

Population Ecology

Definitions:

ECOLOGY

Interactions of organisms with **biological** and **physical** (biotic and abiotic) components of their environments.

Population ecology-The study of fluctuations in population size and the factors

1. Individual-a single organism a plant or animal living in an environment/ A **single** organism capable of **independent** existence
2. Species-a group of organisms with similar characteristics living in an area and can produce viable offspring.
3. Population is a group of species living in an area at a particular time and able to produce viable offspring.
Or A group of organisms of the same species ✓ occupying a definable area ✓ close enough for random interbreeding. ✓ (3)
4. Community a group of different population that live together and interact in an area or

Community – group of populations/species in an area. Ecosystem includes interaction with environment / groups of communities interacting with each other.

Or

Two or more different species occupying the same geographical area and in a particular time.

Ecosystem: all organisms that live in an area and interact with each other with nonliving organisms/ Groups of different species (**'populations'**) that **interact** with each other and the environment.

Population size

Factors that affect population size-

Natality -birth rate in animals/plants mortality death rate

Immigration- movement of organisms into an area and stay

Emigration- movement of organisms out of an area and do not return

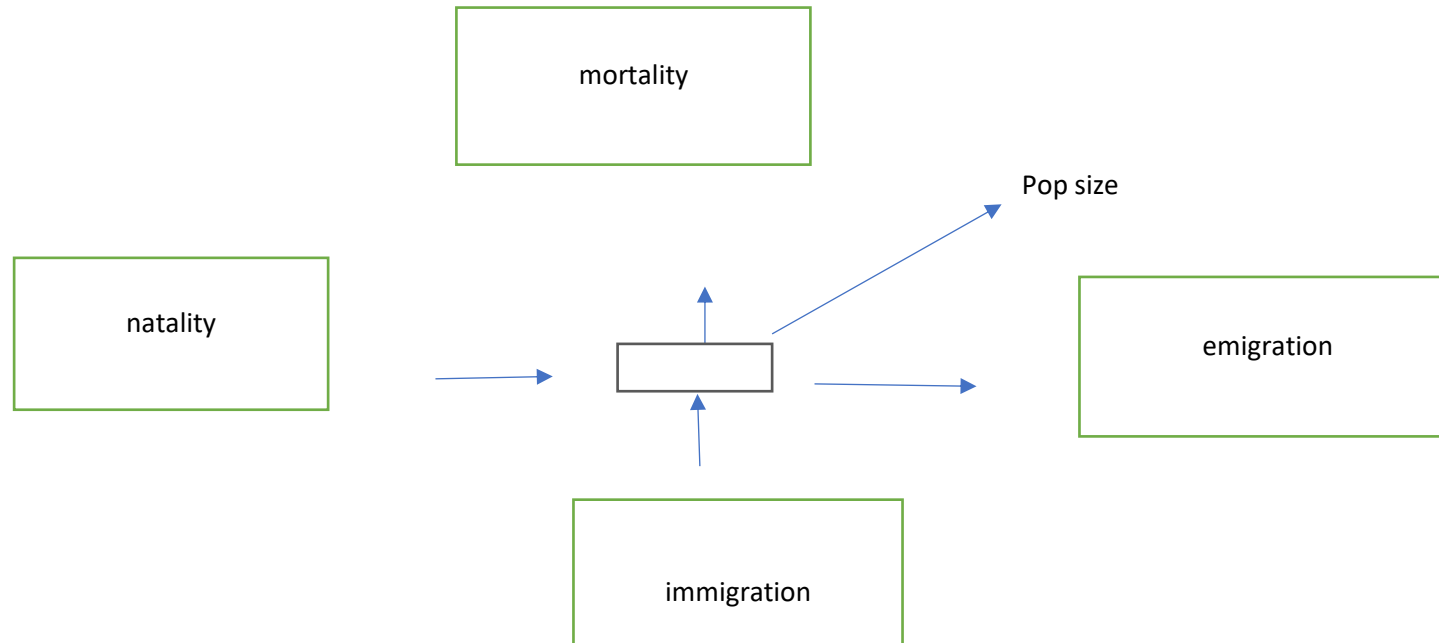
Growing population sizes

Increases when Birth rate and immigration exceed death and emigration

Decline when death and emigration exceed natality and immigration

Remain the same when birth rate and immigration equal to mortality emigration

Factors that affect Population size



Population parameters

Are the factors that affect pop size

E.g., natality and immigration

Mortality and emigration

Types of population

Closed population- is when organism is not allowed to move into and out of the area

Open population- where there is free movement of organisms into and out of the area

Limiting factors

Are factors that reduce population size

These are

1. Density dependent factors
2. Density independent factors

Density dependent factors

Factors that are caused by organism themselves in an area as pop growth e.g., diseases, space, crowded shelter

Density independent factors are natural factors that affect population size e.g.

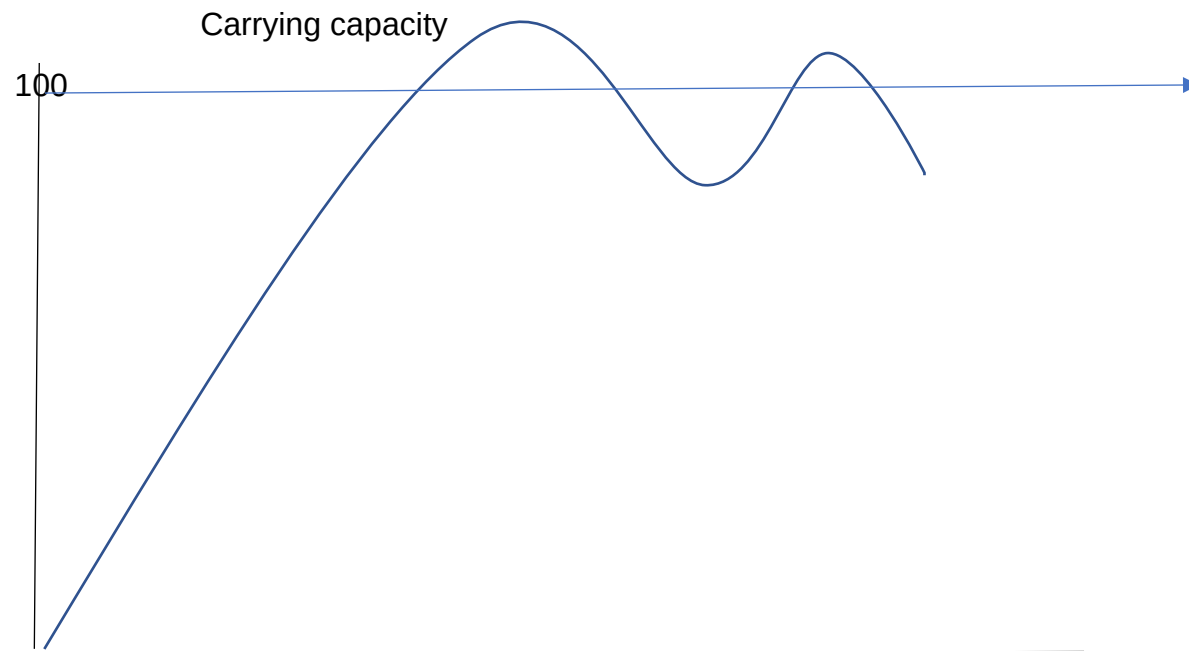
Drought, temperature, floods etc.

Catastrophic factors events e.g., volcano, fire, tsunamis etc.

