questions Field

✔	Type	Description
		Obtain the following supplies for each group if your class size is divided into groups of ≤ 5. **Assorted pipe cleaners, construction paper, glue, scissors, assorted styrofoam shapes (spheres, squares, cones, cylinders), tape**
		Print **Handouts 2.1 – 2.3** to pass out as homework to each student prior to Lesson 2 Class Session. Includes areas to define, provide examples of, write a sentence using, and draw a picture representing their vocabulary words defined in Ecosystems E-Learning module.
		Print one **Handout 2.4** and cut out individual natural disturbance cards to be distributed according to procedures. Print enough of **Handout 2.5 – 2.6** for each group.

	Type	Description
		Prepare **essential questions list** that challenges students to evaluate whether certain ecosystems were better able to remain stable in the face of disturbance. Sample questions include: Which disturbance type caused more damage to your ecosystem? Were ecosystems with fewer unique species better or worse at withstanding disturbance than more diverse ecosystems?

Procedure

1. Provide handouts 1.1 through 1.3 to each student at the *end of the last Lesson 1 class session* to be completed in conjunction with the **Disturbance E-Learning Module**.
   A. Students will log on to **www.DiscoverEntomology.com** to complete short E-Learning modules that are interactive and act to aid in completion of handouts.
   B. See the **Appendix** to find out what needs to be clicked or completed in order to progress through all three E-Learning Modules as you complete them yourself as a way to better describe expectations to students.

2. Begin first class session with discussion of key points in the **Disturbance E-Learning Module** which include citing examples of natural and anthropogenic disturbance and the role of resistance and resilience in maintaining ecosystem stability.

3. Distribute Natural Disturbance cards in handout 2.4 by allowing the same groups from Lesson 1 to choose a card from a box – the way in which you decide to allow students to choose can be randomized through use of dice or can be based on participation in the discussion. First group to answer questions will have first choice and so on.

4. After students draw the natural disturbance card, provide them with handout 2.5 to complete as a group and describe the key to the Natural Disturbance card found in the **Appendix**.

5. Lead discussion that asks students to summarize the effect of the natural disturbance on their ecosystem. Using the swarms natural disturbance card as a way to segue to the topic of insects generally, ask students to describe insects with which they are familiar, what types of wings they have, what they eat, and general insect anatomy so that they are prepared to build an insect.

6. Groups will then construct an insect including three body parts, wings, six legs, eyes, and once finished, surprise them by indicating that the insects they just created will now become an introduced invasive species in a neighboring ecosystem (exchanged either to the left or right, or another similar method).

7. Provide handout 2.6 to be completed by each group in response to the invasive insect and then allow each group to present the effects of the invasive species on their ecosystem and compare it to the effects of the natural disturbance.

8. Using the prepared list of essential questions, challenge students to evaluate which ecosystems were better able to withstand disturbance guiding them to the idea of biodiversity.

9. See Lesson 3 to provide students with handout 3.1 as homework to be completed through their own online research.

Expansion

- Instead of creating craft insects, students can generate a bug using this **Build a Bug** generator.
- Include independent research that identifies a local invasive insect and describe what makes it so successful in outcompeting local species and possible solutions for mitigation.

ANTHROPOGENIC DISTURBANCE

Definition	Examples
Use it in a sentence	Draw a picture

RESISTANCE

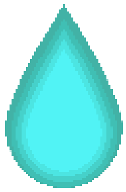
Definition	Examples
Use it in a sentence	Draw a picture

RESILIENCE

Definition	Examples
Use it in a sentence	Draw a picture

Natural Disturbance Activity — Handout 2.4

Flood

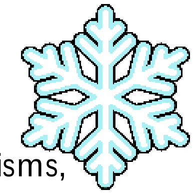


There is a sudden influx of rain in your ecosystem. No worries, your resistant Organisms will be OK.

Resilient organisms will lose **25%** of their population initially, but will return to their original state within **six months**.

Organisms with neither resistance or resilience will lose **10%** of their population, and take **three years** to return to a stable state.

freeze

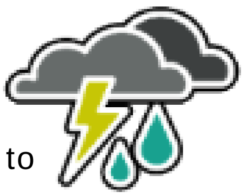


An unexpected cold front has hit your ecosystem. For resistant organisms, this is no problem at all.

Resilient organisms will lose **25%** of their population initially, but will return to their original state within **one year**.

Organisms with neither resistance or resilience will lose **30%** of their population, and take **four years** to return to a stable state.

storm



Watch out for tornado!
Resistant organisms know where to seek cover and survive.

Resilient organisms will only lose **10%** of their population initially, but it will take **five years** to return to their original state.

Organisms with neither resistance or resilience will lose **40%** of their population, and take **three years** to return to a stable state.

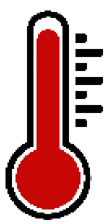
fire

Lightning strike caused a fire.
Good thing your resistant organisms have adaptations to protect them.

Resilient organisms will lose **30%** of their population initially, but will return to their original state within **five years.**

Organisms with neither resistance or resilience will lose **50%** of their population, and take **seven years** to return to a stable state.

drought

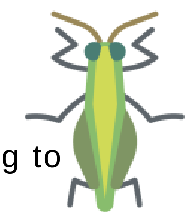


It's been uncharacteristically dry in your ecosystem. Resistant organisms know how to stay hydrated.

Resilient organisms will lose **25%** of their population initially, but it will only take **two years** to return to their original state.

Organisms with neither resistance or resilience will lose **60%** of their population, and take **five years** to return to a stable state.

swarm



Locusts everywhere!
Good thing these bugs want nothing to do with resistant organisms.

Resilient organisms will lose **40%** of their population initially, but will return to their original state within **one year.**

Only Producers with neither resistance or resilience will lose **75%** of their population and will regain stability in **two years.**

Natural Disturbance Activity Handout 2.5

Describe the natural disturbance to your ecosystem.

How does this disturbance affect each of your trophic levels directly? Describe consequences to each organism in your ecosystem citing where resistance and resilience may be at play.

What indirect effects will your ecosystem experience over the short-term and long-term? In other words, if only your producers were directly affected, how will a loss to their populations affect other organisms that may rely on them for energy and how will relationships change across the ecosystem.

