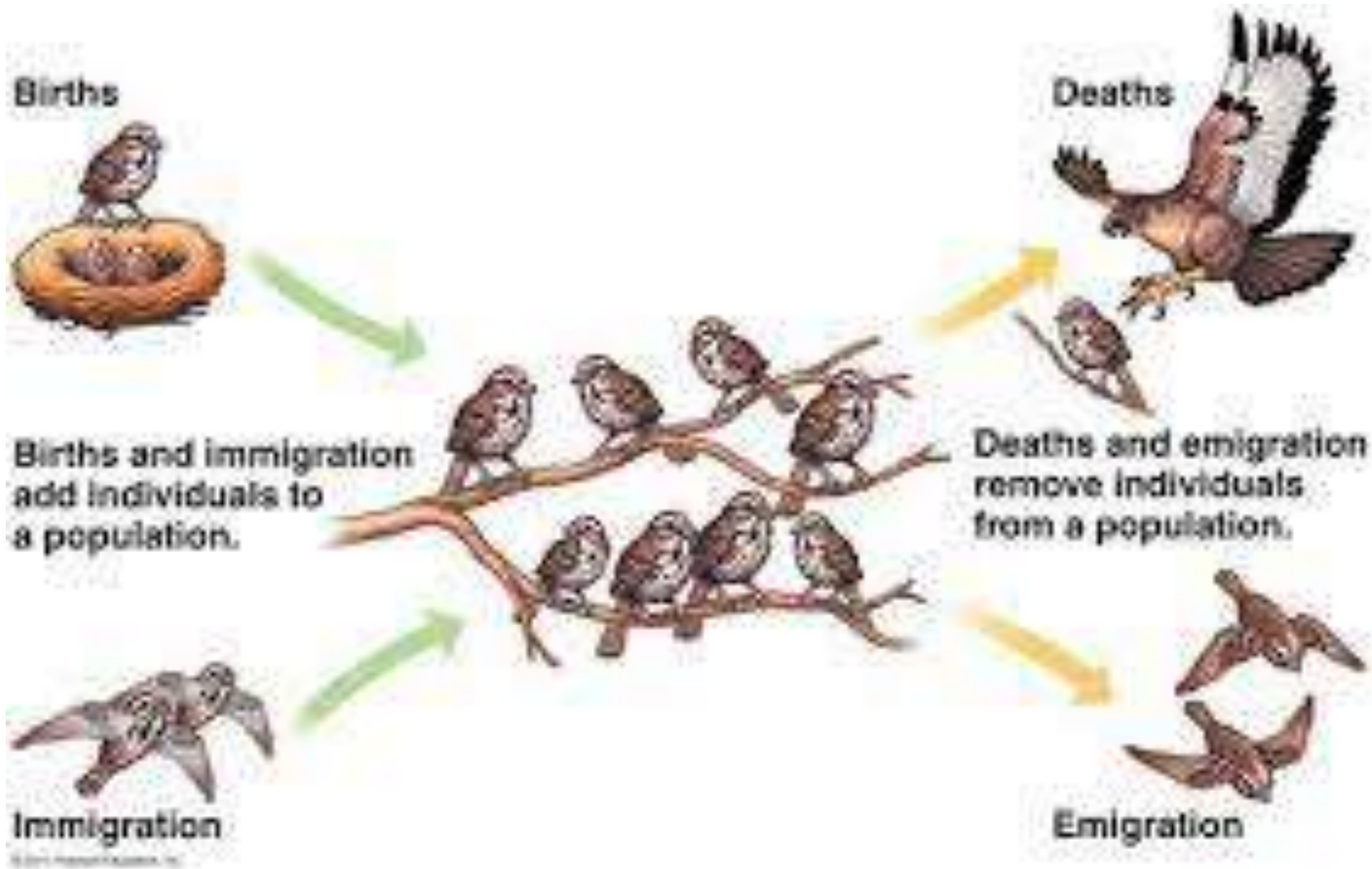
Population Ecology

INTRODUCTION

- **Population :-**
- Individuals of one species simultaneously occupying the same general area, utilizing the same resources, and influenced by similar environmental factors.
- **Population ecology :-**
- measuring changes in population size and composition and identifying the factors that cause these changes.


