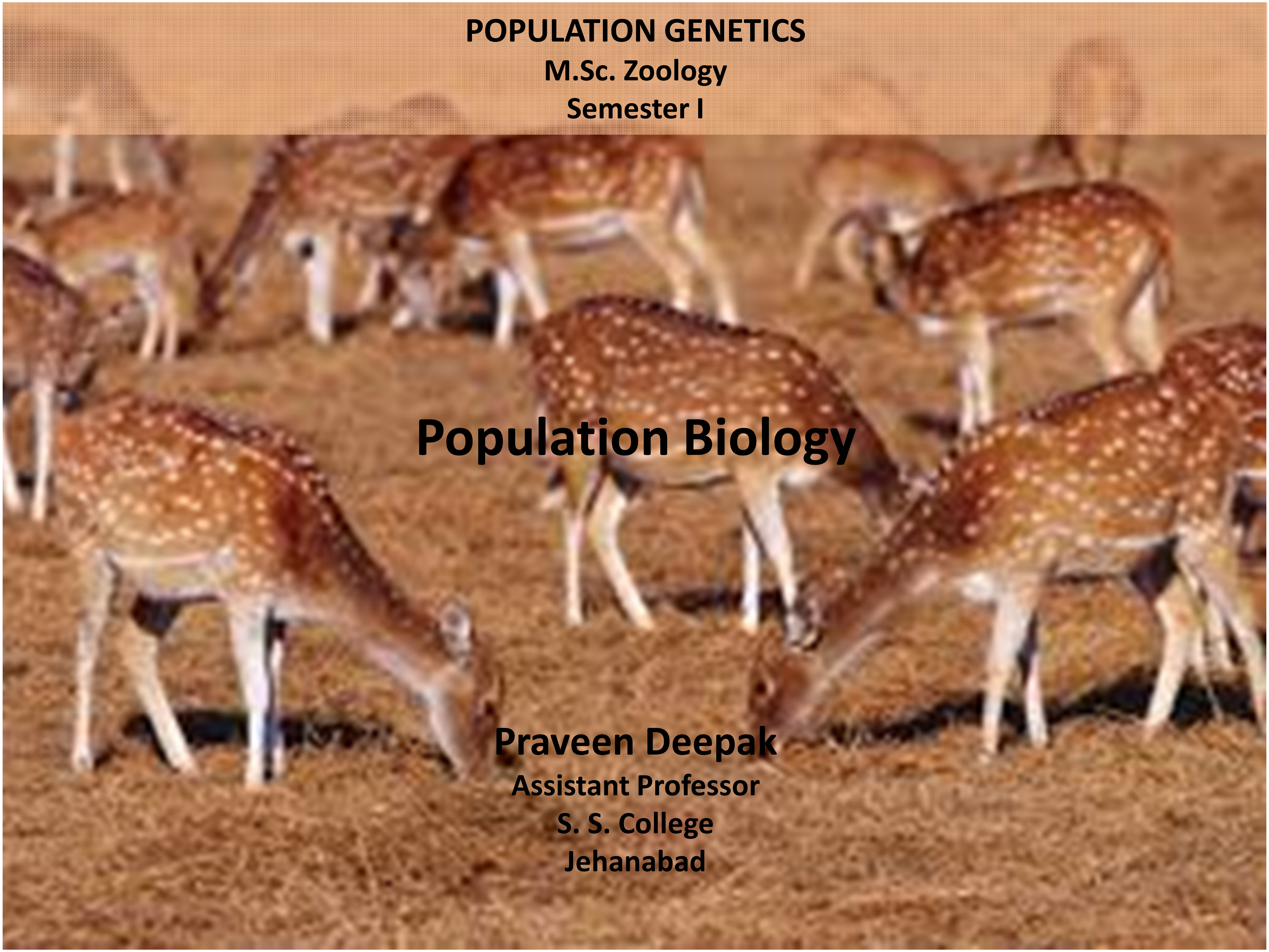

POPULATION GENETICS

M.Sc. Zoology

Semester I

Population Biology

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Terminology

Population

Refers to a group of individuals of a species that interbred and live in the same place at a same time.

Population biology

Refers of a population of a certain species with respect to the growth and regulation of size, genetics, and evolution.