Invasive Species Activity — Handout 2.4

Describe ways in which an insect can be introduced to a non-native ecosystem.

What resources will this invasive species deplete (which organisms will it use to obtain energy?)

Which organisms will be in competition with the invasive insect?

What are the indirect effects on your ecosystem as a result of this new invader?

LESSON 3
BIODIVERSITY

LESSON 3: BIODIVERSITY

Overview

After participating in discussion, students will be able to cite three benefits of maintaining biodiversity and identify the difference between species richness, species abundance, and species evenness. Next, students will work in pairs to calculate the Simpson's Biodiversity Index of three different locations where insects were surveyed and support their delegation of imagined Conservation Funds to go toward maintaining biodiversity at these three sites. Before participating in field observation either on campus or at a local nature center, students will complete a fillable insect field guide identifying keystone and biological indicator species. While in the field, students will be tasked to identify and record insect observations and subsequently infer the ecosystem biodiversity and health of the site observed.

Duration: **1 class session** (50 minutes) **and 1 Field Observation** (50 minutes or full day)

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 of integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

LS2.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)

Cross-Cutting Concepts

Patterns

- Patterns can be used to identify cause and effect relationships. (MS-LS2-2)

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. (MS-LS2-4),(MS-LS2-5)

Vocabulary: **Biodiversity, Species Abundance, Species Richness, Keystone Species, Bioindicator**

Learning Objectives

- Explain three benefits of maintaining biodiversity and support them in the context of ecological, scientific, and cultural values.
- Calculate the Simpson's Biodiversity Index given a set of observation data.
- Recognize the difference between species richness, species abundance, species evenness, and species distinctiveness.
- Describe limitations to measuring biodiversity and the role of keystone species and biological indicators in predicting ecosystem diversity and health.

Assessment Opportunities

- Completion of vocabulary worksheets in conjunction with E-Learning modules.
- Calculation of Simpson's Biodiversity Index for three sites.
- Completion of fillable insect field guide and associated questions.
- Presentation of an argument in support of the conservation of local insect biodiversity.

Background

Biodiversity is the degree of variability of organisms which includes genetic diversity, diversity within species, diversity between species, and the diversity of ecosystems (Gibbs et al. 2008). In other words, biodiversity accounts for the number and abundance of living things in a given area. The study of biodiversity is not necessarily new, however, with growing concern that the variability of life is being eroded by human activity, understanding and valuing biodiversity has become more urgent (Macdonald & Service 2007). Loss of species can have varying consequences depending on their niche within the ecosystem. Often, support for maintaining biodiversity is bolstered by evidence of greater disease resistance and nutrient cycling as well as improved ecosystem services like pollination, water filtration, decomposition, and pollution breakdown. To garner support of programs designed to protect biodiversity, one must not only consider these indirect use values but also consider the direct use values of timber or fuel or food, option values including potential medicines and genetic resources, and existence values such as maintaining the culture of the local people (Primack 2002).

Measuring biodiversity is overwhelming as it can be nearly, if not completely, impossible to conduct a total inventory of every organism in a given area. Ecologists turn to indirect methods of measuring biodiversity through sampling methods like canopy fogging, transect sampling, netting, and observation or collection of focal species. Once a sample has been collected, models for evaluating biological diversity like the Simpson's Diversity Index, allow ecologists to prioritize conservation efforts based on species richness, abundance, evenness, and distinctiveness. Keystone species are one focal species that affects the organization of the ecosystem to a far greater degree than other species in that same system. The loss of a keystone species, which can be found at any trophic level, leads to loss of numerous other species as a result and can severely damage ecosystem stability (Primack 2002). Indicator species, on the other hand, are species associated with an endangered or unique biological community or process and in managing their populations, Primack (2002) suggests it will "protect the range of species and ecosystem processes with the same distribution."

Insects are often used as surrogates for water quality, air quality, and restoration of ecosystems. Tiger beetles, for example, are great indicators due to their stable taxonomy, worldwide distribution, presence in a wide variety of habitats, and specialization of individual species (Speight et al. 2008). Speight, Hunter, and Watt (2008) also indicate that ground beetles in the family Carabidae are a key group in the "evaluation of novel agricultural practices such as genetically modified crops." Accordingly, the prolific nature of insects make them ideal for middle for middle school students to observe and use to argue the value of biodiversity right in their own backyard.

Essential Questions

- What makes some ecosystems more diverse than others? Where do you think the Earth's most diverse ecosystems are located?
- What are some of the issues ecologists face when trying to measure biodiversity?
- Why are keystone and biological indicator species used to estimate ecosystem stability and health? And can they be found at all trophic levels?
- Why is it important to consider ecological, scientific, and cultural values when considering solutions for maintaining biodiversity?

Materials and Planning

Materials Homework Classroom Questions Field

✔	Type	Description
		Print **Handout 3.1** to be passed out to each student as homework prior to Lesson 3 Class Session. Includes questions that challenge students to identify reasons to maintain biodiversity in an ecosystem and includes introduction to valuation of biodiversity.
		Print **Handouts 3.2 – 3.5** to be given to students to complete in pairs. Instructions are provided and students will need to calculate Simpson's Diversity Index for three different sites where insects were collected.

	Type	Description
		Prepare **essential questions list** that challenges students to evaluate biodiversity survey constraints and the reason for using keystone and indicator species as methods for estimating ecosystem stability and health. Sample questions include: Is a total inventory of every species realistic? Why not? What are other methods used to measure diversity indirectly? Any guess as to what a keystone or indicator species is?
		Print **Handouts 3.6 – 3.10** to give to students to complete through individual internet research on the identifying qualities of these five insect orders, butterflies and moths (Lepidoptera), ants and bees and wasps (Hymenoptera), beetles (Coleoptera), true bugs (Hemiptera), and dragonflies and damselflies (Odonata).
		Determine and schedule location of field observations. If on campus, familiarize yourself with areas of high insect traffic like under logs, near flowering plants, trees, or even garbage. If through a local nature center, there will likely be a list or naturalist available to describe to your class the different insects they can expect to see and where to find them.

Procedure

1. Provide handout 3.1 to each student at the *end of Lesson 2* as individual research homework on the topic of biodiversity.

