The Carrying Capacity of a Colony

Grade: 5

Subject Areas: Life Science, Earth Science, Mathematics

Skills: identifying, sorting, reading, discussing, recording

Duration: 1-2 hours

Connections: physical education, resource management, precipitation, water resources, vegetation, wildlife

Vocabulary

extinction
population
competition
dispersion
population density
population growth
carrying capacity
exponential growth
J curve
biomass
harvester ants

Objective:

Students will understand population dynamics in general and will apply carrying capacity to colonies of harvester ants.

Materials

- living ant specimens
- magnification (microscopes or magnifying glasses)
- pictures of ants
- petri dishes or jars to hold ants
- two different sized see-through containers (for demo)
- a pitcher of sand with an easy pour spout
- 6 12 oz. sealable plastic cups (salsa containers)6 20 oz. or larger sealable plastic cups (yogurt cups)
- small brown paper bags or cafeteria cups
- a time keeper
- pinto beans or other type of bean
- 6 pairs of blunt nosed plastic tweezers (to represent flickers)
- 6 plastic spoons (to represent bears)
- 12 paper cups (one for each predator)
- activity tables free of chairs (one per group)

Standards

Strands: Excellence in Environmental Education Guidelines
Strand 1 —A) Questioning: Learners are able to develop, focus, and explain questions that help them learn about the environment and do environmental investigations. **F) Working with models and simulations:** Learners understand many of the uses and limitations of models. **G) Developing explanations:** Learners are to synthesize their observations and findings into coherent explanations.
Strand 2 —2.2 The Living Environment: A) Organisms, populations, and communities: Learners understand that biotic communities are made up of plants and animals that are adapted to live in particular environments. **C) Systems and connections:** Learners understand major kinds of interactions among organisms or populations of organisms.
Strand 3 —3.1 Skills for Analyzing and Investigating Environmental Issues: B) Sorting out the consequences of issues: Learners are able to apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.

California State Educational Standards:
Life Sciences 2a: Students know many multicellular organisms have specialized structures to support the transport of materials.
I and E 5d: Students will predict the outcome of a simple investigation and compare the results with the prediction.

Background

Reaching Limits

No matter what ecosystem one studies each is unique and dynamic in its own way. Every ecosystem includes both living and nonliving factors. How these interact is very complex. For instance soils provide water and nutrients for plants. Within some soils live fungi that live in a mutualistic relationship and therefore benefit only certain plants. In some cases, plants cannot survive without the fungus present.

One indicator of a species' success, is its population size. When populations are large, they tend to have higher survival rates. As populations shrink, there is a higher risk of **extinction**. Generally speaking, the size of a **population** is the number of individuals of the same species within a specific geographical region.

Many factors influence the population size of a certain group including **competition** for space and food, rate of growth, and dispersion. **Dispersion** is the way individuals of a particular population are arranged in space. The main patterns of dispersion include random spacing, uniform spacing, and clumps. For instance, a driver may observe a dozen or more small falcons sitting on power lines as she drives down the highway. Driving at a constant rate, the driver begins to count the number of seconds between individuals and finds that they are evenly spaced. This is probably because each one of these falcons needs a certain area to hunt; and by spacing each other out, competition is reduced. The number of individuals in an area is referred to as **population density**. Larger plants and animals need more space and smaller plants and animals need less space.

Natural **population growth** is limited by resource availability, predation and disease. How many individuals an area can support for a prolonged period of time is called carrying capacity. **Carrying capacity** is an optimal number and is the point where population numbers begin to stabilize after a period of growth. Most populations are not at carrying capacity, however. Most populations follow a similar pattern of population growth. When resources are available, growth begins slowly and then reaches exponential growth over a certain period of time forming what is called a **J curve**. (If this trend were graphed, it would form the shape of the letter J). **Exponential growth** is when numbers begin to double quickly. This

