

SHELFORD'S LAW & CONCEPT OF LIMITING FACTOR

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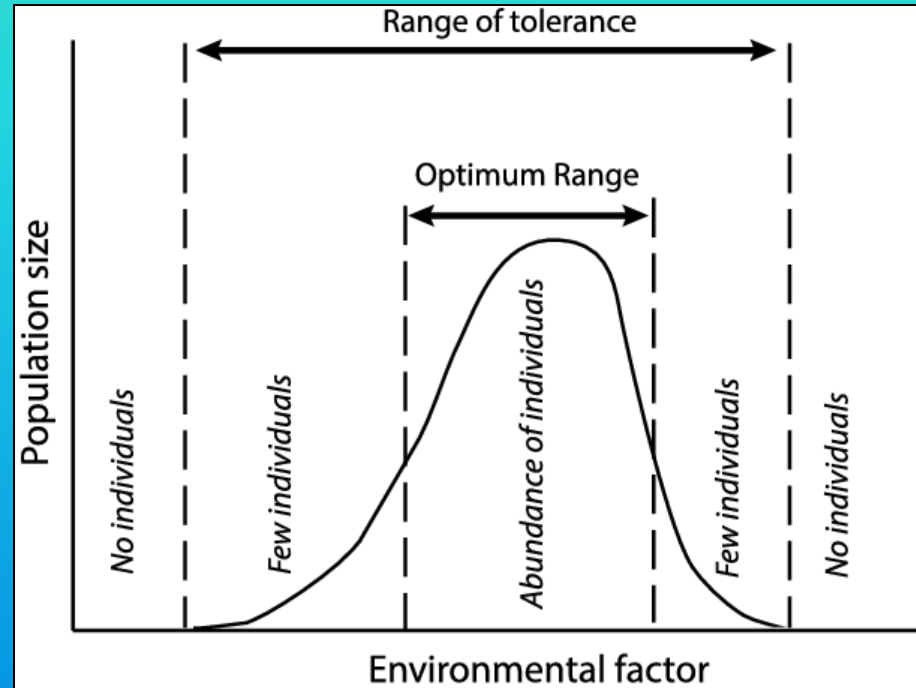
Shelford's Law of Intolerance

- Shelford's law of tolerance is a principle developed by American zoologist Victor Ernest Shelford in 1911.
- Shelford's law of tolerance states that an organism's success is based on a complex set of conditions and that each organism has a certain minimum, maximum, and optimum environmental factor or combination of factors that determine success.
- According to the law of tolerance, populations have optimal survival conditions within critical minimal and maximal thresholds.
- As population is exposed to the extremes of a particular limiting factor, the rates of survival begin to drop.

Shelford's Law of Intolerance

- The distribution of a species in response to a limiting factor can be represented as a bell-shaped curve with three distinct regions:
 1. **Optimal zone:** Central portion of curve which has conditions that favour maximal reproductive success and survivability.
 2. **Zones of stress:** Regions flanking the optimal zone, where organisms can survive but with reduced reproductive success.
 3. **Zones of intolerance:** Outermost regions in which organisms cannot survive (represents extremes of the limiting factor).

Shelford's Law of Intolerance



- According to the Shelford's law of tolerance, there are upper and lower threshold value on the gradient beyond which the species cannot survive. Tolerance range differ for one species to another.

Definition of Limiting Factor

- A limiting factor is a resource or environmental condition which limits the growth, distribution or abundance of an organism or population within an ecosystem.
- These can be either physical or biological factors which can be identified through a response of increased or decreased growth, abundance, or distribution of a population, when the factor is changed and when the other factors necessary to life are not.
- Limiting factors are theorized under *Liebig's Law of the Minimum*, which states that “growth is not controlled by the total amount of resources available, but by the scarcest resource”.

Limiting Factor Definition

- A limiting factor restricts organisms from occupying their *fundamental niche* and results instead in the fulfillment of their actual or *realized niche*.

✓ **Fundamental Niche** – The total range of environmental conditions that is suitable in order for an organism to exist, in the absence of limiting factors.

✓ **Realized Niche** – The actual amount of resources or environmental conditions that an organism is able to utilize within an ecosystem.

Types of Limiting Factor

□ Density Dependent Factors

- Density dependent factors are those factors whose effect on a population is determined by the total size of the population.
- Predation and disease, as well as resource availability, are all examples of density dependent factors.
- As an example, disease is likely to spread quicker through a larger, denser population, impacting the number of individuals within the population more than it would in a smaller, more widely dispersed population.

Types of Limiting Factor

□ Density Independent Factors

- A density independent limiting factor is one which limits the size of a population, but whose effect is not dependent on the size of the population (the number of individuals).
- Examples of density independent factors include environmentally stressful events such as earthquakes, tsunamis, and volcanic eruptions, as well as sudden climate changes such as drought or flood, and destructive occurrences, such as the input of extreme environmental pollutants.
- Density independent factors will usually kill all members of a population, regardless of the population size.

Types of Limiting Factor

□ Physical and Biological Limiting Factors

- Limiting factors can also be split into further categories. Physical factors or abiotic factors include temperature, water availability, oxygen, salinity, light, food and nutrients; biological factors or biotic factors, involve interactions between organisms such as predation, competition, parasitism and herbivory.

