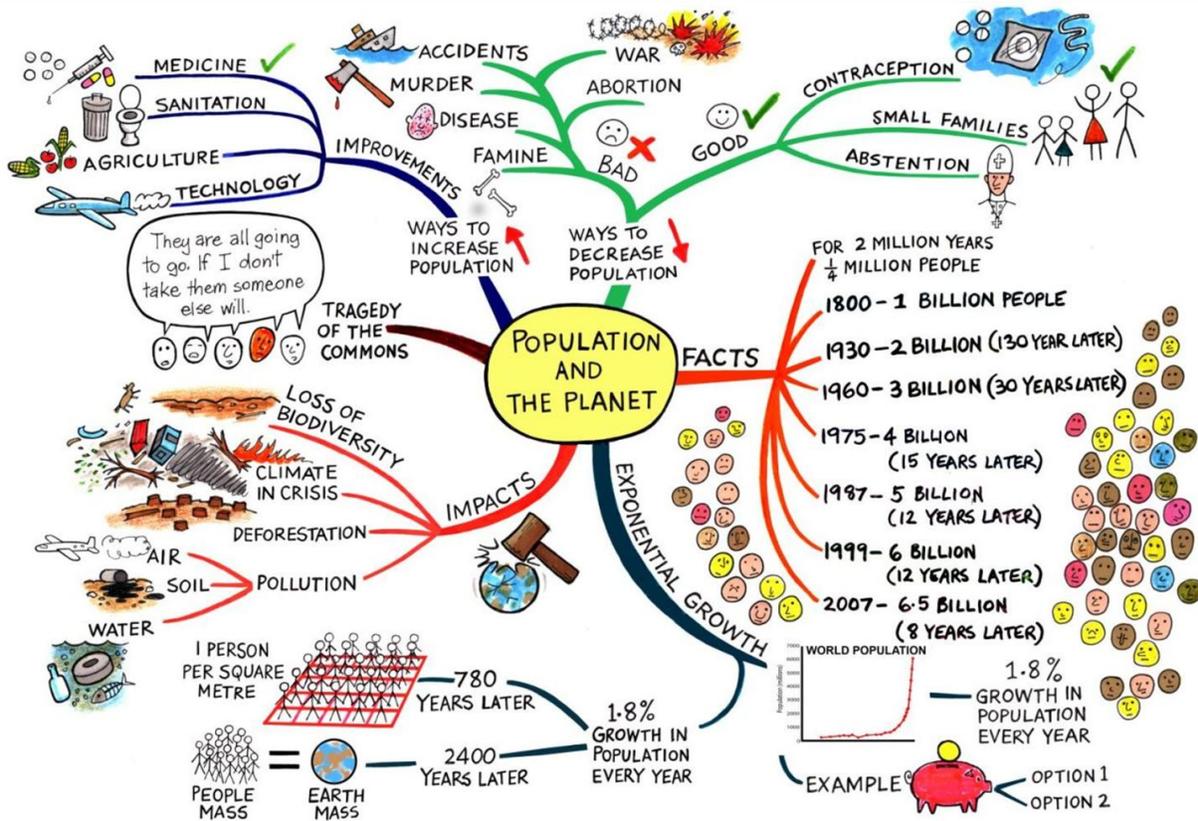


Chapter 4 Population and Environment



Population Ecology

The special branch of ecology which deals with the study of individuals of the same species and the related processes such as aggregation interactions between individuals and the factors leading to those processes is known as population ecology

Population is a group of individuals of a particular species, sharing the common genepool and occupying a particular area at a specific time.

