DEPARTMENT OF EDUCATION

GRADE 12

BIOLOGY

MODULE 2

POPULATION

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GRADE 12

BIOLOGY

MODULE 2

POPULATION

IN THIS MODULE YOU WILL LEARN ABOUT:

12.2.1: SAMPLING METHODS

12.2 2: POPULATION GROWTH

12.2.3: HUMAN POPULATION TRENDS IN PAPUA NEW GUINEA

Acknowledgements

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DIANA TEIT AKIS
PRINCIPAL

Flexible Open and Distance Education
Papua New Guinea

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TABLE OF CONTENTS

SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is a part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution, Government Policies and Reports. It is developed in line with the National Education Plan (2005 - 2014) and addresses an increase in the number of school leavers affected by the lack of access into secondary and higher educational institutions.

Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual
- To develop and encourage an education system satisfies the requirements of Papua New Guinea and its people
- To establish, preserve and improve standards of education throughout Papua New Guinea
- To make the benefits of such education available as widely as possible to all of the people
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced to provide alternative and comparable pathways for students and adults to complete their education through a one system, many pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all those teachers, curriculum writers, university lecturers and many others who have contributed in developing this course.

UKE KOMBRA, PhD
Secretary for Education

MODULE 12.2 POPULATIONS

Introduction

In this module we are going to study about populations of organisms.

Imagine carrying out a census for plants and animals! If that were possible, how could you count all the grasses in your school playing field? Or how about getting ants to stand still for a moment so you can take a head count? Or further still, would you go among the fierce hungry sharks to count them? Having some understanding of the total population of organisms can help us to better manage their environments.

We are already aware of the huge number of organisms and the problems associated with counting them. In this module, you will investigate the different sampling methods and decide on the best one for any organism of study.

We will also study the effects of various birth, death, immigration and emigration rates on population, as well as factors that limit population growth.

This leads to considering human population, and the relationship between world population growth and decrease in Earth's resources. You will become more aware of problems associated with population increase in developing country such as Papua New Guinea and better able to make informed decisions later in life. For example, when planning how many children to have.

You will study about the human effects on populations which lead to extinction of organisms and the effects of introduced species in an environment.

Learning Outcomes

After going through this module, you are expected to:

- define population and population dynamics.
- state that growth, stability and decline are factors that affect population growth.
- define abundance or density of species and state reasons why ecologists measure abundance of species.

- discuss how different sampling methods are used to count abundance of population.
- discuss the ways in which birth, death and migration rates affect size of population.
- discuss examples, of closed and open populations.
- describe with examples the logistic and exponential growth models.
- make a list of the factors that are density dependent and those that are density independent which affect population growth.
- make a comparison of the human population growth between developed and a developing young country.
- investigate and describe environmental factors affecting population growth and distribution.
- interpret a predator-prey graph which shows that a fluctuation in one population may affect another in a relationship.
- state the impacts of human population on species endangerment and make recommendations to address these issues.

Time Frame

Suggested allotment time**: 10 weeks**

If you set an average of 3 hours per day, you should be able to complete the module comfortably by the end of the assigned week. Try to do all the learning activities and compare your answers with the ones provided at the end of the module. If you do not get a particular exercise right in the first attempt, you should not get discouraged but instead, go back and attempt it again. If you still do not get it right after several attempts then you should seek help from your friend or even your tutor.

DO NOT LEAVE ANY QUESTION UNANSWERED

Terminology

Abundance	Number of individuals of a given species per unit area.
Acceleration phase	Stage of growth of a population when its size is sufficient to result in much higher population growth in each generation as compared with the lag phase.
Adaptation	Features that appear to equip an organism for survival in a particular habitat.
Birth rate	Number of organisms born in a given period in a population.
Carrying capacity	Stabilised size reached by a given population in a given habitat.

Crash	A sudden large decline of species.
Death rate	Number of organisms dying in a given period in a population.
Deceleration phase	Stage of population growth represented by the final flat section of an S-curve during which the growth rate progressively declines to zero as the carrying capacity of the habitat is approached.
Decline	To move downwards, to fall or to drop.
Density dependent	Refers to factors whose impact on members of a population is dependent on the size of the population.
Density independent	Refers to factors whose impact on members of a population is not affected by the size of the population.
Emigration	The movement of individuals out of a population.
Endangered species	A species which is in danger of becoming extinct.
Environmental resistance	Impact of any kind of natural disaster that act on the growth of population.
Eutrophication	Accumulation of dissolved mineral nutrients in a body of water.
Exotic species	A species that does not occur naturally in a region, but which has been introduced into the region, either deliberately or accidentally; also known as a non-native species.
Exponential growth	In population biology, a type of growth in which the rate of growth increases as the population size increases.
Extinction	No longer in existence, having died out.
Family planning	Birth control, ways to control the number of children born in a family.
Fertility rate	The birthrate of a population, the number of live births per 1000 people per year.
Habitat	A specific place or natural conditions in which a plan or animal lives.
Immigrations	The movement of individual organisms into a community from outside.

Infant mortality rate	The total number of deaths in a year among infants under one year of age for every 1 000 live births in a society.
Interspecific competition	Competition for resources in an ecosystem involving members of different species.
Intraspecific competition	Competition for resources in an ecosystem involving members of the same species.
Lag phase	Stage of population growth, represented by the initial flat section of both a J-curve and an S-curve that covers the period when the population size is small and growth rates are low.
J-shaped curve	Describes the plot of population size over time under conditions of exponential growth.
Life expectancy	The amount of time one is expected to live.
Limiting factors	Environmental condition that restricts the types of organism that can survive in a given habitat.
Logistic growth	A model of population growth in which growth eventually slows and the population size stabilises at the carrying capacity of the habitat concerned.
Mark-recapture	Technique used to estimate size of an animal population that involves capturing a sample, marking and then releasing each captured animal and later, recapturing a second sample of the same population.
Maternal mortality ratio	Number of maternal deaths per 100,000 live births.
Migration	Refers to the predictable movements of organisms over large distances, which may occur once in the lifetime of an organism.
Morbidity	An occurrence of illness or disease.
Obstetric	The care of women during and after pregnancy.
Pesticide	Anything that kills or suppresses the activities of pests.
Pollution	Contamination of the environment by harmful substances.

Population	Members of one species of organisms living in a specific habitat at a particular time.
Population dynamics	Study of changes in population size over time.
Population explosion	A sudden uncontrolled increase of population.
Predator	An animal that kills and eats other animals as its source of food.
Prey	Living animal that is captured and eaten by a predator.
Quadrats	Areas of known size, often one-metre square, used to outline an area for sampling a population of plants or sessile animals.
Recapture	To capture or catch animals for the second time again.
Sessile animal	An organism, for example a barnacle fixed in one place; immobile.
S-shaped curve	Describe the plot of population size over time under conditions where resource availability limits population size to the carrying capacity of the habitat concerned.
Sampling	Technique by which part of a population is examined and, from this sample, estimates are made about the size of the total population.
Transects	Techniques for sampling the species present in a habitat; may be a line transect or a belt transect; with a line transect, various species present at regular intervals along the line crossing the area of study are recorded; with a belt transect, the abundance of one or more species within a band of known width and length is recorded.
Variables	likely to change from a current state.

12.2.1 Population Sampling

A **population** is a group of individuals of the same species living in the same geographic area at a particular time. All populations undergo three separate stages of their life cycle:

1. Growth
2. Stability
3. Decline

The study of factors that affect population growth, stability or steadiness, and decline of populations is called **population dynamics**.

Population **growth** occurs when there are more resources available in an area than the number of individuals living there that can use them. Reproduction is fast, and death rates are low, producing a net increase in the population size.

Stability is the steadiness in a population and usually the longest phase of a population's life cycle. When the available resources are being used up by the individuals, there is usually a **crash** or fall in the number of species and the population growth is affected.

