Scope, Sequence & Coordination

A National Curriculum Development and Evaluation Project for High School Science Education

A Project of the National Science Teachers Association

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Scope, Sequence & Coordination

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National Science Education Standard—Life Science

The Interdependence of Organisms

Organisms both cooperate and compete in ecosystems. The interrelationships and interdepencencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.

Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.

Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly damaged.

Teacher Material

Learning Sequence Item:

956

Limiting Factors for Populations

March 1996
Adapted by: Beverly Ernzen and Duane Dawson

Organisms, Ecosystems, and Population Growth: Interrelationships and Interdependencies. Students should demonstrate that they understand limiting factors and describe the various areas where limiting factors are applicable. Students should demonstrate that they understand that limiting factors can affect population growth. (Focus on light, water, and mineral nutrients.) (*Biology, A Framework for High School Science Education, p. 120.*)

Contents

This micro-unit was adapted by **Beverly Ernzen** and **Duane Dawson** (Pleasant Valley H.S., Pleasant Valley, Iowa)

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Learning Sequence

Organisms, Ecosystems, and Population Growth: Interrelationships and Interdependencies. Students should demonstrate that they understand limiting factors and describe the various areas where limiting factors are applicable. Students should demonstrate that they understand that limiting factors can affect population growth. (Focus on light, water, and mineral nutrients.) (*Biology, A Framework for High School Science Education, p. 120.*)

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
Bottled Bacteria **Activity 1** Bears? **Activity 2** Roaming Deer **Activity 3** How Does Your Garden Grow? **Activity 4** What's Underfoot? **Activity 5** The Light Touch **Reading 1** Starvation vs. Predation **Reading 4** Blooming Lakes **Assessment 1** Biotic Factors **Assessment 4** Light and Water as Limiting Factors **Assessment 5** Ecosystem Sustenance **Assessment 6** Maintaining a Balanced Ecosystem **Assessments 7, 10** **Biotic Factors** **Assessment 9** Survival of Lions **Assessment 11** Energy Pyramid **Assessments 18, 19**	A New Ecosystem **Assessment 8** Cats: Pheromones **Assessment 15**	Danger: No Sharks! **Reading 2** Brazil's "Green" Asphalt **Reading 3** Gardeners **Assessment 2** Cats: Limiting Factors **Assessment 12** Cats: School Officials **Assessment 13** Cats: Trapping Adults **Assessment 14** Cats: Pheromones **Assessment 15** Cats: Living Space **Assessment 16** Cats: Closed School **Assessment 17**	The Hare and the Lynx **Assessment 3**

Suggested Sequence of Events

Event #1

Lab Activity

1. Bottled Bacteria (20 minutes)

Event #2

Lab Activity

2. Bears? (30 minutes)

Alternative or Additional Experiments

3. Roaming Deer (25 minutes)

Event #3

Lab Activity

4. How Does Your Garden Grow? (40 minutes over several days)

Event #4

5. What's Underfoot? (30 minutes)

Event #5

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

Reading 1 The Light Touch
Reading 2 Danger: No Sharks
Reading 3 Brazil's "Green" Asphalt
Reading 4 Starvation vs. Predation

Readings can be found in the student version of this publication.

Assessment items are at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.

2. Open-ended questions asking for essay responses.

3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Science as Inquiry

Bottled Bacteria

Space as a limiting factor in a population.

Materials:

Per lab group:
3 small jars or containers
beans (large or small), enough to fill the 3 jars

Procedure:

Have students create a data table on which they will record the time and the number of bacteria present each minute. Each small bean represents a bacterium. Each minute the bacterium divides and students add the appropriate number of beans to the jar. Students continue dividing the bacteria until all the jars are filled. When the jars are filled, the bacteria will die with the next division due to lack of space. Initially, give each student group one jar. Emphasize the idea that when the jar is full, the bacteria will die unless more space is found. Arrange a method for students to obtain as many as two additional jars. The following is a sample scheme. "Just before the first container is full, a perceptive bacterium realizes the group needs more space. This bacterium goes on a search mission and finds two more containers. All the bacteria give a sigh of relief, for the group will surely have enough space to live thrive and reproduce. Won't they?" Students should graph their data to see an exponential growth curve.

