Population Size and Limiting Factors

**MS.SC.2.1** - Describes the different ways organisms interact with each other.

**MS.SC.2.4** - Explains how and why communities of living organisms change over time.

Watch: Bozemonscience.com Human Population Size [https://www.youtube.com/watch?v=QShgk6FriX0](https://www.youtube.com/watch?v=QShgk6FriX0) ~10min

Watch: moomoomath.com Limiting Factors in an Ecosystem [https://www.youtube.com/watch?v=pPw51fDTi68](https://www.youtube.com/watch?v=pPw51fDTi68) ~2min

Watch Bozemonscience.com Population Ecology [https://www.youtube.com/watch?v=PQ-CQ3CQIE3g](https://www.youtube.com/watch?v=PQ-CQ3CQIE3g) 5:41 of ~12 minutes at least

(Time Notes on the last video if you’d like-especially the flow chart and the formula to determine growth rate. See Hand Drawn Chart On back of packet for ease of taking notes.)

**Here are Notes you can keep for your binder – you can scan or read/highlight as you see fit.**

**How many penguins is the right number for this beach?**

As many as can survive and have healthy offspring! A population will tend to grow as big as it can for the resources available in its environment. Once the population is too large, some of its members will die off due to competition for space, food or water, or in some cases, some may migrate to a new location. This keeps the population size at the right number.

**Populations**

Biotic and abiotic factors determine the population size of a species in an ecosystem. Biotic factors include the amount of food that is available to that species and the number of organisms that also use that food source. Abiotic factors such as space, water, and climate all help determine a species population.

A population grows when the number of births and immigrated organisms is greater than the number of deaths and emigrated organisms. A population shrinks when deaths exceed births. For a population to grow there must be ample resources and no major problems. A population can shrink either because of biotic or abiotic limiting factors. An increase in predators, the emergence of a new disease, or the loss of habitat are just three possible problems that will decrease a population. A population may also shrink if it grows too large for the resources required to support it, in other words, if there is not enough food, water or space to go around.

**Carrying Capacity**

The carrying capacity of a biological species in an environment is the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment. The carrying capacity depends on biotic and abiotic factors. If these factors improve, the carrying capacity increases. If the factors become less plentiful, the carrying capacity drops. If resources are
being used faster than they are being replenished, then the species has exceeded its carrying capacity. If this occurs, the population will then decrease in size through either death or emigration of some of its members.

**Limiting Factors**

Every stable population has one or more factors that limit its growth. A **limiting factor** determines the carrying capacity for a species. A limiting factor can be any biotic or abiotic factor: nutrient, space, and water availability are examples.

The size of a population is tied to its limiting factor.

In a desert such as this, what is the limiting factor on plant populations?

What would make the population increase?

What would make the population decrease?

What happens if a limiting factor increases a lot?

Is it still a limiting factor? If a limiting factor increases a lot, another factor will most likely become the new limiting factor.

This may be a bit confusing, so let’s look at an example of limiting factors. Say you want to make as many chocolate chip cookies as you can with the ingredients you have on hand. It turns out that you have plenty of flour and other ingredients, but only two eggs. You can make only one batch of cookies, because eggs are the limiting factor. But then your neighbor comes over with a dozen eggs. Now you have enough eggs for seven batches of cookies, but only two pounds of butter. You can make four batches of cookies, with butter as the limiting factor. If you get more butter, some other ingredient will be limiting.

Species ordinarily produce more offspring than their habitat can support (**Figure** below). If conditions improve, more young survive and the population grows. If conditions worsen, or if too many young are born, there is competition between individuals. As in any competition, there are some winners and some losers. Those individuals that survive to fill the available spots in the niche are those that are the most fit for their habitat.
Review  (verbally, or by writing answers, with class, table group, partner or self)

1. What is carrying capacity?

2. What does reaching the carrying capacity do to population growth?

3. What does carrying capacity depend on?

4. What happens if a population exceeds its carrying capacity?

5. Is the carrying capacity constant? What changes it?

6. How do natural disasters affect the population size in a region?

7. Why don't populations continue to grow and grow?

8. What happens if a factor that has limited a population's size becomes more available?
LIMITING FACTORS
All living things need food, water, shelter and space to survive. As long as organisms have all of these things available to them their population will continue to grow. However, populations cannot grow forever. Some form of environmental resistance will stop the population’s growth. The form of environmental resistance is called a limiting factor since it limits the population. However, limiting factors may also increase a population. We will look at many different limiting factors and classify them into density independent factors and density dependent factors.

KEY TERMS THAT WILL HELP YOU IN YOUR READING
- **Natural disasters**: disasters caused by nature
- **Toxic**: poisonous
- **Aquatic**: taking place in or on the water
- **Depletion**: the use or consumption of a resource
- **Tributaries**: a stream that flows into a larger stream or other body of water
- **Invasive**: moves in without right or permission, intrusive
- **Density**: organisms per unit area
- **Tail races**: area of water located behind a dam
- **Penetrate**: to enter or force a way into
- **Turbid**: degree of cloudiness of water

YOUR TASK
1. Read the notes on limiting factors; use what you learn to fill out the graphic organizer with text and symbols
2. Read the scenario about Lake Winnipeg and answer the analysis questions at the end of the article, identifying the limiting factors that affect the survival of the yellow perch.
3. Follow the story about a population affected by many limiting factors. Determine how many remain at the end.
4. If there is time, make up your own story for a partner, your table, or the class to follow.