The limiting factors e.g. density dependent and density independent are collectively known as environmental resistance

Carrying capacity

Refers the maximum number of organism that an area can accommodate without the area getting damaged

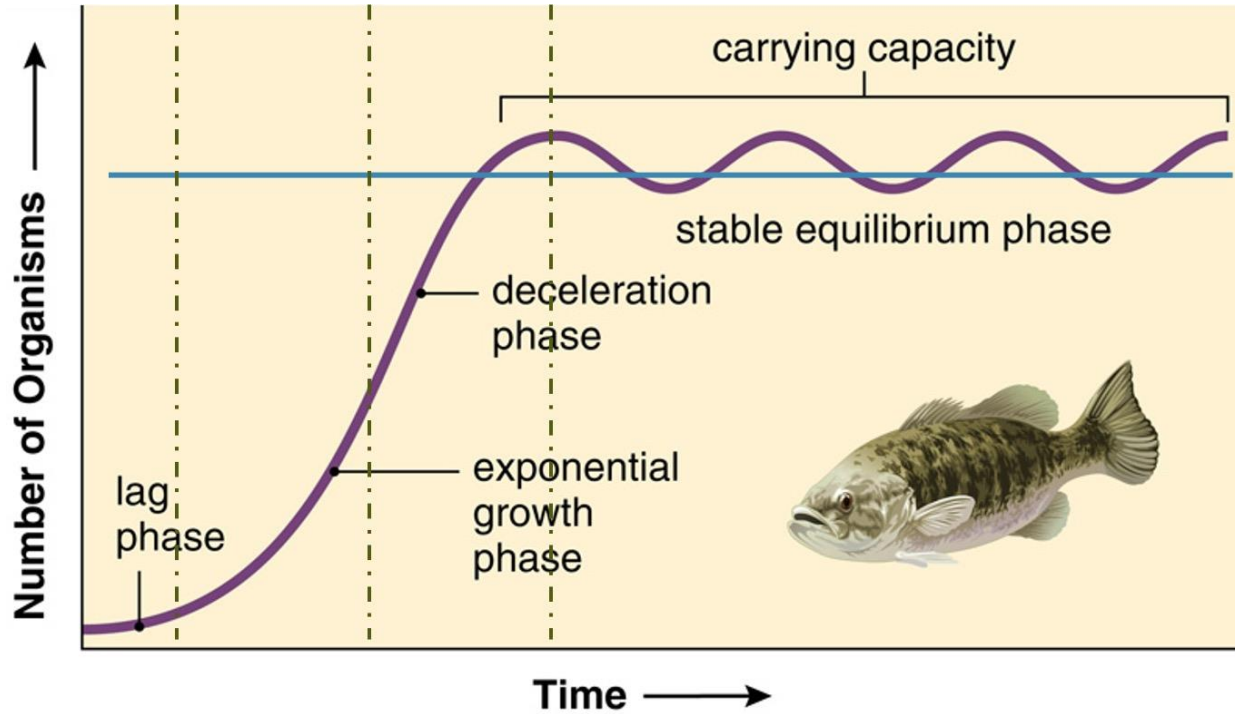


Game park/Farmers

General Strategies/ways of preventing animals from being killed by poachers/depletion/Multiplying.

- Laws in place to stop hunting/poaching.

- Provide healthy environment.
- Wild conservation
- Establish corridors to allow interbreeding
- Breeding programs/ Interbreed and cross breeding/ out breeding
- Research reasons for bottleneck occurrence
- Vaccination against disease
- Artificial selection (involves human choosing for mating)



The population will **fluctuate** around the carrying capacity – seasonally & annually, dependent on resources and environmental pressures.

For fish

- Declare protected areas where no fishing allowed. ✓
- Lift shark nets and find other methods to protect bathers. ✓
- Introduce new individuals to existing populations to allow gene flow. ✓ Start shark breeding programmes. ✓
- Start seal breeding programmes

Greater consequences for shark fishing - legislation
Education programmes about extinction

METHODS OF DETERMINING POP SIZE

1. Mark and re-capture method
 - It is suitable for mobile animals. E.g. antelope, butterflies, birds, etc. but not very easy for fish in the dam.

HOW DO WE DO IT?

1. Mark out a well defined
2. Capture as many individuals as possible and mark them using metal tags or oil paint.
3. Release the marked animals back into the area
4. Allow them to mix with others for some time (years) in order for interbreeding to take place.
5. Re-capture as many individuals as possible
6. Count the total number captured
7. Count the total number of those which have been marked

FORMULAE: $P = \frac{M \times C}{R}$

R

P- estimated pop size

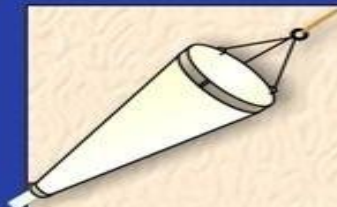
M- total number marked in the first group

C- total number captured in the second group

R- total number marked in the second sample

E.g. Mangwiro has a closed farm that has 200 antelopes. He went to the farm and captured 200 animals and marked them all and released them for 5 years. He went again and caught 300 antelopes and found 50 antelopes that were marked. Calculate the current pop size in his farm.

$$P = \frac{M \times C}{R}$$
$$= \frac{200 \times 300}{50}$$
$$1200$$



Estimating The Population Size



Data obtained from the capture-mark-recapture technique is used to calculate an *estimate* of population size using the following equation:

$$\text{Population size (P)} = \frac{\text{number of organisms in first sample} \times \text{number of organisms in second sample}}{\text{number of marked individuals captured}}$$

Example:

In an investigation into woodland habitats, 42 woodlice were caught, marked and released. Two days later 40 woodlice were caught of which 8 were found to be marked. Estimate the size of the woodlouse population

NEXT

Precautions to take when marking the animals.

- The marking must not damage the individual
- The marking must not affect movement or behavior of the animal
- No immigration is allowed
- Only a short time should pass between 1st and 2nd sampling
-
- Sampling should be repeated more than once and find the average

Make sure tags don't harm rats ✓

Make sure tags are securely on/can't fall off ✓

Make sure tags are not too conspicuous/✓affect recapture or predation

Tags don't affect motility

Tags don't affect behaviour

Technician wears gloves to not leave human smell behind✓

Technicians need to protect themselves from picking up disease/ being bitten✓

[More Mark-Recapture precautions](#)

Minimal time between 1st & 2nd samplings (no births & deaths)

Repetition of samplings and average calculated.

Marking must not damage the individual.

Marking must not affect its movement or behaviour.

Marked individual must freely mix with the populations before new sample is taken (ref. criterion #1)

No immigration / emigration.

2. QUADRANT METHOD

- Is a wooden frame of known size

e.g.  Area = $1\text{m} \times 2\text{m} = 2\text{m}^2$

Steps:

1. Measure the size of the total area
2. Throw randomly in an area and count the animals caught
3. Repeat number 2 several times and record the numbers caught at each throw.

$$P = \frac{\text{average } \underline{\text{number in samples} \times \text{size of area}}}{\text{size of quadrant}}$$

Precautions

- The same quadrant must be used
- Quadrants must be distributed at random

determination of population size

Reliability relies on **10 RATs**:

10. 1– Total area of all quadrats must cover at least **10%** of the area

2 R – Quadrats must be selected at **random**

3 A – Each individual in a quadrat must be **accurately** counted. (Any error is multiplied)

4 T – The total area must be known.

3 Census

- Direct counting of individuals
 - Aerial photographs are taken for the whole area
 - Helicopters are used to count large animals

