6.1 Can populations keep growing forever?

Lesson outcomes

At the end of this activity students will be able to:

- identify patterns in population growth data and explain how limiting factors influence population growth.

Key vocabulary:

Ecology, population, species, exponential growth, J-curve, S-curve, logistic growth, density-dependent and density–independent limiting factors, carrying capacity.

Equipment list:

Each STUDENT will require:

- *Student Guide*
- ***e-Notebook***
- internet access

Things to consider:

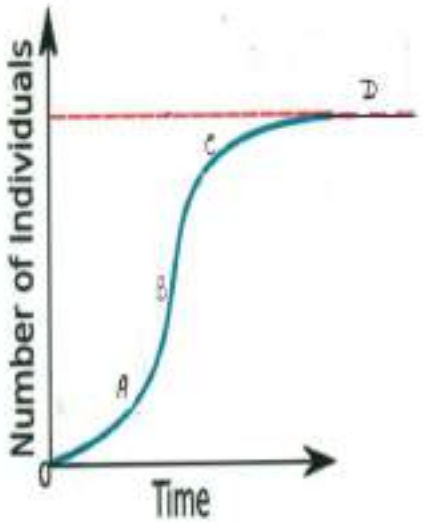
- Consider using a laptop, projector and screen for the first half of this lesson as it involves direct instruction of new terms and graphical representations.
- Familiarise yourself beforehand with the digital resource *African Lions: Modelling Populations*. Students are posed questions and given feedback on their answers as they step through the tutorial.
- Consider showing students where Tanzania is located using Google map. The Ngorongoro Crater is in the northern part of the country.
- The digital activity in the *Follow up* section *Phytoplankton* is housed in Scootle. You (as educator) will need to register on Scootle (https://www.scootle.edu.au/ec/p/home) in order to access this resource for your students. Once registered you can search for it using its ID code (R11861) and add the resource to your own learning path. Click on the 'Add to' button, and choose 'Create new learning path'. Click on 'Learning paths' at the top of the page, open your learning path and copy the six letter PIN number that you can share with your students. Your students need to go to the Scootle home page (https://www.scootle.edu.au/ec/p/home), click on 'Student login' at the top of the page and enter the PIN number.

Teacher Content Information

If bacteria double in number every hour, then after 10 hours one bacterium will form 1024 bacteria.

Population = $1 \times 2^{10} = 1024$

The following graph shows the population growth of a new species in an environment.



At A there is no shortage of resources and the growth rate (gradient) is increasing.

At B the graph shows the maximum growth rate (steepest gradient).

At C the growth rate is reducing due to limiting factors (food, space/shelter, water, disease, increased predation).

At D the growth rate is zero because competition for resources is limiting growth. The number of births and immigration equals the number of deaths and emigration. At D the population has reached the carrying capacity of the population.

Lesson plan

Step 1: Quiz students on their knowledge of populations.

Suggested questions:

- What is a population?
- What causes a population of a species to grow?
- Can a population of a species e.g. sunflowers in a field, duckweed in a pond, humans on planet Earth, keep growing forever? Share your ideas.

Step 2: Show students **Activity 6.1** in the *Student Guide*. Ask students to solve the problem - How many bacteria will there be after 10 hours? Can students write the mathematical equation to solve this problem?

Step 3: Click on the digital link and introduce students to the graphs of exponential growth (J-curve) and logistic growth (S-curve) and the concept of limiting factors.

Step 4: Show students where Tanzania is located in Africa and invite them to click on the digital resource *African Lions: Modelling Populations* and complete the tutorial.

Step 5: Invite students to complete the ***Notebook*** tasks. Conclude with a class discussion of answers to the ***Notebook*** tasks.

Follow up:

Explore predicted human population growth

Examine global population growth over two millennia and see what's coming in the next 50 years. Go to http://www.pbs.org/wgbh/nova/earth/global-population-growth.html and click 'launch interactive'.

Suggested questions:

- Describe the change in human population on Earth in the past 2000 years.
- What are the potential limiting factors that could limit human population growth?

