

POPULATION ECOLOGY

Population ecology – the part of ecology that focuses on the factors influencing the population size, growth rate, growth forms and distribution of individuals inside a population.

Species – group of organisms with similar characteristics, which produce fertile offspring.

Population – group of the same species that are found in an area at a time.

Community – group of populations occurring in an area e.g. populations of lion, zebra, giraffe and rhino in the Kruger National Park.

Ecosystem – a unit of living organisms interacting with each other as well as with the non-living factors in area.

Environment – external factors (living and non-living) surrounding an organism and influencing its development and survival.

Habitat – specific environment (home) in which a plant or animal species normally occurs.

POPULATION SIZE

Population size is the total number of individuals in a population.

Population density refers to the number of individuals of a population per unit area e.g. 10 sheep per hectare.

Population parameters

Four main factors (parameters) influence population size.

- **Natality** – the birth rate of a population (normally expressed as the number of live births per thousand individuals per year).
- **Mortality** - the death rate of a population.
- **Immigration** – the one-way movement of organisms into an area where they become established.
- **Emigration** – the one-way movement of organisms out of an area to become established.

Natality and immigration cause an increase in population size, while mortality and emigration cause a decrease.

A population where immigration and emigration do not occur is known as a **closed population**, e.g. fish in a dam or animals on an island. The only parameters that affect the population size in a closed population are natality and mortality.

Determining population size

Direct techniques – involve the total count of all individuals in the population. These includes:

- Census (in a human population)
- Counting, e.g. large animals in a nature reserve counted with the aid of a helicopter.
- Aerial photographs of groups of animals, e.g. a penguin colony.

Indirect techniques – involve the counting of only part of the population. It includes the following:

- Mark-recapture technique
- Quadrat technique

Mark-recapture technique

- A specific area is demarcated.
- Several individuals are caught, counted and marked (1st sample) and are later released into the environment. They are allowed to mix with the rest of the population.
- Another group of individuals is caught and counted (2nd sample).
- The number of marked individuals in the 2nd sample (marked during the 1st sampling) are counted.
- The data is used to determine the estimated size of the population using the following formula:

$$P = \frac{m \times s}{t}$$

P = estimated population size

m = total number of animals captured and marked in sample 1

s = total number of animals captured in sample 2

t = number of marked individuals in sample 2

To make this technique more accurate (improve), repeat the sampling a few times and calculate an average population size. This technique is only valid under the following conditions:

- The marking method should not injure or damage the organism.
- The marks should be clearly visible for the duration of the investigation.
- The marking method should not affect the movement or behaviour of the organism.
- Marked organisms should be allowed enough time to mix with the rest of the population before the next sample is taken.
- The population must be closed, so no immigration or emigration takes place.
- The period between the two samplings should be sufficiently brief, so that no births or deaths occur.

Quadrat technique

- A square frame of known size is used.
- An area where organisms must be counted is demarcated and the surface area determined.
- The quadrat is placed on the ground in the demarcated area and the organisms concerned are counted inside the square frame.
- This process is repeated a few times in different areas of the demarcated area by placing the quadrat randomly on the ground. Through random sampling, each member of the population has an equal and independent chance of being included.
- The total number of individuals in the population is determined using the following formula:

$$\text{Population size} = \text{average number of individuals per quadrat} \times \frac{\text{surface area of the area}}{\text{surface area of the quadrat}}$$

The reliability of this technique depends on the following:

- The exact number of organisms in each quadrat must be known.
- The surface area of the quadrat must be known.
- The surface area of the demarcated area must be known.
- The quadrat must be placed randomly in the demarcated area.

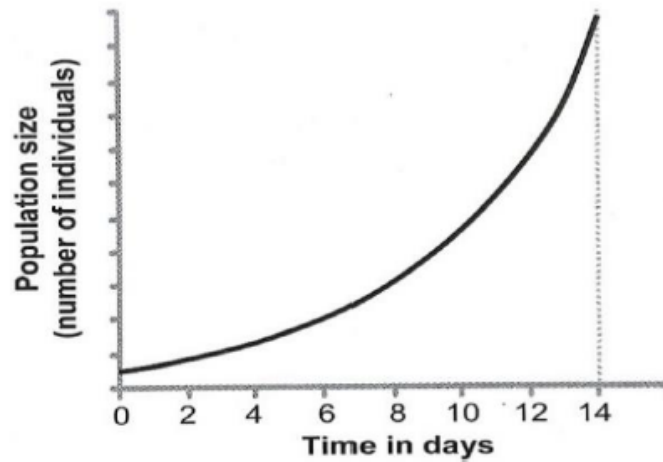
POPULATION GROWTH FORMS

It is the distinctive growth patterns of a population. Two basic growth forms are distinguished:

- Geometric J-shaped growth form
- Logistic or S-shaped (sigmoid) growth form.

