Incorporating the Standards into Ecology and Environmental Science Classrooms

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NGSS Innovations

Learning is three-dimensional:

- **Disciplinary Core Ideas (DCI)**
- **Science and Engineering Practices (SEP)**
- **Crosscutting Concepts (CCC)**

Students engage in explaining phenomena and designing solutions.

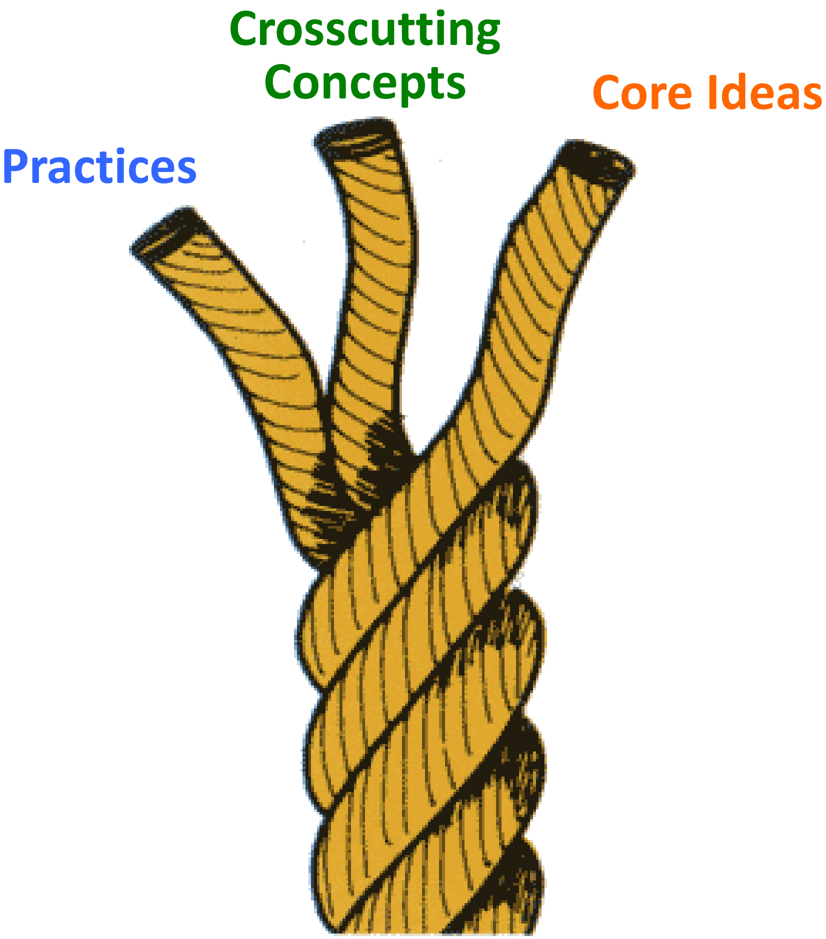
Engineering design and the nature of science are included as SEPs and CCCs.

SEPs, DCIs, and CCCs build coherent learning progressions from K–12.

The NGSS connect to Common Core for English Language Arts (ELA) and Mathematics.

Assessments should align with the 3D goals exemplified by the Performance Expectations (PE).

The **practices (SEP)** are the processes scientists and engineers use to build and test the **disciplinary core ideas (DCI)** that explain the natural and designed world. **Crosscutting concepts (CCC)** are big ideas that help to integrate ideas across topics and science disciplines.



Agenda

10:45 Introductions

Nagle: Moving Next Generation Science Standards into Practice: A Middle School Ecology Unit and Teacher Professional Development Model

Puttick: Environmental Science and Biocomplexity: A case-based approach to learning about complex systems

11:20 Small group discussion

11:45 Report back, group discussion

11:55 Wrap up

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Moving Next Generation Science Standards into Practice: A Middle School Ecology Unit and Teacher Professional Development Model

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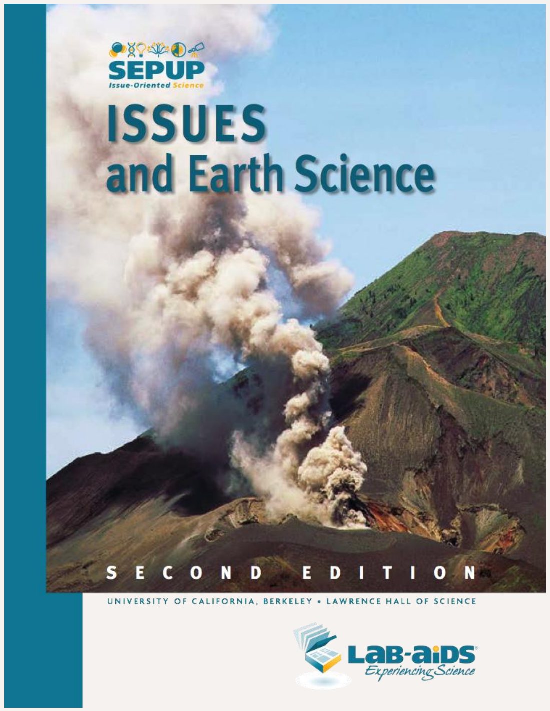
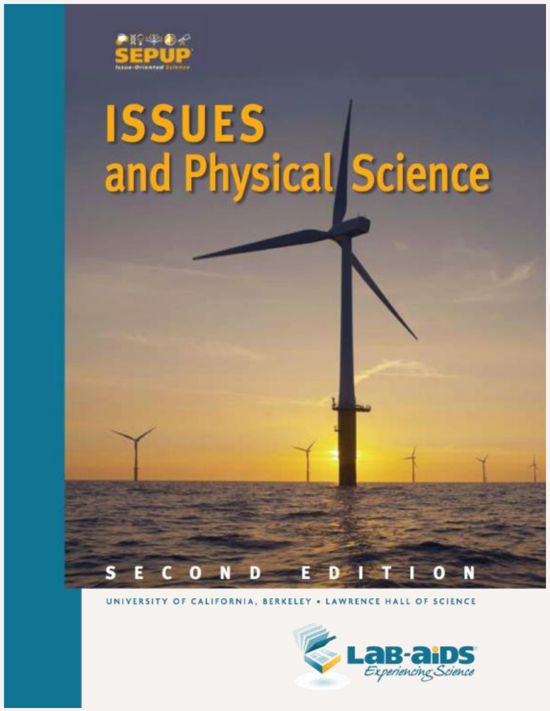
AMERICAN MUSEUM OF NATURAL HISTORY

NSF

SEPUP Middle School Sequence





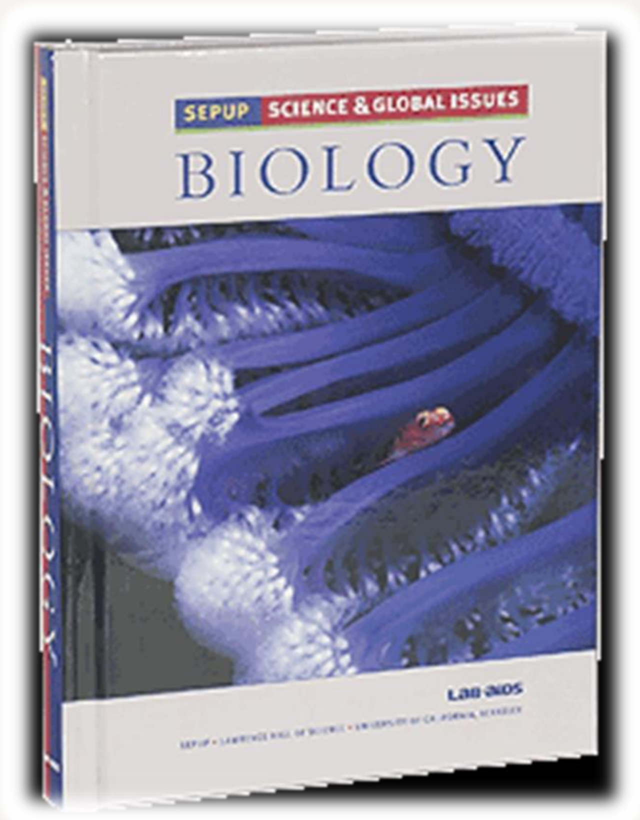
Examples of issues

IAES: Handling nuclear waste, crewed vs uncrewed space exploration

IALS: Studying people, preventing spread of invasive species, bioengineering

IAPS: Treating chemical waste, sources and efficient use of energy

For High School: Science and Global Issues Biology



Units

Sustainability

Ecology: Living on Earth

Cell Biology: World Health

Genetics: Feeding the World

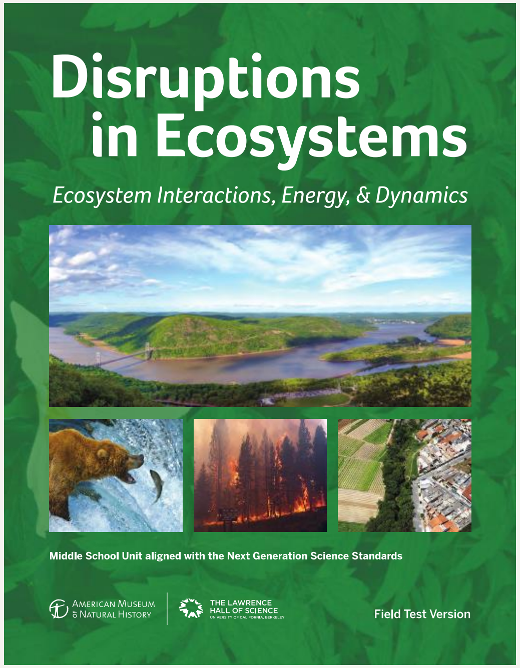
Evolution: Maintaining Diversity

Moving Next Generation Science Standards into Practice

- Four Partners:
  - Lead and Professional Development: American Museum of Natural History (AMNH)
  - Curriculum: Lawrence Hall of Science
  - Research: University of Connecticut
  - Evaluation: WestEd
- Four-year project began September 2014
- First 18 months has focused on developing and testing a curriculum unit

