3. Population

The population has its origin in Latin world populous, meaning people. In ecology population is defined as a group of organisms of the same species at particular area at particular time. Some ecologist recognized follwing types of populations 1**. Monospecific** (individuals of one species) and 2. **Mixed or polyspecific** population (individuals of more than one species). The basic characteristics of population are density, natality mortality, fecundity tables, survivalship curves, age ratio, sex ratio, dispersal and dispersion etc.

- **Size and Density:**

Total size is generally expressed as the number of individuals in a population.

Population density is defined as the numbers of individuals per unit area or per unit volume of environment. Larger organisms as trees may be expressed as 100 trees per hectare, whereas smaller ones like phytoplanktons (as algae) as 1 million cells per cubic metre of water.

Crude Population Density:

When the density is expressed with reference to total area at a particular time then it is called Crude Population Density

The density of population is studied under fallowing heads

(ii) Numerical Density:

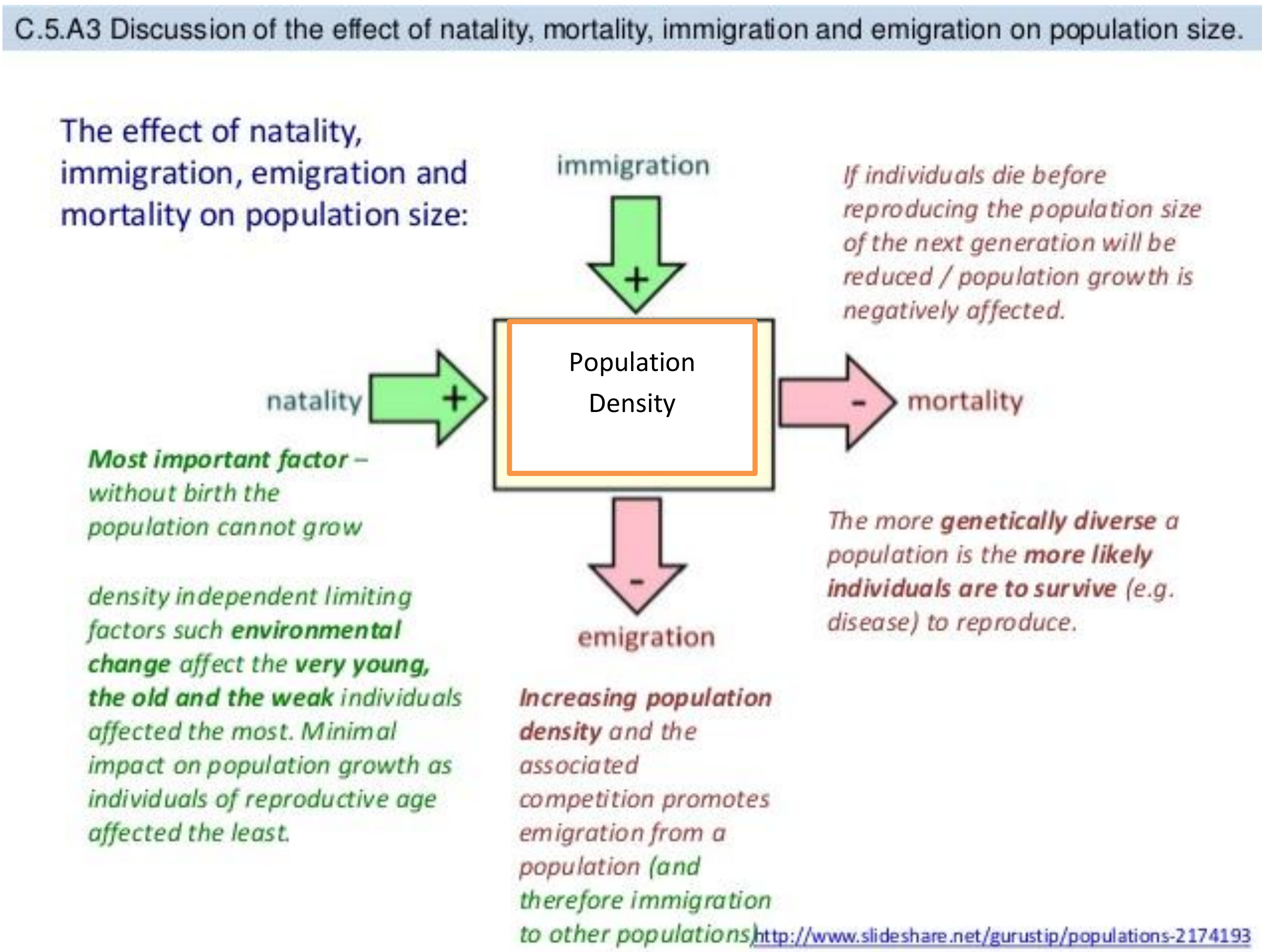
Number of individuals per unit area or volume is called numerical density. It is expressed when the size of individuals in the population is relatively uniform, as in mammals, insects and birds.