Births
Deaths
Births and immigration add individuals to a population.
Deaths and emigration remove individuals from a population.
Immigration
Emigration

Characteristics of Population:

1) Population Density :-

- Every population has geographical boundaries and a population size.
- A population will exhibit two characteristics within its boundaries: density and dispersion.
- The number of individuals per unit area or volume is called as Population density

Measuring Density:-

- It is usually impractical or impossible to count all individuals in a population, so ecologists use a variety of sampling techniques to estimate densities and total population size.

- May count all individuals in a sample of representative plots. Estimates become more accurate as sample plots increase in size or number.

- May estimate by indirect indicators such as number of nests or burrows, or by droppings or tracks.

- May use the mark-recapture method. In the mark-recapture method, animals are trapped within boundaries, marked in some way and after time retrapped.

- The number of individuals in a population (N) is estimated by the formula:

$$N = \frac{(\text{number marked}) \times (\text{total catch the second time})}{\text{number of marked recaptures}}$$

- Assumes marked individuals have same probability of being trapped as unmarked individuals. This assumption is not always valid. number of marked recaptures

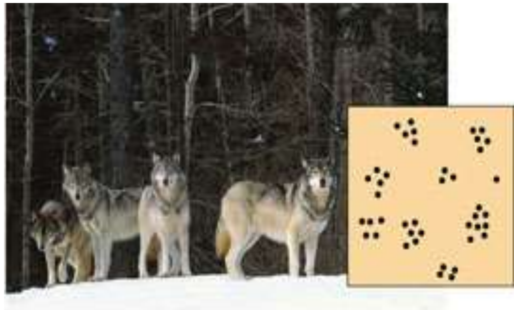
Limits to using density to estimate population size

- **Population dispersion =** The pattern of spacing among individuals within the geographical boundaries of the population.
- Local densities may vary substantially because not all areas of a range provide equally suitable habitat.
- Individuals exhibit a continuum of three general patterns of spacing in relation to other individuals: clumped, uniform, and random.

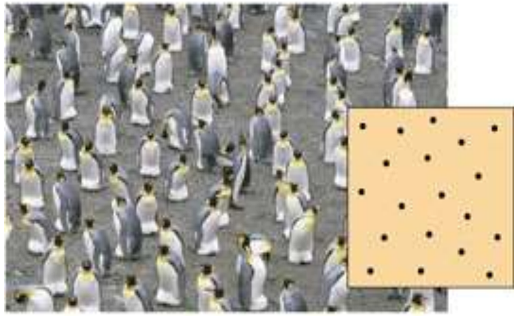
- 1. A clumped pattern is when individuals are aggregated in patches.
- May result from the environment being heterogeneous, with resources concentrated in patches, associated with mating or other social behavior in animals & defense against predators

- 2. A uniform pattern is when the spacing of individuals is even.
- May result from antagonistic interactions between individuals of the population.

- 3. A random pattern is when individual spacing varies in an unpredictable way.
- Occurs in the absence of strong attractions or repulsions among individuals. Not very common in nature.



(a) Clumped. For many animals, such as these wolves, living in groups increases the effectiveness of hunting, spreads the work of protecting and caring for young, and helps exclude other individuals from their territory.



(b) Uniform. Birds nesting on small islands, such as these king penguins on South Georgia Island in the South Atlantic Ocean, often exhibit uniform spacing, maintained by aggressive interactions between neighbors.

(c) Random. Dandelions grow from windblown seeds that land at random and later germinate.

2) Natality:- Birth rate

- The number of individuals produced by birth, haching, germination, multiplication or fission in per unit time.

- Natality of a Population can be calculated by the formula:

$$B = \frac{Nn}{t}$$

B = Birth rate per unit time

N= Initial Number of organisms

n= New individuals in a population

t= time

3) Mortality: Death Rate

- The number of individuals that die in a population in given area in given period of time.
- The rate death of a population can be calculated by the following formula:-

$$\text{Death rate (d)} = \frac{\text{Number of deaths per unit time}}{\text{Average population}}$$

4) Facundity & facundity tables:-

- The number of offspring produced by female
- It varies from species to species according to their size, no. of generations within a year.
- Facundity tables are the diagrammatic representation of the net reproductive rate or net fertility rate of the population.
- It help to find out the reroductive output and survivorship of breeding individuals only
- Parameters are 1) x = age class or interval 2) nx = number of survivors at beginning of age interval x