Disruptions in Ecosystems—Ecosystem Interactions, Energy, and Dynamics

- MS Ecology NGSS
- Backward design approach
  - Define learning goals
  - Draft assessments
  - Develop learning activities
- Now being field-tested by 25 NYC teachers
- Hope to include some CA sites in future testing



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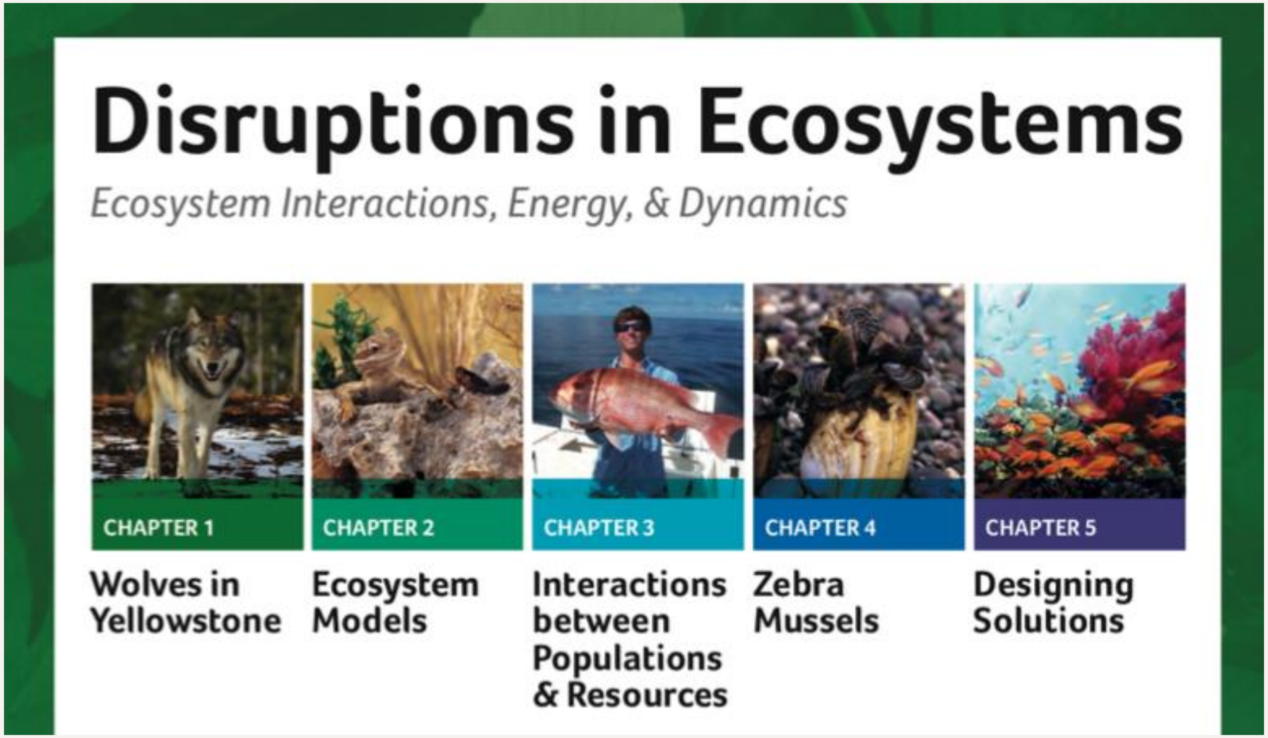
Curriculum Features

- 5E instructional model (Engage, Explore, Explain, Elaborate, Evaluate)
- Common Core connections for ELA and Mathematics
- Three-dimensional assessments
  - Embedded in activities throughout each chapter
  - In a culminating Evaluate activity
  - In end-of-chapter tests with 3-dimensional items
- Materials to support and scaffold students' learning of core ideas, practices, and crosscutting concepts
- "Educative elements" to support teachers
- Supports for diverse learner populations

One unit: Five chapters

Coherence

Instructional materials are organized through a conceptual storyline. The storyline is a connection of scientific ideas (DCIs, and CCCs) that are linked to scientific and engineering practices and nested in a conceptual flow that builds across time. In a coherent storyline, students engage in making sense of phenomena or designing solutions to problems.



Embedded Evaluate Activity: Chapter 1 1

Guiding Question

Should wolves be reintroduced into the northeastern United States?

Controlling Deer Populations

Hunting is one way to control deer populations. White-tailed deer are one of the most commonly hunted species in the U.S., with approximately six million deer killed each year. In most cases, the dead animals are used for food.

In addition to hunting to reduce deer populations, some people have proposed reintroducing wolves into areas such as the Adirondacks in upstate New York. The Adirondacks are a mountainous area inside Adirondack Park, the largest preserve in the lower 48 states and considerably larger than Yellowstone National Park.

The park contains mountains, lakes, rivers, forests, and many types of plants and animals. The park covers about 6 million acres, of which 45% is protected public land. Much of the private land is used for agriculture, forestry, and open space. There are 105 towns and villages within the park, and over 60 million people live within a day's drive of the park.

Summative Assessments

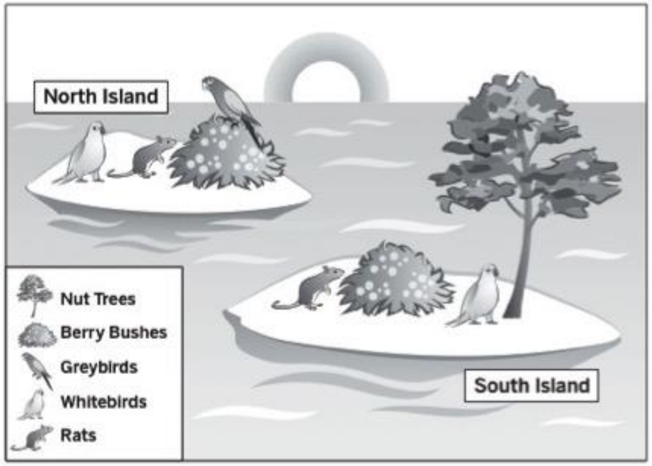
Chapter Tests

Chapter 1 Assessment

1. Graybirds and whitebirds live on North Island. Both types of birds eat the berries of the berry bush. The seeds of the berry bush grow best after the berries are eaten by birds and dropped elsewhere around the island.

Whitebirds are also found on nearby South Island. The white birds on South Island eat berries and the nuts of the nut tree.

Rats are found on both islands. Berries and bird eggs are favorite foods of the rats.



1a. Identify the patterns of interactions between species on each island.

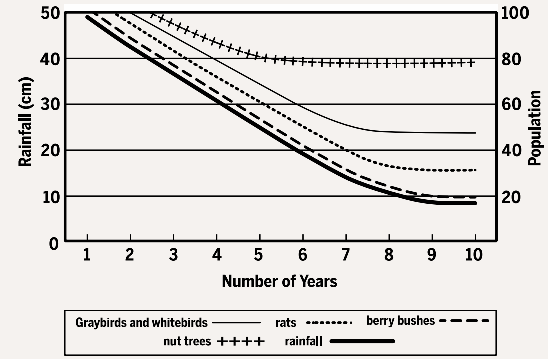
Identify 3 relationships on each island.
Use the words:

- competition
- predator-prey
- mutualism

You may choose to:

- Write a paragraph describing the relationships OR
- Prepare a labeled drawing of the interactions

1c. The graph below shows how the populations on the South Island changed during the same 10-year period of decreasing rain. Nut trees do not need a lot of rain. Construct a complete scientific explanation that answers the question, "Why did the population of whitebirds decrease to about half of what it was before?"



Your explanation should include the following:

- The scientific question
- Your claim
- The relevant evidence that supports your claim
- The science concepts that support the evidence
- Your scientific reasoning that links the evidence and science concepts to the claim

Assessment

Explanation Tool Rubric

Component	Level 3 Proficient	Level 2 Developing	Level 1 Emerging	Level 0 Not Evident
Claim	Claim answers the question, is accurate, and is complete. Completely describes the trend in the relationship between two variables.	Claim does answer the question but it is inaccurate or incomplete.	Claim does not answer the question.	Does not make a claim.
Evidence	Provides appropriate and sufficient evidence to support the claim.	Provides appropriate, but insufficient evidence to support the claim. May include some inappropriate evidence.	Evidence does not support the claim; only provides inappropriate evidence.	Does not provide evidence.
Science Concepts	Includes explanation of science concepts that link evidence to the claim (concepts are appropriate), and science concepts are sufficient (no omission of key concepts) and are clearly stated and accurate.	Includes explanation of some science concepts that link evidence to the claim, but are insufficient (one or more concepts that should have been included are not included) or some are inappropriate.	Restates evidence and does not include explanation of science concepts.	Does not include science concepts.
Scientific Reasoning	Includes logic statements that link the claim, evidence and science concepts (including words such as 'because...' 'therefore...') that clearly demonstrates logical reasoning.	Attempts to include a logic statement that links the evidence to the claim but does not adequately link the evidence to the claim.	Restates evidence or claim and does not include a logic statement that links the evidence to the claim.	Does not include scientific reasoning.