(iii) Biomass Density:

Biomass density is expressed in terms of wet weight, dry weight, volume, and carbon and nitrogen weight per unit area or volume.

Population density can be calculated

Density of human population can be obtained by dividing the total number of individuals in the area by the total land area of the region(per unit area).



http://www.slideshare.net/gurustip/populations-2174193

The above said factors are important that influences population density and size. Immigration and natality have positive influence on density whereas, emigration and motality reduces population density.

2. Natality:

Natality refers to the rate of reproduction or birth per unit time. It is an expression of the production of new individuals in the population by birth, hatching, germination or fission.

Natality is calculated by the following formula:
Birth rate or Natality (B) = Number of births per unit time/Average population.

The maximum number of births produced per individual under ideal conditions of environment is called potential natality. It is also called reproductive or biotic potential, absolute natality or maximum natality.

1.Maximum or absolute or physiological natality: It is the theoretical maximum production of new individuals under ideal conditions. i. e. No ecological limiting factors, reproduction being limited only by physiological factors. It is constant for a given population. This is also called fecundity rate.

2. Ecological or realized natality: It is a natality which refers to population increase under an actual, existing specific condition. It takes into account all the possible existing environmental conditions. This is also designated as fertility rate.

Natality is expressed as
$\Delta Nn / \Delta t$ = the absolute natality rate
$\Delta Nn / N\Delta t$ = the specific natality rate
Where,
N = Initial number of organisms
n = New individuals in the population
t = Time

- Three population characteristics determine the rate at which female produce offspring:
- Clutch size or no. of young produced on each occasion
- The time between one reproductive event and the next
- The age of first reproduction
- Natality rate usually increases during period of maturity and then,falls again as organism gets older. Fecundity (rate at whichmfemales produce eggs), fertility (rate at which females produce zygotes) and sex ratio (proportion of male and female in population) affect birth rate.

3. <u>Mortality (Death Rate)</u>
The other important population characteristic includes mortality.
It refers to death of individuals in the population. Mortality can be expressed as the number of individuals dying in a given period (deaths per time), or as specific rate in terms of units of the total population. Mortality can be distinguished into two types:

1. Minimum mortality: It is also called specific or potential mortality. It represents the theoretical minimum loss under ideal or non-limiting conditions. It is a constant for a population. Thus, even under the best conditions, individuals would die of 'old age' determined by their physiological longevity.

2. Ecological or realised mortality: It is the actual loss of individuals under a given environmental condition. It is not constant and varies with population and environmental conditions. After getting the knowledge of natality and mortality, let's understand the term vital index of population.

Population dispersion or spatial distribution:

Dispersion is the spatial pattern of in-dividuals in a population relative to one another. In nature, due to various biotic interactions and influence of abiotic factors, the following three basic population distributions can be observed:

(a) Regular dispersion/Uniform dispersion

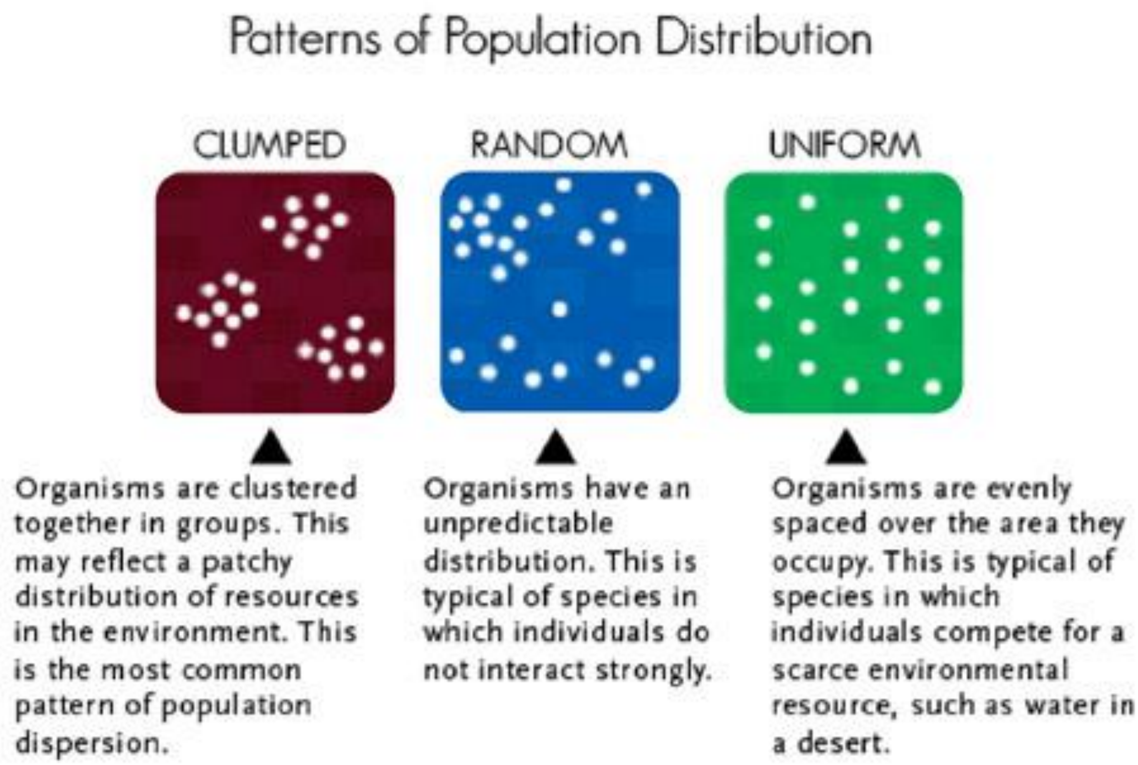
Here the individuals are more or less spaced at equal distance from one another. This is rare in nature but in common is cropland. Animals with territorial behaviour tend towards this dispersion.

(b) Random dispersion:

Here the position of one individual is unrelated to the positions of its neighbours. This is also relatively rare in nature.

(c) Clumped dispersion:

Most populations exhibit this dispersion to some extent, with individuals aggregated into patches interspersed with no or few individuals. Such aggregations may result from social aggregations, such as family groups or may be due to certain patches of the environment being more favorable for the population concerned



3. Age structure:

In most types of populations, individuals are of different age. The pro-portion of individuals in each age group is called age structure of that population. The ratio of the various age groups in a population determines the current reproductive status of the popu-lation, thus anticipating its future. From an ecological view point there are three major ecological ages in any population. These are, pre-reproductive, reproductive and post reproductive. The relative duration of these age groups in proportion to the life span varies greatly with different organisms.

Age pyramid:

The model representing geometrically the proportions of different age groups in the population of any organism is called age pyramid. According to Bodenheimer (1938), there are following three basic types of age pyramids.

(a) A pyramids with a broad base (or triangular structure):

It indicates a high percentage of young individuals. In rapidly growing young populations birth rate is high and population growth may be exponential as in yeasty house fly, Paramecium, etc. Under such conditions, each successive generation will be more numerous than the preceding one, and thus a pyramid with a broad base would result (Fig. A).

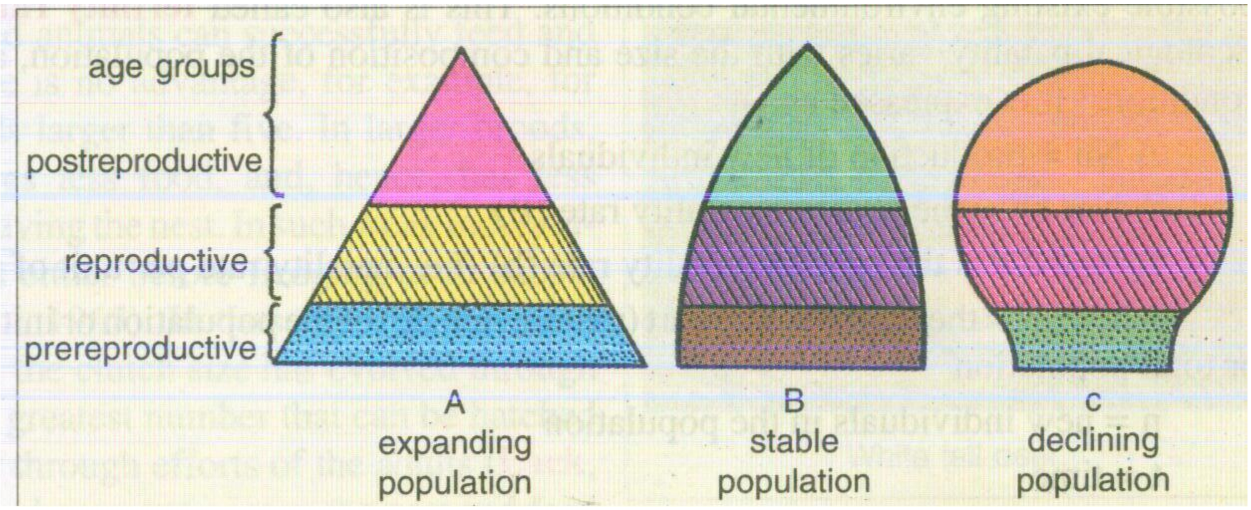
(b) Bell-Shaped Polygon:

It indicates a stationary population having an equal number of young and middle aged individuals. As the growth rate becomes slow and stable, i.e., the pre-

reproductive and reproductive age groups become more or less equal in size, post-reproductive group remaining as the smallest (Fig. B).

(c) An urn-shaped structure:

It indicates a low percentage of young individuals and shows a declining population. Such an un-shaped figure is obtained when the birth rate is drastically reduced the pre-reproductive group dwindles in proportion to the other two age groups of the population.



Mortality:

Mortality refers to the number of deaths in population per unit time.

Mortality rate = D/t, where D is the number of deaths in the time t.

Mortality can be expressed in the following two ways:

(i) Minimum or Specific or Potential Mortality:

It represents the minimum of theoretical loss of individuals under ideal or non-limiting condition. Thus, even under the best conditions individuals of a population would die of old age determined by their physiological longevity. So it is constant for a population.

(ii) Ecological or Realized Mortality:

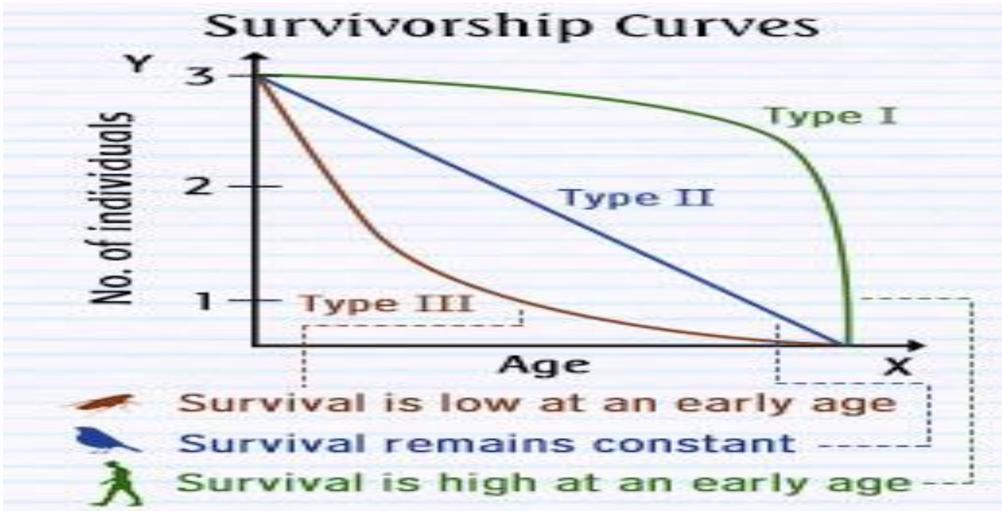
It refers to the death of individuals of a population under existing environmental conditions. Since it varies with environmental conditions, it is never constant. The maximum mortality occurs at the egg, larval, seedling and old age. Mortality is affected by a number of factors, such as, density, competition, disease, predation and environment. Death rates vary among the species and are correlated with birth rates. When the rate of natality is equal to the rate of mortality the population is stationary.

Survivorship curves shows the decline of individuals with age. It can help us to know about various aspects such as life expectancy and age-specified survival of a particular species. This ScienceStruck article elaborates on the different survivorship curves with a few examples of each, and also shows you how to create a survivorship curve on a spreadsheet in a stepwise manner.

In this, the age of the individuals is plotted on the X-axis and the log of the total number of individuals surviving at each age is taken as the Y-axis, on a semi logarithmic graph. According to the curve that is generated, we may be able to comment on the rate of survival and the evolutionary strategies undertaken by the species or the group.