Background:

Most bacteria reproduce by splitting. A single bacterium divides to form two organisms. If two organisms divide they produce four and so on. In effect, the number of bacteria will double after each division. The time required for bacteria to grow and split and grow and split again depends on the species. Many bacteria take as little time as twenty minutes. In this experiment, however, the doubling time has been reduced to one minute. When students graph their results, they will get an exponential growth curve showing the explosive nature of population growth without limiting factors. The graph illustrates the number of bacteria vs. time in minutes.

Adapted from Kutscher, E. *Hands-On Environmental Science Activities*. Maryland: Alpine Publications, 1992.

Science as Inquiry

Bears?

Identifying the influence of food and water as limiting factors in a population.

Materials:

Per class of 30 students:

colored paper (3–4 sheets of each color:
orange, blue, yellow, red, green)
white paper (5 sheets)
1 envelope per student

Prelab Preparation:

1 set of 2 ∞ 2 cards
50 white cards to represent water sources
30 cards of each color

Choose a color for each of the food groups in a bears diet—nuts, berries and fruit, insects, meat, and plants. Code each card with the number of food pounds it represents. See the reference table below.

	5 cards	**25 cards**
nuts	N-20	N-10
berries	B-20	B-10
insects	I-12	I-6
meat	M-8	M-4
plants	P-20	P-10

Procedure:

Scatter the colored paper pieces in a large area. Each student should write his or her name on an envelope and place it on the floor on the perimeter of the open area. This envelope represents a bear's home or den. Students then gather colored "food" items one at a time, returning each time to their envelopes to put the food item away. This pause in gathering represents the amount of time it would take the bear to eat the food item. When all the food items are collected, students add up the numbers on their cards for each color category and total the number of pounds collected.

To determine the health of the bears, compare the amount of food collected to the amount required in each category (see below). This comparison could be done by determining percentages. Each student needs a total of eighty pounds of food and one water card to survive. Students should also calculate the number of bears the habitat can support by taking the total number of pounds collected by the entire class and dividing by eighty.

Background:

The amount of food required for the average bear in ten days is shown by the following table:

Food Source	Pounds
nuts	20 lbs
berries/fruit	20 lbs
insects	12 lbs
meat	8 lbs
plants	20 lbs
Total food	80 lbs

The table does not account for geographical or seasonal changes in food needs. Possible water sources are rivers, lakes, streams, springs, and marshes. Have students brainstorm water sources for bears after the gathering event. You also vary some bears' ability to gather food. Assign an injury or another variable to a few students.

Adapted from *Project WILD*, 1986.

Science as Inquiry

Roaming Deer

Examining the roles of food, water, and shelter as limiting factors in a population.

Materials:

Per lab class of 30:

squares made from sheets of colored paper

- 10 brown squares (deer markers)
- 20 blue squares (water)
- 20 green squares (food)
- 20 red squares (shelter)

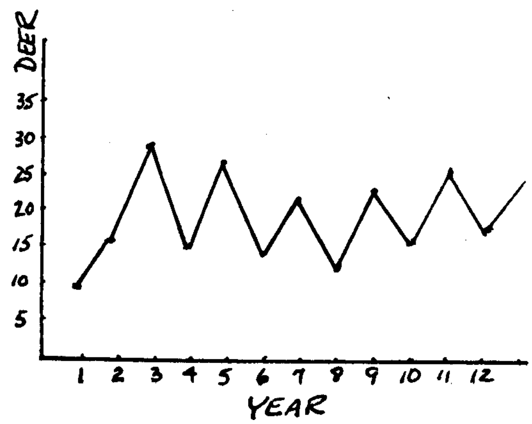
Procedure:

Divide students evenly into four groups. One group represents the deer, the other three groups represent food, water, and shelter. The room should be divided into three areas: one space for the resources, an open space, and a space for the deer. The open space should be between the deer and the resources. At the beginning of a round, each of the sides has its back to the other while they choose the resource they will be or need. Each deer will have a brown square in addition to the colored resource square it needs. The resource people may change what they are each round. They may choose to be all the same resource or to exclude one of the three options. This shift would represent an environmental occurrence such as a drought.