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Teaching Tools

Learning Scaffold for Constructing Explanations

Name ____________________

Explanation Tool

Question What is the scientific question you are investigating?	
Background Knowledge What do you already know related to your question?	**Initial Thoughts** Based on what you already know, what do you think the data will show?

Evidence What are the science observations or data that address your question?	Claim What claim can you make based on the evidence?	Science Concepts What science concepts are connected to the evidence and help explain the claim?

Explanation Tool
Continued

Name ____________________

Does your claim agree with your initial thinking? Why or why not?

Scientific Reasoning

What relevant evidence led you to your claim? How do the science concepts relate to the evidence?

The evidence that led to my claim is (evidence). The concepts that relate to the evidence and support my claim are (science concepts). These concepts support my claim because ________ .

Explanation Tool
Continued

Name ____________________

Construct a Scientific Explanation

Using the information in the boxes you have completed, write a scientific explanation that includes:

- The scientific question
- Your claim
- Relevant evidence that supports your claim
- Science concepts that support the evidence
- Scientific reasoning that links the evidence and science concepts to the claim

Scientific Explanation

Evaluating Solutions

Humans rely upon ecosystems in many ways. They supply us with resources such as food, shelter, energy, and even the oxygen that we breathe. They also provide enjoyment and income for people. Using resources can also threaten the health of the ecosystem. In some cases a problem can become so bad that the environment will not recover by itself. In such cases, a solution is needed. The solution might involve the use of technology, the application of policies and rules, or all of these. After a solution is put in place it must be monitored to see if it is working. In this activity, you will examine several environmental issues and evaluate the sustainability of proposed solutions.

Guiding Question

How can we evaluate whether a solution to an environmental problem is a sustainable one?

Environmental Problem 1

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Environmental Problem 2

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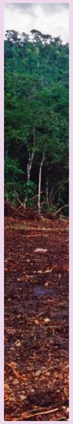

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Environmental Problem 3

Yellowstone Lake is the largest body of water in Yellowstone National Park. It is a very large (350 km^2) freshwater lake with an average depth of 42 m. More than 140 rivers and streams flow into Yellowstone Lake. The Yellowstone River is the largest outflow of water from the lake, eventually reaching the Missouri River. At the present time, no zebra mussels have been spotted in Yellowstone Lake but they have reached neighboring states. Scientists are concerned that one day they might arrive in Yellowstone.

Zebra mussels are an invasive species that first appeared in the Great Lakes in the 1980's. Ever since then they have been spreading around the country. They spread easily partly because each female can lay millions of eggs. Young mussels float along the water currents. Eventually they attach themselves to hard surfaces like rocks and the bottom of boats. Colonies can become very dense with as many as 10,000 mussels per square foot. Zebra mussels also cling to native mussels and other shelled animals. These animals die because they can't feed. Zebra mussels disrupt ecosystems by eating microscopic animals and plankton. This reduces the food available for the native invertebrates and small fish. They also disrupt ecosystem services by clogging water pipes to businesses and power plants. They damage boats, docks, buoys, and other structures.

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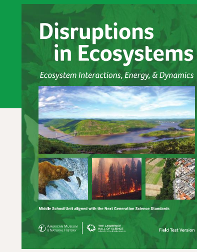

Chapter 1 Overview

Ecosystems Unit
Interactions, Energy, and Dynamics

CHAPTER 1: WOLVES IN YELLOWSTONE

5E Phase	Activities	Science Concepts	Science Practices	Science Vocabulary	Teaching Periods
Engage	**1.1 People and Animals Interacting** Students think about what an ecosystem is and how the living and nonliving parts of an ecosystem interact. They explore an outside ecosystem near their school such as a playground, park, or garden. Students are introduced to the Yellowstone National Park ecosystem and some of the animals found in and around the park (bears, elk, wolves, cattle, humans). The activity focuses on what students already think they know about ecosystems and the types of interactions between the living and nonliving parts of ecosystems.	MS LS2.A.4 (prior knowledge)	Constructing Explanations Engaging in Argument from Evidence (Preconceptions)	ecosystem	1
Explore	**1.2 Ecological Interactions** Students develop food webs as a way of thinking about the patterns of relationships between the different living components of an ecosystem. They use a set of cards to develop a food web of organisms in Yellowstone. Students then explore the influence of humans on food webs and the reintroduction of wolves in Yellowstone and how these might impact the food web.	MS LS2.A.4 Patterns Cause & Effect (predictions)	Developing and Using Models (food webs) Constructing Explanations (food webs)	food chain food web	1–2
Explain	**1.3 Patterns of Interaction Among Organisms** Students are introduced to the concepts of predator/ prey, competition, and other community relationships between living organisms in an ecosystem. A reading and videos are used to introduce these life science ideas. The context continues to be developing a deeper understanding of the patterns of biotic relationships in the Yellowstone ecosystem.	MS LS2.A.4 MS ESS3.C.2 Patterns	Obtaining and Evaluating Information Constructing Explanations (preliminary)	predator-prey competition symbiosis mutualism commensalism parasitism	1–2
Explore	**1.4 Factors Affecting Populations** Students graph and summarize data from two data sets, one involving moose and wolf populations on Isle Royale, Michigan and predicting the effect of a biotic factor (predator-prey interactions), and another involving Sonoran pronghorn fawn populations in the Arizona desert and predicting the effect of an abiotic factor (rainfall). Students are asked to think about what they learned about the relationship between the organisms in these ecosystems that might be useful for understanding wolves in the Yellowstone ecosystem.	MS LS2.A.4 Patterns Cause & Effect (predictions)	Analyzing & Interpreting Data	biotic factors abiotic factors	1–2
Explain	**1.5 Biotic and Abiotic Factors** Students are introduced to the Explanation Tool and use it to construct scientific explanations for two phenomena. The first phenomenon is about the effect of biotic interactions and the impact of wolves on elk in the Yellowstone ecosystem. The second phenomenon is about the effect of abiotic interactions and the impact of humans/ snowmobiles on the Yellowstone ecosystem. For each phenomenon students make a claim and use evidence presented in the activity and reasoning from patterns of what they learned in prior activities to construct a scientific explanation of the phenomenon.	MS LS2.A.4 MS ESS3.C.2 Patterns Cause & Effect (predictions)	Constructing Explanations	evidence claim scientific reasoning *ecosystem* *biotic factors* *abiotic factors*	2–3

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Patterns of Interaction Among Organisms

Types of Interactions

Predator-prey interactions, competition, and symbiosis are all interactions between living factors. A **predator-prey** interaction involves a feeding relationship between two animals. The **predator** is the animal that kills and consumes another animal, called the **prey**. In the photo below the bear is the predator and the fish is the prey.

Competition can occur when two or more species require the same limited resources. Competition can cause one or both populations to go down. For example, European green crabs were introduced into San Francisco Bay in 1989. They are efficient predators, reducing populations of clams and other organisms that provide food for native crabs. Since then, the population of native crabs, such as the yellow shore crab, has gone down 90% in some shoreline areas near San Francisco Bay.

Symbiosis includes mutualism, commensalism, and parasitism. These interactions are defined and illustrated below. Many symbiotic relationships have evolved over time. These established interactions do not usually change population sizes. However, if either population were to be affected by living or non-living factors, the other population might be affected in turn.

Type of Symbiosis

Mutualism helps both species involved.

The Nile crocodile allows the Egyptian plover to enter its open mouth. The plover benefits by eating small bits of food left on the crocodile's teeth. The crocodile benefits by having its mouth cleaned, reducing the chance of infection.

Commensalism helps one species, while neither helping nor harming the other.

Groundhogs (woodchucks) are the major hole-digging mammal of North America. Their abandoned burrows are used for shelter by foxes, opossums, raccoons, and skunks.

Parasitism benefits one species (the parasite), which lives in or on the other (the host). The host is usually harmed.

Tapeworms can live in the intestines of animals. They obtain nutrients from food passing through the intestines and harm the host by depriving them of needed nutrients.