Limitation: This method is suitable only for

- Slow moving animals, plant individuals fixed in one position and small area

Census vs mark and recapture

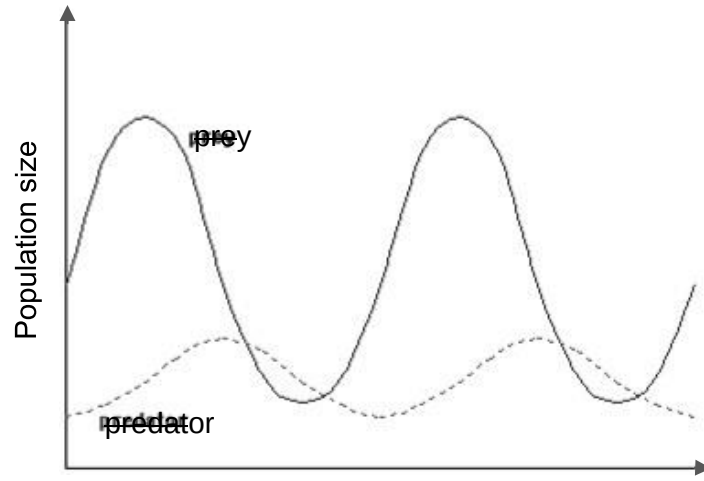
Census needs to count each individual or mark recapture requires a sample, ✓ which is very hard to find as sharks live deep under sea, ✓ so difficult to find and have large territory ✓ so impossible to cover whole area. Mark recapture less expensive or resource/reliability of counting because no tagging (3)

Predator Prey Relationship

Predator > individual that captures and kills the prey.

Prey > is the individual that is killed by the predator

- These individuals live together in one environment. They regulate the pop size by negative feedback.
- That is when the prey increases in number which causes the predator to also increase and when the prey decreases in number the predator also decreases.



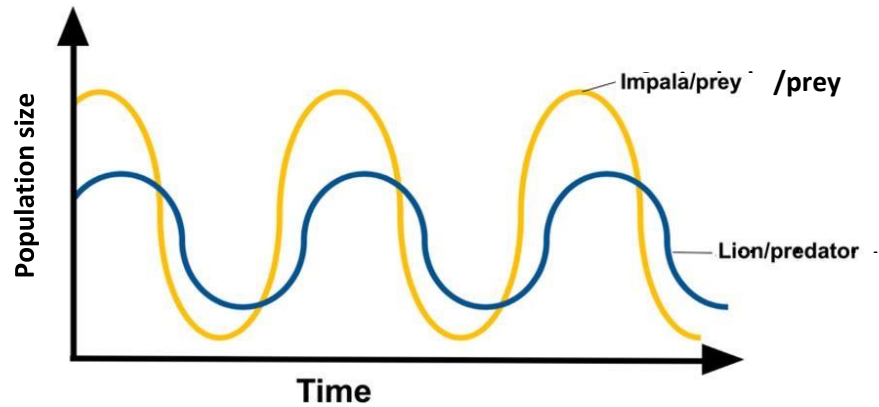
Line A – Prey

Line B – Predator

Predator- Prey relationship

e.g. of predator – pray - Aphids and ladybirds- Zebras and lion

Graph showing predator-prey relationship



Heading x-axis label: time y-axis label: population size/growth/number of animals prey line above predator line predator line lags behind prey line

Lion removes old/weak/diseased individuals

- *So keep the population genetically fit as strongest survive to reproduce*
- *So lowers the number of prey that could serve as hosts to parasites/to reduce overgrazing/allow vegetation to recover*
- *Keystone species so maintain biodiversity*

1. Predation

Predators are a vital part of the environment and contribute to the HEALTH of the environment.

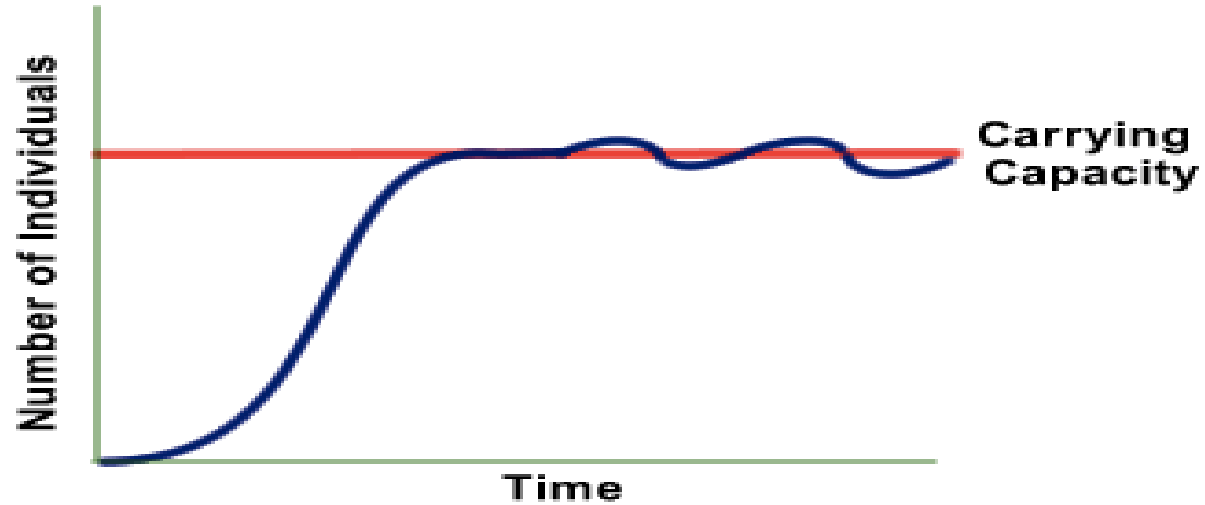
Importance of predators:

1. **Regulate** abundance and distribution of the prey population.
2. **Increase biodiversity** by preventing a single species becoming dominant.
3. Keep the population **genetically fit** by removing the weaker individuals.
4. Provide **food source for scavenger** species.

Stable vs Unstable populations

1. **Stable** population: *fluctuates* around the carrying capacity (but stays near it)

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Stable vs Unstable populations

1Stable population: fluctuates around the carrying capacity.

2Unstable: Population crashes if it far exceeds the carrying capacity, resulting in:

àHabitat deteriorating, thus lowering carrying capacity.