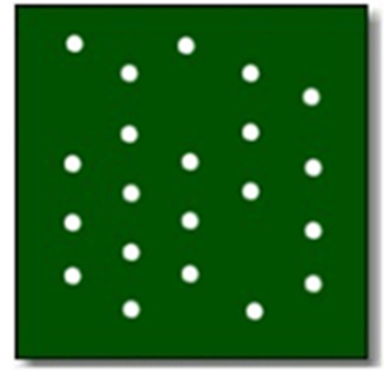
Population ecology

The dynamics of the population of the species in relation to the effect of abiotic and biotic factors in their surroundings.

Population genetics

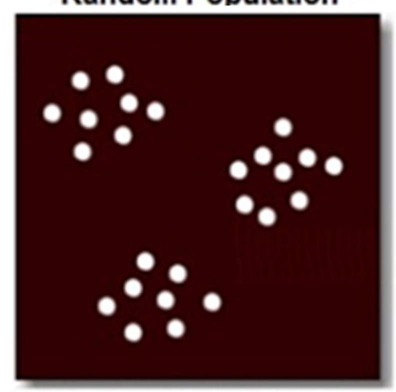
Deals with the study of genetic variation with respect to changes in the frequencies of genes and alleles within populations over space and time.

Types



Uniform Population

Random Population



Clumped Population

Uniform or Even Population

- Group of individuals that are evenly distributed and distance amongst the individuals is minimal.
- Less common.
- Found in bears, owls, tigers, etc.

Random Population

- Group of individuals where position of each individual is independent of the other
- Lacks social interaction amongst individuals.
- Dandelion flowers – *seeds dispersed by winds and germinate when favorable environment.*

Clumped Population

- Group of population in which individuals have patchy distribution in defined geographical spaces.
- Distance amongst the individuals is minimal due to inability of offspring to move independently.
- May also due to habitat heterogeneity.
- Examples are wolves, bison, elephants, and even humans.

Population size and density

Population size

Refers to the number of individuals (N) in a given population.

Population density

Number of individuals within a given area or volume.

− If there is 7 deer in a 3 km^2 area, then the density of the deer population is;

$$Density\ of\ deer\ in\ a\ population = \frac{7}{3} = 2.3\ deer/km2$$

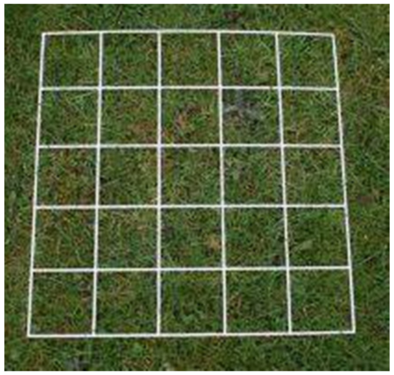
Sampling of a population

Quadrat methods

- Sampling with the use of a quadrat – a frame, traditionally square, used to isolate a standard unit of area.
- For sessile or slow moving organisms.
- Examples include alga, mussels, choral polyps, etc.

Three types:

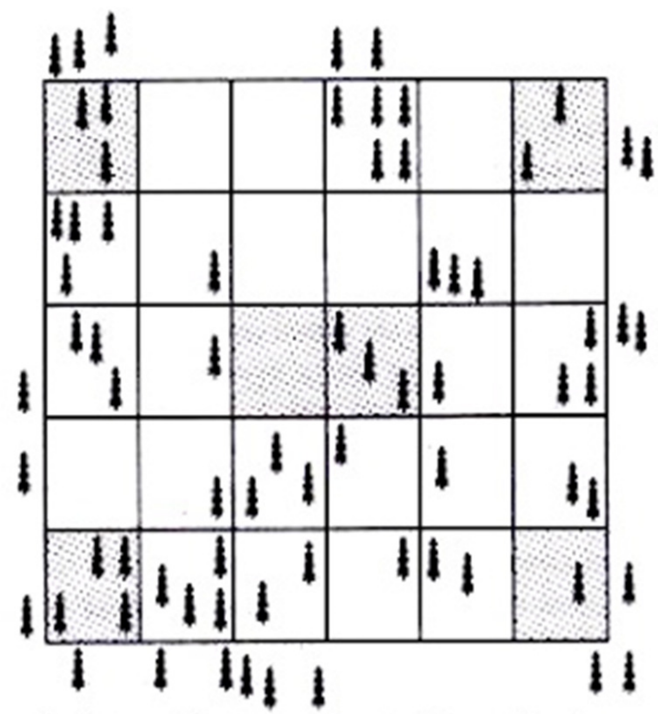
1. **Random sampling**
2. **Systemic sampling**
3. **Stratified sampling**



Quadrat sampling of a population

Random sampling

- For fairly uniform and large area.
- Large numbers of samples/records need to be taken from different positions.
- A quadrat frame is placed on the sampling area and the animals, and/ or plants inside it counted, measured, or collected.
- Used to calculate –
  - **Species frequency** – Chance of a particular species being found within any one quadrat.
  - **Species density** - how many individuals there are per unit area**.**
- Used to estimate –
  - **Percentage cover** – percentage of area inside the quadrat that is occupied by each species.
  - **Abundance scale** – Number of species In a defined area **(**Braun-Blanquet scale)



. Quadrat sampling method for population estimation.