Population **decline** is the decrease in the number of individuals in a population, and eventually leads to disappearance of population or **extinction**.

A general look at populations
Any population can be characterised in terms of several qualities, including: abundance or density, age structure of population, rate of growth. We will look at each of these qualities separately.

Abundance of populations
Abundance or **density** is defined as the number of individuals of a given species living in a unit area. The only way by which one can find out how many individuals there are in a particular area is by making a population count.

Why do biologists measure population abundance?
Biologists are interested in the abundance of populations for various reasons:

- Biologists are concerned with conservation and measure the abundance of populations of endangered species over time to decide if the populations are stable, increasing or decreasing in abundance. If the abundance of the population of an endangered species falls, the risk of extinction increases. **Endangered species** are the species of organisms that are low in number and are likely to disappear.

- Biologists are concerned with the control or removal of introduced species of plants and animals. Some of the non-native and introduced species become pest and cause destruction to other organisms and the environment, therefore biologists need to monitor changes in their abundance and variety.

- Biologists are interested in understanding why some populations can 'explode' or sharply increase in numbers. They must measure population abundance regularly in order to detect patterns to identify possible causes of these explosions.

Counting population to measure abundance
It is sometimes possible to carry out a **total count** or **true census** of a population by counting every member of a population that lives in a given area. Total counts can be done with populations of animals that are large or conspicuous (can be seen) or animals that are slow moving or sessile (not free to move). Examples of such animals are limpets or barnacles on rocks or star fish on the beach. Likewise, total counts can be done on large populations of plant species.

A true census is not possible for small, shy or very moveable animals because many animals will probably be missed. When an entire population cannot be counted, **sampling** techniques are used.

Sampling population to measure abundance
Sampling typically means taking one or more samples randomly from a population and the samples are assumed to be representative of the entire population. Sampling from a known area allows biologists to make estimates of both the abundance and the size of the population.

The abundance of a population cannot usually be based on just one count. This is because of the chance of sampling errors. In order to avoid sampling errors, counts of population are usually repeated several times. Changes in the abundance of a population can occur over time owing to factors such as migration and breeding patterns.

Sampling Methods

Some sampling techniques or methods used to count abundance of population include use of:
1. **quadrats**
2. **transects** and
3. **mark-recapture** technique.

Each technique has its particular applications as .

1. **Use of quadrats (within a square)**
   Quadrats are square areas (frame) of known size and are often subdivided into smaller units. If a one-metre square quadrat is used and the total number of plants of a particular grass species recorded in 10 quadrats is 208, then the abundance of grass species equals 208 plants per 10 square metres or 20.8 plants per square metre.

Quadrats can be used to estimate the abundance or population density of plants, of sessile animals like oysters, mussels, starfish, limpets and anemones, and of slow-moving animals such as chitons and snails. Use of quadrats, however, cannot be used for fast-moving animals that will not wait around to be sampled.


Biologists sampling a population of sessile animals using a square metre quadrat.

For example, a group of biology students carried out a research on the abundance of a particular snail species along Ela beach in Port Moresby. They threw a one metre quadrat 10 times at different parts along the beach.

The data collected were as follows:

Quadrat throw no.	1	2	3	4	5	6	7	8	9	10	Total
Number of snails found	12	10	7	18	11	9	16	13	12	12	120

Prediction of results
There were a total of 120 of the particular snail species found in 10 square metres of the area. Since 120 divide by 10 equals 12.0, it can be predicted that the abundance of the particular snail species in Ela beach area is 12 snails species per metre.

Quadrats can be used to estimate a population in an **area which is fairly uniform.** Examples include lawns, woods and open ground. They can produce three estimates of population size:
(i) **Density** (organisms per square metre).
(ii) **Frequency** (number of quadrats that contain the organism.
(iii) **Percentage cover** (estimated by the sampler).

2. **Use of transects along a line or within a strip**
A transect is a straight line or a strip of any length laid across the area to be studied. Samples are taken along the line at uniform intervals.

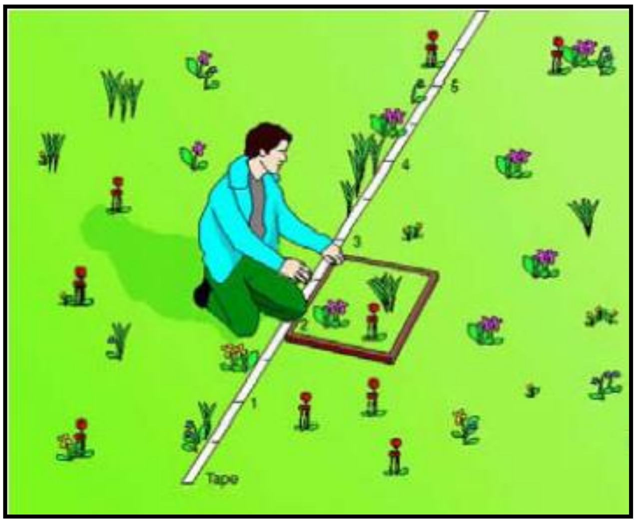
Line transects are particularly useful in identifying changes in vegetation with changes in the environment. The line is marked at fixed intervals.

Examples include seashores (low to high tide); across streams; up hillsides

It can be used together with a quadrat to sample in more detail, otherwise population estimates are limited to frequency.

3. **Strip transects**
   Strip transects are also known as belt transects. They are used to estimate animal populations and can be carried out by observers on foot, in cars, helicopters or fixed-wing aircraft or underwater.

   The type and size of transect depends on the animal population that is being surveyed.



A line transect used together with a quadrat to sample population

4. **Mark-recapture technique**
   Since some animals move around very quickly, it is difficult to use quadrats or transects to count them. Instead, the mark-release-recapture technique is used. Below is the step by step process on how this process is applied.

   a) A sample of the animal is caught without injury from a particular area.
   b) They are all marked in such a way that their survival is not affected. Some of them are usually painted in parts of their bodies while some animals such as fish are marked with tags on their fins.
   c) They are released back into the same area where they were captured.
   d) They are allowed sufficient time to mix with the rest of the population, but not too long to mate and reproduce.
   e) A second, unbiased sample group is captured at the same spot where the previous samples were taken and divided into groups:

      i. those that are marked which have been recaptured and
      ii. those that are unmarked which have been caught for the first time.

   The estimated population is calculated using the equation below:

$$\textbf{Population} = \frac{\textbf{Total in first sample x total in second catch}}{\textbf{Total marked recaptured in second catch}}$$

Below is an example of population count using the mark recapture technique.

A biologist captures a sample of **36** possums in woodland, marks them all and releases them back into the woodland. One week later, the biologist returns to the same area and captures a second sample of possums. The size of this second sample turns out to be **30** possums and the biologist notes that this sample consists of **12** marked and **18** unmarked possums.
Using the equation;

$$\textbf{Population} = \frac{\textbf{Total in first catch x total in second catch}}{\textbf{Total marked recaptured in second catch}}$$

$$= \frac{36 \times 30}{12}$$

$$= 90$$

The biologist would estimate the total population of possums in the woodland to be 90.

Problems can arise with the mark-recapture procedure if:
- The released animals do not mix at random with the rest of the population after release.
- Animals migrate into or from the area over the period of study.

Variables affecting population size
The size of the population of a particular species in a given area is not always stable.
Variables that influence population size include the following.

Birth rate, also called **fertility rate** is the ratio of total births to total population in a specific period of time. This may be expressed numerically (for example, 55 offspring per year).

Death rate, also called **mortality rate** is the number of deaths per given unit of population over a given period of time. This may also be numerically expressed (for example, 10 organisms per week)

Migration rate, or the net gain or loss in population over a given time by movement of individuals either *into* the population from other areas (immigration) or out of the population to other areas (emigration).