Explore population explosions: algal blooms and dead zones

In this Scootle video *Phytoplankton* (R11861) a NASA scientist discusses the study of oceans from space and what can happen when phytoplankton populations bloom in large numbers in marine ecosystems.

http://www.scootle.edu.au/ec/viewing/R11861/index.html

Suggested questions:

- What change in environmental conditions supports the rapid growth of a phytoplankton population, causing a bloom?
- Does a bloom last forever? Why not?
- What is a dead zone and why do they occur?

6.2 How do organisms in an ecosystem interact?

Lesson outcomes

At the end of this activity students will be able to:

- explore and experiment with a simulation model of an ecosystem to identify how producer/consumer and predator/prey relationships affect population size.

Key vocabulary:

Community of organisms, competition, consumer, feral, invasive, native, predator, prey, producer.

Equipment list:

Each STUDENT will require:

- *Student Guide*
- internet access

Things to consider:

- Explore and familiarise yourself with the *Experiment with ecosystems* interactive in **Activity 6.2**. Create a graph and explore the functions for changing its view or scale. Use the 'Take picture' tool to record a screenshot of the graph and store screenshots in 'My Lab Book' in the bottom right corner of the screen.
- Students cannot save data or graphs in the *Experiment with ecosystems* interactive. They can use the *Take picture* function to capture an image of their graphs, but to save the graph they must copy it to their clipboard. Do this by:
    - clicking on the window showing the graph
    - Pressing **ALT** and **PRINT SCREEN**
    - Open their ***e-Notebook*** for **Activity 6.2**
    - Selecting **PASTE.**
- Consider creating, copying and saving a series of graphs to PowerPoint demonstrating concepts you wish to discuss. Use them to stimulate discussion and support students' understanding.
- This population model provides an opportunity to explore the concept of competition between species. Consider using it in relation to competition between foxes and hawks for the same prey (rabbits).

Lesson plan

Step 1: Introduce students to **Activity 6.2** in the *Student Guide*. Explain students will explore interactions between different populations in an ecosystem and identify how population numbers change as a result of relationships such as producer/consumer and predator/prey. Define these terms.

Step 2: Step students through the functions of the *Experiment with ecosystems* interactive, particularly how to change the scale and view of the graph. When ready, invite them to complete the activity and to copy completed graphs to their ***e-Notebooks***. Demonstrate how to save images of graphs to their clipboards, if relevant.

Step 3: Pause at key junctures and invite students to share their understandings. Use your prepared graphs to stimulate discussion and clarify understanding. Facilitate a class discussion on the concept of competition, using competition between hawks and foxes for rabbits.

Follow up:

Explore the *Find out more* section in the *Student Digital* about invasive species in Australia. Encourage students to find out about one or more. Discuss what pest, feral and invasive mean. Discuss pests in relation to competition and the effects on population size in other species.

6.3 What impacts do humans have on ecosystems?

Lesson outcomes

At the end of this activity students will be able to:

- describe what it means when an ecosystem is healthy or unhealthy
- identify ways in which humans interact with ecosystems
- identify positive and negative impacts on ecosystems and relate these to human activity.

Key vocabulary:

Deforestation, contaminants, run-off, nutrients, invasive, bridal creeper, rust fungus, biological control, cesspool, savannah.

Equipment list:

The CLASS will require:

- internet access

Each STUDENT will require:

- *Student Guide*
- ***Notebook***

Things to consider:

- It is beneficial to inform students that understanding human interactions in an ecosystem and relating these to impacts is complex and the answers are not always clear. This activity provides an opportunity for students to practise such skills as forming connections between ideas, inferring and using evidence to form conclusions.
- This activity provides an opportunity to explore *Science as a Human Endeavour*. Consider inviting scientists working in the local environment into the class to discuss how they work and the complexity of factors that affect ecosystems.

Teacher content information:

1. Human interactions with ecosystems

Humans interact with ecosystems in many ways. For example, building infrastructure such as roads, homes and industry; fishing and agriculture; spraying/adding chemicals to soil and crops; mining; changing or clearing land; using up resources e.g. water; doing recreational or tourism activities outside; dealing with waste; protecting and rehabilitating organisms.