There are two types of populations in ecology

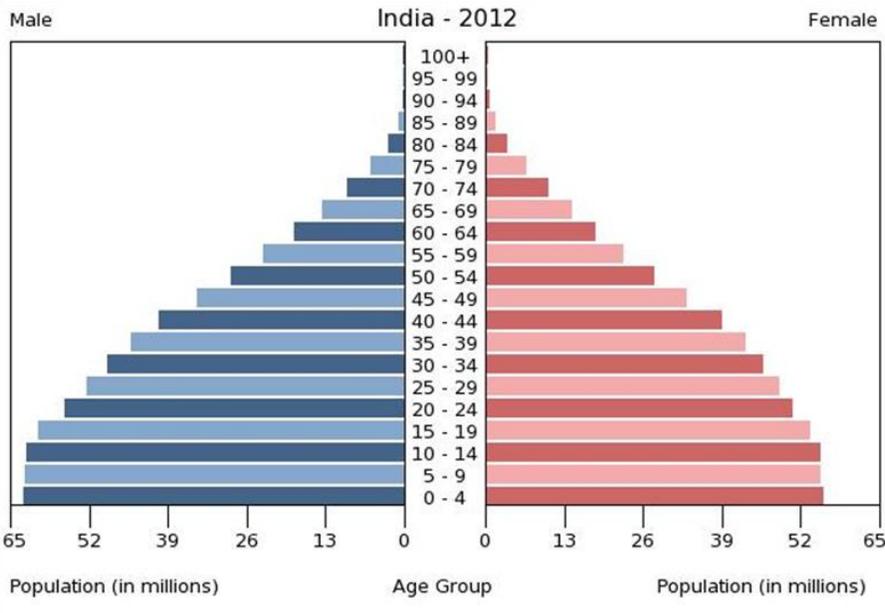
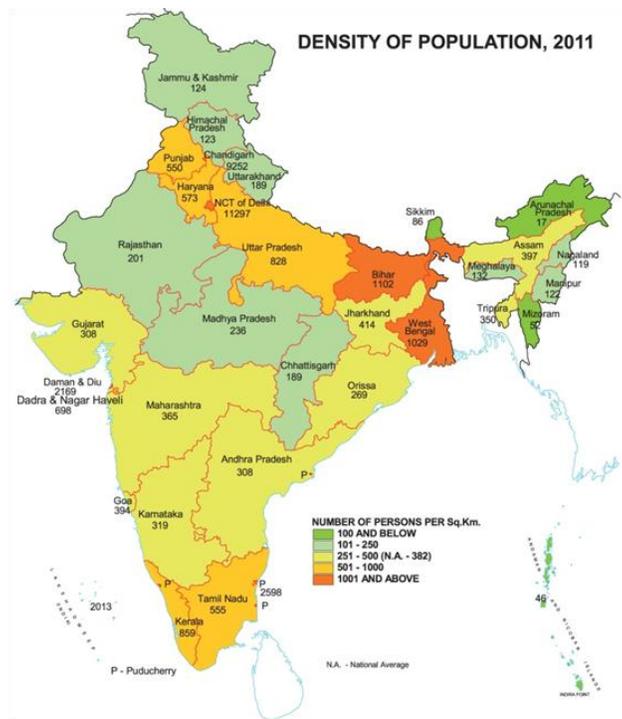
1. Monospecific population (individuals of one species)
2. Mixed or polyspecific population (individuals of more than one species)

Populations ecology may be analysed as

1. Population characteristics
2. Population dynamics
3. Population regulation
4. Population characteristics

A Populations has the following characteristics

1. Size and density;
2. Natality (birth rate);
3. Mortality (death rate);
4. Age distribution ;
5. Dispersion;
6. Life tables



1. Size and density

Size is the number of individuals in a population

Density is the number per unit area (or volume) of environment

Density is further divided in to

A. Crude density

- Density (number or biomass) per unit total space

B. Specific density (ecological density)

- Density (number of biomass) per unit habitat space that can actually be used by the population

It is important to know whether a population is changing its size with respect to time rather than its actual size at any given point of time

2. Natality (birth rate)

The number of offsprings produced per female per unit time is called natality rate

Natality is further divided in to

A. Maximum natality (absolute or potential or physiological natality)

- It is the theoretical maximum production of new individuals under ideal conditions

B. Ecological natality (fertility rate)

- It is the increase in population under and actual, existing specific condition

$\Delta N_n = \text{production of new individuals in the population}$

$$\frac{\Delta N_n}{\Delta t} = B \text{ or natality rate}$$

$$\frac{\Delta N_n}{N \Delta t} = b \text{ or natality rate per unit population}$$

Where

N = initial number of organisms

n = new individuals in the population

T = time

3. Mortality (death rate)

The number of deaths occurring in a given period (death per time)

Mortality is further divided in to

A. Minimum mortality

- It is the theoretical minimum loss under ideal conditions. It is constant for a population.

