PEARSON BIOLOGY QUEENSLAND

UNITS 3 & 4

2nd EDITION

Yvonne Sanders

Skills and Assessment

QCE 2025 Biology SYLLABUS

Contents

Pearson Biology Skills and Assessment Book Units 3 and 4 2nd edition

Contents

How to use this book

The *Pearson Biology Queensland Skills and Assessment Book Units 3 & 4 2nd edition* takes an intuitive, self-paced approach to science education that ensures every student has opportunities to practice, apply and extend their learning through a range of supportive and challenging activities.

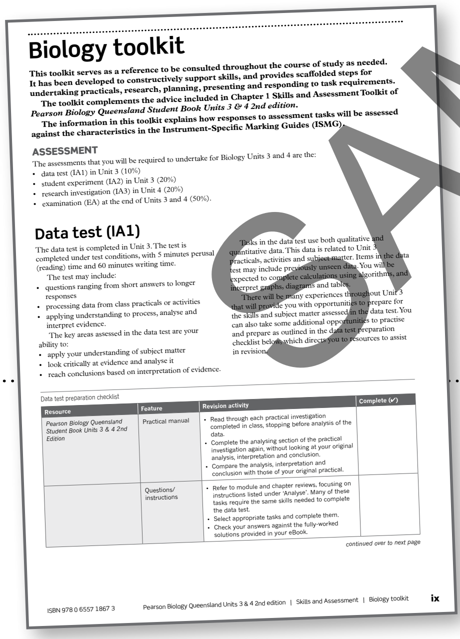
This resource has been developed by highly experienced and expert author teams, with leading Queensland specialists who have a working understanding of what teachers are looking for to support teaching and learning across the new QCE.

Written to fully support the new QCAA Biology 2025 General Senior Syllabus, the Skills and Assessment Book is organised by units. The unit opener outlines the unit objectives. The book is further organised into topics. Each topic addresses all of the subject matter and practicals from the syllabus.

All activities integrate into the *Pearson Biology Queensland Units 3 & 4 Student Book 2nd edition* for a complete teaching, learning and assessment program, making integration of practice and rich learning activities a seamless inclusion. The resource has been designed so it may be used independently of the Student Book, providing flexibility in when and how to engage with it.

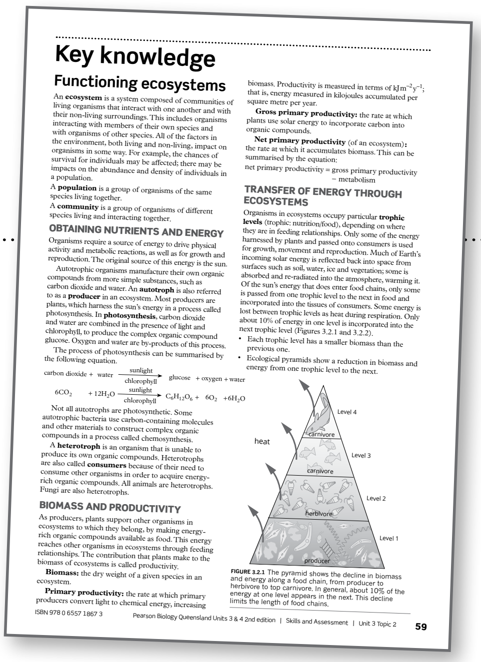
Toolkit

A complementary Biology Skills and Assessment Toolkit supports development of the skills and techniques needed to undertake practical investigations, the data test, the student experiment, the research investigation and the external examination. It covers study skills and includes checklists and helpful hints to assist in fulfilling all assessment requirements.


Biology toolkit

Key knowledge

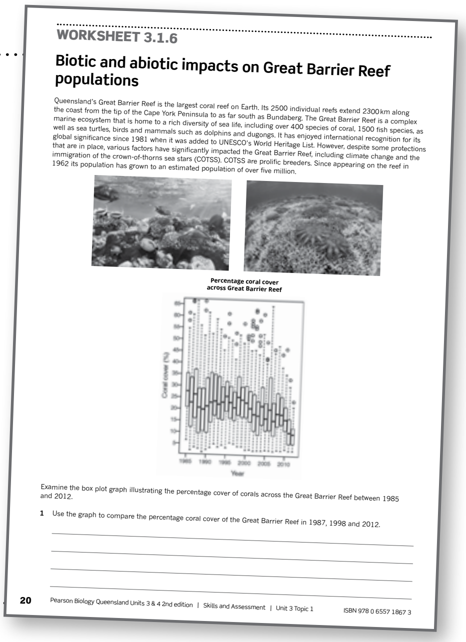
Each topic begins with a key knowledge section. Key knowledge consists of a set of succinct summary notes that cover the subject matter for each topic of the syllabus. This section is highly illustrative and written in a straightforward style to assist students of all abilities to focus on the salient points. Key terms are in bold for ease of navigation and are reflected in the Student Book glossary. Key knowledge also serves as a ready reference when completing worksheets and practical activities. It provides a handy set of revision and study notes.


Key knowledge

Worksheets

A diverse offering of instructive and self-contained worksheets is included in each topic. All topics include a 'Knowledge preview' worksheet to establish prior knowledge and a 'Literacy review' of key scientific terminology. The final worksheet, "Thinking about my learning" encourages students to self reflect on their learning and identify areas for improvement. Other worksheets, with their range of activities and tasks, help consolidate learning and the making of connections between subject matter.

Worksheets may be used for formative assessment and are clearly aligned to the syllabus. A range of questions building from foundation to challenging is included in the worksheets, which are written to reflect the Marzano and Kendall taxonomy of instructional verbs.



WORKSHEET 3.1.6

Biotic and abiotic impacts on Great Barrier Reef populations

Queensland's Great Barrier Reef is the largest coral reef on Earth. Its 2500 individual reefs extend 2300 km along the coast from the tip of the Cape York Peninsula to as far south as Bundaberg. The Great Barrier Reef is a complex marine ecosystem that is home to a rich diversity of sea life, including over 400 species of coral, 1500 fish species, as well as sea turtles, birds and mammals such as dolphins and dugongs. It has enjoyed international recognition for its global significance since 1981 when it was added to UNESCO's World Heritage List. However, despite some protections that are in place, various factors have significantly impacted the Great Barrier Reef, including climate change and the immigration of the crown-of-thorns sea stars (COTSS). COTSS are prolific breeders. Since appearing on the reef in 1962 its population has grown to an estimated population of over five million.

Examine the box plot graph illustrating the percentage cover of corals across the Great Barrier Reef between 1985 and 2012.

1 Use the graph to compare the percentage coral cover of the Great Barrier Reef in 1987, 1998 and 2012.

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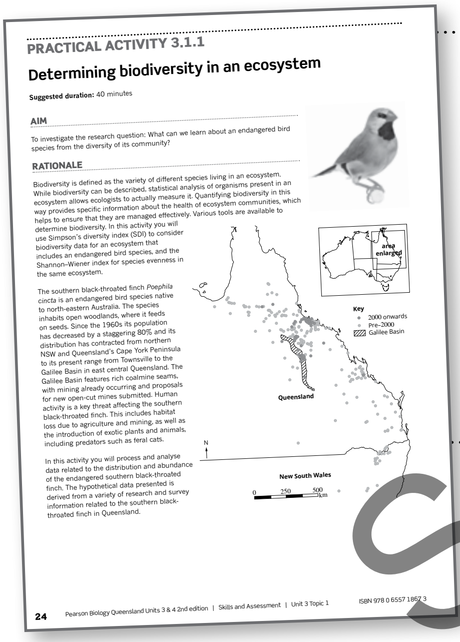

PRACTICAL ACTIVITY 3.1.1

Determining biodiversity in an ecosystem

Suggested duration: 40 minutes

AIM

To investigate the research question: What can we learn about an endangered bird species from the diversity of its community?

RATIONALE

Biodiversity is defined as the variety of different species living in an ecosystem. While biodiversity can be described, statistical analysis of organisms present in an ecosystem allows ecologists to actually measure it. Quantifying biodiversity in this way provides specific information about the health of ecosystem communities, which helps to ensure that they are managed effectively. Various tools are available to determine biodiversity. In this activity you will use Simpson's diversity index (SDI) to consider biodiversity data for an ecosystem that includes an endangered bird species, and the Shannon–Wiener index for species evenness in the same ecosystem.

The southern black-throated finch *Poephila cincta* is an endangered bird species native to north-eastern Australia. The species inhabits open woodlands, where it feeds on seeds. Since the 1960s its population has decreased by a staggering 80% and its distribution has contracted from northern NSW and Queensland's Cape York Peninsula to its present range from Townsville to the Galilee Basin in east central Queensland. The Galilee Basin features rich coalmine seams, with mining already occurring and proposals for new open-cut mines submitted. Human activity is a key threat affecting the southern black-throated finch. This includes habitat loss due to agriculture and mining, as well as the introduction of exotic plants and animals, including predators such as feral cats.

In this activity you will process and analyse data related to the distribution and abundance of the endangered southern black-throated finch. The hypothetical data presented is derived from a variety of research and survey information related to the southern black-throated finch in Queensland.

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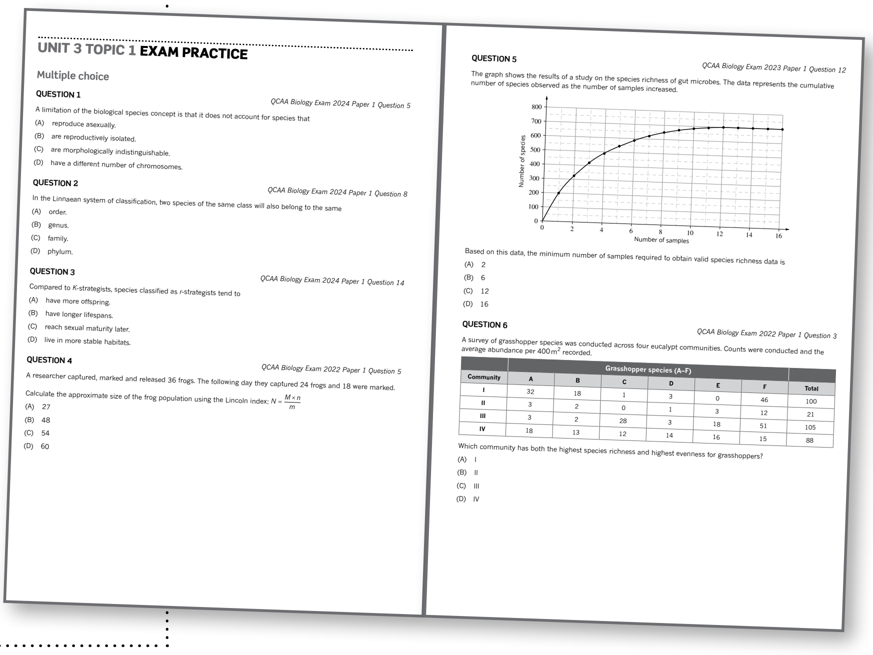
Practical activities

Practical activities are highly scaffolded throughout and give students the opportunity to complete practical work related to the subject matter. Practical activities include a rich assortment of tasks that maximise learning opportunities, while also building experience in skill application to perform calculations and analysis of data, necessary for the data test. Every practical activity is featured, as well as many suggested practicals. A range of questions building from foundation to challenging are included, which are written to reflect the Marzano and Kendall taxonomy of instructional verbs.

Exam practice

Each topic concludes with a set of questions taken directly, or adapted, from previous QCAA exams. These questions have been selected to best represent the content within these exams and balances multiple-choice and short-response questions. Exam practice questions provide an excellent opportunity to experience the subject matter and skills across the breadth of the topic from the perspective of QCAA exams. They also reflect the cognitive verbs used in the syllabus subject matter dot points.



UNIT 3 TOPIC 1 EXAM PRACTICE

Multiple choice

QUESTION 1 QCAA Biology Exam 2024 Paper 1 Question 5

A limitation of the biological species concept is that it does not account for species that

(A) reproduce asexually.
(B) are reproductively isolated.
(C) are morphologically indistinguishable.
(D) have a different number of chromosomes.

QUESTION 2 QCAA Biology Exam 2024 Paper 1 Question 8

In the Linnaean system of classification, two species of the same class will also belong to the same

(A) order.
(B) genus.
(C) family.
(D) phylum.

QUESTION 3 QCAA Biology Exam 2024 Paper 1 Question 14

Compared to *K*-strategists, species classified as *r*-strategists tend to

(A) have more offspring.
(B) have longer lifespans.
(C) reach sexual maturity later.
(D) live in more stable habitats.

QUESTION 4 QCAA Biology Exam 2022 Paper 1 Question 5

A researcher captured, marked and released 36 frogs. The following day they captured 24 frogs and 18 were marked.

Calculate the approximate size of the frog population using the Lincoln index: $N = \frac{M \times n}{m}$

(A) 27
(B) 48
(C) 54
(D) 60

QUESTION 5 QCAA Biology Exam 2023 Paper 1 Question 12

The graph shows the results of a study on the species richness of gut microbes. The data represents the cumulative number of species observed as the number of samples increased.

Based on this data, the minimum number of samples required to obtain valid species richness data is

(A) 2
(B) 6
(C) 12
(D) 16

QUESTION 6 QCAA Biology Exam 2022 Paper 1 Question 3

A survey of grasshopper species was conducted across four eucalypt communities. Counts were conducted and the average abundance per 400 m^2 recorded.