    A. A good source to begin is **GreenFacts,** which also provides links to additional resources.

2. Begin first class session with discussion about the answers to their homework to ensure students are all on the same page with economic, scientific, and cultural value of biodiversity and the Simpson's Biodiversity Index formula used in the activity. (This is **not** the Reciprocal Index).

3. Groups students into pairs and provide handouts 3.2 – 3.5 to each team. Students will then fill in the information using the matrices of insects collected at three hypothetical sites to which they can delegate conservation funds based on their calculations.

4. Lead discussion asking what the Simpson's Diversity Index is for all three sites and ensure that students all arrive at the same numbers, handle any misconceptions to using the formula and then ask for volunteers to share how they delegated funds and why.

    A. Be sure to guide students in using terms like species richness, species abundance, species evenness, and species distinctiveness when describing the sites.

5. Discuss prepared essential questions regarding constraints to monitoring biodiversity and the role of keystone and indicator species to evaluating ecosystem stability and health.

6. Provide handouts 3.6 – 3.10 to each student at the end of class to be completed as homework. Recommended sites for completing the fillable field guides include **www.BugGuide.net** and **http://entomology.unl.edu/scilit/insects-classroom-web-resources**.

7. Meet for field observations and task students to use their fillable field guides and make notes on observations of insects either on campus or at a local nature center. Before the end of the field study, ask students to argue for maintaining biodiversity at the site based on their observations and understanding of biodiversity, keystone species, indicator species, and

Expansion

- Students can complete fillable field guide using a class session and in a computer lab.
- Create an observation table students can use while conducting field observations.

Define Biodiversity.

What are the benefits of maintaining biodiversity?

What are three ways to categorize the value of biodiversity?

What are the differences between species richness, species abundance, species evenness, and species distinctiveness?

What is Simpson's Biodiversity Index and why is it used?

Instructions

You are in charge of delegating conservation funds that will go toward protecting biodiversity between three different sites. These sites have been surveyed for insect biodiversity as indicators of overall ecosystem diversity.

Your job is to calculate the diversity at all sites and then determine where the funds should go based on those calculations and what you know about factors affecting biodiversity.

You will be asked to defend your delegation of funds to the class.

Available Funding

International Union for the Conservation of Nature and Natural Resources (IUCN)

- $10,000 to be directed toward only one site of either high biodiversity or where there is an endemic insect species.

Society for Conservation Biology

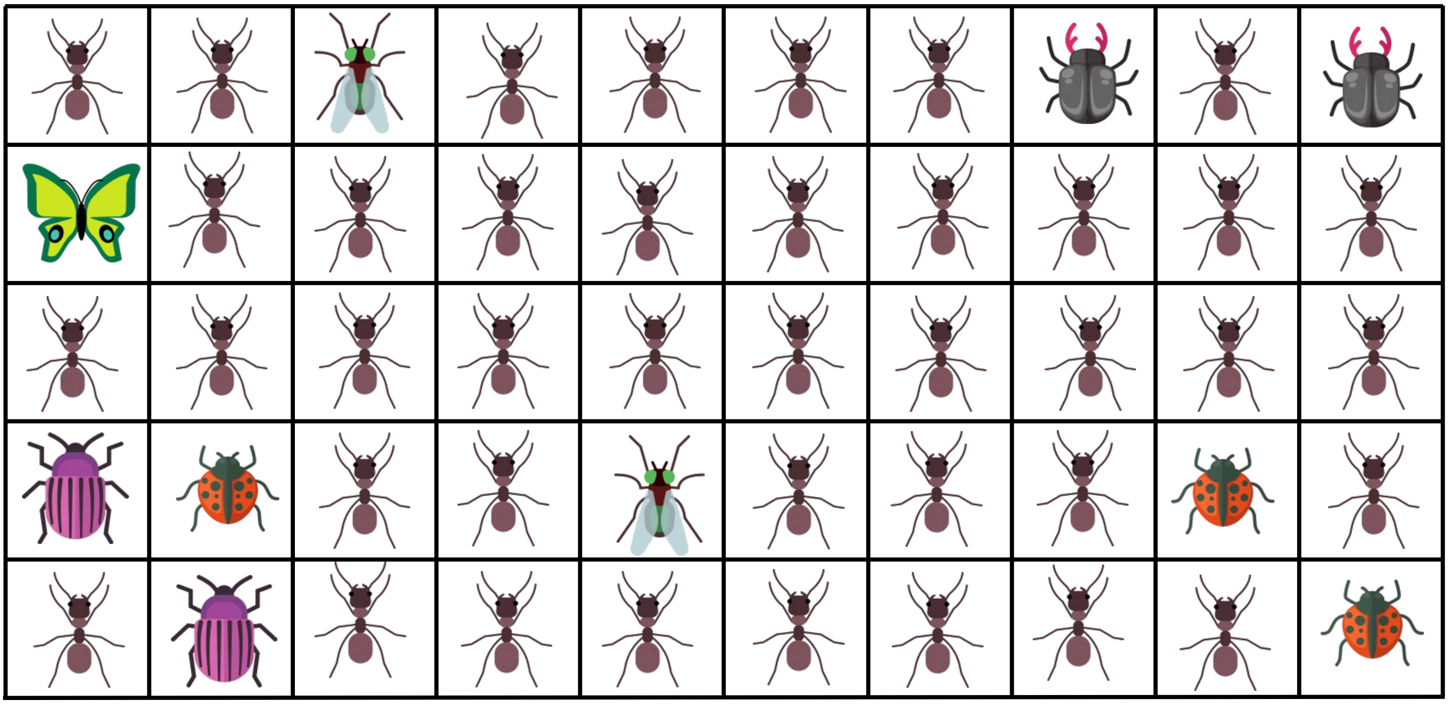
- $5,000 that can be split in any way between any number of sites.

World Wildlife Fund (WWF)

- $15,000 split between two sites, but at least $5,000 must go to a site with high biodiversity.

Adapted from Problem-Solving in Conservation Biology and Wildlife Management by Gibbs, Hunter, and Sterling.

