

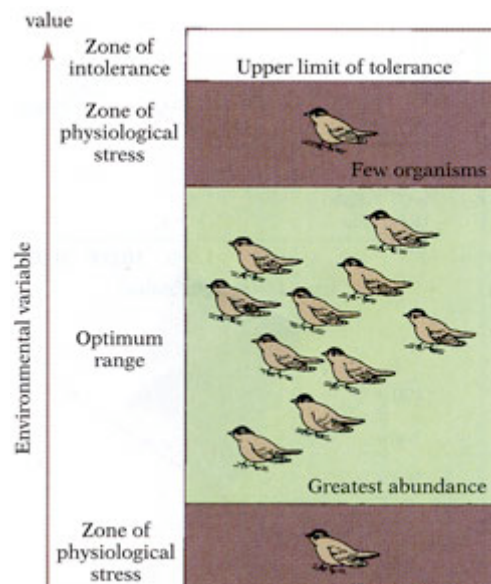
The Law of the Minimum and the Law of Tolerance

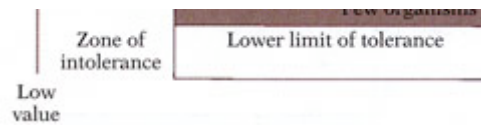
For a species to persist in a given habitat, it must have the physiological potential to survive and reproduce in this habitat. The extremes of the weather – the highest or lowest temperatures of the year, for example, or the longest period without rainfall --- are often the most important in limiting the distribution of an organism. A plant that cannot tolerate temperatures below 0°C will be unable to survive in a region with a warm climate (an average annual temperature of, say, 25°C) if the temperature falls below 0°C for even one day a year. All other conditions in the region may be optimal for the plant, but the one condition it cannot tolerate prevents it from growing there.

Ecologists must analyze the microenvironmental conditions—the **microhabitat**—to understand the physical factors with which organisms must cope. Variations in the weather can be quite local. For example, within a single small area, temperature differences of several degrees may occur between sheltered and exposed places, or between the ground and various elevations above the ground. The same sorts of highly local variations may be found in humidity, wind velocity, amount of sunlight, soil type, and so on. Thus we should not expect to find exactly the same kinds of organisms living at all points even within a very small area.

The same sorts of considerations apply to other aspects of the environment. The climate of a region might be ideal for a particular species of plant, and the soil rich in nitrogen and potassium, but if there is less phosphorus than the plant requires, it cannot grow there. The importance of a single environmental factor was recognized as long ago as 1840 by Justus von Liebig. Liebig's **Law of the Minimum** states that the growth of a plant will be limited by whichever requisite factor is the most deficient in the local environment. V. E. Shelford expanded Liebig's Law, applying it also to animals and taking into account that too much may be as bad as too little. Shelford's **Law Of Tolerance** states that the distribution of a species will be limited by its range of tolerance for local environmental factors (See Figure).

Though the principle behind both Liebig's and Shelford's laws is important in ecology, the assumption that a single factor is always limiting is potentially misleading. In nature, the various environmental factors interact in so many ways that it is often impossible to describe any one factor as the limiting one. When one condition is not optimal – though tolerable – for a species, the limits of tolerance for other factors may be reduced. Moreover, unless the Law of Tolerance is extended to such biotic limiting factors as predation and competition, it has only restricted applicability.





A diagrammatic illustration of the Law of Tolerance. The species in question is most abundant in areas where the environmental variable is within the optimum range for that species. The species is rare in areas where it experiences physiological stress because the environmental variable has either too high or too low a value. The species does not occur at all in areas beyond its upper and lower limits of tolerance.

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