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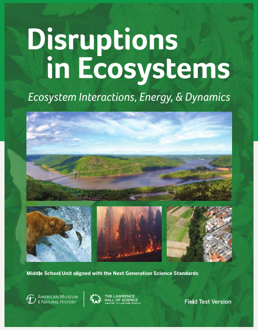

Chapter 1 Overview

Ecosystems Unit
Interactions, Energy, and Dynamics

5E Phase	Activities	Science Concepts	Science Practices	Science Vocabulary	Teaching Periods
Elaborate	**1.6 Analyzing Patterns in Ecosystems** Students use the Explanation Tool to construct explanations based on scenarios and to apply their previous knowledge and explanations involving the reintroduction of wolves into the Yellowstone ecosystem to develop an argument. The first part of the activity presents students with eight scenarios that make claims. Students look for patterns and match the correct evidence to support these claims by analyzing and interpreting graphs. Then each group of students are assigned one of the scenarios for which they construct an explanation. They use the claim presented in the scenario, evidence presented in graphs and reasoning from what they have learned in previous activities about ecosystem interactions, along with the Explanation Tool, to construct their explanation. The second part of the activity shows students how to use explanations about the effect of wolves and elk from the prior activity and use the Argument Tool to develop an argument about whether the wolf population should be allowed to increase, decrease, or stay the same in the Yellowstone ecosystem.	MS LS2.A.4 Patterns Cause & Effect	Analyzing & Interpreting Data Constructing Explanations Engaging in Argument from Evidence	argument *ecosystem* *predator-prey* *competition* *mutualism* *commensalism* *parasitism*	2
Evaluate	**1.7 The Return of the Wolf?** Students construct both an explanation of the effect of deer on the Adirondack ecosystem and an argument about the reintroduction of wolves in the Adirondacks. Before students develop an argument, they use the Explanation Tool to explain the impact of deer on the forest ecosystem. Using this explanation and other knowledge about patterns in ecosystems (based on their understanding of the Yellowstone ecosystem) students engage in argumentation using the Argument Tool. The argument provides an opportunity for students to identify patterns of interaction in the Adirondack ecosystem and the cause and effect relationships that predict the impact of humans on the deer population in the Adirondack ecosystem.	MS LS2.A.4 MS ESS3.C.2 Patterns Cause & Effect	Constructing Explanations Engaging in Argument from Evidence	*ecosystem* *predator-prey* *competition* *mutualism* *commensalism* *parasitism* *evidence* *claim* *scientific reasoning* *argument*	2

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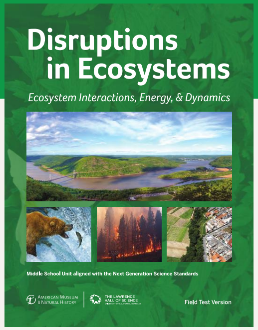
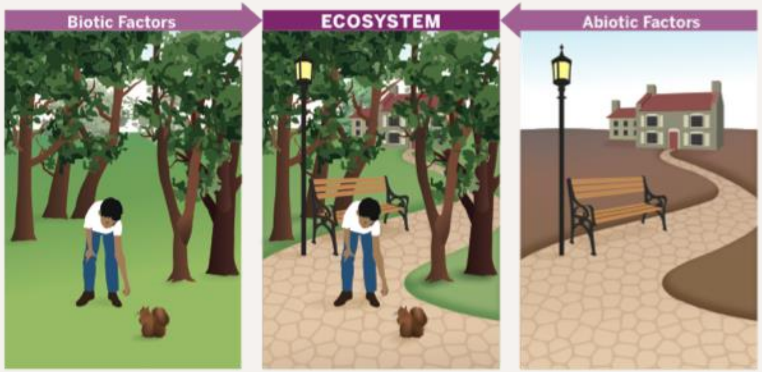


A Sample Activity

Activity 1.6

Elaborate: Analyzing Patterns in Ecosystems

Organisms in an ecosystem interact with both biotic and abiotic factors. For example, squirrels living in and near a city park might be affected by biotic factors such as the availability of nuts, seeds, and berries, people who feed them, and raccoons and hawks that might eat them. Abiotic factors such as water shortages, mild or extreme weather, expansion of the parkland, or construction of homes in the area might also affect the population size.



Guiding Question

How do biotic and abiotic interactions affect populations?

Disciplinary Core Ideas

Science Practices

Crosscutting Concepts

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Process & Procedure

Part One: Analyzing Patterns of Interactions

1. Read the six scenarios described below. Each one describes an interaction between a population and an abiotic or biotic factor.

Scenario 1: Freshwater Lake Fish

Rainbow smelt can survive in a wide range of lake environments. When rainbow smelt were introduced to Crystal Lake in northern Wisconsin, they quickly changed the ecology of the lake. For example, they ate up much of the food preferred by other fish. They have nearly eliminated the yellow perch, another type of fish.

Scenario 2: Marine Worms and Ocean Temperatures

A kind of scaleworm lives on sea stars in shallow ocean waters in the Pacific northwest. The population of the worms increases when water temperatures drop in winter, and then drops as water temperatures rise through the summer.

Scenario 3: Insects in Fields and Orchards

Insects are a pest in crop fields, orchards, and other farmland. Evidence suggests that the introduction of a parasitic wasp can cause the levels of certain insect pests in in farm fields to decline.

Scenario 4: Phosphorus and Algae Growth

Phosphorus is an essential nutrient for plants and algae. When phosphorus levels in water rise due to the presence of sewage waste, the population of algae increases.

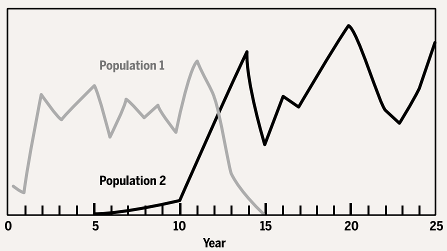
Scenario 5: Canadian Lynx and Snowshoe Hare

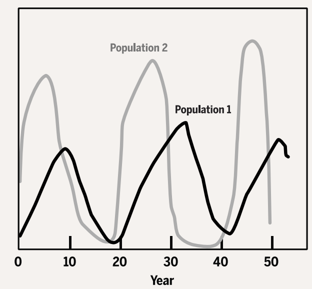
The Canada lynx is a member of the cat family, not much larger than a house cat. In northern Canada, the lynx's preferred diet is the snowshoe hare. When the snowshoe hare population decreases, the lynx kittens are often unable to survive.

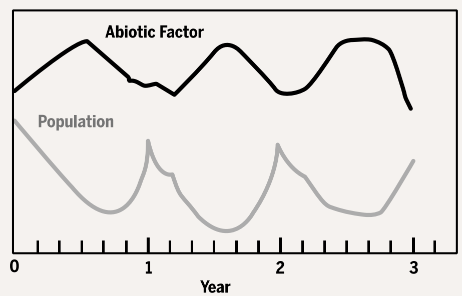
Scenario 6: Oxygen and Fish Populations

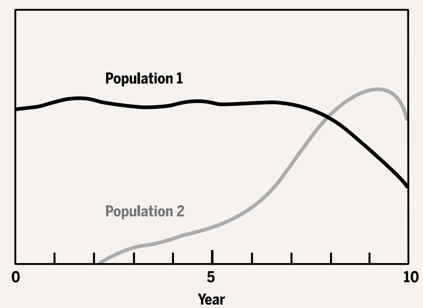
Investigations of a fish population in a lake showed that it was able to survive some decrease in oxygen. But as oxygen levels continued to drop, the fish population decreased rapidly.

Analyzing Patterns of Interaction: Match each scenario at left to one of six graphs









Then, create an explanation for one of the scenarios and its matching graph.

Analyzing Patterns of Interaction

Process & Procedure

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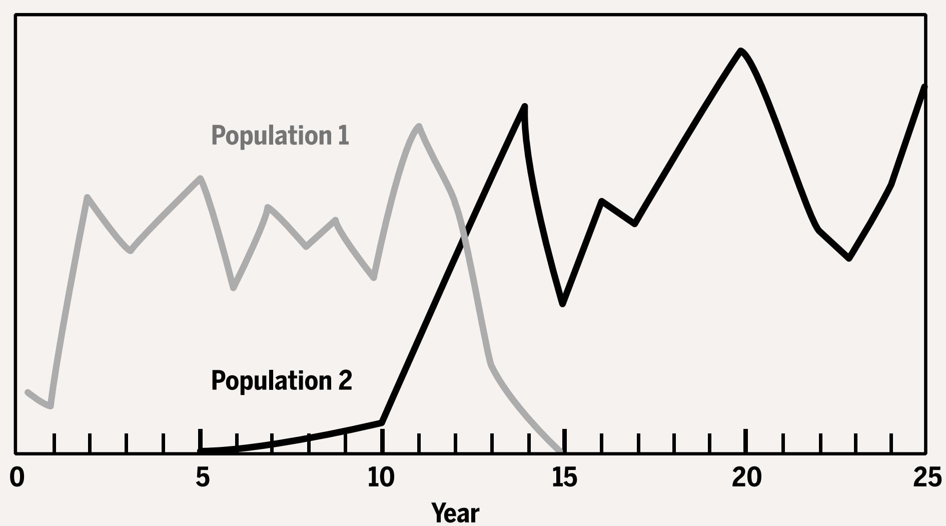

Competition

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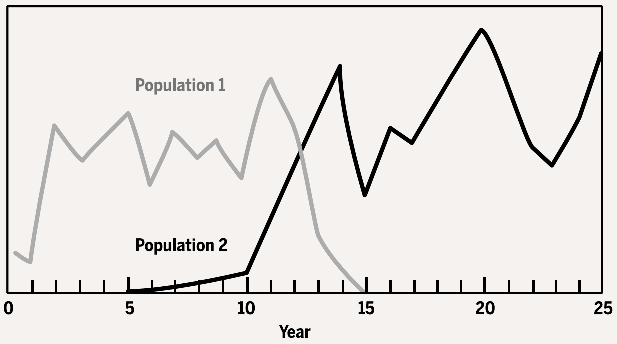
Constructing Science Explanations

5. With your group, discuss what you think might happen to the organisms on each graph over time.
6. Your teacher will assign your group to focus on one of the scenarios. Explain why you think the graph you selected matches the scenario.
7. Using the Explanation Tool, construct a scientific explanation about the patterns of interactions in your scenario. Use the list below to guide you as you use the Explanation Tool.

- **Question:** Record the question "Which graph best represents the patterns of interactions described in your scenario?"
- **Initial Thinking:** Record your thinking from Step 5 for your scenario.
- **Evidence:** Examine the data in the graph(s) that you matched with your scenario. What patterns do you notice? Describe these patterns to use them as evidence.
- **Claim:** Based on the evidence, state a claim about the patterns of interactions in your scenario. Does your claim agree with your intial thinking?
- **Science Concepts:** Apply the science concepts you have already learned to explain how the evidence supports your claim.
- **Scientific Reasoning:** Use the template provided on the Explanation Tool to describe the scientific reasoning that explains how the evidence and science concepts lead to your claim.