Examples of Limiting Factors

□ Resources

- Resources such as food, water, light, space, shelter and access to mates are all limiting factors. If an organism, group or population does not have enough resources to sustain it, individuals will die through starvation, desiccation and stress, or they will fail to produce offspring.
- In the case of photosynthesizing organisms such as plants, light is a vitally important limiting factor, essential for their growth. This is most prominent in understory plants of a forest, where photon energy from light is made less available, as it is unable to penetrate through higher canopy levels. However, many different plants are adapted to withstand different levels of light, allowing them to survive with less light energy input

Examples of Limiting Factors

- As well as light, growth of plants is limited by the availability of the nutrients nitrogen (N), phosphorus (P), potassium (K) and sulfur (S). Each plant needs a specifically balanced ratio of these nutrients in order to survive. If one of the nutrients is not present in sufficient amounts, this is considered the limiting factor to growth.
- The limiting resource within an ecosystem determines the *carrying capacity* (K).

✓ **Carrying Capacity** – The number of populations or organisms within a population, which an environment can sustain indefinitely without environmental degradation.

Examples of Limiting Factors

- In an ecosystem with unlimited resources, no predators and no disease, populations may experience exponential growth. The carrying capacity therefore acts as a moderator of population size; once limiting resources start to become depleted by increasing numbers of individuals, *intraspecific competition* occurs and the growth rate of the population begins to slow as individuals die or fail to reproduce. Eventually the growth rate levels off at a plateau – this plateau is the carrying capacity. Once the carrying capacity of an environment has been reached, individuals may begin to search for resources elsewhere, migrating away from the original population and creating new populations. If the populations become separated indefinitely, this can lead to *speciation*.

Examples of Limiting Factors

□ Environmental Conditions

- Limiting factors are also present as environmental conditions. Two of the most prominent examples are temperature and precipitation; these are widely affected by the climate, and seasonal changes within the climate. The effect that each factor has on a particular organism is determined by each individual species' *life history traits*.
- Maintaining a correct body temperature is vitally important for almost all organisms in order to perform metabolic functions effectively. With many organisms, this means they can only inhabit certain depths, as in marine organisms, certain elevations, as in mountain dwelling animals and plants, and certain latitudes of the earth, i.e. the tropics or the Northern hemisphere.

Examples of Limiting Factors

- Although sunlight tends to be a factor which controls the temperature of a habitat, and thus affects photosynthesis in terms of photon energy, correct temperature is also important for *catalyzing enzymes* in photosynthetic reactions. Above the optimum temperature, enzymes are catalyzed at an increased rate, which can lead to *denaturing* of the enzymes. This is called a *light independent reaction*. Increased temperature also leads to desiccation of leaves, as it causes increased *evapotranspiration* and removes too much water from the plant. Conversely, if temperatures fall too low, frost may form on leaves, which damages the cell walls and cell contents.

Examples of Limiting Factors

- The amount of precipitation in an environment is also important for plants. The absorption of water as a resource is vital for plant growth and other functions, so lack of rainfall can lead to wilting, scorching and damaged cells. Precipitation is also important because many plants are evolved to withstand different amounts of atmospheric humidity. As the thin, tough leaves of cacti make them specifically adapted to surviving in hot and arid conditions, too much rainfall can affect their ability to reproduce, which in turn restricts the population growth. Too much rainfall may also flood the soil, reducing the amount of oxygen available to the roots, causing root loss or leaving the plants susceptible to fungal damage.

Examples of Limiting Factors

□ Biotic factors

- As well as resource and climatic factors affecting population growth, biotic factors such as *predation*, *herbivory*, *parasitism*, and interspecific and intraspecific competition, are also limiting factors; these tend to be density dependent factors.
- Parasitism, like disease, is generally more destructive to large, dense populations because the parasite is able to effectively parasitize more individuals if they are in close contact. Within tropical ecosystems, the Cordyceps fungus is a prominent parasite, and has many strains specialized on different species. Because it is such a successful parasite, it keeps many populations down, working as a limiting factor, and it is thought to be one of the main reasons that most species in tropical rainforests are *rare*. The availability of host species, which the Cordyceps fungus can parasitize, is a limiting factor for the fungus.

Examples of Limiting Factors

- The population density of predators and prey are limiting factors for each of these parties. If a population, for example deer, reaches high numbers because there has been an increase in a resource that is their limiting factor – such as increased tree growth after a warm summer – their predators, for example, wolves, will experience an increase in their food source. The wolf population, with a surplus of deer to eat, may then be able to reproduce more freely, increasing their own population. As the population of wolves increases, they will require the high number of deer, which was available as their limiting factor when the population grew. As the wolves heavily predate the deer populations, the resources will eventually become scarce, and the wolf population will no longer be sustainable. As wolves die, pressure on the deer population is reduced and the numbers will be able to increase again; thus the cycle continues.

Examples of Limiting Factors

❑ Human Limiting Factors

- The increase in human population is responsible for placing many limiting factors on species that did not historically exist. Density dependent limiting factors such as decreased availability of space due to deforestation is a global issue, causing decline and extinctions in many populations.
- Resources are also increasingly scarce due to hunting and leaching of nutrients from soil, which causes intraspecific and interspecific competition within and between populations. Removal of predators has also disturbed the balance of natural biotic, cycle of predators and prey; in some cases, prey animals have been able to thrive in the absence of predators, exceeding the carrying capacity of ecosystems and causing environmental damage. Predators have also been introduced as *invasive species* into ecosystems, putting pressure on prey populations and thus on the prey's natural predators.

Examples of Limiting Factors

- There are also many density independent factors that have been caused by humans. Leaking pollutants and other habitat destruction has destroyed entire ecosystems. The onset of *climate change* as a result of burning *fossil fuels*, is rapidly increasing global temperatures, as well as changing weather patterns and increasing the rate of natural disaster events, such as hurricanes, floods, fires and more.

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