WHAT ARE LIMITING FACTORS?
All living things need food, water, shelter and space to survive. As long as organisms have all of these things available to them their population will continue to grow. However, populations cannot grow forever. Some form of environmental resistance will stop the population’s growth. The form of environmental resistance is called a limiting factor since it limits the population. However, limiting factors may also increase a population. We will look at many different limiting factors and classify them into density independent factors and density dependent factors.
DENSITY INDEPENDENT FACTORS

Density independent factors can affect a population no matter what its density is. For example: natural disasters, temperature, sunlight, human activities, physical characteristics and behaviors of organisms affect any and all populations regardless of their densities.

*Natural disasters* such as droughts, floods, hurricanes and fires can be devastating to aquatic life. For example, a severe drought could lower the water levels of Lake Winnipeg and decrease its carrying capacity. Thus, the fish population would decrease.

*Temperature* influences the activity and growth of organisms. Temperature also determines which type of organisms can live in a lake. Usually, higher water temperature increases the activity in a lake. However, all aquatic species have a preferred temperature range. If temperatures vary too much out of this range the species will either die or move to a different location. Temperature also influences the chemical properties of water. The rate of chemical reactions in the water increases as temperature increases. For example, warm water holds less oxygen than cool water, so even though there is more activity in warm water there may not be enough oxygen for the activity to continue for long periods of time.

*Sunlight* can only penetrate to a depth of 30 meters in water. Thus most photosynthesis in aquatic environments occurs near the surface. This means that most plants cannot grow if they are at the bottom of a deep lake.

*Human activities* can also affect population dynamics. For instance, lake sturgeon spawn in fast water and sometimes use the “tailraces” of hydroelectric dams. However, the water level in this location often drops suddenly and the eggs die because they become exposed. Other human activity includes farming, logging, mining, hunting, fishing, building a subdivision, etc.

*Physical characteristics* of organisms can affect their population. Many organisms have adapted and evolved in order to increase their chance of survival. For example, some species of fish have colored markings to warn predators that they may be toxic. Or, some species use camouflage colors to help them hide and avoid being eaten.

*Behaviors* of organisms can also affect their population. For example, some species migrate to find new food sources or to mate. Some organisms create societies or feeding territories. For instance, white bass live in schools and work together to drive emerald shiners to the surface for feeding. Some species may have mating or courtship behaviors that affect their population.
DENSITY DEPENDENT FACTORS

Density dependent factors can only affect a population when it reaches a certain density. For example, competition, predation, disease, parasitism, crowding, and stress are all factors that only affect populations with high densities.

*Competition* can occur between many organisms that live in the same habitat. Resources are limited in a habitat so organisms must compete for food, water, space, and shelter. For example, both northern pike and walleye prey on yellow perch and so they compete for the same food source. However, this competition is only apparent when the populations of northern pike and walleye have high densities OR the population of yellow perch has a low density.

*Predation* occurs when the population density of predators is high. The predators will consume their prey and increase their own population. However, the population of the prey will decrease. On the other hand, the lack of predation (when the population density of predators is low) will cause problems for the prey’s population. When there are few predators, the prey’s population increases very quickly and this can lead to the depletion of resources and increase disease.

*Disease* in a population increases with the density of that population. High densities make it easier for parasites to find hosts and spread the disease.

*Parasitism* is a relationship in which one species benefits at the expense of the other. A parasite is an organism that lives in or on another organism (called a host) to get nourishment. While the parasite benefits from this relationship the host is harmed or killed.

*Space Availability* is the amount of space available for an organism to live. Organisms require a certain amount of space in order to survive. Over-crowding can cause depletion of resources, disease and stress on the organisms.

*Stress* usually has a negative effect on populations. Stress can make organisms weak and more prone to disease.
Limiting Factors

Any Abiotic or Biotic factor that restricts the number or reproduction of organisms in an ecosystem

Independent Factors

Factors that can affect a population no matter what its density is

Dependent Factors

Factors that can only affect a population when it reaches a certain density
SCENARIO: YELLOW PERCH IN LAKE WINNIPEG

Located 712 feet above sea level, Lake Winnipeg is a shallow lake composed of two basins: a wide north basin and a narrow south basin. On average, Lake Winnipeg is only 40 feet deep and receives 20.3 inches of precipitation annually.

Lake Winnipeg provides a habitat for over 50 different species of fish including yellow perch, chestnut lampreys and rainbow smelt. Yellow perch prefer water that has little current. They can tolerate moderate turbidity. Also, they prefer a temperature range of 64 to 68 degrees Fahrenheit. If the temperature of the water varies too much above this range, yellow perch will either move to a new location or die.