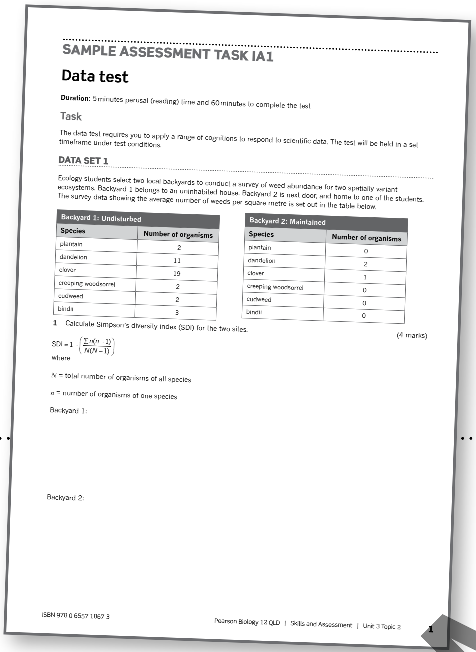
Community	Grasshopper species (A–F)						
	A	B	C	D	E	F	Total
I	32	18	1	3	0	46	100
II	3	2	0	1	3	12	21
III	3	2	28	3	18	51	105
IV	18	13	12	14	16	15	88

Which community has both the highest species richness and highest evenness for grasshoppers?

(A) I
(B) II
(C) III
(D) IV

Sample assessment tasks

Sample assessment tasks for the data test, student experiment and research investigation provide opportunities for students to practise responding to these assessment tasks. The activities are designed to support students by guiding and scaffolding them through each aspect of these assessments.



SAMPLE ASSESSMENT TASK IA1

Data test

Duration: 5 minutes perusal (reading) time and 60 minutes to complete the test

Task

The data test requires you to apply a range of cognitions to respond to scientific data. The test will be held in a set timeframe under test conditions.

DATA SET 1

Ecology students select two local backyards to conduct a survey of weed abundance for two spatially variant ecosystems. Backyard 1 belongs to an uninhabited house. Backyard 2 is next door, and home to one of the students. The survey data showing the average number of weeds per square metre is set out in the table below.

Backyard 1: Undisturbed	
Species	**Number of organisms**
plantain	2
dandelion	11
clover	19
creeping woodsorrel	2
cudweed	2
bindii	3

Backyard 2: Maintained	
Species	**Number of organisms**
plantain	0
dandelion	2
clover	1
creeping woodsorrel	0
cudweed	0
bindii	0

1 Calculate Simpson's diversity index (SDI) for the two sites. (4 marks)

$$SDI = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

where

N = total number of organisms of all species

n = number of organisms of one species

Backyard 1:

Backyard 2:

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Icons and features

The **safety icon** highlights significant hazards, indicating caution is needed.

The **safety glasses icon** highlights that protective eyewear is to be worn during the practical activity.

Rate my learning

This innovative feature appears at the end of most worksheets, all practical activities and sample assessment tasks. It provides students with the opportunity for self-reflection and self-assessment. Students are encouraged to consider how they can continue to improve, and to identify areas of focus for further skill and subject matter development. This tool has been based on the Marzano and Kendall taxonomy of instructional verbs.

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

Teacher support

Fully-worked solutions, suggested answers and responses to sample assessment tasks, as well as practical activity support, including full risk assessments, expected results and handy hints are provided for teachers through the teacher support subscription.

Biology toolkit

This toolkit serves as a reference to be consulted throughout the course of study as needed. It has been developed to constructively support skills, and provides scaffolded steps for undertaking practicals, research, planning, presenting and responding to task requirements.

The toolkit complements the advice included in Chapter 1 Skills and Assessment Toolkit of *Pearson Biology Queensland Student Book Units 3 & 4 2nd edition*.

The information in this toolkit explains how responses to assessment tasks will be assessed against the characteristics in the Instrument-Specific Marking Guides (ISMG).

ASSESSMENT

The assessments that you will be required to undertake for Biology Units 3 and 4 are the:
- data test (IA1) in Unit 3 (10%)
- student experiment (IA2) in Unit 3 (20%)
- research investigation (IA3) in Unit 4 (20%)
- examination (EA) at the end of Units 3 and 4 (50%).

Data test (IA1)

The data test is completed in Unit 3. The test is completed under test conditions, with 5 minutes perusal (reading) time and 60 minutes writing time.

The test may include:
- questions ranging from short answers to longer responses
- processing data from class practicals or activities
- applying understanding to process, analyse and interpret evidence.

The key areas assessed in the data test are your ability to:
- apply your understanding of subject matter
- look critically at evidence and analyse it
- reach conclusions based on interpretation of evidence.

Tasks in the data test use both qualitative and quantitative data. This data is related to Unit 3 practicals, activities and subject matter. Items in the data test may include previously unseen data. You will be expected to complete calculations using algorithms, and interpret graphs, diagrams and tables.

There will be many experiences throughout Unit 3 that will provide you with opportunities to prepare for the skills and subject matter assessed in the data test. You can also take some additional opportunities to practise and prepare as outlined in the data test preparation checklist below, which directs you to resources to assist in revision.

Data test preparation checklist

Resource	Feature	Revision activity	Complete (✓)
Pearson Biology Queensland Student Book Units 3 & 4 2nd Edition	Practical manual	• Read through each practical investigation completed in class, stopping before analysis of the data. • Complete the analysing section of the practical investigation again, without looking at your original analysis, interpretation and conclusion. • Compare the analysis, interpretation and conclusion with those of your original practical.	
	Questions/ instructions	• Refer to module and chapter reviews, focusing on instructions listed under 'Analyse'. Many of these tasks require the same skills needed to complete the data test. • Select appropriate tasks and complete them. • Check your answers against the fully-worked solutions provided in your eBook.	

continued over to next page

Resource	Feature	Revision activity	Complete (✔)
	Chapter 1 Biology Skills and Assessment Toolkit	• Refer to the Chapter 1 Biology Skills and Assessment Toolkit, Part A, in the eBook. • Use this reference as needed to improve your mathematical, analysis and visual interpretation skills.	
Pearson Biology Queensland Skills and Assessment Book Units 3 & 4 2nd Edition	Practical activities	• See suggestions and support for practical activities, which include working with data.	
	Exam practice	• Refer to the exam questions at the conclusion of topics in Unit 3 for samples of the style of items on the data test.	
	Practice data test	• Complete the 'Sample assessment task IA1: Data test' provided in this book. • Complete these questions under exam conditions.	

Student experiment (IA2)

The student experiment investigates a research question, generated from a previously completed class practical activity, and draws a conclusion from the analysis of the primary data. The student experiment uses practical investigation methodology, including a research question developed by the student, the collection of primary data, and then analysis and synthesis of that data.

The research question must:

- relate back to a practical activity already completed in class
- modify, refine, extend or redirect the class practical.

You will deliver your findings either as a multimodal presentation (using two or more modes) within a time limit of 11 minutes or as a written report of no more than 2000 words.

Your report must address the following criteria:

- Forming
- Finding
- Analysing
- Interpreting and evaluating.

Refer to the student experiment checklist below for further details.

CONDUCTING THE STUDENT EXPERIMENT

A great deal of preparation is needed before starting the experiment and much thought is required throughout the internal assessment task. Use the following student experiment checklist as a guide.

Student experiment checklist

Task		Activity	Due date	Complete (✔)
Form ideas and develop the research question	initial practical	• identify the practical to be modified for your experiment		
	background	• use a journal to record all aspects of the assessment task • research relevant background information • understand the data from the original practical		
	variables	• identify the dependent and independent variables of the original practical		
	modification	• modify the original practical		
	rationale	• justify/provide rationale for the modification to a new research question		

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Task		Activity	Due date	Complete (✓)
	methodology	• plan and describe the modifications to the original method that will be carried out in the new practical		
	materials	• make a list of all equipment, chemicals and materials used in the modified practical • include quantities (consumables) and sizes (equipment)		
Find the data	risk assessment	• identify and manage risks and potential dangers by completing the risk assessment form on the next page		
	practical	• conduct the practical • collect the relevant data to answer the research question		
	results	• prepare a data plan that includes what will be observed and what data will be recorded; include how data will be recorded by preparing a table in your journal for results • record all measurements taken during the experiment as well as observations • collect sufficient and relevant data • observations may be recorded as text, diagrams, photos or videos • most common records of primary data are tables with titles and units • check for errors and mistakes in data collected • repeat measurements where there are obvious anomalies		
Analyse the evidence	organise data collected	• process the data using mathematical techniques and graphs • most common records of processed data are tables and graphs and can include calculations, such as mean and uncertainty; remember to include units and measurement uncertainty in the column titles of tables • identify the trends, patterns or relationships • identify the uncertainties and limitations of the evidence		
Interpret and evaluate the evidence	work with data collected; relate back to the research question	• draw and justify conclusion(s) from the evidence that address the research question • evaluate the reliability and validity of the experimental process • evaluate the method used • comment on whether results relate to the research question • provide suggestions for improvements and extensions to the experiment		
The report	presentation format	• decide on the presentation format (written or multimodal) • check length requirements for your selected format		
	communication	• communicate ideas in scientific language and representations • include in-text citations and a reference list • write using your own words to avoid plagiarising • ensure length requirements are not exceeded		

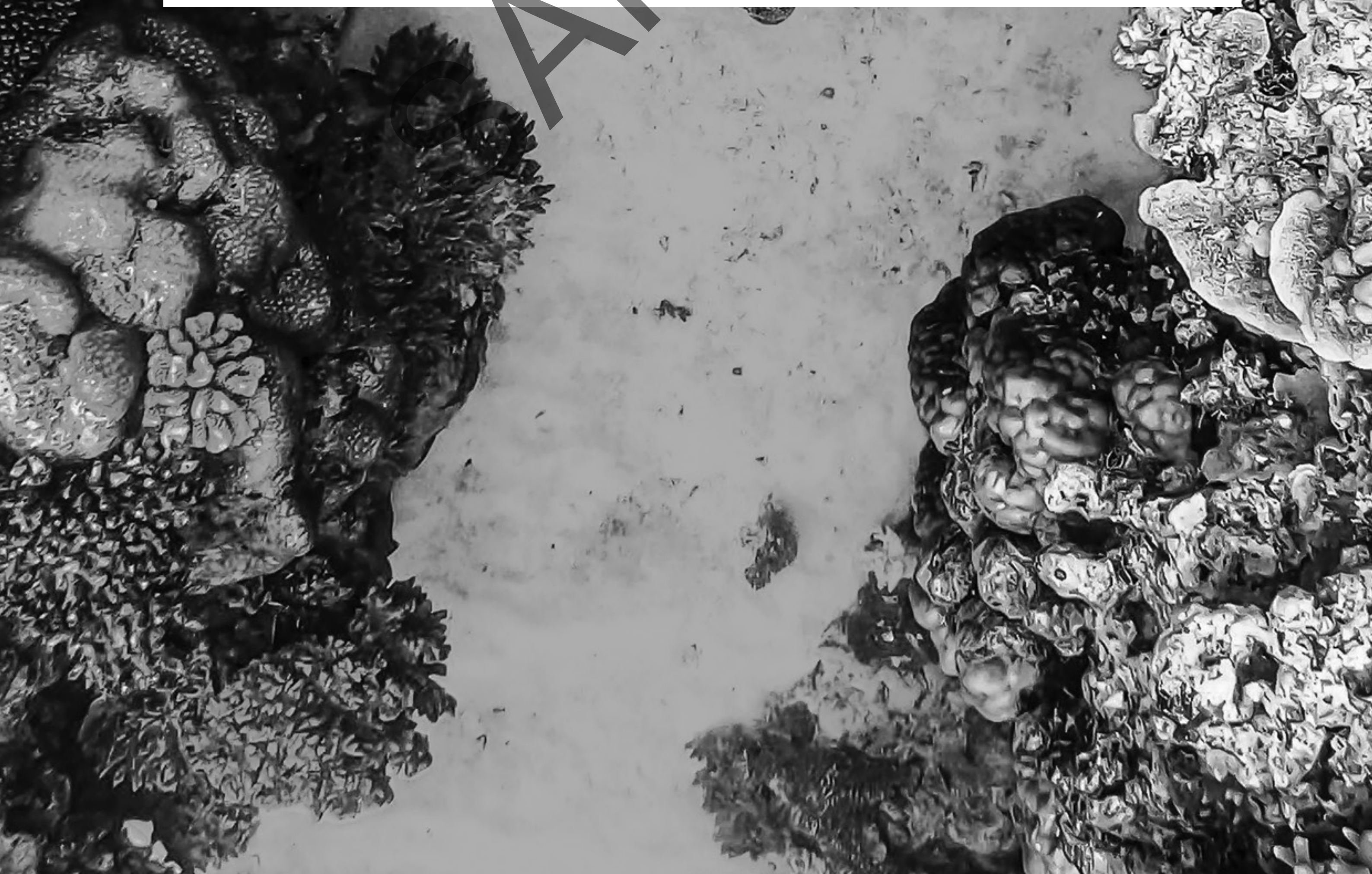
UNIT 3 Biodiversity and the interconnectedness of life

TOPIC 1 Biodiversity and populations

TOPIC 2 Functioning ecosystems and succession

Unit 3 objectives

- Describe ideas and findings about biodiversity and populations, and functioning ecosystems and succession.
- Apply understanding of biodiversity and populations, and functioning ecosystems and succession.
- Analyse data about biodiversity and populations, and functioning ecosystems and succession.
- Interpret evidence about biodiversity and populations, and functioning ecosystems and succession.
- Evaluate processes, claims and conclusions about biodiversity and populations, and functioning ecosystems and succession.
- Investigate phenomena associated with biodiversity and populations, and functioning ecosystems and succession.