Local Connection

Humboldt Wildlife Center

The Humboldt Wildlife Care Center (HWCC) is a non-profit and permitted organization that looks after injured and sick wildlife. It was established in 1979 and runs strictly on volunteer efforts. All volunteers are dedicated to the rescue, treatment, and rehabilitation of orphaned and injured wildlife in Humboldt, Trinity, and Del Norte Counties. Ideally, their hope is to rehabilitate wild animals so they are strong and healthy enough to be returned to their native habitat. Good information about how to help a sick or injured wild animal is available at their website (http://humwild.org)

The HWCC provides care for most native species of birds and small mammals, including protected and endangered wildlife. Animals that cannot be treated by the organization are transported to other specialized rehabilitation centers. They have popular educational outreach programs. For a small fee, teachers can request a variety of programs. If you would like to schedule a presentation, call (707) 822-8839 or e-mail contact@humwild.org. Ambassadors (animals unable to be returned to the wild) that may be brought into the classroom include hawks, owls, bats and the occasional falcon. Seeing wild animals up close is a great way for kids to learn about them and gain a deeper appreciation for them. The HWCC education team strives to expand awareness about wildlife and to enhance knowledge about our local ecosystems.

Ambassador Al: A Great Horned Owl (*Bubo virginianis*). She was brought in as a two month old with a broken wing after her nest tree was cut down. One of the people at the logging site rescued her. She cannot fly well enough or quietly enough to be in the wild. (from HWCC)

type of growth can best be modeled by the use of exponents. For instance 101, 102, 103 are equivalent to 100, 1,000, and 10,000 respectively. In this lesson, harvester ants will be used to model various principles affecting population growth and size.

Harvester Ants

There are many different kinds of ants living in many different habitats around the world. As a matter of fact, some sources claim that the weight of all ants combined on the planet would exceed the combined weight of all humans on the planet. That is a lot of ants! Regardless of whether this fact is true, we do know that ants are highly successful organisms. They inhabit every continent except Antarctica. They are of extremely important insects. They have close relationships with many plants and some reduce pests. Because ants live mostly underground, they aerate the soil and add nutrients to it. Ants are a type of insect and are related to bees and wasps.

Some of the many different kinds of ants are leaf cutter ants, fire ants, bullet ants, harvester ants, carpenter ants and weaver ants. There are many types of ants found in the King Range National Conservation Area including carpenter ants, harvester ants and "sugar ants". This lesson will focus on **harvester ants** because they can be easily found.

Western harvester ants are very social and have a complex social system. Ants like these have been referred to as "superorganisms" because they work together as a team acting like a single entity. A new fertilized queen starts a nest. After the nest is established, she lays many eggs, which become mostly sterile females. These sterile females are the workers. Most harvester ants build nests that are 2-10 inches high and 1-4 feet wide. Their nests can often be overlooked because at a mere glance they look like a pile of dirt. To stay warm, the colony of ants will cover their nest with nearby objects like rocks, dead leaves and charcoal camouflaging the nest even more.

Harvester ants get their name because they search far and wide for food. They do not leave trails or scent markings as they roam. Harvester ants mostly eat seeds and some insects, usually focusing on one type at a time during different times of the year. These kinds of ants have a clumped dispersion pattern compared to solitary ants meaning they live in a colonies.

The population of harvester ants fluctuates with the age of the colony and the degree of disturbance. Studies have shown that new colonies grow gradually and then very quickly over time show exponential growth; the classic "J shaped" curved. At least one study has revealed that older colonies can recover from disturbances more quickly than younger ones. Most ants don't live longer than one year however, the site of a colony may be reused for 15-20 years. Older nests tend to be much bigger than younger ones. Once it is time to mate, certain male ants grow wings, mate with a queen in flight and then die. Worker ants never mate.