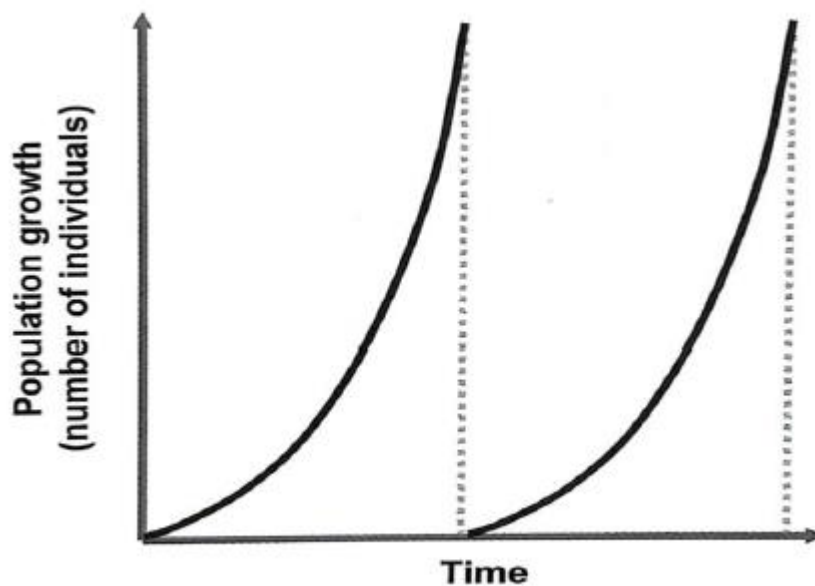
Geometric (J-Shaped) Growth Form

Unlimited resources such as food, water, space and no predators can make a population reach its full reproductive potential. These ideal environmental conditions result in the maximum possible growth rate and population figures increase rapidly.



Characteristics of geometric growth form

- A distinctive J-shape.
- Increase in number is slow at the beginning, as there are few individuals.
- In time there is a sharp increase in individuals due to optimum environmental conditions.
- A sudden standstill often occurs. This occurs when conditions become unfavourable, e.g. shortage of food, unfavourable temperature or poisoning.
- Once conditions are favourable again, the growth pattern can be repeated.



LIMITING FACTORS

Factors that prevent unlimited growth in a population. They play a huge role in the regulation of population size.

Limiting factors can be classified as:

- Density dependent factors – factors that take effect when population size or density increases. The larger the population, the greater the effect of these factors. Examples include shortage of food and water, shortage of living space, shortage of shelter, predation, spread of diseases and parasites, accumulation of toxins.
- Density independent factors – factors that limit the size of a population regardless of the size or density of the population. Examples include extreme changes in temperature, natural disasters (floods, drought, fire, earthquakes, tsunamis, volcanic eruptions and hurricanes).

Together, they are called **environmental resistance**. When the numbers a population increase, the environmental resistance increases.