On your cue, the individuals face each other, move about, and the deer try to get the resources they need. The deer need to find food, water, and shelter to survive. In each round, the deer choose to locate one of these items. A deer may not change what it is looking for during the round. If it survives, it may change what it is looking for in the next round. If it dies, it returns to the resource side. Plan to run 15 rounds at a brisk pace. When a deer successfully locates its needed resource, it brings that individual back to the deer side to represent its ability to reproduce that year. Keep track of the number of deer before the first round and at the end of each round.

Background:

You will expect to see fluctuations in the deer populations over the 15 rounds or years. Typically, when food, shelter, and water are available the population will increase. As the population grows, these same items will become limiting factors. When a deer dies because it does not find what it needs, and the individual returns to the resource side, it represents the recycling of nutrients in an ecosystem. A sample graph of fluctuations in a deer population is included here for reference.



Adapted from *Project Wild*, 1986.

Science as Inquiry

How Does Your Garden Grow?

Determining the influence of water and temperature as limiting factors in seed germination.

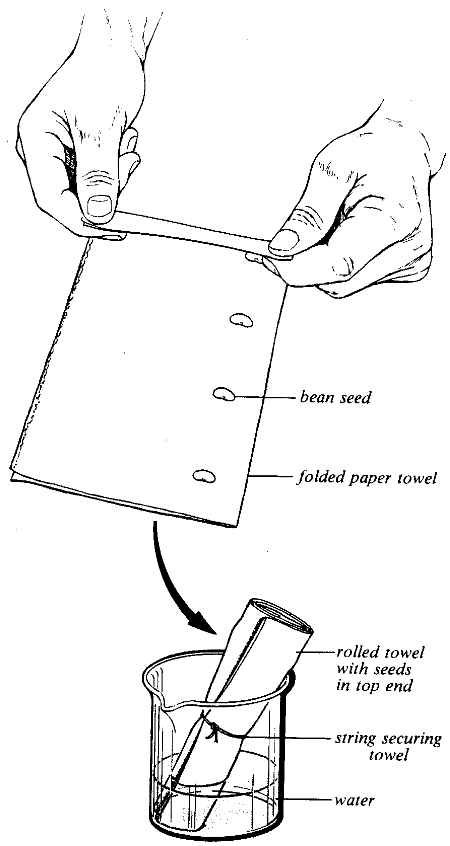
Materials:

Per lab group:

20–25 bean seeds (viable for germination)
16–20 paper towels
4 jars or beakers (250 mL)
100-mL graduated cylinder
4 rubber bands

Procedure:

On a stack of 3 or 4 paper towels, students place 5 or 6 seeds in a straight line. They cover the seeds with another paper towel and roll the paper towels and seeds tightly. Proper rolling is important. See the diagram. They then secure the roll with a rubber band. Four rolls of seeds should be prepared in this way.



Part A:

In this part of the activity, temperature is held constant. Water is considered a limiting factor. Students obtain two beakers and place one seed roll in each beaker, making sure the seeds are at the top of the roll, sticking out of the beaker. In one of the beakers, they put 100 mL of tap water, adding additional water to keep the paper moist as time passes. No water should be put in the other beaker.

Have students place both beakers in the same location at room temperature for 4–5 days. After waiting for several days, students determine the number of germinated seeds in each roll and get an individual group total as well as a class total. They should then determine the percent germination for each sample type, using both group and class totals.

Part B:

In this part of the activity, water is held constant. Temperature is considered a limiting factor. Students obtain two beakers and place one seed roll in each beaker, making sure the seeds are at the top of the roll, sticking out of the beaker. They then put 100 mL of tap water in each beaker.

Have students place one beaker at room temperature for 4–5 days and place the other beaker in a refrigerator for the same period of time. After waiting for several days, they determine the number of germinated seeds in each roll and get an individual group total as well as a class total. They then determine the percent germination for each sample type, using both group and class totals.

Background:

Students should find that the seeds with water germinated, while the seeds without water did not. In part B, they should find the seeds held at room temperature germinated better than those in the refrigerator. If the beakers run out of water before the fourth day, have students add enough water to each beaker to keep the paper towels moist. Depending on room temperature, germination may vary. Students should consider any seed that is sprouting or is swollen and cracked to be germinated. The following is a sample table for either individual or group totals. Navy beans seeds work well for this activity.