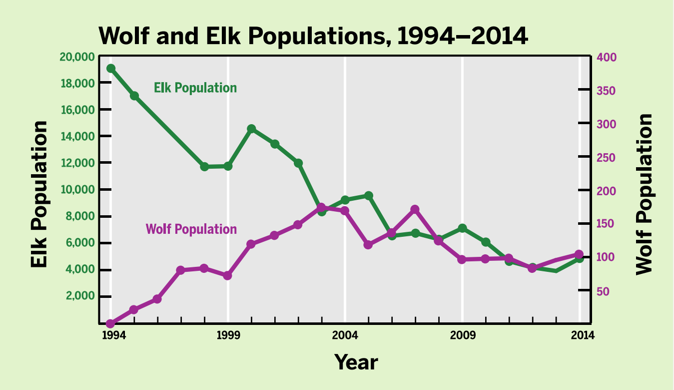


Competition

Engaging in Argument from Evidence

Part Two: Constructing an Argument

9. Use information and data from the text and graphs on the following pages, your explanation about wolves and elk from Activity 1.5, the concepts you have learned in this chapter, and the Argument Tool to construct a scientific argument about whether the number of wolves should be allowed to increase, decrease, or stay the same. Use the list below to guide you as you use the Argument Tool.



- **Question:** Record the question: "Should the wolves in the Greater Yellowstone Ecosystem be allowed to increase, decrease, or stay the same?"
- **Science Concepts:** What science concepts have you learned in this chapter that could be used to answer the question?
- **Evidence:** What evidence do you have that is related to the question?
- **Claims:** Record the three possible claims that could be made in response to the question.
- **Evidence:** What specific evidence supports each of the three claims?
- **Scientific Reasoning:** For each claim, critique the quality and strength of evidence that supports that claim.
- **Argument:** Decide which claim you think is best supported by the evidence and scientific reasoning.
- **Rebuttal:** Why did you rule out the other claim(s)?

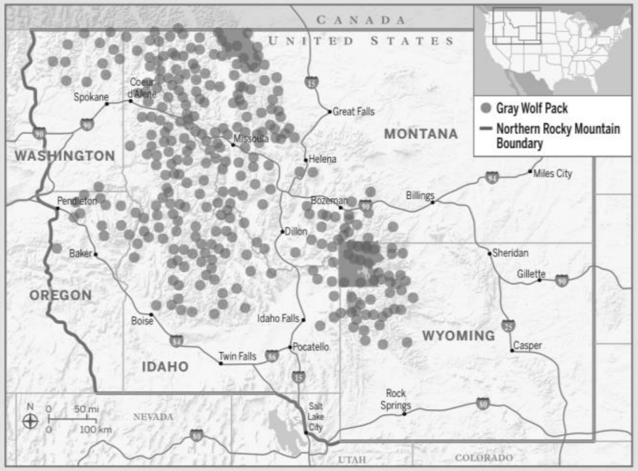
Wolves in the Greater Yellowstone Ecosystem

Wolves and Their Impact

Gray wolf numbers have steadily increased since the introduction of 66 wolves into Yellowstone National Park and central Idaho in 1995 and 1996. As their population grew, wolves spread to the areas of the Northwestern United States shown below. Today they number close to 2,000. Although wolves mainly eat large mammals such as elk, deer, moose, and bison, they sometimes kill and eat livestock and pets.

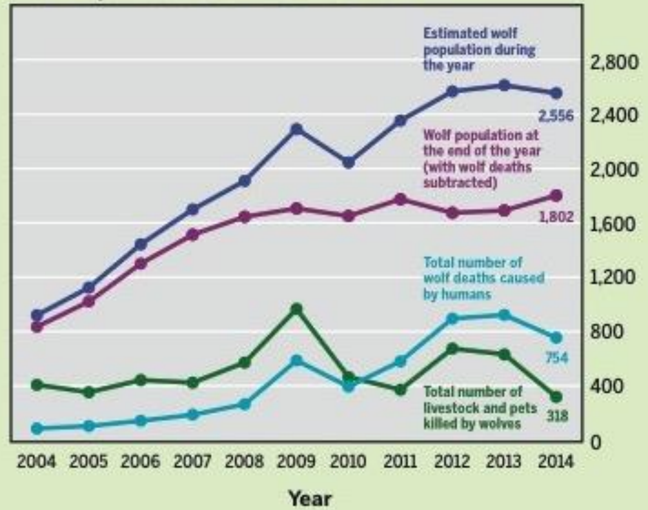
Distribution of Wolf Packs in 2014

in the Northwest United States



Scientists keep records of wolf deaths caused by humans, such as those due to wolf control measures, hunting, and vehicle collisions. Examine the graphs below of data collected between 2004 and 2014.

Wolf Population and Kills 2004–2014



Analysis

1. Pigeons are native to Europe, Asia, and northern Africa. They originally nested on cliffs and ledges. Their diet included seeds, grains, and some fruit and insects. Their predators included large birds, such as hawks, and mammals, such as raccoons and foxes. Pigeons are one of the few animals that are very successful in urban ecosystems with dense human populations.

   Why are pigeons successful in urban ecosystems? Use what you know about biotic and abiotic interactions in your answer.

Environmental Science and Biocomplexity

A case-based approach to learning about complex systems

Gillian Puttick
TERC

Cary Institute of Ecosystem Studies

Funded by the National Science Foundation

STEM Smart workshops are funded by the National Science Foundation grant #1449550. Any opinions, findings, conclusions or recommendations at this event or in these materials are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Biocomplexity overview

- Capstone Course for Grades 11-12
- Interdisciplinary
- Consistent with the vision and goals of NGSS

Biocomplexity R&D

- Extensively implemented and revised
- Piloted with 13 teachers
- Field-tested with 33 teachers (650+ students)
- Significant learning gains
- Available from Its About Time publishers

Case-based learning

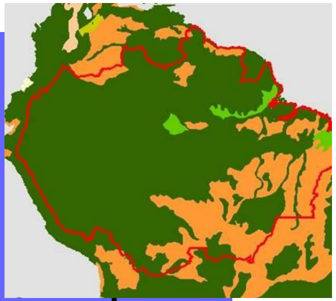
- **Real world scenarios**
- **Real data**

URBAN:
Local school decision about building a new sports field

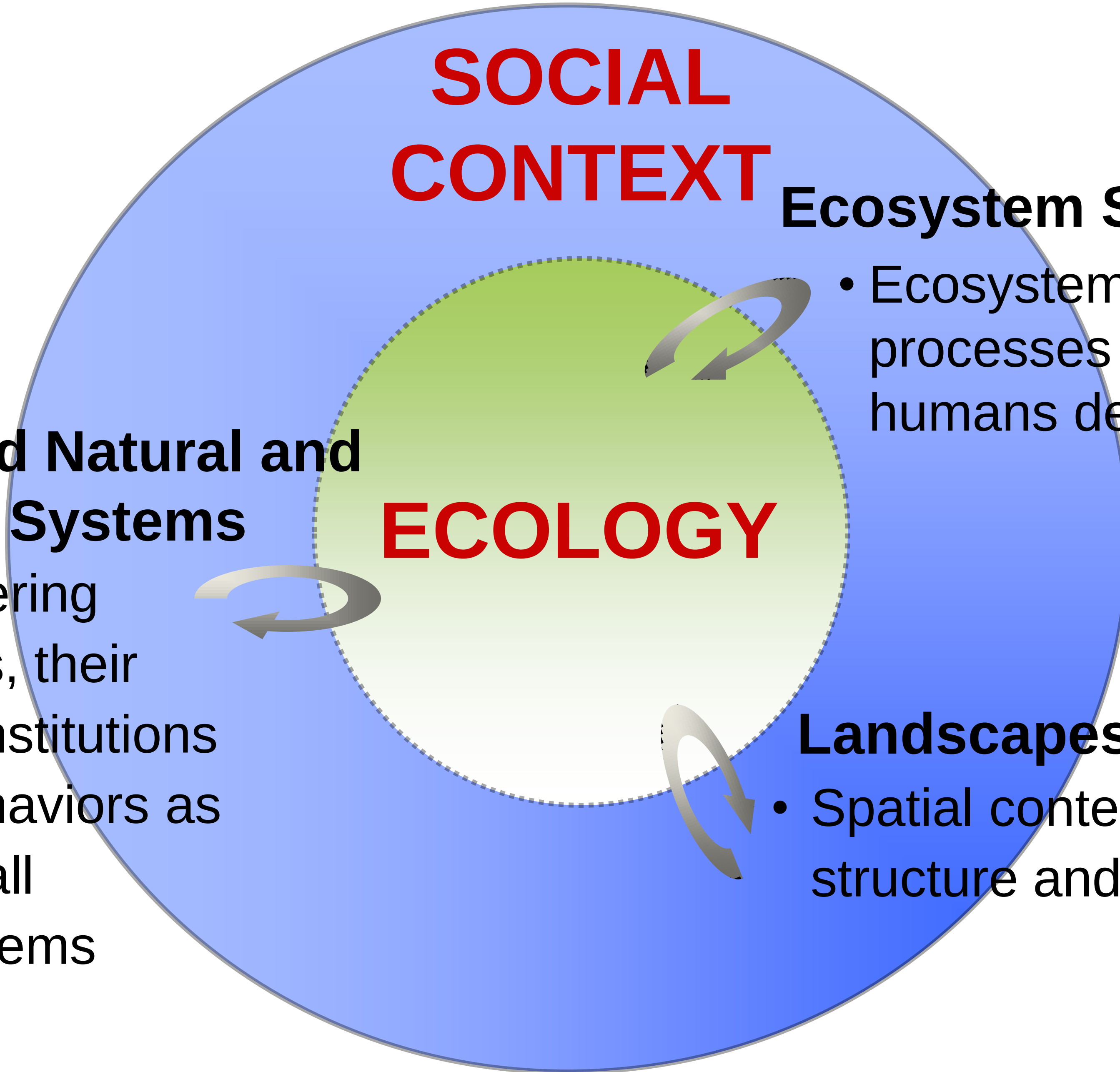
ARCTIC:
Local species conservation in light of global climate change impacts

SPRAWL:
Regional land use plan for farm land, housing development, conservation

AMAZONIA:
Biome-wide land use plan considering rights of indigenous peoples, rainforest conservation, and ranching



What is Biocomplexity?