2. Positive and negative impacts to ecosystems

When humans interact with ecosystems there are impacts. An impact is a positive or negative change to the health and wellbeing of the environment and ecosystems of a place (including the social and economic health of humans). Examples include a reduction or increase in biodiversity; an increase or decrease in disease; a positive or negative change to soil, water or air quality.

Knowing the relationship between human interactions and their impacts is challenging. It requires a deep understanding about an environment and all the inter-related components of the ecosystem.

3. Human responses to negative impacts

Society can try to reduce or control negative impacts on ecosystems. Examples include scientists monitoring and researching an organism that is under threat; rehabilitation processes on river banks or forested areas; locals protecting endangered wildlife and changes to government policy; regulations and rules affecting how humans interact with the environment.

These responses form new human interactions with ecosystems, which lead to further impacts - and so a cycle evolves.

Video title: *Farm run-off*	
List any interactions that humans have with the ecosystem	**List any impacts (positive or negative) described in the ecosystem**
• (upstream)humans involved in deforestation/cutting down trees/clearing land • (upstream) Humans e.g. farmers Increasing fertiliser use	• (downstream) nutrients running into water increase plant growth – **positive (initially)** • (downstream) nutrients cause too much plant growth - may have a **negative impact** (it is not specified as to the nature of this negative impact)
Video title: *Smellbourne no more*	
List any interactions that humans have with the ecosystem	**List any impacts (positive or negative) described in the ecosystem**
• (in the past) human sewage goes in the river • (recent times) humans transport waste water away where it runs through lagoons and other processes prior to being discharged into the port • Human develop processes developed to recycle excess nitrogen to agriculture and even homes	• Typhoid and sickness in humans in the past – **negative** • Improved water quality - **positive** • Increased nitrogen in the water potentially causing the growth of algae and other weeds that deplete the supply of oxygen in the water, killing marine life. **negative** • Reducing nitrogen reduces impact on marine environment **positive** • Saving a scarce resource (nitrogen) **positive**

Video title: *Tropical Savannah bush fires*	
List any interactions that humans have with the ecosystem	**List any impacts (positive or negative) described in the ecosystem**
• Scientists study savannahs and aboriginal practices • (in the past) Local aboriginals engage in practices for burning the landscape • (in the present) see reduction in aboriginal practices • (in the present) possibly humans introduced grasses	• (in the past) biodiversity of the savannah maintained- **positive** • (in the present) more big fires burning that are hot and destructive to the savannah - causing reduction/extinction of species- **negative**
Video title: *Bridal Creeper*	
List any interactions that humans have with the ecosystem	**List any impacts (positive or negative) described in the ecosystem**
• Humans grow bridal creeper in gardens, introduced by nurseries • Humans throw plants out • Scientists research a rust fungus disease that kills the Bridal creeper • Scientist introduce rust fungus disease to test sites	• (in the past) Creeper took over natural vegetation – **negative** • (in the test sites) – over 75% bridal creeper killed by rust fungus disease - **positive**

Lesson plan

Step 1: Begin the lesson by showing students the video: *12 Canoes – The Swamp*.

After a short introduction click on 'The Swamp' in the lower right of the screen. Facilitate a class discussion about human interactions in the video. Encourage students to discuss and generate ideas and express opinions. View the following paraphrases from the video and suggested follow up questions to stimulate discussion:

Suggested question/s:

- *"The balance of humans in the past with the swamp … we take care of it and it takes care of us".* What do you think this means about the relationship between the swamp ecosystem and the locals?

- *"With modern times, came cattle and invasive weeds … what can we do about these plants that invade our swamp?"* What do you think? Isn't farming important? Why did the weeds come?
- *"With government came rules about what can be done in the swamp."* Why do you think these government rules are made?
- *"Five crocs per season, leading to increased population growth in crocs."* Who gets to choose how many crocodiles are taken in this ecosystem?
- *"The coming of roads and planes brings tourists and money e.g. hunting and fishing in the swamp. But if tourists are not caring for the swamp, how do we decide about those tourists when we need their money?"* What do you think? Are tourists important? How do you bring tourists to an ecosystem without damage?