B. Ecological mortality (realised mortality)

- The loss of individuals under a given environmental conditions. It is not constant but varies with time.

Vital index

the birth to death ratio for a population (birth/death X 100)

Survival rate (how many survive from death) is expressed as survivorship curve

1. Highly convex curve

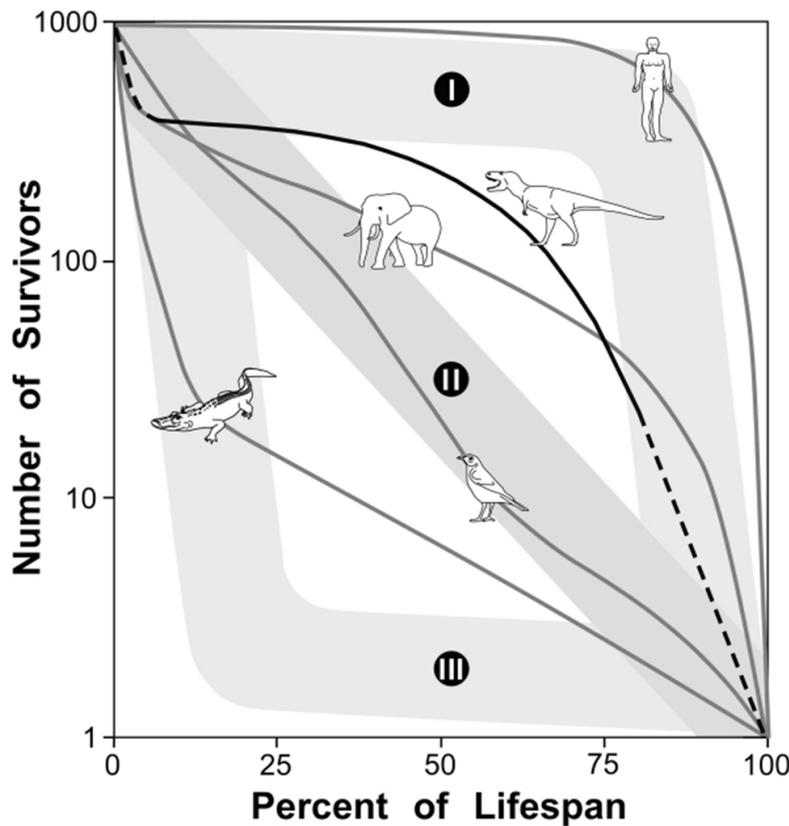
- Here the population , mortality is low until the end of the life span (deer, man)

2. Highly concave curves

- Mortality rate is high during the young stages (oyster, shell fish)

3. Diagonal curves

- The curve approaches a straight line due to more or less constant age-specific survivability
 - Constant proportion of organism dying per unit time
 - No population has constant age-specific survival rate
 - Undergo metamorphosis



Survivorship curve

The convex **Type I** pattern seen in some *captive animals* and in *humans*, shows relatively low initial mortality followed by massive die-offs as maximal lifespan is approached.

The diagonal, **Type II** pattern (characteristic of small, short-lived *birds, mammals, and lizards*) occurs in animals whose mortality is relatively constant throughout life.

The concave, **Type III** pattern (in *crocodilians and other large long-lived reptiles*) experience high, early attrition, with the few survivors that reach threshold sizes standing to experience low mortality and reach maximal lifespan.