àHabitat unable to support the extended population,

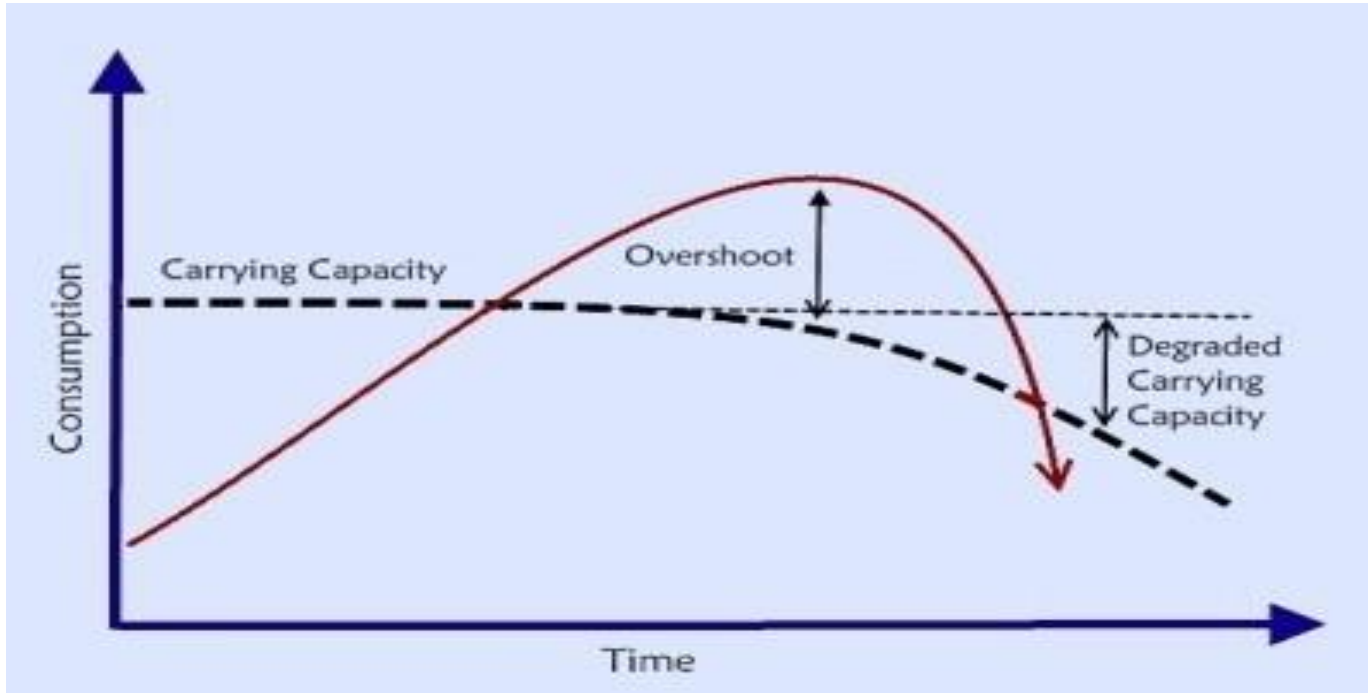
àPopulation decreases rapidly,

àPossibly become extinct, or may recover and restart at a low

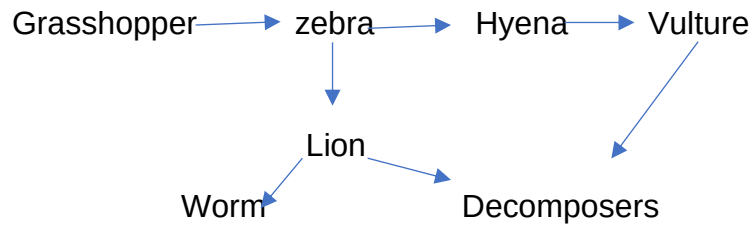
population level à begin lag phase again.

- Graphically...

Stable vs Unstable populations



The food web

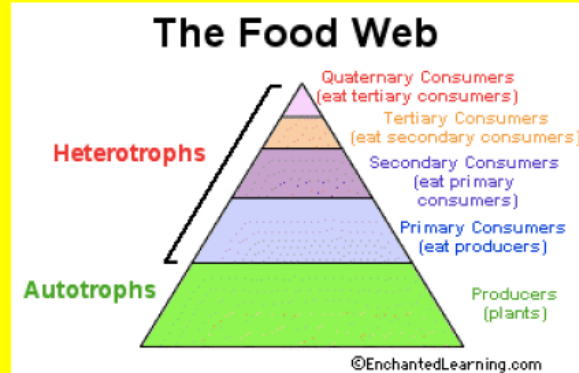


Community Structure - **REVISION**

1. PRODUCERS

- Convert radiant energy into chemical energy using carbon dioxide and water during the process of ____? ____.
- Make their *own* food, therefore are called...

AUTOTROPHS



Community Structure

2. CONSUMERS – HETEROTROPHS - feed on other organisms.

Primary – Herbivores

Secondary – eat the herbivores (animals) thus called ____?____.

Tertiary – 3rd level: Eat animals that have eaten other animals.

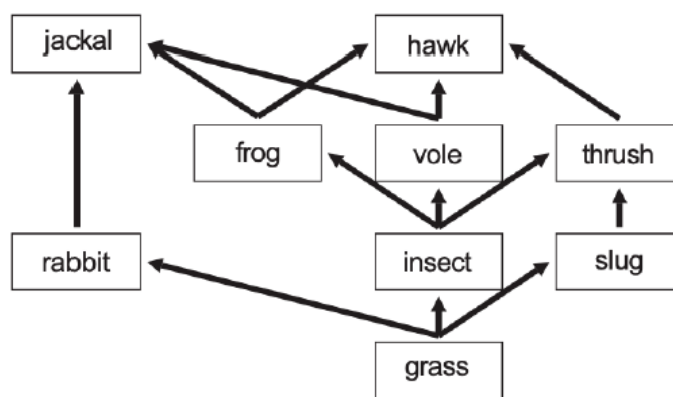
3. DECOMPOSERS – bacteria, fungi, etc that breakdown the organic matter.

Saprophyte = a plant, fungus, or microorganism that lives on dead or decaying organic matter.

(*Sapros* = "putrid/rotting")

How food webs impact on populations

How does the removal / increase of one population affect the rest of the food web?



Vole

An example of a food web

Community Interactions - PredPrey, Competition

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Social organizations

Refers to animals that live in a group or colonies, herds. These animals have greater impact on environment compared to animals living as an individual.

- Competition

Inter specific competition occurs where individuals of different species compete for the game resources. E.g. Lion and hyena competing for zebra.

Intraspecific competition between same species. E.g. lions competing for a zebra

Ecological niches

- Is all the resources and conditions necessary for the survival of each species
E.g. physical – temperature, terrain & nutrients
Biological – coping with competition and avoiding predators

Explanation: Ecological niche

For a population to survive, its individuals must a) survive, and b) reproduce.

To do this they must:

1. Tolerate the physical environment (temperature, pH, dry/wet, etc)
2. Obtain nutrients & energy.
3. Cope with competition.
4. Avoid predation.

This is their **ecological niche**. (*'nish'* - French)

In ecology, a niche is the match of a species to a specific environmental condition. ([Wikipedia](#))

Niche - a role taken by a particular type of organism within its community.



Niche (5:12)
Bozeman Science

Community Interactions - PredPrey, Competition

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Strategies of reducing competition by organism

(a) Niche partitioning/Resource partitioning.

It allows them both to co-exist by reducing competition using resources differently with different niches/at different depths in same habitat.
(3)

Plants grow to different heights because they have different light requirements so they can exist in same area without competing. Canopy vs shrubs vs undergrowth, etc

Individuals of different species, living in the same area and sharing the same resources differently e.g. feeding at different times browsers and grazers.

Giraffe and kudu

Share resources in habitat by having different feeding habits

Giraffe browse on higher branches in trees while kudu feed off the lower branches

- Resources partitioning of light.

(b) Co-existing predators. E.g. Lions and Leopards

Advantages of prey living in a group/herd

The herd keeps the young in the centre to protect them.

The herd has many eyes and ears to detect danger of predators.

The sheer size of the herd will intimidate predators.

When the herd moves, all the individual movements cause a confusing mass which does not allow predators to focus.

Stripes break the outline so predator cannot form clear image of animal. In herds, all the stripes blend together so individuals cannot be singled out.

Advantages of predators living in a group/herd

Large number of animals allows them to take down prey larger than themselves.

Pack can develop strategies for the hunt involving spreading out over large area to trap prey.

Pack can attack animal from all sides ensuring successful kill.

Single breeding pair ensures that most of pack is in peak physical condition for hunting.

Nursemaids left to look after pup ensures that hunting pack are focused on hunt and not on protecting young.

Individuals take turns in leading the chase ensuring that the whole pack does not tire.

Communication within pack leads to the ability to hunt as a collective force.