Ecosystem #1



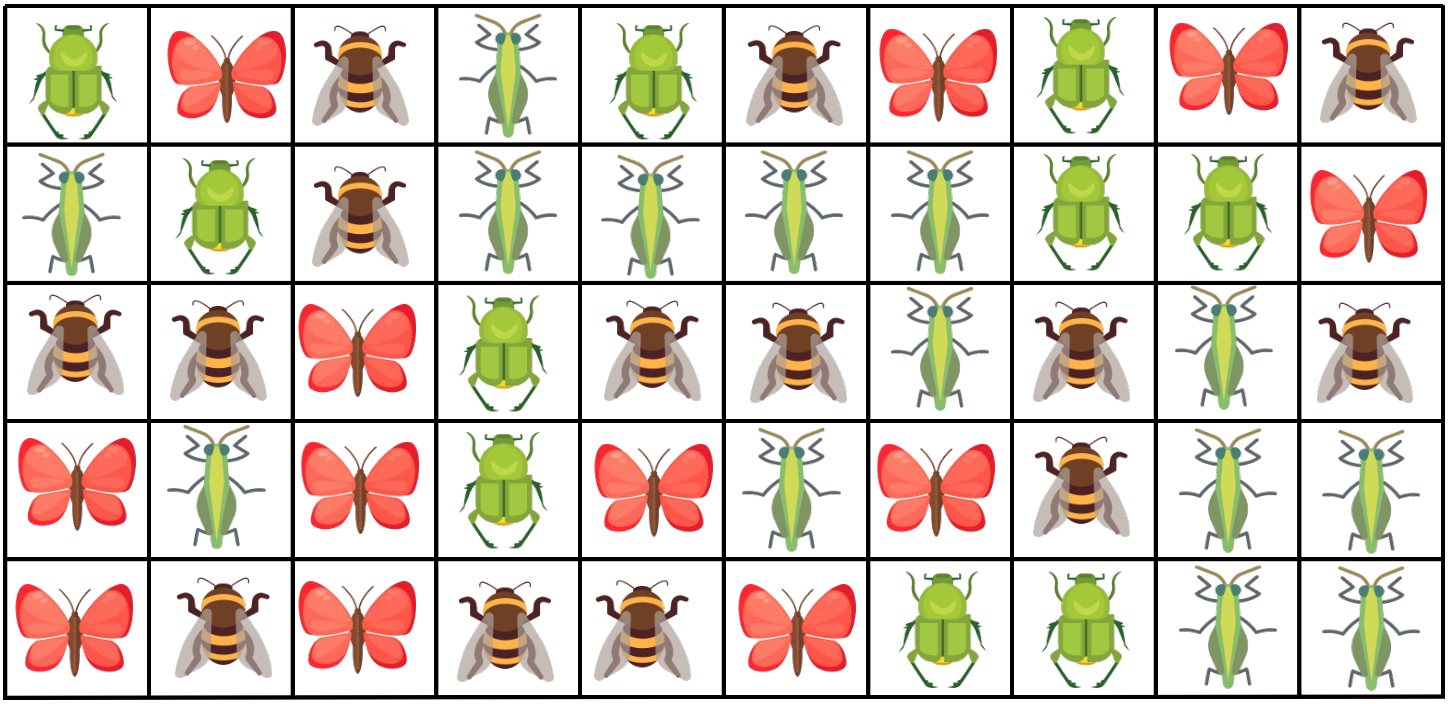
Species Richness : ______________

Species	n	n-1	n (n-1)
Total			

D =

Adapted from Problem-Solving in Conservation Biology and Wildlife Management by Gibbs, Hunter, and Sterling.