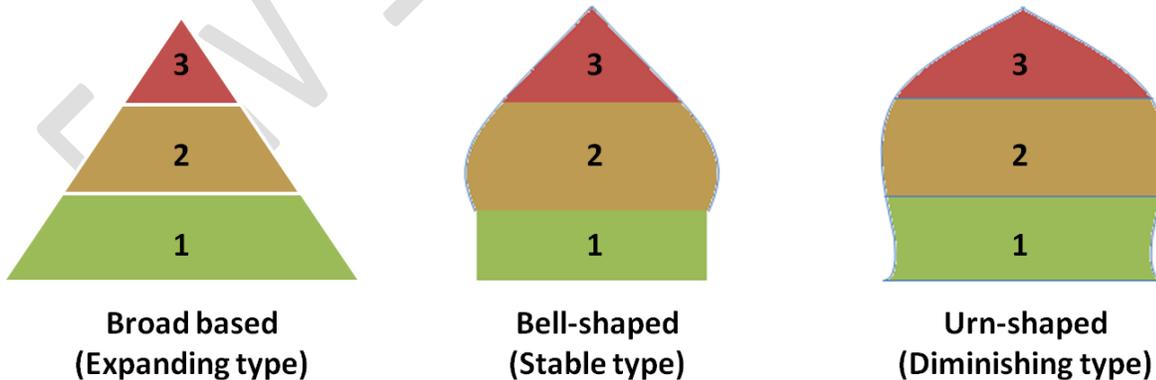
Long-lived, typically moderate to *large birds and mammals* show a **sigmoidal**, pattern with high initial mortality rates, subsequent lower mortality, and increased mortality prior to extinction of the cohort.

Age distribution it influences both natality and mortality

The ratio of different age groups in a population determines the current reproductive status of the population

1. **Pre-reproductive age;**
2. **Reproductive age;**
3. **Post-reproductive age**

The proportion of different age groups in any population is usually expressed geometrically as pyramids shown below



1. **Broad-based pyramid**

- Birth rate of the young population is high, growth is rapid and it may be exponential.
- High percentage of young individual

- Each successive generation is higher in number than the previous one
2. **Bell shaped polygon**
 - Moderate proportion of young to old
 - Pre-reproductive \approx reproductive $>$ post-reproductive
 3. **Urn-shaped pyramid**
 - Dying-off population
 - If birth rate decreases pre-reproductive group decreases, correspondingly other two groups also decreases
 - there is low percentage of young people

Developing and under-developed countries have rapid population growth. Ex. India, China

Dispersion

The spatial pattern of individuals in a population, relative to one another

1. **Regular dispersion**
 - Equal distance between individuals
 - Vary rare in natural system; but common in man-made system (crop land)
2. **Random dispersion**
 - Individuals are not having equidistance.
 - Not common in nature
3. **Clumped dispersion**
 - Results from social aggregation
 - Certain patches of favourable environment for the population concerned

Life tables

- *Natality, mortality in different age groups with respect to sexes are tabulated in tables*

Life table notation

- x Exact age (eg exact age 5 corresponds to 5 years and 0 days).
- l_x Number of people alive at exact age x from the original group of 100,000 (10). L_x Average number of people alive in the age interval x to $x + 1$.
- d_x Number of deaths in the age interval x to $x + 1$.
- ${}_5m_x$ Central death rate for population in the age group x to $x + 5$.
- Population dynamics

The characteristic pattern of population increase is called **population growth forms**

Population growth form is studied using

- (1) Laboratory studies
- (2) Field studies
- (3) Modeling

Modeling is further divided in to

Theoretical models

Population changes are expressed as equations and its validity is ascertained by comparison with real population

Simulation models

From the data collected from real population future population behaviour is predicted under specific environmental conditions

Population growth theories

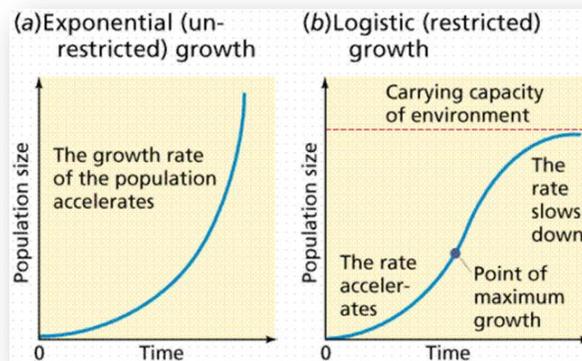
Population growth rate is the net result of births, deaths and dispersals.