Treatment	# germinated	# of seeds used	% germinated
warm temp			
cold temp			
water			
no water			

Teacher Sheet

Science as Inquiry

What's Underfoot?

Linking the amount of organic matter in a soil sample with the types of plants found growing in the soil.

Materials:

Per lab group:
100-mL graduated cylinder
10-mL graduated cylinder
rubber tubing (approx. 15 in.)
short glass tube or straw (2–3 in.)
shallow pan
water
20 mL fresh 3% hydrogen peroxide
goggles
1 large test tube with tight-fitting one-hole stopper
soil sample (teacher or student collected)
peat moss
test tube support

Prelab Preparation:

The test tube apparatus should be constructed prior to the lab. Fit the glass tube into the stopper. Connect the rubber tubing to the glass tube sticking out of the top side of the stopper. Check the stopper fit in the test tube. It is important that the seals are tight to prevent oxygen from escaping.

Procedure:

Have students collect soil from a variety of environments. Possible sites are gardens, vacant lots, forests or wooded areas, lawns or football fields, beaches or sandy lots, and stream banks. When they collect a soil sample, they should write a description of the plants growing in the area. A practice trial with peat moss is suggested, which should help students collect better data from their soil samples.

Students place 1 g of a soil sample in the bottom of the test tube. They fill the shallow pan with water and fill the 100-mL graduated cylinder with water, invert it, and place it in the shallow pan. They then place the rubber tubing inside the graduate, being careful not to let it slip out during the collection time.

Have students add 10 mL of H_2O_2 to the soil and stopper immediately. They should place the test tube in a test tube rack or beaker for support. They collect the gas for 10 minutes, recording the volume of gas collected by reading the graduate. As a control, have them repeat the procedure without a soil sample.

Background:

Students determine the amount of organic matter in a soil sample by reacting the soil with hydrogen peroxide. Oxygen is produced when the H_2O_2 reacts with the carbon in the organic matter. The oxygen is then collected by water displacement. One would expect forest and garden areas to have more organic matter than sand and therefore create more bubbles. The control should produce no bubbles.

Students should compare data on all the different soil types to link nutrient supply with the type and number of plants growing in the area. Peat is used as a trial sample because it contains a large amount of organic matter. That's why it is often used as a soil additive. Students may need to crush the soil to increase surface area if it has lots of large clumps.

To successfully invert the graduate, students should use a large enough pan to fill the cylinder underwater and to invert it without bringing it above the surface. If they need to fill the cylinder at a faucet, they should fill it until there is a convex surface, cap it with a palm, and invert in the pan. If a bubble remains, have them subtract its volume from their final reading.

Adapted from *Biology: Living Systems*, Glencoe, 1994

Science as Inquiry

Blooming Lakes

Item:
A lake in Minnesota contains healthy, balanced populations of aquatic plants and animals. A few weeks after nearby fields are fertilized and planted, the lake literally "blooms" with a green growth covering the whole surface. What probably happened?

A. The fish stopped eating the green algae when the temperature warmed.
B. The fertilizers supplied nutrients to the lake that may have been in short supply.
C. The animals stopped eating the plants.
D. Animals in the lake produce more carbon dioxide in the summer as they become more active.

Justification:
Explain your answer in terms of the factors that influence population size.

Answer:
The correct choice is B. The runoff from the fields increased the nutrients needed by the plants. Without this limiting factor, the plant population increased.

Science in Personal
and Social Perspectives

Gardeners

Item:
Many gardeners get anxious to get into their gardens and plant them early in the spring when air temperatures warm up. If they plant too soon, the seeds may just lie in the ground and mold and decay. Explain why the seeds may not grow. Include the requirements for germination that most seeds need.

Possible Student Answers:
The seeds do not germinate because the ground is too cold or too moist. Seeds generally need warm soil and just the right amount of water to begin growth.

