Computer models to support scientific understanding in 7-12 students

Ecology Examples

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Unit Introduction

Very young children's progressions in reasoning about organisms and ecosystems starts with anthropocentric or human centered reasoning (Driver et al., 2007). Young children focus first on individual organisms such as pets or farm animals. Older adolescents note the role of wild animals and by their middle school years develop the concept of populations. Not until much later, do students consider the role of scarce resources and competition in ecosystems. Science teachers employ a variety of representations intended to help students develop the systems thinking needed to understand the inter-relationships between organisms in a food chain or web.

Unit Description

This unit introduces three different ExploreLearning computer simulations, one in each of the three lessons presented. In each lesson, a brief description of student naïve conceptions related to the lesson focus is followed by an introduction to the simulations. Finally, you will be able to conclude how each simulation provides opportunities for students to gain scientific understanding, especially in content areas that have traditionally been challenging.

This unit addresses students' naïve concepts about food webs and ecosystems and aims to inform teachers about common student ideas in order to better address them in instruction. Some urban students could have problems trying to identify and comprehend the ecosystem of the prairie, while country students could have trouble understanding a city ecosystem.

Unit Objectives

- Know the naive concepts that students have regarding food webs and ecosystems.
- Explore three different simulations that deal with these concepts.

- Discuss the importance of models and visual representations in science teaching.
- Evaluate a model's strengths and weaknesses, and know how to use the model properly in classrooms.
- Identify appropriate learning objectives for each simulation.

Naïve Concepts

The arrow notation used in food chain or food web depictions to indicate the relationships between members of the chain often cause confusion (Senior, 1983). The predator prey relationships between members of a food web are often confused with energy sources and flow within the web (Driver, et al., 2007). Top consumers are often seen as eating anything below them in the chain due to their greater energy. The interactions among organisms that make up the food web are often poorly understood by students. Teleological reasoning leads some students to believe that plants exist solely for the benefit of humans (Roth & Anderson, 1985).

Next Generation Science Standards

According to the *Next Generation Science Standards (NGSS),* students who demonstrate understanding can construct an explanation that predicts patterns of interactions among organism across multiple ecosystems (MS-LS2-2). The Ecology student learning progressions suggested in the NGSS are shown in Figure 1.

These standards connect to the literacy Common Core State Standards SL.8.4: Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details.

	K-2	3-5	6-8	9-12
LS2.A Interdependent relationships in ecosystems	Plants depend on water and light to grow, and also depend on animals for pollination or to move their seeds around.	The food of almost any animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants, while decomposers restore some materials back to the soil.	Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory and mutually beneficial interactions vary across ecosystems but the patterns are shared.	Ecosystems have carrying capacities resulting from biotic and abiotic factors The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem.

Figure 1. Next Generation Science Standards. Ecology.

Lesson Description

The three lessons that this unit includes are:

- Food chain
- Prairie ecosystem
- Forest ecosystem

Lesson 1: Food Chain

Introduction

This lesson deals with a simple ecosystem which consists of four organisms. Students may manipulate the population of the organisms in order to determine their relationships.

Naïve Concepts

- A population located higher on a given food chain within a food web is a predator of all populations located below it in the chain (Crawley & Arditzoglou, 1988; Griffiths & Grant, 1985; Munsen, 1994;).
- A change in one population of the food chain would only affect another population if they two are directly related as predators and prey (Griffiths & Grant, 1985; Munsen, 1991).
- If the size of one population in a food web is altered, all other populations in the web will be altered in the same way (Driver et al., 2007).

- Varying the size of the population of some organisms will not affect the ecosystem because they are not important organisms (Munsen, 1991).

Learning Objectives

- Students will be able to understand and explain the concept of a food web or chain.
- Students will be able to understand and explain what happens when one of the populations in a food web is altered.

ExploreLearning Food Chain Simulation

The Food Chain simulation (http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=381) presents a pyramid with images of four organisms: hawks, snakes, rabbits, and grass. The viewer has the option to increase or decrease the population of any of the four organisms as well as select between healthy and diseased organisms. Adjacent to the pyramid, three tabs allow the viewer to select a display depicting population of the organisms in a table, bar chart or as a graph (Figure 2).

Notice that the initial settings for the system show an equilibrium condition. Decrease the population of the snakes and run the simulation and observe what happens; repeat this process by decreasing or increasing the population of the other organisms and record your observations. How does the simulation help students gain scientifically sound views of the relationship between organisms in an ecosystem?