Types of Survivorship Curves

Survivorship curves can be broadly classified into three basic types:



Type I
This type of curve is a highly convex curve. In this type of survivorship, the rate of survival of individuals is high at an early and middle age and goes on decreasing as the individual progresses into old age. In this population, most of the individuals survive till they reach adulthood, and their rate of mortality is maximum at an old age. These individuals receive parental care till they reach early adulthood. As a result, they produce comparatively less number of offspring. This strategy of these individuals is called K strategy.

Examples: Many large animals including humans (basically almost all mammals) and rotifers exhibit this type of survivorship.

Type II
This type of curve is a linear or a diagonal type of curve. In this type of survivorship, the rate of survival of the individuals remains the same throughout their lives. This also implies that their mortality rate remains constant at every age. These individuals exhibit a strategy that is intermediate to type I and type III survivorship. This type is largely theoretical.

Examples: Many birds, mice, and rabbits exhibit either slightly sigmoid or concave curves that are very similar to a linear curve. Some animals like hydra, gull, and the American robin exhibit a linear curve.

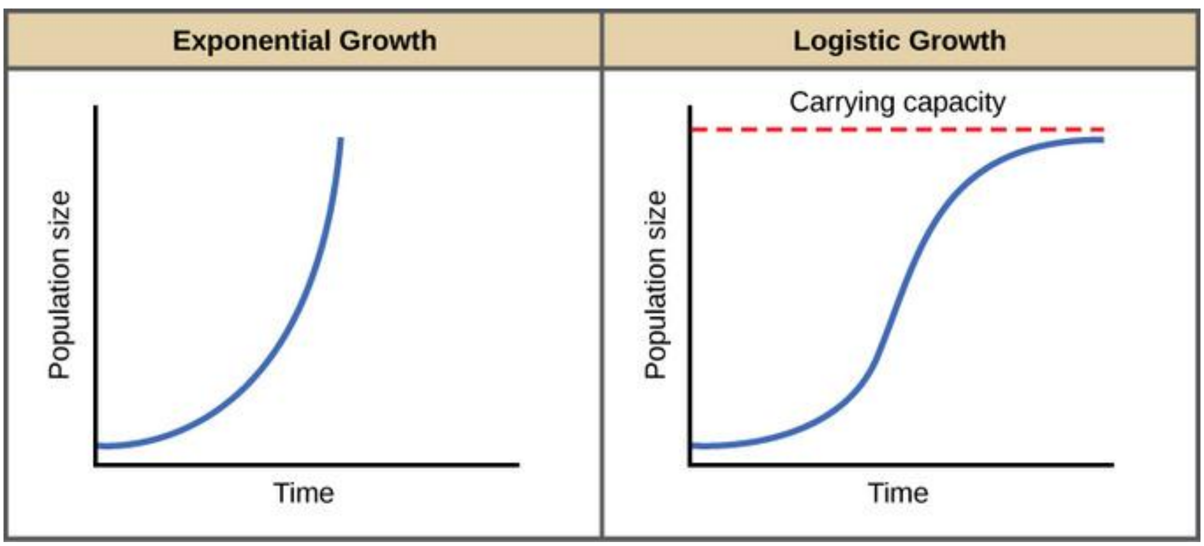
Type III
This type of curve is a highly concave curve. In this type of survivorship, the rate of survival is very low in the early ages of the individuals and increases comparatively later in their lives. Again, this implies that their rate of mortality is quite high in the early ages and may decrease comparatively in their later lives. In order to compensate for this, these individuals produce a large number of offspring. As a result, the offspring receive very little parental care. This strategy of these individuals is said to be the r strategy.

Examples: Some birds, black-tailed deer, oysters and other shellfish, some insects, and oak trees exhibit this type of survivorship curve.

Exponential growth

Thomas Malthus published a book in 1798 stating that populations with unlimited natural resources grow very rapidly, after which population growth decreases as resources become depleted. This accelerating pattern of increasing population size is called exponential growth.

The best example of exponential growth is seen in bacteria. Bacteria are prokaryotes that reproduce by prokaryotic fission. This division takes about an hour for many bacterial species. If 1000 bacteria are placed in a large flask with an unlimited supply of nutrients (so the nutrients will not become depleted), after an hour there will be one round of division (with each organism dividing once), resulting in 2000 organisms. In another hour, each of the 2000 organisms will double, producing 4000; after the third hour, there should be 8000 bacteria in the flask; and so on. The important concept of exponential growth is that the population growth rate, the number of organisms added in each reproductive generation, is accelerating; that is, it is increasing at a greater and greater rate. After 1 day and 24 of these cycles, the population would have increased from 1000 to more than 16 billion. When the population size, N, is plotted over time, a J-shaped growth curve is produced.