There are several things that can directly affect population numbers and carrying capacity of Harvester ants such as space, competition and the availability of food. If birth rate is higher than death rate, a population will grow relatively rapidly. A healthy older colony tends to grow the fastest. One new challenge facing native ant species, is the arrival of an invasive non-native ant called the Argentine ant. This invasive ant is spreading worldwide and is competing for food and space.
An ant colony can get disturbed by predators. A type of woodpecker called the Northern Flicker eats mostly ants and will visit a colony many times to snack on them. Bears, skunks, and raccoons along with many other animals will also eat ants. Another major disturbance is human activity. By altering the landscape, habitat for ants can be reduced. By studying the populations of these amazing colonial organisms, people can begin to understanding their needs and relationship to the natural world.

Activity 1: Observing Ants

Preparation

If possible, collect ants out in the field. This may be difficult to do if it has been cold and rainy recently. Harvester ants will be the easiest to find if you find their nest. Solitary ants like woody areas. Sometimes, you may be able to find ants in barren parking lots or other warm places. Ants will be more active in the afternoon after the land has heated up. Collect at least a dozen ants and some leaf litter. If you need to do this the day before, you can store the ants in the refrigerator overnight without harming them. After one hour they should heat up enough to become active again. Be sure to return them as close to the place of collection as possible when you are done.

Materials

- **living ant specimens**
- **magnification (microscopes or magnifying glasses)**
- **pictures of ants**
- **petri dishes or jars to hold ants**

Procedure

1. Begin by introducing students to the world of ants by showing pictures of them. Point out the different features and let the students observe them using a magnifying glass or dissecting microscope. Give a gentle reminder that they should try not to injure the ants. Note: If they smash one it might stink because of the formic acid that is commonly released.

2.Situate the ants in containers that will not allow them to escape. Place them in several spots around the room to allow students to adequately view them up close. While in containers, have the students observe them up close using a magnifying glass. While observing have the students draw an ant including as many features as possible in the given amount of time.

3. After the students have observed the ants, ask the students what new features or behaviors they observed. Have the students share something about ants that they didn't know before today. You may want to go around the room and have every one say one new thing they have learned about ants after today's lesson.

- *What do you know about ants?*
- *What sort of animal is an ant?*
- *How many legs does ant have?*
- *Do ants sting?*
- *Do ants have antennae?*
- *Do ants have mouthparts?*
- *What do ants eat?*
- *What type of ant starts a colony?*
- *Does anyone know where ants live?*
- *How many ants to you think can fit into a colony?*
- *What kinds of animals eat ants?*

Activity 2: Modeling Carrying Capacity

Materials

- two different sized see-through containers (for demo)
- a pitcher of sand with an easy pour spout
- 6 12 oz. sealable plastic cups (salsa containers)
- 6 20 oz. or larger sealable plastic cups (yogurt cups)
- small brown paper bags or cafeteria cups
- a time keeper
- pinto beans or other type of bean
- 6 pairs of blunt nosed plastic tweezers (to represent flickers)
- 6 plastic spoons (to represent bears)
- 12 paper cups (one for each predator)
- activity tables free of chairs (one per group)

Preparation

Fill each brown bag with 100 or more pinto beans. Find out how many kernels fill the containers being used ahead of time.

Procedure

1. Before the students begin the simulation, define carrying capacity and draw a "J-shaped" graph on the board. Next, perform this quick demonstration. Hold out a small see-through container and begin to slowly fill it with sand until the half way point. While doing so, explain to the students that the container represents the amount of space a population has and the sand represents a population (how much of something there is). Explain that the capacity of the container has not yet been reached. Ask them to tell you at what point will carrying capacity be reach. Say "tell me when". Increase the flow rate as you fill up the container. Once the sand touches the brim of the container, carrying capacity has been reached (hopefully several students will have shouted out "when"). Continue to pour more sand into the container even though it overflows, and ask the students if think they thing carrying capacity is ever exceeded in nature.