The combined action of these variables; birth, death, and migration rates produce changes in the size of a population over time. This may be represented by the equation below:

Growth rate = (Births + Immigration) – (Deaths + Emigration) per unit time.

The growth rate is positive for example 27 organisms per year when population size increases. The growth rate is negative when the population size decreases. When gain by births and immigration are matched or is equal to losses by deaths and emigration, a population is steady and is said to have **zero population growth**.

Examples of positive and negative population growth rates

The Grade 12 biology students of Wandu Secondary school monitored the population growth rate of tilapia fish in the school pond as part of their major project. The project was started with the introduction of 500 fish fingerlings into the pond in January.

A summary of the students findings at the end of April and July were formulated as shown below. The starting population is 500 fish.

End of April

Birth of young equals 280
Introduction of new fish (immigration) = 250
Harvested and sold (deaths) = 100
Transferred to new pond = 200

End of July

Birth of young fish = 637
Introduction of new fish (immigration) = 0
Harvested and sold (deaths) = 550
Transferred to new pond = 200

Using the equation

Growth rate = (Births + Immigration) – (Deaths + Emigration) per unit time.

1. Growth rate at the end of April = 280 + 250 - 100 + 200
   = 230

Growth rate is positive. There is an increase of 230 fish in addition to the original 500 fish. The starting total from end of April is 500 + 230 = 730.

2. Growth rate at the end of July = 637 + 0 – 500 + 200
   = - 63

Growth rate is negative. There is a decrease of 63 fish from the previous total of 730 fish.
The new starting total will be 730 – 63 = 667

Open and closed populations

A population is defined as either **open** or **closed** depending on whether or not migration can occur. In **closed populations** there is no migration while there is migration into and out of **open populations**.

Closed populations are isolated from other populations of the same species, as for example, a lizard population on an isolated island. Other closed populations include monkey populations in closed forests on various mountains where the mountains are separated by open grassland and desert that the monkeys cannot cross.

It is now time for you to complete Learning Activity 1. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Summative Test 2 (which you will send in for assessment)

Learning Activity 1

40 minutes

Answer the following questions in the spaces provided.

1. Define the terms below:

(a) Population

____

____

(b) Stability

____

____

(c) Decline

____

____

(d) Population dynamics

____

____

(e) Endangered species

____

____

(f) Birth rate

____

____

(g) Death rate

____

____

(h) Immigration

____

____

(i) Emigration

____

____

2. An Ecologist decided to count the total population of carp fish at Lake Sirunki. He threw his net into the water and caught a total of 1800 fish. He placed tags on the fins of all of those fish and returned them back into the lake.

   Two days later he returned back to the same spot in the lake and threw his net again. This time he caught a total of 2250 carp fish. Out of the second catch, a total of 450 fish had tags on their fins while 1800 had no tags.

   (a) Calculate the total estimated number of fish in the lake using the equation given in the reading. Show your working out.

   ____
   ____
   ____
   ____

   (b) What kind of sampling method was used by the ecologist above?

   ____

3. What is the main purpose of using a line transects by ecologists to do population count?

   ____
   ____
   ____

4. What types of organisms are best sampled by the use of the quadrat method?

   ____

5. Name three variables that affect population size.

   a) ____
   b) ____
   c) ____

Thank you for completing your Learning Activity number 1. Check your work. Answers are at the end of this module.

It is now time for you to complete Practical Activity 2 in your Assessment Book 2 before you go on to the next topic.

Population Growth

Models of population growth

Population dynamics deal with changes in population size over time. Is a population increasing, decreasing or remaining unchanged in size? If changing, how fast is the change occurring? Models relating to changes in population size over time have been developed.

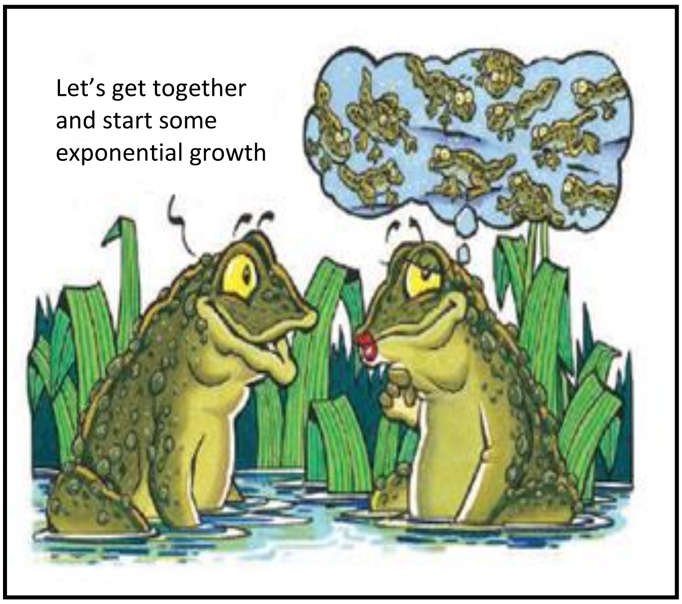
In a closed population two models of growth have been developed and they are:
(1) **Exponential growth model and**
(2) **Logistic growth model**.

These models are simples and use a few variables. In reality, the dynamics of populations in the real world are very complex and involve many variables. These models, however, give some understanding on how populations change in size over time.

(1) Exponential growth model (the J shape)

Exponential growth is a very fast and unlimited growth of a population. Exponential growth would be expected to occur when a new species is introduced into a lake or onto an island where there are no predators, no disease and where food and other resources are in plentiful supply.

This pattern of growth can occur for several generations as long as resources are plentiful. The rapid growth in numbers of some introduced pests in Australia, such as cane toads (*Bufo marinus*), is because of a period of exponential growth.



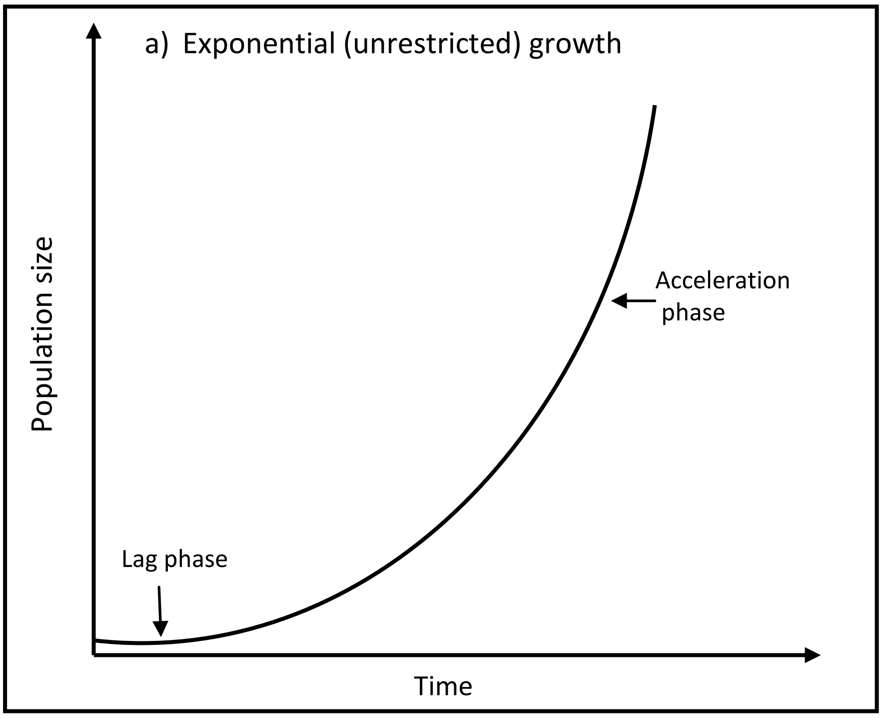
Exponential growths can take place in cane toads

Exponential growth is also seen in the growth of bacteria. The increase in population size over each generation is not identical.