Does this simulation help students overcome their naïve concepts? For those with a license, there are questions underneath the gizmo about the system. Questions are about the impacts of the changes in parts of the pyramid on the balance in the ecosystem. Can you think of

some questions or graphs that could use for your students to test their understanding of the ecosystem and the food chain?

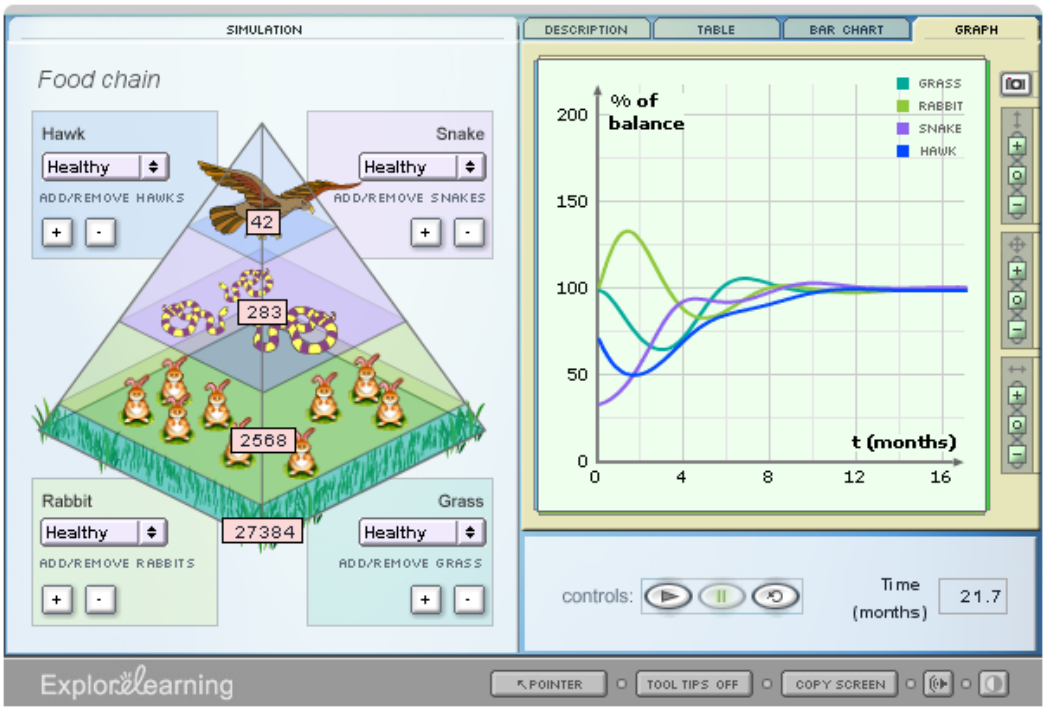

Figure 2. Explore Learning Food Chain.

Summary

Students have naïve concepts about food chains and the relationships between organisms in an ecosystem. The interactions between factors in an ecosystem is a central theme in understanding that all organisms co-exist within a biological system and that changes to any part of the system will have effects on the rest of that system. How does the simulation demonstrate the relationships between organisms in an ecosystem and the effects of altering the population of one of the organisms?

Now that you have explored the simulations that deal with food chains, complete the following table to report your findings (Figure 3).

Learning Objectives before using the simulation	How does the simulation address the learning objective?
Students will be able to understand and explain the concept of a food chain.	
Students will be able to understand and explain what happens when one of the populations in a food chain is altered.	

Figure 3. Rubric for Food Chains

What other learning objectives might you consider for this simulation?

Lesson 2: Prairie Ecosystem

Introduction

This simulation presents a prairie ecosystem with four organisms. Students manipulate the population of the organisms in order to determine how increasing or decreasing the number of one part of the ecosystem affects the populations of other members of the ecosystem.

Naïve Concepts

Students may have the following naïve concepts regarding food chains:

- Student may perceive "arrows" as predator-prey relationships rather than indications of energy transfer (Driver et al., 2007).
- A change in the size of a prey population has no effect on its predator population. A change in one population would not be passed along several different pathways or food chains. (Driver et al., 2007).

Learning Objectives

- Students will identify four members of a prairie ecosystem and describe the predator/prey relationships between them.
- Students will be able to understand and explain what happens when one of the populations in a food chain is altered.