Ecosystem #2

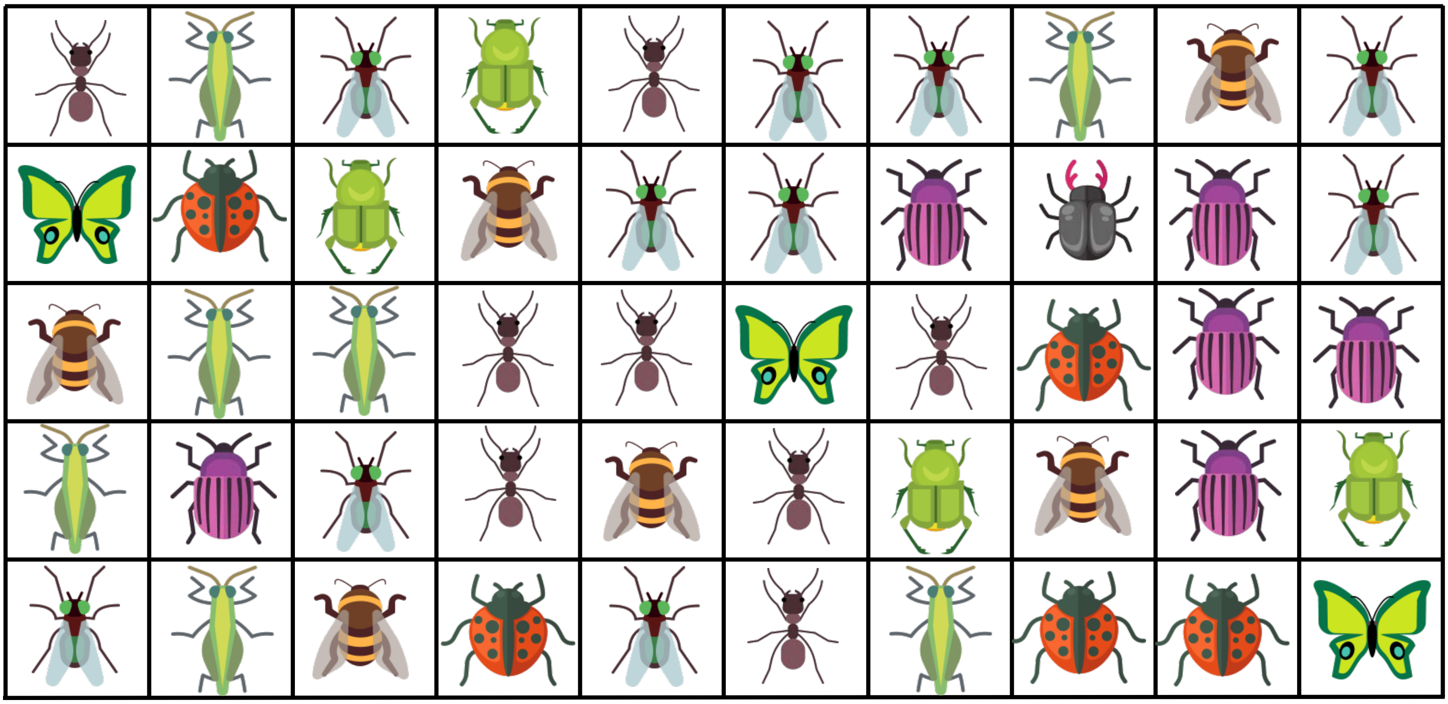


Species Richness : ______________

Species	n	n-1	n (n-1)
Total			

D =

Ecosystem #3



Species Richness : _______________

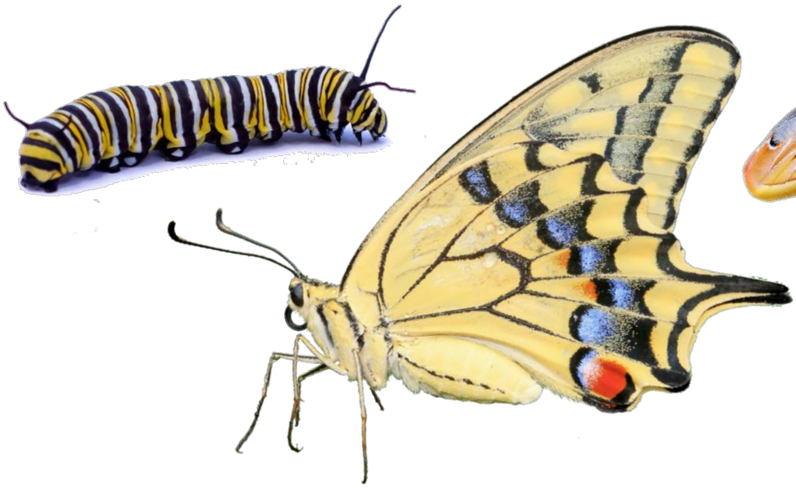
Species	n	n-1	n (n-1)
Total			

D =

Adapted from Problem-Solving in Conservation Biology and Wildlife Management by Gibbs, Hunter, and Sterling.

Butterflies and Moths

Order ______________________________



Life Cycle:

Diet:

How would you identify this order of insects in the field?

Describe an example of these insects being either keystone or indicator species.

What ecosystem services are provided by this group?

Bees, Ants, and Wasps

Order ________________________________

Life Cycle:

Diet:

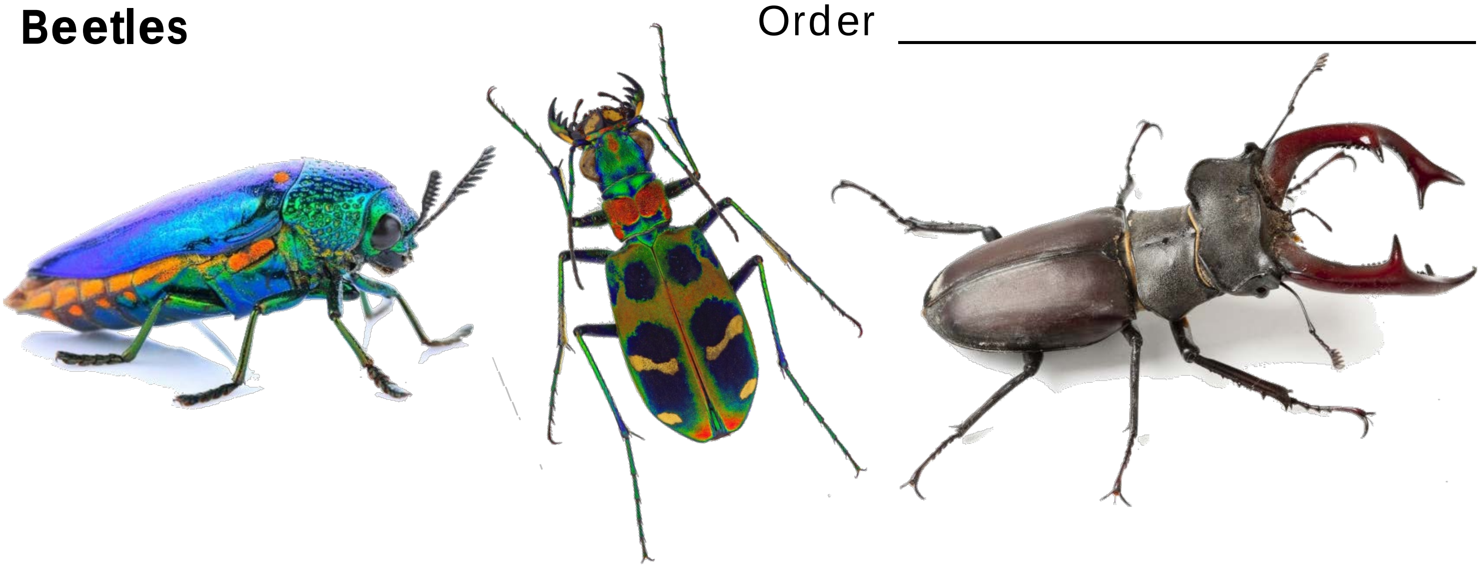
How would you identify this order of insects in the field?

Describe an example of these insects being either keystone or indicator species.

What ecosystem services are provided by this group?

Beetles

Order ______________________________



Life Cycle:

Diet:

How would you identify this order of insects in the field?

Describe an example of these insects being either keystone or indicator species.

What ecosystem services are provided by this group?