Quadrat sampling of a population

Systematic sampling

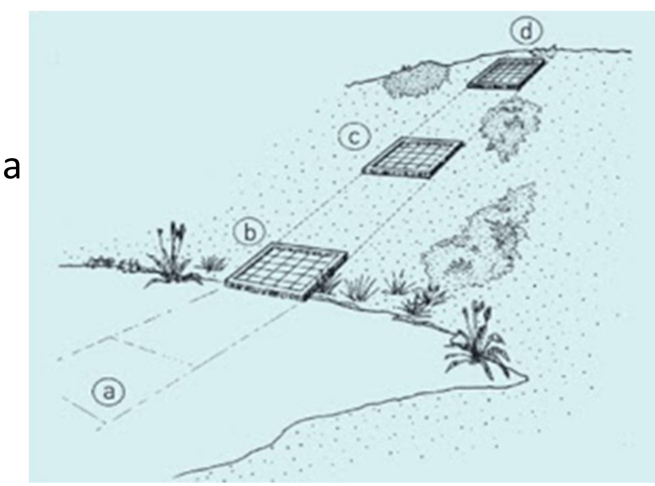
- ❑ Calculate species-distribution where physical condition is not constant.
- ❑ Such as altitude, soil moisture content, soil pH, exposure/light intensity, etc.
- ❑ Two methods; Line transect method and Belt transect method.

Line transect method

- Made using a nylon rope marked and numbered at 0.5m, or 1m intervals, all the way along its length. This is laid across the area we wish to study.
- Count the number of organisms that touch the line at set distances.

Belt transect method

- Performed by widening of the line transect to form a continuous belt or a series of a quadrat.
- Quadrat is placed at regular interval.
- Abundance of species recorded.



Quadrat sampling of a population

Stratified sampling

- Used to take into account different areas (or strata), which are identified within the main body of a habitat.
- The strata are sampled separately from the main part of the habitat.
- For example, scrub patches within a heathland area, or areas of bracken in grassland.
- Proportion of samples taken within the unit is determined by the area of the unit in relation to the overall area of the habitat.
- In a grassland, total area is 200 meter, with the bracken patch occupying 50 m of this total area. Say it is decided that a total of 12 samples need to be taken then total number of area sampled is;

$$Number\ of\ quadrats\ sampled\ in\ the\ unit = \frac{Area\ of\ the\ unit\ \times Total\ no.of\ quadrats\ sampled}{Total\ area\ of\ the\ habitat}$$

Therefore, from the above example;

$$Number\ of\ quadrats\ sampled\ in\ the\ unit\ = \frac{50\ \times 12}{200} = 3$$

Sampling of a population

Mark and recapture methods

- First used by C. J. G. Peterson in studying marine fishes and F. C. Lincoln in studying of waterfowl population, hence also known as Lincoln index or Peterson index.
- Used for sampling mobile organisms such as insects, fish, birds, wild animals, etc.
- Involves marking individuals, counting their number, returning to their natural habitat, and recapturing and again counting to estimate their size in mixed population.
- It is understand that the before and after recapturing the individuals, their population is same.

$$\frac{R\ (marked\ recaptures)}{T\ (total\ number\ in\ second\ sample} = \frac{M\ (marked\ initially)}{N\ (total\ population\ size)}$$

Population growth and growth curve

- Population is a dynamic process.
- Size of a population depends on fecundity, mortality, emigration, immigration.
- Population growth differs in the presence and absence of limiting factors i.e. abiotic and biotic factors or density independent and dependent factors.

Density independent factors

Reduces population regardless of population size e.g. drought, flood, hurricane, weather, fires, etc.