TOPIC 1

Biodiversity and populations

- ☐ Worksheet 3.1.1 Knowledge preview—the language of biological diversity

BIODIVERSITY AND CLASSIFICATION

- ☐ Worksheet 3.1.2 Classifying organisms
- ☐ Worksheet 3.1.3 Sampling techniques to monitor diversity in an ecosystem
- ☐ Worksheet 3.1.4 Classifying ecosystems
- ☐ Practical activity 3.1.1 Determining biodiversity in an ecosystem
- ☐ Practical activity 3.1.2 Sampling populations using line transects
- ☐ Practical activity 3.1.3 Estimating a flatweed population using quadrats
- ☐ Practical activity 3.1.4 Classifying an ecosystem

POPULATION DYNAMICS

- ☐ Worksheet 3.1.5 Population dynamics
- ☐ Worksheet 3.1.6 Biotic and abiotic impacts on Great Barrier Reef populations
- ☐ Practical activity 3.1.1 Determining biodiversity in an ecosystem
- ☐ Practical activity 3.1.2 Sampling populations using line transects
- ☐ Practical activity 3.1.3 Estimating a flatweed population using quadrats
- ☐ Practical activity 3.1.5 Analysing population growth

- ☐ Worksheet 3.1.7 Literacy review
- ☐ Worksheet 3.1.8 Thinking about my learning
- ☐ **Unit 3 Topic 1 Exam practice**

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Key knowledge

Species and diversity

A vast number and diversity of organisms exist on Earth and inhabit a broad diversity of ecosystems. Studying and understanding organisms is most conveniently done by dividing them into groups.

CLASSIFICATION AND THE LINNEAN SYSTEM

Classification is the sorting or grouping of items based on shared similarities. Biological classification typically focuses on grouping organisms into various classification levels based on morphological and/or molecular similarities. Organisms may also be classified according to reproductive strategies and methods of interaction. Classification processes also extend to the sorting of ecosystems based on their particular features.

The classification of organisms into groups is important because it provides information and understanding about the biological and evolutionary relationships between organisms. Using the same protocols and language for classification allows for effective communication between scientists.

The naming of biological groups is referred to as **taxonomy**. Each classification group is called a **taxon** (plural taxa). Groups can be large or small, and are represented in the form of a **hierarchy**. Groups at the top of the hierarchy contain many organisms that share a few major similarities, while those at the bottom contain fewer organisms that share many common characteristics. Organisms that belong to the same **class** must also belong to the same **domain**, **kingdom** and **phylum**. At the bottom of the hierarchy is the species level. The hierarchy of biological classification is shown in Figure 3.1.1.

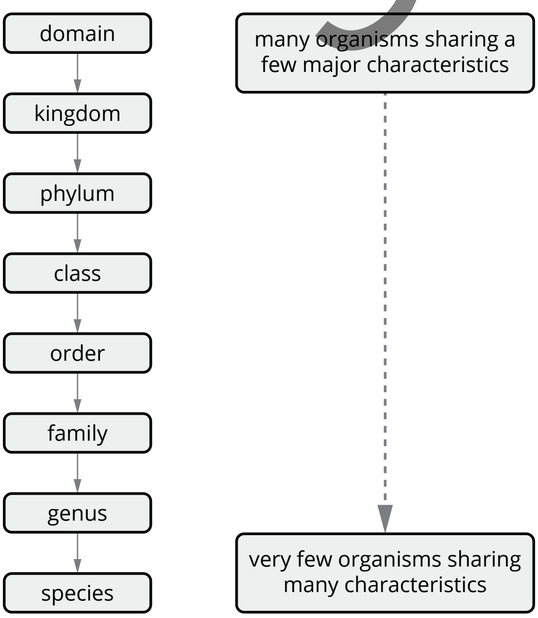

FIGURE 3.1.1 Hierarchy of biological classification

A **species** is a group of similar individuals that are able to sexually reproduce in their natural environment to produce fertile offspring. Some limitations and variations on the definition of 'species' are worth noting, given some particular exceptions. For example, some species of bacteria rarely undergo sexual reproduction. Members of some species of organisms only reproduce in captive situations, such as farms and zoos. However, such conditions do not represent the natural environment of those species. The offspring of a mating between two different species is called an **interspecific hybrid**. This phenomenon is exemplified by the mating between a horse and donkey—the two share some general physical features, and can mate to produce offspring called mules, but the offspring are infertile.

The naming of species is based on a **binomial system** developed by Swedish botanist Carl Linnaeus in the 18th century. This system is referred to as the **Linnaean system** of classification. Each organism is given two Latinised words for its scientific name. The first is the generic name (genus name). The second is the specific descriptive name.

For example, the red kangaroo (common name) has the scientific name *Macropus rufus*.

This naming system avoids ambiguity and clearly indicates which organism is being referred to, regardless of the language you speak.

Classification systems have changed over the years, mainly due to our ever-growing knowledge of organisms and the advances in technology that allow us to study them in more detail (e.g. DNA technology). Organisms have been classified into five kingdoms, but more recently, three overarching classification groups called domains have been recognised, with the five kingdoms divided between them (Figure 3.1.2).

Classification keys allow organisms to be identified based on observable features. A **dichotomous key** is a classification tool that provides two mutually exclusive descriptors to select from at each step until a single accurate identification is reached. Dichotomous keys can be set up as branching diagrams or as pairs of statements. For example, a ladybug, an ant, a dragonfly and a bee (Figure 3.1.3) can be keyed out simply using the dichotomous keys shown in Table 3.1.1 and Figure 3.1.4.

TABLE 3.1.1 Tabular dichotomous key

1a	has wings	2
1b	does not have wings	ant
2a	wings concealed by exoskeleton	ladybug
2b	wings not concealed by exoskeleton	3
3a	body elongated	dragonfly
3b	body not elongated	bee

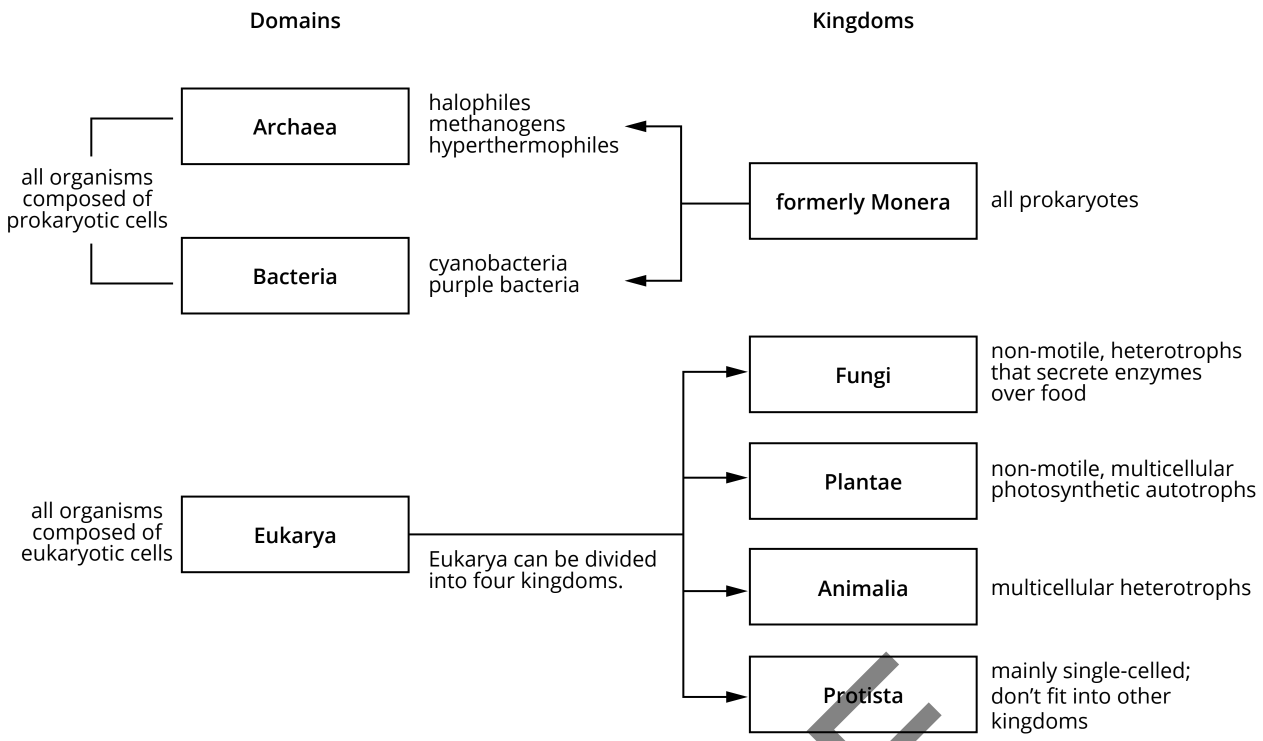

FIGURE 3.1.2 Relationship between the three-domain and five-kingdom classification systems

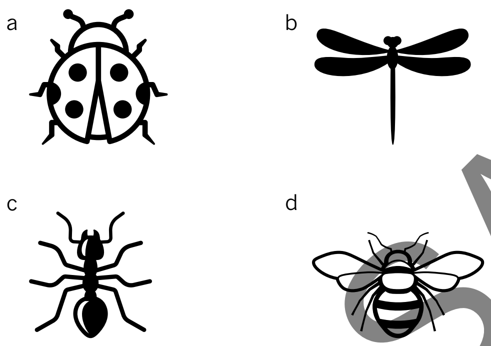

FIGURE 3.1.3 (a) Ladybug, (b) dragonfly, (c) ant and (d) bee

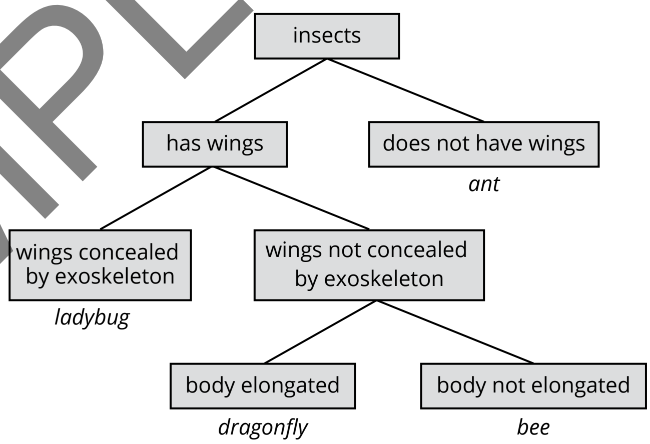

FIGURE 3.1.4 Branching dichotomous key

CLASSIFYING ORGANISMS BY REPRODUCTION AND METHODS OF INTERACTION

Organisms can be classified based on other factors besides morphological and molecular similarities. Other useful approaches can be based on reproductive strategies and methods of interaction.

Classifying organisms by reproductive strategies

Organisms can be divided into two key groups depending on factors related to their reproduction.

- ***r*-strategists** are organisms that typically feature a short lifespan and high rate of reproduction, with individuals maturing rapidly. Such organisms tend to have many offspring at a time and demonstrate little or no care for their young. Examples include insects, spiders, rodents and bacteria. *r*-selection is an advantage to organisms inhabiting unstable (changing) environments.
- ***K*-strategists** are organisms that typically feature a relatively long lifespan and low reproduction rate, with individuals maturing slowly. *K*-strategists tend to have relatively few offspring at a time and demonstrate care for their young. Examples include most mammals, and reptiles such as sea turtles. *K*-selection is common to organisms that inhabit stable environments.

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Classifying organisms by methods of interaction

Organisms interact with their biotic (living) and abiotic (non-living) environments, and can be classified according to these interactions. Table 3.1.2 summarises some of these key interactions.

These species' interactions are important because they impact on the structure and integrity of the ecosystems in which the organisms live. The survival of one species is dependent on the other species with which it interacts. Population sizes also have an effect on other species. For example, a small population of prey cannot sustain a large population of predators. See page 63 in Topic 2 for further information related to population dynamics in ecosystems.

TABLE 3.1.2 Species interactions

Relationship	Description	Example
predator–prey	Members of one species hunt and consume individuals of another species.	Eagles prey on snakes.
competition	Members of different species vie for resources, such as food and shelter.	Possums compete with parrots for nesting sites in tree hollows.
symbiosis	Individuals from different species demonstrate a close association.	Coral polyps and photosynthetic algae (zooxanthellae) form an alliance in which both species benefit.
disease	An impairment occurs in the normal functioning of an organism, caused by pathogens or non-infectious factors such as environmental or genetic factors.	Infectious diseases are caused by pathogens, such as bacteria, fungi or viruses. Non-infectious diseases are caused by environmental factors such as nutrient deficiency (e.g. rickets is caused by severe vitamin D deficiency) or by genetic factors (e.g. cystic fibrosis is caused by a faulty gene).

CLASSIFYING ECOSYSTEMS

An **ecosystem** is a system of organisms interacting with one another and with their non-living surroundings. Ecosystems and the larger regions to which they belong can also be classified.

Classifying different kinds of environments is based on various criteria.

- A **bioregion** is a large area defined by its geology, landform, climate and ecosystems.
- An **ecoregion** is a large region of Earth's surface distinguished by its latitude and geography, and generally containing similar ecosystems.
- A biome is distinguished primarily by its plant community. The kinds of plants suited to particular biomes depend on features such as type of soil and climatic conditions. Examples of biomes include desert, temperate rainforest, tropical rainforest, grassland, alpine, coral reef, freshwater river or estuary. The distribution of major biomes in Australia is shown in Figure 3.1.5.

Many features are considered in ecosystem classification. These include major abiotic factors such as bioregion and landform, as well as more local factors such as temperature and rainfall, whether an ecosystem is marine or freshwater or terrestrial. The kinds of plant and animal communities are also considered, including identification of the most abundant or dominant species (e.g. oyster community or eucalyptus forest).