True Bugs

Order ____________________________

Life Cycle:

Diet:

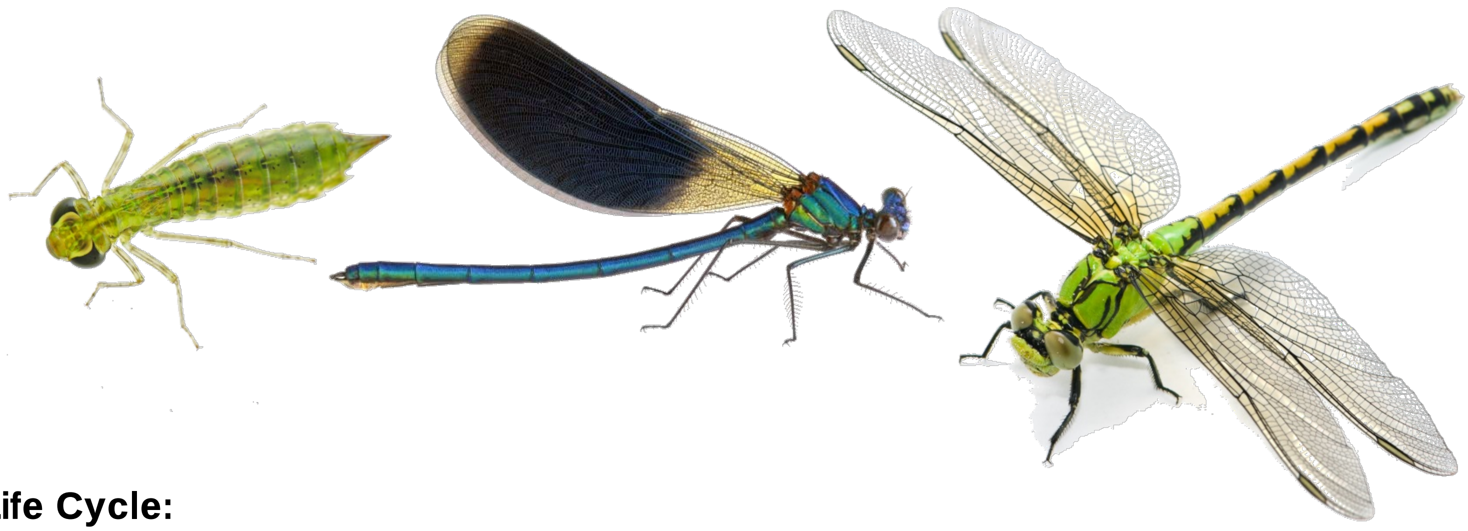
How would you identify this order of insects in the field?

Describe an example of these insects being either keystone or indicator species.

What ecosystem services are provided by this group?

Dragonflies & Damselflies

Order ______________________________



Life Cycle:

Diet:

How would you identify this order of insects in the field?

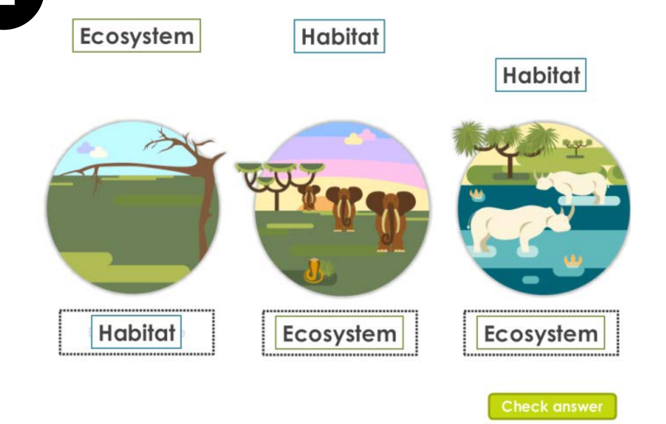
Describe an example of these insects being either keystone or indicator species.

What ecosystem services are provided by this group?

Appendix

Ecosystems E-Learning Guide

1

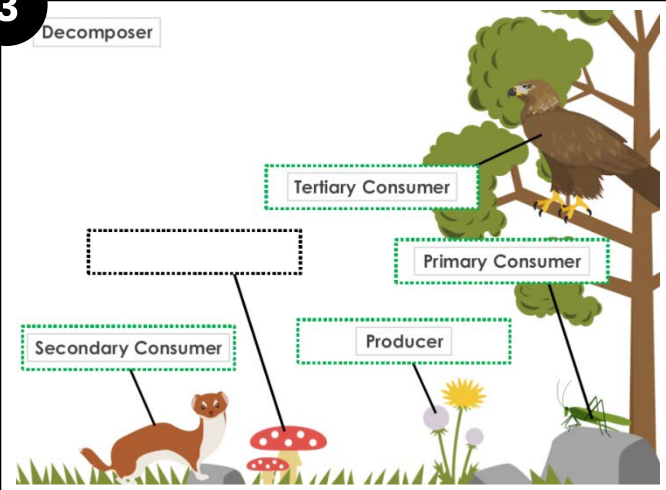


Drag the labels at the top into the drop targets under the images. Students will need to label Habitat, Ecosystem, Ecosystem from left to right and then click the check answer button to progress.

2

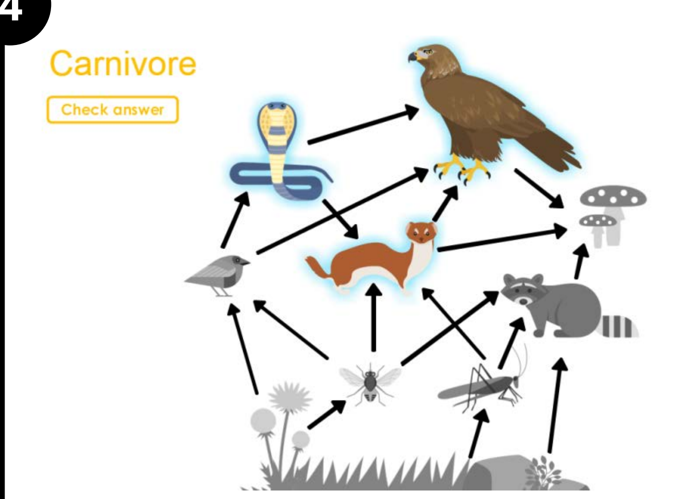
Click on each of the images to reveal a www.fuseschool.org video describing the hydrological cycle, nitrogen cycle, and energy flow in ecosystems. Once all three are visited, students will be able to progress.