Step 2: Explain the difference between human interactions and impacts in an ecosystem. ***Brainstorm*** examples of both. You may use the *12 Canoes - The Swamp* video to step through examples. Ask students to consider ways they interact with an ecosystem and how this could lead to impacts.

Suggested question/s:

- How did you directly or indirectly interact with your local ecosystem in the last month?
- Give examples of negative impacts to an ecosystem? Positive? How did you decide?

Step 3: Refer students to the ***Notebook*** task and the other videos in **Activity 6.3**. Ask them to watch each video and bullet point every human interaction heard and every impact described. They must decide if the impacts are positive or negative.

Step 4: Facilitate a class discussion of the interactions and impacts students observed. Ask the class to identify when a human interaction *led* to or *caused* an impact. Remind students this can be complex. Help students express and justify their ideas and opinions.

Suggested question/s:

- How did … cause …?
- Why do you think that?
- What evidence is there that …?
- Who can add to that?

6.4 The grassland debate

Lesson outcomes

At the end of this activity students will be able to:

- make a decision and justify it using evidence, in relation to a proposed building development on a grassland ecosystem.

Equipment list:

The CLASS will require:

- internet access

Each STUDENT will require:

- *Student Guide*
- ***Notebook***

Things to consider:

- The digital activity *Grassland and its use* is housed in Scootle. You (as educator) will need to register on Scootle (https://www.scootle.edu.au/ec/p/home) in order to access this resource for your students. Once registered you can search for it using its ID code (R11958) and add the resource to your own learning path. Click on the 'Add to' button, and choose 'Create new learning path'. Click on 'Learning paths' at the top of the page, open your learning path and copy the six letter PIN number that you can share with your students. Your students need to go to the Scootle home page (https://www.scootle.edu.au/ec/p/home), click on 'Student login' at the top of the page and enter the PIN number.
- Identify students' prior experiences of using scientific evidence to formulate arguments and make decisions, and the concept of bias. Plan to support them in this process.

Teacher content information:

There are a number of recovery plans in place for the striped legless lizard (Delma impar). Refer to http://www.environment.gov.au/cgibin/sprat/public/publicspecies.pl?taxon_id=1649 for links to various states and territories.

Lesson plan

Step 1: Refer students to the *Student Guide* which introduces the striped legless lizard. Explain that the lizard is a threatened species because very few natural grasslands remain in its distribution.

Step 2: Invite students to click on the *Grassland and its use* link and then click *Student login* at the top of the page. Give students the six letter PIN to enter and access the interactive (see *Things to consider* above).

Step 3: After the introduction students will read or listen to statements by each of the six council members. They then click on *Supporting Statements* and decide which statements are supporting or against the development.

Step 4: Have a class discussion where students can discuss personal opinions and ideas about this scenario.

Suggested questions and starters include:

- How do you know this? What evidence is there to support what you are saying?
- Why is it better than …? Why is … so important?
- What might happen if …?

Step 5: Invite students to complete the ***Notebook*** task individually, justifying their decisions. View students completed ***Notebook*** tasks and provide your assessment feedback to students. This is an opportunity to discuss strengths and strategies to improve such aspects as identifying what is valuable scientific evidence and concepts such as bias.

Follow up

Invite students to play the catchment detox game in the *Find out more* section. They are challenged to manage a river catchment so that after 100 years there is a healthy economy and a healthy environment. Inform students it is very challenging to be successful.

6.5 Ecological study: How and why do local ecosystems differ?

Lesson outcomes

At the end of this activity students will be able to:

- observe biotic and abiotic factors in an ecosystem and record data accurately
- analyse data and draw conclusions
- evaluate conclusions, including ways to improve the quality of data.

Equipment list:

The equipment used in this activity will depend on the local ecosystem and the techniques and tools used for gathering abiotic and biotic data. View *Things to Consider* for more details.