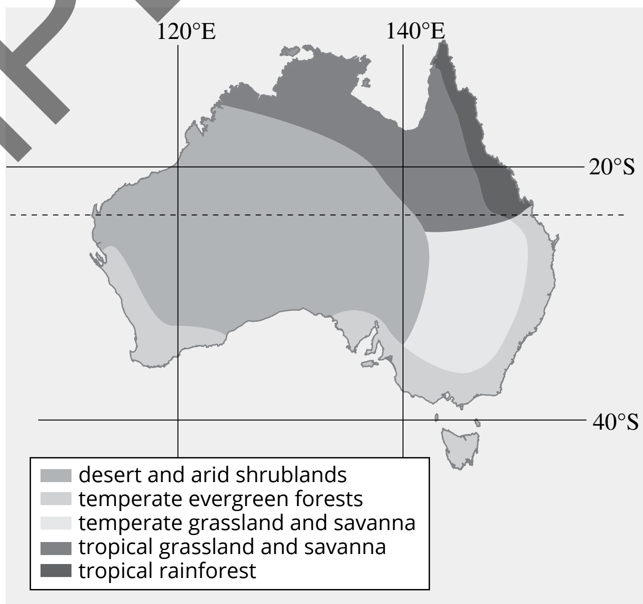

FIGURE 3.1.5 Distribution of major biomes of Australia

In Queensland, ecosystem classification is based on a three-step process that involves identification of bioregion type, landform and vegetation.

The Holdridge life zone classification scheme is a useful tool in assessing bioregion (latitudinal), landform (altitudinal) and vegetation types for a region, as a means of appropriately naming ecosystems (Figure 3.1.6).

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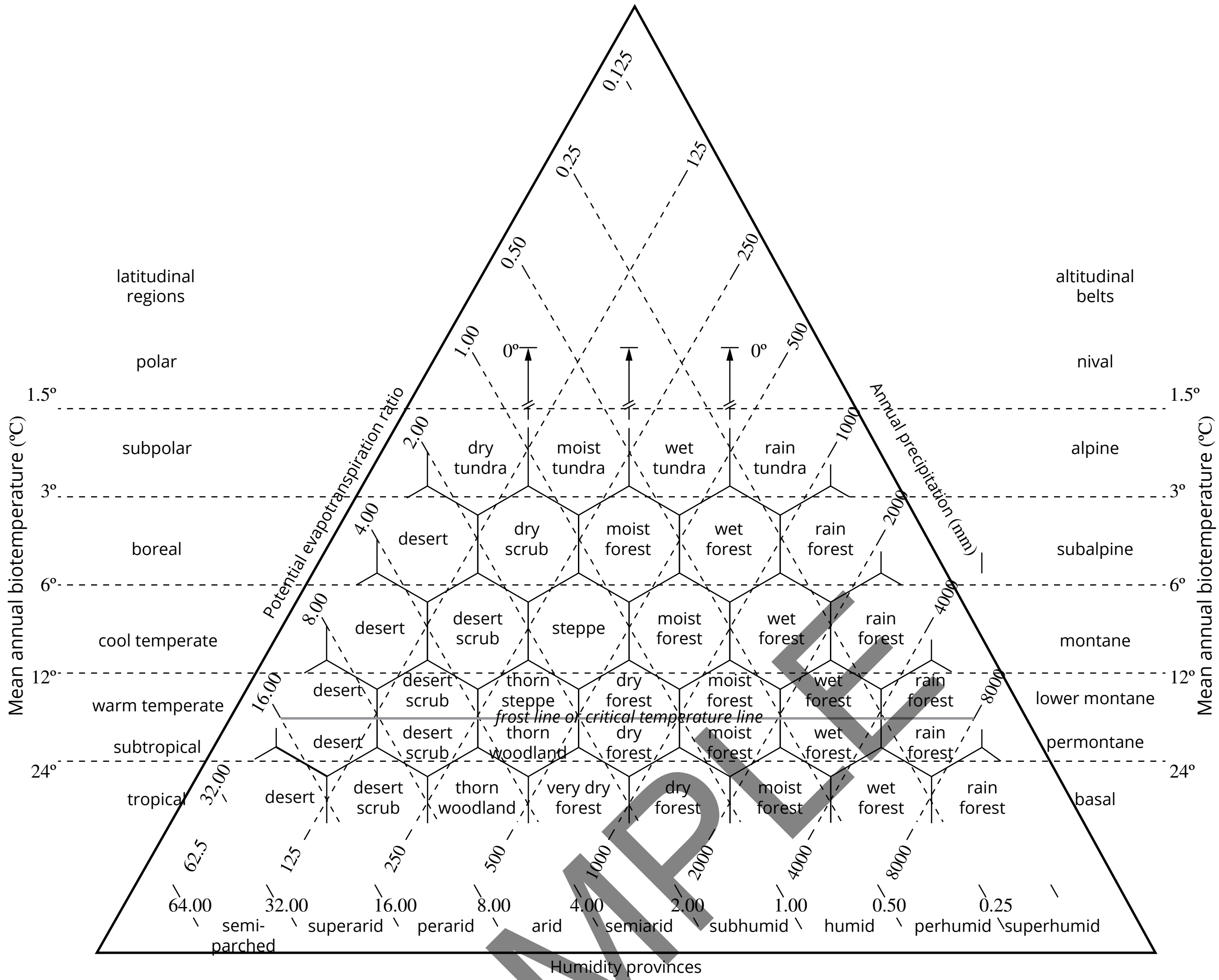

FIGURE 3.1.6 Holdridge life zone classification scheme

Ecosystems are often described in terms of their plant communities. Specht's classification system (Table 3.1.3) uses a combination of the tallest or most dominant plant and the percentage of sunlight coverage of the canopy (e.g. closed forest) to classify an ecosystem's vegetation.

Used together, the Holdridge life zone classification scheme and Specht's classification system provide a useful combination tool for accurately identifying the large- and small-scale profile of ecosystems.

TABLE 3.1.3 Specht's structural classification of vegetation

Life form of tallest stratum	**Projective foliage cover of the tallest stratum**				
	70–100%	**50–70%**	**30–50%**	**10–30%**	**<10%**
trees >30 m	tall closed forest	tall forest	tall open forest	tall woodland	n/a
trees 10–30 m	closed forest	forest	open forest	woodland	open woodland
trees >10 m	low closed forest	low forest	low open forest	low woodland	low open woodland
shrubs >2 m	closed scrub	scrub	open scrub	tall shrubland	tall open shrubland
shrubs (s) 0.25–2 m	closed heathland	heathland	open heathland	shrubland	open shrubland
shrubs (ns) 0.25–2 m	n/a	n/a	low shrubland	low shrubland	low open shrubland
shrubs (s) <0.25 m	n/a	n/a	n/a	dwarf open heathland	dwarf open heathland

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Life form of tallest stratum	Projective foliage cover of the tallest stratum				
	70–100%	50–70%	30–50%	10–30%	<10%
shrubs (ns) <0.25 m	n/a	n/a	n/a	dwarf shrubland	dwarf open shrubland
hummock grasses	n/a	n/a	n/a	hummock grassland	open hummock grassland
tussock grasses	closed grassland	grassland	grassland	open grassland	very open grassland
sedges	closed sedgeland	sedgeland	sedgeland	open sedgeland	very open sedgeland
herbs	closed herbland	herbland	herbland	open herbland	very open herbland
ferns	closed fernland	fernland	fernland	n/a	n/a

s = sclerophyllous
ns = non-sclerophyllous

The biosphere is the stratum of Earth's surface inhabited by living things and contains all of Earth's ecosystems.

Abiotic (non-living) factors in a particular area are key in determining the kinds of ecosystems that develop and the kinds of organisms that can live there. Climate is a significant abiotic factor. For example, ecosystems in polar zones are fundamentally different from those in temperate and tropical zones. Other abiotic factors include altitude, temperature, geology (rock/soil type and depth) and light intensity. Table 3.1.4 lists abiotic characteristics of habitats.

TABLE 3.1.4 Abiotic characteristics of habitats

Terrestrial			Aquatic	
tropical (north)	temperate (south)	semi-arid to arid desert	freshwater	marine
• high rainfall • warm • rainforests	• cool • high altitudes • winter snow	• low rainfall • desert-like environment • hot	relatively low water salt concentration; inland lakes, rivers, streams	relatively high water salt concentration; sea/ocean

Biotic factors refer to living organisms. Organisms are adapted (suited) to the environments in which they live. They interact with one another and with their non-living surroundings. Their survival depends on these interactions.

- **Environment—**a broad term that can be applied to the entire planet, as well as to defined local areas. An organism's environment is the sum total of all of the factors that affect it in its lifetime.
- **Population—**a group of individuals of the same species living in a particular area.
- **Community—**a group of different species living together and interacting in their environment.
- **Habitat—**the place where an organism lives at a particular time. An organism's habitat can change. For example, migratory birds move from one habitat in summer to a different one in winter.
- **Microhabitat—**a small habitat inside a larger one that is home to particular organisms; a microhabitat features slightly different local factors from the wider habitat of which it is a part. For example, a tree hollow will have less light penetration and may be cooler than the habitat of the rest of the tree.

Understanding the nature of ecosystem classification is central to ecosystem management and conservation. This includes protecting vulnerable species of flora and fauna from extinction, as well as effectively managing natural resources for human benefit.

Biodiversity

Biodiversity refers to the vast range of different kinds of organisms on Earth. Different kinds of species occupy different kinds of environments to which they are suited (adapted). Organisms in ecosystems form communities, with individuals interacting with one another and with their non-living surroundings.

MEASURING DIVERSITY OF SPECIES

Biodiversity can be measured in terms of genetic and species diversity and in terms of ecosystem diversity. There are some important patterns to note in terms of increased diversity and robustness of species and ecosystems. For example, the greater the genetic diversity within a species, the greater its potential to tolerate environmental change. The greater the species diversity within an ecosystem, the more stable the ecosystem and the less likely it will be to collapse because of small environmental changes. Measuring biodiversity is important because it informs management and conservation strategies.

Sampling populations in an ecosystem

A range of sampling techniques is available to ecologists to monitor factors in ecosystems (Figure 3.1.7).

Quadrats and transects

A **quadrat** is an area marked out with a frame for the purpose of gathering data related to populations of organisms in a given area.

- It is usually 1 m^2 but can be adapted to suit the specific ecosystem.
- Organisms inside the quadrat are counted and recorded.
- A number of quadrats placed randomly around the habitat can provide a useful estimate of the presence, abundance and density of different species within an area. This method is useful for estimating the percentage frequency of a plant in a surveyed area.

A **transect** is a line marked out randomly through a habitat.

- Every organism on the line at regular intervals or within the transect is recorded.
- Variations in community composition throughout the habitat can be assessed.
- **Line transects** are time-efficient and can minimise disturbance to the environment. However, species of low abundance can be missed. Systematic **sampling** is used to monitor areas that feature an environmental gradient. For example, running a line transect to gather data at intervals from the shoreline of a lake, across grassland and into nearby woodland.
- **Belt transects** extend out a specific distance to either side of the line. They are time-intensive but can provide more accurate estimates of community populations.

Permanent quadrats and transects can be used to measure, estimate and predict changes in the diversity and abundance of populations over time.

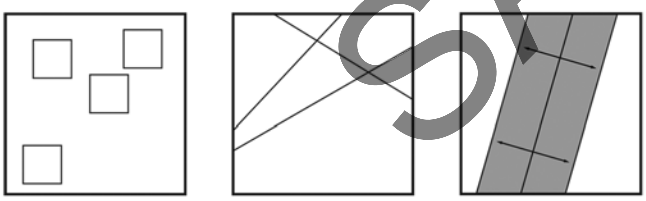

FIGURE 3.1.7 Sampling techniques

Animal populations are often measured using the Lincoln index. The **Lincoln index** is a tool used by ecologists to estimate population size when counting every individual is difficult to do. It relies on the **capture–recapture** method, whereby individuals are tagged and released. They can then be easily identified when they are spotted again. This avoids counting individuals multiple times or missing them altogether. The Lincoln index can be calculated using the formula:

$$N = \frac{M \times n}{m}$$

where

M = number of individuals caught, tagged and released in the first sampling

n = number of individuals caught in the second sampling

m = number of tagged individuals caught in the second sampling.

To ensure reliability of sampling data, different kinds of ecosystems may require different sampling techniques, depending on factors such as the kind and distribution of habitats and the microhabitats that they contain, and the degree of uniformity/variation of species.

Stratified sampling

Stratified sampling is an approach to ecological surveying that is used to monitor ecosystems that are not homogeneous or consistent throughout. It involves using regular techniques, such as transects and quadrats, to sample different strata throughout the area to estimate population size and density, as well as distribution of organisms. Stratified sampling is also used to shed light on differences in abiotic factors (environmental gradient) that influence the distribution and abundance of organisms in different zones of the ecosystem in question.

Other ecological survey techniques

Percentage cover is a calculation of the percentage of a given area covered by a particular organism, usually a plant. This approach is more effective in circumstances where counting individual organisms is difficult. For example, calculating percentage cover is useful for estimating the abundance of plants such as blackberry or ivy in a forest or measuring the abundance of corals or sea grasses in a reef ecosystem.

Percentage frequency refers to the percentage of quadrats in which a particular species occurs.

Species richness refers to the abundance or total number of species in an ecosystem.

Simpson's diversity index (SDI) is a tool used to measure the diversity in a population or the biodiversity of a community. The formula for SDI is set out below.

$$\text{SDI} = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

where

N = total number of organisms of all species

n = number of organisms of one species

SDI is always measured within the range from 0 to 1, with scores close to 1 indicating high diversity and scores close to 0 indicating low diversity.