In a population that is growing exponentially, the population size in one generation depends on:
(i) the previous generation and
(ii) the rate of increase.

This means that as the population increases in size, the growth over each generation also becomes larger. The pattern for exponential growth is always the same, namely an initial slow increase in the size of the population when the population size is small.

This is the (1) **lag phase** that corresponds to the nearly flat section of the graph. This is the initial slow increase phase. Then, as the population size increases, the numbers increase more sharply in each generation. This is the (2) **acceleration phase** and begins when the curve turns around the bend.



Exponential growth model. The J - shape

As the population size increase the curve rises. After this, the size grows more and more rapidly with each generation and the gradient of the graph is almost vertical.

The graph of exponential growth is called a **J-shaped curve** (for obvious reasons). The generation times involved may be minutes, days or weeks depending on the species.

Consider the example of the Australian bush fly (*Musca vetustissima*).

Let us start a population with just one female bush fly and her mate. Assume that she lays 100 eggs and dies soon after. Of the eggs, assume that 50 develop into females with a generation time of 8 weeks. If exponential growth occurred, this single female bush fly and her mate would have 31 billion descendants in just under one year.

General population	Total
0	2
1	100
2	5 000
3	250 000
4	12 500 000
5	625 000 000
6	31 250 000 000
7	1 562 500 000 000
8	78 125 000 000 000

Exponential growth of bush fly over 8 generations with reproductive rate of 50

In reality, however, this number cannot eventuate because exponential growth of populations cannot occur forever.

The conditions required for exponential growth are: unlimited resources such as food and space which can last for only a few generations. Every habitat has limited resources and can support only populations of a limited size.

Let us look at another model of population growth that gives a better fit with reality.

(2) Logistic growth (The S-shape)

A pair of rabbits in a suitable habitat with abundant food and space initially multiply over several generations. The population grows at a faster rate, this is a period of exponential growth. However, this rate of growth does not continue. Growth slows and finally stops when the so called **carrying capacity** of the habitat is reached. This is the moment when all the available resources in the habitat have been used up.

The carrying capacity is the maximum population size that a habitat can continue to support.

To survive, members of a population must have access to particular resources in their habitat. In the case of plants, these resources include *space*, sunlight, *water* and mineral nutrients.

In the case of animals, necessary resources include *food, water* and *space* for shelter and breeding. These resources are the **limiting factors** in the growth of a population.

Population growth in the presence of these limiting factors follows a pattern that is termed **logistic growth**, also known as **density-dependent** growth.

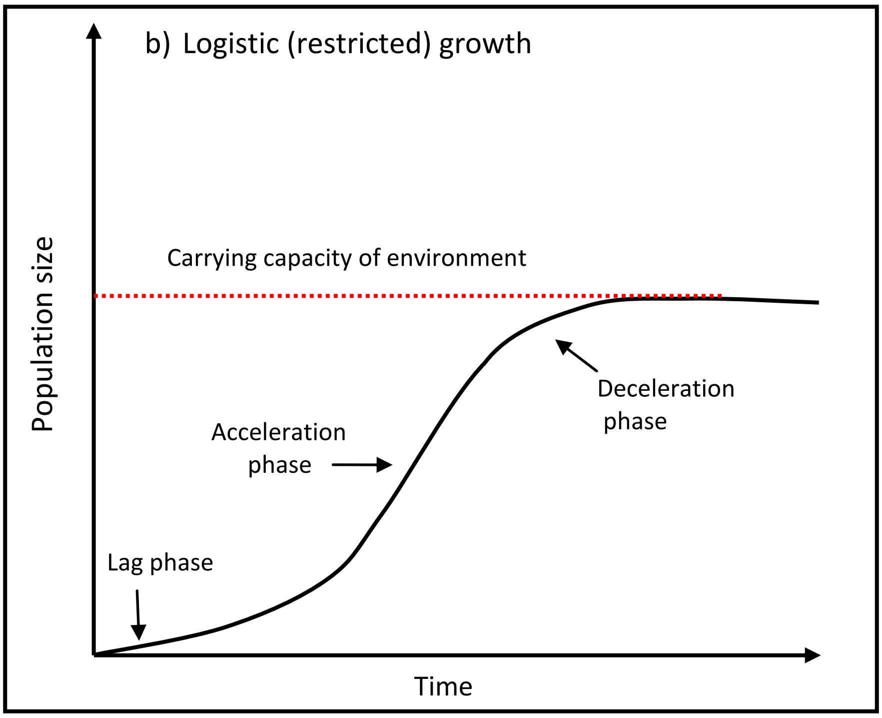
When the population size is well below the carrying capacity, the growth of the population is rapid, but as the population size approaches carrying capacity, growth slows and stops.

The growth is at first like the exponential growth pattern, but as the population grows, the rate of growth slows and finally stabilises at the carrying capacity.

This pattern is known as an **S-shaped curve**. The early part of an S-shaped curve has both a lag phase and an acceleration phase. As environmental resistance to growth becomes stronger, population growth slows down.

This period of slowing down is the **deceleration phase**. Then the population size stabilises at the value of the carrying capacity and this is shown in the flattening out of the growth curve. At this stage, the growth rate is zero.

As a population increases in size, the pressure on resources increases and population growth slows and then stops.



Logistic growth model. The S- shape curve

This results from several factors including **competition** for very limited resources. When two organisms of the same species compete for the same resource, it is called **intraspecific competition.**

When individuals of two different species live in the same habitat and compete for the same resource, we describe it as **interspecific competition.**

This competition can lead to starvation, overcrowding, spread of diseases and parasites, and increased predation slows population growth. The effect of these factors on individuals in a population depends on the population size.

When a population is small, the impact of these factors is low or absent. When a population becomes large, however, these factors have a major impact on each member of a population.

Factors affecting population growth are classified into two:
Factors whose impact is related to population size are said to be (1) **density dependent**. Such factors as mentioned earlier are diseases, limited space, predation, parasitism and others.

Populations are also affected by factors, such as drought, bushfire and flood, which are secondly (2) **density independent** factors. The impact of these factors is not influenced by the size of a population; for example, a fire has the same effect on members of a small population as a large population. Collectively, the impact of any kind of natural disasters that act on the growth of populations is called **environmental resistance** to growth.

Populations affect other populations
All living organisms within an ecosystem are interdependent. A change in the size of one population affects the population size of all other organisms within the ecosystems. For example, the size of a plant population will be affected by the size of the populations of herbivores that feed on that plant.

Other density-dependent factors that influence the size of one population include the size of populations of its parasites and its predators. For example, if there are more flies and mosquitoes in a household the number of geckos would increase rapidly.

Let us look at how predator and prey populations interact and the impacts on their population sizes.