Each STUDENT will require:

- *Student Guide*
- ***Notebook***

Things to consider:

- The aim of this **summative assessment** task is to get students into the field to authentically study ecosystems. It is recommended they first practise the skills and techniques required for success in this task in **Activities 5.2** and **5.3**.
- As you plan, preview the *Teacher Guide* **Activity 5.2** which provides practical ideas and resources for constructing different ecological studies and support to develop questions students can investigate. Consider comparing two sites in an ecosystem that are more or less impacted (e.g. by human actions).
- Create a task sheet and ***Rubric*** to show students what they must do and how they will be assessed. Consider the scaffold in **Activity 6.5** of the ***e-Notebook*** to support students conduct their investigation and write a final report. This can be modified.
- Practical issues should be considered when planning fieldwork. Consider the following questions as you plan*:*

  What type of ecosystem could students study in your area?

  Is there an ecosystem within walking distance of the school?

  What can you practically achieve in a lesson in the field?

  Should you consider planning a variation to routine i.e. one or more external field trips?

  What are the alternatives if a field trip is impossible?
- Ensure you understand health and safety requirements and risk assessments for student field trips.
- Ensure you and your students understand ethical issues and requirements when studying living organisms. These will directly affect the type and manner in which different organisms are interacted with and may also influence your planning.

Lesson plan

Step 1: Refer students to **Activity 6.5** in the *Student Guide*. Explain that students will form groups to investigate and compare several sites in a local ecosystem. Give students the task sheet and ***Rubric*** you have developed for this exercise. Explain this is a **summative assessment** task.

Step 2: Form groups. Allocate group and/or individual responsibilities for the investigation. Refer students to any planning support you have and step through the abiotic and biotic factors that can be observed and measured. Demonstrate the tools and equipment they will use. Remind them of ethical responsibilities and safety when visiting the sites.

Step 3: Onsite, help students gather and record information on physical and biotic aspects. Support them to gather quantitative data and sample for living organisms. At the site or in class, identify and tally the organisms present.

Step 4: In the classroom support students as they process and analyse the data collected. Prompt them to draw on their knowledge of ecosystems from this unit when analysing their data and forming conclusions. Ensure they critically evaluate the quality of their data and suggest improvements.

Suggested question/s:

- Is there any data that does not fit the pattern? Why do you think it is different?
- What changes would you make to your investigation to improve the quality of your data?

6.6 Back to where it all began! Systems, systems everywhere

Lesson outcomes

At the end of this activity students will be able to:

- record their ideas about biological systems
- create ***Concept Maps*** to represent their learning in the unit
- reflect on their learning.

Key vocabulary:

Concept map, system, balance, balance point, input, output, feedback mechanisms.

Equipment list:

Each STUDENT will require:

- *Student Guide*
- ***Notebook***

Things to consider:

- The three images represent a human undergoing homeostasis after exercise, an ecosystem and the human nervous system. This activity was first conducted in **Activity 1.5.** Students will consult back in their ***Notebook*s** to **Activity 1.5** to compare and reflect on their learning during the unit and identify gaps and changes to their understanding.

Lesson plan

Step 1: Refer students to the images in **Activity 6.6** in the *Student Guide.* These mystery images were first observed in **Activity 1.5**. Invite students in pairs to identify each image and share their ideas with the class. Explain each image represents biological systems in action. Remind students of the terminology of systems. Can they identify these elements in any of the pictures?

Suggested question/s:

- How is this an example of a system?
- What are the parts to this system?
- What do you think are some of the inputs and outputs in this system?
- What organisms are within this system?
- When will we know if this system is in balance and healthy or out of balance and unhealthy?

Step 2: Ask students in pairs to ***brainstorm*** everything they now know about each image.

Suggested question/s:

- What is the image showing? What are the parts involved? What is happening?

Step 3: Ask students to individually begin the ***Notebook*** tasks. Students complete the reflection questions and then construct concept maps about the three mystery images.

Step 4: Invite students to share their reflections and concept maps with their learning partners. Ask students to compare their work now with what they produced in **Activity 1.5**. Discuss with their partner any changes in their learning.

Step 5: Conclude with a class discussion of each of the reflection questions.

6.7 Sample test

A sample **summative test** and **marking scheme** have been developed and are available to teachers from *Science by Doing* at sbd@science.org.au Both are editable versions so you can adapt them to your students' needs. You may choose to use this in addition to the **summative assessment** task outlined in **Activity 6.5 Ecological study - how and why do local ecosystems differ?**

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