Ecosystem Services

- Ecosystem processes on which humans depend

Coupled Natural and Human Systems

- Considering humans, their social institutions and behaviors as part of all ecosystems

Landscapes

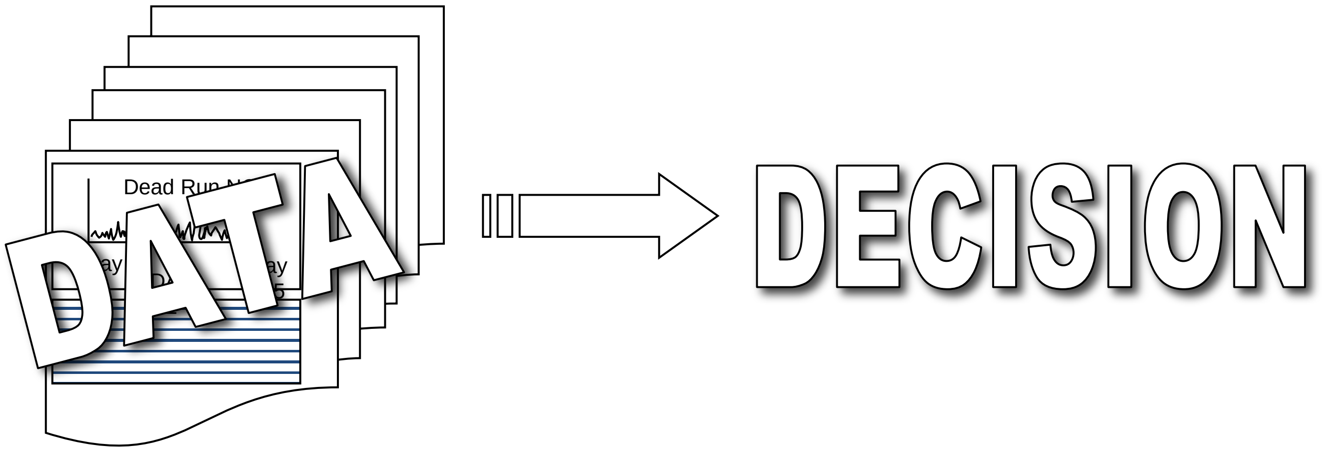
- Spatial context and its structure and patterns

Storyline

All Units are organized to address a Guiding Question.

Example: Should the school replace the streamside woodland on the school grounds with an additional athletic field?

Real world scenarios



NGSS 3 dimensions: Sprawl unit

Crosscutting Concepts

- Scale
- Systems
- Patterns

Practices

- Planning/carrying out investigations
- Analyzing/interpreting data
- Developing/using models
- Using data as evidence
- Communicating results

Core Ideas

- Cycles of energy and matter
- Ecosystem dynamics
- Biodiversity
- Ecological succession
- Climate change

NGSS 3 dimensions: Sprawl unit

Practices

- Ask questions
- Plan and conduct investigations
- Analyze data

Disciplinary core ideas

- Organization for matter and energy flow in organisms

Crosscutting Concepts

- Energy and matter

NGSS 3 dimensions: Sprawl unit

Practices

- Constructing and using models

Disciplinary core ideas

- Cycles of matter and energy flow in ecosystems

Crosscutting concepts

- Using mathematics and computational thinking
- Energy and matter

NGSS 3 dimensions: Sprawl unit

Practices

- Constructing and using models

Disciplinary core ideas

- Cycles of matter and energy flow in ecosystems
- Human impacts on Earth systems

Crosscutting concepts

- Using mathematics and computational thinking
- Energy and matter
- Scale

NGSS 3 dimensions: Sprawl unit

Practices

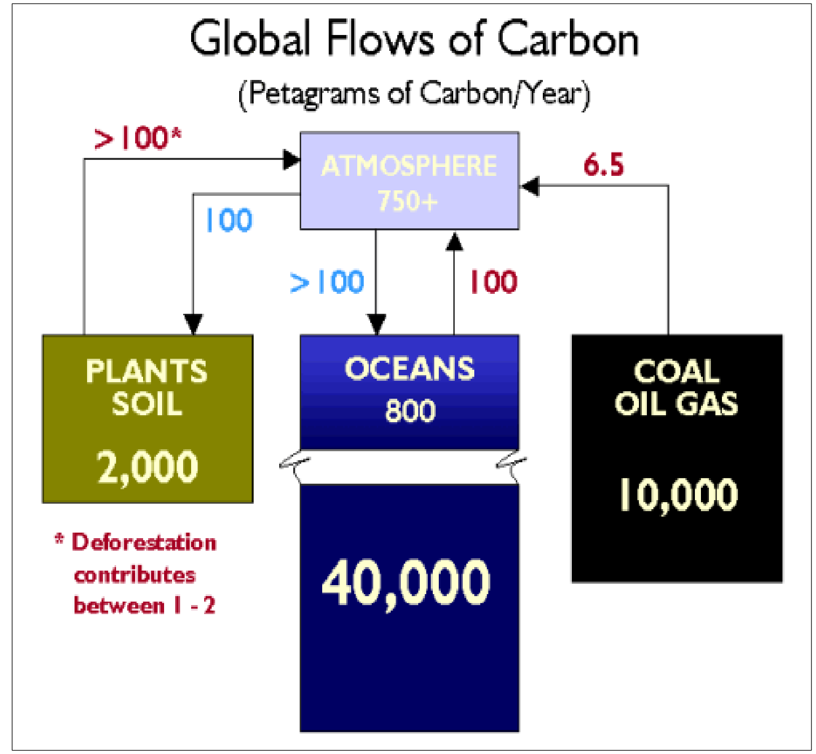
- Using models
- Analyzing/interpreting data
- Math/comp. thinking

Disciplinary core ideas

- Global climate change
- Earth and human activity

Crosscutting concepts

- Energy and matter
- Scale
- Stability and change



NGSS 3 dimensions: Urban unit

Practices

- Ask questions
- Plan and conduct investigations
- Analyze data

Disciplinary core ideas

- Cycles of matter and energy flow in organisms
- Ecosystem Dynamics, Functioning, and Resilience
- Earth and human activity

Crosscutting Concepts

- Energy and matter
- Patterns
- Systems and systems models

NGSS 3 dimensions: Urban unit

Practices

- Ask questions
- Plan and conduct investigations
- Analyze data

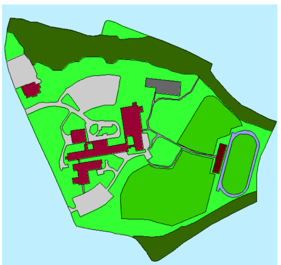
Disciplinary core ideas

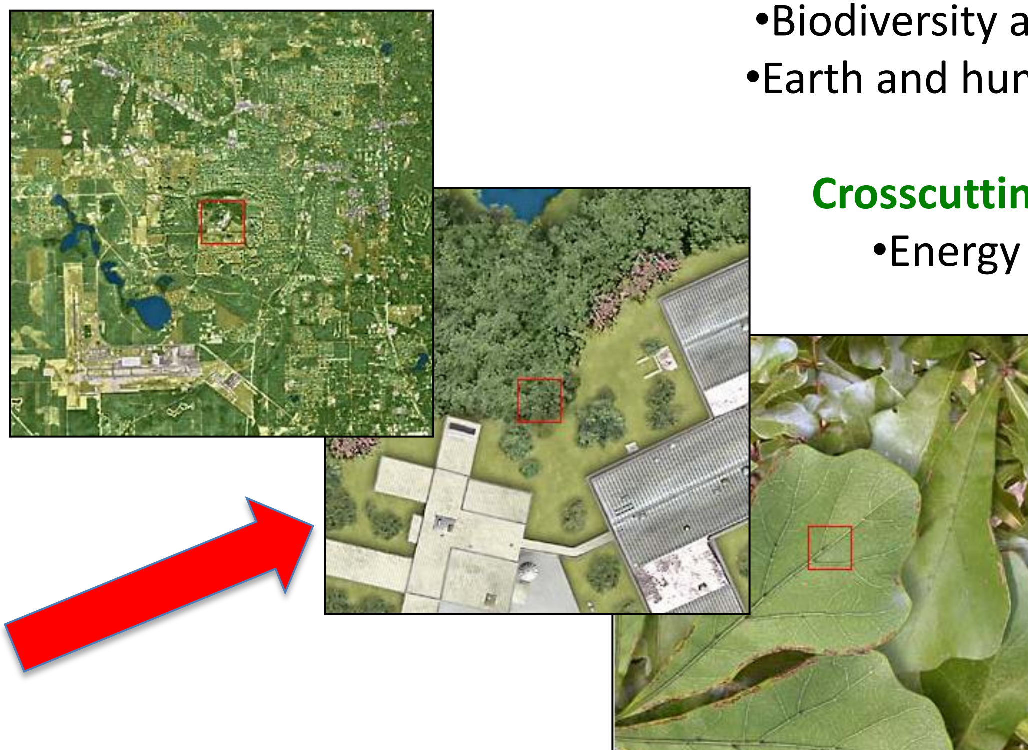
- Cycles of matter and energy flow in organisms
- Ecosystem Dynamics, Functioning, and Resilience
- Biodiversity and humans
- Earth and human activity