Dominant breeding pair / alpha male and female prevent other members from breeding, fittest genes passed to offspring raising pups a group activity increasing pup survival rate care of sick / old a group activity increasing chances of living longer more numbers better chance of fending off predators

Feed the pups/ elderly/ injured first increases survival

Advantages of packs/ groups/ herds

- Predators can kill large animals
- They can camouflage themselves with the environment
- Increases chances of survival
- Prey confuses predator
- Can develop hunting strategies as a pack ensuring more successful hunts (or they can discuss a particular hunting strategy)
- Work as a pack so can bring down bigger prey
- More eyes and ears to look for prey
- Can communicate with each other to alert each other to proximity of prey/strategies thus more success
- Some females stay behind to look after pups so that all hunters can
- be focused on the hunt

Social Organizations (castes)

Advantages

Division of labor – Individuals do specific jobs in a group.

E.g. Bees, ants, termites

1. Queen – fertile females is only for mating and producing offsprings
2. Workers – they build the nest and bring food
3. Soldiers – they protect the nest
4. Drones – male bees for reproduction.

Male reproductive – fertilise female eggs

Female reproductive – produce eggs/new offspring

Soldier – defend colony/queen

Worker – feed babies/build nest/clean queen, etc.

Winged reproductive – spread species/form new colonies

Can specialise on a particular job and thus become structurally suited to perform with excellence/colony can survive even when individuals die – survival of species

Ecological Succession

Is a predictable pattern of gradual change over time in the type of species in a community following a disturbance.



Types of succession

1. Primary succession/pioneer
 - Where species occupy a habitat that was not previously occupied.
e.g. plants occupying sand dunes, bare rocks

* Pioneer> refers to plants that occupy area for the first time

2. Secondary succession
 - New plants occupy area that has been burnt or abandoned for some time
3. Climax – these are lost species that occupy an area.

Stages in succession

- (a) **Pioneer species stage/primary stage**- grow in area that was not occupied before

Features /characteristics of pioneer

-are hardy, establish themselves quickly, have spores or seeds that disperse over long distances and they do not grow in shady areas

-these plants built-up and enrich the soil

Pioneer plants are hardy/can withstand extreme variations in temperature

Can tolerate low moisture levels

Establish themselves rapidly/fast growing

Produce many spores or seeds

Spores can disperse over long distances

Spores/seeds germinate quickly

Do not have to grow in the shade

Can tolerate low nutrient levels/very little to no soil/only on rock Small/low growing to withstand wind, etc.

No agent required for pollination/wind pollinated

(b) **Secondary stage**- occupy an area that was once occupied before but has been disturbed by natural disasters eg veld fire, floods etc. the plants grow in rich soil

Started with soil / not bare rock / soil present / plants grew here before / no lichens and moss / annual plants first colonisers

Secondary succession (*must have*) Soil is present/colonisation is not on bare rock/there had already been plants in the area Seeds present in the soil

© climax stage

This is the last or end point of succession. The trees, plants and animals are very large

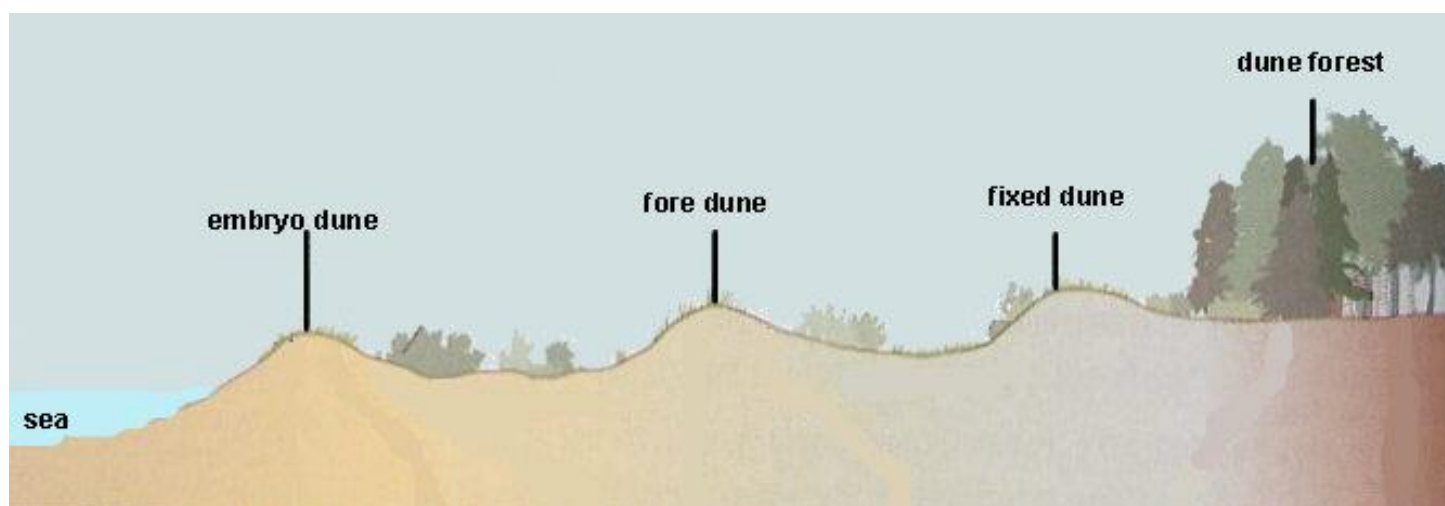
Factors that cause the climax to come to an end

In adequate rainfall, overgrazing, draining of wetlands, climate change, invasion by alien plants

Table showing differences between climax and pioneer communities

Pioneer	Climax
First stage	Last stage
Short living	Longer living/more stable
Lichens/fungi	Climax veg of biome
Low Biomass	High biomass

STUDY THE DIAGRAM BELOW AND ANSWER THE QUESTIONS THAT FOLLOWS



2.3.1 a. The text describes an ecological phenomenon known as “succession”. What is meant by the term “succession”? (3)

b. What type of succession is described in this text? Use information in the text to justify your answer. (2)

2.3.2 What term is used to describe

a. the organisms that colonise the embryo dunes (1)

b. the community that forms the dune forest (1)

POPULATION GROWTH/ Logistic growth form

- Refers to the characteristic pattern of increase in the population size.