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Species evenness refers to the proportional representation or relative abundance of different species throughout an ecosystem. Tools such as the Shannon–Wiener index can be used to calculate species evenness. The formula for this index is shown below.

$$E = \frac{-\Sigma(p_i[\ln p_i])}{\ln S}$$

where

p_i = proportion [number of individuals of the species/total number of individuals of all species present]

S = total number of species [species richness]

ln = natural log

The Shannon–Wiener index is also measured within the range 0 to 1. Scores close to 1 indicate that the species represented are relatively equally abundant, with no single species dominating above others. Scores close to 0 indicate unevenness of species abundance, usually with one species more dominant than others.

Minimising bias

In order to ensure that field data from ecosystem sampling will be as accurate as possible, steps must be taken to minimise bias. Several approaches are effective in ensuring the reliability of field data. For example:

- the larger the number of quadrats sampled, the more representative the data is likely to be
- using random number generators to select sites for sampling decreases any unwitting bias by field workers
- applying counting protocols ensures consistent counting of individuals throughout the sample area
- ensuring equipment is correctly calibrated (e.g. data loggers); poorly maintained and incorrectly calibrated equipment leads to unreliable data that fails to provide a true assessment of populations under investigation in ecosystems.

Data presentation and analysis

Once all of the field data from various sampling techniques have been gathered and recorded, it can be processed and analysed to provide meaningful information and conclusions about the ecosystem under investigation. Information can be represented in various useful ways, including tables and profile diagrams, as well as notes and photographs. Processing tabulated data may include calculations such as population means, standard deviation and diversity indices. Reliability of data should be recognised and can be calculated in measures of error. Data can be manipulated for presentation in graphical form, facilitating its interpretation and making it easy to identify trends.

Data analysis can include deducing information about relationships between species in ecosystems, population ratios such as predator–prey interactions, endangered species numbers and habitat status. It includes the use of field guides and dichotomous keys to classify and identify species, adding to understandings of biotic factors and their requirements, challenges and interactions. Ecosystem features can also be analysed to classify the kind of ecosystem.

Reliably collected, processed and analysed field data is critical in understanding interactions between organisms and between organisms and the abiotic factors of ecosystems, including identifying factors that may limit the distribution and abundance of organisms. Together, all the information helps to implement best practice in resource management and conservation strategies.

MONITORING ABIOTIC FACTORS

Environmental factors affect the ability of organisms to function at an optimal level. Various tools and techniques are used to monitor environmental factors. Table 3.1.5 summarises some of these abiotic factors. The use of such tools and techniques is important in the management of plants, animals and environmental resources.

TABLE 3.1.5 Techniques to monitor environmental change

Factor	Technique for monitoring factor	Notes
pH	A pH probe measures the degree of acidity/alkalinity in soil or water.	Different species of plants have particular pH requirements to grow efficiently. Australian inland waters have a pH range of 6 to 9. Aquatic organisms tolerate a wide pH range, but will be adversely affected if pH goes beyond this range.
light	A light meter (also known as a lux meter) measures the intensity of light at different levels of penetration in a habitat.	The intensity of light is an important factor affecting the distribution of producer organisms (plants) in a given habitat. This, in turn, affects the abundance and distribution of animals that feed either directly or indirectly on the plants.
oxygen	Probes are available to monitor oxygen concentration.	Oxygen is a requirement for organisms; when oxygen availability is reduced below the tolerance limit for an organism, cellular respiration cannot occur at a rate sufficient to meet the energy needs of cells and the organism dies.
carbon dioxide	Probes are available to monitor carbon dioxide concentration.	Plants require carbon dioxide for photosynthesis; high levels are toxic to animals.

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Factor	Technique for monitoring factor	Notes
soil structure	Soil samples can be dehydrated and sifted to establish the size of soil particles.	The type of soil (e.g. sandy or clay) impacts on its porosity and water-holding capacity; this in turn influences the kinds of plants that can grow and the kinds of organisms the plant community can support.
salinity	The salt content of soils is measured by determining its electrical conductivity.	While some kinds of plants are well suited to saline conditions, most plants are sensitive to salinity and deteriorate when exposed to high salt levels. When a plant community succumbs to saline soils, the animal community it supports is also affected. When plant communities die out in response to saline conditions, their roots no longer bind the soil, and erosion of soil follows.

Population ecology

FACTORS THAT AFFECT POPULATION SIZE

Many factors operate on species of organisms in ecosystems, affecting the abundance and density of populations. These include biotic factors such as food availability, predation, disease, reproductive mates and competition for resources, and abiotic factors such as suitable shelter, adequate space, water and other nutrient availability, and environmental conditions.

Distribution: the geographic range over which the individuals in the population live.

Abundance: the actual number of individuals in the population.

The distribution and abundance of species are related to the availability of each species' requirements. This includes food, water, shelter, reproductive mates and suitable environmental conditions. Environmental conditions must provide conditions within which organisms can survive. This is called the **tolerance range** for the organism.

A **limiting factor** is a factor that acts on a population to slow its growth. It can be either biotic or abiotic. The presence of predators restricting populations of organisms from exponential growth, thereby keeping populations in check, is an example of a biotic limiting factor. A shortage of nesting sites for parrots is an example of an abiotic limiting factor.

Density-dependent factors

A **density-dependent factor** is a factor that influences population size and density, but the magnitude of its effect depends on the existing population density. High-density populations mean there is increased competition for resources, such as food or nesting sites, in a given area. In denser populations, the spread of infectious disease is expected to be greater than for less-dense populations. Density-dependent factors include:

- predation
- crowding—the higher the density of a population, the greater the impact of competition for resources such as food; crowding also means increased competition for available nesting spaces
- parasitism
- disease.

Density-independent factors

A **density-independent factor** impacts on a population regardless of the population size or density; for example, natural disasters, such as bushfire, cyclone, flood and drought. More common density-independent factors in ecosystems include environmental temperature, intensity of sunlight, pH of soil and water, and salinity.

FLUCTUATIONS IN POPULATION SIZES

Population density and distribution are influenced by many abiotic and biotic factors. Generally, when the resource requirements of a population are met and there are limiting factors acting on the population (e.g. predation limiting prey numbers), population size can remain stable.

The size of a population can be affected by four processes:

- **natality** (births or germination)
- **mortality** (deaths)
- **immigration** (organisms moving into a population from another population)
- **emigration** (organisms moving out of a population).

Birth and immigration bring new population members and thus increase the population size. Death and emigration decrease the population size. Immigration and emigration are collectively known as **migration**. These four processes determine the rate of change in a population over time (Figure 3.1.8).

Populations increase when the combined rates of birth and immigration are greater than the combined rates of death and emigration, as per the following rule:

abundance = birth + immigration − death − emigration

When factors such as birth rate and immigration are in balance with the death rate and emigration, populations remain stable.

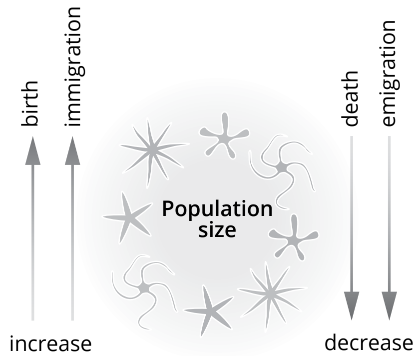

FIGURE 3.1.8 The size of a population depends on birth rate, death rate and migration.

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PATTERNS OF POPULATION GROWTH

Exponential population growth

When the birth rate remains higher than the mortality rate, population size increases and, depending on other factors, may eventually increase at an exponential rate (Figure 3.1.9a). Species that tend to experience exponential population growth are those that have a short generation time and give rise to large numbers of offspring.

Exponential growth is normal for some species when environmental conditions are favourable and resources are abundant. Because these conditions generally last only a short time, exponential growth is usually short-lived. But if favourable conditions continue, then a population explosion may occur, in which the population increases rapidly. The introduction of several species into Australia demonstrates this phenomenon. The prickly pear cactus, introduced with the First Fleet in 1788, is an invasive plant that is well suited to Australian conditions. It reproduces prolifically, quickly becoming a significant pest species. Introduction of the cactus moth, *Cactoblastis cactorum*, in the 1920s, eventually succeeded in controlling the population. Rabbits and cane toads represent other introduced species that have experienced population explosions.

A population crash occurs when the number of individuals exceeds the carrying capacity of the ecosystem. For example, previously abundant resources such as food become scarce due to overgrazing, resulting in a rapid decline in population.

Logistic population growth

The S-shaped graph in Figure 3.1.9b shows **logistic growth**. The initial exponential growth of a population flattens out as it begins to be affected by density-dependent factors. The population growth rate may decline until birth and death balance each other and the population is limited to the carrying capacity of the environment.

The changing nature of ecosystems means that their carrying capacity can change over time. For example, as the availability of resources fluctuates, so too does its potential to maintain populations of organisms.

Carrying capacity

In the absence of limiting factors, the population growth of a species would always be exponential (i.e. always increasing) (Figure 3.1.9a). However, in a real ecosystem, population growth is affected by density-dependent factors such as competition for resources. When a population reaches equilibrium and becomes relatively constant, with the number of births and deaths in the population cancelling each other out, the species has reached the maximum population size that the ecosystem can sustain indefinitely. This is the ecosystem's **carrying capacity** for that species (Figure 3.1.9b). The carrying capacity of an ecosystem is the number of organisms of a particular species that the ecosystem can sustain.

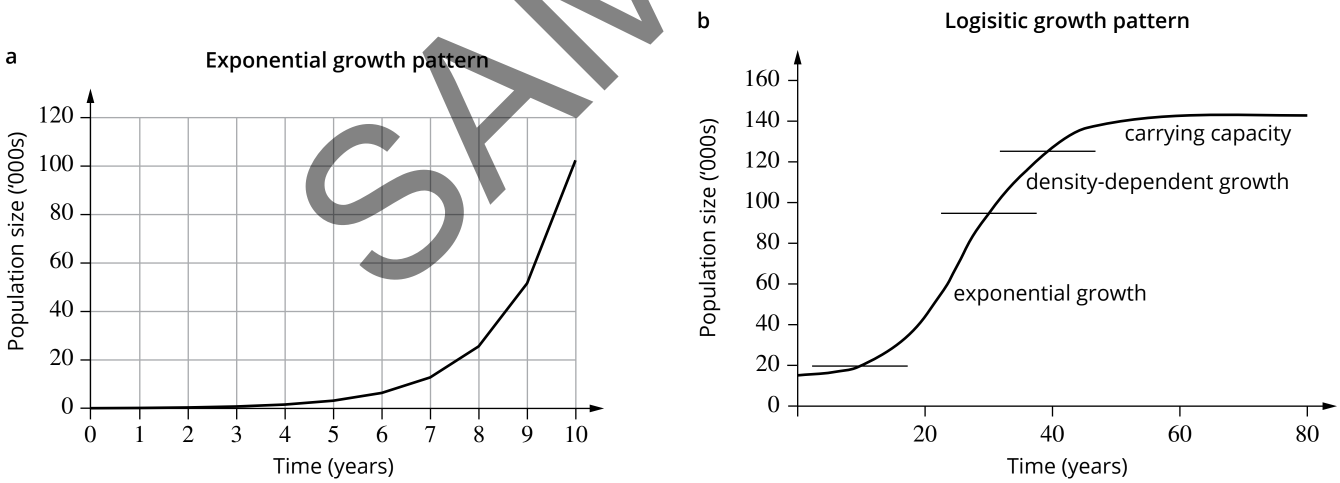

FIGURE 3.1.9 (a) The size of a population over time (years), showing exponential population growth. (b) A population growth curve showing exponential growth (where no limiting factors are acting), followed by density-dependent growth, where factors such as predation and competition begin to limit population growth. When population growth plateaus, the carrying capacity of the ecosystem has been reached.

WORKSHEET 3.1.1

Knowledge preview—the language of biological diversity

1 Recall your understanding of each of the terms listed below and write down your own definition in the space labelled 'Initial definition'. Then use your resources to check your understanding and write a more formal definition.

	Term	Initial definition	Formal definition
a	species		
b	biodiversity		
c	ecosystem		

2 State whether or not the following pairs of organisms are members of the same species. Explain your reasoning in each case.

a African elephant and Asian elephant

b Australian cattle dog and labrador

c horse and donkey

3 The following list is divided into abiotic and biotic factors. Look for similarities in the items in each list.

Abiotic			Biotic		
air	snow	earthquake	spider	lichen	gum tree
water	cloud	sand	grasshopper	moss	kookaburra
rock	lava	lightning	earthworm	fern	koala
rain			mushroom		

Define the following terms.

a abiotic

b biotic

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

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WORKSHEET 3.1.2

Classifying organisms

1 Use the key words listed and your knowledge of classification to complete the summary notes and table below.

order	Bacteria	biodiversity	class	Plantae	Animalia	phylum
genus	family	Protista	Fungi	taxonomy	species	Archaea

a The enormous variety of living organisms on Earth is described as ____________________. Scientists group or classify organisms according to features they possess. This practice is called ____________________. The smallest taxonomic group is a ____________________. There are three domains and five kingdoms. The eight levels of classification are: domain, kingdom, ____________________, ____________________, ____________________, ____________________, ____________________, species.

b

Domain	Kingdom	Features of organisms in this taxonomic group	Examples of organisms
Bacteria and Archaea	Formerly Monera		
	Protista		
	Fungi		
	Plantae		
	Animalia		

c A species is defined as: ____

____

____

d By convention, species are named using the binomial system, which is a system that: ____________________

____

____

e Describe three reasons scientists classify organisms.