History and Nature
of Science

The Hare and the Lynx

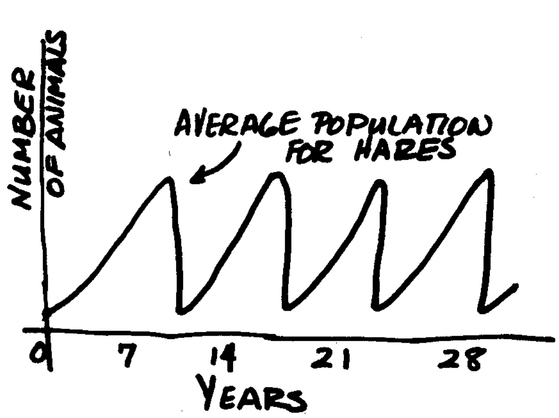
Item:

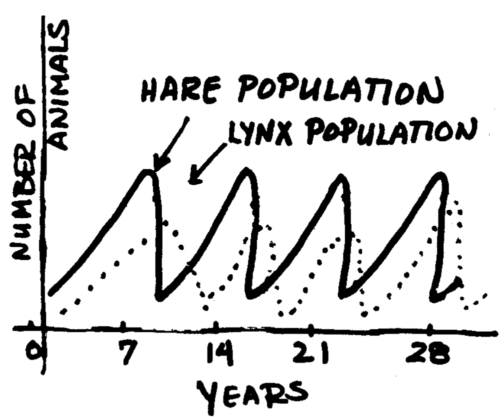
Early in American history, trappers in the Hudson Bay area shipped snowshoe hare and lynx pelts from America to Europe. In analyzing the data of these trappers, researchers found the hare populations to grow for seven to nine years before crashing. Lynx follow the same pattern but lag one year behind the hare populations.

Explain the trends seen in the hare and lynx populations. Why would the lynx show a time lag? Use the graph below to assist in your explanation.

Possible Student Answers:

As the hare population increases, so does that of the lynx. In this situation, the hare is the food source for the lynx. When the hare population crashes, the lynx start running out of food and the population decreases. As the lynx population decreases, the hare population increases because there are not as many predators. This occurrence creates a repeating pattern.





Science as Inquiry

Biotic Factors

Item:
Which would be an important biotic factor operating within an ecosystem?

A. the type of climate in a given region
B. the carnivores that consume a certain type of prey
C. the amount of carbon dioxide gas in the air
D. the rate of flow of water in a river

Justification:
List three important biotic factors and three important abiotic factors which could be found in a tropical ecosystem. Explain why each factor is important to the ecosystem.

Answer:
B. The other answers refer only to factors that are abiotic.

Science as Inquiry

Light and Water as Limiting Factors

Item:
Design an experiment to determine whether light, water, or a combination of the two are limiting factors for the growth of a culture of freshwater algae.

Answer:
Scoring Rubric:

4 The response is complete, including list of materials, workable procedures, nature and frequency of observations, data gathering technique, safety measures, use of controls, and nature of evidence used to draw conclusions.
3 The response has most of the parts of the above but lacks organization.
2 The response is incomplete.
1 The response is inappropriate and “off the mark.”

Science as Inquiry

Ecosystem Sustenance

Item:
An ecosystem, such as an aquarium, is self-sustaining if it involves interaction among organisms, a steady supply of energy, and the presence of:

A. more animals than plants
B. equal amounts of plant and animal matter
C. material cycles
D. nonrenewable material

Justification:
Explain the similarities and differences between the way matter travels in an ecosystem and the way energy travels in an ecosystem.

Answer:
C.

Science as Inquiry

Maintaining a Balanced Ecosystem

Item:

As a long-term science class project, a group of ninth-graders has successfully maintained a balanced freshwater aquarium for a semester. Their teacher has now challenged them to keep that aquarium without the use of plastic plants, artificial lights, chemicals, or air pumps. Discuss things that these students need to do to meet the challenge posed by their teacher.

Answer:

A complete response should include use of natural light; use of aquatic plants, including algae; changing water more often; use of natural means to remove chlorine from water by letting it stand in an open container for a few days; reducing the number of fish; addition of algae eaters to keep the glass clean or removal of algae mechanically.

Scoring Rubric:

4 The response discusses all of the above points.
3 The response discusses most of the above mentioned points, especially moving the aquarium closer to a window, use of live aquatic plants, and using fewer fish.
2 The response has only two of the major points.
1 The response is inappropriate and “off the mark.”