ExploreLearning Prairie Ecosystem Simulation

When you run the simulation (http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=647) you will see a window with four organisms: foxes, prairie dogs, ferrets, and grass. If your students are not familiar with these organisms, researching their habitat and food preferences will provide some important background. Viewers have the option to increase or decrease the population of any of the four organisms. On the top of the window two tabs allow the viewer access to data using different representations: "prairie" shows a picture of the prairie with the population of each organism; the other tab called "data" shows a graph with the population of all organisms vs. time (Figure 4).

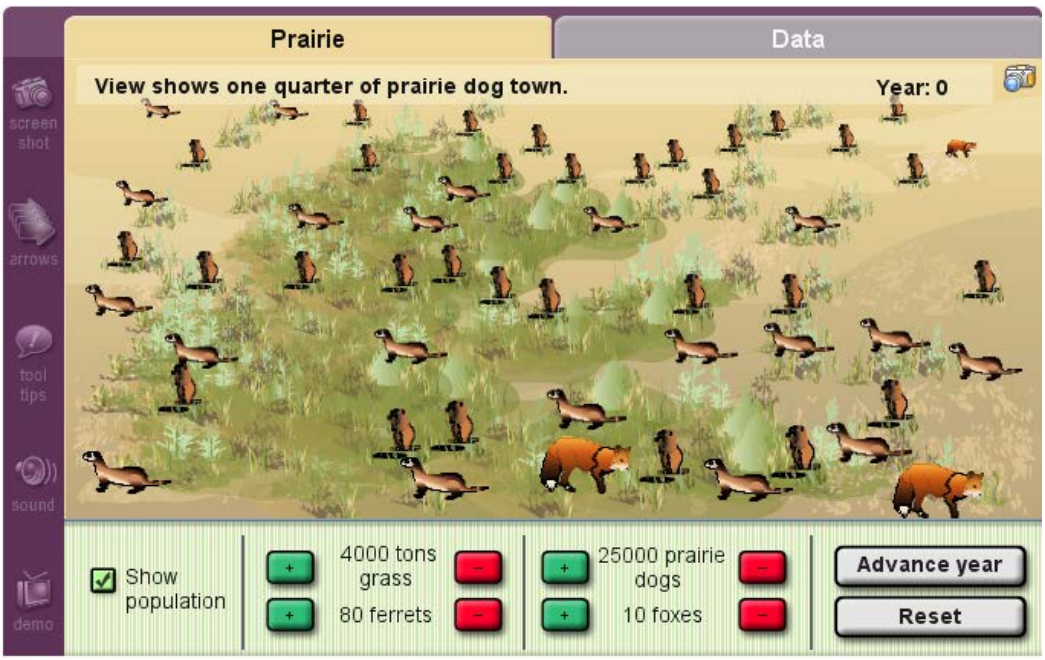

Figure 4. ExploreLearning Prairie Ecosystem.

In this simulation students explore the relationship between organisms in the prairie ecosystem. By increasing or decreasing the population of an organism and advancing the years, the population of the other organism in the ecosystem will be altered. In the data tab students will be able to view the change of the organism with respect to time.

Do you think this simulation will help students to determine the relationship of the four organisms in this ecosystem? Does this simulation help students overcome their naïve concepts?

Summary

Students struggle to apply systems thinking to organisms. The concept of populations competing for scarce resources is an integral part of the understanding of ecology. Students who live in the prairie may have a better understanding of this simulation than students who live in urban or suburban areas. After you explore the simulation, consider how you think the

representations help students develop scientifically sound understandings of food webs and ecosystems. Record your thoughts in the rubric below (Figure 5).

Learning Objectives before using the simulation	How does the simulation address the learning objective?
Students will be able to understand and explain the prairie ecosystem	
Students will be able to understand and explain what happens when one of the populations in a food chain is altered	

Figure 5. Prairie Ecosystem Rubric.

Lesson 3: Forest Ecosystem

Introduction

This lesson presents a forest ecosystem which consists of four organisms. Students may manipulate the population of the organisms in order to determine their relationships. After exploring the simulations, you will analyze how they address the learning objectives identified at the beginning of the lesson

Naïve Concepts

Students can have the following naïve concepts regarding food chains:

- A population located higher on a given food chain within a food web is a predator of all populations located below it in the chain (Crawley & Arditzoglou, 1988; Griffiths & Grant, 1985; Munsen, 1994;).
- A change in one population of the food chain would only affect another population if they two are directly related as predators and prey (Griffiths & Grant, 1985; Munsen, 1991).
- If the size of one population in a food web is altered, all other populations in the web will be altered in the same way (Driver et al., 2007).