Exponential population growth: When resources are unlimited, populations exhibit exponential growth, resulting in a J-shaped curve. When resources are limited, populations exhibit logistic growth. In logistic growth, population expansion decreases as resources become scarce. It levels off when the carrying capacity of the environment is reached, resulting in an S-shaped curve.

The bacteria example is not representative of the real world where resources are limited. Furthermore, some bacteria will die during the experiment and, thus, not reproduce, lowering the growth rate. Therefore, when calculating the growth rate of a population, the death rate (D; the number organisms that die during a particular time interval) is subtracted from the birth rate (B; the number organisms that are born during that interval). This is shown in the following formula:

. The maximal growth rate for a species is its biotic potential, or r_{max}, thus changing the equation to:

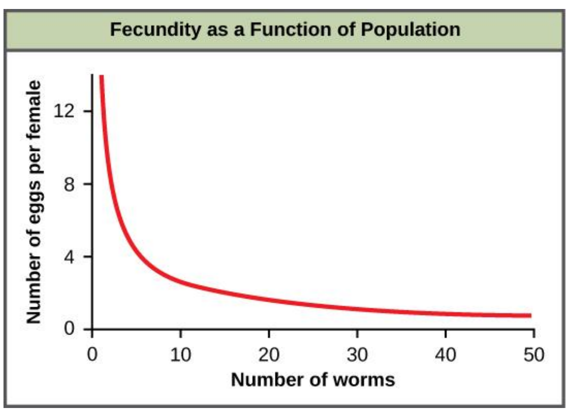
$dN/dT=r_{max}N$dN/dT=rmaxN

Logistic Population Growth

Logistic growth of a population size occurs when resources are limited, thereby setting a maximum number an environment can support

Density-dependent regulation:

In population ecology, density-dependent processes occur when population growth rates are regulated by the density of a population. Most density-dependent factors, **include predation, inter- and intraspecific competition, reproductivity, accumulation of waste, and diseases such as those caused by parasites.** Usually, the denser a population is, the greater its mortality rate. For example, during intra- and interspecific competition, the reproductive rates of the individuals will usually be lower, reducing their population's rate of growth. In addition, low prey density increases the mortality of its predator because it has more difficulty locating its food source. An example of density-dependent regulation is shown with results from a study focusing on the giant intestinal roundworm (*Ascaris lumbricoides*), a parasite of humans and other mammals. The data shows that denser populations of the parasite exhibit lower fecundity: they contained fewer eggs . One possible explanation for this phenomenon was that females would be smaller in more dense populations due to limited resources so they would have fewer eggs. This hypothesis was tested and disproved in a 2009 study which showed that female weight had no influence. The actual cause of the density-dependence of fecundity in this organism is still unclear and awaiting further investigation.



Effect of population density on fecundity

In this population of roundworms, fecundity (number of eggs) decreases with population density.

Density-independent regulation and interaction with density-dependent factors

Many factors, typically physical or chemical in nature (abiotic), influence the mortality of a population regardless of its density. They include weather, natural disasters, and pollution. An individual deer may be killed in a forest fire regardless of how many deer happen to be in that area. Its chances of survival are the same whether the population density is high or low.

In real-life situations, population regulation is very complicated and density-dependent and independent factors can interact. A dense population that is reduced in a density-independent manner by some environmental factor(s) will be able to recover differently than would a sparse population. For example, a population of deer affected by a harsh winter will recover faster if there are more deer remaining to reproduce.

Gause's principle:Two species that have identical ecological requirements cannot exist in the same area at the same time.

The principle of competitive exclusion was proposed by G.F. Gause which states that two species competing for the same resources cannot coexist. This law is also known as Gause's law.

One population will drive off the other one. If any of the members of the depleted population remains, that would be because they have adapted themselves according to the different niche.

The genus Paramecium includes several species of one-celled protists that live in freshwater. When there is enough food, water, and space but populations of these species grow rapidly and follow a pattern known as exponential growth, in which the total number of potentially reproducing organisms increases with each generation.However, populations of any organism will not increase indefinitely. Eventually, limitations on food, water, and other resources will cause the population to stop increasing. When a population arrives at the point where its size remains stable, it has reached the carrying capacity of the environment. The carrying capacity is the greatest number of individuals a given environment can sustain. Competition for resources among members of a population (intraspecific competition) places limits on population size. Competition for resources among members of two or more different species (interspecific competition) also affects population size.