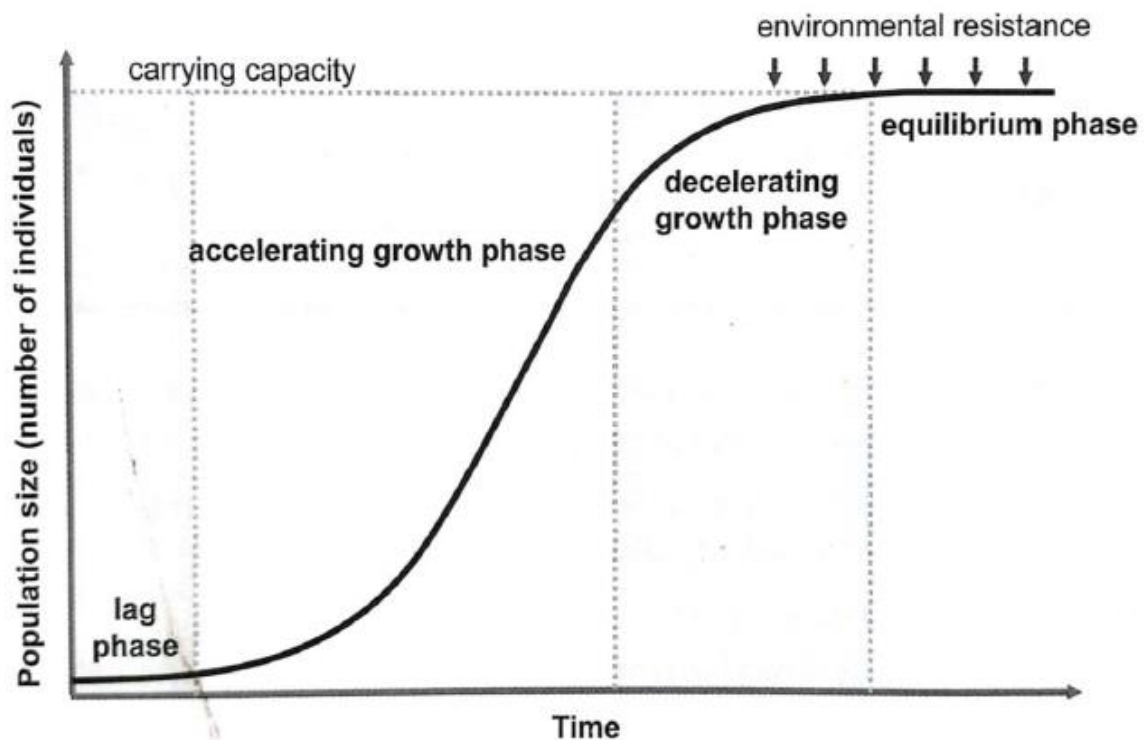
Logistic (S-shaped) Growth Form

Limiting factors (environmental resistance) can transform the J-shaped curve into an S-shaped curve.

An S-shaped growth form occurs when a young population consisting of only a few individuals is in an area with sufficient food, water, space and little predation.

Four distinctive phases can be distinguished on the logistic (S-shaped) curve:

- Lag phase
- Geometric/ exponential/ accelerating growth phase
- Decelerating growth phase
- Equilibrium/stationary phase.



Lag phase

The population grows slowly at the beginning. This is because;

- population acclimatises and adapt to the environment.
- individuals must become sexually mature.
- individuals seek partners for mating.
- it takes time before new offspring are produced (gestation period or incubation).

Geometric/exponential/accelerating growth phase

The population grows rapidly and reaches its maximum growth rate. There is very little or no environmental resistance at this stage. Natality is higher than mortality.

Decelerating growth phase

Growth rate decreases due to an increase in environmental resistance. Natality is still higher than mortality. As the population grows, the available resources decrease, and competition increases.

Equilibrium/stationary phase

The population number now reaches the carrying capacity of the environment and stabilise around this value. Natality and mortality are approximately equal during this phase.

Carrying capacity is the maximum number of individuals that a specific environment can sustain.

REGULATION OF POPULATION SIZE

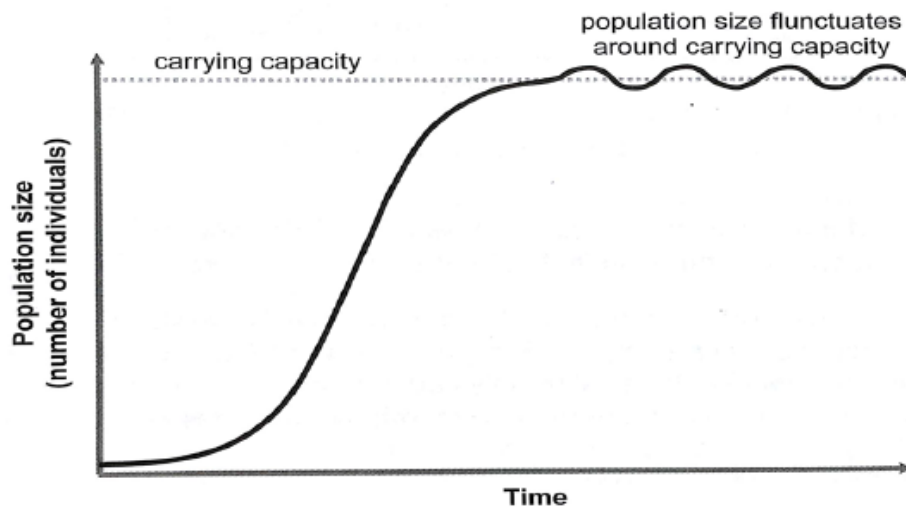
Once a population reaches its maximum size the numbers will not remain constant. The numbers will **fluctuate** due to changes in environmental resistance.

The size of a population may fluctuate seasonally or annually depending on environmental factors and available resources.

The limiting factors play an important role in the regulation of population size. These are the factors that increase or take effect when the population numbers increase and are also called the **density dependent factors**. **Density dependent factors** are therefore factors that take effect when population size or density increases. Density dependent factors include food supply, living space, disease, shelter etc. An increase in population size results in a greater demand for food, water, living space, shelter etc.