3



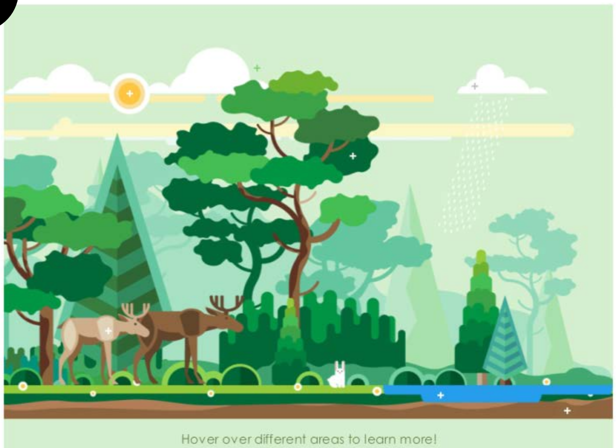
Once students label the trophic levels for this scene, they will progress to the next one.

4



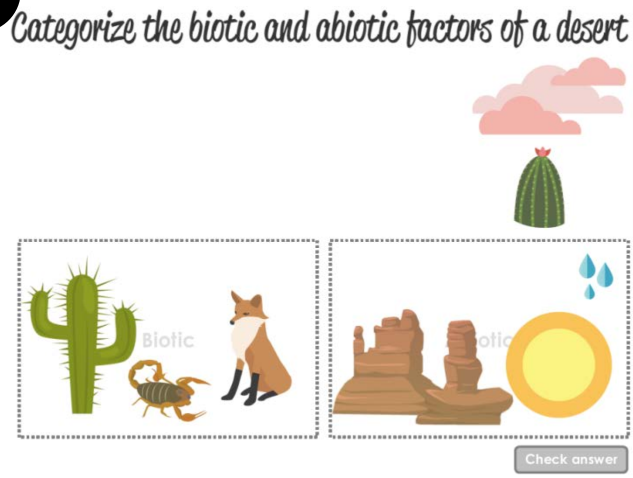
Type Carnivore in the space provided to move on, students will have three attempts before automatically being jumped ahead.

5



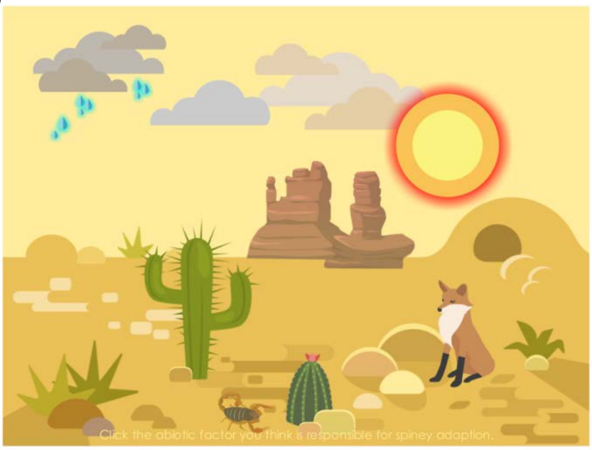
There are small + signs in this scene that students will hover over – once they have all been visited, the next button appears.

6



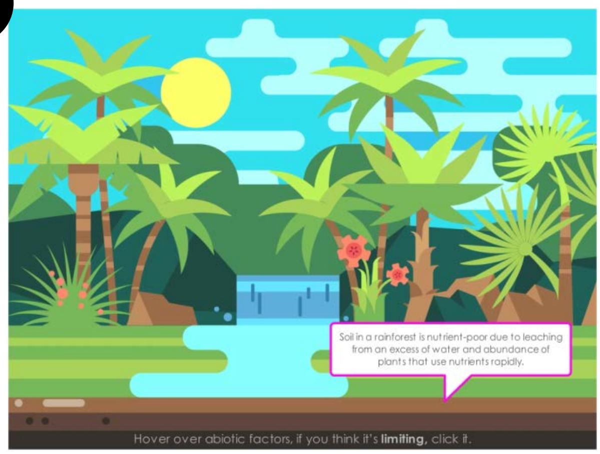
Students will need to drag the images at the top to the appropriate boxes before moving forward.

7



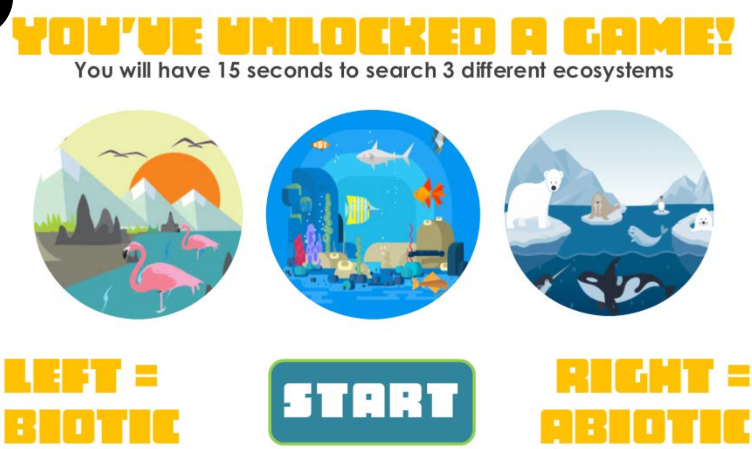
Click on the rain drops or sun to advance to the next scene that defines limiting factors.

8



Students will need to hover over sections of this scene and then click on soil and sun as limiting factors before being able to advance.

9



This game concludes the course and students will have a chance to search 3 ecosystems and correctly identify biotic and abiotic factors.

Interdependent Relationships E-Learning Guide

1

Click on predatory to watch the video to learn more.

2

Students can optionally click on the video link on the varroa video or click Parasitoids text to continue through course.