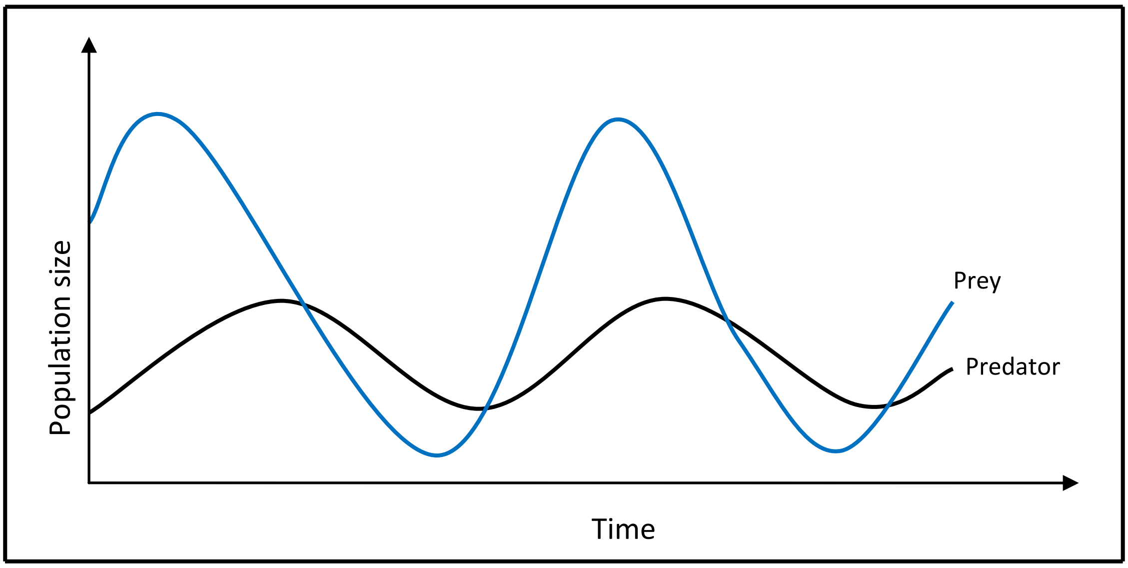
Predator and prey relationship
All living organisms within an ecosystem are dependent to each other in order to survive. A change in the size of one population affects all other organisms within the ecosystem. This is shown clearly by the relationship between predator and prey populations.

There is a continuous battle between predators and their prey. Predator species need to be adapted for efficient hunting if they are to catch enough food to survive. Prey species on the other hand, must be well adapted to escape their predators if enough of them are to survive for the species to continue.

If the prey population in an ecosystem grows, predator numbers will respond to the increased food supply by increasing as well. Growing predator numbers will eventually reduce the food supply to the point where it can no longer sustain the predator population and so on. In such cases, cycles of what is called ‘boom-and-bust’ can be seen in both populations.

A rise in prey population is immediately followed by a rise in the predator population and as the prey population drops, it is followed by a drop in the predator population. This continues on as the ’boom - bust – cycle’.

The graph below shows the theoretical expectation of these boom-bust cycle.



Fluctuation in population size in a prey population and in the predator population that feeds on it.

It is now time for you to complete Learning Activity 2. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Summative Test 2 (which you will send in for assessment).

Learning Activity 2

30 minutes

Answer the following questions.

1. So many factors limit growth of populations in organisms. List down

   (a) three different limiting factors that are density dependent.

   (i) ______________________________

   (ii) ______________________________

   (iii) ______________________________

   (b) three factors that are density independent.

   (i) ______________________________

   (ii) ______________________________

   (iii) ______________________________

2. A female and a male rabbits were introduced into Papua New Guinea from Australia. The reproduction rate for the rabbits is 15 baby rabbits and they have a generation time of 4 weeks.

Calculate and write down the total population of rabbits for each generation in the table shown.

(Consider that there were no limiting factors and the population was growing exponentially and at a rate of 15).

Generation	No of Rabbits
0	2
1	15 x 2 = 30
2	15 x 30 = 450
3	
4	
5	

3. In a predator and prey relationship there is a 'boom bust' cycle which occurs. Briefly explain what happens to the population of the two species of organisms during the cycle.
____
____

4. Explain the difference between an interspecific competition and an intraspecific competition.
____
____

Thank you for completing your Learning Activity 2. Check your work. Answers are at the end of this module.

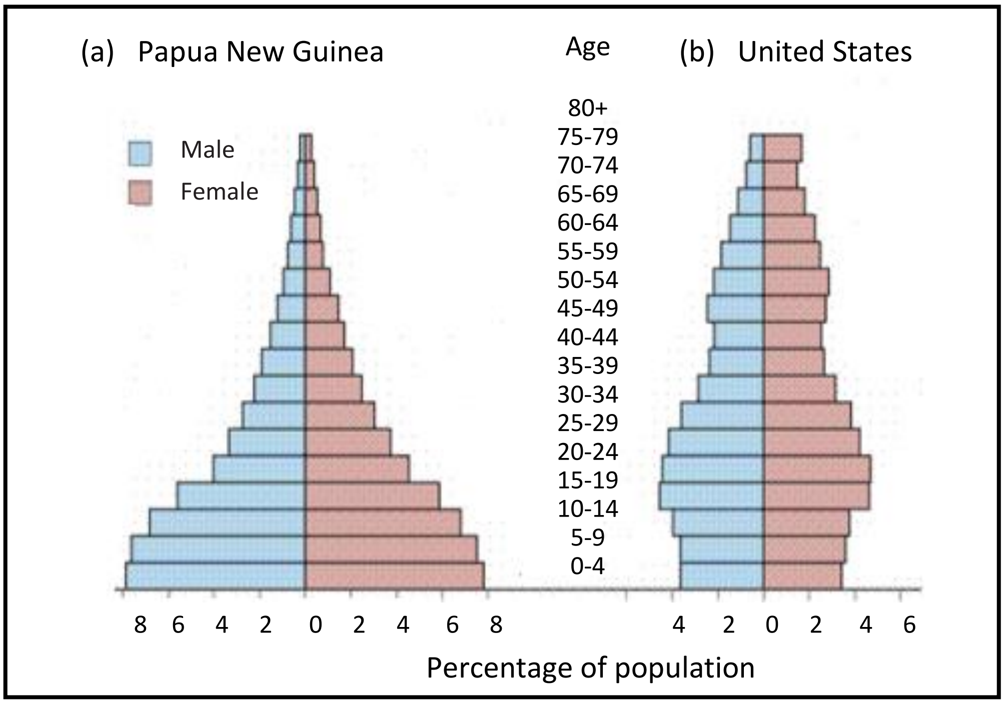
Human Population Growth

In 1,000 AD, the world population was about 300 million. In the early 19th century it rose to 1000 million (1 billion), and by 1984 it had reached 4.7 billion. In 2000 it reached about 6 billion and might stabilise at 10 billion by 2100.

Age structure of populations

Age structure refers to the relative proportion of individuals in each age group of a population. Populations with more individuals aged at or before reproductive age have a pyramid-shaped age structure graph. It can expand rapidly as the young mature and breed. Stable populations have relatively the same numbers in each of the age groups.

The graphs on the next page show a comparison of the population age structure in the United States and Papua New Guinea. United States is a developed country while Papua New Guinea is an example of a developing country.



Comparison of the population age structure in the United States and Papua New Guinea

Graph (a) represents some populations that are relatively young, that is, they have a large proportion of people in the younger age groups. The high-fertility countries of Africa with large proportions of young adults and children are examples.

Graph (b) represents other populations that are relatively old, such as many countries in Europe and the United States. These two types of populations have clearly different age compositions. A population's age structure has a great deal to do with how that population lives.

Developing countries such as Papua New Guinea have relatively young populations while most developed countries have old or "aging" populations.

In many developing countries, 40 percent or more of the population is under age 15 years, while four percent (4%) is 65 years or older.

The wide base of the pyramid shaped graph indicates very high birth rate and low average life expectancy. The bulk of the population is under 25 and the population is likely to increase very rapidly as the majority of young people mature and reproduce.

On the other hand, in almost every developed country, less than 25 percent of the population is under age 15 and more than 10 percent is 65 or older. The almost rectangular pattern in the graph is characteristic of an industrialized society, with a steady birth rate and a life expectancy of about 70 years. This kind of population is almost stabilised where growth rate equals birth rate and there is no increase in population.

Human population growth
About 20 years ago, the human population was increasing at the rate of 2 percent a year. This may not sound very much but it means the world population was doubling every 35 years. This doubles the demand for food, water, space and other resources. Recently, the growth rate has slowed to 1.3 percent but it is not the same everywhere. Nigeria's population is growing by 2.9 percent each year, but the population in Western Europe grows at only 0.1 percent.