Life Table Calculations

Age class (X)	Number died	Number alive	Survivorship (L_x)	Birth (m_x)	$L_x m_x$	$X L_x m_x$
0	223	530	1.0 (530/530)	0	0	0
1	145	307	0.579 (307/530)	5	2.95	2.95
2	89	162	0.306 (162/530)	10	3.06	6.12
3	58	73	0.138 (73/530)	11	1.52	4.56
4	15	15	0.028 (15/530)	9	0.26	1.04
5	0	0	0			

Sum = 7.70 14.67

Net Reproductive Rate (R_o) = # female offspring produced in one female's lifetime

$$R_o = \sum_{i=1}^{x} l_x m_x \quad 0+2.95+3.06+1.52+0.26 = 7.70$$

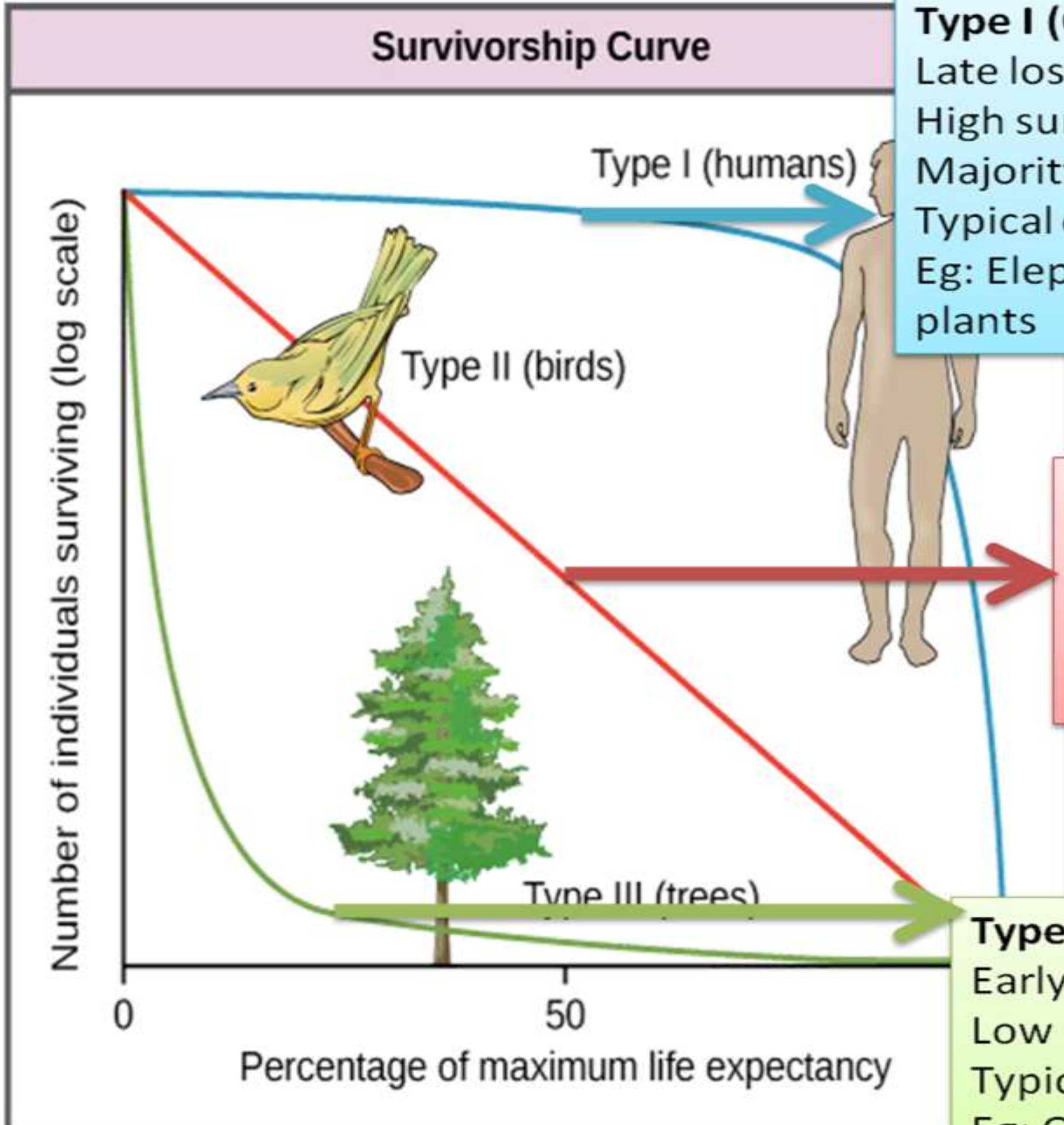
$$\frac{\sum X(l_x)(m_x)}{\sum(l_x)(m_x)} = \text{Generation Time} = \frac{(1*2.95)+(2*3.06)+3*1.52)+(4*0.26)}{7.70} = \frac{14.67}{7.70} = 1.905$$