3

Students will move forward after clicking on the far left photo

4

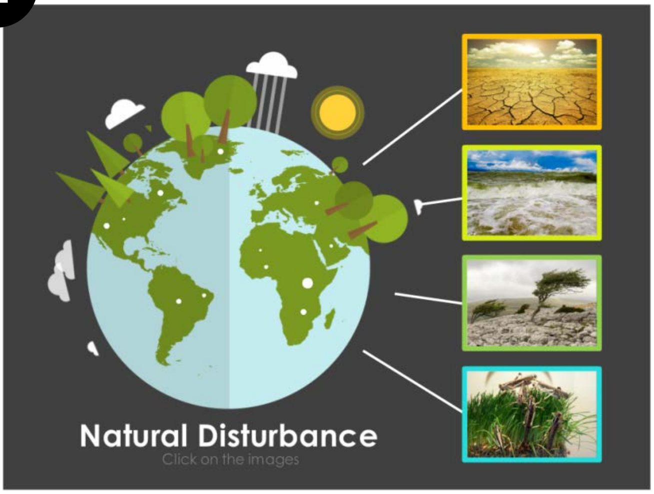
Student s will need to click on the word Competition to progress from here.

5

Click on Mutual to move forward to watch one more video, but no more interaction required.

Disturbance E-Learning Guide

1

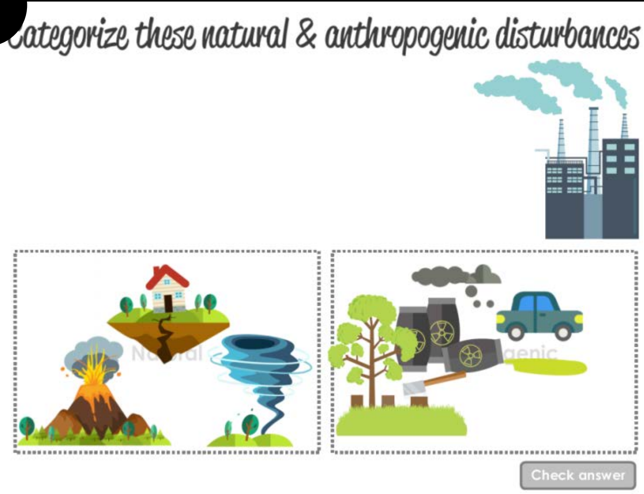


Click on the four images to the right to uncover short videos before the next button appears.

2

After a description and examples of anthropogenic disturbance, students will see the next button appear automatically.

3



Students will drag the images into the appropriate boxes before being able to move forward.

4

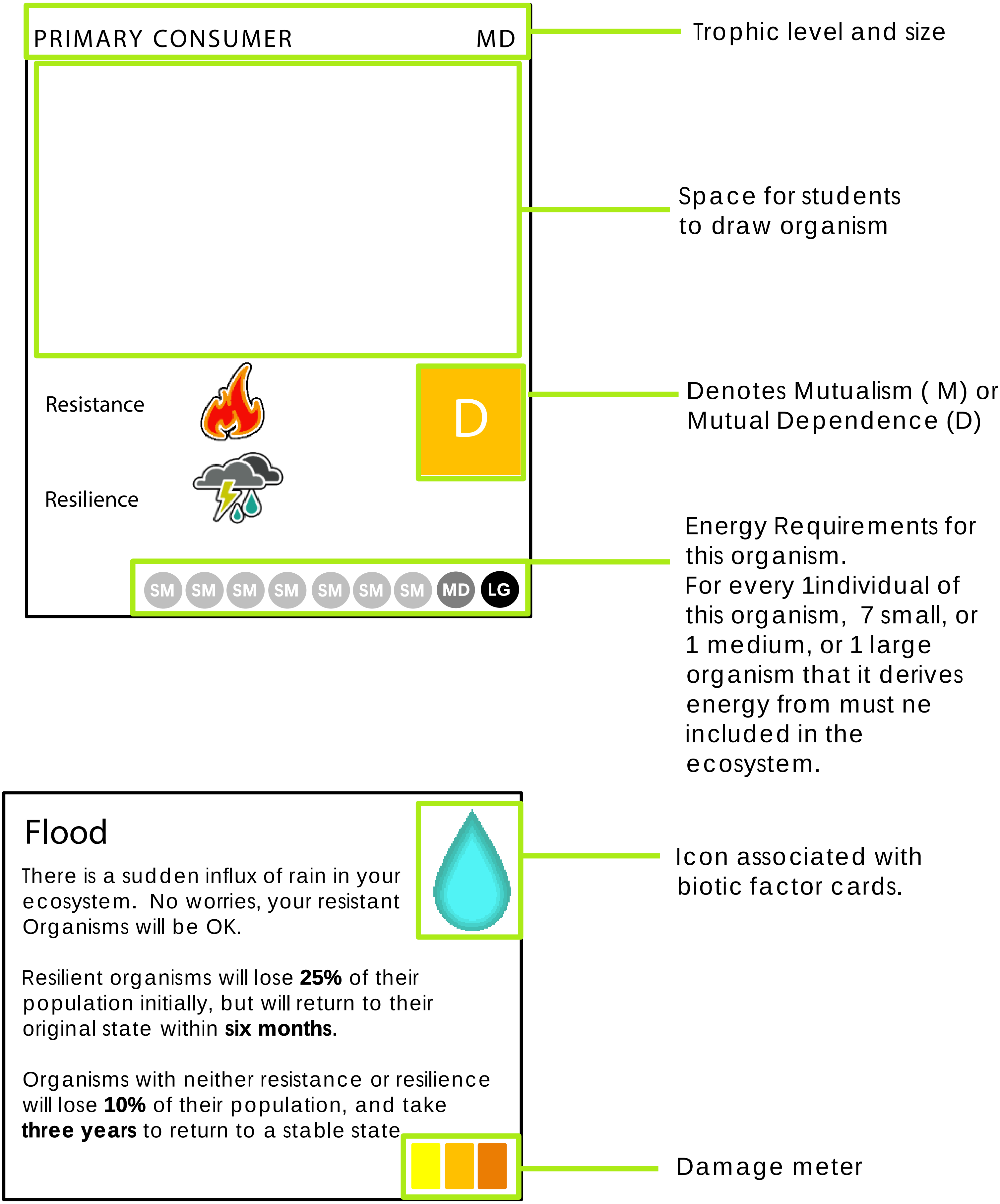
Click on each key word, Resistance and Resilience to uncover definitions and once both are visited, students will reach the conclusion slide.

5

This is the end of the course, with a brief reiteration of different types of disturbances and how resilience and resistance serve to protect ecosystems.

Key to Biotic Factor and Natural Disturbance Cards

Each card represents one species.



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