Crosscutting Concepts

- Energy and matter
- Patterns

NGSS 3 dimensions: Urban unit





Practices

- Asking questions and defining problems
- Obtaining, evaluating and communicating information

Disciplinary core ideas

- Matter and energy flow
- Ecosystem Dynamics, Functioning
- Biodiversity and humans
- Earth and human activity

Crosscutting Concepts

- Energy and matter
- Patterns
- Scale

NGSS 3 dimensions: Arctic unit

Practices

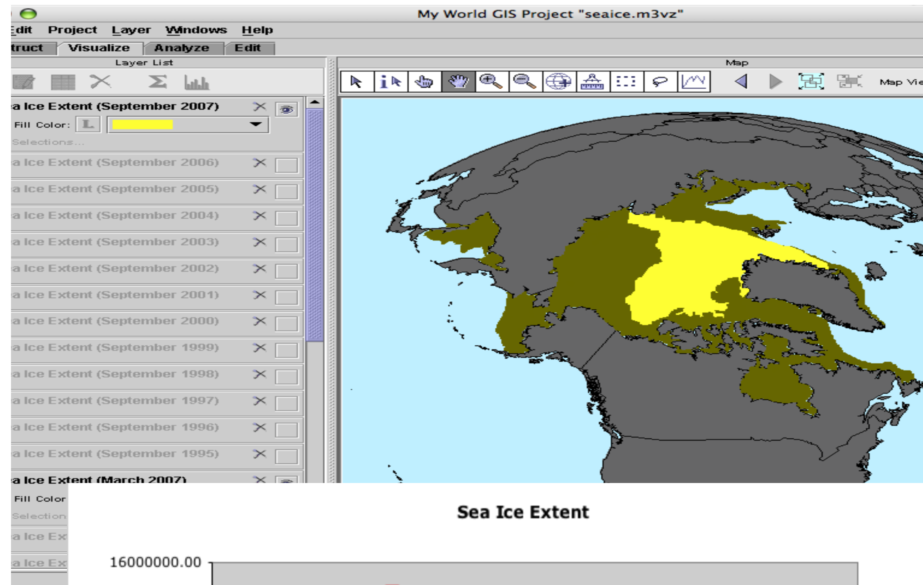
- Developing and using models
- Using mathematics and computational thinking
- Analyzing and interpreting data

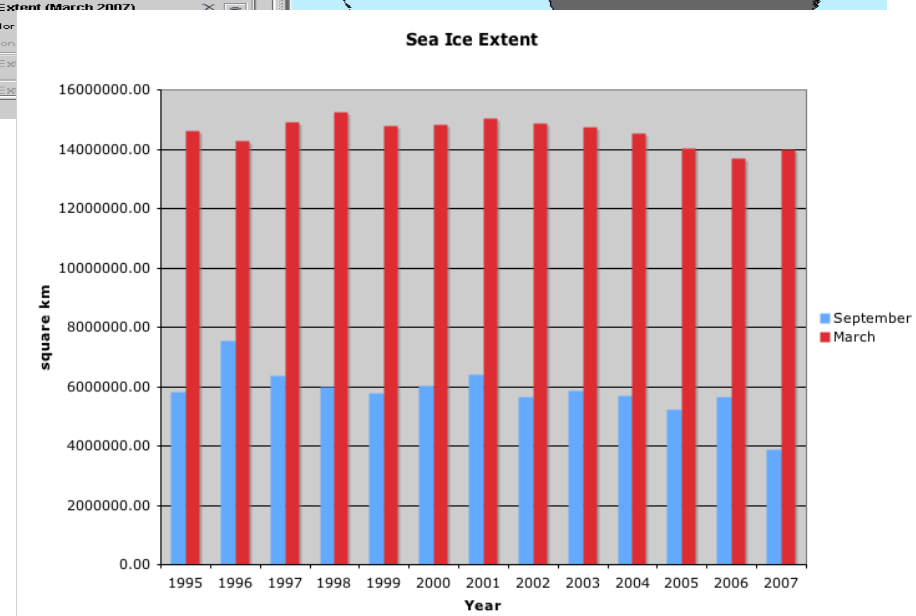
Disciplinary core ideas

- Global climate change
- Human impact on Earth systems
- Cycles of matter and energy transfer in ecosystems

Crosscutting Concepts

- Cause and effect
- Systems and system models
- Energy and matter
- Stability and change





Practices

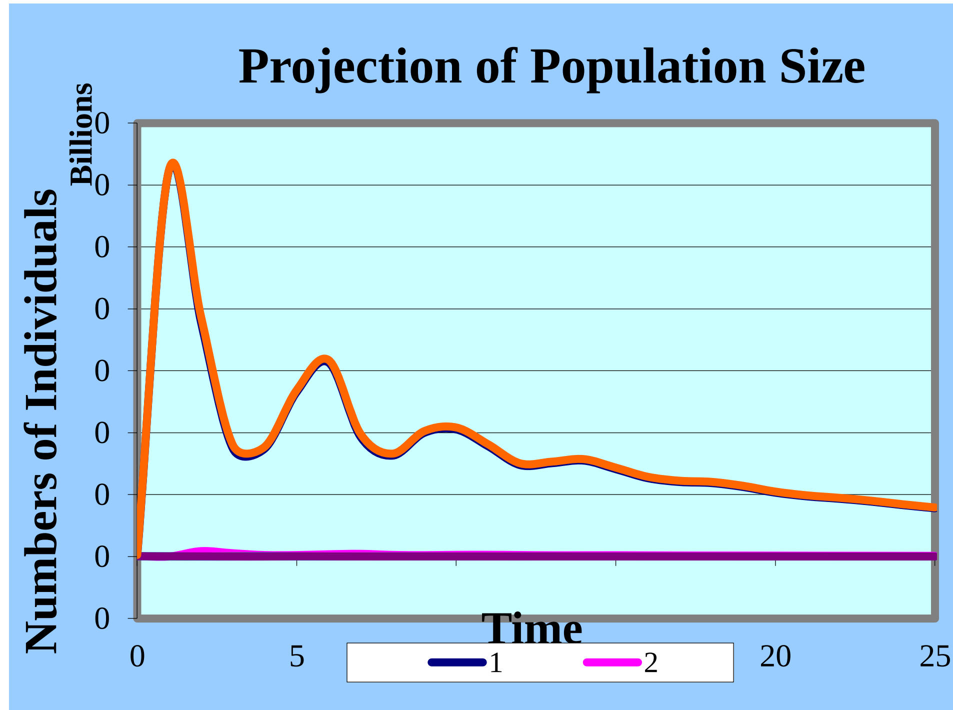
- Develop and use models
- Use mathematics and computational thinking
- Analyze and interpret data

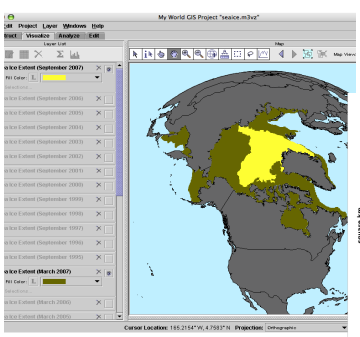
Disciplinary core ideas

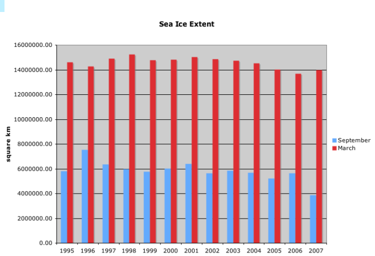
- Ecosystem Dynamics, Functioning, and Resilience

Crosscutting Concepts

- Cause and effect
- Stability and change
- Patterns

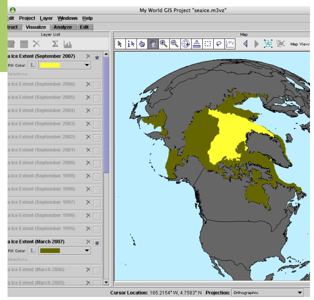


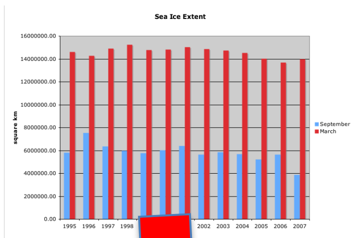


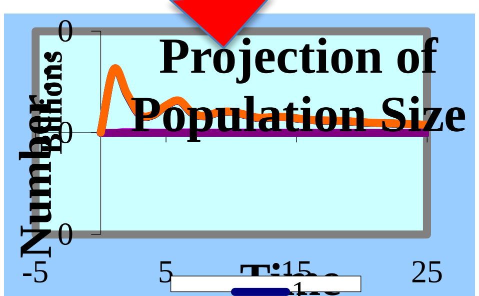


Age Class	Number Indivs	ReproOutput	GradProb	TIME	Total Population
1	10	0	0.014	0	50
2	10	0	0.058	5	5380
3	10	325	0.8	10	4170
4	10	409	0.8	15	2872
5	10	514	0	20	2098