Traditionally, it is assumed that population growth is limited by famine, disease or war. These factors are affecting local populations in some parts of the world today but they are unlikely to have a limiting effect on the rate of overall population growth.

Diseases such as malaria (spread by mosquitoes), and sleeping sickness have for many years limited the spread of people into areas where these insects carry infections.

Diseases such as bubonic plague and influenza have signified population growth from time to time, and the current AIDS epidemic in sub-Saharan Africa and some other countries is having significant effects on population growth and life expectancy.

Factors Affecting Human Population Growth

(1) **Birth rate**
If a population grows, the birth rate is higher than the death rate. Suppose a population of 1000 people produces 100 babies each year but only 50 die. This means that 50 new individuals are added to the population each year and the population will double in 20 years or less if the individuals start reproducing at 16 years.

(2) **Infant mortality rate**
The death rate for children less than 1 year old is called infant mortality. Populations in the developing world are growing, not because of an increase in the number of babies born per family, but because more babies are surviving to reach reproductive age.

(3) **Increase in life expectancy**
The life expectancy is the average age to which a newborn baby can be expected to live. If more children survive and live longer to reproduce, the population will continue to grow.

(4) **Death rate**
Agricultural development and economic expansion lead to improvements in nutrition, housing and sanitation, and clean water supplies in Papua New Guinea. These improvements reduced the incidence of infectious diseases in the general population.
These social changes plus the improvement of medical techniques, account for three-quarters of the decrease on deaths.

Stability and growth

Up to 300 years ago, the world population was relatively stable. Fertility (the birth rate) was high and so was mortality (death rate). Probably less than half the children born lived to have children of their own. Many died in their first year (infant mortality), and many mothers died during childbirth.

In the past 300 years, the mortality rate has fallen but the birth rate has not gone down to the same extent. As a result the population has expanded rapidly. In the developing world, the fertility rate has dropped from about 6.2% to 3.0%. This is still higher than the mortality rate. An average fertility rate of 2.1% is necessary to keep the population stable.

As a community grows wealthier, the birth rate goes down. There are believed to be four reasons for this.

- Larger and better education.
- Better living conditions.
- Increase in agricultural products and more cities.
- Application of family planning methods.

It takes many years for social improvements to produce a fall in birth rate. Some countries are trying to speed up the process by encouraging couples to limit their family size, or by penalising families who have too many children.

Meanwhile the population keeps on growing. The United Nations expect that the birth rate and death rate will not be in balance until the year 2100. By that time the world population may have reached 10 billion, assuming that the world supply of food will be able to feed this population.

Population pressures

More people, agriculture and industrialisation will put more pressure on the environment unless we are very watchful. The destruction of ozone layer, increases atmospheric carbon dioxide, release radioactive products or allow farmland to erode, we may meet with additional limits to population growth.

Population decline and extinction

Extinction is the elimination of all individuals in a group. **Local extinction** is the loss of all individuals in a population. **Species extinction** occurs when all members of a species and its component populations go extinct.

Scientists estimate that 99% of all species that ever existed are now extinct. The ultimate cause of decline and extinction is environmental change. Changes in one of the physical factors of the environment may cause the decline and extinction; likewise the fossil record indicates that some extinction is caused by migration of a competitor.

It is now time for you to complete Assignment 2 in your Assessment Book 2 before going on to the next topic.

Human Impacts on Population

The growth in human population due to use of technology has caused the natural population to either bloom or becomes extinct in certain species.

Described below are some human impacts on the environment.

(1) **Types of Pollution**

Pollutions are unplanned releases of substances into the air and water which cause harmful effects on the environment and organisms.

Many lakes have nitrogen and phosphorous as limiting nutrients for aquatic and terrestrial plants. Runoff from agricultural fertilisers increases these nutrients, leading to runaway plant growth, or **eutrophication**. Increased plant populations eventually lead to increased bacterial populations that reduce oxygen levels in the water, causing fish and other organisms to suffocate.

Eutrophication is the enrichment of the natural waters by plant nutrients such as nitrogen and phosphorus which causes an over growth of aquatic plants.

(2) **Pesticides and Competition**

Removal of a competing species can cause the ecological release of a population explosion in that species competitor. Pesticides sprayed on wheat fields often result in a secondary pest outbreak as more-tolerant-to-pesticide species expand once less tolerant competitors are removed.

(3) **Removal of Predators**

Predator release is common where humans hunt, trap, or otherwise reduce predator populations, allowing the prey population to increase. For example, elimination of wolves and panthers has led to increase in their natural prey: deer.

(4) **Introduction of new species**

Introduction of exotic or alien, non-native species into new areas is the greatest single factor which affects natural populations. Once an introduced species becomes established, its population growth is explosive.

Kudzu, a plant introduced to the American south from Japan, has taken over large areas of the countryside. The introduction of an aquatic plant, **water hyacinth** into the Sepik River has spread rapidly over the water surface. This may cause fish and other animals in the water to reduce in number. The spread of the hyacinth also makes it difficult for people to paddle their canoes along the river.

Water hyacinth, which grows and spreads rapidly over the surface of natural waters create problems for people and other animals that survive in the water.

On a positive note, human-induced population explosions can provide needed resources for growing human populations. Agriculture now produces more food per acre, allowing and sustaining increased human population size. Human action is causing the extinction of species at thousands more times than the natural rate. Extinction is caused by change of a population's environment in a harmful way.

Habitat disruption

Habitat disruption is the disturbance of the physical environment of a species, for example cutting a forest or draining wetlands. Habitat disruption is currently the leading cause of extinction.

Changes in the biological environment occur in three ways.

1. **Species introduction**
   An exotic species is introduced into an area where it has no predators to control its population size, or where it can greatly out compete native organisms. Cane toads (*Bufo marinus*) is an introduced species to Papua New Guinea. They do not have predators and multiply very fast.
2. **Overhunting**
   When a predator population increases or becomes more efficient at killing the prey, the prey population may decline or go extinct. In prehistory, humans may have caused the extinction of the mammoths and mastodons due to increased human hunting skills. The extinction of echidnas which lived in some parts of the highlands of Papua New Guinea before was purely due to overhunting.
3. **Secondary extinction**
   Loss of food species can cause migration or extinction of any species that depends largely or solely on that species as a food source. Destruction of bamboo forests in China, the food for the giant panda, may cause the extinction of the panda. The extinction of the dodo bird has caused the Calviera tree to become, unable to reproduce since the dodo ate the fruit and processed the seeds of that tree for dispersal and germination.

Echidna – an egg laying mammal had extinct in Papua New Guinea due to over-hunting.

Human Population Trends in Papua New Guinea (PNG)

Papua New Guinea's population reached 7.3 million according to the 2011 National Census. Between the 1980 and 1990 censuses, the average annual growth was 2.3%, while for the 20-year period 1980 to 2000 it was 2.7%, and between 2000 and 2011 it was 3.1%.

According to the estimated levels of fertility and mortality, the natural growth rate is estimated at only 2.1% which in the absence of significant international migration, should be the approximate overall population growth rate. The total population of PNG has doubled over the last 20 years, and present population projections indicate a population of 10 million by 2030.

According to the 2000 census, life expectancy is 54 years and 55 years for males and females, 25 per cent of children are unable to attend school, and adult literacy is around 50 per cent. By 2006, infant mortality had reached 57 per 1000 live births (64 in the year 2000) and **maternal mortality** was 733 per 100,000 live births.

The challenges of distance, isolation, lack of transport and an extreme shortage of skilled birth attendants, highlight the hazards of childbirth in PNG. The rate of malnutrition is unacceptably high and remains a significant underlying factor for **morbidity** and **mortality** particularly for children under five years.