Science and Technology

A New Ecosystem

Item:
Assume that a small group of humans is leaving Earth to colonize another planet that has suitable abiotic factors but no existing life forms. You are on a committee to develop plans for a well-organized ecosystem in the new environment. Report on your plans.

Answer:

(Adapted from Merritt, 1986)

Science as Inquiry

Biotic Factors

Item:
An ecosystem includes the community of organisms in a given area, together with their physical environment. A team of researchers plans to study a small river system in a mountain forest. Which would be an important “biotic factor” operating within the ecosystem that should be included in the study?

A. the type of climate in a given region
B. the carnivores that consume a certain type of prey
C. the amount of carbon dioxide gas in the air
D. the rate of flow of water in a river

Justification:
Which of the “abiotic” factors in the question above would have the greatest direct effect on the biotic factor you chose?

Answer:
B is the right choice because it involves living, or biotic, components of the ecosystem. The other choices all involve nonliving, or abiotic, factors.

Science as Inquiry

Maintaining a Balanced Ecosystem

Item:

It is possible to set up a self-sustaining ecosystem within a very small enclosure if certain essential components necessary in all ecosystems are included. An ecosystem such as an aquarium is self-sustaining if it involves interaction among organisms, an energy supply, and the presence of:

A more animals than plants
B. only plants and no animals
C. a way to recycle materials
D. nonrenewable materials

Justification:

If you chose A, why is it necessary to have more plants than animals in a self-sustaining ecosystem?
If you chose B, why are animals not needed in a self-sustaining ecosystem?
If you chose C, explain how at least one material is recycled in a self-sustaining ecosystem.
If you chose D, what types of nonrenewable resources are needed for a self-sustaining ecosystem and why?

Answer:

Choice C is correct. Carbon dioxide and water are changed into oxygen and carbohydrates by plants. Oxygen and carbohydrates are changed back into carbon dioxide and water by animals.

Science as Inquiry

Survival of Lions

Item:

A remote foothill community is composed of deer, shrubs, grass, rabbits, mountain lions, and decomposers. Observations by wildlife management researchers studying the mountain lion population over many generations has concluded that the number of adult lions in the area has been declining. Which of the other living organisms in the community could affect the lion's ability to survive as a species?

A deer only
B deer and rabbits only
C deer, rabbits, grass, and shrubs only
D deer, shrubs, grass, rabbits, and decomposers

Justification:

Describe how each organism listed in the question above interacts with other organisms in the community. Include all organisms for which any relationship exists.

Answer:

The correct choice is D. Organization of ecosystems is based upon populations interacting with each other and with abiotic factors of the environment. Interactions of populations set up a community. Predator-prey relationships show a positive as well as negative association. The cycling of nutrients in an ecosystem is essential to maintain a balance in that ecosystem and the overall health of each species in the community. Ecosystems are dependent upon resources that are used by organisms and the recycling of wastes disposed by them.

Science in Personal
and Social Perspectives

Cats: Limiting Factors

Item:

A community of cats has established itself on a school campus. The principal is concerned that the number of cats will become so great that they will be a nuisance to the school and the neighborhood. Assume that there are equal numbers of male and female cats that will mate and reproduce as much as possible. The cats feed primarily on garbage left over from students' lunches. They live in the large spaces under the school buildings.

Describe the factors that may limit the cats' population growth.

Science in Personal
and Social Perspectives

Cats: School Officials

Item:
A community of cats has established itself on a school campus. The principal is concerned that the number of cats will become so great that they will be a nuisance to the school and the neighborhood. Assume that there are equal numbers of male and female cats that will mate and reproduce as much as possible. The cats feed primarily on garbage left over from students' lunches. They live in the large spaces under the school buildings.

What is the best way for school officials to slow the cats' population growth?

Science in Personal
and Social Perspectives

Cats: Trapping Adults

Item:
A community of cats has established itself on a school campus. The principal is concerned that the number of cats will become so great that they will be a nuisance to the school and the neighborhood. Assume that there are equal numbers (over 50) of male and female cats that will mate and reproduce as much as possible. The cats feed primarily on garbage left over from students' lunches. They live in the large spaces under the school buildings.

Describe what would happen to the population growth if you started trapping adult cats at a rate of two per night.