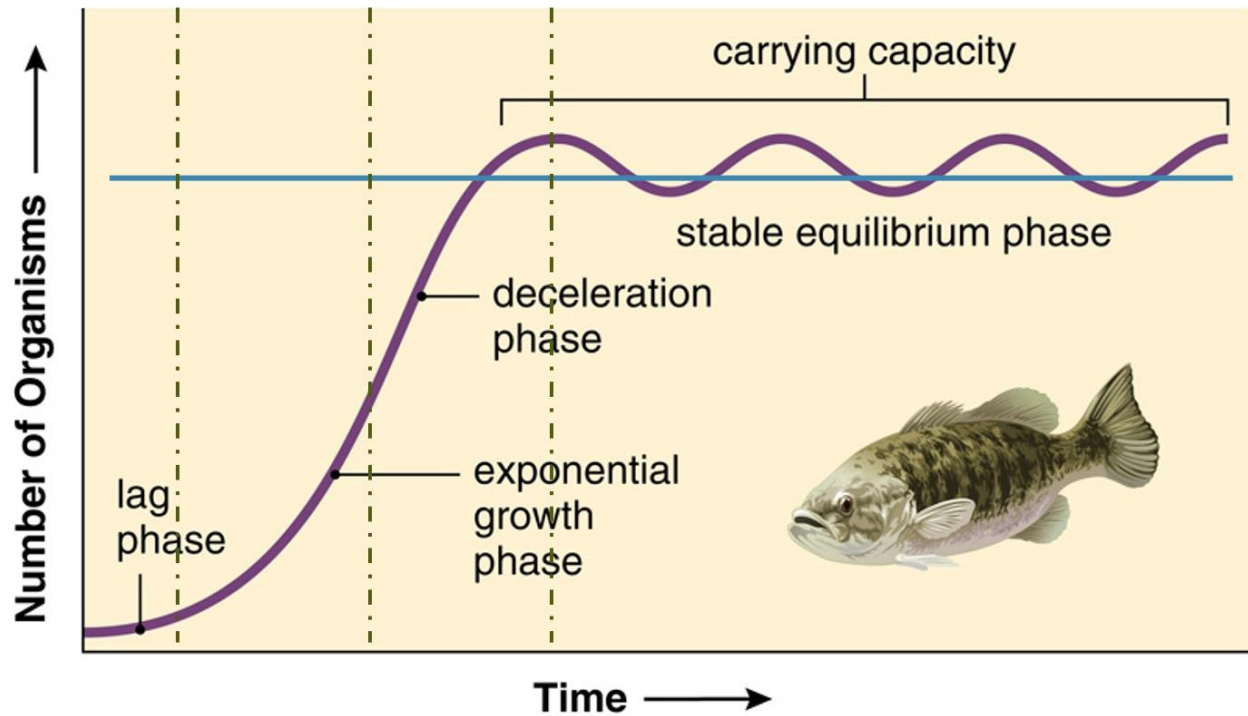
The two patterns are

- Geometric Growth form / J graph
- Logistics Growth Pattern

Geometric Growth form



Logistic growth form /S -shaped

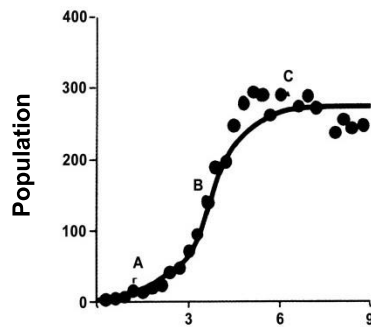


A – Lag phase

- Little growth of pop size
- Organisms are adapting to the environment

B – Growth phase

- Rapid growth of population



- A- Lag phase
 B- Growth phase
 C- Equilibrium phase
 D- Death phase

Phase	Positive or negative growth?	Slow or fast growth rate?	Reason for speed of growth.
A	Positive	Slow	Establishing themselves/low numbers
C	Positive	Fast	Abundant resources/living below carrying capacity
D	Positive	Slow	Approaching carrying capacity/ environmental resistance/ competition

A – very rapid steep/exponential/accelerating growth ✓ as there are abundant resources/name resource ✓/favourable conditions for reproduction/below carrying capacity/ little environmental resistance.

B – slower growth/decelerated ✓ as resources are starting to be limiting ✓ or name one resource/ approaching carrying capacity./ environmental resistance increasing/ conditions unfavourable for reproduction/increased competition (4)

Dependent factors that causes a decline of population size are: food ✓/space ✓/build-up of toxins/disease/predation./shelter/

Patterns of Natality

There are two patterns of natality, which are: -strategy and K-strategy

The R-STRATEGY

- These are organisms that produce in large number of offspring with little or no parental care.
- These are often organisms that enter a new area

- Which means large number e.g. they will die because they are not aware of the dangers of the new area.
- Also there is no parental care, which causes few of the large offspring to reach maturity.

Summary of R-STRATEGY

- Produce many offspring
- Little or no parental care
- Enter a new area first
- Therefore, colonize new areas
- They are therefore pioneers

K-Strategy species

These organisms have a low natality rate- they produce few offspring.

- There is high parental care
- High survival rate
- They enter a habitat that is already developed
- So they are called climax species

Summary of K-STRATEGY

- These organisms produce few offspring
- There is high survival rate
- Climax organisms/ species

HUMAN POPULATION

POP dynamic is the study of how and why POP change in size of structure over time.

FACTORS that determine pop dynamics are

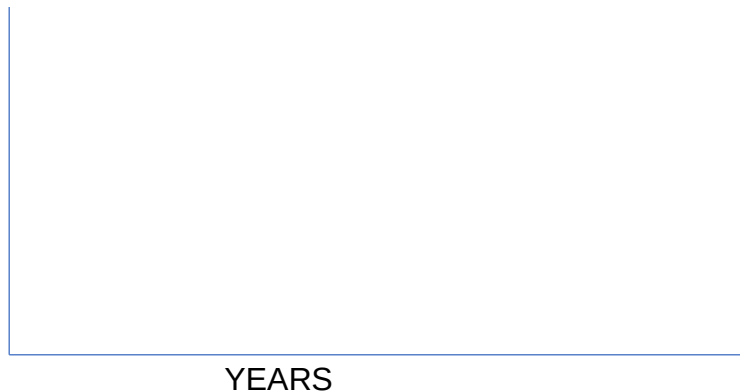
- Rate of reproduction
- Death and immigration

World population growth

10 000 years ago population growth was 10m earth. Death rate was high because

- People died from starvation and
- Instant mortality rates were high.

After 1000 years pop rate increases exponentially (increasing more and more)



Reasons of exponential growth

- Reduced environmental resistance
- Food production has increased by more land being cultivated, improved methods of food production
- Methods of treating disease have improved greatly

Reasons of low pop rate in the next 150 years

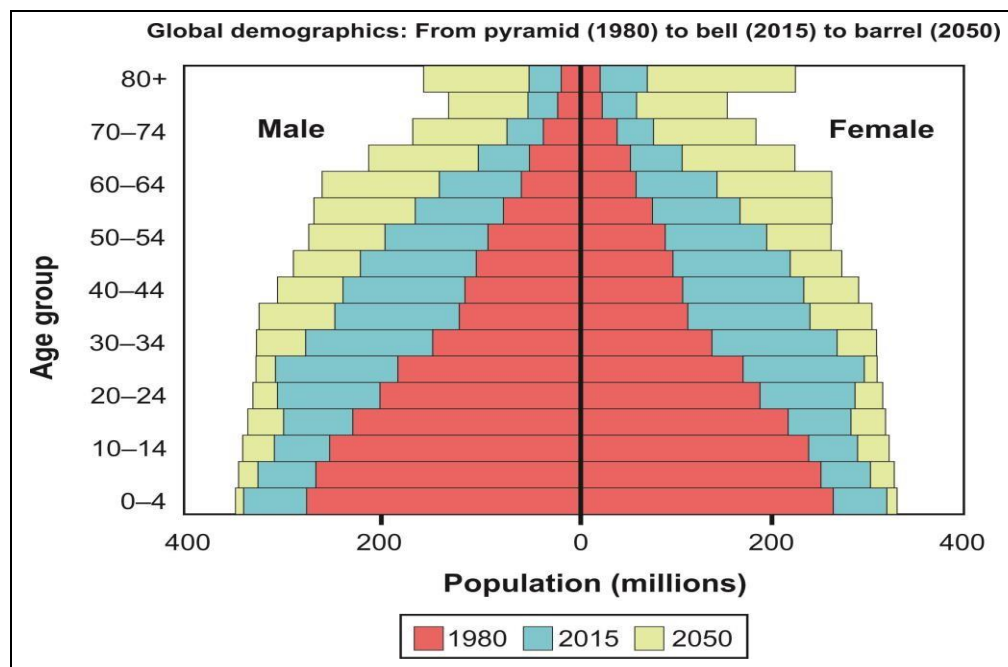
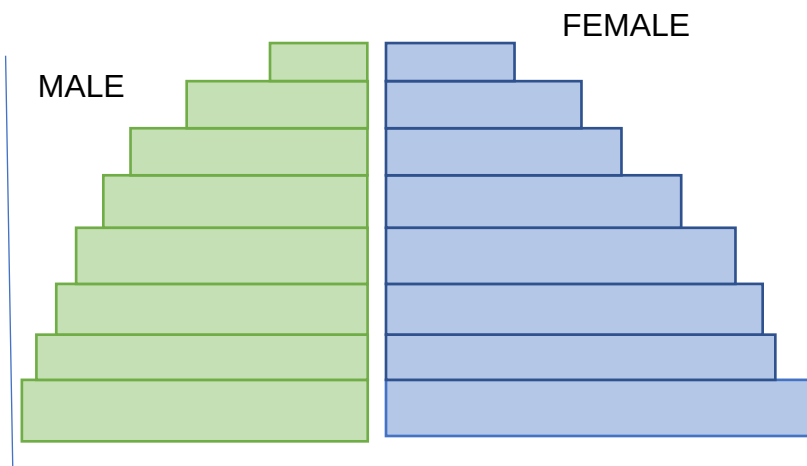
- Abstinence, late marriage
- High birth control.