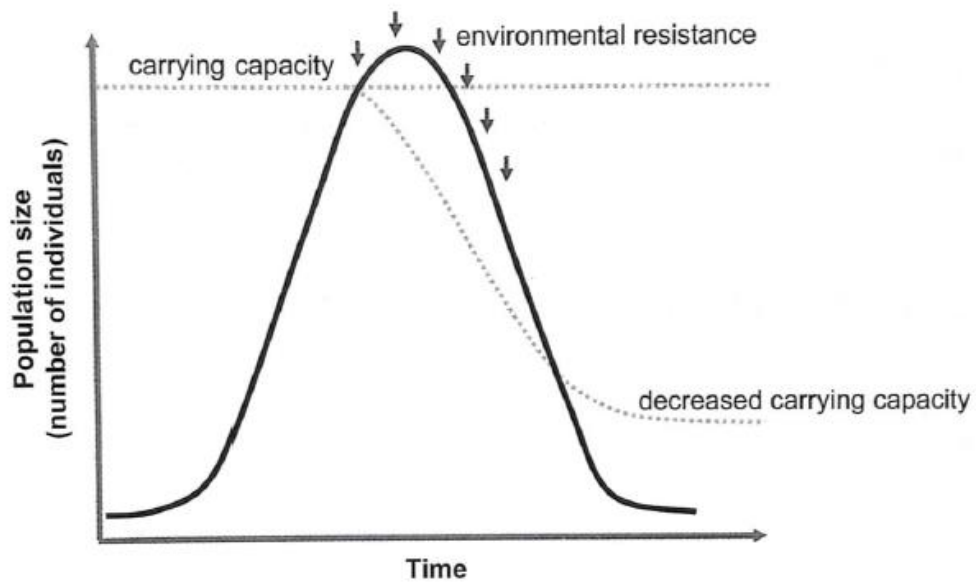
Density independent factors e.g. extreme changes in temperature, droughts, floods, earthquakes etc. are factors that regulate population size regardless of the size or density of the population. These factors result in a drastic decline in population numbers.

A **stable population** is a population where the numbers fluctuate around the carrying capacity.



When population numbers far exceed the carrying capacity, the habitat will most likely be damaged, leading to a decrease in the carrying capacity of the environment. This type of population is called an **unstable population**.

The environment can no longer sustain the population and the population numbers will decrease, it may even become extinct.

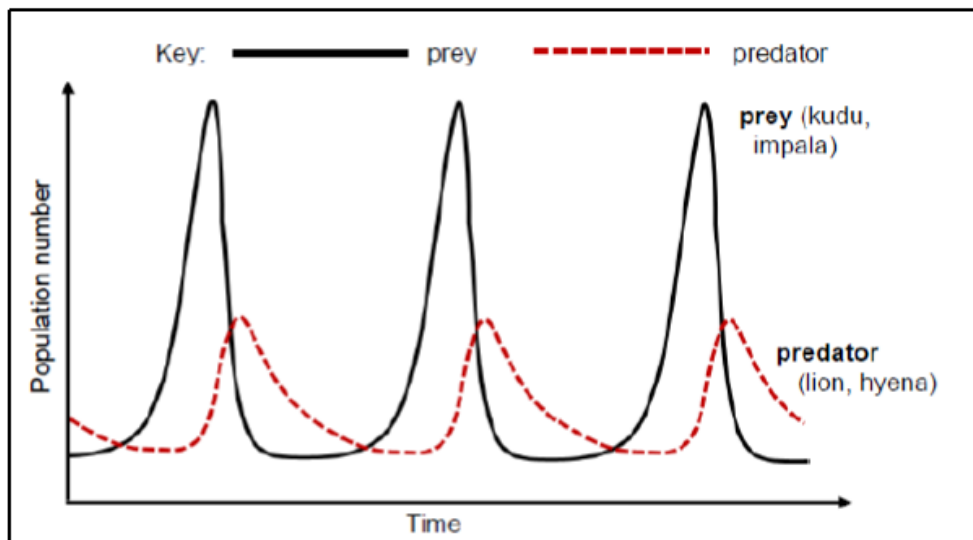


4.1.5 INTERACTIONS IN THE ENVIRONMENT

4.1.5.1 PREDATION

- Feeding interaction where one organism, the **predator** (e.g. lion), hunts, kills and eats another organism, the **prey** (e.g. zebra).
- Predation helps to control the size of populations.
- The higher the prey numbers, the more predation will occur.
- The lower the prey numbers, the fewer predators will survive due to a shortage of food.

Figure 14: Graph showing predator-prey relationship



Predation is therefore a **density-dependent factor**.

Each species has a specific role to play in the community. This role is known as its **ecological niche**. In its specific role, each species needs a particular set of environmental conditions and resources to survive and reproduce in its habitat. The survival of a species therefore depends on how successfully the organisms use their available resources.