5) Survivorship Curves

- Expressed specific mortality rate of a population

- Three types

- 1) Diagonal curve (B) or (II):-
- 2) Convex Curve (A) or (I):-
- 3) Concave Curve (C) or (III):-



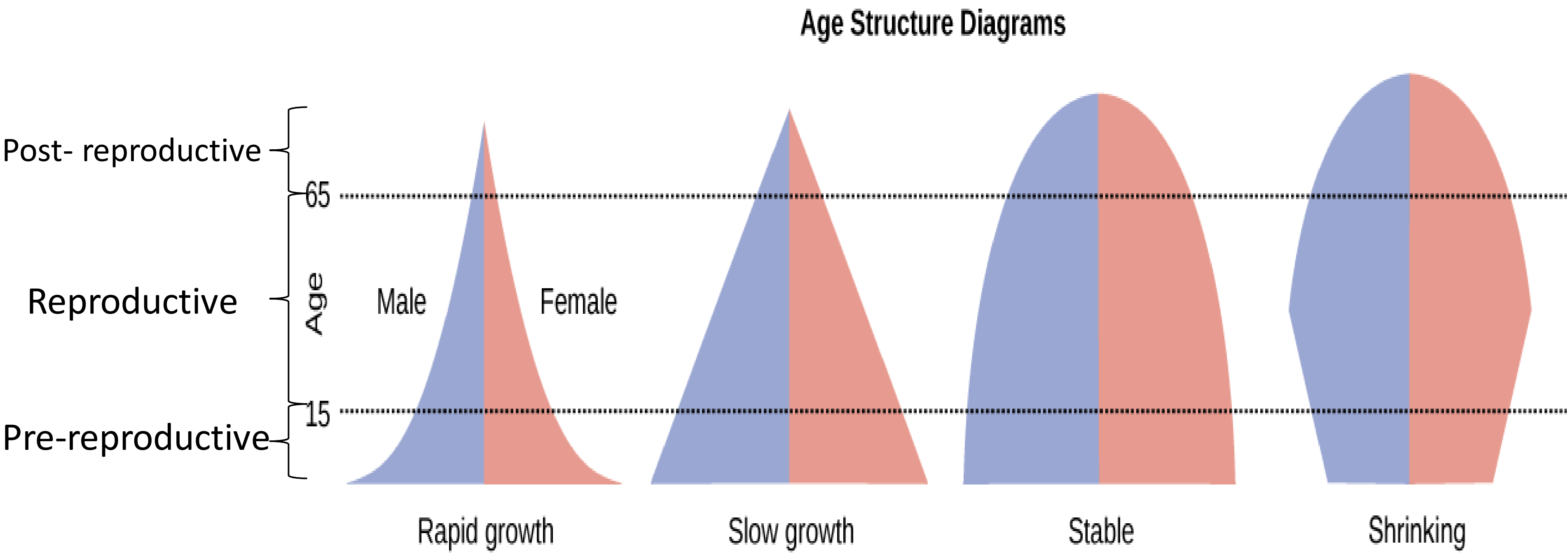
Type I (Convex curve)
Late loss
High survivorship throughout life
Majority reaches maturity
Typical of k selected species
Eg: Elephants, Humans, annual plants

Type II (Diagonal curve)
Constant loss
Independent of age
Eg: Birds, rodents, Hydra, perennial plants

Type III (Concave curve)
Early loss
Low mortality after maturity
Typical of r -selected species
Eg: Oysters, Small fishes, trees