Yellow perch spawn in May or early June when water temperatures are above 43 degrees Fahrenheit. First, they migrate to tributaries and then several males attend a female while she releases her eggs. Yellow perch can grow to 12 inches in length. Their life span is approximately 9 years. If there is a lack of resources or too many of them (over-population), yellow perch adapt by stunting. This means that instead of starving, they simply do not grow as large as normal. Thus, they are able to live off less food.

Yellow perch feed in midwater or on the bottom of Lake Winnipeg. They eat a wide variety of invertebrates, and fish such as emerald shiners (the fish pictured at right). The eyes of yellow perch allow them to see almost 360 degrees around them. Thus, they are better able to spot their prey and evade predators.

In Lake Winnipeg, yellow perch are eaten by northern pike and walleye. They are also caught for food by commercial fishers and anglers. Chestnut lampreys are also found in Lake Winnipeg. Lampreys (pictured at left) are parasitic fish that attach to other species of fish (such as yellow perch) to feed on their blood and tissues. Recently, rainbow smelt have been introduced into Lake Winnipeg. Rainbow smelt are a very invasive and competitive species. They have been thought to have caused a decrease in the emerald shiner population.

Lake Winnipeg provides a home for many species of fish. However, a severe drought could disrupt this ecosystem greatly. Lake Winnipeg’s water level would drop, the temperature could change and it could become more turbid. Thus, the carrying capacity of the lake would change. But, in its current condition, Lake Winnipeg is an excellent habitat for many species of fish.
ANALYSIS

Each of the statements below involves a situation that will affect the growth of a population. Identify the limiting factor at work, talk as a class, at your table or with a partner to explain why you chose the limiting factor, and then circle the appropriate type of limiting factor.

1. Rainbow smelt and yellow perch attempt to occupy the same area. The more aggressive smelt survive; the perch do not.
   Limiting factor?
   Pair/Share Explanation
   Density dependent or density independent?

2. A severe flood brings a lot of sediment and silt into Lake Winnipeg. The turbidity of the lake increases greatly.
   Limiting factor?
   Pair/Share Explanation
   Density dependent or density independent?

3. A drought decreases the water level in Lake Winnipeg. The carrying capacity of the lake decreases.
   Limiting factor?
   Pair/Share Explanation
   Density dependent or density independent?

4. Due to the introduction of rainbow smelt, Lake Winnipeg becomes crowded and some fish species do not survive.
   Limiting factor?
   Pair/Share Explanation
   Density dependent or density independent?
5. Since northern pike prey on yellow perch, an increase in the perch population causes an increase in the pike population.
   Limiting factor?________________________________________________________
   Pair/Share Explanation
   Density dependent or density independent?

6. Many fish die due to an increase in water temperature.
   Limiting factor?________________________________________________________
   Pair/Share Explanation
   Density dependent or density independent?

7. Due to over-fishing, the number of walleye in Lake Winnipeg decreases.
   Limiting factor?________________________________________________________
   Pair/Share Explanation
   Density dependent or density independent?

8. A population is growing quickly when parasites cause disease to spread quickly.
   Limiting factor?________________________________________________________
   Pair/Share Explanation
   Density dependent or density independent?

9. Since lake sturgeon migrate long distances to spawn, many do not survive the trip.
   Limiting factor?________________________________________________________
   Pair/Share Explanation
   Density dependent or density independent?
Once upon a time there were 10 bunnies. Two mother bunnies each had 3 baby bunnies. Then 2 baby bunnies were caught by a hawk. Two old bunnies died of a disease. Three adolescent bunnies emigrated to a new field in search of adventure. One mother bunny had 4 baby bunnies. Three bunnies from a neighboring farm came looking for a new home and decided to stay. Then the farmer caught two bunnies and gave them to a girl down the street. A teenager down the road got a gun for Christmas and went out hunting and got 2 bunnies for his mom to cook for supper. She used the fur to make some gloves for him. Sadly three bunnies got hookworm, and two of them died. One lived long enough to have 2 baby bunnies, but it was too stressed out from the birth while sick and weak that it died. The temperatures dropped and all the bunnies started to grow in their white winter coats, which was good, because the hawk was back and had taken another bunny. The logging crew down the road clear cut the land and a whole family of 8 bunnies immigrated to live with their cousins. One of them brought a disease with it and died with its mate who had also been infected. In the spring, four of the bunnies mated and the mother bunnies each had 4 baby bunnies! Unfortunately a big spring thaw flooded the area and two of the babies didn’t survive the necessary relocation. When the sun came out for weeks at a time and the weather got really hot in July, they had a hard time finding food to eat. Everything was so brown and dry, there just was not enough food or water to go around. The whole family was getting weak from lack of food and water, except two of the bunnies who were selfish and hogged much of it. Those two were strong enough to mate and have a fine litter of six bunnies, but five of the others emigrated to a neighboring town in search of more resources. Five others died from malnutrition. Two others were caught by predators since they were two slow from being hungry. Luckily a nice summer storm came in and filled up puddles full of water, and made the whole countryside green again. Then the farmer forgot to put fencing around his vegetable garden and they really had a feast. They got so full and healthy that all eight of the females had 3 baby bunnies each. Their little family was the largest it had ever been. How many were there in all?