4.1.5.2 COMPETITION

- Competition takes place when two or more individuals compete for the same limited resources e.g. food, water, mating partners etc.
- **Intraspecific competition** takes place between individuals of the **same species** e.g. male lions competing for a female
- **Interspecific competition** takes place between individuals of different species e.g. hyenas and vultures competing for the same food source.

4.1.5.3 COMPETITIVE EXCLUSION

- Two different species that need the same limited resources cannot occupy the same niche in the same habitat over a long period.
- The one species will outcompete the other which will result in the emigration or extinction of the other species.
- This is known as the principle of competitive exclusion.

4.1.5.4 RESOURCE PARTITIONING

- Two species can co-exist in one habitat but use the same resources differently e.g. one species feeds during the day and the other at night, two species feeding on different heights of the same tree etc.

Types of resource partitioning includes:

- Using the resource at different times, e.g. one species feed during the day and the other at night.
- Using different parts of the resource, e.g. two different species of ape feed at different heights in a tree.
- Using the resource in different habitats, e.g. two different species of monkey feed on the same species of tree, but in different parts of the forest.

SYMBIOSIS

Some organisms of different species live together in a relationship. This relationship is known as symbiosis.

4.1.5.5 MUTUALISM

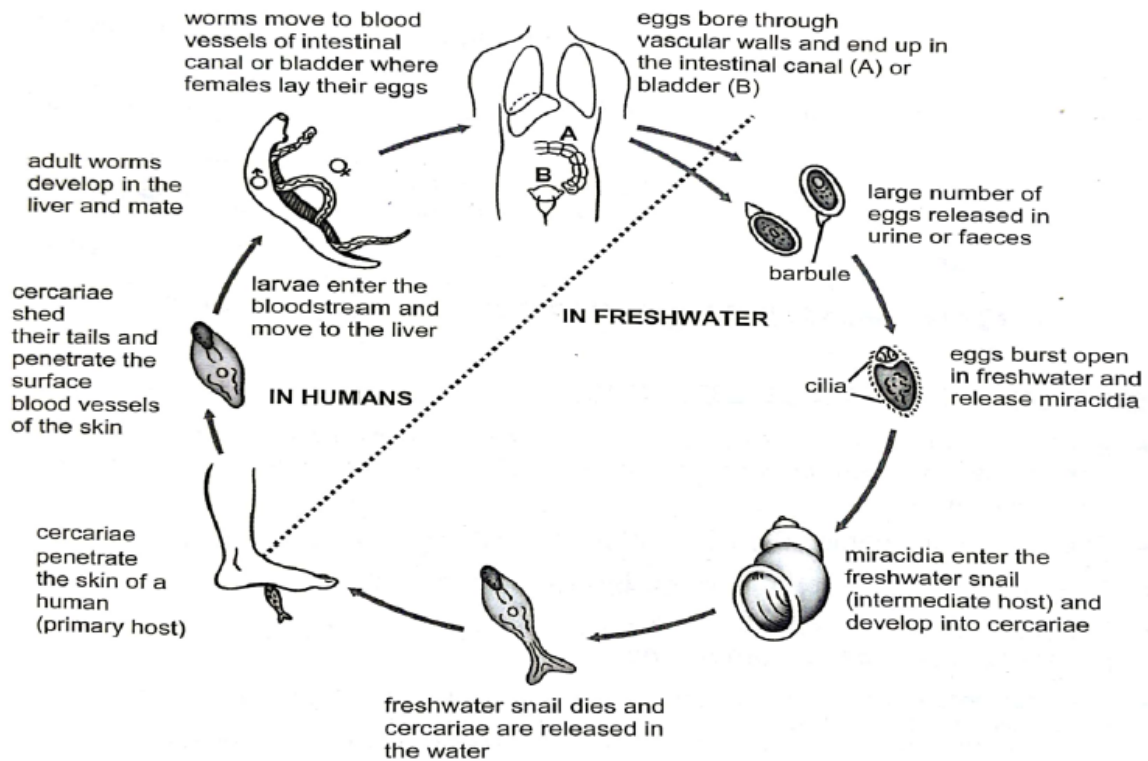
- A symbiotic relationship between two organisms of different species where **both benefit** e.g. bees getting food from a flower and the flower is cross-pollinated.

4.1.5.6 COMMENSALISM

- A symbiotic relationship between two organisms of different species where the **one benefits** and the **other neither benefits nor is harmed** e.g. the suckerfish on sharks that feeds on the leftover food and the suckerfish also gets protection.

4.1.5.7 PARASITISM

- A symbiotic relationship between two organisms of different species where **one benefits (parasite)** and the **other is harmed (host)** e.g. **ectoparasites** like lice, fleas and **endoparasites** like the tapeworm.