The pop in developing countries will continue to rise because of improved health facilities.

POP Pyramid/ Age sex population

- Is a bar graph that shows the composition by age and sex of a nation's pop at the time of a census.

POP PYRAMID FOR A DEVELOPING COUNTRY

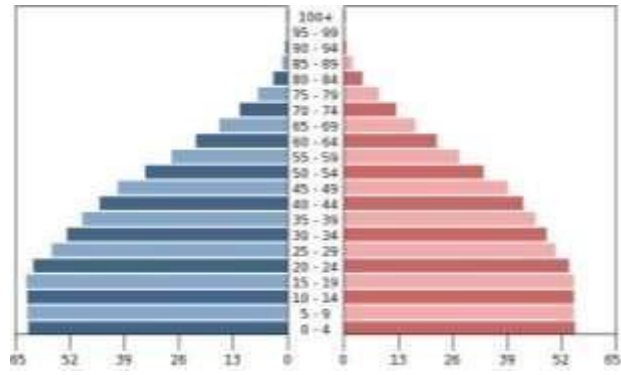


[Adapted from : <<http://blogs.worldbank.org> >]

A

Male

Female

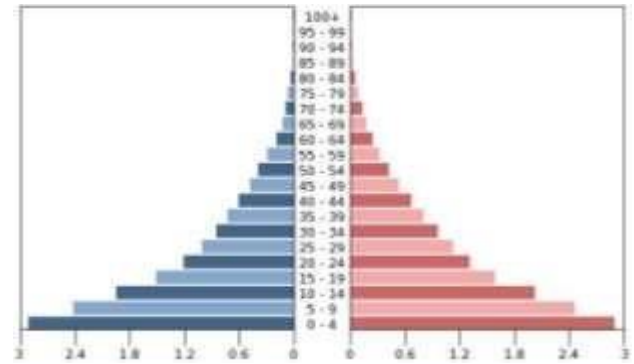


Population (in millions) **Age group**
Population (in millions)

B

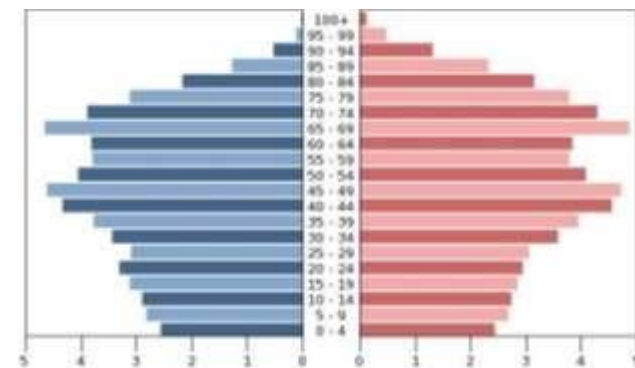
Male

Female



Population (in millions) **Age group**
Population (in millions)

C



Male
Female

Population (in millions) **Age group**
Population (in millions)

POP SIZE

* Characteristics of pop pyramid of developing country

- High birthrate - High death rate - Poor health facilities - Poor education facilities- Few adults - High young pop - Low life expectancy

typical pyramid-shaped (triangular) graph high birth rate, small numbers of elderly, broad base and narrow apex, low life expectancy

* Characteristics of pop pyramid of developed country

- low birthrate - low death rate - r health facilities - good education facilities - many adults - low young pop - high life expectancy

Fewer births due to education/contraception, so smaller base. Less steep pyramid as larger number of older individuals surviving due to better medication/ nutrition.

Carbon footprint- amount of carbon dioxide emissions produced by an individual /company per year

Larger footprint / image on in developed countries use more natural resources / ecological debtor to sustain lifestyle represented by larger figure in cartoon indicates more land use and more negative impact on the environment.

Smaller footprint / image on left in developing countries no shoes/ thinner figure suggests lack of use of resources / ecological creditor

Ways of sustaining an over populated country/area

improved methods of agriculture to increase amount of food produced improved life span by better medical technology more people can live in same area due to high rise building

HUMAN POPULATION REVISED

Human Population Dynamics

10000 years the world population was less than 10m

- High death rates caused by starvation and diseases.
- Infant mortality rate was high.

Current Population (7,3b).

REASONS:

- Reduced environmental resistance.
- Increased carrying capacity of the world's food producing regions.

HOW

1. Food production has increased, more land being cultivated, improved methods of food production such as use of artificial fertilizers which increased production of monoculture crops.
2. Methods of treating diseases have improved.

Developed Countries (More Developed Countries)

- Have stable population growth.
- Low birth rates due to late marriages.
- Birth control, abstinence.

Developing countries (Less Developing Countries)

Growing population- due to Improved medical treatments, women have longer reproductive years.

Population Pyramid (age sex pyramid)

-Is a bar graph that shows the composition by age and sex of nation's population at the time of census.

A population contains three major ages/sex groups

- Pre-reproductive
- Reproductive
- Post reproductive

The age structure – the relative numbers of index of each age in a population.

Sustainable development- Development that meets the needs of the present while not compromising the needs of future generations.