6) Age Ratio

Affects both natality & mortality



Pre- reproductive & post- reproductive & Reproductive Phases

7) Sex Ratio

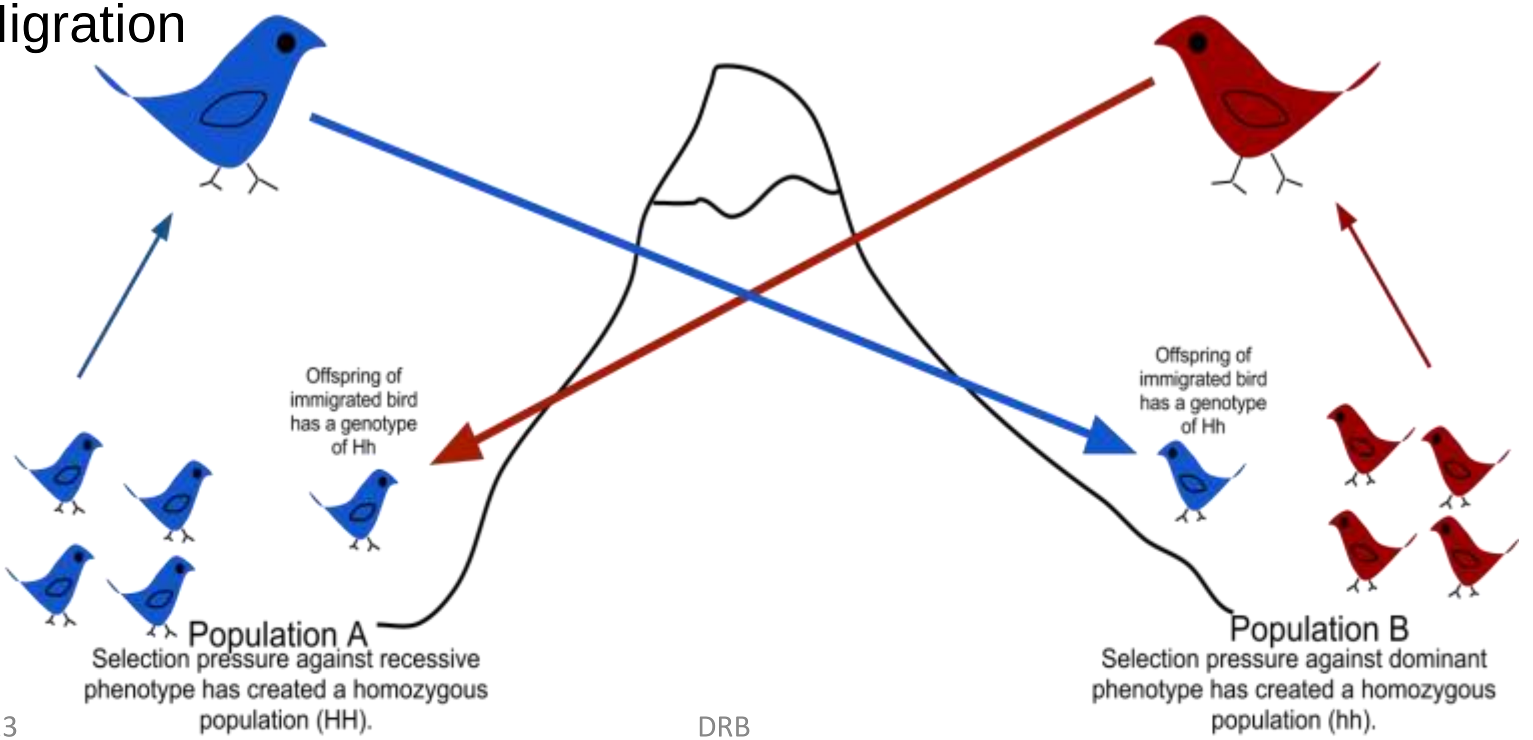
- The ratio of males & females in a population
- In sexually reproducing species, the ratio tends to 1:1
- It varies according to age profile

- Four subdivisions-
  1) Primary Sex ratio
  2) Secondary Sex ratio
  3) Tertiary Sex ratio
  4) Quaternary Sex ratio

8) Population Dispersal

- The movement of individuals & the products of their reproduction into & out of the population is called as population dispersal.