NGSS 3 dimensions: Arctic unit







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Practices

- Developing and using models
- Using mathematical and computational thinking
- Analyzing and interpreting data

Disciplinary core ideas

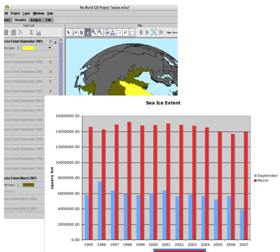
- Variation in traits
- Natural selection

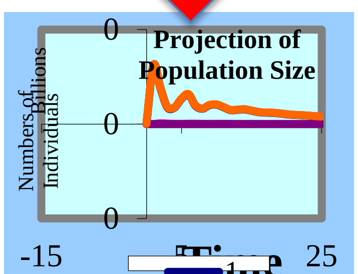
Crosscutting Concepts

- Cause and effect
- Stability and change
- Patterns

NGSS 3 dimensions: Arctic unit

Sea ice





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Population model

Practices

- Construct explanations and design solutions
- Engage in argument from evidence

Disciplinary core ideas

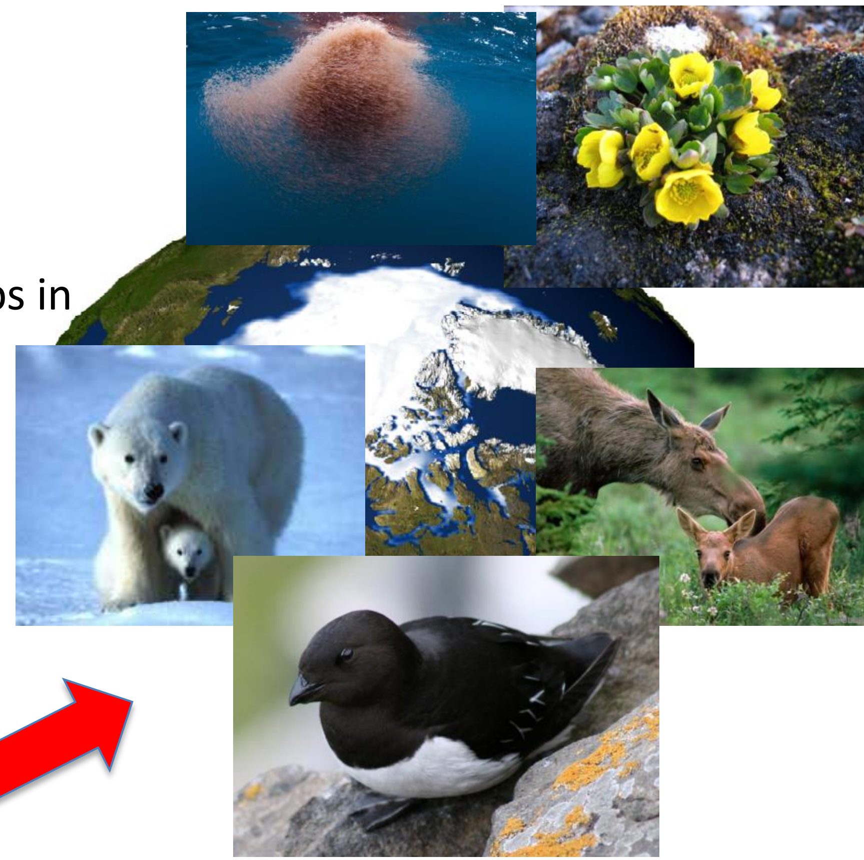
- Natural selection
- Adaptation
- Biodiversity and humans Interdependent relationships in ecosystems
- Biodiversity and Humans

Crosscutting Concepts

- Cause and effect
- Stability and change
- Patterns

Fast plants

Evolution



NGSS 3 dimensions: Sprawl unit

Crosscutting Concepts

Practices

Core Ideas

First steps towards alignment: Analyzing a single lesson

1. Core ideas
- *identify learning goals*
- *identify learning experiences that align with the target core ideas*
- *eliminate learning experiences that don't*

2. Questions that drive student learning
- *identify questions that frame activities in the lesson*

3. Evidence (highlighting practices)
- *identify what evidence students will need to develop explanations*
- *consider what classroom activities will allow students to collect evidence*

3. Student opportunities to make meaning
- *identify opportunities for students to communicate and explain – to share their thinking and reasoning, arguing from evidence*

Biocomplexity curriculum

- Accompanying “educative” Teacher Guide
  - Background science information
  - Examples of student work
  - Formative and summative performance assessments
  - Additional resources online

Biocomplexity Teacher Guide

- The instructional approach
  - “Flipped classroom”
  - 3 types of questions

Disciplinary Core Ideas

What are *human impacts on Earth systems* in Amazonia?

Land uses in Amazonia:

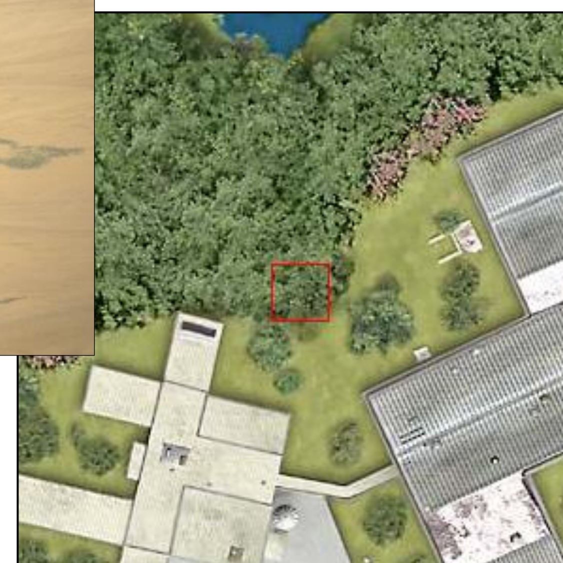
- Soy farming
- Cattle ranching
- Ecotourism
- Conservation
- Development

Cycles of energy and matter

Carbon

Energy

Nitrogen
+ Water



Disciplinary Core Ideas

Ecosystem dynamics and resilience…
Biodiversity…

…contrasting prairie and agriculture

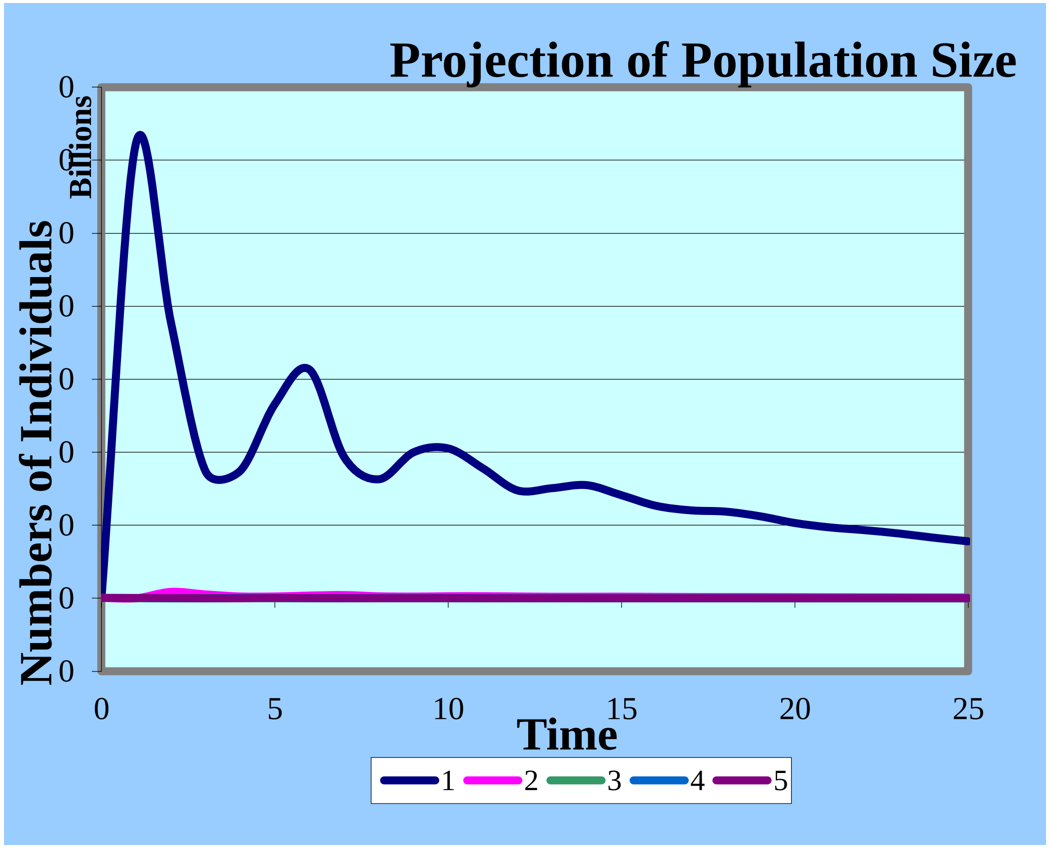
Scale - Time

15-20 year life span

1-1.5 month life span

http://www.ars.usda.gov/Main/site_main.htm?modecode=12-75-41-00
http://www.ars.usda.gov/is/graphics/photos/jun02/k5680-1.htm

NGSS 3 dimensions: Arctic unit



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http://www.nrri.umn.edu/worms/forest/ecosystems.html