Limiting Factors

Nothing lives forever. Even the ancient bristlecone pine trees of the high mountains of the western United States die after a few thousand years. Most organisms live much shorter lives. Many insects live a few months; fish and small mammals a few years; many plants, reptiles, birds, and large mammals a few decades; and a scattering of others, like trees, a few centuries. Life is a temporary thing...for the individual.

If a species is to continue to exist on Earth, the species must produce new individuals continually. Producing new individuals to maintain a population is **reproduction,** and every species has a way of reproducing.

The rate at which a species can increase its population is its **reproductive potential.** Some species, like elephants, have modest reproductive potential. A female elephant reproduces a single offspring every 4 years. A single female Atlantic cod, on the other hand, can lay 10 million eggs a year. Clearly the potential for the cod to increase its population is much greater than the potential for the elephant to increase its population.

So why don't populations spiral out of control? Why aren't there billions of billions of trillions of Atlantic cod filling all the oceans from top to bottom after 5 or 10 years? Because there are **limiting factors** imposed on every population on Earth. Limiting factors control the sizes of populations.

BIOTIC LIMITS: PREDATION

One way that populations are limited is through **predation.** Every organism is desirable to some other organism as a source of food. As we know, food provides the energy that is essential for survival. Therefore, if a species reproduces a lot of biomass, it will attract predators to take advantage of the energy source. We see this kind of population control in Mono Lake when the brine shrimp feed on the planktonic algae, reducing their numbers, and in turn the brine shrimp are eaten by phalaropes and gulls, reducing the population of shrimp. Predation can occur at any stage in the life cycle of an organism, including eggs and seeds, young, mature, and old. Populations are limited by removal of individuals as they are eaten.

Diseases limit populations in the same way. Even though we don't usually think of a large animal or plant being attacked by a microscopic bacterium, the result can be the same. A mountain lion capturing a deer, or a hawk taking a squirrel, removes an individual organism from the population. A disease organism can enter a population and kill many organisms, which also limits the size of the population.

BIOTIC LIMITS: RESOURCES

Populations are limited by food supply. If an organism cannot acquire the energy needed to survive and reproduce, the population will decline and, with it, the potential for producing the next generation. If a snake cannot find enough mice to

sustain itself, it will starve to death. Even if it survives, it may be so weak that it can't reproduce. Similarly, if there is a poor crop of acorns, squirrels may starve. Even if they survive, they may not be able to feed their young. In 1982 a reduced population of brine shrimp in Mono Lake prevented the California gulls from successfully feeding their chicks. Most of the gull offspring died that year. Lack of food is one of the most important limitations on populations.

ABIOTIC LIMITS: REPRODUCTIVE ENVIRONMENTS

Many organisms require specific conditions in order to reproduce. If the number of locations where reproduction can occur or their quality is limited, reproduction will be limited. Bank swallows need sandy cliffs in which to dig nesting burrows. If a sandy cliff tumbles down during a flood or earthquake, suitable nesting sites are lost. Salmon need clean gravel streambeds in which to lay their eggs, and black bears need winter dens in which to give birth. Without an environment that provides for the physical conditions needed to reproduce, young will not be born. Lack of access to required reproductive environments for a species limits populations.

ABIOTIC LIMITS: SEASONS

Seasonal changes put pressure on populations. In the temperate and polar latitudes, winter is a major factor in population limitation. During winter, days are shorter, so primary production by photosynthetic organisms slows or, in the case of deciduous trees, stops entirely. Often winter brings rain, snow, and wind, each of which adds stress to populations. Some animals respond to the threat of wind, flood, and freezing by leaving the area. Birds, because of their mobility, are famous for migrating to warm regions. Others, like the American bison and caribou, go on long treks to find greener winter environments. Some organisms become dormant, basically shutting down until spring. Frogs, fish, bears, squirrels, snakes, maple trees, and hosts of other organisms use dormancy, reduced activity, and winter sleep to wait out the winter.

These strategies work if a number of conditions have been met:

- The wintering place offers sufficient protection.
- The organism has accumulated enough fat or has stored enough food to survive the winter.

Winter is the main limiting factor for many temperate and polar populations. Many populations decline to minimal levels, like the brine shrimp in Mono Lake, and then expand rapidly in the spring. Seasonal fluctuations in population size such as those at Mono Lake are normal and healthy.

CARRYING CAPACITY

When you stand back and take the large view of life on Earth, you realize it is a struggle to survive there. Every living thing has fundamental requirements for life, and if it doesn't get those things, it dies. One of the most critical requirements is energy.

Energy enters the ecosystem as sunlight. Photosynthetic organisms capture the energy and transform it into carbohydrates, like sugar, that we call food. The energy is in the chemical bonds. The amount of food

that can be produced is limited by several factors, including access to light, space for living, and availability of resources such as water, carbon dioxide, and minerals. For any given ecosystem there is a limit to the amount of food that the producers can make.

We know that the other populations in an ecosystem acquire energy by eating each other. Primary consumers eat producers, secondary consumers eat primary consumers, and so on. The number of consumers is limited by the amount of production.

The total number of individuals of a population that can be sustained indefinitely by an ecosystem is the **carrying capacity** for that species. For instance, a backyard ecosystem might support three rabbits year after year on the amount of grass and other vegetation growing there. The carrying capacity for rabbits is three. If six rabbits move in, the carrying capacity of the ecosystem is exceeded. As a consequence, in order to survive, the rabbits will eat so much of the vegetation that they will damage the ability of the producers to produce in the future. Exceeding the carrying capacity of an ecosystem always produces changes that will alter the nature of the ecosystem.

In an ecosystem the consumers never eat all the organisms they prey upon. Squirrels never eat all the acorns, caterpillars never eat all the oak leaves, mountain sheep never eat all the grass, sharks never eat all the seals, and so on. This is very important because if they did, the prey species would be gone. The predators' offspring would have nothing to eat, and the predator population would die off. In healthy ecosystems there are always survivors of every kind in sufficient numbers to reproduce and keep the population going.

Usually the primary producers establish the overall carrying capacity of an ecosystem. How much food energy is produced by the photosynthesizers that can be consumed and distributed throughout the food web of the ecosystem? When you know the answer to that question, you are closer to knowing the carrying capacity of the ecosystem.

Mono Lake is an ecosystem with a tremendous carrying capacity for its size. Mono Lake has plenty of light, water, carbon dioxide, and minerals. The algae reproduce rapidly. The limiting factor for Mono Lake algae is one element—nitrogen. Even so, the biomass of algae produced in the lake supports trillions of brine shrimp and brine flies. These in turn nourish millions of birds and a few coyotes. A lot of life flows through Mono Lake each year.

Contrast this with a grassland on the Great Plains. Grasses grow more slowly, thus taking longer to regenerate their biomass. The amount of grazing by insects, rodents, deer, and cattle must not exceed the capacity of the grasses to regenerate. The carrying capacity of the grassland is less than the carrying capacity of Mono Lake.