2. Tell the students to think of the sand as the population of something — say grasshoppers. Referring to the demonstration, Ask: "Where would the extra (overflow) grasshoppers go? (they die). Why would the grasshoppers die? (not enough resources to sustain them) Next ask: "What would have to change in this situation to allow more grasshoppers to live? (a larger container is needed — more space or food, etc.). Repeat the demonstration, this time using a larger see-through container. Try and use the same volume of sand and begin pouring again. Once you have finished, ask the students to come up with certain factors that may influence the size of any given population. Write these factors on the board (food, competition, space, predation, etc.).

3. Next, explain to the students how population growth is calculated. Growth = birthrate — death rate. Refer to a graph of a "S-shaped" curve including a point where the growth rate levels out or stabilizes. Label this point carrying capacity. Ask the students where on the graph a full container is represented. Option: Have the students take notes.

4. Ask the students to come up with factors that may influence the size and growth rate of an ant colony specifically. Briefly describe an ant colony to them. Tell the students they are going to perform an activity where predation is the main factor. Lay down some safety rules to avoid rough competition like kicking and grabbing one other.

Overview

1. The following activity is designed to show factors affecting population growth and carrying capacity of a colony of ants. The beans (in brown bags) represents newly hatched ants. The different sized plastic containers represent the area in which a population lives. Every bean added to the container represents a newly hatched ant. There are two predators in this simulation: flickers and bears. Flickers are a type of woodpecker that eat ants. Those students who are flickers

will try and "eat" ants using a pair of blunt nosed tweezers. Bears "eat" ants using a spoon. Predators will disrupt the colony and reduce population numbers. The purpose is for the "ants" to reach carrying capacity as fast as possible.

2. If time allows, the students should repeat the exercise to compare different volumes of containers. They should get a count of ants per container and then compare numbers. How does carrying capacity change with additional space? They should first start with a small container.

3. To begin, separate the students into groups of four or six. Have a central container to represent the ant colony. This activity will move quickly so you may want to use a group to model the exercise slowly first. Which role students have can be determined by counting off. Flickers will be given a pair of tweezers and bears will be given a spoon. Both should be given cups which represents their stomach. Predators need to get the popcorn into a cup in order to "eat" successfully. All other students will be given a bag of beans (ants). For groups of four have 3 "ant hatchers" and 1 predator. For groups of 6 have 4 "ant hatchers" and 2 predators. The students who have the beans need to move the beans from their bag to the central container using their hands. This should be done one kernel at a time as fast as they can. No one should start until the instructor gives a signal. This activity should be timed. Predators should enter after 15 seconds or so (use a time keeper).

4. Explain to the predators that they will not enter the scene for 15 seconds, so in the beginning, they should stand three steps away from the "ant colony". Give a signal and have all groups start filling their colony at the same time. After 15 seconds, have the predator(s) come in. They should take beans away as fast as they can. To start, the instructor should shout out "predators go!" The game is over when the ants have reached carrying capacity or after _____ minutes. Note: The instructor should lay down some basic rules before beginning. Any colony that spills their container, dies. If a predator spills the container, he or she is disqualified. Feel free to add other consequences.

5. After the salsa tub has been filled to capacity, each colony of "ants" should count their population (number of beans). These numbers should be recorded on a data sheet. Repeat the simulation using a larger container. Note: you may have to add more beans to their brown bags in order for them to reach carrying capacity. Have the students compare the sizes of the two populations once finished. Before ending the session completely, review with the students some of the main concepts leaned this activity.

- *In this simulation, when was carrying capacity reached?*
- *How did the two populations differ?*
- *What challenges did each population face?*
- *What are some of the limits of using a simulation or a model to represent real life?*
- *In real life, what factors influence the size of a population?*
- *Which ones were missing in this simulation?*
- *What sorts of human activities affect natural population sizes?*
- *Do populations normally reach carrying capacity?*

Extensions

- Have students graph changes in a population over time and have them interpret these graphs.
- Have the students find their lung capacity by trying to fill a balloon in one exhale.
- Encourage students to make a model of a human heart and research the capacity of blood that a healthy human heart can pump.
- Raise an ant colony in the classroom by buying an ant farm.

References

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