SS&C MICRO-UNIT 956[1] Teacher Guide: Limiting Factors for Populations

UNIFYING THEME
Relationships within the Living Environment

FOCUS QUESTION
How do limiting factors affect population growth?

LESSON OVERVIEW
Students will engage in activities exploring the affect of limiting factors on populations and their growth.

LESSON DURATION
The activity requires a total of 3 hours to complete.[1]

ENGAGE: Lab Activity 1. Bottled Bacteria (20 minutes)
EXPLORE: Lab Activity 2. Bears? (30 minutes)
EXPLAIN: Assessment 8. A New Ecosystem (20 minutes)
ELABORATE: Lab Activity 3. Roaming Deer (25 minutes)
EVALUATE: Assessment 5. Light and Water as Limiting Factors (85 minutes)

LEARNING OBJECTIVES
Students will be able to

- examine limiting factors and the various areas where limiting factors are applicable, including how they affect population growth (focusing on light, water, and mineral nutrients.)

STANDARDS
This activity provides all students with opportunities to progress towards these Next Generation Science standards:

LS2-1 Ecosystems: Interactions, Energy, and Dynamics

- LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*

PREPARATION
Cut out squares for Explore and Elaborate.

MATERIALS
Consumables: per team of three

Item	Quantity	Activity
SS&C Student Micro-Unit 956, pages 3-6 (4 pages)	3	
beans (large or small), enough to fill the 3 jars	1 lb. per team	1
colored paper, orange	3-4 sheets	2
colored paper, blue	3-4 sheets	2
colored paper, yellow	3-4 sheets	2
colored paper, green	3-4 sheets	2

[1] The BSCS 5Es Instructional Model is used with the permission of BSCS, Colorado Springs, CO

white paper	5 sheets	2
envelope	3	2
2 x 2 cards	1 set	2
white cards to represent water sources	50	2
30 cards of each color		2
squares made from sheets of brown paper (deer markers)	10	3
squares made from sheets blue paper (water)	20	3
squares made from sheets green paper (food)	20	3
squares made from sheet red paper (shelter)	20	3

Nonconsumables: per team of three

Item	Quantity	Activity
small jars or containers	3	1

Teacher Materials

Item	Quantity	Activity
SS&C Student Micro-Unit 956, pages 3-6 (4 pages)		
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SAFETY ISSUES
None

SCIENCE BACKGROUND FOR TEACHERS
The organization of ecosystems is based upon populations interacting with each other and with abiotic factors of the environment. The interaction of populations sets up a community. Populations may interact in positive or negative ways. An example of a positive interaction is seen in the pollinating activities of flowering plants. In this symbiosis, the flower is fertilized while the pollinator collects its food.

Predator-prey relationships show a positive as well as negative association. Competition for resources can also cause negative interaction. In this case the population most affected by the competition is eliminated from a niche. Because of these interactions, numerous adaptations have evolved that prevent elimination of populations from a selected ecosystem. Species have adapted to be able to coexist with each other by sharing resources, reducing competition, and entering into positive symbioses.

In any community, populations will tend to replace each other in an orderly process. This is due to the fact that habitat populations change. Use of nutrients and other "abiotic" factors by resident populations causes habitats to change, resulting in a replacement process, or succession. This process of community change results in a series of transitory communities until a final or mature community is established. Given sufficient time and stability of biotic and abiotic factors, a climax will be reached. The climax community can last for hundreds of years uninterrupted.

All populations have an inherent tendency to increase in size. This potential increase is extremely high for most species. This type of exponential growth begins slowly and then continues on a rapid incline as more reproductive individuals are produced each generation. Control of population growth is based upon limiting factors and population interactions in each ecosystem. Resources such as food, water, oxygen, and space availability, as well as predation, competition, and parasitism, place environmental limits on population growth. These limits set the carrying capacity of the ecosystem. Population size will oscillate around this carrying capacity. When a population exceeds carrying capacity, a strain upon resources could result in a sharp decline in the population.

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Human civilization has brought about dramatic changes in the ecosystems of the world. These changes have resulted in major environmental problems, which in turn directly affect the survival of all species on Earth. Because of agricultural practices, technological advances, and medical triumphs, world population growth has reached a size well over 5 billion. This "population explosion," coupled with a lack of understanding of ecological principles, has resulted in massive pollution of land and water, destruction of habitats and loss of biodiversity, possible climate changes that could result in global warming, and penetration of the protective ozone layer shielding all life from harmful UV rays. Policy decisions facing planet Earth should focus on population control, recycling of human waste, and development of alternative energy sources, and should develop a better understanding of the human impact on ecosystem balance.

LESSON STEPS
ENGAGE: Lab Activity 1. Bottled Bacteria

Focus Question: How does space act 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, B. Hands-On Environmental Science Activities. Maryland: Alpine Publications, 1992.

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EXPLORE: Lab Activity 2. Bears?
Focus Question: How do food and water act 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 x 2cards
- 50 white cards to represent water sources
- 30 cards of each color

Choose a color for each of the food groups in a bear's 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-l0
insects	1-12	1-6
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

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EXPLAIN: Assessment 8. 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.

Adapted from:
Merrill, 1986

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ELABORATE: Lab Activity 3. Roaming Deer
Focus Question: What are 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)

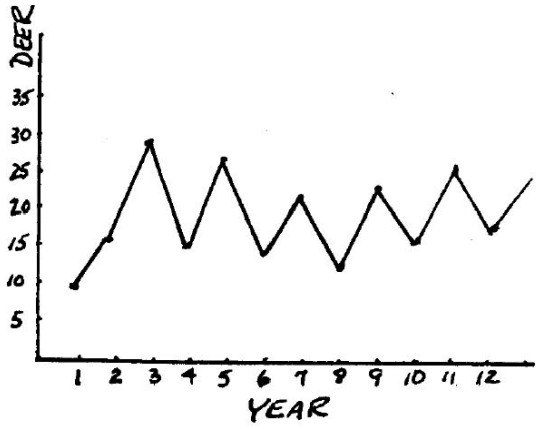
Procedure:

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.

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EVALUATE: Assessment 5. Light and Water as Limiting Factors Roaming Deer
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."

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ADDITIONAL ASSESSMENTS

Survival of Lions

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.

Cats: Limiting Factors

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.

Cats: School Officials

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?

Cats: Trapping Adults

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.

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Cats: Pheromones

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?

Cats: Living Space

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.

Cats: Closed School

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.