Life cycle of the bilharzia parasite

SOCIAL ORGANISATION

Many organisms occur in groups (herds, packs or swarms) or colonies where the animals are interdependent. There is a social organisation evident in these groups or colonies that consists of various survival strategies. These strategies help the animals to survive in their environment.

Herds or swarms as anti-predation strategy

Each individual group member reduces the danger to itself by staying as close as possible to the centre of the group – staying as a unit.

The herd can also scatter in all directions. This confuses the predator and makes it harder to catch the prey.

In some cases, a predator can be attacked by a large herd or flock.

Some animals confuse predators with colouring that makes them difficult to identify. For example, a single zebra is clearly visible on a grassy plain, but in herd of zebra, the stripes merge together and present the predator with one confusing image.

Packs as a successful hunting strategy

Some predators such as the African wild dog, lions and hyenas, hunt together in packs – **cooperative hunting**. It seems that this hunting strategy in a species consists of learned behaviour rather than instinctive behaviour, which is passed from one generation to another.

Sharing of tasks (castes)

Animals that reach the highest level of social organisation in a community are called eusocial animals and live together in highly organised colonies. The most well-known examples are social insects, such as bees, ants, termites and wasps.

The only mammalian examples are the naked mole rat and the Damaraland mole rat.

In social insects (e.g. bees), there are different groups or castes that perform specialised functions in the colonies. These functions include finding food and building nests, (workers), protecting the nest (soldiers) and caring for the young. A single dominant fertile female, the queen, is characteristic of these colonies.

COMMUNITY CHANGES OVER TIME

ECOLOGICAL SUCCESSION

This refers to the sequence of communities, where one community replaces another over time, resulting in long-term changes in the ecosystem. These changes continue until a complex, stable ecosystem develops. This is known as the **climax** or **endpoint of succession**.

The first plants and animals that become established in an area are known as **pioneers** or **pioneer communities**. The pioneers change or alter the environment and create conditions that are favourable for the establishment of more complex organisms. Pioneers are usually replaced by herbaceous plants, then shrubs and trees.

A distinction is made between primary succession and secondary succession.

Primary succession

It takes place when plants and animals settle for the first time in an area where there was previously no life. This usually occurs in areas where initially there was no soil (e.g. bare rocks, sandy surfaces, areas with lava deposits or newly formed dams/lakes).

Secondary succession

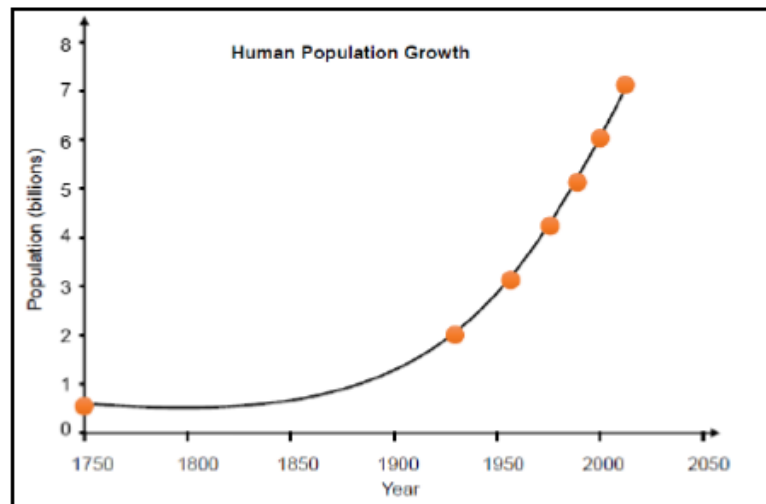
This takes place when plants and animals settle in an area disrupted by human activities, such as ploughed fields or cleared forests, or by natural disasters, such as bush fires or floods.

It takes place much faster than primary succession, because the area where the pioneer species is settling already has soil, organic nutrients and seeds from previous growth.

4.1.6 HUMAN POPULATION GROWTH

- The human population growth was very slow in earlier years because of a high mortality rate as a result of diseases, plagues etc.
- The population growth became exponential around 1750 i.e. a rapid increase in population over a short period (see graph below).

Figure 15: Human population growth



- The following are reasons for the exponential growth:
 - Advances in the medical field e.g. improved methods for treating diseases, development of vaccinations against infectious diseases
 - Increase in agricultural productivity e.g. the cultivation of new disease – resistant food crops, the use of fertilisers and the use of more effective farming methods.
- The population growth rate in less-developed countries is higher than in more developed countries.

Age-gender population pyramids

Data regarding a population can be gathered through conducting a census and then ordered according to the number of individuals of a certain age category and of a certain gender. The results are then presented as a population pyramid.