Reason 1: ____

____

Reason 2: ____

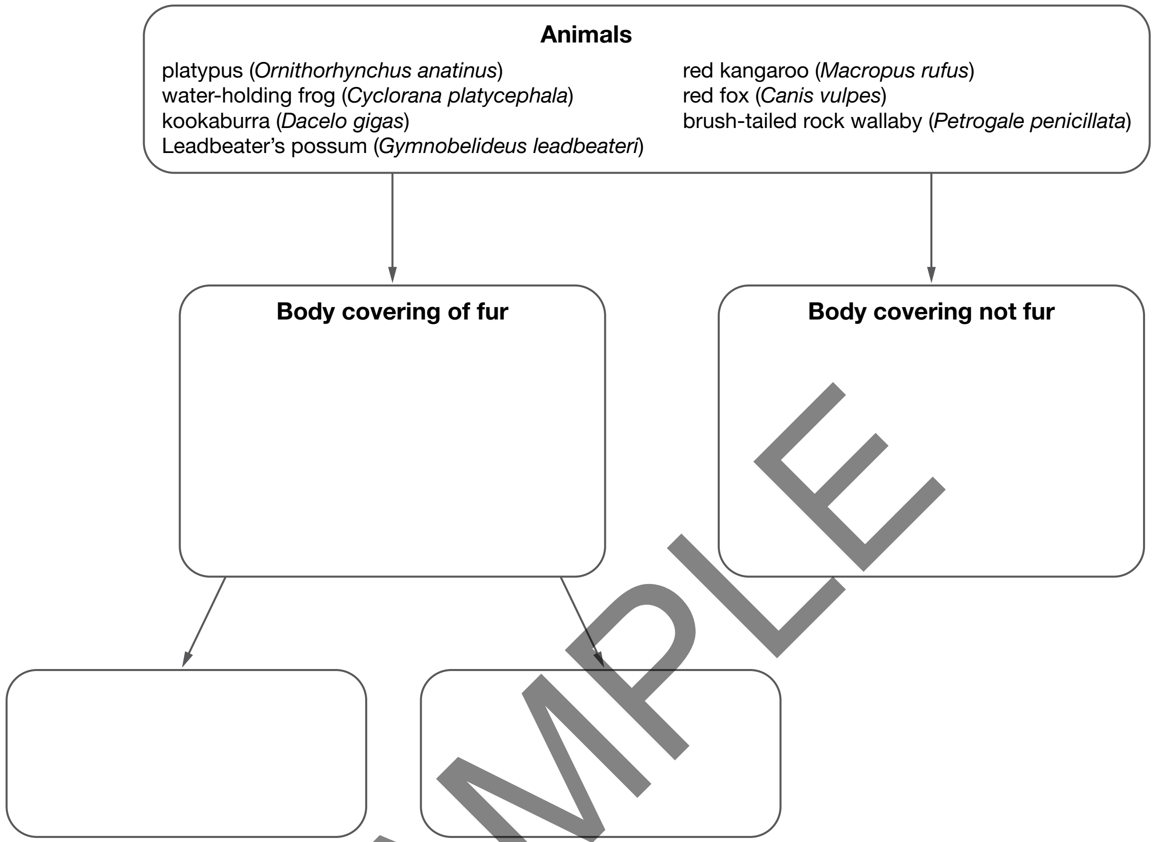
____

Reason 3: ____

____

2 Classification keys are used to identify organisms, placing them into taxonomic groups with other organisms that share similar features.

Consider the animals listed in the figure below. Use and extend the dichotomous key provided until you have classified the red kangaroo into a group containing only this organism.



RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

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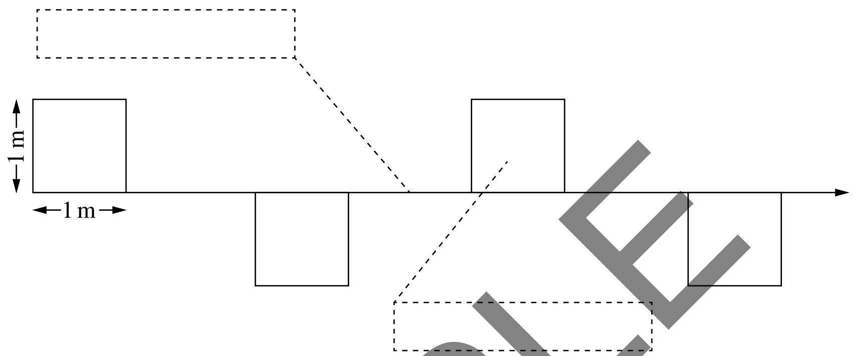
WORKSHEET 3.1.3

Sampling techniques to monitor diversity in an ecosystem

Sampling techniques and biodiversity assessment are important approaches to establishing the health of ecosystems. This applies to large-scale ecosystems, such as national parks, as well as to small-scale ecosystems, including local parks and backyards.

1 The sketch below represents common approaches to ecosystem sampling. Select from the terms listed to correctly label the diagram.

quadrat	belt transect	line transect



2 The table below lists the types of organisms and the number of individuals of each type included in a newly established backyard pond. The pond's biodiversity has been assessed as 0.49 using Simpson's diversity index (SDI), while its species evenness has been identified as 0.65 using the Shannon–Wiener index.

Species	Number
waterlily	1
goldfish	10
rush	1
pondweed	2

a Identify the species richness for this pond ecosystem.

b Interpret an SDI of 0.49 for this pond ecosystem.

c Interpret the species evenness for the pond.

d Describe two different strategies used in the sampling of the pond that would reduce bias and increase reliability of the field data obtained.

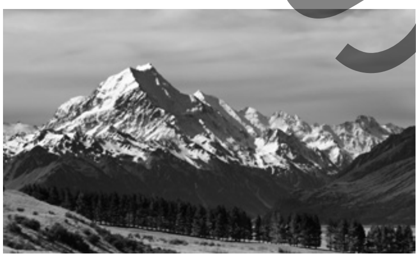
RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

WORKSHEET 3.1.4

Classifying ecosystems

Ecosystems are classified based on factors including latitude, climate, rainfall, temperature, landform morphology, elevation and vegetation. The kind of ecosystem that develops in a region is shaped in the first place by the abiotic factors to which the environment is subjected. Only organisms suited to the conditions can survive there.

Examine the four different kinds of ecosystems represented below. Think about the impact that abiotic factors are likely to have in the development of each ecosystem and how this in turn influences the kind of community living there. Consider the abiotic factors that shape them and the kinds of organisms that inhabit them, adding these to the table. Use the specific information for each ecosystem and refer to the Holdridge life zone classification scheme on page 6 to identify them.

	Ecosystem	Key features	Abiotic factors that have helped to shape the ecosystem	Organisms in this community (list at least five)	Holdridge ecosystem classification
1	 mean annual temperature: 22°C mean annual rainfall: 85 mm potential evapotranspiration rate: 12				
2	 mean annual temperature: 2°C mean annual rainfall: 410 mm potential evapotranspiration rate: 0.3				

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3	 mean annual temperature: 18°C mean annual rainfall: 3200 mm potential evapotranspiration rate: 0.35				
4	 mean annual temperature: 5°C mean annual rainfall: 200 mm potential evapotranspiration rate: 1.4				

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

PRACTICAL ACTIVITY 3.1.1

Determining biodiversity in an ecosystem

Suggested duration: 40 minutes

AIM

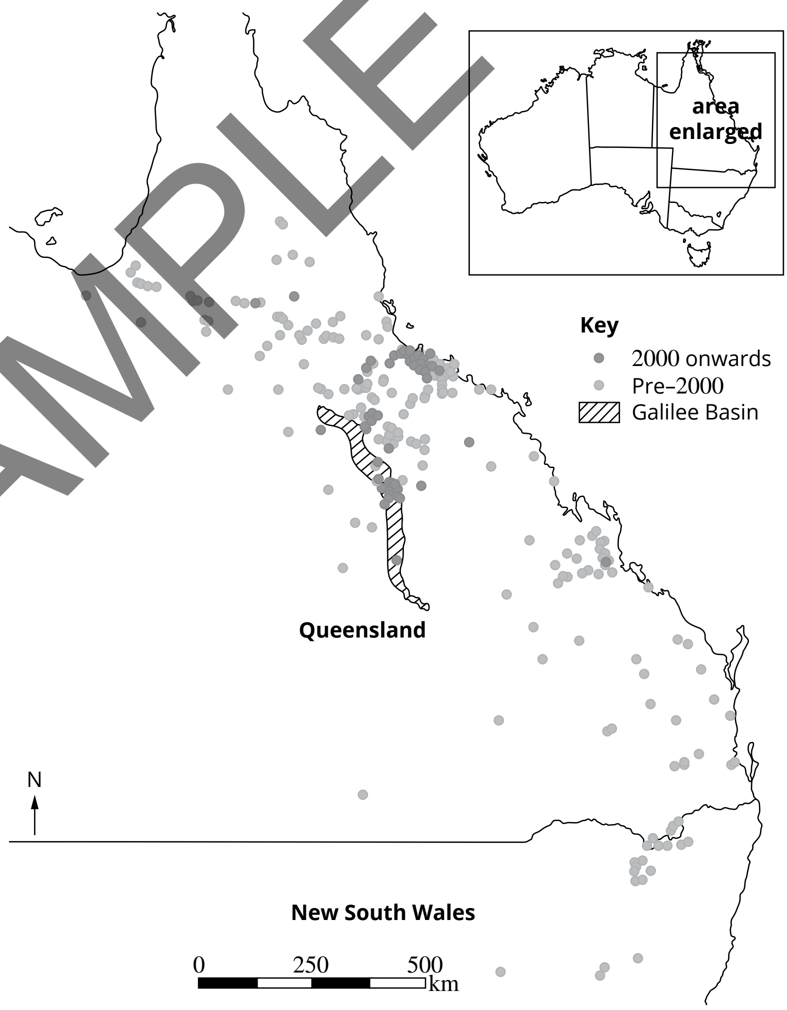
To investigate the research question: What can we learn about an endangered bird species from the diversity of its community?

RATIONALE

Biodiversity is defined as the variety of different species living in an ecosystem. While biodiversity can be described, statistical analysis of organisms present in an ecosystem allows ecologists to actually measure it. Quantifying biodiversity in this way provides specific information about the health of ecosystem communities, which helps to ensure that they are managed effectively. Various tools are available to determine biodiversity. In this activity you will use Simpson's diversity index (SDI) to consider biodiversity data for an ecosystem that includes an endangered bird species, and the Shannon–Wiener index for species evenness in the same ecosystem.

The southern black-throated finch *Poephila cincta* is an endangered bird species native to north-eastern Australia. The species inhabits open woodlands, where it feeds on seeds. Since the 1960s its population has decreased by a staggering 80% and its distribution has contracted from northern NSW and Queensland's Cape York Peninsula to its present range from Townsville to the Galilee Basin in east central Queensland. The Galilee Basin features rich coalmine seams, with mining already occurring and proposals for new open-cut mines submitted. Human activity is a key threat affecting the southern black-throated finch. This includes habitat loss due to agriculture and mining, as well as the introduction of exotic plants and animals, including predators such as feral cats.

In this activity you will process and analyse data related to the distribution and abundance of the endangered southern black-throated finch. The hypothetical data presented is derived from a variety of research and survey information related to the southern black-throated finch in Queensland.



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PRACTICAL ACTIVITY 3.1.1

ANALYSING

Surveying of the southern black-throated finch is routinely conducted to monitor population distribution and abundance. The data set out in Table 1 lists organisms present in an intact woodland habitat for the southern black-throated finch.

TABLE 1 Southern black-throated finch woodland habitat

Species	Number (*n*)
southern black-throated finch	8
Eucalyptus melanophloia (silver leaf ironbark)	9
Melaleuca (tea tree)	27
Acacia (wattle)	11
native grasses	23
dense patches of buffel grass (exotic grass)	2

SDI is a tool used to measure the biodiversity of a community and is described by the formula:

$$SDI = 1 - \left(\frac{\sum n(n-1)}{N(N-1)} \right)$$

where

n = total number of individuals of one species

N = total number of individuals of all species.

1 Apply the formula shown above to calculate the SDI for the location. Table 2 has been included to assist your calculations.

TABLE 2 Calculation of SDI

Organism	*n*	*n* – 1	*n* (*n* – 1)
southern black-throated finch			
Eucalyptus melanophloia (silver leaf ironbark)			
Melaleuca (tea tree)			
Acacia (wattle)			
native grasses			
dense patches of buffel grass (exotic grass)			
Total			

2 Identify the species richness for this location.

INTERPRETING AND EVALUATING

3 Interpret the SDI for this ecosystem.

4 Species evenness is calculated at 0.89 for this ecosystem, according to the Shannon–Wiener index. Explain what a species evenness of 0.89 means for this ecosystem.

5 Describe two limitations related to this biodiversity investigation.

CONCLUSION

6 Answer the research question in this investigation. Draw on data from the investigation to support your response.

7 Assess the significance of biodiversity in ecosystems.

8 Predict two potential outcomes of continuing with and expanding coal mining in the Galilee Basin. Justify your answer.

9 Describe an improvement to counter the limitations described in Question **5** and explain how such improvements are expected to increase the reliability of the biodiversity data gathered.

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

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UNIT 3 TOPIC 1 EXAM PRACTICE

Multiple choice

QUESTION 1

QCAA Biology Exam 2024 Paper 1 Question 5

A limitation of the biological species concept is that it does not account for species that

(A) reproduce asexually.

(B) are reproductively isolated.

(C) are morphologically indistinguishable.

(D) have a different number of chromosomes.

QUESTION 2

QCAA Biology Exam 2024 Paper 1 Question 8

In the Linnaean system of classification, two species of the same class will also belong to the same

(A) order.

(B) genus.

(C) family.

(D) phylum.

QUESTION 3

QCAA Biology Exam 2024 Paper 1 Question 14

Compared to *K*-strategists, species classified as *r*-strategists tend to

(A) have more offspring.

(B) have longer lifespans.

(C) reach sexual maturity later.

(D) live in more stable habitats.

QUESTION 4

QCAA Biology Exam 2022 Paper 1 Question 5

A researcher captured, marked and released 36 frogs. The following day they captured 24 frogs and 18 were marked.