Density dependent factors

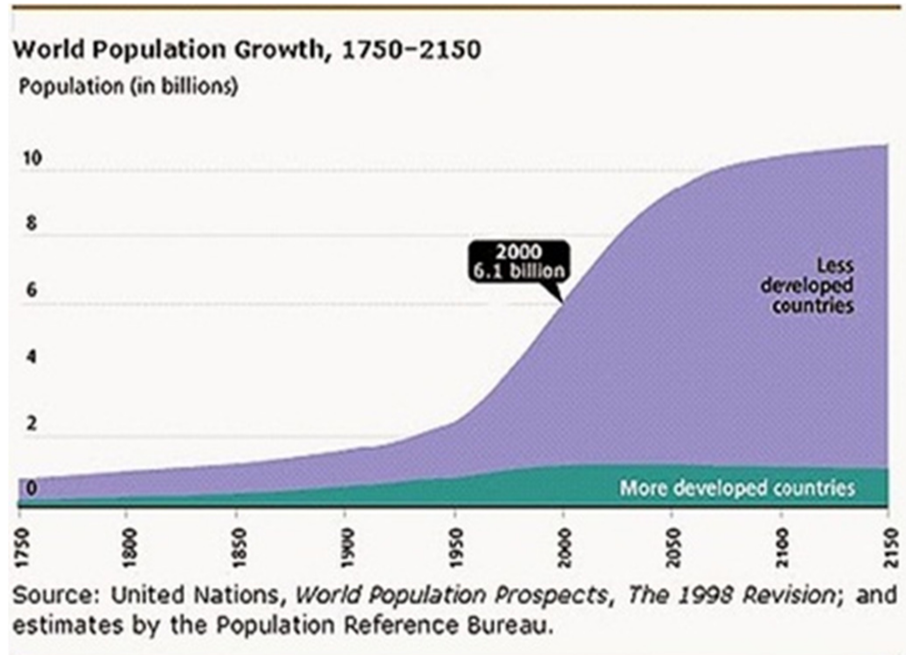
Triggered by increasing population density e.g. food shortage, space limitations, waste accumulation, human activities, disease, etc.

Population growth and growth curve

Population growth in the absence of limiting factors (J-shaped curve)

− Also called exponential growth.
− No stationary or death phase.
− Log phase continue upwards.
− Delayed or no plateau observed.
− Occurs in human population.

<ins>Favorable factors includes;</ins>
− Improvements in food supply.
− Improvement in health service.
− Reduction in child mortality rate.
− Increase in life expectancy.



Population growth in developing and developed nation

Population growth and growth curve

Population growth in the absence of limiting factors (J-shaped curve)

- Bacterial growth is also a good example of exponential growth.
- Takes about an hour for most bacteria to be doubled in abundant nutrient supply.
- Accelerated population growth.
- Some bacteria die and could not reproduce.
- Therefore, growth rate of is $\frac{\Delta\,(Change\ in\ number)}{\Delta\,(Change\ in\ time)} = B\ (Birth\ rate) - D\ (Death\ rate)$
- For a population; birth rate is ***bN***, and death rate is ***dN***. Therefore, growth rate of population (G) is

$$G = bN - dN = (b - d)N$$

If (b – d) is assumed as intrinsic rate of increase of the population ***(r)***, then

$$G = rN$$

- r may be positive, negative, or zero, therefore, population growth is calculated by replacing 'r' with 'r_{max}' i.e. biotic potential of population changes