- Three types
  1) Emigration
  2) Immigration
  3) Migration

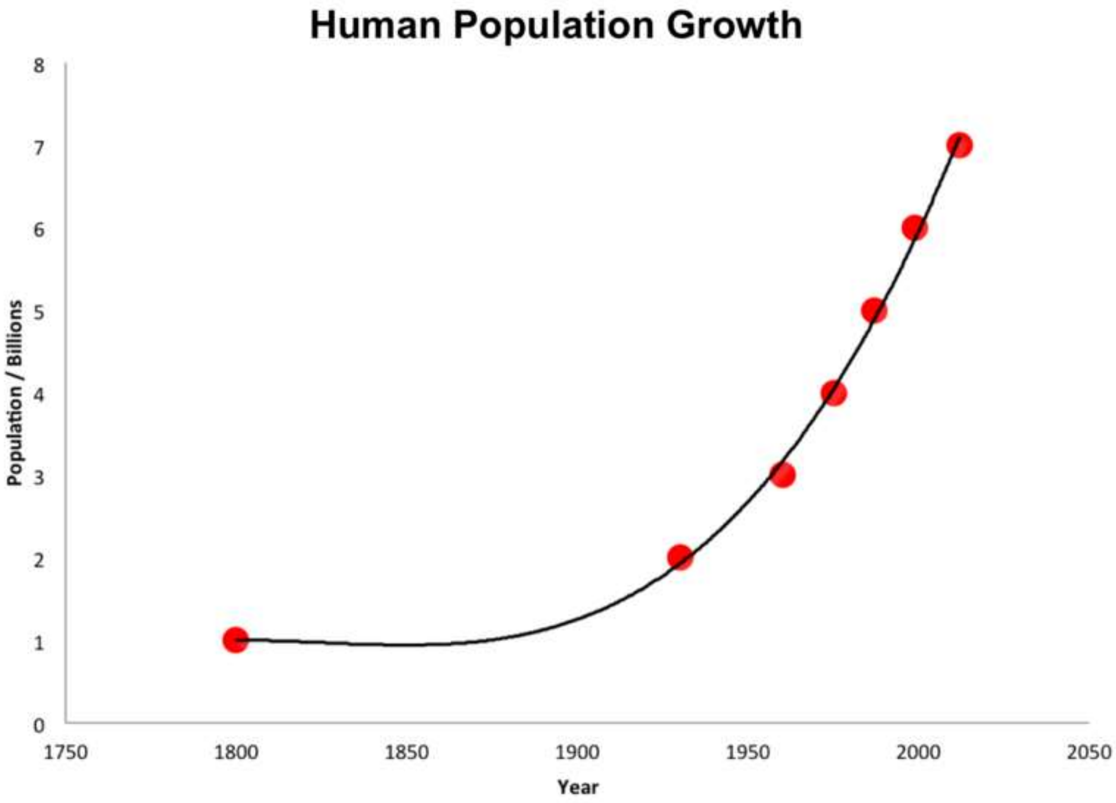


The growth curves

Exponential Growth

- The exponential growth refers to a growth of a population whose rate is proportional to the size of the population over a specific period of time.
- The size of the population depends on the rate of birth and the rate of death.
- The exponential growth occurs when plentiful of resources are available for the individuals in the population.
- It results in a J-shaped curve when the number of entities is plotted against time.
- At the beginning, the size of the population is small.
- With time, the size of the population increases. The growth rate rapidly increases along with the increasing size of the population.
- The exponential growth shows a fixed percentage rate of increase over time. The doubling time refers to the period of time required to double the number of in a particular population.

- The most precise example of exponential growth is the growth of the human population.
- The increase in the number of microorganisms in a culture until the essential nutrients in the culture become limited.
- The spread of a virus if no artificial immunization is available is also an example of exponential growth.