Calculate the approximate size of the frog population using the Lincoln index: $N = \frac{M \times n}{m}$

(A) 27

(B) 48

(C) 54

(D) 60

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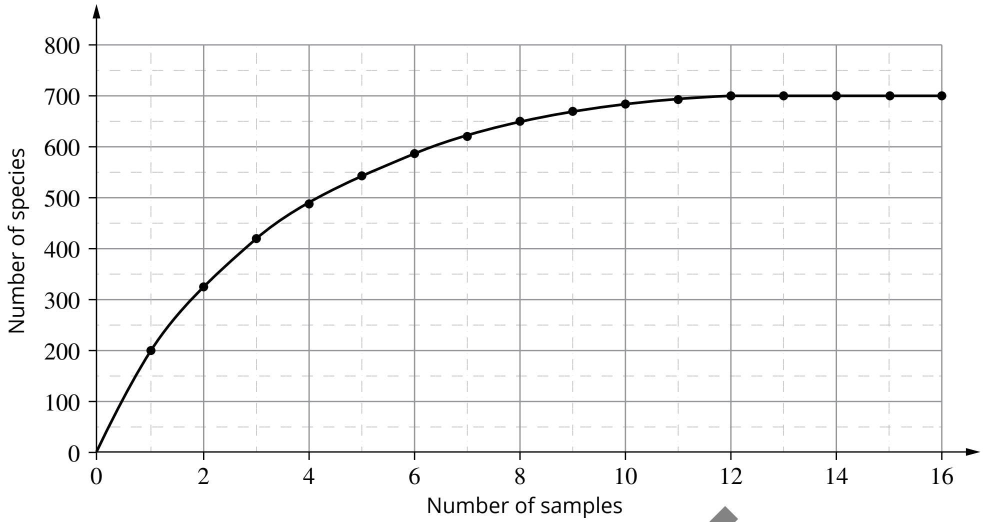
QUESTION 5

QCAA Biology Exam 2023 Paper 1 Question 12

The graph shows the results of a study on the species richness of gut microbes. The data represents the cumulative number of species observed as the number of samples increased.



Based on this data, the minimum number of samples required to obtain valid species richness data is

(A) 2

(B) 6

(C) 12

(D) 16

QUESTION 6

QCAA Biology Exam 2022 Paper 1 Question 3

A survey of grasshopper species was conducted across four eucalypt communities. Counts were conducted and the average abundance per 400 m^2 recorded.

	Grasshopper species (A–F)						
Community	**A**	**B**	**C**	**D**	**E**	**F**	**Total**
I	32	18	1	3	0	46	100
II	3	2	0	1	3	12	21
III	3	2	28	3	18	51	105
IV	18	13	12	14	16	15	88

Which community has both the highest species richness and highest evenness for grasshoppers?

(A) I

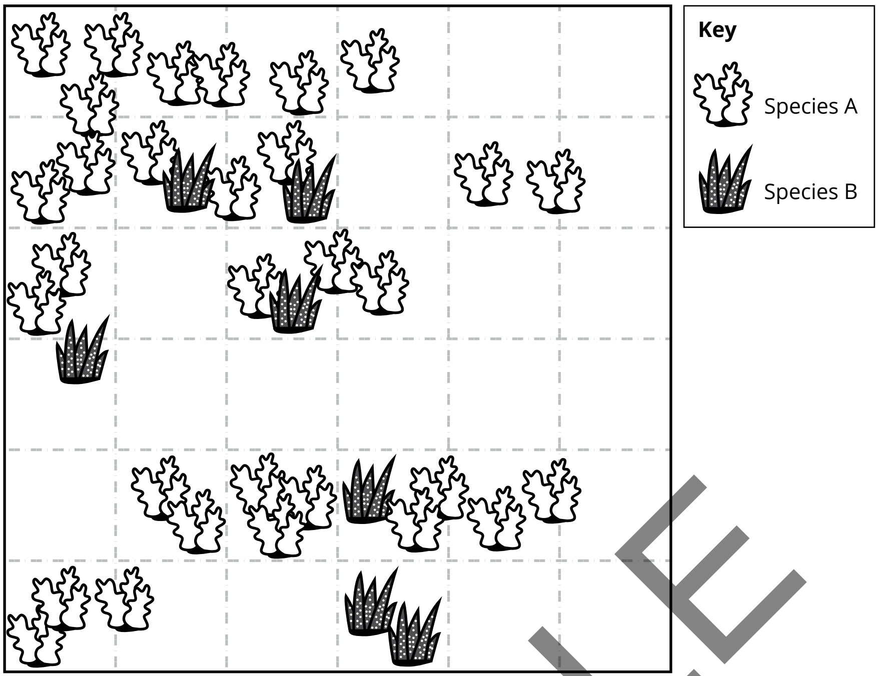
(B) II

(C) III

(D) IV

QUESTION 7

The image represents a gridded quadrat of 20 cm × 20 cm squares used in a plant survey. To calculate cover for a species, the surveyor identified each plant species and then counted the number of squares in which the species appeared.



Not to scale

What is the approximate percentage cover of species A?

(A) 22%

(B) 44%

(C) 53%

(D) 58%

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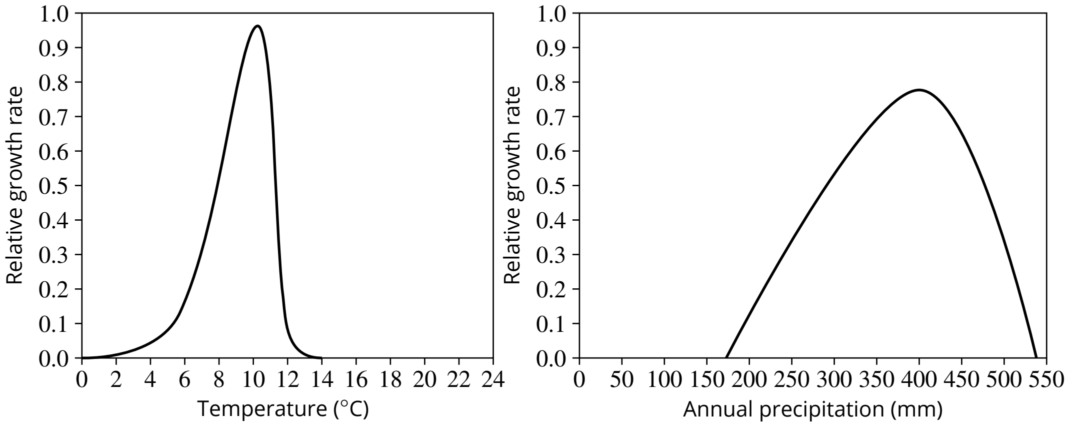
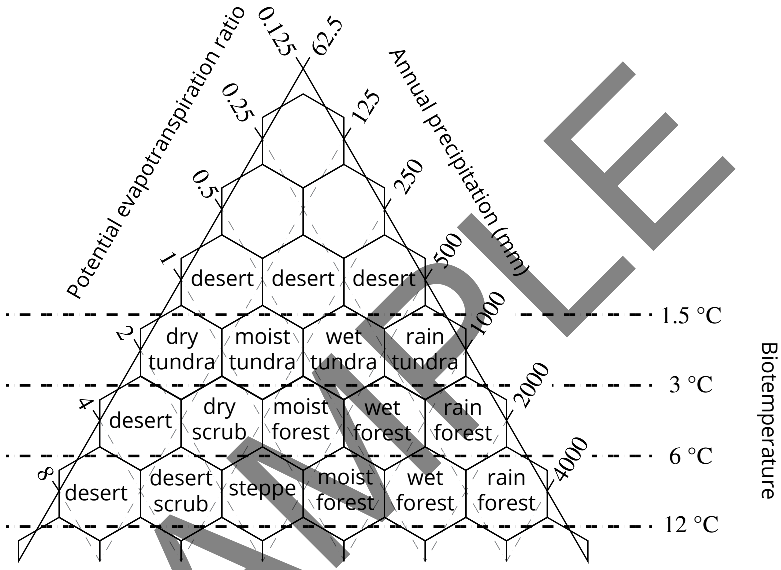
QUESTION 8

QCAA Biology Exam 2024 Paper 1 Question 7

Tolerance ranges for species X and a Holdridge life zone classification chart are shown.





Based on this data, the preferred habitat for species X is

(A) desert.

(B) steppe.

(C) wet tundra.

(D) moist forest.

QUESTION 9

QCAA Biology Exam 2023 Paper 1 Question 3

The table provides population data for a species of fairy-wren.

Year	Population on 1st January	Births	Deaths	Immigration	Emigration
2022	15 200	7600	4310	790	24

The population growth rate in 2022 was closest to

(A) 17%

(B) 27%

(C) 55%

(D) 73%

QUESTION 10 *QCAA Biology Exam 2020 Paper 1 Question 9*

The table provides population statistics for a species of tree kangaroo in northern Queensland.

Year	Births	Deaths	Immigration	Emigration	Final population
2016	253	175	153	131	1100
2017	290	167	182	140	

Determine the population growth rate for tree kangaroos in 2017.

(A) 14.6%

(B) 15.0%

(C) 26.5%

(D) 86.9%

Short response

QUESTION 1 (6 marks) *QCAA Biology Exam 2020 Paper 2 Question 4*

An ecologist investigated the species composition of mangrove trees in a natural mangrove forest and an adjacent 30-year-old planted mangrove forest.

Three 10 m-wide belt transects were sampled from inland to the sea for each of the forests, each covering 100 m on average and placed to cover various strata.

The species diversity of forest A was determined using Simpson's diversity index (SDI): $SDI = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$

	Population count	
Species	**Forest A (natural)**	**Forest B (planted)**
grey mangrove	91	77
red mangrove	23	14
river mangrove	11	8
orange mangrove	3	0
Diversity	0.46	

a) Use the SDI formula to calculate the diversity index for forest B. Round your answer to two decimal places. [*2 marks*]

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b) Identify three reasons why the ecologist used a belt transect rather than line transects or randomly placed quadrats for collecting data to compare these two forests. [*3 marks*]

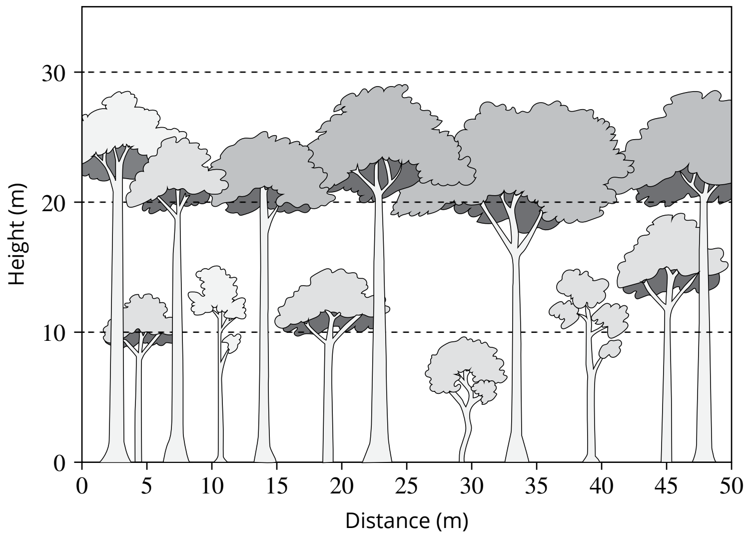
c) Identify one way in which the ecologist minimised bias in the sampling. [*1 mark*]

QUESTION 2 (4 marks) *QCAA Biology Exam 2021 Paper 2 Question 1*

Explain how one abiotic and one biotic factor will affect the population of mosquito larvae in a freshwater pond.

QUESTION 3 (6 marks) *QCAA Biology Exam 2023 Paper 2 Question 1*

The profile diagram shows a representative section of an ecosystem.



This table can be used to classify ecosystems based on Specht's classification system.

	Foliage cover of tallest plant layer		
Life form and height of tallest stratum	**Dense (70–100%)**	**Mid-dense (30–70%)**	**Sparse (10–30%)**
trees >30 m	tall closed forest	tall open forest	tall woodland
trees 10–30 m	closed forest	open forest	woodland
trees 5–10 m	low closed forest	low open forest	low woodland
shrubs 2–8 m	closed scrub	open scrub	tall shrubland

a) Classify this ecosystem. [*1 mark*]

b) Describe how field data could be collected for the purpose of classifying this ecosystem using Specht's classification system. Include at least one strategy to minimise bias. [*3 marks*]

c) Explain how Specht's classification system could be used to monitor how the ecosystem recovers after a logging event that removes 80% of trees from the tallest plant layer. [*2 marks*]

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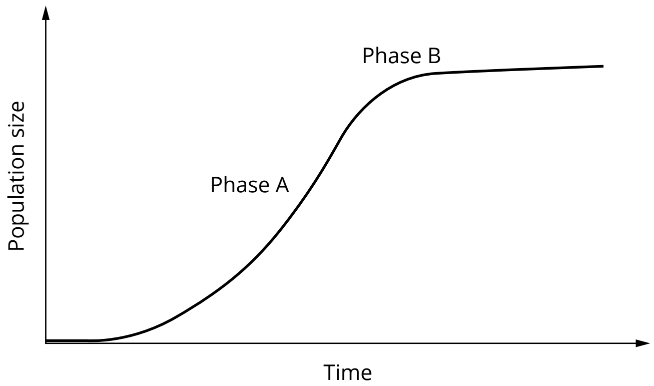
QUESTION 4 (3 marks) *QCAA Biology Exam 2021 Paper 1 Question 28*

The graph depicts the population change of a species after it is introduced into a previously disturbed environment.



Referring to phase A and phase B, determine the population growth model for the species.

QUESTION 5 (2 marks) *QCAA Biology Exam 2024 Paper 2 Question 3*

The table shows data for a population in 2023.