The top of the pyramid shows- Older population

The Bottom of the pyramid- Younger population

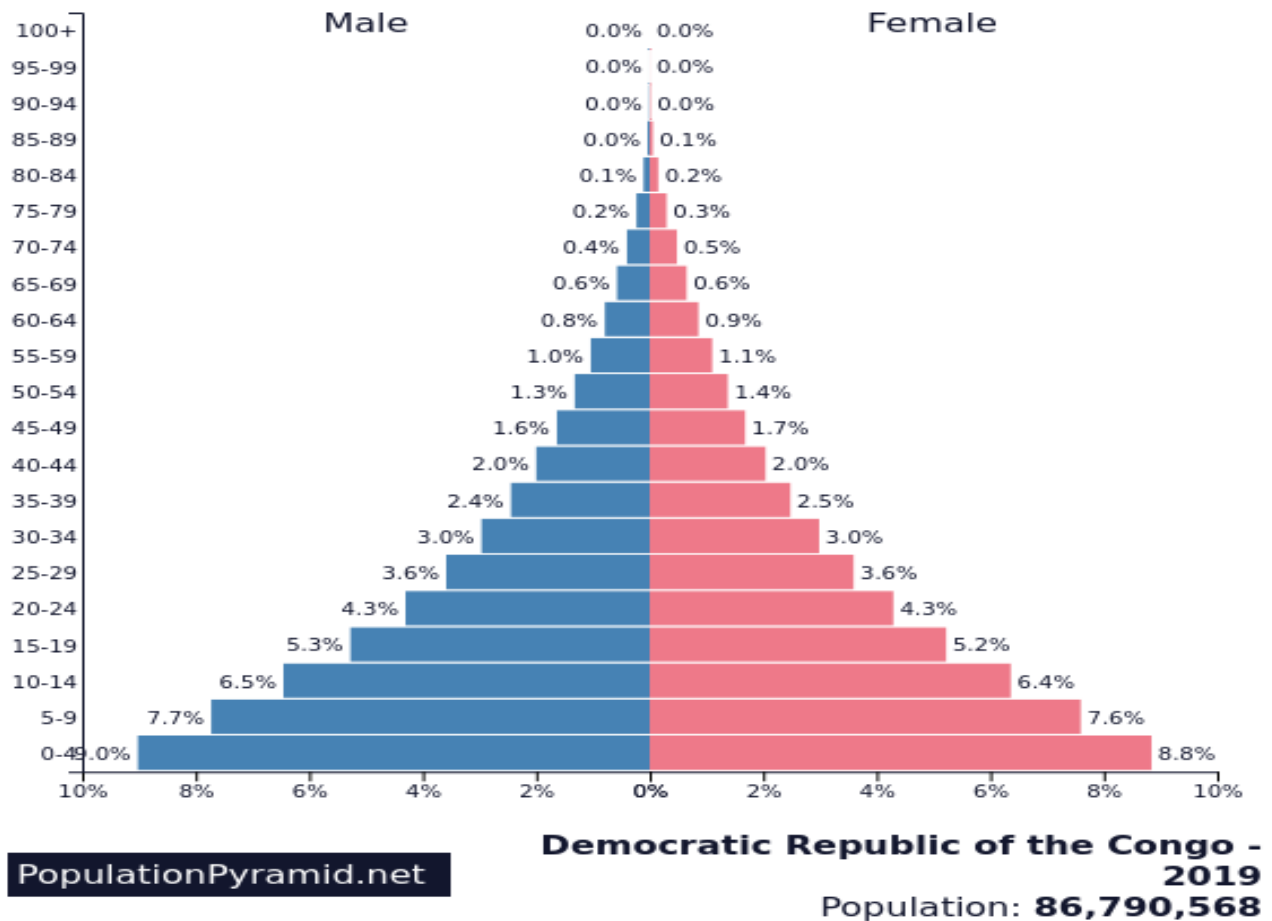
The Males are shown on left side while females on the right side of the pyramid

Types of population growth

a) Rapidly growth population (Less developed countries) LDCs

Characteristics

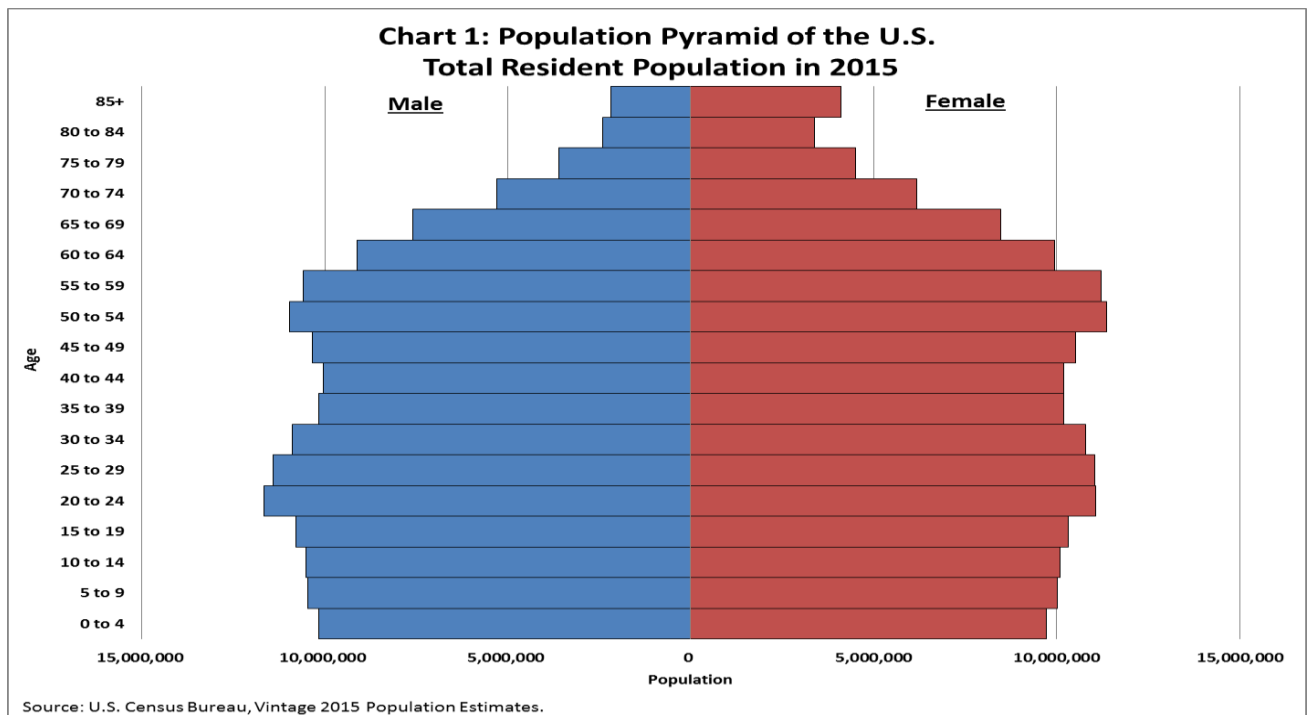
- High birth rate
- Short life expectancy
- Rapid fall in each upward age group due to high death rate and low life expectancy



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Stable population (more developed countries)

- Declining birth rate
- Low birth rate
- More old people
- Longer life expectancy
- Higher dependency ratio



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what is the purpose of population graphs

it determines trend of population size.-Rapid or slow

- Shows if a country is developed or less developed
- Shows history of a nation's growth
- Shows how many people of age group range live in a country
- it determines the number of economic dependents being supported so that the working population supports these dependents.

0-15 – Economically dependent group

15-65 – Productive, working group

65+ - Dependent group

Factors that can cause population to change

- HIV/AIDS – affects reproductive age
- High proportions of young immigrants into a country or high emigration of able bodied youths

- Reduces birth rates – during time of economic crises.
- Wars – loss of able-bodied men.

SA population growth

- 2014-54m present time 62m. what might have caused the population growth?

Economical footprint

-Is a measure of human demand on Earth's ecosystems.

- It represents biologically productive land and sea area necessary to supply the resources a human population consumes and assimilate the waste generated.

What constitutes footprint?

- Carbon emissions from fossil fuels
- Demand on food sources
- The quantity of living resources required to make the goods we consume
- Available land for production, building cities and roads.

Globally the world's ecological footprint is 2.7 global hectares per person. So, there is an ecological deficit of 0.6 global hectares per person.

Bio- capacity - the amount of productive land and water available to produce the resources we use and to absorb the waste we produce.

A country with an ecological deficit is called an ecological debtor country while Ecological creditor deficit is a country without ecological deficit.

Importance of ecological footprint.

It is an indicator of environmental sustainability.

- Many MDCs are running ecological deficit:
- Have a large footprint than their biological capacity.
- Their deficit is compensated by using resources from other countries.
- They require more land, energy and water
- They produce more waste than LDC's
- LDC's use little of ecological footprint
- Urban population is increasing as well as standard of living hence they are using more resources which will cause depletion of resources and causing permanent damage of the earth.

SA ecological footprint is growing due to growing towns and cities which:

- Generate and accumulate more wealth
- are centers of education, employment and culture
- These cities take over productive agricultural land and use large quantities of water, energy and raw materials and generate large amounts of waste and pollution.
- Agriculture, forestry, and mining are causing large environmental degradation.
- There is a need to conserve natural resources

Whose responsibility?

The constitution, provinces and national governments must share the responsibility in conserving the natural resources.