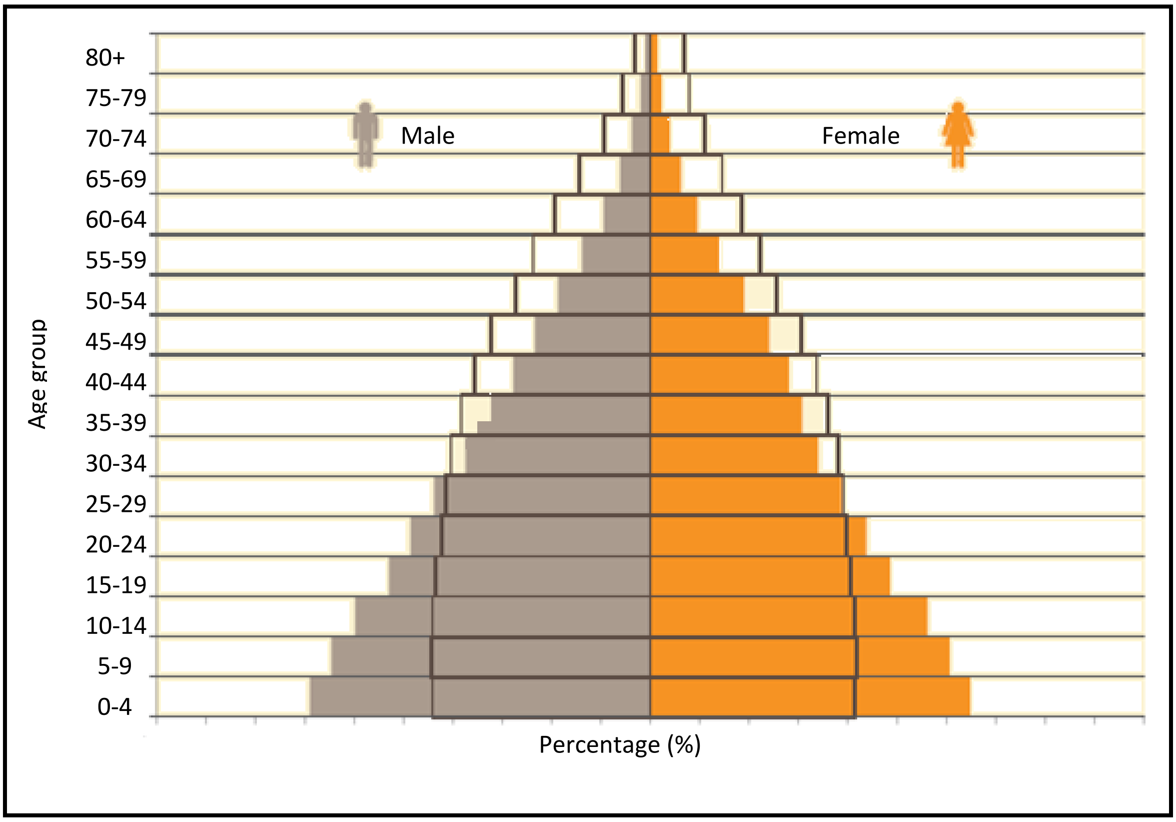
PNG faces numerous challenges in comparison to the other Pacific Islands countries.
PNG has:

- One of the highest proportion of people aged younger than 25 years of age (58%).
- Very high overall **fertility rates**. Family planning and reproductive health programmes need to be strengthened.
- Very high **adolescent fertility rates** - Access to youth-friendly services throughout the country, particularly in rural areas. Family life education in schools will help to raise awareness of the consequences of early child-bearing.
- Highest **Maternal Mortality Ratio** (MMR)- targeted intermediations to address the underlying causes of maternal mortality are needed. Access to safe motherhood and emergency **obstetric** care needs to be improved.
- Lowest proportion of births attended by skilled professionals.
- Highest Infant Mortality Rate (IMR) .Some of the measures that should be undertaken to reduce infant mortality rates, is to improve infant, child and maternal health by improving primary health care programmes, improve emergency obstetric care to decrease neo natal mortality, and expand **immunization** programmes.
- Highest HIV prevalence rates.
- Lowest Life expectancy at birth.

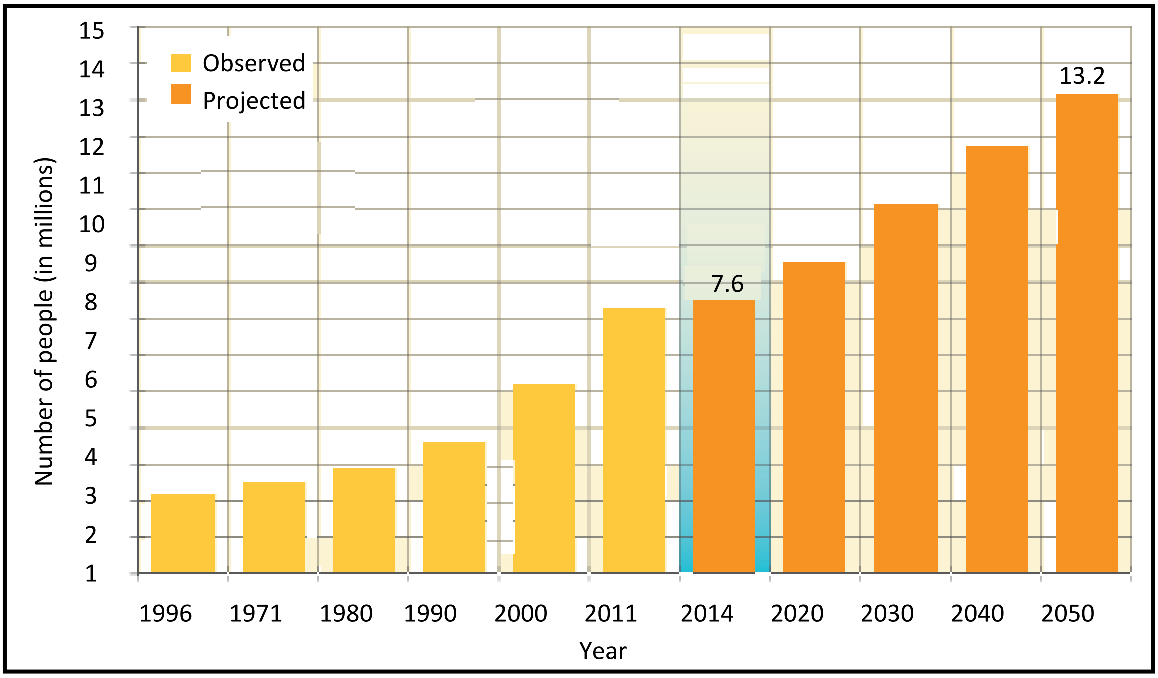
Population and development indicators

Indicator	Value	Year
Population last census	7,275,324	2011
Current population estimate	7,587,200	2014
Estimated growth rate (annual %)	2.1	2014
Rate of natural increase (%)	2.1	2014
Net migration rate (%)	0.0	2014
Total fertility rate, TFR (total/urban/rural) 4.4/3.6/4.	5	2006
Adolescent fertility rate, per % (total/ urban/rural)	65 /55/67	2006
Infant mortality rate (IMR)	56.7	2006
Life expectancy at birth (M/F)	53.7/54.8	2000
Population 0 -14 (%)	38	2014
Population 15 - 24 (%)	20	2014
Population 25 - 59 (%)	38	2014
Population 60 and older (%)	4	2014
Median age	21.1	2014

POPULATION BY AGE AND SEX 2015 (SHADED AREA) AND 2050 (OUTLINED)



POPULATION TREND IN PAPUA NEW GUINEA



It is now time for you to complete Learning Activity 3. Remember, learning activities are not sent in for assessment. However, this learning activity will help you complete Summative Test 2 (which you will send in for assessment)

Learning Activity 3

20 minutes

Answer the following questions on the space provided.