Key terminology

Age-gender pyramids	also called an age-sex pyramid where a demographic graph depicts the age and gender of a population per age group
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Three types of population pyramids can be observed according to whether or not the population size is growing or declining, namely:

- expanding or growing population pyramid
- stable population pyramid
- declining population pyramid

Expanding population growth pyramid

- more youth than elderly
- both natality and mortality rates are high
- few individuals reach old age - not much medical and social welfare assistance
- life expectancy, education levels, general standard of living are all quite low
- characteristic of developing countries / third world countries / many African countries

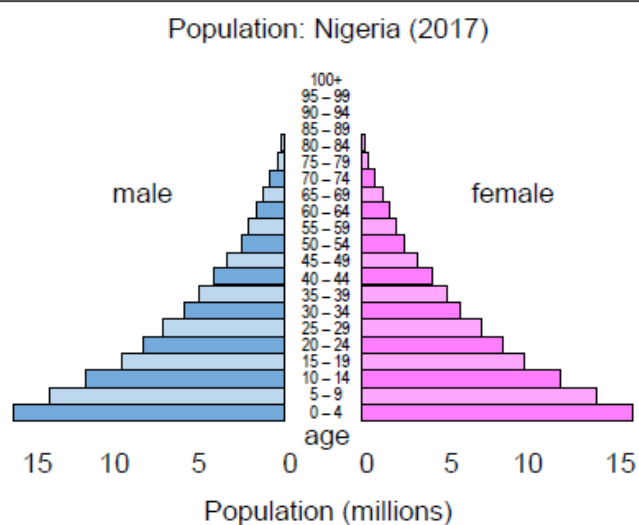


Figure 31: Positive growth of Nigeria's population in 2017

Stable population growth pyramid

- number of pre-reproductive individuals approximately the same as the number of reproductive individuals
- natality rates are low
- many individuals reach older ages because of medical and social welfare services
- life expectancy, education levels and general standard of living are all relatively high
- characteristic of certain developed countries, e.g. USA and China

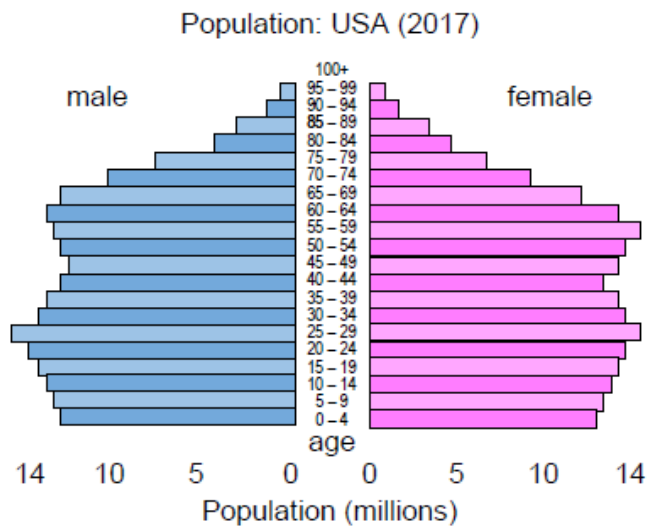


Figure 32: Stable growth of the USA's population in 2017

Negative or declining growth pyramid

- pre-reproductive groups are smaller than reproductive group
- natality and mortality rates are low
- many individuals reach older ages because of medical assistance and strong social welfare
- life expectancy, education levels and general standard of living are relatively high
- characteristic of developed countries, e.g. UK, Japan, Denmark and Italy

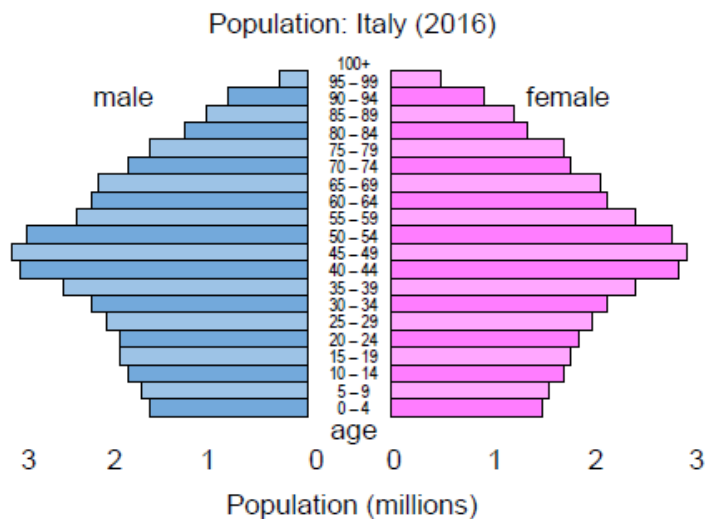


Figure 33: Negative growth of Italy's population in 2016

Apart from the above, human populations are also regulated by the prevailing global environment at the time, e.g. wars, famines, economic recessions, incurable super-bugs that are easily transmitted through international travel.