- Varying the size of the population of some organisms will not affect the ecosystem because they are not important organisms (Munsen, 1991).

Learning Objectives

- Students will identify four members of the forest ecosystem and describe the predator/prey relationships between them.
- Students will be able to understand and explain what happens when one of the populations in a food chain is altered.

ExploreLearning Forest Ecosystem Simulation

When you open the Forest Ecosystem simulation (http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=639) four organisms are observed: bears, deer, trees, and mushrooms. You have the option to increase or decrease the population of any of the four organisms. On the top of the window you will find two tabs, one called "forest" which shows a picture of the forest with the population of each organism; while the other tab called "data" shows a graph with the population of all organisms vs. time (Figure 6). By increasing or decreasing the population of an organism and advancing the years, the population of the other organism in the ecosystem will be altered. In the data tab students will be able to view the change of the organism with respect to time. In addition, the role of human intervention in the ecosystem is presented through hunting and logging options for the forest.

Do you think this simulation will help students to determine the relationship between the four organisms in this ecosystem? How does this simulation help students overcome their naïve concepts about ecosystems and food webs? Underneath the simulation are questions for the students to answer. The questions are about which organisms are producers and consumers and

the expected relationships in the food chain when the forest is depleted. How could such questions provide information on the learning of your students?

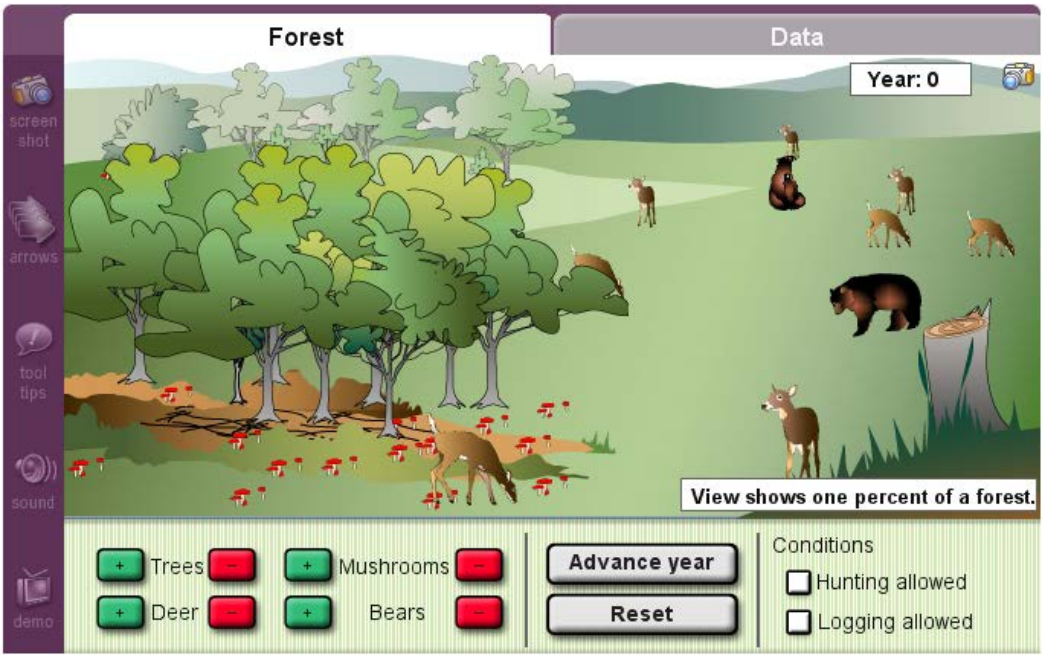

Figure 6. ExploreLearning Forest Ecosystem.

Summary

Students have naïve concepts about ecosystems that change as they mature. Young children often present a teleological view of nature assuming that rabbits are plentiful because foxes are hungry. As they become more aware of domestic and non-domesticated animals and plant organism, their eco-system understanding grows. However even at the high school level, students often struggle to understand the interdependence of organisms in a complex ecosystem. How well does the Forest Ecosystem address these student ideas? Record your thoughts in the rubric below (Figure 7). What would an ecosystem for an urban environment look like?

Learning Objectives before using the simulation	How does the simulation address the learning objective?
Students will be able to understand and explain the forest ecosystem	
Students will be able to understand and explain what happens when one of the populations in a food chain is altered	

Figure 7. Forest Ecosystem Rubric.

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