Science and Technology/
Science in Personal and
Social Perspectives

Cats: Pheromones

Item:

A community of cats has established itself on a school campus. The principal is concerned that the number of cats will become so great that they will be a nuisance to the school and the neighborhood. Assume that there are equal numbers (over 50) of male and female cats that will mate and reproduce as much as possible. The cats feed primarily on garbage left over from students' lunches. They live in the large spaces under the school buildings.

What would happen to the population growth if you used cat pheromones (natural chemical scent), which attract male cats only, for trapping cats?

Science in Personal and
Social Perspectives

Cats: Living Space

Item:
A community of cats has established itself on a school campus. The principal is concerned that the number of cats will become so great that they will be a nuisance to the school and the neighborhood. Assume that there are equal numbers of male and female cats that will mate and reproduce as much as possible. The cats feed primarily on garbage left over from students' lunches. They live in the large spaces under the school buildings.

Predict what might happen if you eliminated the living space by filling it in but did nothing about the food supply.

Science in Personal and
Social Perspectives

Cats: Closed School

Item:
A community of cats has established itself on a school campus. The principal is concerned that the number of cats will become so great that they will be a nuisance to the school and the neighborhood. Assume that there are equal numbers of male and female cats that will mate and reproduce as much as possible. The cats feed primarily on garbage left over from students' lunches. They live in the large spaces under the school buildings.

Predict what might happen if the school closed and people quit coming to the site.

Science as Inquiry

Energy Pyramid

Item:

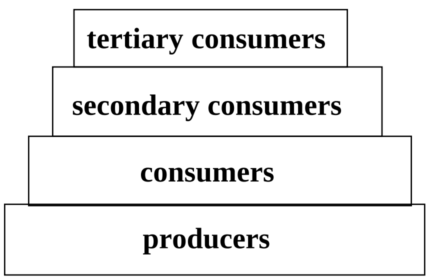


Figure 1

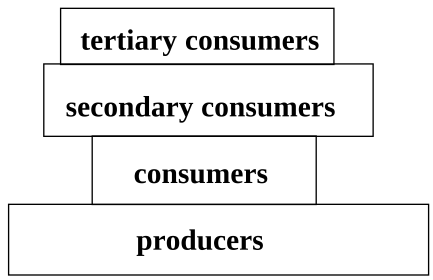


Figure 2

Figure 1 above shows an energy pyramid that represents a stable ecosystem. Figure 2 shows the same ecosystem a while later that is no longer in a stable condition. Draw a pyramid to show what you think the pyramid would look like one or two years later than shown in Figure 2.

Answer:

The upper portions should shrink so that they form a new but smaller pyramid on the reduced-size consumers (herbivores). The herbivore population would likely recover to a somewhat larger size.

Science as Inquiry

Energy Pyramid

Item:

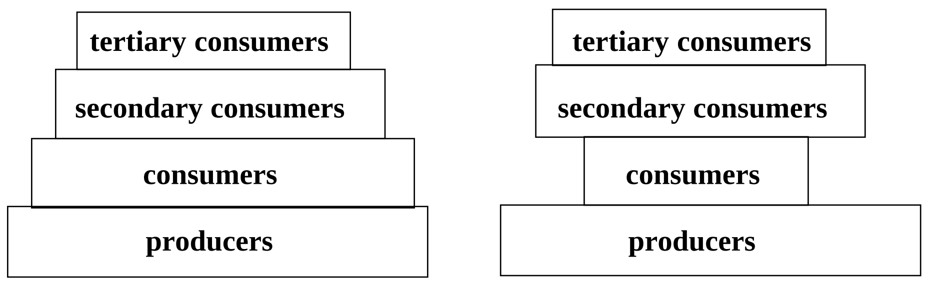


Figure 1 Figure 2

Figure 1 above shows an energy pyramid that represents a stable ecosystem. Figure 2 shows the same ecosystem a while later that is no longer in a stable condition.

Explain what features of this diagram represent an energy flow and why the stable ecosystem is expected to have a pyramid shape.

Answer:

The amount of stored energy is decreased, while the amount of energy "lost" as heat to the surroundings increases as the food chain progresses from autotrophs to secondary carnivores. The sizes of the boxes represent these changes and the number of individuals that the energy can support.