Governments can also regulate their population sizes through legislation. Some countries choose a more direct method to regulate their population whereas other would want to decrease it through legislation and policy.

The South African population

The South African population, like the global population, has shown a steady increase and is projected to increase further in the future. Table 2 summarises SA's population in 10-year intervals, and Figure 34 is a graphic representation of the population growth.

Table 2: SA population and projections (in millions)

1960	1970	1980	1990	2000	2010	2020	2050
17,4 m	22 m	27,6 m	35,2 m	44 m	50 m	58,7 m	65,5 m

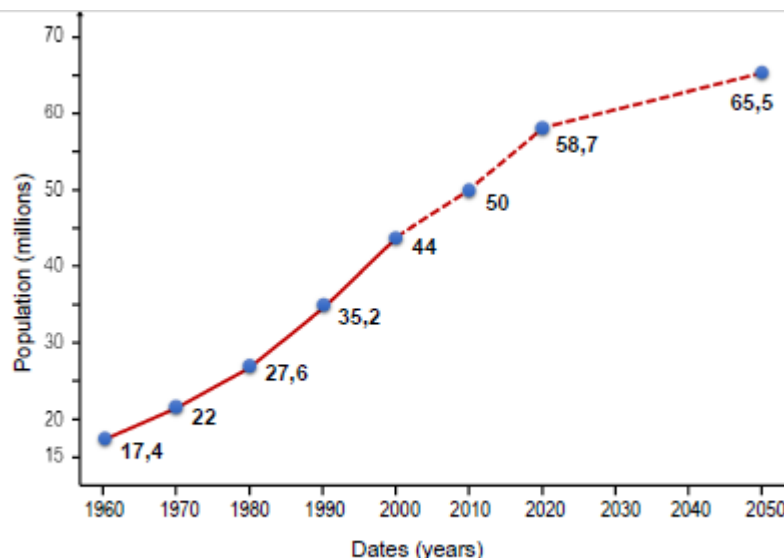


Figure 34: Graph of South African population from 1960 to 2018, and projected to 2050

Projections beyond 2018

The South African population grew steadily over the last 58 years (1960 – 2018) by about 40 million people.

This growth rate is expected to slow down significantly in the next 30 years, adding only a further 8 million.

- The fecundity rate (birth rate) has already shown a large decrease
 - in 1955, the average SA female bore 6,05 children in her lifetime
 - in 2018, the birth rate had decreased to 2,52 children

Life expectancy

The life expectancy of the average South African was 49 years in 1960 but reached 60 years in 2016. This is however still significantly lower than the global average of 70,5 years.

Possible reasons for the longer life expectancy globally

- better health and sanitation
- social welfare improvements
- increased primary health care services

Figure 35 below gives the population pyramid for the South African population in 2016.

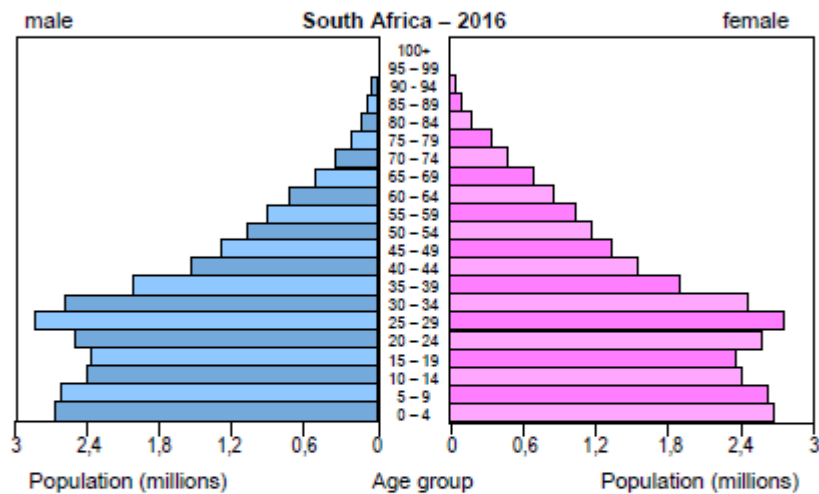


Figure 35: South African population (2016)

What does all this mean for the future of South Africa?

Statistical data acquired from population estimates should help policy makers, government and society think about South Africa's future. Our population's size is growing. People are growing older and the world of business is becoming more complex and sophisticated daily. Proper planning needs to take place. City planning and civil societal planning on how many schools, hospitals, industrial development zones are needed, needs to take place.