Starting population	Births	Deaths	Immigration	Emigration
4000	835	324	34	65

Calculate the population growth rate. Show your working.

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SAMPLE ASSESSMENT TASK IA1

Data test

Duration: 5 minutes perusal (reading) time and 60 minutes to complete the test

Task

The data test requires you to apply a range of cognitions to respond to scientific data. The test will be held in a set time frame under test conditions.

DATASET 1

Ecology students select two local backyards to conduct a survey of weed abundance for two spatially variant ecosystems. Backyard 1 belongs to an uninhabited house. Backyard 2 is next door, and home to one of the students. The survey data showing the average number of weeds per square metre is set out in the table below.

Backyard 1: Undisturbed	
Species	**Number of organisms**
plantain	2
dandelion	11
clover	19
creeping woodsorrel	2
cudweed	2
bindii	3

Backyard 2: Maintained	
Species	**Number of organisms**
plantain	0
dandelion	2
clover	1
creeping woodsorrel	0
cudweed	0
bindii	0

1 Calculate Simpson's diversity index (SDI) for the two sites. (4 marks)

$$\mathrm{SDI} = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

where

N = total number of organisms of all species

n = number of organisms of one species

Backyard 1:

Backyard 2:

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2 Compare the SDI for the two backyard lawns, making sure to describe the significance of any similarities and differences identified. (3 marks)

3 Identify the species richness for the two backyard lawns. (2 marks)

Backyard 1:

Backyard 2:

4 Determine by what factor the undisturbed backyard species richness is greater than the maintained backyard. (2 marks)

5 Predict the outcome in Backyard 2 if the maintenance were to lapse. (2 marks)

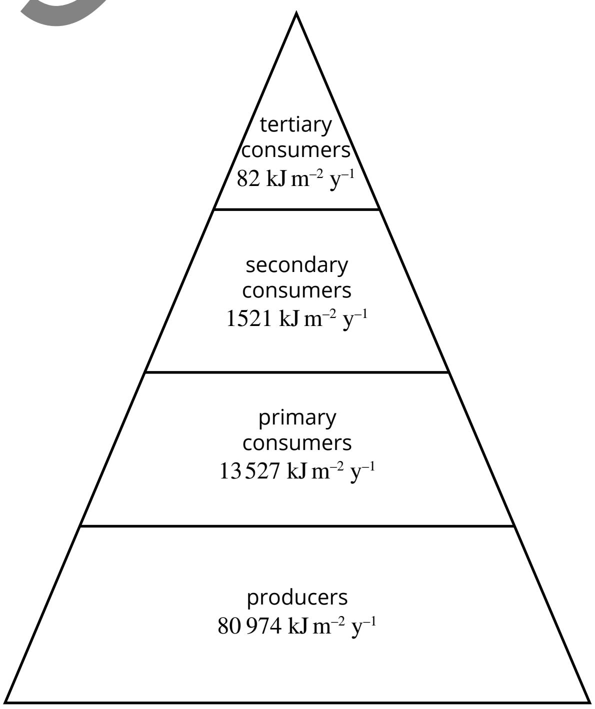
6 Infer a reason to account for the diversity in Backyard 1 compared with Backyard 2. (2 marks)

DATASET 2

Students analyse field data related to a Tasmanian forest ecosystem, constructing two food chains and a biomass pyramid.

grass → grasshopper → marsupial mouse → snake → Tasmanian devil

grass → grasshopper → marsupial mouse → snake → hawk



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1 Calculate the approximate mass of grass that has contributed to the biomass of an 8 kg Tasmanian devil. (2 marks)

2 Calculate the mass in kilograms of plant material required to support a hawk of mass 3 kg. (2 marks)

3 Determine the tertiary consumer biomass as a percentage of the producer biomass for this ecosystem. (2 marks)

DATASET 3

Field surveys monitoring the abundance of the endangered black-throated finch reveal the following capture–recapture data two years apart.

Black-throated finch abundance		
Number of birds	**Survey 1**	**Survey 2**
number of birds caught, tagged and released (*M*)	16	12
number of birds caught in sample 2 (*n*)	13	9
number of tagged birds caught in sample 2 (*m*)	8	6

1 Calculate the population of endangered finches in the sampled area at the beginning of the survey period. Use the Lincoln index. (2 marks)

Formula:

$$N = \frac{M \times n}{m}$$

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2 Determine the population change over the two-year period. (2 marks)

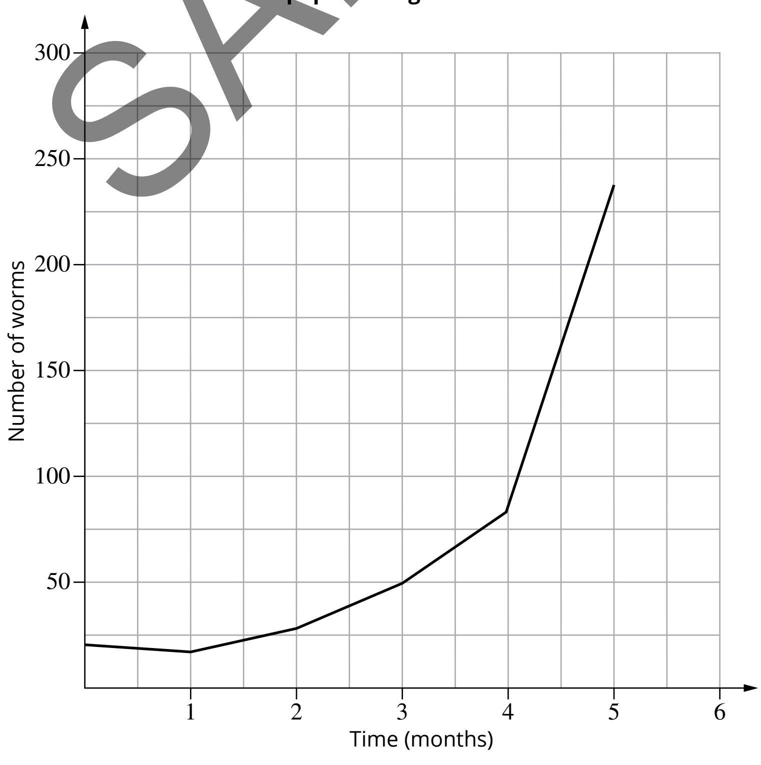
3 Calculate the percentage change in the population over the two-year period. (2 marks)

4 Predict the population trend if the black-throated finch were surveyed again in another two years. Justify your answer. (2 marks)

DATASET 4

Students conduct an experiment to monitor earthworm populations in a recently set-up compost bin. The starter population is 20 earthworms. The graph illustrates the population growth over several months.

Earthworm population growth over 5 months



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1 Deduce a plausible explanation for the trend from 0 to 1 month. (1 mark)

2 Identify the earthworm population at the end of five months. (1 mark)

3 Identify the month at the end of which the earthworm population is close to 80 earthworms. (1 mark)

4 Identify the month in which the earthworm population approximately doubles. (1 mark)

5 Identify the population growth pattern evident for earthworms in the compost bin. (1 mark)

6 Predict a likely outcome for the earthworm population if some earthworms are not eventually moved out of the compost bin and into the garden. (1 mark)

7 Infer two limiting factors expected to impact on the earthworm population during the six-month period. (2 marks)

8 Draw a conclusion about the requirements of the earthworms in this compost bin. Justify your answer. (2 marks)

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

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SAMPLE ASSESSMENT TASK IA2

Student experiment

Introduction

The student experiment requires you to follow the full scientific method over an extended and defined period of time. You will develop your own research question to investigate, based on an initial practical already completed in class.

The student experiment forms an important component of assessment in this unit. It is an opportunity to further explore concepts already covered and of particular interest to you, with some latitude for self-direction. You will select a practical activity already undertaken and modify it, using it as the basis from which to launch your own investigation.

The task is estimated to take approximately 10 hours of class time. Your time will be divided into Forming (research and planning), Finding (the experiment), Analysing, and Interpreting and evaluating, as well as preparing your report. Regular discussion with and feedback from your teacher will be an important part of the planning process. Feedback will be given on one draft.

A suggested breakdown of the time frame is:

Forming:	2 hours
Finding:	2 hours
Analysing:	1–2 hours
Interpreting and evaluating:	1–2 hours
Final report:	2–3 hours

Communicating your findings

Your report for this assessment task requires that you demonstrate the research and planning you have undertaken in preparing for the experimental investigation, and then report your findings either in written form, for example, a scientific report (maximum 2000 words) or using a multimodal format (maximum 11 minutes).

It will be helpful to prepare your report using specific headings or by ensuring clear reference is made to each required element. The following plan has been prepared to guide you through the task. This sample student experiment, focusing on factors that affect the distribution of a common backyard weed, provides a template to assist you in completing the task. Some elements of this sample assessment task have been completed for you.

FORMING

- Rationale
  - Introduce the investigation by identifying and outlining the original class experiment (e.g. title and page number in this book), together with its results and a short summary of the concept demonstrated by the experiment.
  - Outline what this modified experiment sets out to investigate, providing a detailed explanation of the theoretical reason why the results are expected to differ.
- Research question
  - Develop and state a specific question that will form the basis for planning the investigation. The question must be relevant to and drawn from the theme of the original experiment.
- Modifications
  - List the key adjustments made to the method that will drive the modified experiment. For example, identify the new independent and dependent variables, any changes in sample size and changes in equipment required. Justify each modification concisely, using logical reasoning (avoid theory).

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FINDING

- Risk assessment
  - Describe risk management strategies you will put in place to ensure safety hazards and ethical considerations are recognised and minimised.
- Results
  - Record and display the results (raw data) of your experiment. Think about convenient, informative and concise ways to do this. There are various approaches to displaying experimental data, including tables, graphs, diagrams and photographs.
  - Ensure all relevant raw data is displayed and the pertinent information such as units, titles and labelled axes are included.
- Use of scientific language and representations
  - Scientific language
  - Ensure use of symbols and units
  - Correct use of significant figures

ANALYSING

- Processing and analysing
  - Present accurate and relevant processing and analysis of the experimental data/results.
  - Include calculations, identification of patterns, trends and relationships evident from the experiment.
- Limitations and uncertainties
  - Identify any limitations and uncertainties encountered in the investigation.
  - Discuss the reliability and validity of the results.
  - Include the source of the reliability, standard error and outliers.

INTERPRETING AND EVALUATING

- Conclusions
  - Draw and justify conclusions from the experimental data, linking these to the research question.
- Evaluation
  - Justify the reliability and validity of the methodology in this experiment.
  - Consider anomalies or outliers (if they can be identified) and their effect on the results.
  - Determine the statistical rigour of the results and their effect on the analysis.
- Suggested improvements and extensions
  - Once evaluation of the experimental method has identified any sources of error, you can detail refinements and improvements to the methodology that will increase reliability (reduce error).
  - Suggest relevant extensions to the experiment that arise in the course of the experiment or as an outcome of its results and analysis.

REFERENCE LIST

- Include all references that were used when developing the research question, as well as any references you used throughout the experiment.

The flatweed census—distribution of a flatweed species

FORMING

Rationale

Hypochaeris radicata is a flatweed commonly known as the dandelion. Quadrat sampling of this flatweed in some lawns reveals irregular distribution. To understand this uneven distribution, it will be important to consider various factors operating in the habitat of the lawn, for example, light exposure, light intensity, gradient/water run-off. The impact of these factors can be investigated in turn.

This investigation is a modification of a previously completed practical activity. The original activity was Practical activity 3.1.3 Estimating a flatweed population using quadrats from *Pearson Biology Queensland Units 3 & 4 2nd edition Skills and Assessment book* (page 32). In this modified investigation, the focus is shifted from population abundance to factors affecting the distribution of the weed in a lawn. Specifically, this investigation focuses on the effect of the abiotic factor of light intensity on the distribution.

Light intensity significantly impacts plant growth, influencing photosynthesis, stem length, leaf colour and flowering, with plants needing a balance between adequate and excessive light. More light leads to a higher rate of photosynthesis, allowing plants to produce more sugars and energy. Plants have an optimal light intensity range for growth; exceeding this can lead to damage. Shape and structure of plants can also be affected by the amount of light.

The modified focus for this investigation has necessitated a change in methodology. This modified investigation includes the following variables.

Independent variable: light intensity

Dependent variable: weed distribution

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Research question

What is the correlation between changing light intensity and flatweed distribution in a lawn?

Method

Given the research question, reference the original method, listing and justifying any changes required.

MATERIALS

From source practical
- quadrat (1 m^2 is a suitable size)
- tape measure (10 m)
- clipboard, paper and pencil
- weed species chart or field guide

Additional materials
- light meter (lux meter)

FINDING

Risk assessment

- Identify potential hazards and/or other issues related to this investigation
- Describe steps you will set in place to minimise potential hazards and/or address other issues you have identified
- Remember to complete a risk assessment form

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Results

The experimental results will include all the data collected during the fieldwork and other information relevant to the investigation. This may include:

- sketches of the area in question
- a profile of the area showing further information, such as gradient
- notes and lists related to factors observed in the area
- population data collected from each quadrat
- light (lux) readings for each quadrat.

Light (lux) reading/weed count		
Quadrat number	**Number of weeds**	**Light intensity (lux)**
1		
2		
3		
4		
5		
6		

ANALYSING

Process the experimental data collected. This will include using the quadrat data to calculate the average population per square metre and projected overall population for the area. For this investigation it will be important to identify and describe patterns of weed density in quadrats across the lawn and any alignment with patterns in light intensity.

Use the data to calculate mean, standard deviation and uncertainty.

Describe limitations encountered during the experiment.

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INTERPRETING AND EVALUATING

Conclusions

Evaluation

Suggested improvements and extensions

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