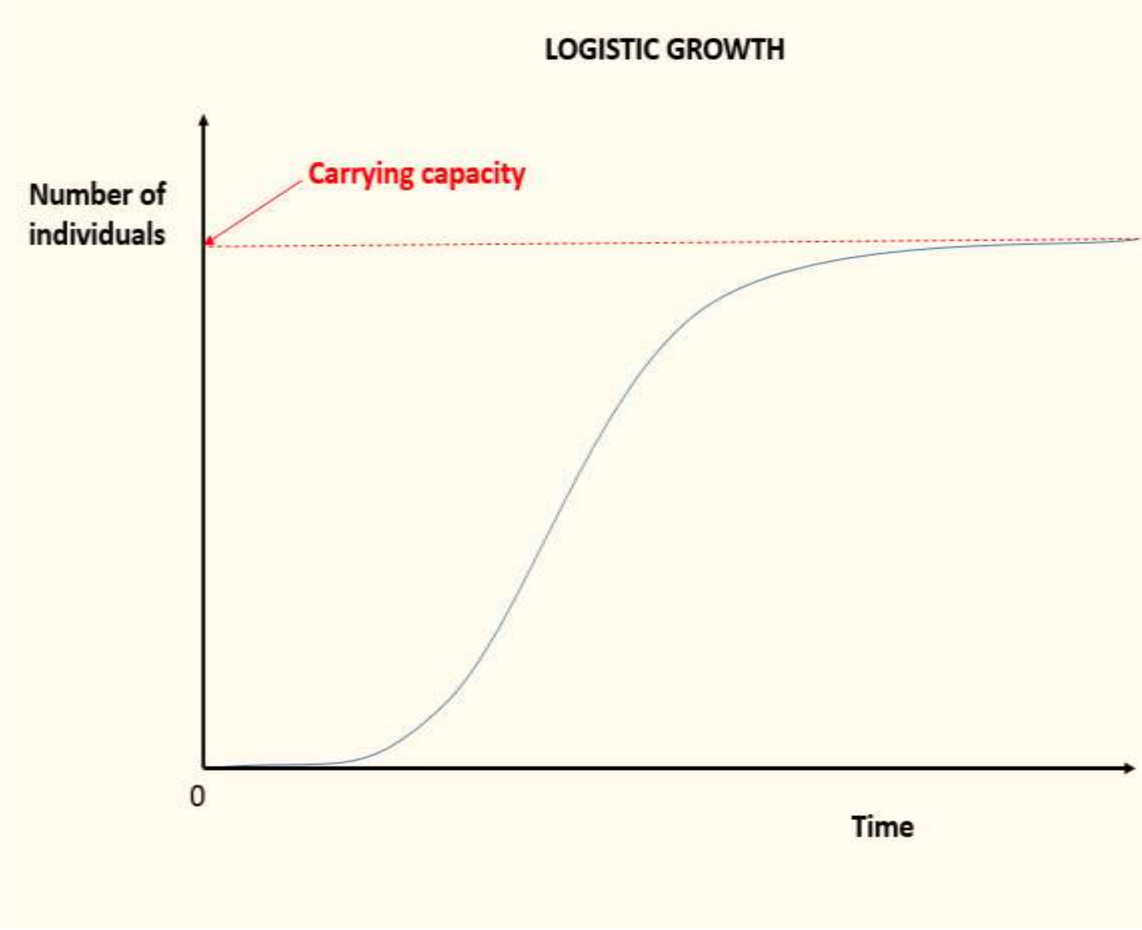


Logistic Growth

- The logistic growth refers to a population growth whose rate decreases with the increasing number of individuals and it becomes zero when the population becomes its maximum.
- When the food supply and space become limited, a competition arises among individuals in the population for the resources.
- Therefore, the rate of growth does not only depend on the size of the population.
- The rate of birth and the rate of death depend on the ability to grab resources in the environment.
- Hence, the size of the population does not exceed the carrying capacity of the environment.
- The carrying capacity refers to the maximum population size the environment can sustain.
- When the growth of the population reaches the carrying capacity of the environment, the rate of the growth decreases.

- It is more realistic than exponential growth model, the logistic growth model can be applied to the most populations on the earth.

- The logistic growth is a sigmoid curve when the number of entities is plotted against time.



Difference between Exponential growth& Logistic growth

Exponential growth of a population refers to a growth whose rate is proportional to the size of the population over a specific period of time	Logistic growth refers to a population growth whose rate decreases with the increasing number of individuals
Growth curve is J-shaped	Growth curve is sigmoid
Depends on the size of the population	Depends on the size of the population, competition and the amount of resources
Occurs when the resources are plentiful	Occurs when the resources are limited
Does not frequently reach a stationary phase	Reaches a stationary phase
Does not have an upper limit	Has an upper limit called the carrying capacity
Applicable to any population that does not have a limitation for the growth	Applicable to any population that comes to its carrying capacity
Has two phases: lag phase and log phase	Has four phases: log phase, lag phase, deceleration phase, and stationary phase
Causes an explosion of the population	Causes relatively constant growth rate in the population
Population crash occurs due to mass mortality	Population crash occurs very rarely
Commonality does not occur	Commonality often occurs

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