1. Answer the following two questions in terms of the difference in birth and death rates.

   (a) Why was the human population steady in the past?

   ____

   ____

   (b) Why is the human population increasing rapidly in the last 300 years till now?

   ____

   ____

2. A growing population is likely to increase while a steady population does not increase or decrease in size. Write STEADY or GROW beside the following statements.

   (a) Life expectancy is high. __________
   (b) An old and aging population. __________
   (c) A developing young country. __________

(d) Age structure graph is almost rectangular shaped. ___________
(e) Most of the population are under reproductive age. ___________

3. Match the items in **column A** with **column B**. Write the letter of the correct answer on the space provided.

	A	**B**
___________1.	Introduction of a new species.	(a) Extinction of species
___________2.	Removal of a predator species .	(b) Suffocation and death of aquatic animals.
___________3.	Increase of nitrates in the waters.	(c) Over explosion of the species
___________4.	Removal of a competing species.	(d) Species increase in the prey species.
___________5.	Over-hunting.	(e) Population explosion in a species competitor.

4. Define the terms below.

(a) Infant mortality

____
____

(b) Extinction

____
____

(c) Pollution

____
____

(d) Eutrophication

____
____

5. What will be the total population in Papua New Guinea by the year 2050?

____

6. What will be the significant change in the population between now and the year 2050 as shown by the age structure?

____

Thank you for completing your Learning Activity 3. Check your work. Answers are at the end of this module.

REVISE WELL USING THE MAIN POINTS ON THE NEXT PAGE.

SUMMARY

You will now revise this module before doing **SUMMATIVE TEST 2**. Here are the main points to help you revise. Refer back to module topics if you need more information.

- A population is said to increase when there is more available resources, reproduction is fast and death rate is low.
- A decline in a population leads to extinction.
- Ecologists measure population abundance in order to;
  - conserve the risk of endangered species from being extinct.
  - control and monitor introduced species.
  - detect patterns of some populations that sharply increase in number.
  - identify possible cause of the explosion.
- Ecologists measure population abundance by using sampling techniques.
- Variables which affect population size are birth rate, death rate, and migration rate.
- When birth and immigration equals death and emigration, there is zero population growth.
- Population growth can be represented by two types or graphs, an exponential J-shaped graph and a logistic S-shaped graph.
- Population growth can be affected by factors whose impact is related to population size called density dependent factors.
- Factors whose impact is not related to population size is called density independent factors.
- Organisms are interrelated, an increase or decrease in a prey population affects the population size of the predator species that feeds on it.
- The human population on Earth is estimated to reach 10 billion and become stabilize by the year 2100.
- A young and developing nation is represented by a pyramid shaped age structure. A developed nation can be represented by an almost rectangular shaped age graph.
- Majority of the population of a developing nation are under reproductive age.
- Removal of predators may cause a bloom in the prey species.
- Species extinctions can be caused by, over hunting, new species introduction, habitat destruction.
- A wealthy community has low birth rates.
- An educated community is wealthier, they have more knowledge of family planning and agriculture and their population growth rate decreases.

NOW DO SUMMATIVE TEST 2 IN YOUR ASSESSMENT BOOK AND SEND IN TO THE PROVINCIAL COORDINATOR FOR MARKING.

ANSWERS TO LEARNING ACTIVITIES 1 - 3

Learning Activity 1

1. (a) Group of individuals of the same species living in the same geographical area at a particular time.
   (b) Steadiness in a population and usually the longest phase of a population's life cycle.
   (c) Is the decrease in the number of individuals in a population.
   (d) The study of factors that affect population growth, stability, and decline of populations .
   (e) Species of organisms that are low in number and are luckily to disappear.
   (f) Ratio of total births to total population in a specific period of time.
   (g) Number of deaths per given unit of population over a given period of time.
   (h) Movement of individuals *into* the population from other areas.
   (i) Movement of individuals *out of* a population to other areas.

2. a) Population = $\frac{\text{Total in first catch x total in second catch}}{\text{Total marked recaptured in second catch}} = \frac{1800 \times 2250}{450} = 9000$

   b) Mark recapture method

3. Line transects are useful in identifying changes in vegetation with changes in the environment.
4. Plants, sessile animals like oysters, mussels, star fish, limpets and anemones, and of slow-moving animals such as chitons and snails.
5. (i) birth rate
   (ii) death rate
   (iii) migration rate

Learning Activity 2

1. (a) (i) Lack of space
   (ii) Lack of food
   (iii) Disease outbreak
   (iv) Increase in predator
   (v) Parasitism

   (Any 3 of the above factors in any order)

(b) (i) Fire,
(ii) flood,
(iii) frost,
(iv) earthquake,
(v) drought,
(vi) cyclone,
(vii) landslide,

(Any 3 kinds of natural disaster in any order)

2.

Generation	No of Rabbits
0	2
1	30
2	450
3	6 750
4	101 250
5	1 518 750

3. The rise in the predator population occurs after the rise in the prey population, and a fall in the predator population occurs after a fall in the prey population.

4. Interspecific competition is the competition between organisms of different species. Intraspecific competition is the competition between organisms of the same species.

Learning Activity 3

1. a) Because birth rate was equal to death rate.
   b) Because birth rate was higher than death rate.

2. a) GROW b) STEADY c) GROW d) STEADY e) STEADY

3. 1. e 2. d 3. b 4. c 5. a

4. a) Death of children under one year of age.
   b) Elimination of all individuals of population in a group.
   c) Are unplanned releases of substances into the air and water which cause harmful effects on the environment and organisms.
   d) Enrichment of the natural waters by nitrogen and phosphorus which causes increased growth of algae.
5. 13.2 million people
6. Population under 29 years of age will decline in number.

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FODE PROVINCIAL CENTRES CONTACTS

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2	BUKA	P. O. Box 154, Buka	9739838	72228108	72229073
3	CENTRAL	C/- FODE HQ	3419228	72228110	72229050
4	DARU	P. O. Box 68, Daru	6459033	72228146	72229047
5	GOROKA	P. O. Box 990, Goroka	5322085/5322321	72228116	72229054
6	HELA	P. O. Box 63, Tari	73197115	72228141	72229083
7	JIWAKA	c/- FODE Hagen		72228143	72229085
8	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	72229069
9	KEREMA	P. O. Box 86, Kerema	6481303	72228124	72229049
10	KIMBE	P. O. Box 328, Kimbe	9835110	72228150	72229065
11	KUNDIAWA	P. O. Box 95, Kundiawa	5351612	72228144	72229056
12	LAE	P. O. Box 4969, Lae	4725508/4721162	72228132	72229064
13	MADANG	P. O. Box 2071, Madang	4222418	72228126	72229063
14	MANUS	P. O. Box 41, Lorengau	9709251	72228128	72229080
15	MENDI	P. O. Box 237, Mendi	5491264/72895095	72228142	72229053
16	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194/5423332	72228148	72229057
17	NCD	C/- FODE HQ	3230299 ext 26	72228134	72229081
18	POPONDETTA	P. O. Box 71, Popondetta	6297160/6297678	72228138	72229052
19	RABAUL	P. O. Box 83, Kokopo	9400314	72228118	72229067
20	VANIMO	P. O. Box 38, Vanimo	4571175/4571438	72228140	72229060
21	WABAG	P. O. Box 259, Wabag	5471114	72228120	72229082
22	WEWAK	P. O. Box 583, Wewak	4562231/4561114	72228122	72229062

FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics – General/Advance
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

GRADES 11 & 12 COURSE PROGRAMMES			
No	**Science**	**Humanities**	**Business**
1	Applied English	Language & Literature	Language & Literature/Applied English
2	Mathematics -General/Advance	Mathematics -General/Advance	Mathematics –General/Advance
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry, Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:

You must successfully complete 8 courses: 5 compulsory and 3 optional.