1. Exponential or geometric fashion growth
2. Sigmoid growth form or Logistic growth

1. Exponential or Geometric growth

The population density keeps on increasing exponentially or geometrically until some resources runs out or encounters some other limitation

For example binary fission produces double the offsprings every successive generation. It is also know as J-shaped growth form.



The number of organisms (N_g) present in any generation is given by

$$N_g = N_o (2^g) \quad \text{where } N_o \text{ is the number of individual in generation "O"}$$

For a larger generation it is represented as

$$N_g = N_o (e^{rg})$$

"e" is a universal constant (2.718) "r" (*intrinsic rate of natural increase or Malthusian parameter*) is a constant for a particular population under specific environmental conditions

Intrinsic rate of natural increase

If, in a hypothetical population of size N , the birth rates (per capita) are represented as b and death rates (per capita) as d , then the increase or decrease in N during a time period t will be $dN/dt = (b-d) N$

where $(b-d)$ is called the 'intrinsic rate of natural increase'.

Carrying capacity

- In any natural ecosystem, biota and various abiotic factors work in such a way that a population should have an upper size limit that can not be exceeded. Such a limit is called carrying capacity of the environment on that population.
- It can be determined by the availability of resources (food and space)

2. Sigmoid growth form or Logistic growth

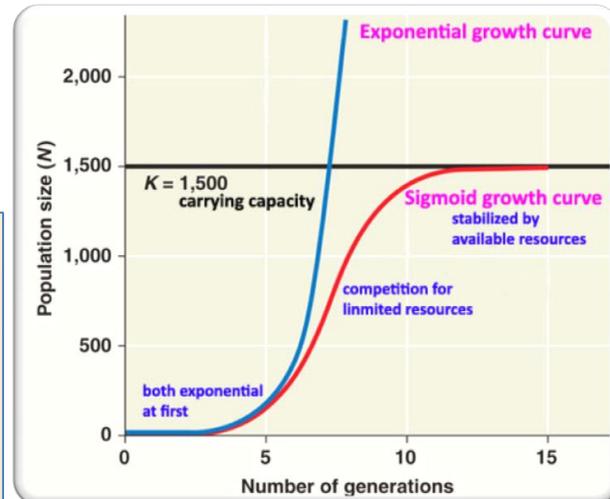
- Population growth has upper limit
- Increase in density reduces the rate of growth
- It is S- shaped on arithmetic coordinates
- It is less steep than exponential growth

The logistic growth equation is written as (exponential growth)

$$N_g = N_o (e^{r(K-N)/K})^g$$

The logistic growth equation is written as (differential calculus)

$$dN/dt = rN (K-N)/K$$



Ecological Population regulation

Logistic model (assumption) population will level off at its carrying capacity

Key issues related to population regulation

1. Types of factors and population density
2. Key value analysis
3. Self-regulation of population
4. Immigration, emigration and population dynamics

1. Types of factors and population density

population density is increased by natality or immigration and decreased by mortality or emigration

Density dependent factors (Competition predation)

Density independent factors (Abiotic environmental factors)

2. Key value analysis

- The factor which may act as a regulator of population density in a community is called *key factor* or *key value*
- The k-values for each mortality factor, together with the total k (sum of all factors) are plotted for several successive generations
- The k-factor that most closely follows the pattern of k is called key factor.

3. Self-regulation of population

- Intraspecific, density dependent interactions regulate many populations in laboratory
- Accumulation of waste products and social behaviour may depress population growth

4. Immigration, emigration and population dynamics

- Increase or decrease of population density due to both Immigration, emigration

r or k selection

- r-selected population have high intrinsic rate of growth
- Under favourable condition population density increases
- k-selected population have a relatively constant density at or near optimum limit

Drawbacks of Logistic theory (assumptions made)

1. Environment is assumed to be constant
2. No time lag occurs in response of the population to the change in density
3. Regardless of age or sex or density, all the individuals are ecologically identical
4. Growth is continuous
5. There is no age structure change in the successive generations.

Modified Logistic theory (assumptions made)

1. Inclusion of a time lag
2. Take in to account the fluctuations in the carrying capacity
3. Consider the probable chance events for survival, reproduction and death of an individual due to environmental factor
4. Consider the discontinuous growth of some population with little or no overlap between successive generations