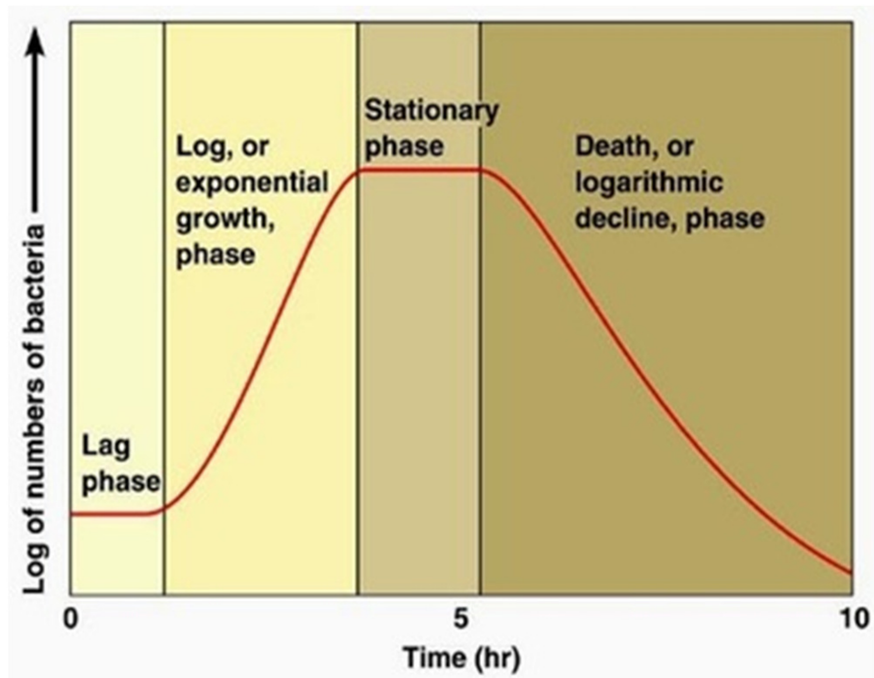
$$G = r_{max}N$$

Population growth and growth curve

Population growth in the presence of limiting factors (S-shaped curve)

Lag phase

New population takes time to settle and mature to before breeding begins so the doubling of number does not have much impact. The line of graph rises very slowly.



Log (exponential) phase

Rapid breeding in an increasing population causes a significant increase in numbers that produces a straight line.

Stationary phase

Rate of reproduction and deaths in community are equal leading to horizontal line of the graph.

Death phase

As food runs out, more organisms die than are born, so the number in the population drops.

Population growth and growth curve

Population growth in the presence of limiting factors (S-shaped curve)

− Population size that an environment support is called **carrying capacity**, or **K**.

− Carrying capacity or K is the moderating force in the logistic population growth.

− Population change can be indicated by $\boldsymbol{K - N}$.

− Therefore, fraction of the carrying capacity available for growth is $\frac{\mathbf{K - N}}{\mathbf{K}}$.

− $(\frac{\mathbf{K - N}}{\mathbf{K}})$ is the factor that restricts population growth to be exponential.

− Therefore, growth of a population can be represented by;

$$G = r_{max}N\,\frac{(K - N)}{K}$$

− If N is very small, then $\frac{\mathbf{K - N}}{\mathbf{K}}$ becomes almost 1 **– *growth converted to exponential*.**

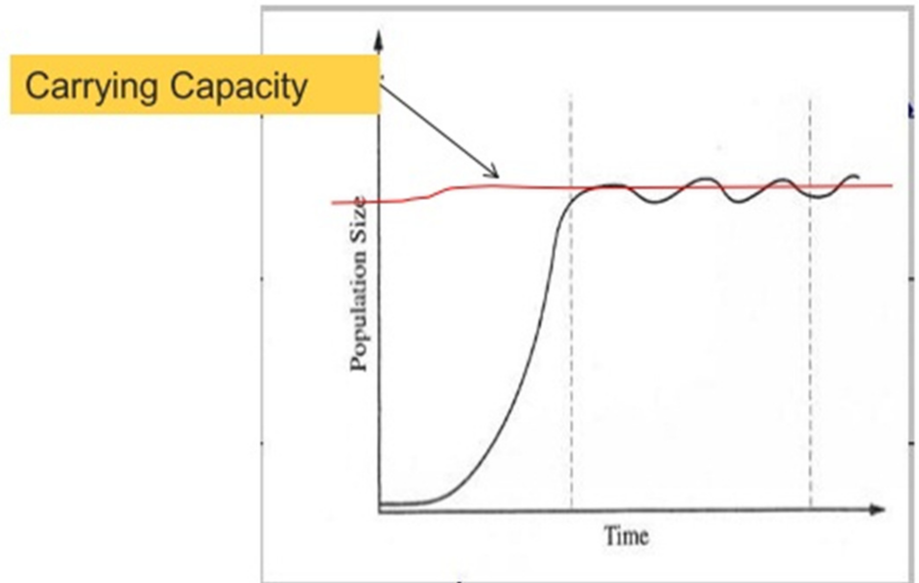
− If N is large, then $\frac{\mathbf{K - N}}{\mathbf{K}}$ come close to zero **– *growth might be zero*.**

Shows how carrying capacity control the growth of a large population.

Population growth and growth curve

S-shaped curve or logistic growth curve with respect of carrying capacity

- Population oscillates up and down.
- Remain an overall equilibrium.
- Exhibits a number of trough and crest traversed through an equilibrium line or with carrying capacity.



Logistic growth curve

Favorable factors includes;

- Improvements in food supply.
- Improvement in health service.
- Reduction in child mortality rate.
- Increase in life expectancy.

References

- Biology Notes for a Level
- Population Growth Curves
- Population Genetics